A PRELIMINARY SURVEY of the INFLUENCE OF WHITE MAN ON THE VEGETATION OF YOSEMITE VALLEY

by

R. P. Gibbens

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INTRODUCTION

Yosemite Valley, a remarkable example of the work of geological forces, assumed its present configuration during recent geologic ages. Although the Valley is, in the geologic sense, very young, its age is great when compared with its short historical period. Man, and particularly the white man, is a newcomer to the Valley. Aboriginals occupied the Valley for an indeterminate number of years, but even their occupation does not extend far into antiquity. In his short tenure, man, both aboriginal and white, has exerted a great influence on the vegetation of the Valley. The primitive culture of the aboriginals included manipulation of vegetation to supply basic needs. The white man, with a culture developed to a point where plants could supply material gains as well as food, clothing, and shelter, has been much more of an exploiter. Fortunately, this exploitation was tempered by the early realization that the scenic values in Yosemite Valley were unique and should be preserved. However, the preservation of those values has resulted in vegetational changes which have necessitated management.

The scenic wonders of the Valley have attracted a steadily increasing number of visitors each year. That the vegetation has been influenced by this tide of humanity, now exceeding 1,200,000 persons a year, is only to be expected. The objective of this study is to determine the nature, extent, and causes of the changes which have occurred since white man arrived on the scene. The character of the vegetation as it exists today and the ecological forces operative upon it will also be

considered. The material presented will, it is hoped, help to explain the changes which have occurred and assist in the management of Yosemite Valley, one of the world's scenic wonders, as unchanged as practicable.

METHOD OF STUDY

To evaluate changes in the vegetation since white man discovered Yosemite Valley, it was necessary to go to the historical record. To this end, a large number of administrative reports and works published by early visitors and residents were read. In the latter category, findings of pertinent facts were disappointing. Even such naturalists as John Muir, who wrote extensively, included little specific information on the plants in the Valley. For quantitative comparisons, statements like "verdant banks of new leaves, and groves of half-open ferns, and thick settlements of confident flowers . . . ." (Muir, 1915) are of dubious value. Fortunately, a few sources were found containing definite observations and no doubt others exist.

Photographs, both early and recent, provided the best source of information for determining vegetational changes. There are literally thousands of early photographs of Yosemite Valley. A large number were examined. Some of the early views, excellent from a vegetational standpoint, were rephotographed in 1943 (Ernst, 1943b). Many of these were selected and retaken in 1961. By continuing the series of the same views their value will be enhanced, not only for this study but also for future reference.

As will be evident in the picture series which is here included, the scenes do not always match exactly. This is partly due to

differences in focal lengths and inclusion angles of the lenses used and partly to failure to ascertain the exact position of the original photographer. In some cases exact reproduction of the original view was undesirable because of recent obstructions so the taking point was deliberately moved. Selected portions of the early pictures were used in most cases. The goal was the best rendition of the character of the vegetation, not of scenic beauty.

Quantitative data, other than photographs, on the vegetation of the Valley were very limited. Therefore, vegetational sampling was done with currently available techniques. A modified step-point method was used for sampling herbaceous vegetation. Three steps were taken along a compass line and a pin placed at the toe of the front boot. The closest rooted plant in front of the pin was recorded. This method allows comparison of different areas as to species composition and relative density.

The herbaceous vegetation was sampled during August and early September. By that time the spring aspect was past so this segment of the vegetation was inadequately sampled. The tops of early blooming annuals were often dead and broken off, but most of the perennial plants were identifiable. Nomenclature is based on Munz (1959).

The forest stands on the Valley floor were sampled by the quarter method (Cottam and Curtis, 1956). A line of march was selected, 100 feet paced off, and a plot center established by means of a rod placed at the toe of the boot. With the line of march as one axis and a line at right angles to it as another axis, four 90 degree angles, or quarters, were established. The distance from the pin to the nearest tree over 2 inches d.b.h. (diameter breast high or about 4.5 feet)

was measured and recorded by tree species for each quarter. In each stand, 25 points were sampled, giving 100 measured individuals. From the data thus obtained the relative density and relative dominance for each species was calculated.

The age of many trees was determined by growth ring counts on cores taken from standing trees with an increment borer. Also, the age of recently cut stumps was determined.

To provide a measure of the influence of campers on the habitat, soil compaction and the amount of litter inside and outside of campgrounds were measured. Soil compaction was measured with a soil penetrometer which gives the yielding point of the soil to a penetrating surface. The readings of this instrument are used as a relative index only. Litter samples were collected from randomly located square foot quadrats and the weights are on an oven-dry basis.

The vegetational type map is based on recent aerial photographs supplemented with extensive field checking. The area included in the map, and in the study as a whole, extends from Happy Isles and Mirror Lake at the upper, or eastern, end of the Valley to Pohono Bridge at the lower, or western end. The north and south boundaries are the vertical walls of the Valley.

