

180 New Montgomery Street
San Francisco, California

August 17, 1959

Memorandum

To: Superintendent, Sequoia and Kings Canyon
From: Regional Director, Region Four
Subject: Ecological Research Study--Sequoia and Kings
Canyon National Parks

Attached are two copies of A Report on the Status, Changes, and Ecology of Back Country Meadows in Sequoia and Kings Canyon National Parks, which was submitted July 28, 1959, by Dr. Carl W. Sharsmith in accordance with the terms of Contract No. 14-10-434-232. We have reviewed this report in detail and believe you will agree that it is the product of an unusually thorough and competent field investigation.

A substantial amount of time was required by Dr. Sharsmith to evaluate his field data and reach the carefully reasoned conclusions which are embodied in the report. We feel that this time and the resulting delay in receipt of the report have been fully justified by the final results inasmuch as the value of such ecological research is to be measured by the amount of professional thinking that goes into it.

We believe the two sets of comparative photographs, one set taken in 1940 and the other in 1958, speak for themselves. The text of the report is divisible into two major fields of inquiry. One of these summarizes the basic ecological processes and trends that have taken place in the past fifty years in Sequoia and Kings Canyon National Parks. This information is basic to an interpretation of the high country as well as to an understanding of the trends from year to year in the various back country areas. Inasmuch as you will be analyzing this report yourself, it appears superfluous to offer extended comment on this subject. However, for the record, we would like to call attention to the evidence repeatedly offered in the report indicating that the majority of High Sierra back country meadows may remain essentially unchanged for centuries provided they are not subjected to unnatural ecological impacts.

The other aspect of the report, which covers a detailed ecological examination of certain areas that have long been subject to heavy visitor impact will, we believe, be of great interest to you. It is our hope that the ecological conclusions presented regarding these critical areas may offer support to programs that you already have in operation or under consideration for extending protection to these areas.

When transmitting a copy of the report to the Washington Office, we would like very much to include with our comments any you might have together with recommendations and proposals for action.

We believe you will be gratified that Dr. Sharnith's findings indicate in some areas considerable recovery over conditions existing 18 or more years ago, and also that relatively few areas now are in very serious condition. Additionally, you may be pleased that the soil and moisture conservation program has so clearly been the means of saving various important meadows from extinction.

(SGN) LAWRENCE C. MERRIAM

Lawrence C. Merriam
Regional Director

In duplicate

Attachments (2)

~~Copy to: Director~~

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A REPORT ON THE STATUS, CHANGES, AND ECOLOGY

OF BACK COUNTRY MEADOWS

IN

SEQUOIA AND KINGS CANYON NATIONAL PARKS

Submitted
July 23, 1958
by
Carl W. Sharsmith

A REPORT ON THE STATUS, CHANGES, AND ECOLOGY

OF BACK COUNTRY MEADOWS

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SEQUOIA AND KINGS CANYON NATIONAL PARKS

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INTRODUCTION

As a result of the impact of overuse various meadows of the back country of Sequoia and Kings Canyon National Parks are in a deteriorated condition. Furthermore, owing to the mounting tide of visitors the damage on them is progressively becoming worse. The present report is the result of an attempt to study these meadows with reference to their deterioration and especially in connection with extremely important questions as to the rate at which the deterioration is increasing.

In order to obtain as much information as possible in regard to their status and rate of change in their ecology a survey was made through all of the problem areas (areas of particular concern with respect to the problem of deterioration). Moreover, in order to obtain a basis for comparison with impaired ones, some time was devoted to examining and noting a few practically unused meadows which lie beyond the ordinary course of travel.

Through the larger part of the survey the search for evidence of change and rate of change was enormously assisted by photographs which show a very considerable number of the meadows as they appeared some years ago. Use of them was made whenever one was available for any particular meadow. The photographs in question were the excellent ones in the reports by Sumner (1941, 1947) and by Armstrong (1942), those by Sumner serving as the major resource because of the much larger area they cover. Those which were used were reprinted and appear in the present report.

The main portion of the present report is, in a sense, a running account of observations. Although in the search for evidence of change and rate various meadows yielded little or nothing, these meadows are mentioned also. In this portion the order in which the problem areas are arranged corresponds with that of a previously established order of priority of attention. The results of the present study show this sequence is largely correct.

Preserved plant specimens to serve as vouchers for the species mentioned in the report and which were obtained at one or another of the localities noted are deposited at the office of the Park Naturalist at Ash Mountain Headquarters, Sequoia National Park.

For the unfailing encouragement and much-needed assistance given to him at various points along the way, the writer is deeply indebted to Mr. E. Lowell Sumner, Regional Research Biologist.

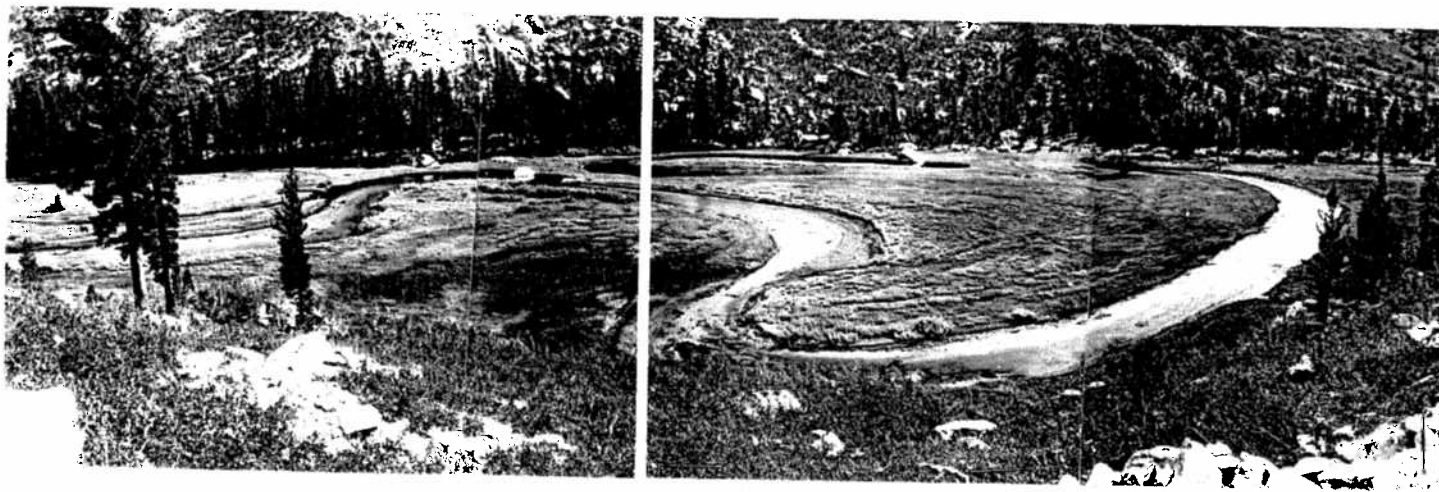
ITINERARY

Must have been 1955

Sugarloaf Meadow	July 10, 1959.
Scaffold Meadow	11.
Grave Camp	12.
Cement Table	13.
Boggy Meadow	14.
Williams Meadow	15-16.
Junction Meadow on Bubbs Creek	18.
Charlotte Lake and Bullfrog Lake	19-20, 24.
Vidette Meadow	21-22, 24.
East Lake and Ouzel Meadow	23.
Junction Meadow and Charlotte Meadow on Bubbs Creek	25.
Paradise Valley	27.
Rae Lakes and Sixty Lakes Basin	28-30.
Woods Lake	July 31--August 1.
Castle Domes Meadow	August 2.
Paradise Valley	3.
Tent Meadow and Fallen Moon Meadow	5.
Simpson Meadow	6.
Palisade Creek and Grouse Meadow	7.

ITINERARY (continued)

Little Pete and Big Pete Meadows; Daisy Basin	August 8.
Simpson Meadow	9-10.
Upper Leconte Canyon	11.
Colby, McClure, and Evolution Meadows	12-13.
Grouse Meadow	14-15.
Simpson, Daugherty, and Pallen Moon Meadows	16-17.
West Mountain Meadows; Wildermuth Meadow	18-19.
Paradise Valley	21.
Cement Table	23.
Junction Meadow on the Kern	24-25.
Timberline Lake and Crabtree Meadow	26-28.
Big Pet, Scaffold, and Williams Meadows	29-30.
Hockett, Sand, Mitchell, and South Fork Meadows	September 3-6



Grouse Meadow

**THE BACK COUNTRY MEADOWS: THEIR GENERAL FEATURES AND ECOLOGY, AND STABILITY
UNDER NATURAL CONDITIONS**

The back country meadows occur in various situations: on forested or brushy, sometimes fairly steep slopes, in swales or large, level or gently inclined spaces more or less surrounded by often heavy forest, on flats in valley or canyon bottoms, in level, filled-in lake basins, and on open, subalpine or alpine slopes and benches. In the zone of forest they range from minute representations to large, clean expanses of sixty or more acres, while at open, higher altitudes they may extend brokenly over almost indefinite distances. They occupy residual or mostly transported soils composed of gravels, sands, or silts, the parent material of which is almost wholly of granitic origin. In wet meadows the amount of organic matter in the soils may perhaps range at times to as high as fifty percent or more.

Although in some cases it is difficult to account for the presence of a meadow in a given site, the reasons are often quite evident. In any event, within the overall climate circumstances of the topography, soils, and soil moisture provide the essentials of the local habitat, and within the latter the primary factor which governs their existence is the soil moisture supply. Roughly beyond an altitude of 7500 feet, above which the majority lie and extend from thence to higher than the treeline, any role played by fire in contributing to their origin rapidly diminishes in importance.

Sumner (1941) described the meadows in Kings Canyon National Park in terms of range types and utilized for this purpose the broad classification into wet meadow, woodland meadow, and shorthair meadow. This grouping serves as well for Sequoia National Park. The wet meadow, as the name implies, occurs where the soil is prevailing wet, whereas the woodland meadow he regards as probably being a former wet meadow which has been invaded by forest. The aptly named shorthair type is best developed in and largely restricted to the

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higher altitudes. It extends above the treeline whereas the others are confined to the zone of forests. Since these three intergrading types have some vegetational distinctions and partly involve soil moisture differences, this classification has a somewhat ecological basis. Another convenient classification and one which is in wider use is a broad division into two types or classes: the mid-altitudinal or montane, and the high altitudinal or subalpine and alpine. By implication in terminology it should take cognizance of changes in all factors with increasing altitude.

Although ecologically regarded as grassland, the meadows can be referred to this type of vegetation only under a broad concept. Even under undisturbed, natural conditions numerous non-grassy herbaceous species often enter into their composition. Normally, however, the grass form of growth greatly predominates, and the vegetation is commonly either an intimate mixture in varying proportions of grasses, sedges, and rushes, or a varying mosaic of more or less pure stands of these plants. More usually than not, sedges tend to predominate, and in a wet meadow they may form nearly all of the cover. As noted by Sumner (1941) the roots of the sedges form a remarkably tough sod. As opposed to the more delicate, fibrous roots of grasses, those of sedges are coarser and much tougher. In a dense stand of the plants they are almost inextricably interwoven, and play a very effective role in binding the meadow.

It becomes obvious from their very diverse forms and occurrences that the meadows have had various modes of origin. The most commonly known means is through lakes by the cumulative effects produced by the development of vegetation and continual deposition which in time change the former aquatic habitat into a terrestrial one. Others have developed on or along moist or wet stream deposits. Still others have arisen wherever drainage by some cause or another had become impeded, or where as a result of shifts in position of the ground water level seepages developed. They have also originated where water saturated conditions were maintained in accumulations of sands and

gravels which cover slopes or fill depressions, and on slopes above the tree-line they have sometimes also arisen as a result of nivation.

Succession is the orderly sequence of transformations in vegetation resulting from the interactions between plants and their habitat. It culminates when the interactions reach a state of relative equilibrium known as the climax. In the broad zone lying between foothill and treeline the regional or overall climax is forest which in turn is determined by the regional climate. Within this wide belt, however, peculiarities of topography and local soil conditions exert local, controlling influences on the course of succession. Although because of natural changes in the complex of ecological factors some meadows have succumbed in varying degrees to the regional climax, in others the conditions are very stable and the meadows as a result are of long duration. In any event, under natural conditions usually the rate of invasion is relatively very slow, and in some instances any invasion whatever may be very long withheld. Often sharply defined limits of meadow, marked by an encircling wall of old forest, show by the age of the trees that the boundary between meadow and forest has remained stable for centuries. Even long after extraneous forces have changed conditions and provoked invasions by forest the position of the ancient, original boundary may still be in evidence by the abrupt change in the age of the trees.

By and large with gain in altitude the rate of succession (as well as rate of recovery following overuse) becomes increasingly slower. This applies also to the rate of invasion and to changes in general. Obviously these rates will tend to be about the same in meadows situated at comparable altitudes, except of course as modified by differences in site, exposure, soils, and moisture supply. Owing to the rather progressive diminution in the number of species with increasing altitude, the stages of succession tend to become correspondingly fewer and more simplified.

Back country meadows of any size or consequence which at some time or

another have not been subject to the impact of use are rare or perhaps non-existent. On the other hand there are a few that are only very lightly or rarely used or have not been grazed at all for a number of years. The following meadows, although unfortunately of very limited number, are on the whole good examples of this kind. They are in an essentially natural or "unused" state, and photographs provide some grounds for judging their degree of stability or rate of change over an interval of eighteen years. They also provide a basis for comparison with used meadows with respect to the same questions and over the same period of time. Except for the last one mentioned, all of them are situated in the area near Goat Mountain and Granite Pass.

On Tent Meadow or the wet, uppermost portion of the area with this name the grassy cover is in as virgin a condition as when noted in 1940 by Sumner (1941), and from a distance the meadow shows no appreciable change in its former size or shape of outline, nor any apparent alteration in its general appearance (figs. 1, 2). Changes have been much slower to appear than on portions of a neighboring slope where invasion by Red Fir has occurred with such rapidity as to completely obscure the view of the meadow from a point from which it was formerly visible.

Goat Mountain Meadow No. 1 likewise seems to show no change, at least none that is important (figs. 3, 4). On Goat Mountain Meadow No. 2, a false-hellebore invasion, which Sumner (1941) suggested as being perhaps the result of stock grazing in early days, shows no appreciable amount of expansion. Its front appears to be practically stationary, and evidence for this is readily apparent on close examination of the almost identical views (figs. 5, 6). At the far end of the meadow a lodgepole invasion, also begun some years prior to 1940, seems to have made no further, forward advance. Evidently conditions which for a time were rapidly changing finally became stable and have remained so for nearly two decades.

On Wildermuth Meadow nearby, the growth is as virgin as when observed by



Fig. 1. Tent
Meadow as it
appeared in
1940.



Fig. 2. Tent
Meadow, from a
closer but other-
wise similar
view, as it
appeared in
1958. No change
is evident.



Fig. 3. Goat Mountain Meadow No. 1, as it appeared in 1940.



Fig. 4. The same meadow in 1958. It shows no important change.



Fig. 5. Goat Mountain Meadow No. 2, as it appeared in 1940. It then showed invasion by falsehellebore and, in the far distance, also invasion by lodgepole.

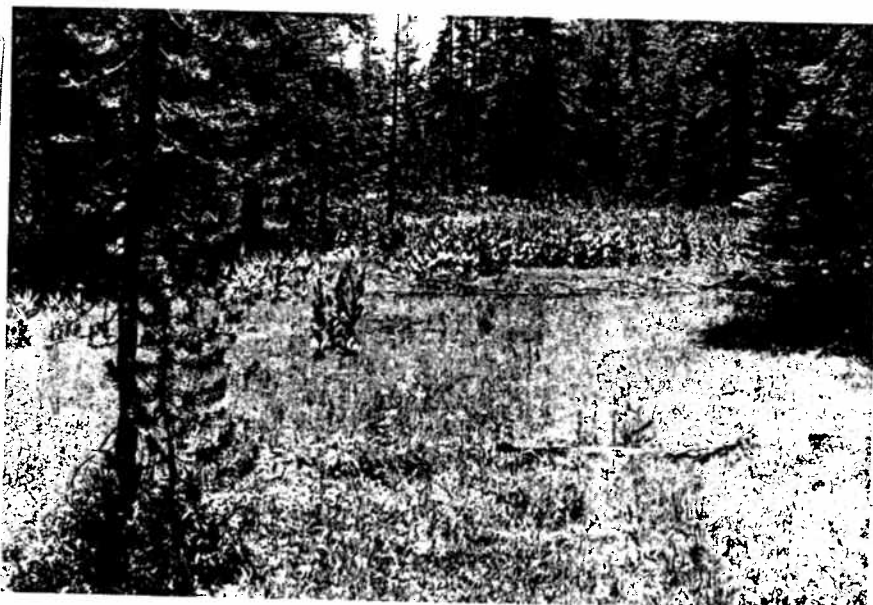


Fig. 6. The same view of the meadow in 1958. The "front" of the falsehellebore invasion stands at the same position it stood in 1940, and the same seems to apply to the lodgepole.

Summer (1941). Over much of its surface the dense, luxuriant cover of mainly grasses and sedges of two to four or, in some spots, up to five or six feet high, grow. Other than the disappearance of a few, scraggly patches of low woody growth which appear to have been decadent in 1940, the meadow seems to have undergone no essential change (figs. 7, 8). On a bench directly above Wildermuth the margin of a wide, marshy, sedge meadow is extending itself further into the shallows of a lake at a rate which seems to be rather negligible for eighteen years (figs. 9, 10). Furthermore uniform and rather stable conditions seem to be shown by the meadow as a whole. Its composition is almost unvarying from end to end; the same few species of sedge seem to compose the marsh nearly throughout and, except on a very inconspicuous eminence, its appearance has not noticeably changed.

The meadow in Granite Basin is not only a good example of recovery from former, local damage, but is also of interest in clearly showing no change in the distribution nor even much alteration in the form, size, and density of the willow thickets and shrubs (figs. 11, 12). In a distant view of another meadow, namely the highest of a series on the north side of Granite Pass, no apparent change is observable at least in the larger aspect of its intricate pattern of surface features (figs. 13, 14). At still another, in the lowest meadow of this series, a near view shows no appreciable change of essential detail (figs. 15, 16).

Fallen Moon Meadow, situated at a lower, rather drier level on the same side of the pass, has a practically unchanged appearance (figs. 17, 18). It also gives evidence of stability in another way, namely through the form of growth assumed by the extremely few lodgepoles which have succeeded in invading its open expanse (fig. 19). In the foregoing connection this point is worthy of some elaboration. On a lightly used or unused meadow, or one on which conditions have not altered in such a way as to favor invasion, repression by a varying combination of adverse factors occurs. The mechanical and



Fig. 7. In 1940 Wildermuth Meadow showed a virgin condition which it had long previously sustained.



Fig. 8. In 1958 Wildermuth was in the same virgin condition. The falsehellebore in the foreground, shown more clearly by tilting the camera, is about as distant as it was in 1940 from the nearest, tallest tree out in the meadow.



Fig. 9. Sedge marsh and lake beneath Goat Mountain in 1940.