CHRONOLOGY OF EVENTS AFFECTING THE VEGETATION

Chronologies of historical events in Yosemite Valley have been prepared by Russell (1959) and by Paden and Schlichtmann (1955). In them one can find the sequence of the arrival of prominent persons, erection of buildings, changes in administration, and other items.

There has been a series of events, some of minor historical interest, which has affected the vegetation. These events, along with items of major historical interest, are chronicled by 10-year periods to give an overall picture of the sequence and nature of the factors operative upon the vegetation.

The chronology is, of necessity, based largely on subjective deductions. Contemporary writers tended to place in the written record only those items which were of special interest to them. The commonplace was often omitted and descriptions of vegetation usually fell into the commonplace category. Also, the changes in vegetation were subtle and were recorded only when they had reached considerable magnitude. In most cases assumptions must be made as to the causes and dates of the actual changes.

1851 - 1860

Russell (1959) gives credit to the party led by J. M. Walker for first sighting Yosemite Valley in 1833. Paden and Schlichtmann (1955) present a logical argument that Walker did not see the Valley and credit William Penn Abrams with the discovery in 1849. The long-accepted date of discovery, 1851, marks the first recorded entry of white man into the Valley (Bunnell, 1911).

For an indeterminate number of years the Valley had been part of the territory occupied by the Awanichi, a small tribe of Miwok Indians. This tribe was decimated by disease in the late 1700's or early 1800's and survivors left the Valley. The Miwok group which re-entered the Valley at least one generation before the arrival of the white man was

strongly mixed with Paiute Indians physically and culturally (Bennyhoff, 1956). There is considerable evidence that the Indians influenced the character of the vegetation by using fire and hand eradication to suppress the establishment of brush and trees in the Valley (Ernst, 1943a; Reynolds, 1959).

The visit of the Mariposa Battalion in March of 1851 and a company of the same Battalion in May, 1851 had as an objective the "bringing in" of the Miwok Indians inhabiting the Valley. In 1852 a punitive expedition again drove the Indians, who had been allowed to return, from the Valley. The Indians returned to the Valley in 1853 but suffered further depletion. Russell (1959) throws some doubt on Bunnell's (1911) account of the massacre of chief Tenaya and many of his band by Mono Indians in retaliation for horse stealing. Regardless of the means, the tribe was drastically reduced in numbers by 1854 and their culture, as a major influence on the vegetation, largely ended. This disruption of the Indian culture was the first influence of white man on the vegetation. If we credit the Indians with maintaining a static period in the ecological succession of plants in the Valley the period of change began.

The first visits were significant in another respect. By 1855 several accounts of the expeditions to the Valley had appeared in San Francisco newspapers (Russell, 1959). These accounts attracted the attention of James M. Hutchings who, in 1855, organized the first tourist party to visit the Valley. Accompanying Hutchings was Thomas Ayres, an artist, who made the first published sketches of the Valley (Russell, 1959). This early visit by a publisher and an artist is

significant because the Valley received publicity that greatly accelerated its occupation.

Hereafter events moved swiftly. The first trail to the Valley was completed in 1856, only 5 years after the first entry. A remarkable feature of tourism to the Valley is the large number of people who made the long, tedious trip in the early years (Table I). The first permanent structure, the "Lower Hotel" was erected in 1856 near the base of Sentinel Rock. This was followed by a canvas-covered house near the present Sentinel Bridge in 1857 and the "Upper Hotel" at the same site in 1858 (Bunnell, 1911). Owners of these structures catered to the needs of visitors and established focal points of activity which persisted for many years.

The first settler in the Valley, James C. Lamon, arrived in 1859. He located a preemption claim in the upper end of the Valley, built a log cabin, planted an orchard, and cultivated a garden (Hutchings, 1886). This small amount of cultivation probably had less influence on the vegetation than grazing. Early visitors, of course, rode horses and the grazing of these animals became increasingly significant. The Miwok Indians were not horsemen and it is doubtful that grazing has been a major factor in the Valley at any time prior to the white man.

1861 - 1870

During the preceding decade visits to the Valley were confined to the summer months. Mr. Lamon was the first white man to spend the winter in the Valley, staying alone during the winters of 1862-63 and 1863-64. With the arrival of Hutchings and his family in 1864 year-round occupation of the Valley was firmly established (Hutchings, 1886).

Table I. Number of visitors to Yosemite Valley, Compiled from Hutchings (1868) and National Park Service File No. A88.

1855-1864	653	1920	68,906
1864	147	1921	91,513
1865	369	1922	100,506
1866	438	1923	130,046
1867	502	1924	146,070
1868	623	1925	209,166
1869	1,122	1926	274,209
1870	1,735	1927	490,430
1871	2,137	1928	460,619
1872	2,354	1929	461,257
1873	2,530	1930	458,566
1874	2,711	1931	461,855
1875	2,423	1932	498,289
1876	1,917	1933	296,088
1877	1,392	1934	309,431
1878	1,183	1935	372,317
1879	1,385	1936	431,192
1880	1,897	1937	481,492
1881	2,173	1938	443,325
1882	2,525	1939	466,552
1883	2,831	1940	506,781
1884	2,408	1941	594,062
1885	2,590	1942	332,550
1899	4,500	1943	127,643
1902	8,023	1944	119,515
1903	8,376	1945	251,931
1904	9,500	1946	641,767
1905	10,103	1947	775,878
1906	5,414	1948	749,861
1907	7,102	1949	802,572
1908	8,850	1950	830,241
1909	13,182	1951	850,585
1910	13,619	1952	963,536
1911	12,530	1953	969,225
1912	10,884	1954	1,008,031
1913	12,255	1955	984,201
1914	15,154	1956	1,114,173
1915	31,646	1957	1,138,716
1916	33,396	1958	1,139,343
1917	34,510	1959	1,061,471
1918	33,527	1960	1,150,385
1919	58,362	1961	1,227,110

Like Lamon, Hutchings planted an orchard and cultivated a garden. Because of the necessity of providing winter feed for livestock, hay was harvested and fields were plowed to provide grain. Thus the meadow lands were subjected to influences other than grazing. The forests or woodlands were also affected. Early buildings were constructed of logs procured locally and firewood had to be obtained in large quantitites.

The year 1864, only 13 years after first entry by the white man, marked the granting of Yosemite Valley and the Mariposa Big Tree Grove to the State of California as a public trust to preserve and "be held inalienable" for public enjoyment. A survey to establish the boundaries of the grant, which extended back from the cliffs an average distance of one mile, was made in 1864. The commissioners appointed by the Governor to manage the grant met and organized in 1866, when legal acceptance of the grant by the State was completed. (Commissioners' Report, 1874-1875). Reports of this Commission and the Guardians appointed by it are valuable sources of information on what occurred in the Valley during the ensuing years.

Although under the administration of the Commissioners, there was little change in the activities of people in the Valley during the remainder of the decade. With more travelers and permanent residents, grazing, haying and other farming activities increased and the few Indians residing in the Valley probably continued their former custom of burning off the herbaceous vegetation.

1871 - 1880

This decade saw the expansion of facilities catering to tourists.

"The Cosmopolitan," long famous as "the finest saloon in California," was built during the decade. Trails were constructed to points of interest (Russell, 1959). In 1874 two stage roads, the Coulterville and the Big Oak Flat roads, made entry to the Valley.

During the period the claims of settlers in the Valley were under litigation with both Hutchings and Lamon attempting to prove the validity of their claims. The United States Supreme Court eventually ruled against them and in 1875 the Commissioners attained full control of the Valley. Although ownership of the land passed to the state, the practice of granting leases, which had been the policy since the formation of the grant, was continued. Very few land use restrictions were placed on lessees.

The first recorded attempt to control the Merced River appears in the Commissioners' Report for 1879.

> In the way of general improvements the Commissioners, during the past season, have turned the Merced River back into the old channel, above the Sentinel Bridge, by clearing it of obstructions and constructing a dam where it was washing away the bank. This was necessary to prevent it cutting a new course for itself through the low land north of where it now flows. They have also had the rocks blasted above the rapids at the 'Bridal Veil Bridge', so as to lower the stream and relieve it at this point.

Lowering the stream may have lowered the water table in the meadows at the western end of the Valley and resulted in vegetational changes toward drier meadow types.

A statement in the 1880 Commissioners' Report indicates that, after 30 years of use, conditions in the Valley had reached a state which was causing concern.

> 1. Most of the available land is under lease for pasture and garden purposes.
>
> 2. The enclosed fields are being invaded by willows, wild roses, and other growth, to the damage of their value and of the beauty of the Valley.

3. The upper portion of the Valley, which has been set apart for the convenience of campers, is largely overgrown with willows and young pines. The views are obstructed, the pasturage destroyed, and the appearance injured.

4. There is no practicable and unobstructed carriage road around the Valley, near the base of the cliffs. At present all who attempt to make the circuit of the floor of the Valley, must pass through gates and fields, lose some of the finest views, and be subjected to annoyance and loss of time.

1881 - 1890

During the first part of this decade, road building extended access around the edge of the Valley, much as it exists today. Log jams were removed from the river and other channel control measures were accomplished.

Encroachment of trees into the meadows became a matter of increasing comment. The Commissioners' Report for 188 -1888 mentions clearing in front of the Stoneman House and other areas in the upper end of the Valley. The same report contains one of the few accounts of fires in the Valley since the coming of the white man. Commissioner Chapman made the following comments:

> Several times during the period of my labors on your behalf, it required suddenly almost the entire force of twenty or thirty men to divert the all consuming course of forest fires on the floor of the valley. Since the annual practice of the Indians in burning off the dried grasses and leaves has been discontinued, and even forbidden by law, the accumulation of vegetable matter beneath the trees has been practically undisturbed, until a growth of young pines has sprung up all over the valley, and destroyed much fine meadow land. A campfire carelessly left, or a match thrown among the leaves, has caused several fires within the past two or three years that could not be extinguished. They burned until the walls, the roadway, and streams defined and determined their course.