Fig. 10. Essentially the same view of the marsh in 1958. Although willows in the foreground partly obscure the view, the extent of marsh and lake appear to be about the same.

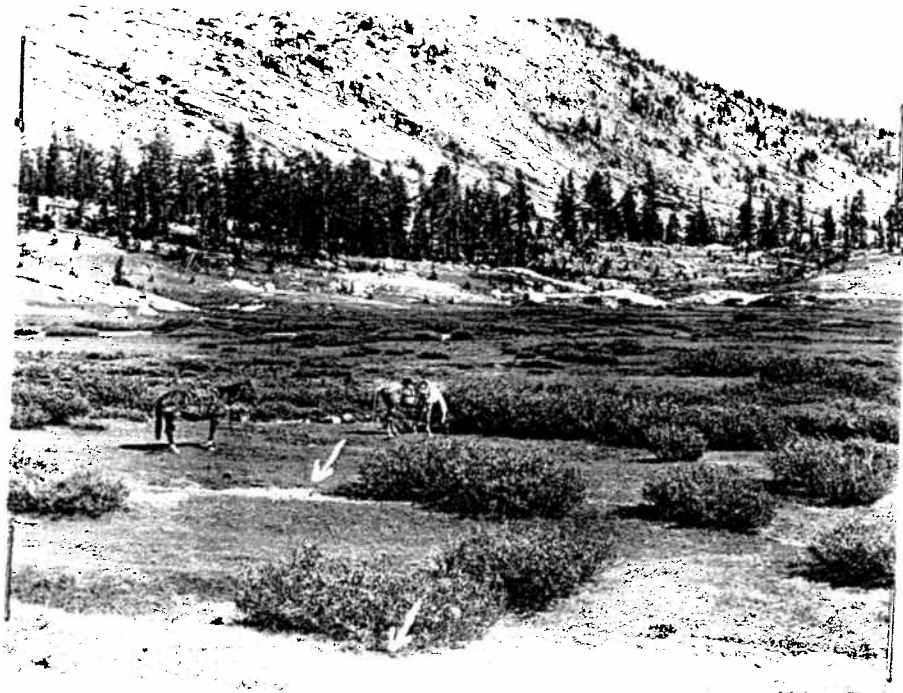


Fig. 11. Meadow in Granite Basin as it appeared in 1940. Dust wallows caused by fairly heavy use are indicated by arrows.



Fig. 12. By 1958 the scars of the former dust wallows had healed. Their former location serves as a means of orienting this view. No appreciable change is shown in the form, density and distribution of the willows.



Fig. 13. The highest meadow of a series on the north side of Granite Pass as it appeared in 1940.



Fig. 14. The same meadow in 1960. The distribution of its surface now to show an irregular pattern.



Fig. 15. The lowest meadow of the series on the north side of Granite Pass in 1940.



Fig. 15. The same view in 1968. There appears to be no significant alteration whatever in the features of this meadow.

other barriers presented by the close ground cover greatly inhibits successful germination of lodgepoles. Because of disfavorment in local competition with the long established and dense grasses and sedges, if germination has occurred growth is very slow. As growth ensues the leader and various branches may become injured or killed by the ravages of a very small bark beetle (Ips). The new branches, which in time have come to replace the dead, may become affected similarly by the same agent. On a given meadow the depredations may be largely or sometimes wholly confined to the invaders: the young and other lodgepoles in the nearby forest border may remain untouched. At times possibly exposure because of the open site also has repressive influences, and the net result is a dwarfed, mis-shapen individual of rather characteristic appearance. On the open expanse of Fallen Moon Meadow the very sparse invasion by individuals all with this form of growth obviously indicates that stable meadow conditions are being rather strongly maintained.

In the Bubbs Creek Area, on Ouzel Meadow just above East Lake, the dense grassy cover shows no significant difference since 1940 except a seasonal one and a less used appearance. On the other hand a few mostly storm battered lodgepoles have arisen, but almost all of them are associated with the willow thickets, and the latter have not advanced. Some change is therefore occurring in the woody vegetation, but the meadow itself remains practically the same (figs. 20, 21)

In conclusion, all the above meadows show a large lack of change. It reflects the achievement of equilibrium or balance between forces, and is associated with the large absence of extraneous disturbance. Although shifts in the point of balance may sometimes occur under wholly natural conditions, and therefore exceptions undoubtedly exist, the above instances and observations still warrant the conclusion that, under those conditions back country meadows are very stable generally, and that changes of any importance are only very slowly achieved.



Fig. 17. Fallen Moon Meadow as it appeared in 1940.

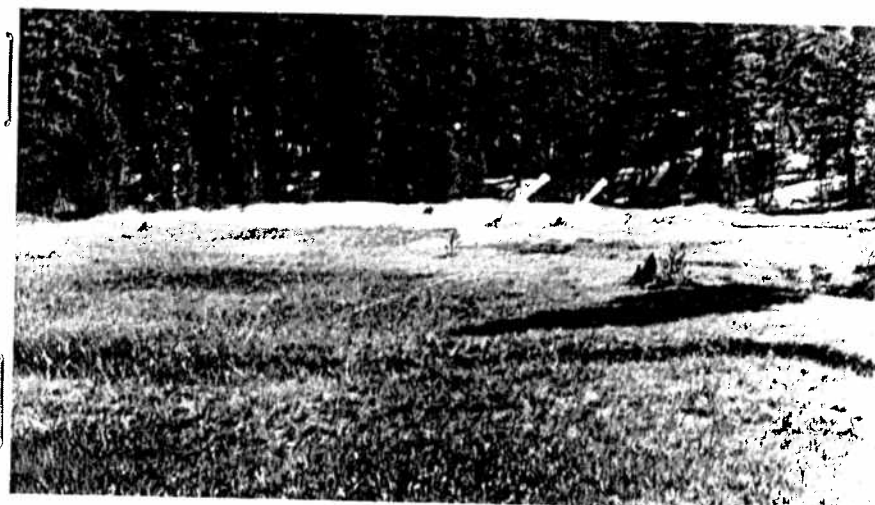


Fig. 18. The same view of Fallen Moon Meadow in 1958. Although some lodgepoles have recently established themselves on its border, very few have succeeded in invading its open expanse in eighteen years.



Fig. 19. A close-up of still the same view shows more clearly two of the invading lodgepoles. Their growth is much repressed.



Fig. 20. Ouzel Meadow as it appeared in 1940.



Fig. 21. Ouzel Meadow in 1958. A few lodgepoles have appeared, but most of these have been broken down by storms. Other than this there appears to have been relatively little change.



Fig. 20. Cuzel Meadow as it appeared in 1940.



Fig. 21. Cuzel Meadow in 1958. A few lodgepoles have appeared, but most of these have been broken down by storms. Other than this there appears to have been relatively little change.

THE STATUS AND CHANGES OF MEADOWS IN THE PROBLEM AREAS

1. THE BUBBS CREEK AREA

Vidette Meadow. Vidette Meadow, on comparing its appearance in 1940 with that of 1958, shows, in paired photographs (figs. 22, 23), the following changes: (1) willows which formerly occurred on the open meadow seem to have disappeared completely; (2) willow thickets along its borders and within the fringing margin of the forest have been eliminated and replaced by extensions of close-cropped meadow; (3) elsewhere in the bordering forest former openings between the scattered older trees have become filled in by stands of young lodgepoles; (4) the forage, at least that nearest the observer, seems to have assumed a somewhat improved appearance.

Field scrutiny of the meadow itself showed that actually, on the open meadow, the willows are almost, but not quite, gone; the few that remain are hidden in depressions and drainage ways, and are dwarf, half dead, or dead. At the border of the meadow, a former dense willow thicket eight to ten feet high which stood under a leaning snag (shown at left margin of figs. 22, 23) has practically disappeared in death. Although but few invading lodgepoles have succeeded in establishing themselves out on the open, here and there vigorous, occasionally dense stands of invasion are developing in the spaces between the scattered, very much older, larger trees which stand along the border of the meadow. A gap of several centuries of time separates the age of the invasion from that of the original forest (fig. 24) although occasionally some of the trees are seemingly intermediate in age and thus a sharp separation of the two age classes is not always possible. No ring counts were made; but as an estimate, an age of roughly forty years would seem about correct for the oldest trees of the invasion. Turning to the seemingly improved forage (foreground of

fig. 23), actual examination showed it to be a sparse stand, composed wholly of native species, and representing in the succession predominatingly a primary and secondary weed stage (Torrey Popcornflower, Rose Pussytoes, Carpet Clover, Northwest Cinquefoil, Meadow Penstemon, and Western Yarrow) intermingled with a low, scattered, feeble beginning of a subclimax or climax stage (Canyon Sedge, Kentucky Bluegrass, Tufted Hairgrass, and Baltic Rush). This weak beginning of trend to improvement was, however, confined to a few peripheral spots which escape the very heavy use the main body of the meadow suffers generally.

Sumner (1941) noted for this meadow the existence of incipient traces of erosion. In 1958 erosion did not appear to have developed much if at all beyond this stage.

Conclusions. As compared with Vidette Meadow of 1940, the smoothed-out, more heavily used and more distinctly pasture-like appearance, the injured, repressed and nearly exterminated shrubby growth, the new extensions in area of closely cropped meadow, the localized but increasing lodgepole invasion active within its forest border, the failure even in fortuitous spots of a display of more than bare beginnings of recovery despite highly favorable, seasonal growth-conditions, and the as yet infrequent but new and almost exotic advent of weed patches (fig. 25), collectively indicate a marked advance in the trend to deterioration and the net result of an insufficient degree of protection over the years. Obviously this trend could be halted or even reversed by promptly applying and enforcing more stringent restrictions on all of the grazing use.

Charlotte Lake Meadows. In this group of wet subalpine meadows the one in great need of relief from continued misuse is the first meadow of the series which begins just below the lower end of Charlotte Lake. In 1940 Sumner (1941) already found this meadow badly trampled and actively eroding.



Fig. 22. Vidette Meadow as it appeared in 1940. The willow thickets were thinning out.



Fig. 23. Vidette Meadow in 1958. The willows have practically disappeared. Evidently the degree of use to which this meadow is subjected is such that it does not promote an increase of willows.



Fig. 24. The sharp distinction into two age-classes of trees is easily seen in this view of the stand of lodgepole which borders Vidette Meadow. This clear separation is rather confined to the meadow margins. Local disturbance was undoubtedly the cause of the upsurge of reproduction.



Fig. 25. This perennial patch of nettles covers most of the nearby shaded area shown in this view of Vidette Meadow. It is immune to grazing.

The factors responsible for these circumstances have not been alleviated, and over the years it has come to assume an appearance that without doubt is very unlike that which it had originally. In a primitive, unused, wet subalpine meadow of this type, the dense grassy sod that borders the streamways (or lakes) normally extends over the banks as a solid, rounded, billow-like, curving mass, the outermost, lower edge of which touches the surface of the water or, during times of high water, extends below it. Except perhaps at the outer side of curves in rapidly flowing streams no vertically cut banks of raw soil are visible. In the meadow in question, however, raw banks are clearly and commonly in evidence (figs. 26, 27) and the sod along their rims is cut away as sharp, horizontal lines. Since 1940 these effects of erosion have very probably become accentuated. They cannot be measured as to amount. On the other hand the extent to which erosion has occurred since 1940 along the banks of only a small, intermittent, very minor branch of the main drainage stream may at least be judged by making a close comparison of the appearances (center foreground of figs. 26, 27). The slight differences seen are not illusory. At the site itself the change in profile of the banks from sloping to vertically-cut is visibly evident and suggestive of the volume of soil which must have been eroded from the meadow generally. This overall volume must be very considerable, especially when note is taken of the fact that sheet erosion has been continually augmented by the creation and extension of new bare spots. These are common along the trailside border of the meadow (fig 28) and are scattered over the meadow itself as well. In view of all the foregoing a very rough estimate of some few but very important inches of topsoil loss for the meadow as a whole during the eighteen year interval may not be unreasonable.

In possessing sphagnum in abundance, this meadow is of particular ecological interest in view of its rather southerly location. It is one of the very few sphagnum-rich subalpine meadows this far south in the Sierra which is readily accessible by trail, and may well be among the most southerly of

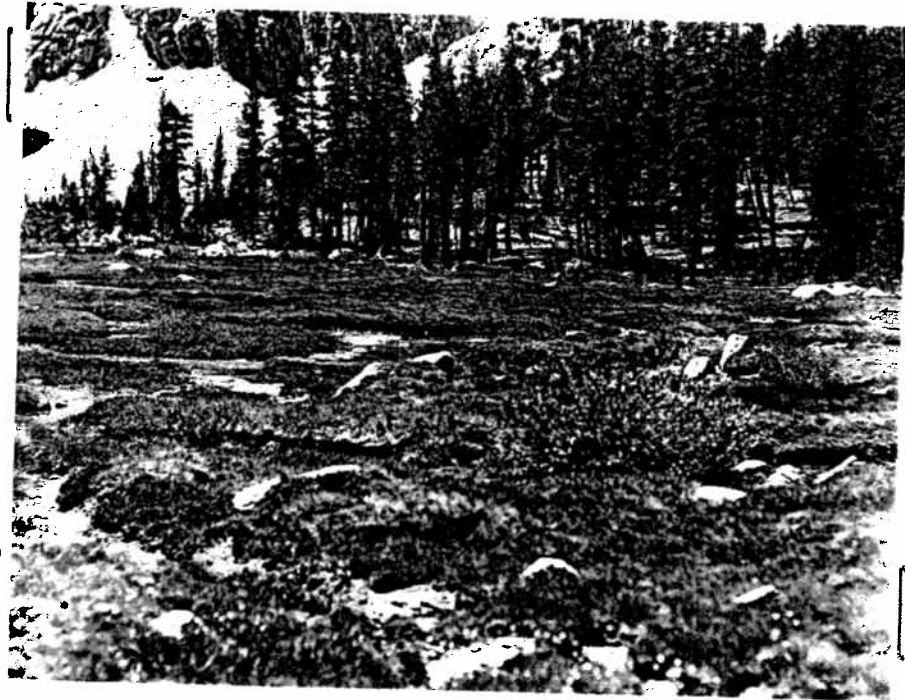


Fig. 26. First Charlotte Lake Meadow in 1940. The effects of erosion are quite evident.



Fig. 27. First Charlotte Lake Meadow in 1958. High water conceals some but not all of the effects of the continued, severe erosion. Since 1940 several inches of soil have been removed from the stream banks which show in the middle foreground.

sphagnum-rich high mountain meadows in western United States. Aside from its special botanical peculiarities, sphagnum is indicative of a deep layer of soil organic matter. Entrenchment of the meadow by erosion with consequent lowering of the water table would rapidly deplete this organic matter by oxidation following aeration, while the sphagnum itself, despite its great capacity in raising the water table by its growth, would gradually thin out and disappear (fig. 29).

Little invasion of lodgepoles has occurred. On the open meadow the relatively few invaders which do occur are stunted or repressed, and probably about half of them are more or less deadened because of attacks by the Ips beetle.

The remaining meadows of the series are in about the same good condition as was noted by Sumner (1941).

Conclusions. In view of the circumstances and conditions described above, any further grazing use of Charlotte Lake Meadow is wholly unwarranted. Likewise unwarranted is the present location of the trail which extends along its northern border. In its present location it transects the boggy margins of the meadow and thereby is the cause of continual severe damage to those margins by users of that trail.

It is appropriate at this point to indicate that for the back country patrolling ranger charged with protection of the Bullfrog Lake area the location of his residence at Charlotte Lake is a handicap. Unfortunately at the present time the only cabin existing in the Bullfrog Lake area is at Charlotte Lake. As utilized as a patrol cabin it is too far removed and hence isolated from the main course of public travel in the Bullfrog Lake area to most effectively serve as a base for the protection of that area.

Bullfrog Lake. Although no old photographs of the heavily used meadows bordering Bullfrog Lake and other nearby lakes were available for



Fig. 28. View of only one of the trampled and severely eroding areas along the trail bordering first Charlotte Lake meadow. The regular trail (right margin) is "running a creek."



Fig. 29. Sphagnum curving as a bilow over a bank on first Charlotte Lake meadow. Probably no other kind of plant is more efficient in raising the water table. Knife-handle (right) is 3½ inches long.

comparison, it is quite evident here that deterioration from overuse is continuing. Particularly plain is excessive localized damage by trampling. Livestock held habitually near the lakeshore perhaps mainly by passing parties making temporary stops has created large bare spots (fig. 30). At the high altitude of Bullfrog Lake such spots with complete destruction of cover would require for their entire, natural recovery complete protection over a period of probably not less than about twelve years.

Conclusion. Owing to its badly damaged condition any grazing use of the meadow area around the inlet to Bullfrog Lake is unwarranted at the present time.

East Lake. As basis for judging the rates of any changes in the meadows adjoining ^{West} East Lake old photographs were available only for Ouzel Meadow which lies just above the ^{West} ~~east~~ shore of the foregoing lake. Ouzel Meadow, probably because of lack of easy means of access bears evidence of only light, occasional use (fig. 31) and has remained in an essentially natural state. It has therefore been treated at an earlier point in this report. East Lake Meadow which is situated in the valley of East Creek above East Lake has such sparse useable forage and boggy ground that it is only of limited use for stock (Sumner, 1941). The inadequately-drained trail and its boggy margins which lead to it from East Lake shows signs of heavy use and of erosion.

Conclusions. Until Sumner's (1941) recommendation to improve the access to [and simultaneously to restrict the use of] the forage at Ouzel Meadow is adopted, any effective addition to the very limited amount of grazing area available in the environs of East Lake is precluded.

Junction Meadow. In the eastern portion of Junction Meadow the stand of aspens and brush which according to Sumner (1941) was capturing this area (fig. 32) has in eighteen years (1940-1958) undergone various alterations. Aspen reproduction which was on the ascendancy in 1940 has since declined and



Fig. 30. Local destruction of cover, Bullfrog Lake Meadow.

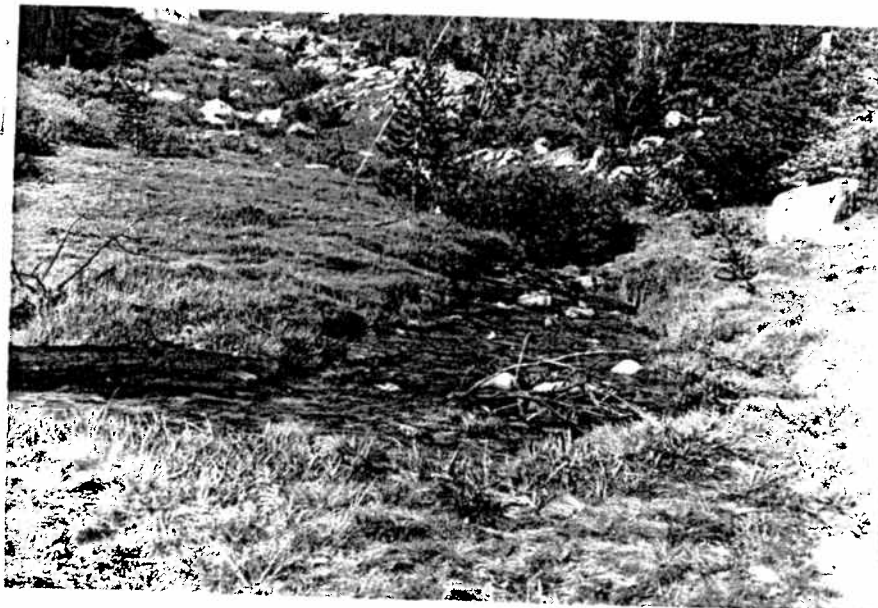


Fig. 31. Guzel Meadow shows very little change over the years.

several patches of the trees have disappeared. The growth of brush has not been sufficient to cover the former numerous bare spots, and the patches merely show various shiftings of position and changes in density with a probable overall increase in amount of Wax Currant. Meanwhile Red Fir has come to replace some of the aspens and brush, and this fact, together with the rapid appearance and growth of the fir, attests the probable trend of this area to forest (fig. 33). The sum of all these changes would seem to indicate a diminishing supply of soil moisture as primary factor functioning adversely for continuance of aspen but favorable for the ascendancy of Red Fir. Any scant forage which existed in this formerly trampled and overgrazed area has in the meantime practically disappeared.