The location in the Valley and the area covered by the fires are not given. Such fires would, of course, have an effect on existing and subsequent vegetation.

In 1881 Wm. Ham. Hall, State Engineer, visited the Valley and his recommendations to the Governor included the following: extension of the grant to control the entire watershed of the Valley; regulation of grazing; clearing of brush and trees; and "perhaps" the plowing and reseeding of meadow lands. He also suggested clearing and irrigation of non-meadow lands to correct the deficiency in forage (Hall, 1882).

The recommendations made by Hall may have influenced land use in the Valley. "Farming" activities had reached such proportions by the latter part of the decade that public opposition to the management of the Valley was aroused. Editorials in "The Century Magazine" and articles by John Muir (Muir, 1890) in the same periodical furnished nation-wide publicity. Articles also appeared in the "San Francisco Examiner" in July and November of 1888 which painted a black picture of Yosemite conditions. Complaints centered around the presence of fences throughout the Valley, the use of meadows for pasturage and hay by operators who charged the public high prices, and the cutting of trees.

The widely publicized mismanagement led to an investigation of the Yosemite Valley situation by the State Senate in 1889. In 1890 a new board of commissioners was appointed and a few corrective measures instigated. The year 1890 also marked the creation of Yosemite National Park which completely surrounded the state controlled grant.

1891 - 1900

Purposeful manipulation of the vegetation was exercised during this decade. The Commissioners' Report for 1891-1892 contains the following statement:

> A considerable area of the floor of the valley was cleared of recent underbrush and disfiguring dead trees, and other obstructions to the view, which have been too long permitted to accumulate.
>
> . . . . . .
>
> The clearing was begun during the year on plots N, L, M, O, and G, the total area of said plots being 395 acres.

The location of the plots is not given but in the Commissioners' Report for 1893-94 a communication from the guardian (Galen Clark) is included which specified that 150 acres were affected by the work.

The Commissioners' Report for 1897-1898 mentions that grazing was regulated. During 1898 the policy was to prevent pasturage until, "meadow grasses were ripe and the flowers well seeded, and further, to prevent over-pasturage at any time." Considerable replacement, realignment, and removal of fences was done. The position of these early fences had a definite effect on the vegetation as they delimited the areas grazed and served as boundaries for clearing operations.

The Commissioners obviously attempted to rectify conditions which raised such a hue and cry during the preceding decade. However, they were hampered by lack of funds and little was accomplished.

1901 - 1910

State administration of the Yosemite Grant ended with the cession of the Valley to the Federal government in 1905. The Commissioners were replaced by the U. S. Army which administered Yosemite National Park for the Department of Interior. The Army moved its headquarters from

Camp A. E. Wood at Wawona to Fort Yosemite, which was located on the present site of Yosemite Lodge. Another important event was the completion of the Yosemite Valley Railroad to El Portal in 1907.

Examination of reports of the military commanders who were the acting superintendents indicates that grazing, mowing, and cultivation continued. There was considerable comment on the necessity of clearing thickets in the Valley, apparently without action. A few fences were removed in 1909 but their locations were not given.

1911 - 1920

The most significant event during this decade was the popularization of the automobile. With the admission of cars to the park in 1913 the number of visitors began to increase sharply with grazing and hay growing operations declining. By 1915 motor stages had replaced horse drawn stages in the Valley (Russell, 1959).

Another highly significant event was the establishment of the National Park Service in 1916. By the end of the decade the policies of this agency were well established. One policy of note with respect to vegetation was the initiation of the vista clearing concept in relation to tree removal (Punchard, 1919).

Before the creation of the Park Service steps to eliminate woody growth were taken again. The Acting Superintendent's Report for 1911 mentions removal of undergrowth and clearing of thickets. In 1914 and 1915 considerable clearing was done in connection with wood cutting (Acting Superintendent's Report, 1914 and 1915). Control of insect infested trees was also started in 1915.

There was still mowing and cultivation of certain meadows in 1913. In the Acting Superintendent's Report an item of $1,000 is listed for the plowing and seeding of fields. Intentional burning of some of the meadows was practiced during the last years of the decade (Ernst, 1943a).

Beginning in 1912 and continuing through 1920, a program to eradicate ground squirrels, mice and gophers was carried out.

1921 - 1930

The last of the dairy herds was removed in 1924 and the widespread grazing of meadows ended. Local areas continued to be grazed for a number of years, particularly the elk paddock which was built in Cook's meadow in 1921 to hold survivors of the once-abundant, but not native to Yosemite Valley, Tule elk. El Capitan and Lamon meadows continued to be used. According to the Superintendent's Monthly Report for April, 1924, fences were removed from Bridalveil Meadow, Leidig Meadow, and from around the field opposite Camp No. 17 (Currently the residence area east of the Village Store).

Removal of the fences opened the meadows to another type of use. Tourists picnicked, camped, and drove over them more or less at will. Ditches were constructed around the meadows to halt this use in 1929 (Superintendent's Monthly Report, June, 1929). Although the ditches reduced the use of the meadows they may have had more far-reaching consequences by affecting drainage.

Wood contractors cut trees for firewood and poles in thinning or vista clearing operations and efforts were made to keep the meadows

open by removing young trees (Superintendent's Monthly Report, March, 1930). Swampy areas in campgrounds were filled. The Superintendent's Monthly Report for December, 1930 lists the following accomplishments for the year: 9 1/2 miles of old roads eliminated; 12 acres of ground plowed, harrowed, and seeded with grass where necessary; 300 plants and shrubs transplanted; 1000 stumps blasted out where adjacent to roads; 200 feet of old paved road torn up.

During 1930 the deer population was reduced by the capture and removal of 93 head to Miguel Meadows.

1931 - 1940

An abundance of labor made available by the ECW, WPA, and CCC programs resulted in unprecedented activity. More ditches were constructed, campgrounds delimited, screening trees planted, dead trees removed, thickets thinned, insect infested trees cut and burned, meadows drained for mosquito control, river and creek channels cleared, ground squirrels eradicated, and deer trapped and removed. According to the Superintendent's Monthly Reports for the period there were few areas in the Valley which did not receive a facelifting of some sort. "Landscaping" activity was largely halted by the flood of December, 1937, as labor was diverted to repair extensive damage to roads, bridges, and buildings.

1941 - 1950

The CCC activities were continued until 1943. One of the last jobs was the removal of young trees from the meadows (Ernst, 1943a).

World War II created a manpower shortage and activities came to a standstill. During the war the Navy maintained a rehabilitation center in the Valley. The Army and Air Force also used the Valley to some extent for recreation and training. Some of the campgrounds were closed for a three year period (Ernst, 1947).

With the end of the war the number of people visiting the Valley increased rapidly each year.

1951 - 1961

Activities affecting vegetation during this period were largely confined to maintenance-type work; thistle control in the meadows, removal of dead and dangerous trees, limited vista clearing, relocation of the Old Village and other structures. The dominant factor has been people. In 1954 the visitors numbered more than 1,000,000 and from 1956 to 1961 these have been many more (Table I).

THE ENVIRONMENT

Matthes (1930) has amply described the formation of Yosemite Valley. Certain aspects of his work are pertinent to a study of vegetation because the origin and nature of the soil materials are given. With the retreat of the last glacier, perhaps 20,000 years ago, and the formation of Ancient Lake Yosemite behind the terminal moraine, the Valley floor began to form through delta extension.

> The present valley floor, . . . , does not represent the original delta plain . . . but is a relatively new plain that lies at a level 14 to 16 feet lower. Probably as the result of a rather sudden breaching of the moraine dam, the Merced River cut down

> its bed and trenched the plain until at length it established a new grade similar to the first. Then, winding sluggishly from side to side, it widened out a new plain at the expense of the old one.
>
> The present valley floor has the characteristic features of what is properly termed a flood plain; low natural levees along the river banks slope gently away from the stream and are breached in places by overflow channels, and in the plain beyond are numerous crescent-shaped sloughs outlining old oxbow bends abandoned by the river when it shifted its course. All these features show that the river has almost ceased to cut and at times of high water builds up the valley somewhat by depositing sediment.

The remnants of the original delta plain mentioned above are found overlooking Tenaya Creek at the head of the Valley, in front of Camp Curry, and north of Cathedral Spires and Cathedral Rocks (Matthes, 1930). These terraces are sandy in texture but, having been influenced by vegetation for a longer period, may have a higher organic matter content than the lower, more recent, delta. The level floor, or lower delta plain, is sandy in nature and in many places is topped by a layer of fine sand left by recent floods.

Between the walls and the level plain lie the talus slopes. These are composed largely of rock waste shed from the cliffs. Most of the rock has accumulated from weathering of the walls but at the foot of El Capitan and the foot of Mirror Lake are large deposits of rock rubble of earthquake origin (Matthes, 1930). On the talus slopes soil has formed by the accumulation of finer materials and organic matter between the larger blocks which still protrude thickly from the soil surface.

In addition to the river-borne deposits and the talus slopes there are outwash fans, mostly of coarse rock waste, produced by torrent action of the streams emptying into the Valley (Matthes, 1930).

These are well developed by Illilouette Creek, Indian Creek, Yosemite Creek, Eagle Creek, Ribbon Creek and Bridalveil Creek. In some cases they extend outward over the level floor nearly to the river. Because deposition is a continuing process in these fans, soils are very poorly developed.

The deposits in the Valley were found to be nearly 2,000 feet thick at the deepest point, near the head of the Valley (Gutenberg, Buwalda, and Sharp, 1956). This deep deposit of granitic sands and gravels does not mean that the soils are all well-drained. The same barriers which impounded the ancient lake retard underflow drainage except where breeched by the river and maintain the water table at the approximate level of the river. This fact may be significant if, through boulder blasting and stream-confinement actions, the cutting power of the river were increased and its level lowered.