Western portions of Junction Meadow are in the same badly overgrazed condition as was reported for 1940 by Sumner (1941) or are in an even worse condition than they were at that time. In the small meadow at the junction of East Creek (fig. 34) weeds and especially annual ones predominate over grasses and thereby indicate a late stage of deterioration. The vigorously-growing aspens that form a dense bordering thicket are sending out root sprouts into the meadow, while elsewhere around the meadow thickets of Wax Currant show considerable use as browse if not by deer then by hungry stock in its almost vain search for adequate forage. At another meadow in the near vicinity the forage is by midseason already cropped to within an inch or two of the ground (fig. 25, a photograph taken July 22) and patches of weeds composed mostly of Hollowstem Lupine and sharply avoided by livestock have arisen within perhaps the last few years.

Regulations limiting grazing use apparently do not apply to all alike. In an adjoining very wet and excessively trampled meadow the several head of stock, belonging to the trail crew camped nearby, wandered through the night. The nearby sign reads: "stock limit two head per party per day..."



Fig. 32. Eastern portion of Junction Meadow as it appeared in 1940.



Fig. 33. Same view of eastern portion of Junction Meadow as it appeared in 1940. During the interval 1940-1988 the growth of aspens and brush has not been sufficient to cover the numerous bare spots; invasion by Red Fir has increased, while at the same time the scanty forage has almost disappeared.

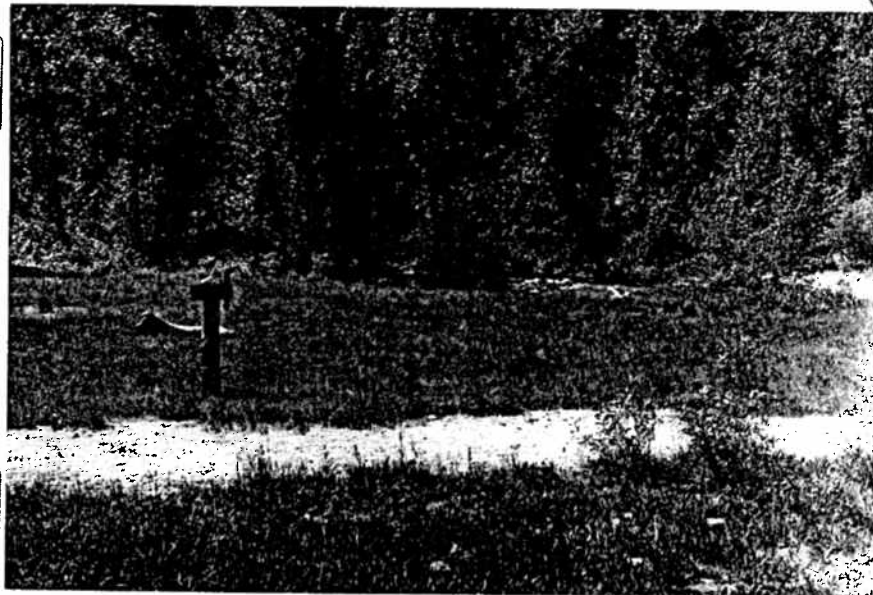


Fig. 34. Most of the ground cover in this view of a portion of Junction Meadow is composed of weeds in which annual species predominate and thereby indicate a late stage of meadow deterioration.



Fig. 35. The weed patches scattered in this badly overgrazed portion of Junction Meadow began their existence not more than about seven years ago.

Conclusions. Until recovery of forage has been assured through closure over an appropriate period of time, all further grazing use of Junction Meadow is unwarranted. While the question as to where any nearby grazing areas could be found as substitutes for Junction Meadow during the period of complete withdrawal is perhaps incapable of solution, the urgent need to stem the deterioration by the most effective and rapid means possible clearly outweighs any considerations of the inconvenience or even difficulties which would be imposed upon travel as soon as such a drastic but temporary measure was placed in effect. Following its recovery certainly the conditions would remain improved only under considerably more stringent limitations regarding its use than those which now apply. Finally, in connection with the whole problem mention should be made of the excellent proposal, made by Sumner (1941) and by Rutter and Black (1953), of a Charlotte Creek Trail. Obviously the existence of such a trail would go far in decreasing the pressure on Junction Meadow.

Charlotte Meadow. Despite the impression which might be gained by a view from the brushy trailside (figs. 36, 37), Charlotte Meadow, situated a short distance below the junction of Charlotte Creek and Bubbs Creek, is in a remarkably improved condition over that described by Sumner (1941). The only evident indication of reduction in area is a dense growth of Western Bracken which has come to occupy the rocky ground on the side towards Bubbs Creek; elsewhere the original bounds of the meadow seem to be little changed in position. A tall and dense growth of native forage now covers the area. Nebraska Sedge is three feet high and all other forage species are developed similarly in proportion. Except at the corner nearest to the trail where a few non-native weeds still linger, the meadow has attained an essentially complete recovery of its original virgin luxuriance (figs. 38, 39).

Conclusions. Charlotte Meadow began its recovery when the excessive use to which it had been subjected diminished sufficiently. It became by-passed some time since 1940 possibly because of trail improvements which substantially



Fig. 36. Charlotte Meadow as it appeared in 1940. At that time this meadow was badly trampled and overgrazed.



Fig. 37. The same view of Charlotte Meadow in 1958. The taller, heavier brush now almost conceals the abundant forage from view.

Q

Q

Q



Fig. 38. This view of Charlotte Meadow in 1958 shows a return of forage to a state of almost virgin luxuriance. Unless the ground dries out the patch of Western Bracken shown in the background beneath the largest rock should not advance appreciably.



Fig. 39. Another view of Charlotte Meadow in 1958. Nebraska Sedge is three feet high.

decreased the amount of time necessary for reaching higher forage areas, or else because of closure although no posting to this effect was evident. Notwithstanding that this event may have occurred even more than ten years ago, on the basis of rates of recovery indicated elsewhere in the problem areas, the length of time involved in reaching its present (1958) highly improved condition from a heavily overused state very probably required no more than ten consecutive years immediately preceding 1958, or perhaps no more than seven. Furthermore, although its present condition is maximal owing to the good soil moisture conditions of the wet 1958 season, its stage of development with respect to succession is climax. Aside from differences in amount of seasonal development as occasioned during wet as opposed to dry years, and unless disturbance by overuse enters the picture, when once the status of climax is attained a meadow would tend to remain relatively unchanged. Thus the present appearance of Charlotte Meadow may have been established several years before 1958.

2. THE UPPER KERN AREA

Junction Meadow. If a final stage of deterioration is a thinning, beaten forage cover largely or wholly replaced by weeds in an eroding meadow already taken over by a closing stand of a lodgepole invasion, then Junction Meadow on the Kern is one which is rapidly approaching this state. The lodgepole invasion itself now covers a very considerable portion of the meadow. Although the few ring counts and branch counts obtained would suggest that the invasion began abruptly, between twenty and twenty-five years ago, the maximum age of perhaps most of the trees is no more than ten to fourteen years. This would indicate a rapid increase in the rate of invasion. Numerous survivors of trampling have now grown up beyond reach of further injury by livestock (fig. 40), and their elevated leading shoots are rapidly elongating (as much as two feet gain in length during the growth season of 1956). The increasing density

of the stand, together with the expanding areas of unpalatable weeds, is furnishing additional areas of shelter for newly arrived seedling trees. Reproduction is speeding up. Despite initial suppression by trampling the invasion has already captured perhaps thirty percent of the meadow (fig. 41) and its rate of progress is such that in about ten more years it may have completely taken over the remainder. Meanwhile erosion is also reducing the area of meadow (fig. 42).

The present invasion is not the first one to have developed on Junction Meadow. In a report by Sumner (1936) is a photograph showing the meadow as it appeared in 1936. (By an oversight the availability of this photograph for comparative purposes in the field in 1958 was overlooked.) Evidently the area was considerably larger in 1936 than now (1958) owing not only to the effects of a fire, which not more than a few years previous to 1936 had swept the meadow, but also to the removal, shortly before or following that fire, of essentially all of the lodgepole invasion which had existed at that time. Although the cause of the fire is perhaps unknown, the thickly occurring small stumps remaining after the young trees had been removed plainly indicate that a deliberate attempt had been made to "open up" the meadow at least by cutting away the invasion.

Tree invasion of meadows is initiated through seed from the neighboring forest. Removed lodgepoles rarely if ever sprout from the stump. According to ring- and branch-counts already noted the present invasion on Junction Meadow began anew soon after the one preceding it had been removed. It differs from this earlier one only in that it has had a longer time in which to develop and thereby to preempt a larger area.

The causes underlying the persistent trend and rapid rate of invasion of Junction Meadow may be complex. Although overgrazing is undoubtedly one of these causes, there is a possibility, raised as a suggestion by Sumner (1936), that if activity of the Kern River is a factor, then a shift of the river to a



Fig. 40. Junction Meadow on the Kern. The leader of the nearest lodgepole invader grew two feet in length in 1956.



Fig. 41. Junction Meadow on the Kern in 1958. As a result of invasion during the ten to fourteen years immediately preceding 1958, lodgepoles have captured perhaps thirty percent of this meadow. The hat on the ground is merely to show more clearly the overcropped cover. At the time when the photograph was obtained practically no available forage existed.

point more distant from its former position with respect to the meadow is involved. Such a shift, if it occurred, would have deprived the meadow of a formerly more abundant moisture supply since, as he indicates, except for a small, sluggish branch, the Kern River is situated at some distance from the meadow, and the latter is prevailingly dry.

Circumstances necessitating the use of this meadow may at times pose a problem, as in the following instance. As on meadows elsewhere throughout the Problem Areas during 1958, the growth conditions on Junction Meadow were highly favorable. Despite this fact, by August 24th of that year the degree of use had been such that no useable forage remained. Although a dense, continuous turf covered fairly extensive areas, it had been cropped so short that a thimble lying on it would have been visible fifty feet away. On arriving at sundown, the stock used by the present writer in reaching the meadow gave up the search for feed in only ten minutes. The scant feed discovered for them some time later at some distance down the canyon sufficed the three head only until 3:00 A.M. It was fully expected that the forage would be scarce, but not as scarce as this.

Conclusions. Junction Meadow is undergoing a rapid trend to extinction, and neglect may result in its essential disappearance in another decade. Scarcity of forage in this portion of the Kern is such that even the poorest is of value. Situated as it is by unalterable topography at the point of convergence or departure of four important trails, by its very location the meadow assumes an importance strategically which cannot be overlooked. On these grounds clearly a serious attempt to improve the meadow is warranted in addition to withdrawing it immediately from current use.

Timberline Lake Meadow. The badly overused meadow at Timberline Lake has and is continuing to undergo rapid, deteriorating changes in the low, boggy portion which constitutes its major area (fig. 43). Formerly this portion was



Fig. 42. Meanwhile erosion is also reducing the area of meadow shown in this view of Junction Meadow of the Kern.



Fig. 43. Timberline Lake Meadow is being quickly transformed by the invasion of an inferior forage that promptly replaces a superior one which is rapidly being destroyed.

well covered over with a valuable forage composed of a dense, low growth of shorthair grasses and sedges. On a large amount of the lower ground the original meadow thus constituted has been largely destroyed, and often only mere fragments of it remain (fig. 44). That which has disappeared contained a depth of as much as four or five inches of richly humified, structured top-soil which required an untold number of years to build. Beaked Sedge is now rapidly filling the beaten ground wherever respite from trampling permits, and provides but an inferior substitute for the valuable forage it has come to replace. Thus the transformation into this inferior forage quickly ensues in the wake of the destruction.

On meadow stringers just below Timberline Lake the trail has over the years merely shifted to provide new sites for gullying (fig. 45).

Conclusions. Although the sedge cover which has invaded the major portion of Timberline Lake Meadow would provide a limited use, the broken remnant of valuable shorthair sod which still remains on the boggy ground is far too susceptible to destruction; hence any further grazing use is unwarranted. Also unjustified is damage to meadow stringers by a trail which could easily be relocated to a position where no damage to them would occur.

Crabtree Meadow. This extensive meadow in 1958 appeared to be in good condition generally (fig. 46). There is scarcely any evidence of invasion, and little of erosion. The lower end of the largest area showed signs of former trampling, but is now on the way to recovery (fig. 47).

3. THE RAE LAKES AREA

Rae Lakes. Aside from erosional damage at the base of the trail to Sixty Lakes Basin, and occasional bare spots caused by the tethering of livestock, there is little evidence that any marked changes have occurred in the meadows by, and in the vicinity of, Rae Lakes. In general these meadows show indications of receiving heavy use, but they remain essentially undamaged

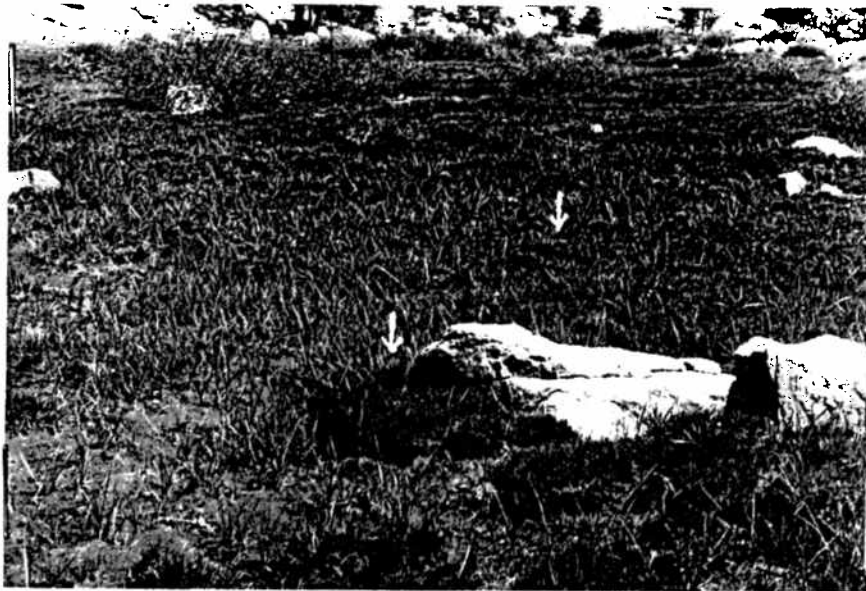


Fig. 44. Timberline Lake Meadow. Mere remnants of short-hair meadow remain in badly trampled portions.



Fig. 45. Meadow stringer below Timberline lake Meadow showing an exchange of new gullying sites for old. The trail which formed the first gully has been abandoned.



Fig. 46. Crabtree Meadow. The lack of invasion, the dense, uniform growth of herbage, and the normally developed streambanks shown in this view indicate stable ecological conditions.

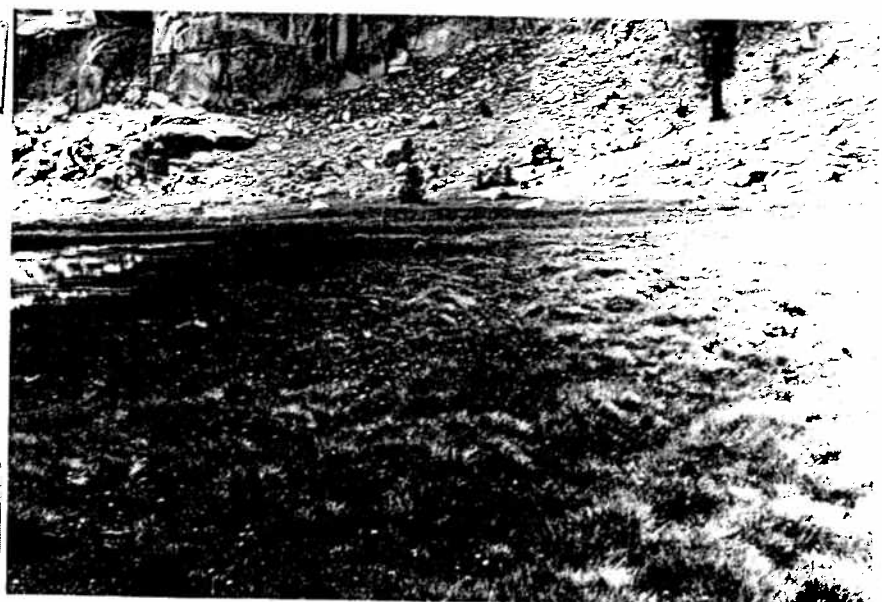


Fig. 47. The lower end of Crabtree Meadow shows stages in recovery from the effects of severe trampling.

(figs. 48, 49). Replacement by native weeds, if any, is occurring only at the very slow and negligible natural rate (fig. 50). Non-native weeds are rare or absent. Bounds of forest are essentially at a standstill. Erosional damage caused by certain sections of the trail to Sixty Lake Basin is, however, serious. If the primitive former trail which led to the Basin in 1940 had been the seat of erosional damage as now exists, then without doubt it would have been noted in the report by Sumner (1941). Therefore all of it must be relatively recent, and has been produced rapidly. It is mostly confined to sections of the constructed portion and where it traversed meadowy strips on the slope above Rae Lakes (fig. 51), and is worst at its point of beginning at Rae Lakes (figs. 52, 53). Along its whole length this trail bears evidence of rather heavy use.

Conclusions. Relocation of the foot of the trail to Sixty Lake Basin to such a position as would avoid further damage to the meadow, and the provision elsewhere on the same trail of more substantial and effective means of trail drainage, would in the course of time permit recovery from the only undesirable changes which have occurred in the Rae Lakes Area.

Sixty Lakes Basin. Beyond the terminus of the constructed portion of the trail to Sixty Lake Basin primitive trails and duck lines run in various, confused directions, but aside from these indications of considerable recreational use there appears to be no important change.

4. THE SIMPSON MEADOW AREA

Altitudinally the Simpson Meadow Area is the lowest of any of the problem areas, and ecologically it is one of considerable ecological complexity because of (1) the numerous differences in the characteristic amounts of soil moisture which occur over short distances and the correspondingly varied nature and density of the vegetation and (2), the influence fire has had as a factor

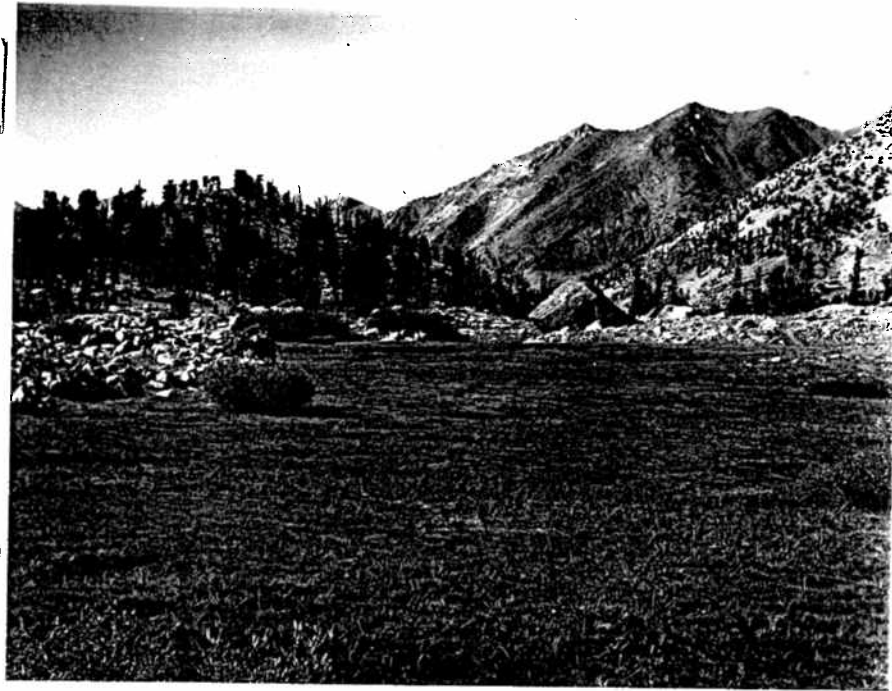


Fig. 48. One of the meadows in close proximity to Rae Lakes, as it appeared in 1940. It then showed evidence of heavy use.



Fig. 49. The same meadow (as shown in Fig. 48) as it appeared in 1958. There are no evident changes. It still shows signs of heavy use.



Fig. 50. Sloping margin of a heavily used but largely undamaged meadow bordering Rae Lakes. The erosion shown is normal. The colony of Jeffrey Shootingstars is making only a negligibly slow, forward advance.



Fig. 51. Erosional damage along the Sixty Lakes Basin trail on a meadow slope above Rae Lakes.



Fig. 52. Sixty Lakes Basin trail needlessly crossing and damaging a meadow at Rae Lakes.



Fig. 53. The point of origin of this erosional damage on a meadow by Rae Lakes is the same Sixty Lakes Basin trail which in this view crosses from left to right under the snowbank and is invisible. It is very doubtful of this damage existed eighteen years ago.

in affecting the meadows. The Area includes only Simpson Meadow and the adjoining Goddard Pasture.

Simpson Meadow. Simpson Meadow appears to have undergone no important changes in eighteen years aside from alterations in the willow thickets which occur along one side of it (figs. 54, 55). The recent destruction of certain of these thickets by fire provided a means of determining the indicators and the presumptive rate of progress of the successional sequences in the return to meadow climax, with fire as the initiating factor. Late in the fall of 1956 and well after the fire season was over one of the smaller of the above willow thickets was thoroughly burned out, intentionally, by Mr. Ben Lovering. A reconstruction of the two (primary and secondary) weed sequences of vegetational succession which was attained in three years on this rather moist site (fig. 56) is given herewith. (1) Invasion by Sierra Willowweed, White Hedge-nettle, and Blue Wild Rye (the latter only sparingly and perhaps actually an advance guard of the next (or possibly final) stage; (2) invasion by Field Mint and (again sparingly) Blue Wild Rye. In a neighboring, drier site (fig. 57) the succession during a presumably equivalent amount of time following fire destruction of a small willow thicket was in the following sequence. (1) Invasion by Cheatgrass Bromes and Annual Hairgrass; (2) invasion by Creek Goldenrod, Mixleaf Mugwort Wormwood, Western Yarrow, Largeleaf Avena, and Blue Wild Rye. Surrounding each of the above sites was a zone of transition to sub-climax or climax (although the latter was represented only by relicts). From this zone the invasion of the final stages of succession into each of the burned areas had already begun and leads one to presume that the invasion of the final stage would become largely complete in an additional three to five years. Thus by way of summary, in six to eight years following fire destruction of willow thickets on Simpson Meadow there may be developed: (1) on moist sites a meadow subclimax composed of a dense growth of sedges and Baltic Rush interspersed with some Blue Wild Rye and (2), on drier sites a meadow

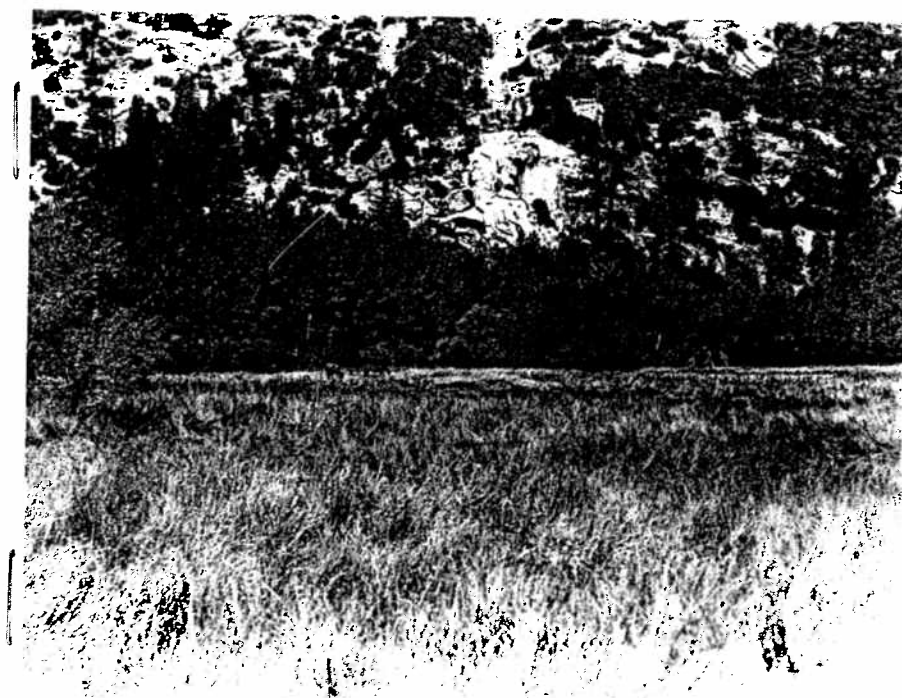


Fig. 54. Simpson Meadow as it appeared in 1940.



Fig. 55. Simpson Meadow in 1958. Willow thickets have been removed or have become altered by fire, but other than this the meadow appears to have remained unchanged. The area was in good condition.

climax containing Blue Wild Rye, Slender Wheatgrass, and Mountain Brome.

The above sequences or stages can be reconstructed, though less easily, by observation elsewhere over the meadow proper. They can be constructed similarly, though the species composing them are more numerous, in Goddard Pasture where the moisture conditions are more varied and where the influences of fires have been profound. The major portion of Goddard Pasture is a rather extensive boggy area, criss-crossed in places by down logs, and with an abundant and luxuriant forage of sedges and tall grasses in the numerous openings of the jungle of dead or recovering cottonwoods and willows burned in the fire of 1948 (fig. 58). At the upper end it merges more or less abruptly into a very dry, overgrazed and badly trampled flat (fig. 59). In all these areas although the species involved may differ the stages are the same regardless of whether they were initiated by fire or overgrazing and trampling.

Under disturbance such as may be created by continued overgrazing the succession may be "thrown back" to an earlier stage. Under these circumstances the weed stages become indicators of deterioration (degeneration) and the Primary Weed Stage would represent the final stage. Beginning with the climax or subclimax common indicators for the Simpson Meadow Area follow. (1) Climax or Subclimax: Blue Wild Rye, Slender Wheatgrass, Mountain Brome, Fringed Brome, Bearded Fescue, Tufted Hairgrass, Elmer Needlegrass, and Baltic Rush; (2) Secondary Weed Stage: False-tarragon Sagebrush, Mixleaf Mugwort Wormwood, Creek Goldenrod, Western Yarrow, Field Mint, and Largeleaf Avens; (3) Primary Weed Stage: Cheatgrass Brome, Douglas Knotweed, Annual Hairgrass, Sierra Willowweed, and White Hedge-nettle.

No old photographs or other ready means of obtaining a clue on rate of replacement of climax vegetation by weeds over the years was available, hence no data were obtained in this regard.

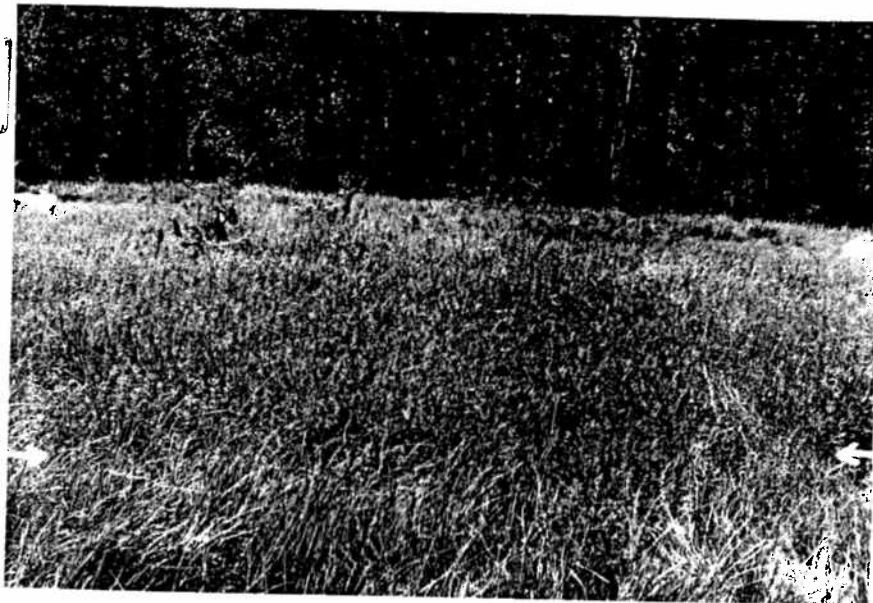


Fig. 56. Simpson Meadow. Succession in a moist, burned out site which three years earlier was covered by a dense willow thicket. The outer margin of the burn is dimly visible as a line extending from left to right in the far distance as well as across the foreground.

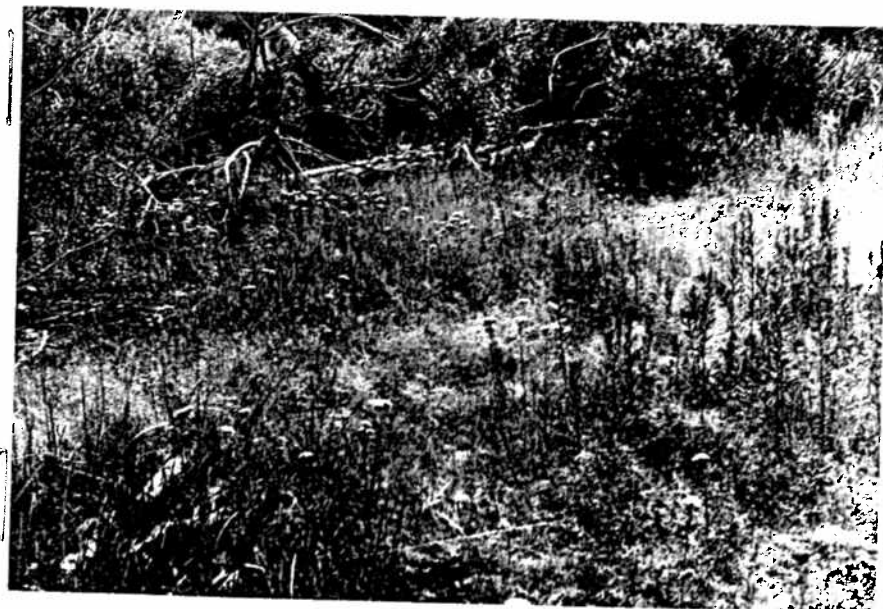


Fig. 57. Simpson Meadow. Succession in a drier burned out site which about three years earlier was also covered by a dense willow thicket. The early weed stage composed of an annual grass is giving way to a secondary weed stage composed of broad-leaved herbs.



Fig. 58. Portion of Goddard Pasture ten years following the fire of 1948. The luxuriant stand of Tufted Hairgrass is four feet high.



Fig. 59. Trampled dry flat at the upper end of Goddard Pasture. The thinning stand of herbage in front of the scattered shrubs of Sagebrush and Goldenbush represents a primary and secondary weed stage which in this instance is mostly composed of Cheatgrass Brome, Bottlebrush Squirreltail, and Elmer Needlegrass, and is indicative of the overgrazing.

5. PARADISE VALLEY

Important data were obtained for the two more important forage areas in Paradise Valley. Using Sumner's (1941) designations these two areas are Lower Meadow and Middle Meadow.

Lower Meadow. In 1941 this meadow was by Sumner (1941) regarded as the largest and most important forage area in Paradise Valley. Today it is quite generally and correctly known to be in an advanced stage of deterioration. Often, wholly denuded spots composed of almost sterile gravels now occur where in former years a thin but still appreciable and seemingly intact cover of perennial grasses remained despite the heavy use (figs. 60, 61). Falsehellebore has increased in abundance, and at one point the meadow is rapidly being transformed into forest by a lodgepole invasion which has abruptly arisen almost within the last decade. In general the trees of this invasion possess full complements of whorls of branches which furthermore are widely spaced owing to rapid growth; hence these trees provide an easy, rapid, and rather accurate means for determining their age. Thus on the basis of branch-whorl counts the age of the average larger-sized individual of the trees comprising the invasion is twelve years. This figure closely corroborates the maximum age suggested for the invasion by comparing the dated photographs (figs. 62, 63).

From its point of origin this invasion has already advanced into the meadow about fifty or seventy-five feet, and altogether now covers perhaps half an acre. Since the entire meadow itself approximates only fifteen acres, the question arises as to how much time would be needed for the remainder of the meadow to become invaded similarly. Obviously an answer to this question cannot be given, even in simple terms. One cannot make the assumption that since invasion of half an acre was completed in twelve years then invasion of one whole acre would require twenty-four years, and so on. The variables are too numerous and complex. Furthermore, once the stage is set similar "explosions"



Fig. 60. ✓ Lower Meadow of Paradise Valley as it appeared in 1940.



Fig. 61. Lower Meadow of Paradise Valley as seen in 1958 from exactly the same viewpoint as that used in 1940 for Fig. 60. A tree which concealed from view the aspen thicket at the upper left has since 1940 died and fallen, and on the meadow continued overuse has resulted in bare spots and an increase of falsehellebore.



Fig. 62. Another view of Lower Meadow of Paradise Valley as it appeared in 1947. The beginning of lodgepole invasion from the forest at the far end of the meadow is barely if at all suggested.



Fig. 63. The same view of Lower Meadow of Paradise Valley but as seen in 1966. The dotted line encloses arrows indicate to the invasion which has developed essentially since 1946.

could appear at any time. All one can say is that the invasion began as a result of changes which ultimately made available for lodgepole that particular environmental element or factor essential for initiating its successful germination and growth on the meadow. Hitherto on that portion of meadow that factor was unavailable. Once it became available it no longer was limiting. Upon removal of that barrier other resources already in the meadow then became accessible immediately, and thus the conditions for invasion suddenly became highly favorable.

It seems probable that the invasion is related to an abrupt lowering of the water table. The invasion itself is confined to a small area delimited on one side by the cut bank of the river (South Fork) and on the other (the meadow side) by an erosion gully. The gully carries the drainage from the meadow and at one point is eighteen inches deep.

Conclusions. The exclusion of all grazing use, the removal of the lodgepole invasion, and the effective plugging of the erosion gully, are means whereby the restoration of this meadow could be brought about.

Middle Meadow. Although Middle Meadow is open to plain view from the trail while Lower Meadow is not, it shows signs of less use, especially by the presence of a small, more or less broken stand of meadow climax species. Owing to chance and the good growth conditions of the season some headway to improvement was evident in this stand by the tall stature of the season's shoots, the presence of flowering heads, and the successful setting of seeds. It is quite evident, however, that the stand is reliquial (fig. 64). Aside from bare spots and this patch of precariously persisting forage the vegetation of the meadow is rather generally composed of weed species and especially of those which indicate a late stage of meadow deterioration.

A rapid survey of the meadow provided the following results as to common indicators of stages present. (1) Climax or Subclimax Stage: Rusty

Sedge, Mountain Brome, Slender Wheatgrass, Kentucky Bluegrass, Subalpine Needlegrass (all the foregoing being vigorous plants 2-4 feet high);

(2) Secondary Weed Stage: Ticklegrass, Falsetarragon Sagebrush, Western Yarrow, Greek Goldenrod, and Common Selfheal; (3) Primary Weed Stage: Annual Hairgrass, Pullup Muhly, Cheatgrass Brome, Sheepsorrel, Gayophytum sp., Gudweed, Hairy Popcornflower, Littlehead Clover, Whitetip Clover, Mountain Blue-curls, Slender Tarweed, and Douglas Knotweed.

Conclusions. This meadow is largely in an advanced stage of deterioration and the scant useable forage is persisting only precariously. Until its recovery is assured as a result of a period of exclusion of the meadow from all grazing the further use of this meadow is not warranted.

A short distance below Paradise Valley patches of Cheatgrass Brome have invaded the beaten or otherwise unstable ground bordering the trailside. This species is a sign of disturbed conditions, and in meadows it is an indicator or a late stage of deterioration. It is a non-native plant and its accidental transportation to high meadows would be ineffectual since it is not adapted to the more severe climatic conditions prevalent at higher altitudes. Above about 7000 feet it dwindles in numbers and disappears (fig. 65).