The average annual precipitation, based on a 56-year record, is 37 inches. With the exception of occasional summer thunder storms, practically all of the rainfall occurs during the winter months. The average temperature for the warmest month, July, is 72° and for the coldest month, January, 36°. Due to the high rock walls and their orientation along an east-west axis, there is a large difference in the insolation received by the south and north sides of the valley, particularly during the winter months. Reflection from the granite cliffs is greater on the northern side of the valley and this tends to make it drier than the south side.

VEGETATION AT THE TIME OF DISCOVERY

To determine the changes which have occurred in the vegetation of Yosemite Valley during the tenure of white man it is necessary to establish, as accurately as possible, the appearance of the vegetation in 1851. Unfortunately the earliest record contains very meager descriptions of the vegetation. Plants and vegetation were weak rivals for attention compared with cliffs and waterfalls when early descriptions were written -- and this is true today. However, there does appear in various chronicles enough material to supply a broad description of the original vegetative cover. This impression is strongly reinforced by early photographs.

L. H. Bunnell, a member of the Mariposa Battalion which entered the Valley in 1851, wrote of the early history of the Valley but failed to include a description of the vegetation other than that it was "parklike". A brief comment on vegetation by Bunnell was included in the Commissioners' Report for 1889-1890.

> the valley at the time of discovery presented the appearance of a well kept park. . . . There was then little undergrowth in the park-like valley, and a half day's work in lopping off branches along the course enabled us to speed our horses uninterrupted through the groves.

Galen Clark, long a Guardian of the Valley, in a letter to the Commissioners dated August 30, 1894 said in part:

> My first visit to Yosemite was in the summer of 1855. At that time there was no undergrowth of young trees to obstruct clear open views in any part of the valley from one side of the Merced River across to the base of the opposite wall. The area of clear open meadow ground, with abundance of luxuriant native grasses and flowering plants, was at least four times as large as at the present time.

These excerpts are representative of the early descriptions available.

The sketches of Thomas Ayres, the artist who visited the Valley with Hutchings in 1855, also suggest that the existing trees were widely spaced on the floor of the Valley. The species of trees can be deduced from later descriptions but the species and amounts of herbaceous plants cannot be determined accurately.

To obtain a more comprehensive description of early conditions, it is necessary to jump to the 1860's and specifically to 1866. At that time the State Geographical Survey Party under the direction of J. D. Whitney made a detailed geographical and geological survey of the Yosemite Valley region. This survey was published in 1868 as The Yosemite Book, which contains the first detailed descriptions of vegetation. It seems unlikely that extensive changes had occurred during the 15 year period since white man entered the Valley as Indians were still burning the vegetation. Baxley (1865) described his arrival at the Valley in the fall of 1861 as follows:

> A fire-glow in the distance, and then the wavy line of burning grass, gave notice that the Indians were in the valley clearing the ground, the more readily to obtain their winter supply of acorns and wild sweet potatoe /sic/ root -- 'huckhau'. This unwelcome discovery was soon after confirmed by the barking of dogs, that same echoing from the walls of this grand corridor in startling reverberations.

Even though the Indians were no longer at their former numbers they, on occasion, continued the burning credited with maintaining the park-like appearance of the vegetation.

Whitney (1868) included a lengthy description of the vegetation as it existed in 1866, portions of which appear below: Currently used names are shown in brackets.

> Along the banks of the river and over the adjacent rather swampy meadows, we find a somewhat varied vegetation, according to the locality, the narrow portions of the Valley differing considerably from the broader ones. In the former, near the falls, there is a dense growth of alder (Alnus viridis), /A. rhombifolia/ . . .

associated with this are small trees of Rhamnus Menziesii, [? ?] . . . . A few willows [Salix spp.] the Douglas spruce (Abies Douglasii), [Douglas-fir, Pseudotsuga menziesii] and, in the upper part of the Valley, an occasional sugar pine. [Pinus lambertiana] are also found in this position. Where the Valley widens out, and the river banks become lower, so that sloughs and swamps are formed, the Balm of Gilead poplar (Populus balsamifera) [black cottonwood, P. trichocarpa] comes in; this is a common tree in the Valley, . . . with this occur large willows and abundance of the Douglas spruce, and also the Azalea occidentalis, ... The meadows are swampy, with a deep peaty soil; their vegetation consists chiefly of carices or sedges and a few coarse grasses . . . .

The sandy region of the Valley proper forms a connecting strip along the edge of the rocky talus, on both sides of the river. . . . This is peculiarly the arboriferous belt of the Valley, and various portions of its area exhibit different characters of vegetation to correspond with the differences of soil. On the drier and looser portions, the pitch (or yellow) pine (P. ponderosa) and the bastard cedar [incense-cedar] (Libocedrus decurrens) are the most abundant and characteristic trees; both these species occur of considerable size and of fine proportions, the pines being usually from 125 to 150 feet high. Below the Bridal Veil Fall, near the debris, the fir (Picea grandis) [white fir, Abies concolor], a noble tree, comes in; near the swampy land, the black oak (Q. Sonomensis) [Quercus kelloggii] is abundant. The sandy region also bears a great number and variety of shrubs and undergrowth; . . . .