6. THE ROARING RIVER AREA

In the time available for the study of this area during the present survey every meadow within reach was sought out for any feature which might supply data for estimating any rates of change, even though some of those meadows are a part of various grazing allotments and find as yet little recreational use by the visiting public. The reason for this extra attempt was the exceptionally large number of old photographs available for comparison in this area which are contained in the reports by Sumner (1941, 1947) and Armstrong (1942). It was regretted that, owing to limitations of time, it was possible to utilize only a small fraction of this very large number of

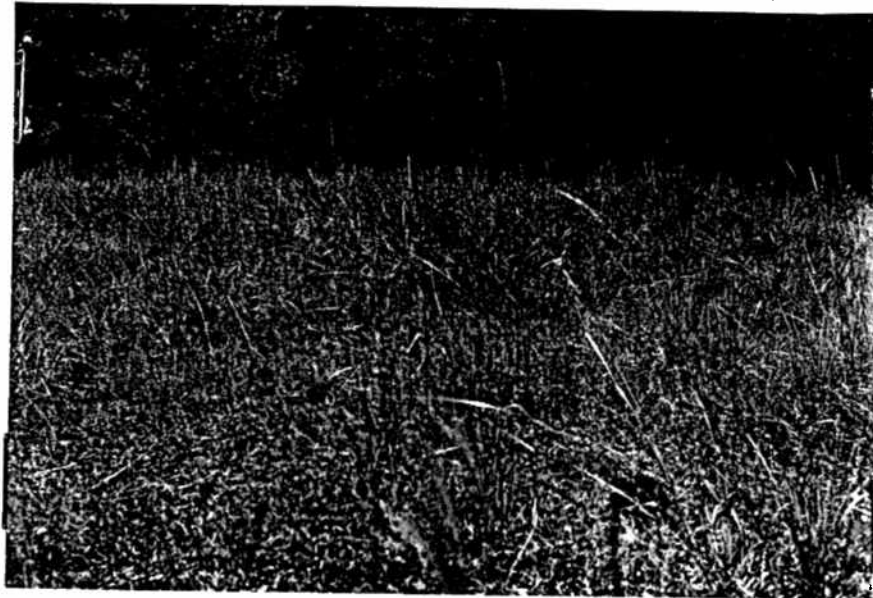


Fig. 64. View of portion of Middle Meadow of Paradise Valley, showing a patchy stand of meadow climax persisting amid a secondary weed stage of the succession.



Fig. 65. Bank covered with Cheatgrass *Bromus* along the trail one mile below Paradise Valley. In the Sequoia-Kings this non-native weedy grass and pioneer in the succession does not flourish at altitudes much above 7,000 feet.

highly important photographic records of past appearances.

For convenience of treatment major conclusions regarding meadows of the Roaring River Area are embodied in a discussion and summary given at the end of this portion of the report.

Scaffold Meadow. At Scaffold Meadow primary attention was given to its largest area, namely the tourist pasture. In 1947, according to Sumner (1947) it showed increase in deterioration and of weed invasion intensified by the drought conditions which then prevailed (fig. 66). In 1958, however, it exhibited a marked improvement of appearance over that of 1947 in having regained a continuous although short-cropped cover (fig. 67). It seems therefore to have resumed an appearance comparable to that which it had in 1940 (figs. 68, 69) which was a wet year rather comparable to 1958.* In terms of "range condition" actually the area was good in some portions, fair in others, and by late season (August 29) considerable portions showed evidence of overuse, while in the woodland meadow immediately below it large spots had been denuded or excessively trampled. This would indicate that an increase in the degree of protection would be desirable.

Bordering the tourist pasture is a more or less broken, rather inconspicuous stand of young lodgepoles representing an invasion which began roughly thirty-five or forty years ago. It never advanced very far and has come to a standstill. No evidence of any removal of tree invasion was noted.

Grave Camp. The meadow, situated by Grave camp in Deadman Canyon and known as Quaking Meadow, is in good condition.

*Precipitation figures in this connection are as follows. At the nearest significant recording station (Giant Forest, Sequoia National Park), the total precipitation in inches respectively for the years 1939 and 1940 was 24.40 and 67.65 (totalling 92.05 for the two year period), for 1946 and 1947 it was 41.79 and 18.31 (totalling 60.10), and for 1957 and 1958 it was 49.36 and 58.89 (totalling 102.25). Obviously only a portion of the precipitation of the second year in any two year interval is applicable in any given case.



Fig. 66. Scaffold Meadow tourist pasture in 1947. The deteriorated appearance is evident rather generally, and the foreground shows only a very sparse cover and patches of bare soil. The deterioration because of overuse was, however, intensified by the drought conditions which then prevailed.

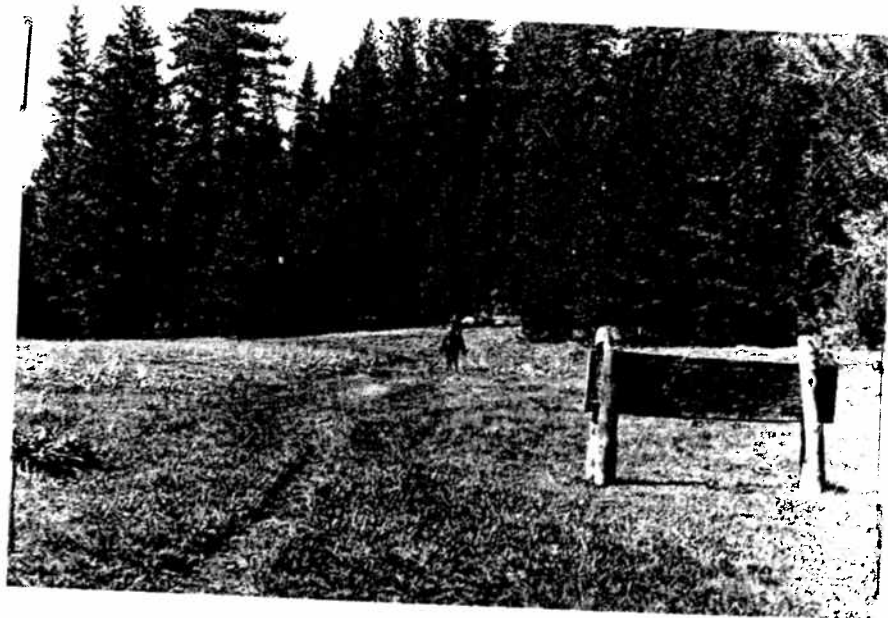


Fig. 67. Scaffold Meadow tourist pasture in 1938. It shows much improvement over the condition of 1947, but the favorable effects of protection have also been promoted by the very good moisture conditions.



Fig. 68. Scaffold Meadow tourist pasture in 1940 (September 25).



Fig. 69. Scaffold Meadow tourist pasture in 1958 (August 29). The appearance of the meadow seems to be much as it was in 1940, which was also a wet year.

Grasshopper Meadow. This small meadow is situated in Cloud Canyon about one mile above Scaffold Meadow. What superficially looks forage on its major portion is largely weeds. These weeds belong to an early or later primary stage in the succession (fig. 71), and are indicative of a late stage of meadow deterioration at this general altitude (6500-8000 feet). At Grasshopper Meadow they are represented in particular abundance by Annual Hairgrass, Hairy Orthocarpus, and Whitetip Clover. A factor contributing strongly to this deterioration is the heavy trampling along both sides of the trail which cuts right through the meadow. Relocation of this trail so that it would skirt the meadow would offer no problem whatever.

Cement Table. The meadow by Cement Table in Cloud Canyon is in good condition. The adjacent woodland meadows, although showing some increased invasion by lodgepoles, are likewise in good condition.

Big Wet Meadow. Big Wet Meadow in 1958 shows an improvement of condition over that shown for 1940 (figs. 72, 73) which at first sight might be attributed merely to the earlier date in the season. A closer view, however, shows that unquestionably it is largely the product of a strong, uninterrupted trend toward recovery which has been maintained since about 1940. The basis for this statement is the conspicuous evidence of recovery of damage caused by past erosion. In 1940, sand bars and deeply cut stream banks indicating serious erosion in the past (Sumner, 1941) were of common occurrence along the river (fig. 74). By 1958 recovery of this erosional damage was nearly complete. The sand bars had become largely covered by the invasion of forage; the sharp, overhanging edges or collapsed margins of the meadow had become rounded off or welded together by the constructive forces of plant growth, while elsewhere the cut, naked banks of meadow soil had become more completely covered over by the curving, wavelike advance of vegetation on a meadow margin which is no longer being eroded away (fig. 75). The attainment of these various

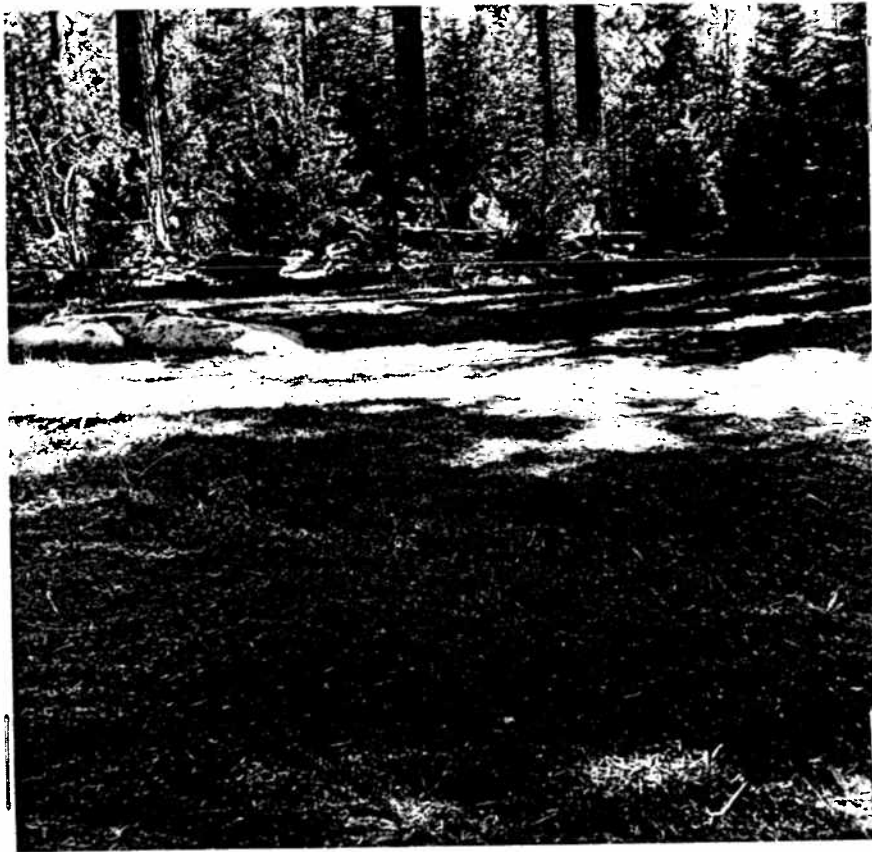


Fig. 70. Patches of secluded woodland meadow immediately below Scaffold Meadow tourist pasture show the results of excessive, concentrated use.



Fig. 71. What looks like forage in this view of Grass-hopper Meadow is mostly weeds indicative of a late stage of meadow deterioration.



Fig. 72. Big Wet Meadow as it appeared in 1940 (September 23).



Fig. 73. Big Wet Meadow in 1958 (August 29). The improved condition of the area is due to more than merely the more favorable moisture conditions of an earlier date in a wetter season.



Fig. 74. Stream banks in Big Wet Meadow as they appeared in 1940. The bare sand bars and undercut and broken banks were evidence of serious overgrazing in the past.



Fig. 75. The same stream banks in Big Wet Meadow in 1958. A remarkable amount of recovery has occurred since 1940.

expressions of recovery is the result of slow, uninterrupted, healing processes enabled through the erosion control effected by the concomitant recovery of the meadow as a whole, and involves many years.

On the other hand the ever-widening path of trampled forage and bare mud created by the passage of livestock in its attempt to avoid boggy places while traversing the trail through the meadow is a needless detriment (fig. 76). The meadow is flanked all the way along both of its sides by slopes along the dry lower borders of either of which a trail could easily be constructed. Relocation of the trail to higher ground would not only avoid this severe and growing damage aggravated especially during wet seasons but would also greatly facilitate or in fact make passage at all possible in early season when, as is usually the case, the meadow is flooded.

In the small subalpine meadow which lies directly at the east base of Whaleback severe damage by trampling was created by thirty-five head of stock held there two days around August 24, 1958. The stock belonged to Lee Maloy. Without doubt excessive use of meadows is prohibited by regulations regarding the use of grazing areas which apply to all pack and saddle stock permittees.

Boggy Meadow. Boggy Meadow (fig. 77), according to District Ranger Stanley Bechtel (oral comm., 1958), was gutted in 1926, and obviously the enormous gully then created has been open to invasion to lodgepoles since that time. In 1949 during the application of restorative measures Boggy Meadow was placed under fence; therefore only since then has this invasion into the gully ensued without the hindrance (or assistance) of trampling cattle. Initially the gully was barren; all soil had been completely stripped away, and only sterile sand and gravel remained. Up to 1949 only relatively few lodgepoles had found a foothold in the gully, and in 1949 in recognition of their value as agents of erosion control these trees were not disturbed. Although since then their growth has been rapid and a few additional trees have

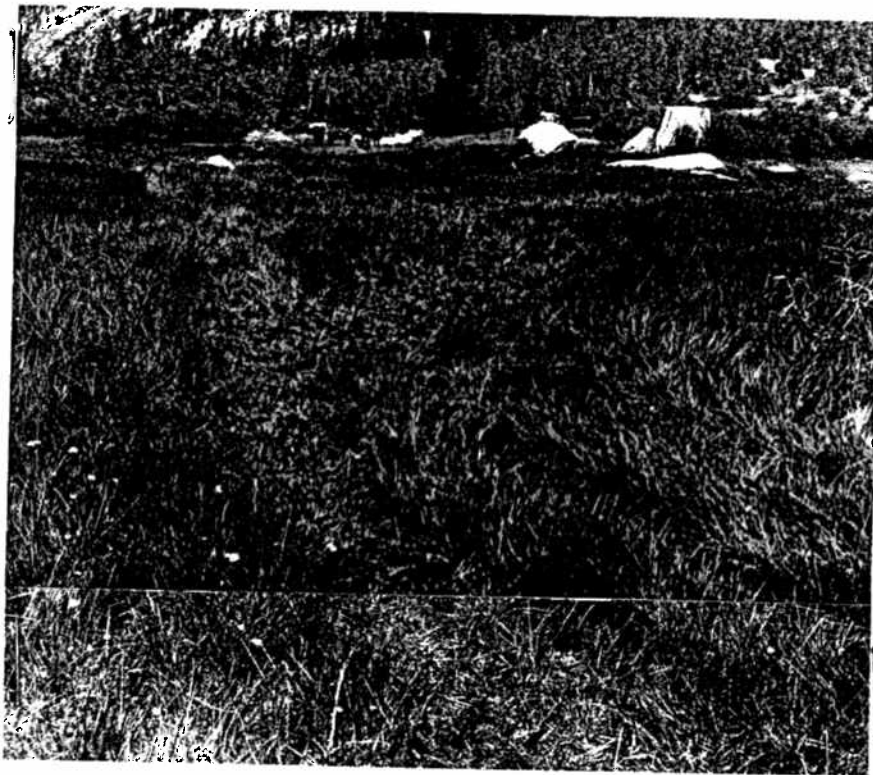


Fig. 76. All this damage to only one portion of Big Wet Meadow could be avoided by relocating the trail to the higher ground which skirts the meadow. There is no longer any good reason for the continued existence of the trail through the meadow. Even aside from the damage it creates, because of the deep mud and bog holes it isn't even a short-cut to the other end, and the meadow, like any other wet meadow, would be much better off (and so would the stock) if the trail went around it instead of through it. In Sequoia - Kings Canyon National Parks the aggregate total of meadow trampled out of existence into mud by heavy use of trails through them during one wet season must in terms of acreage be very considerable.



Fig. 77. Boggy Meadow as it appeared in 1947.



Fig. 78. In 1949 Boggy Meadow was fenced and measures were applied to prevent further erosion. In 1958 when this photograph was obtained the improvement over the same view (as that shown in Fig. 77) was obvious. On the area of meadow on the left the formerly deteriorated cover of Baltic Kush has attained full recovery.

appeared, on the whole the stand is still sparse; therefore, if the adverse or favorable effects of trampling cattle are excluded, thirty-two years (1926-1958) has not been a sufficient length of time for the invasion to become "complete" (figs. 79, 80, 81). Obviously the real cause is to be sought in the bankruptcy of the gully with respect to soil (fig. 83). On fully developed meadow soil, twelve years may be long enough for a lodgepole invasion to arise and to assume complete dominance on an area not previously occupied by trees, as has been shown for Paradise Valley Lower Meadow earlier in this report.

In the nine years of enclosure which have intervened since Boggy Meadow was fenced and measures were undertaken for its restoration, full recovery of wet meadow type forage has been attained in the wet bottom of the gully. Meanwhile not only has full recovery of forage also been achieved on the drier portion of meadow which forms the rim of the gully but also the formerly oversteepened and unstable sides of the gully itself are rapidly becoming stabilized (figs. 78, 82). These results of the work of the Soil Moisture Conservation Program to this and other damaged meadows seen in the Roaring River Area by the present writer are extremely gratifying. Clearly every effort should be made to continue and to expand this program.

Sugarloaf Meadow. The formerly much-damaged lower end of this meadow was fenced in 1948. It now shows complete recovery to meadow climax.

Comanche Meadow. During the 1958 season Comanche Meadow remained saturated with water, and portions of its margins and slopes were literally those of a "quaking" bog. Numerous dead lodgepoles occur in these wetter portions. Many of them have been dead for many years. Although the actual cause of their death may be unknown, it should be noted that the degree of tolerance of lodgepoles for a continually water-saturated soil is doubtlessly limited (fig. 84). The species does not habitually grow in bogs, and in meadows of the Comanche type it is not beyond the realm of possibility that during



Fig. 79. Portion of gully in Boggy Meadow in 1947. More than just mechanical injury by trampling cattle accounts for the sparse success of invasion by lodgepoles over a period of 21 years (1926-1947).



Fig. 80. A view of the same portion of gully in Boggy Meadow in 1958 shows the flourishing state of mostly the same invaders. But it has taken altogether 32 years for this much invasion to occur.



Fig. 81. In 1941 or fifteen years after the catastrophe occurred the gully in Boggy meadow in this view was still largely barren.



Fig. 82. In 1968 or thirty-two years after the catastrophe recovery is at last making some real headway.

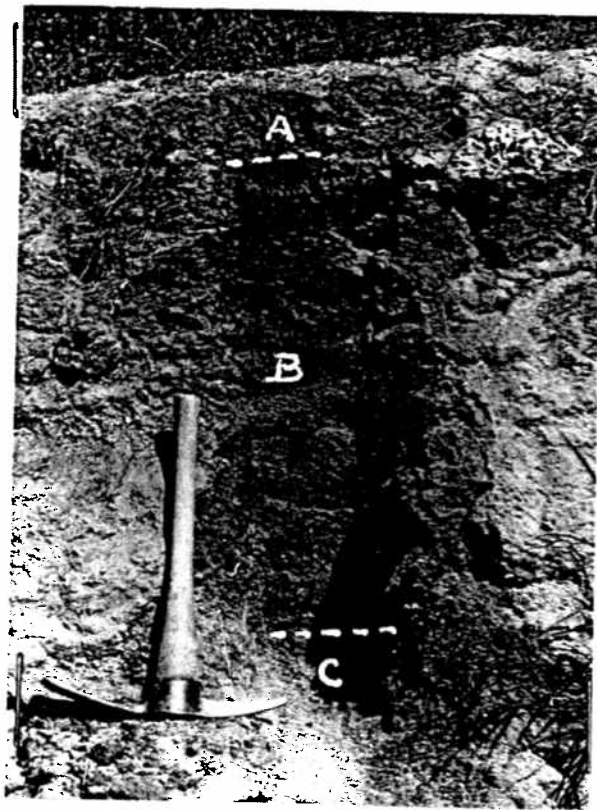


Fig. 83. This shows in vertical section mature meadow soil in Boggy Meadow such as was stripped away when the gully was formed. The overall length of the pick handle is $16\frac{1}{2}$ inches. At "A" is a 5-inch layer of the more productive topsoil, at "B" a considerably deeper layer of subsoil, at "C" the uppermost portion of the weathered but sterile parent material which lies below the soil. It is rather probable that soil of this depth is rather typical of mature meadow soil of residual origin in meadows situated at altitudes between 6000-8000 feet.



Fig. 84. Comanche Meadow was so saturated with water all through the 1958 season that much of it was a quaking bog. The tolerance of lodgepoles for a soil which becomes continually water-saturated is limited.

successive years of a long, wet climatic cycle a rise of the water table may eliminate many of the lodgepoles.

Williams Meadow. In its wide expanse, clean, sweeping lines, and magnificent setting Williams Meadow is one of the finest of any of the meadows in the Roaring River Area (figs. 85, 86). In connection with measures to prevent its destruction by the effects of overgrazing in the past, in 1950 fencing and means for erosion control were provided for the particularly damaged and vital lower end. In 1958 the formerly barren sand flat in this portion of the meadow showed a very marked improvement (fig. 87). In the manner characteristic of the return to recovery of sandy or gravelly sites the early stage (marked by the growth of Umbellate Passypaws) was giving way to a closing forage of Mat Muhly, Bottlebrush Squirreltail, and especially Ovalhead Sedge (fig. 88).

The Roaring River Area: Discussion and Summary. In general the meadows along the main routes of travel in the Roaring River Area are undergoing a trend to recovery. This generalization is based primarily on a comparison of present (1958) meadow conditions with those shown for earlier years in photographs and descriptions in the reports by Sumner (1941, 1947) and Armstrong (1942). Although neither the meadows from Scaffold to Sphinx Meadow nor those in Deadman Canyon above Grave Camp were seen during the present study, it is believed that since their more remote location would diminish their degree of use the same generalization would apply to them also.

The rate of this trend, as well as the degree of recovery, varies in accordance with altitude, site, and especially with degree of use. In some measure this recovery owes its existence to the very good soil-moisture conditions which obtained during the 1958 season. The unusually heavy and long-persistent snows and the rainy summer (as well as the probably good moisture conditions of the preceding year) made that season an exceptionally favorable



Fig. 85. View of Williams Meadow as it appeared in 1947. Except for the weeds in the foreground and the few, scattered lodgepoles invading across its wide expanse, there is little to suggest the deterioration and erosional damage which then existed in this scenically very impressive meadow.



Fig. 86. Early in the season of 1958 and before the cattle had arrived the same view of Williams Meadow was more suggestive of its original, primitive state. Note the absence of the former, invading lodgepoles.



Fig. 87. View of sand flat at lower end of Williams Meadow as it appeared in 1958. Up to 1950 this flat had been severely abused and except for a scattering of lodgepole invaders it was practically destitute of vegetation. The present improved appearance is obvious. The lodgepole invaders, however, which formerly had been suppressed by trampling livestock are now growing vigorously and will soon shoot up.

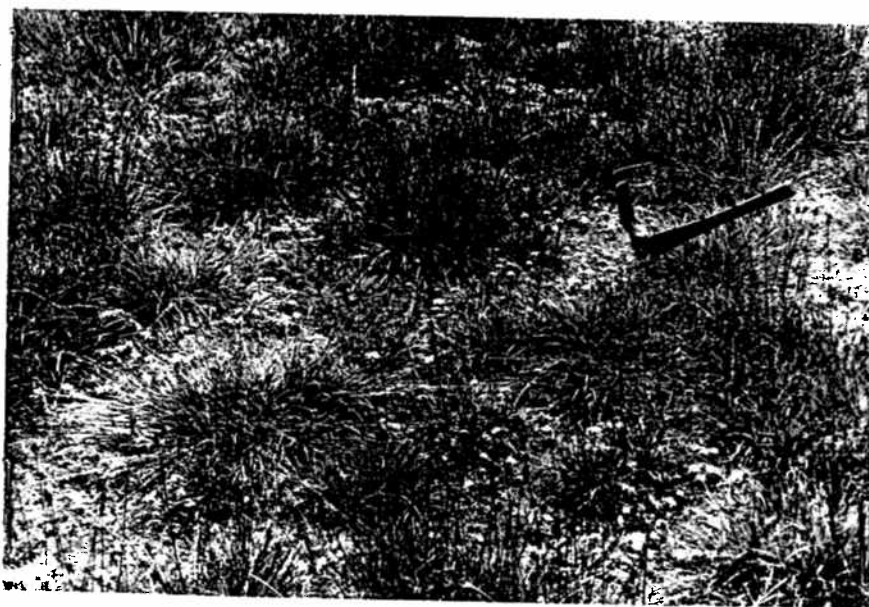


Fig. 88. Close view of the same flat in 1958. The clumps of Ovalhead Sedge have developed within a few years of protection. They indicate improved soil moisture conditions and will continue to succeed the pioneer weeds.

one for the growth of vegetation. This fact should be borne in mind when any attempt is made to evaluate the amount and rate of recovery in terms of the degree of protection which is being provided. As already implied the recovery noted is not alone due to the favorable season. It also shows evidence of being based in part upon a trend to improvement which has been under way for some time.

One special difficulty standing in the way of establishing the rates of recovery is the lack of precise knowledge as to when the trend which led to the recovery in any given meadow began. Enclosures of known date of installment around deteriorated sites are the only means of resolving this difficulty. Fortunately a few enclosures exist in the Roaring River Area. Fencing which was installed to prevent cattle from creating further harm to badly damaged sites has thus served a double purpose. The only drawback which remains in regard to their use for the present problem is the lack of records of changes in species composition and density which over the years developed within the enclosures since the latter were established.

With respect to the primary objectives of the present study the most important information obtained in the Roaring River Area was that which provides some answers to the particular question of recovery rates. This information, organized under two headings, is summarized below. Although dates when the enclosures were established have been indicated, it is assumed that the degree of protection for any of the following grazing areas is also known.

Summary of rates of meadow recovery from severe overuse, as based on observations made in 1958. (1) In enclosures at 7400-8000 feet altitude the time required for the attainment of complete recovery (meadow climax) is a minimum of about seven years to a maximum of ten years. (2) In grazing areas under the degree of protection provided up to 1958, (a) Scaffold Meadow tourist pasture, 7200 ft.: eleven years to attain a moderate (and insufficient) degree of recovery; (b) Big Wet Meadow, and probably also Cement Table and Grave Camp,

8500-9000 ft.: about nine years rather than as many as eighteen to attain complete recovery.

7. THE DUSY-PALISADE CREEK AREA

Grouse Meadow. Grouse Meadow, a large wet meadow of approximately fifty acres is, on the whole, roughly divisible into two types of area or vegetation as determined by differences in the length of time flood conditions persist over the various parts of its surface. The first of these is subject to flooded conditions until late in the season. It is therefore prevaillingly marshy and contains a vegetation predominatingly composed of coarse, tough-leaved sedges. It constitutes by far the major portion of the meadow and is often inaccessible to stock until late in the season. The second tends to be less subject to long-persistent flooding, especially during drier years. It contains a vegetation composed mainly of finer-leaved sedges with a smaller admixture of grasses, and is mostly confined to the lower and upper ends of the main, marshy body of the meadow. Since this second type is useable to stock earlier in the season generally and also contains the more palatable and hence preferred forage, over the long run it tends to receive considerably more prolonged and heavier use than does the much larger, marshy portion.

On comparing the appearance of Grouse Meadow in 1958 with that of 1940, the marshy larger portion showed it had undergone no important change during that interval. In sharp contrast to the marshy portion, however, the smaller areas composed of better forage exhibited two important changes from their appearance in 1940. Although these changes coincide with the areas of preferred forage, they do not occur together in the same sites: one of them is largely restricted to the lower, the other to the upper, end of the meadow.

The most conspicuous of the two changes, namely a heavy invasion by falsehellebore, occurs at the lower end of Grouse Meadow near the trail (fig. 90). Although in 1940 this portion showed little or no invasion by this

species (fig. 89), it seems very probable that conditions favoring such an invasion have been developing over a considerable number of years both before and since that date as a result of overuse of the locality under drier conditions. Thus during 1940 according to Sumner (1941) it had already received heavy use by August 28, and by that date it was a small dry flat which contained a preponderance of unpalatable weeds and showed evidence of some streambank erosion. This degree of use and overgrazed appearance stemming also from previous years probably is exemplary for the locality since 1940 during times when conditions are locally dry. In contrast, under wet conditions some recovery ensues, as in 1958 when at least up to August 9 it showed signs of little use owing to the boggy conditions when they prevailed even in this portion of the meadow. Probably whenever such conditions occur heavy use is largely precluded, and the fair amount of recovery and good condition which it showed in 1958 was the net result of periods of respite. Evidently, however, intervals of recovery have been insufficient to stem the falsehellebore invasion.

Falsehellebore is a relatively short-lived perennial which each season renews and multiplies its shoots from a thick rootstock. The rootstock which is its sole means of vegetative reproduction remains short, and thus the ability and speed of the plant in invading a meadow through vegetative means alone is quite limited and slow. The seeds produced are, however, numerous, and they become widely scattered. Therefore rapid increase is through the dispersal of seeds. Since within its range the species often appears to be absent in localities of appropriate altitude and which seemingly possess the other necessary conditions, probably there are limitations even in its capacity to spread widely through seed dispersal, and thus for an uninvaded meadow seeds are in all likelihood derived primarily if not exclusively from colonies already established on its periphery or in the near neighborhood rather than from any more distant source. At the locality in Grouse Meadow the oldest colonies



Fig. 89. Grouse Meadow as seen from its lower end in 1940 (August). The area in the foreground shows signs of heavy use, but little or no *falschellebore* is in evidence.



Fig. 90. Same view of Grouse Meadow, as it appeared in 1958. A recently-begun and rapidly increasing invasion of *falschellebore* is advancing into the meadow.

and therefore the most likely original sources for the invasion are situated around its periphery.

Probably in common with most herbaceous perennials flowering and fruiting in California, falsehellebore does not normally begin until the third year following germination from seed. Hence, if at the time when the flowering season was at its height locally for the species, and an invading population contained a large proportion of non-flowering plants, the indications would be not only that the invasion was increasing rapidly but also that it was recent in origin. In the portion of Grouse Meadow in question the invasion contained a large number of non-flowering plants or shoots, but otherwise it was at the height of its flowering period. Thus it is probable that a significant increase of invasion began only recently. Furthermore, on the basis of the general appearances, it seemed likely that the whole invasion was not more than about ten years old in 1958.

The other important change shown by Grouse Meadow is largely confined to its upper third. In 1940 a significant portion of this area showed an open expanse of fairly dry ground and very little lodgepole invasion (fig. 91), but in 1958 invasion by lodgepole showed a distinct increase (fig. 92). As in the area containing the falsehellebore invasion this portion contains a more palatable forage and in drier years becomes more early useable for stock. Hence it is probable that in general the use is heavy.

The coincident occurrence of both of the changes in question with areas of preferred, more useable, and hence more heavily used forage appears to reflect a cause-and-effect relationship between overgrazing and increased invasion by weeds or forest. In the case of the falsehellebore invasion already indicated, that relationship seems unquestionable and very direct. With the lodgepole invasion, however, the relationship with overuse is obscure or, if overuse is at all concerned, then it plays only a secondary and indirect role in a relationship which primarily involves a sequence of natural, promoting

factors. On the open expanse of Grouse Meadow, and particularly on its upper third, lodgepole invasion is associated with and is strongly dependent upon a prior invasion by Westernbog Blueberry. As a consequence of its growth the blueberry forms within its developing thicket an accumulation of litter, leaf-mold, and humus. On Grouse Meadow almost invariably young lodgepoles arise only within thickets of this invading shrub (figs. 92, 93, 94).

This natural sequence may be explained more fully as follows. Westernbog Blueberry, in common with many other species of its genus, is an indicator of acid soil. In Grouse Meadow it is often associated with a neighboring growth of sphagnum. The latter is also and very reliably an indicator of acid soil. Grouse Meadow is, however, a predominatingly sedge marsh and as such it is indicative of predominatingly circumneutral soil conditions. These conditions are maintained by the moving neutral waters of the Middle Fork. In the areas less subject to long-persistent flooding, and on which the surface is dry for protracted periods, probably the natural acidity of humus situated above the level of the neutral ground-water is not neutralized. Westernbog Blueberry then becomes established on the more acid sites, and the developing thicket with its leaf-mold and moist but well drained humus provides a favorable seed bed and nursery for lodgepoles.

The relationship of overuse even as an indirect agency in promoting this invasion is not known. In producing changes on the original drainage relations of the soil overuse may have some bearings on the matter, but inasmuch as the invasion itself is on low ground the effects of such extraneously caused changes would be minimized, and thus the occurrence of the invasion in an area of rather heavy use may be largely if not wholly a coincidence of location.

On the open meadow the lodgepoles in the blueberry thickets generally show only a slow rate of growth. They tend to be stunted, and most of them are considerably older than their size might indicate. In the soil presumably conditions which are hyper-acid above and water-saturated in the deeper levels



Fig. 91. Grouse Meadow as seen from its upper end in 1940 (August). (With respect to the arrows, see below.)



Fig. 92. The same view of Grouse Meadow as it appeared in 1958 (August). A slow increase in lodgepole invasion is under way. The same small lodgepoles (indicated by arrows) show very little increase in size since 1940. The area below the dotted line shows the blueberry thicket from which they arise.

beneath are retarding influences which tend to offset or minimize the effects of favorable ones. Furthermore, on the open meadow the lodgepoles are rather prone to attack by the Ips beetle. Several dwarfed individuals which had partly or wholly succumbed to its depredations were noted in the invasion.

With the blueberry on the other hand, a factor which may contribute to some degree in suppressing its own effectiveness in relation to lodgepole invasion is the attraction it has for deer. As a source of browse it is relished by them to the extent that shrubs are frequently browsed down to twigs the thickness of a lead pencil. Even a normal-sized deer population tends to overbrowse the shrub and thereby repress its growth. On Grouse Meadow, however, none of the shrubs observed showed any use by deer. Passing in this connection it should be mentioned that few deer or their signs were observed by the writer in 1958 in the remaining portions of the Dusy-Palisade Creek Area. Likewise few were seen in the Simpson Meadow Area and canyon of the Middle Fork which intervenes between the foregoing areas. This impression of deer scarcity in these sections was shared at the time by trail-crew foreman Ben Lovering in conversation with him at Simpson Meadow.

The complex of interrelationships involving Westernbog Blueberry and lodgepole invasion is of special ecologic interest. In back-country meadows in the problem areas of Sequoia-Kings Canyon National Parks Westernbog Blueberry appears to be most common in and near Grouse Meadow and elsewhere at appropriate altitudes in the drainage basin of the Middle Fork Kings, with a minor development in the Evolution Problem Area. Subalpine meadows on the other hand such as sphagnum-rich Charlotte Lake Meadow lie above its upper altitudinal limits. At subalpine altitudes it is replaced by Dwarf Blueberry but the latter appears to be only slightly involved as a precursor of lodgepole invasion.

Conclusions. On Grouse Meadow the falsehellebore invasion is very probably an unnatural one provoked by overuse. Although the area predated



Fig. 93. Lodgepole arising from blueberry thicket on the open expanse of Grouse Meadow in 1958.



Fig. 94. All the lodgepoles in the middle distance of this view of Grouse Meadow in 1958 arise from blueberry thickets.

by it is small the invasion is increasing rapidly. While without much difficulty the plants could be removed by grubbing them out, unless some means could be devised whereby the grazing pressure could be lightened in this portion of the meadow, it seems likely that an invasion would only begin anew. Since the distance over which seeds are carried by ordinary means of dispersal is probably limited, removal of all the plants not only on the meadow but also in the near neighborhood would presumably end the problem. Such a large-scale attempt toward eradication obviously would be impracticable. It seems clear, therefore, since in any case it would be a relatively simple task, that the occasional removal of the invasion as a matter of course would be the best solution.

As already indicated the lodgepole invasion on the other hand is primarily a natural one. On the whole its rate of increase is slow, and therefore it should offer no problem for some time. Furthermore, since it illustrates an interesting, natural, ecological relationship and sequence of events, its continued protection is warranted.

Stillwater Meadow ("Lower Deer Meadow" of Sumner, 1941). The present writer stayed at this meadow briefly in 1929 and is inclined to recall it as then being fairly open except for scattered clumps of lodgepoles. In 1940 Sumner (1941) found it as a woodland type of meadow though more open than most woodland meadows, and described it as being in an excessively overgrazed and trampled state at season's end. Now (in 1958) it is nearly all distinctly woodland, and contains in addition to lodgepoles large, dense thickets of aspens and willows. The few, small areas or patches with forage were, however, in good condition.

Conclusion. It appears rather evident that increase in woody growth, associated with heavy use, has been such that the appearance and area of this meadow has become drastically altered and diminished. Obviously only a clearing away of at least the younger invasion would be the means of regaining some

of the original acreage.

Dusy Basin. Except for some erosion caused by trails, to judge from the relatively unaltered development of the low herbage characteristic of meadows at this high altitude (11,300 ft.), the meadows in Dusy Basin on the whole have probably undergone but little change over the years.

No old photographs available for Dusy Basin Meadows, Deer Meadow, and Stillwater Meadow were suitable for comparison.

Little Pete Meadow. For this meadow the only old photograph available was of a distant view unsuitable for comparison. A few spots do occur, however, which show a recent but moderate increase in falsehellebore. The range condition was good.

Big Pete Meadow ("Upper Little Pete Meadow" of Sumner, 1941). Since 1940 this meadow has developed the beginnings of a falsehellebore invasion around its southern end (figs. 95, 96, 97), and meanwhile an increase in lodgepole invasion is underway on its western side (fig. 97). The colonies of falsehellebore appear to be about the same age as those invading Grouse Meadow, and some of the lodgepole invasion is associated with blueberry. The range condition was good.

Meadows in Upper LeConte Canyon. In 1940 because of overgrazing, erosion of stream banks was occurring (Sumner, 1941). In 1958 the effects of some stream-bank erosion was evident locally; otherwise the meadows were in fair condition, and comparison with a distant view of the meadows photographed in 1940 showed no important change in the pattern of the streamways (figs. 98, 99).

8. THE EVOLUTION AREA

Colby Meadow. In commenting on this meadow as it appeared in 1940



Fig. 95. Big Pete Meadow in 1940 showed evidence of heavy use.



Fig. 96. In 1958 the same view of Big Pete Meadow shows the beginnings of a false-hellebore invasion.



Fig. 97. On closer view Big Pete Meadow in 1958 exhibits an increase of lodgepoles in a small area on its opposite side.



Fig. 98. Distant view of meadows in Upper LeConte Canyon in 1940.



Fig. 99. The same view of the meadows in Upper LeConte Canyon in 1958 shows no important alteration in the pattern of the streamways.