The most characteristic tree of the debris piles is, perhaps, the mountain live-oak [canyon oak] (Q. chrysolepis, Liebm.) . . . .

Portions of the description listing relatively minor species are omitted from the quotation. This description furnishes one basis for describing the vegetational changes that have occurred.

The spectacular scenery attracted early photographers. The first pictures were taken in 1859 by C. L. Weed (Russell, 1959). The same photographer took additional photographs in 1863. Examination of some of these show that between the above dates and 1866 when C. E. Watkins took an extensive series, few changes can be detected. Since the Watkins photographs were more readily available, they have been used to depict the "original" conditions on the Valley floor (Fig. 1A, 2A, and 3A). Whitney's description fits the conditions shown by the

photographs. For example, the "arboriferous belt" is plainly visible in Figures 1A and 2A.

White man had altered conditions to some extent (Fig. 1A). Cultivated areas are evident, as are split rail fences, hay stacks, and buildings. That trees had been cut is an obvious deduction. The effects of grazing are not detectable and were probably not severe. However, the assumption seems reasonable that conditions were not greatly different in 1866 from those existing in 1851.

Whitney (1868) also gives the extent of the vegetational types. "There are, altogether 1,141 acres of land in the Valley proper, of which 745 are meadow, and the remainder, a sandy soil, a little more elevated, partly covered with a sparce growth of forest trees and partly with pertinacious ferns." The plat shown in Figure 4 was evidently the one on which these acreage figures were based as the figures given above and the ones on the map legend are the same. The angular bends of the river indicate that the map in Figure 4 is stylized. A more realistic map, prepared by King and Gardner, members of the same survey party, appears in the back of <u>The Yosemite Book</u> and is reproduced in Figure 5.

Whitney (1868) evidently restricted his definition of meadows and "land in the Valley proper" to low-lying areas which were periodically flooded. Based on planimeter readings from the 1961 U. S. Geol. Survey map of Yosemite Valley the 4,000-feet contour line encloses approximately 2,240 acres from Pohono Bridge to the eastern end of the Valley. The elevation at Pohono Bridge is about 3,880 feet and the elevation of Sentinel Bridge, opposite Yosemite Falls, is 3,960 feet.

From the foregoing evidence the vegetation in 1866 seems to have consisted of extensive wet meadows bordering the river and open forests along the sides of the Valley. Much of the forest area had the characteristics of an open woodland type (Fig. 6).

The tree population in the Valley at the time of white man's arrival was composed of two distinct age groups. One was an old growth stand consisting primarily of black oak and scattered individuals of ponderosa pine, incense-cedar, white fir, and douglas-fir. Counts of growth rings in large stumps indicate the age of this group of trees to be largely in excess of 250 years. Reynolds (1957), besides noting the old growth stands, detected a "stand of intermediate age" consisting of ponderosa pine and incense-cedar. On the basis of increment bore samples, he placed the age of this group of individuals at about 150 years; the date of origin being 1800, plus or minus 10 years. The theory advanced by Reynolds to explain the origin of this intermediate-aged stand was based on the history of the Yosemite tribe as related to Bunnell (1911) by Chief Tenaya. According to Chief Tenaya's account, the Indians fled the Valley when disease, presumably smallpox or measles, decimated the population. The tribe did not return for a number of years. Reynolds speculates that this period when the Valley was empty might well have been about 1800, which would coincide with the origin of the intermediate aged stand. The trees were able to become established because the Indians were not present to carry out their usual practice of burning.

The presence of the intermediate aged stand is significant because it indicates that a successional trend toward a forest cover existed before the white man arrived. One wonders what preceded the old growth

stands. Plant succession only to a black oak stage in 10,000 years since the filling of ancient Lake Yosemite seems highly unlikely. Plant succession probably did not pass through the marsh, bog, and meadow stages because the lake was filled by delta formation which would allow colonization by trees on a well-drained substrata. The hypothesis that woody plants appeared at an early date is supported by Matthes (1930).

> It is probable, . . . , that like the [present] deltas at Merced Lake and Washburn Lake, the delta at the head of Lake Yosemite was largely covered with vegetation. Its more stable portions bore forest trees, and its shore was fringed with willows. That the climatic conditions permitted vegetation thus to establish itself can scarcely be doubted, for there are indications in various parts of the Sierra Nevada that even during glacial time extensive forests of pine and sequoia flourished on its lower slope and well up on the ridges between the canyons.

Evidence of former forests in Yosemite is found in old soil profiles. Matthes (1930) noted the presence of four distinct layers of rock debris in the talus slope crossed by the Big Oak Flat Road at the western end of the Valley. Each layer was separated by, "a thin layer of dark earthy matter of vegetal origin, doubtless ancient soil. Roots and stumps of forest trees were imbedded in these soils." If forests developed on the talus slopes to the extent that soil profiles were formed it is also likely they appeared on the Valley floor. Destruction of these ancient forests could be accounted for by rockslides on the slopes or by fire on both slopes and level ground.