Summer (1941) observed that, being well-watered, it had withstood remarkably well the heavy use to which it was then being subjected; nevertheless erosion was evident (fig. 100).

At the present time (1958) Colby Meadow seems to show no further erosional damage (except as noted below with regard to the trail). Thus the formerly eroded streambank (fig. 100), although almost covered up to the brim by high water, now appears to show no important change (fig. 101). This assumption is strongly supported by the unmistakable evidence of strong recovery from damage in spots nearby which formerly were trampled and denuded (figs. 102, 103). Moreover, the substantial development of this local recovery, together with the lack, elsewhere on the meadow, of trampled and denuded spots such as appeared in the past, strongly suggests that a well-established trend to improvement is under way over the meadow generally.

As already noted for other wet meadows, the trail which traverses it is the site of very bad damage caused by trampling around it to avoid deep mud and bogholes.

McClure Meadow. In 1958, owing to prolonged flooding and excessive wetness, McClure Meadow was not useable for stock until midseason, and as a result very heavy use occurred locally just at the critical period during which growth, long delayed by flooding, was being resumed in the forage (figs. 104, 105, 106, 107). Moreover, because of the boggy conditions, particularly severe damage was created along and around the trail through the meadow by the passage of saddle and pack-stock parties and the usual attempt on the part of the stock to avoid the numerous bogholes (fig. 110). Other than the foregoing indications of heavy, too early use locally, and the probably increasing trail damage, the meadow appeared to show no important change.

Conclusions. This meadow is susceptible to flooding. Early conditions prevailing even as late as midseason in McClure Meadow ^{as} is to be expected



Fig. 100. ✓ In this view, Colby Meadow in 1940 showed destruction of sod and streambank erosion.



Fig. 101. The same view of Colby Meadow in 1958 shows that the rim of the streambank has remained intact, which in itself would indicate that streambank erosion has not increased.



Fig. 102. View of Colby Meadow in 1940 showing a trampled and denuded patch.

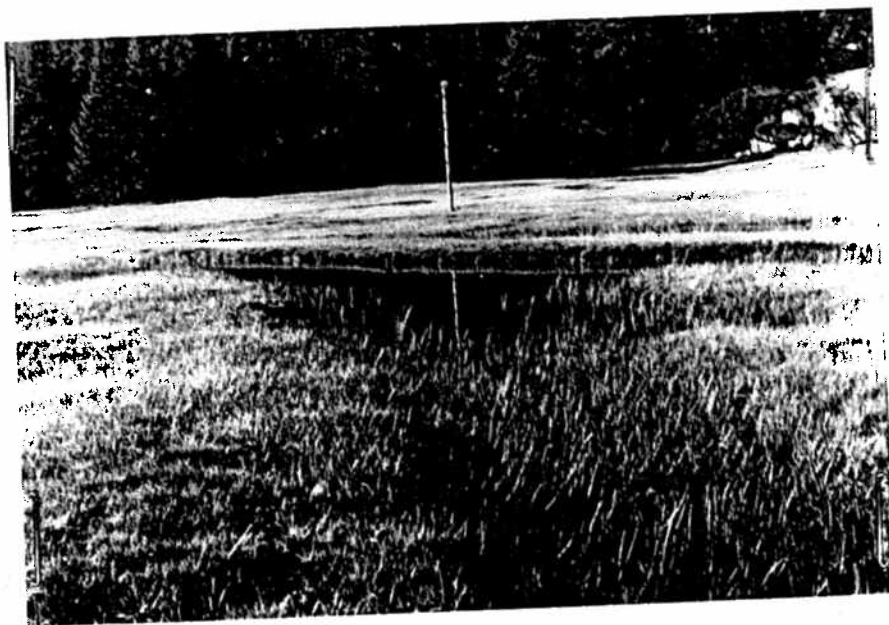


Fig. 103. The same view of Colby Meadow in 1958 showing the strong trend to recovery on the same formerly trampled and denuded patch. Beaked Sedge is the advancing pioneer.



Fig. 104. McClure Meadow as it appeared in 1940 (August 31-September 1).



Fig. 105. The same view of McClure Meadow in 1958 (August 13) showing flooded conditions persisting well into August.



Fig. 106. ✓ Another view of McClure Meadow in 1940.



Fig. 107. Except for the signs of "early-season" overuse showing in the foreground, in 1958 the same view of McClure Meadow showed no important change.

occasionally as the result of the late withdrawal of flood waters, and for forage the devitalizing effects of early season use is well known. Nearby Evolution Meadow (see below) is a dry meadow, and during 1958 when McClure Meadow was subject to the above local overgrazing, the good, mature forage of Evolution Meadow was only lightly used. It is clear, therefore, that the institution of local, seasonal grazing restrictions and routing of use would be the means of handling exigencies of this kind. Finally, with respect to the trail and the damage caused by its use, it should be stated here that, in addition to Colby, for no other meadows seen during the present study would the relocation of the trail to a point skirting them be an easier task.

Evolution Meadow. This dry meadow with its abundance of Sierra Rice-grass is, in common with the more moist McClure Meadow, ecologically very much the same as Tuolumne Meadows in Yosemite National Park. In 1940 Summer (1941) saw it had been more extensively invaded by lodgepoles than had McClure or Colby meadows (fig. 108). This larger amount of invasion in Evolution Meadow he attributed to its drier condition than that obtaining in the other two, and suggests that it may have been aided by grazing pressure. By 1958, however, neither Colby nor McClure meadows showed any further increase in lodgepole invasion, while on Evolution Meadow itself the amount of increased invasion since 1940 seemed to be relatively slight. For the most part the appearance of increased invasion on Evolution Meadow since 1940 is actually superficial, owing largely to the fact that the same trees involved in the invasion noted by Summer have merely grown in size (fig. 109). Any new invasion since that time is not only relatively meager but the new invaders themselves also generally a suppressed, slow growth. Occasionally they are partly or wholly deadened by Ips.

This meadow currently is in good condition.

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Fig. 108. Evolution Meadow as it appeared in 1940, showing some lodgepole invasion.



Fig. 109. The same view of Evolution Meadow in 1958. There has been relatively little lodgepole reproduction since 1940; only the size of the trees has increased.

9. THE WOODS CREEK AND WOODS LAKE AREA

Woods Lake Basin. To judge from their generally intact appearance the meadows around and near Woods Lake do not appear to have undergone any important change except, of course, along boggy trails where often severe damage by trampling occurs (fig. 111). Damage of this nature doubtless has increased in amount commensurate with increasing travel in the Problem Areas generally.

Junction of South and North Forks of Woods Creek. Sumner (1941) description of the appearance of this section in 1940 as a swampy, half-extinguished, overgrazed and weedy woodland meadow scattered through heavy forest matches its appearance in 1958 except that unquestionably the increase in woody growth and weediness has further reduced its area.

Conclusion. As pointed out by Sumner (1941) the scarcity of forage in this portion of the Kings (including Castle Domes Meadow, see below) is such that even the poorest is of strategic importance. In view of the continuing overuse and its effect in increasing invasions the apparent lack of grazing restrictions is surely unwarranted.

Castle Domes Meadow ("Woods Meadow" of Sumner, 1941). This small but important meadow is very rapidly changing in appearance through invasions. On the one hand it is quickly giving way to falsehellebore, and on the other it is yielding, though more slowly, to forest.

No other meadow seen during the present study showed evidence of a more rapid and thorough invasion within recent years by falsehellebore than this one. This invasion is so extensive that it alters conspicuously the scene the meadow presented in 1940 (fig. 112, 113), and in all probability it has been equally rapid since 1940 in glades immediately adjoining the meadow and where evidently falsehellebore formerly was essentially confined though according to Sumner (1941) it was not abundant.

This invasion (or increased invasion), rather than having been a slow,



Fig. 110. Severe trampling injury along the trail through McClure Meadow in 1958. This damage is as extensive as that caused by the trail through Colby Meadow. Each animal chooses a different route and unless the meadow dries out quickly (which is scant hope for a wet meadow) the damage becomes progressively worse.



Fig. 111. Similar injury along the trail just above Woods Lake in 1958.

gradual process, seems to have begun abruptly and simultaneously in numerous sites. The largest, most mature, and hence oldest colonies of the invasion, namely those crowded in openings between thickets of willows at the distant margin of the meadow (fig. 113), appear to be contemporary in age on the basis of their uniform density with respect to flowering. Being equally developed in this regard they probably represent an even-aged stand, and the inference follows that their origin or increase in point of time was presumably a simultaneous event.

Although the year or years when this increased invasion began is difficult if not impossible to determine exactly, there are certain features shown by the invasion which, if interpreted correctly, provide a means of arriving at a rough approximation of the date when that increase was initiated. The above largest and most well-developed colonies of approximately simultaneous origin do not appear to be of long standing. In appearance they are obviously the oldest, yet the dense uniformity in the mass of flowering already noted suggests they are a recent development rather than one which began as long ago as eighteen years. Furthermore, many of them are in a state of rapid expansion. This is shown by their continuous gradation outwards from a mature, full-flowering center into progressively less mature plants. Active extension of the area occupied by these colonies is actively in progress. All these features strongly suggest that these oldest colonies arose or else began their strongest development only very recently.

The clumps of falsehellebore scattered about on the open meadow have arisen from seeds derived mainly or wholly from the above parental colonies. From these older ones they grade continually in age downward into isolated, individual seedlings. As already noted for Grouse Meadow, in seedlings a flowering commences probably not earlier than the third year of growth. Many of the colonies scattered on the meadow are just beginning this phase of their

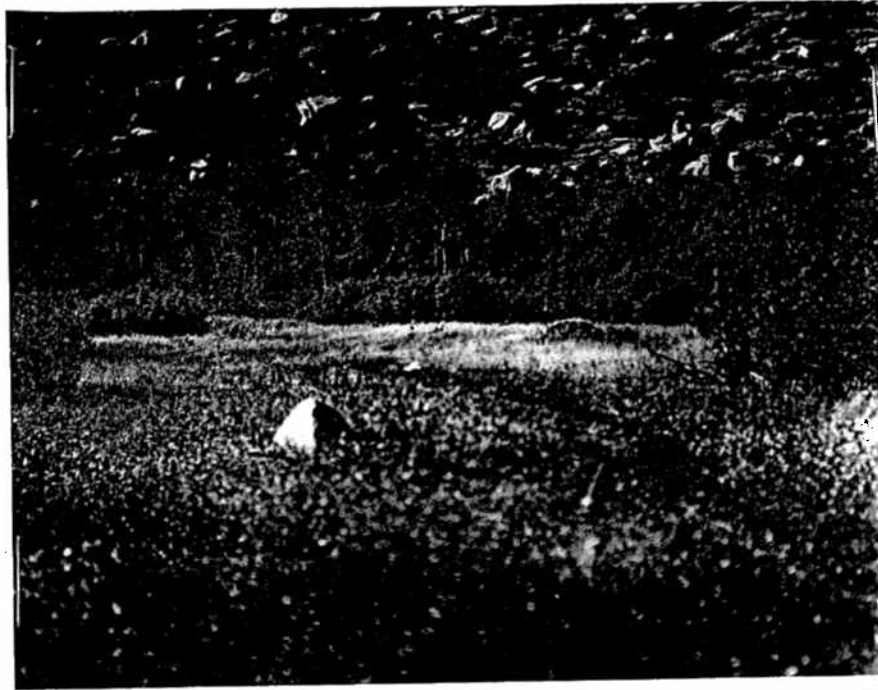


Fig. 112. Castle Domes Meadow in 1940 (about August 13). Little or no falsehellebore was evident in this view.



Fig. 113. Same view of Castle Domes Meadow in 1958 (August 2). Falsehellebore is now rampant.

growth cycle. Others are more advanced, and thus lead backward in age to the parental colonies from whence they were derived.

Thus the entire invasion is a unit which was begun by a simultaneous increase peripherally and a subsequently rapid, centripetal advance. Returning to the original question, namely the time when the invasion or increase began, on the basis of the above it is estimated that a span of ten or twelve years at the most was easily sufficient to bring about the whole appearance of falsehellebore as shown in 1958. Thus the invasion or increase presumably began around 1947.

Despite the undisturbed appearance of the forage on the largest open portion on August 2 (fig. 113), signs of heavy use were common elsewhere on Castle Domes Meadow.

In contrast to the falsehellebore invasion that of the lodgepole is of much older origin. Its largest trees have the appearance of being in the neighborhood of forty years old. From thence the stand dwindles downward to younger individuals. To judge from the relative openness of the stand, this lodgepole invasion is undergoing only a relatively slow increase (fig. 114).

On Castle Domes Meadow there seems to be no other factor responsible for provoking these invasions, and especially that of the falsehellebore, than over-use. The almost explosive increase in falsehellebore appears to be an abnormal event in that no forces intrinsic in natural conditions seem to be involved; hence it is probably attributable to no other cause than that indicated.

Conclusions. On this meadow a great upsurge of falsehellebore has begun very recently. Invasion has advanced with rapidity. Within ten or twelve years the area of Castle Domes Meadow has become strongly reduced by these weeds. Treatment would point to the conclusions given under Grouse Meadow. For other conclusions, see Junction of Forks of Woods Creek above. (And see also fig. 115.)

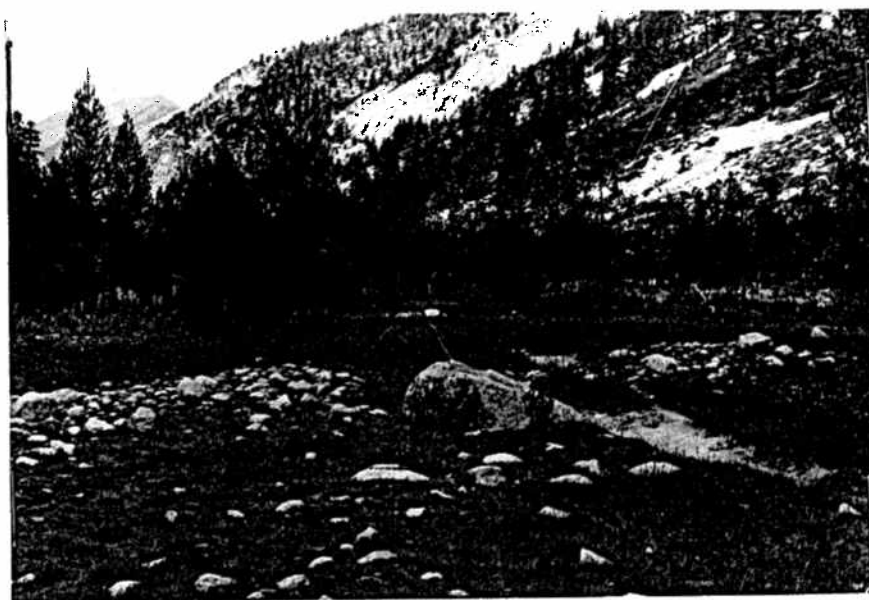


Fig. 114. Another view of Castle Domes Meadow in 1958. A lodgepole invasion is undergoing a slow increase.



Fig. 115. Castle Domes Meadow. As in the adjacent portions of the Kings, forage in this meadow is so scarce that even the poorest is of strategic importance. There appears to be no good reason why the trail should be located where it serves to extinguish some of it.

10. THE HOCKETT AREA

With respect to the problem of ecological changes and their rates, the four largest meadows of the Hockett Area, namely Hockett, Sand, South Fork, and Mitchell meadows, are of particular interest in that they represent a case in which lodgepole invasion shows evidence of having been initiated on at least two and presumably on all four of them simultaneously. Whether or not other meadows in this area show the same situation is not known to the present writer since they were not visited during the present study. Aside from recent damage by floods on South Fork Meadow the meadows named above appear to show no other feature indicative of important changes, and the range condition was good on all alike. Hence the following treatment is primarily concerned with the case in point and begins with Sand Meadow since here it exhibits its most clear-cut and conspicuous example.

Sand Meadow. On Sand Meadow the invasion forms a belt of varying width which nearly surrounds the meadow on all sides (fig. 116). As seen in a view looking in various directions across the grassy expanse it contrasts strongly against the background formed by the old forest which towers above directly behind it (fig. 117).

The complete absence of any transition and great disparity in age between the invasion and the old forest describes a very sharp boundary. With respect to the meadow this boundary is of special ecological significance. On the side facing the old forest it obviously shows every indication of having been not only the original one which formerly and very definitely marked the limit between meadow on the one hand and forest on the other, but also that it had remained stable and in the same position for centuries. Large old trees such as those which dominate within the original stand commonly predominate along the very border of the latter. Ring counts made to determine the age of the few fire scars which seemed to be discoverable only on old trees showed evidence



Fig. 116. ✓ Around the margin of Sand Meadow the belt of lodgepole invasion extends almost unbrokenly, but only a portion of it is shown in this view.



Fig. 117. ✓ The wall of old forest, the belt of invasion, and evidence of repression are all clearly shown in this very instructive view of Sand Meadow.

of slower than usual growth rate. Beneath the canopy of the old, bordering trees, reproduction is proceeding only very slowly. Conditions just within the original stand have therefore long remained static.

Turning now to the invasion itself. The invading stand forms a belt which in some places is quite narrow while in others it is much wider. As an estimate for the whole meadow, the average distance of displacement of forest-meadow boundary, from its original location to that of its present position along the front of the invasion, is perhaps one hundred fifty feet. Outwardly from the former meadow-forest boundary, at any one point the dense invasion tapers downward from the tallest (20-25 feet high) trees in the rear to the smallest along the present margin of the meadow. Except conspicuously along one sector where forward movement was rapid and a scattered, stunted growth developed, in general the invasion is advancing forward only rather slowly. Evidence for this is the relative scarcity of seedlings together with the dwarfed, repressed growth commonly shown by the smallest trees occurring along its front. The conspicuous exception to a slow, forward advance and as already noted is situated in a small area at the lower end of the meadow. In this site, however, the intensity of repressive factors is evidently very high. All of the trees are dwarfed and mis-shapen and many of them have been affected by Ips (fig. 117).

An attempt was made to determine the year or years when the invasion began. At widely separated sites on different sides of the meadow trees presumed to be the oldest ones of the invasion were cleanly cut as closely to the ground level as the axe would allow. In all cases the highest number of annual rings found indicated an age of fifty-eight years (in 1958), and although the sampling of the population was small the same highest figure was found repeatedly. This would point to the year 1800 as the approximate date when the invasion was initiated.

Very generally in this invasion the cross-sections of the cut stumps showed that suppression was the rule during the first eight to twelve years of

growth, and that rapid growth ensued promptly and continuously thereafter.

In connection with the question of invasion-provoking factors it should be noted that the body of the meadow itself appears to have undergone no important change. Although even drier than Mitchell and considerably more so than Hockett or South Fork Meadow the herbaceous vegetation is the native climax characteristic of a meadow of this type. This is in itself evidence of relatively stable conditions. No indication of erosion other than a moderate, normal amount was noted. In all probability the very slow or retarded rate of advance now shown by the invasion generally is related to the stabilized conditions, and evidently these conditions have been in existence for some time. Therefore any clue as to the provocative factors would appear to lie in the more remote past.

At the outset of an inquiry into the past it should be mentioned that the invasion does not appear to be related to any natural, initiating factor. The evidence of centuries-long stability in position of the original forest-meadow boundary indicates a strongly undeviating balance of conditions over too long a period. Furthermore, meadows normally are not flanked by an abrupt invasion, and moreover in lodgepole the initiation of a new cycle of reproduction as in the present instance does not await a lapse of two to four or more hundreds of years before it occurs. In view of these and other aspects which would eliminate natural factors from consideration, some extraneous force is indicated. Over an interval involving some few decades which terminated in the early 1930's, grazing by cattle, which was probably heavy, existed in the Hockett Area. Although according to Mr. E. L. Kirk, long-time permanent ranger in this area, that interval ended on the above date, just when it began is perhaps uncertainly known. If heavy use had already developed by the year 1900 which is the postulate date for the beginning of the invasion, some correlation with that date might apply. On Ellis Meadow considerably to the north on the Roaring River Area, Armstrong (1942) found a close coincidence in the dates

when disturbance of meadow-margin by cattle and invasion of lodgepole began. On the basis of the coincidence of time he suggested that the beginning of disturbance and of invasion may actually be correlated. Aside from the fact that the response to disturbance would not be immediate, his judgment essentially was probably correct.

In connection with early-day use of meadows by pioneer cattlemen and sheepmen, burning of forest, believed by them to be a means of increasing and improving the forage, was practiced on leaving the meadows in the fall. Conspicuous succession of lodgepole immediately following fire as seen elsewhere in the West is seldom the case in the Sierra. Therefore fires set by pioneers would not generally invoke invasions; yet the fire scars themselves would long remain in evidence on the original forest trees which border the meadows. Around the margin of Sand Meadow, however, ring counts of old fire scars possibly attributable to the above burning practice showed they long antedated the time of any commercial or domestic grazing.

Therefore the only positive indication that the large invasion is actually related to extraneous rather than solely natural forces lies in the evidence shown of an originally and highly stable forest-meadow boundary and of a sudden shift on the latter during a period of early-day, probably heavy, grazing disturbance.

Mitchell Meadow. According to Mr. E. L. Kirk, Mitchell Meadow, which comprises about forty acres, is not currently grazed at all and, furthermore, according to him no stock has used it since cattle left the Hockett Area (fig. 118). Therefore, aside from natural causes, lodgepole invasion must be attributed primarily to early-day "unnatural" provocation. In any event, invasion on this meadow is very scanty on the whole, and occurs in but a few spots localized along its margin. At one corner on the northeastern side charred, rotted stumps give evidence of a former fire. Standing between or directly

against these stumps are trees of an invasion which appears to be contemporary in origin with the large one surrounding Sand Meadow. Ring counts essentially confirmed this view, since its maximum age was found to be fifty-four years. The intimate association of some of the oldest trees with the charred stumps suggests that it probably arose soon after the fire and that the age of the invasion and of the burn are almost contemporary. The only other invasion of note is one confined to and covering low eminences composed of dry, sandy gravels. It represents a recent rapid advance and is perhaps rather contemporary with the one at the lower end of Sand^d Meadow (fig. 119).

The close similarity and contemporaneity in origin of the particular invasion in question with the corresponding one on Sand Meadow is strongly indicative. As on Sand Meadow and on the same grounds they are related in origin to an extraneous influence which operated essentially at the same time on both of them. On Mitchell Meadow fire was followed only by a moderate succession of lodgepole. Rapid recent advance has occurred only on low, dry eminences which by their very nature are susceptible to natural invasion. Elsewhere bordering the meadow invasions appear to be almost absent. This is in keeping with lack of use since the removal of cattle. It may also constitute evidence that during the period of cattle-grazing disturbance was relatively light.

South Fork Meadow. Although no ring counts were obtained on South Fork Meadow (nor on Hockett) the invasion here has every appearance of being largely the same age as the older one on Sand and Mitchell meadows. Within recent years its advance or increase has greatly slowed and in some places has ceased entirely. It may not, however, continue to be retarded. Owing to the floods of the winter of 1955-1956 and which decimated the South Fork Pasture, the stream bed has become rather deeply entrenched along certain portions of its course through the meadow. Lowering of the water table followed by an increased rate



Fig. 118. ✓ Except for the faint trace of a former trail across the foreground and perhaps aside from the beginnings of invasion, Mitchell Meadow from this view has the appearance of a meadow which has never been disturbed.



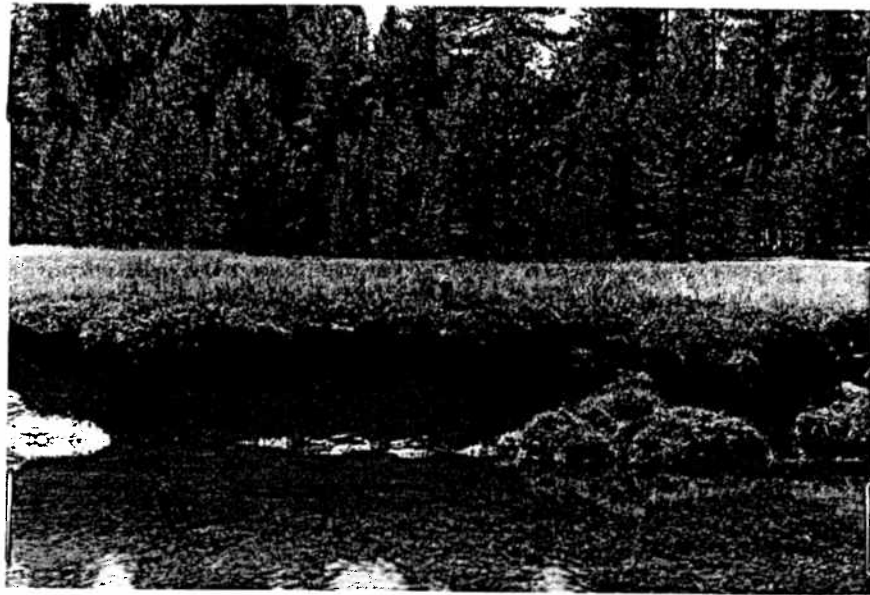
Fig. 119. ✓ Mitchell Meadow. The invasion shown on the right was probably caused by disturbance; the one on the left is natural.

of invasion might therefore be an expected result (figs. 120, 121).

Hockett Meadow. Except in portions at its lower end where the trees are scattered and the original forest-meadow boundary is only rather vaguely defined, in general the invasion on Hockett Meadow conforms in character and probably in age with the one described for Sand Meadow, although it is not developed as extensively.

Conclusions. Ecologically Hockett, Sand, South Fork, and Mitchell meadows are very instructive. A lodgepole invasion around their borders shows evidence of having arisen on all of them almost simultaneously. In all probability this abrupt beginning was a response produced by extraneous forces of contemporary existence which had disturbed their margins with rather equal effect. Sand Meadow, in particular, demonstrates most markedly the results of these influences on the ancient, formerly stable meadow-forest boundary. The retarded rate of invasion which now is presumably rather general on these meadows suggests that a trend toward re-establishment of a new, relatively stable meadow-forest boundary is under way. It also suggests that the degree of protection which is being provided against overuse of these meadows is probably adequate. Only on South Fork Meadow, where entrenchment of the stream may have lowered the water table, is a strong increase of invasion possibly to be anticipated.

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Fig. 120. Lodgepole invasion on a portion of South Fork Meadow in 1958. As elsewhere on the meadow the extent of the stand is apparently not being augmented as rapidly as it was when the invasion was initiated. New reproduction is relatively scant. Thus any result which entrenchment of the stream channel may have by indirectly effecting the rate of invasion is not yet evident; however, only two years have elapsed since the floods occurred.



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Fig. 121. Flood damage at the lower end of South Fork Pasture. Floods of an intensity sufficient to create damage of this extent are produced by rare combinations of meteorologic causes and therefore are extremely infrequent and may not strike the same meadow again for hundreds of years. Their effect on the ecology of the meadow is profound. They often result in a drying out of the circumjacent borders and increased lodgepole invasion but owing to variables the prediction for any given case is fraught with hazard.

GENERAL CONCLUSIONS

1. Rate of change in meadows under natural conditions as compared with the rate in meadows of the problem areas. The rate of change in meadows under natural conditions tends to be very slow. Meadows which are relatively unused and therefore under almost or essentially natural conditions show during an eighteen year interval only a negligible amount of forest invasion or other changes, if indeed invasions or any other significant changes have at all occurred. During the same period, various problem area meadows have undergone important changes. Invasions have occurred at a rate which strongly exceeds that in unused ones and, on some also the rate of erosion is abnormally advanced. All this acceleration must be charged to the action of excess in use.

2. Rate of forest invasion of meadows in the problem areas. On meadows of the problem areas most of the numerous invasions by forest have been initiated within the past fifty years, and the speed of their encroachment proceeds at various rates. In a few, the rate of advance has become so greatly diminished that stability has become essentially realized along their front. This greatly decreased rate is associated with meadows in good or excellent condition. Other invasions show varyingly greater rates of forward movement. The most rapid of all are always associated with meadows in the worst state of deterioration.

Rate of invasion is perhaps most conveniently expressed in terms of amount of meadow captured within a given amount of time. In terms of distance between the point of initiation and the front of the invasion, the amount captured may be as little as fifty feet in fifty years, or it may be as much as one hundred feet in only a dozen years. In the case of the most rapid actually the rate of invasion is even faster than is indicated by the foregoing extreme. The invasion is already an accomplished fact as soon as the seedlings

have become established. Having successfully passed the critical stage of germination, their continued growth is reasonably assured. In the seedling stage, however, the invasion easily escapes notice. Depending on rate of growth it may not become conspicuous from a distance until several years have elapsed.

5. Rate of weed invasion of meadows in the problem areas. Data regarding rate of invasion by *Falschellebore* was obtained. They indicate that a maximum of roughly one hundred feet of forward advance into meadows may occur in probably not more than about ten or twelve years.

4. Rate of erosion of meadows in the problem areas. An abnormal rate of erosion occurs on First Charlotte Lake Meadow. It is also being promoted on various other meadows of the problem areas by use of the regular routes established through them by the trails.

5. Time remaining for reaching a solution with regard to deteriorated meadows. Just how much time remains for reaching a solution before the damage becomes irreversible depends upon the degree of deterioration and the rapidity with which the deterioration is increasing. Although no meadows seen have as yet gone beyond the limits of recovery, certain ones are closer to being in a critical condition and are more rapidly approaching that state than are others. The ones for which the amount of time for reaching a solution is the least are Lower (and probably also Middle) Meadow of Paradise Valley, Junction Meadow on Bubbs Creek, Junction Meadow on the Kern, First Charlotte Lake Meadow, and Timberline Lake Meadow. For these a solution needs to be sought immediately.

6. Impairment of wildlife habitat, with reference to Sierra bighorn. No evidence was found which would assist in determining the extent and nature of overlapping use of alpine forage by livestock and Sierra bighorn. (At Rae Lakes, Sixty Lakes Basin, and in the above Woods Lake in the Baxter area

no signs indicating bighorn were seen. One mile above Evolution Lake, however, what appeared to be characteristic tracks of bighorn were seen on August 12.)

CHECKLIST OF PLANT INDICATORS OF SUCCESSIVE
STAGES OF DETERIORATION

Plant indicators of deterioration of meadows in the problem areas are most numerous at the lower altitudes or below about 8000 feet. One reason for this is the greater diversity of native species which exists at these levels as compared with that at the higher. Therefore more are available to serve as indicators. Another reason is the occurrence of various non-native weeds, almost all of which are indicators of disturbed conditions. These non-natives are most abundant in and are almost wholly confined to the lower altitudes. They are climatically unsuited to the higher, and above about 9000 feet they are rare or absent.

The non-natives are common and widespread over the lowlands, and have been transported into the meadows by man's activities. Almost invariably they are indicators of disturbed conditions, and many of them are well known and reliable indicators of range deterioration. In contrast, little is known as to the indicator value of the native species. On the other hand they show two features common to proven indicators. One is their common occurrence on variously deteriorated sites or meadows. The other is the annual habit of growth which they share in common with the non-native ones. In being annual they quite fulfill the characteristic frequent in many proven indicators in being temporary species that for a time replace the former, more stable plants which have been weakened or else eliminated by overgrazing and which may reappear during the process of meadow recovery. At higher altitudes, however, even the native annuals become fewer in kind, and in general at these levels the only indicators available are the usual appearances of an overgrazed area as shown by the thinning ground cover, bare spots, incipient gullying, and evidence of increased erosion.

The mere presence or even abundance of various non-palatable native

species such as falsehellebore may or may not be indicators of overgrazing, notwithstanding the fact that they often increase in abundance when overgrazing occurs.

In the checklist given below, the species of particular reliability are indicated by an asterisk. With further study the list could be materially extended.

1. Indicators of a late stage of deterioration.

Annual Hairgrass*	White Hedge-nettle
Cheatgrass Broms*	Sierra Willowweed
Sheepsorrel*	Mountain Bluecurls
Cudweed*	Whitetip Clover
Douglas Knotweed*	Littlehead Clover
Lambquarters Goosefoot	Hairy Orthocarpus
Hairy Popcornflower	Gayophytum sp.
Slender Tarweed	

2. Indicators of an earlier stage of deterioration.

Western Yarrow*	Common Selfheal
Falsehellebore Sagebrush	Ticklegrass
Mixleaf Mugwort Wormwood	Largeleaf Avens
Field Mint	Creek Goldenrod

SCIENTIFIC NAMES OF PLANT NAMES USED IN TEXT

The common names used in the following list conform to those given in Standardized Plant Names (1942) if they appear in that work. Otherwise the names conform to those given in widely used botanical manuals. In each case the corresponding scientific name appears at the right.

Annual Hairgrass	<u>Deschampsia danthonioides</u>
Baltic Rush	<u>Juncus balticus</u>
Bearded Fescue	<u>Festuca subulata</u>
Blue Wild Rye	<u>Elymus glaucus</u>
Bottlebrush Squirreltail	<u>Sitanion hystrix</u>
Canyon Sedge	<u>Carex fissuricola</u>
Carpet Clover	<u>Trifolium monanthum</u>
Cheatgrass Brome	<u>Bromus tectorum</u>
Common Selfheal	<u>Prunella vulgaris</u>
Creek Goldenrod	<u>Solidago elongata</u>
Cudweed	<u>Gnaphalium palustre</u>
Deerbrush	<u>Ceanothus integerrimus</u>
Douglas Knotweed	<u>Polygonum douglasii</u>
Dwarf Blueberry	<u>Vaccinium caespitosum</u>
Elmer Needlegrass	<u>Stipa elmeri</u>
Falschellebore	<u>Veratrum californicum</u>
(California Falschellebore)	
Falsetarragon Sagebrush	<u>Artemisia dracunculoides</u>
Field Mint	<u>Mentha arvensis</u>
Fringed Brome	<u>Bromus ciliatus</u>
Gayophytum sp.	<u>Gayophytum ramosissimum</u>
Goldenbush	<u>Chrysothamnus sp.</u>
Hairy Popcornflower	<u>Alloccarya hispidula</u>
Hairy Orthocarpus	<u>Orthocarpus hispidus</u>
Hollowstem Lupine	<u>Lupinus pratensis</u>
Jeffrey Shootingstar	<u>Dodecatheon jeffreyi</u>
Kentucky Bluegrass	<u>Poa pratensis</u>
Lambquarters Goosefoot	<u>Chenopodium album</u>
Largeleaf Avens	<u>Geum macrophyllum</u>
Littlehead Clover	<u>Trifolium microcephalum</u>
Ovalhead Sedge	<u>Carex festivella</u>
Meadow Penstemon	<u>Penstemon oreocharis</u>
Mixleaf Mugwort Wormwood	<u>Artemisia heterophylla</u>
Mountain Bluecurls	<u>Trichostema oblongum</u>
Mountain Brome	<u>Bromus marginatus</u>
Nebraska Sedge	<u>Carex nebraskensis</u>
Northwest Cinquefoil	<u>Potentilla gracilis</u>
Pullup Muhly	<u>Muhlenbergia filiformis</u>
Rose Pussytoes	<u>Antennaria rosea</u>
Sagebrush	<u>Artemisia tridentata</u>
Sheep Sorrel	<u>Rumex acetosella</u>
Sierra Willowweed	<u>Epilobium brevistylum</u>
Slender Tarweed	<u>Nadia gracilis</u>
Slender Wheatgrass	<u>Agropyron trachycaulum</u>

Sphagnum (Peatmoss)
Subalpine Needlegrass
Ticklegrass
Torrey Popcornflower
Tufted Hairgrass
Umbellate Pussytoes
Wax Currant
Western Bracken
Western Yarrow
Westernbog Blueberry
White Hedge-nettle
Whitetip Clover

Rusty Sedge

Sphagnum sp.
Stipa columbiana
Agrostis scabra
Plagiobothrys torreyi
Deschampsia caespitosa
Calyptridium umbellatum
Ribes cereum
Pteridium aquilinum var. pubescens
Achillea lanulosa
Vaccinium occidentale
Stachys albens
Trifolium variegatum

Carex subfusca

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APPENDIX

EXPLANATION OF APPENDED MAPS

Although ecologically each meadow is of interest certain ones are of particular significance in this regard and deserve more study. The two appended maps are intended to show their localities (indicated in red). Important features concerning them have been discussed earlier in the report. These are briefed below and permit some additional comments.

Lower Meadow of Paradise Valley (map 1). Seat of lodgepole invasion which began around 1946. It would be of interest to know how much area the invasion has preempted on this small and sadly deteriorated but very important meadow.

First Charlotte Lake Meadow (map 1). Shows effects of abnormal erosion on a deeply scoded subalpine meadow. The amount of sphagnum which occurs is remarkable in view of the southerly latitude, and the ecological conditions of its existence are a very remarkable contrast to those of the dry, concave, sand flats which occur along the trail about one mile in the direction towards Bullfrog Lake.

Simpson Meadow (map 1). Shows excellent examples of ecological succession following fires of known dates. Floristically, this is the richest of all the problem area meadows.

Grouse Meadow (map 1). Contains at the lower end a recent and fairly extensive falsehellebore invasion. At upper end and elsewhere on the meadow a lodgepole invasion is associated with a prior invasion by Westernbog Blueberry. At the very extreme upper end lodgepole invasion is more massed as a body, and the trees have grown far more rapidly than those out on the meadow.

Undoubtedly the soil conditions are more neutral here than those where sphagnum occurs. An abundance of Sundew, an insectivorous plant, occurs in association with the sphagnum.

Junction Meadow on the Kern (map 2). An outstanding example of a strategic but very deteriorated meadow. Seat of two extensive lodgepole invasions. The first one was removed probably not long before 1936. The second began anew around the border of the meadow and made most of its gains in further invasion since around 1947.

Timberline Lake Meadow (map 2). The low, wet portion is a characteristic example of a subalpine meadow with impeded drainage. This type of meadow is probably the most vulnerable of all to damage by trampling.

Sand Meadow (map 2). The features characteristic of a lodgepole invasion which originated as a sudden burst from the old forest are diagrammatically clear and are shown on a large scale.