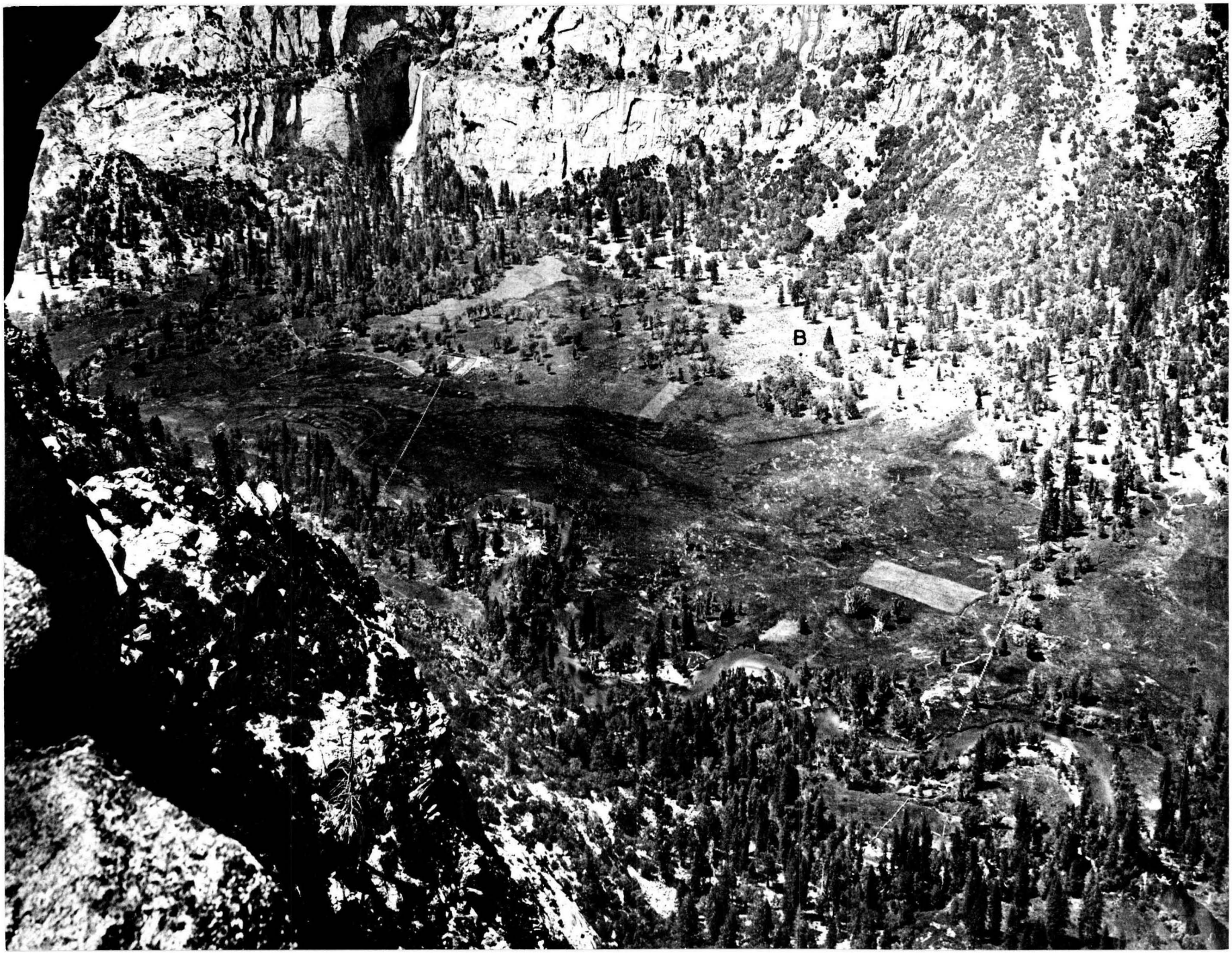
The probable establishment and destruction of past forests suggests that the aboriginals arrived following, or took advantage of, such a destruction and arrested succession toward another forest cover at the stage best suited to their needs. As will be seen in the following pages the arrival of the white man has brought other influences into play.

Figure 1A. The floor of Yosemite Valley as it appeared from Glacier Point in 1866. The Hutchings' home and corral and several split-rail fences may be seen. What appear to be haystacks are also visible. The areas marked A and B are referred to in the text. A portion of a photograph by C. E. Watkins in 1866. Print from N.P.S. copy negative made by R. H. Anderson.

Figure 1B. The floor of Yosemite Valley as it appeared from Glacier Point in 1943. Areas which were formerly meadow or open ground now support stands of ponderosa pine and incense-cedar. A portion of a N.P.S. photograph taken by R. H. Anderson in August, 1943.

Figure 1C. The floor of Yosemite Valley as it appeared from Glacier Point in 1961. The forest cover is essentially the same as in 1943 although alteration of roadways and other construction has caused minor changes. A portion of a photograph by R. P. Gibbens in September, 1961.

IA



1B

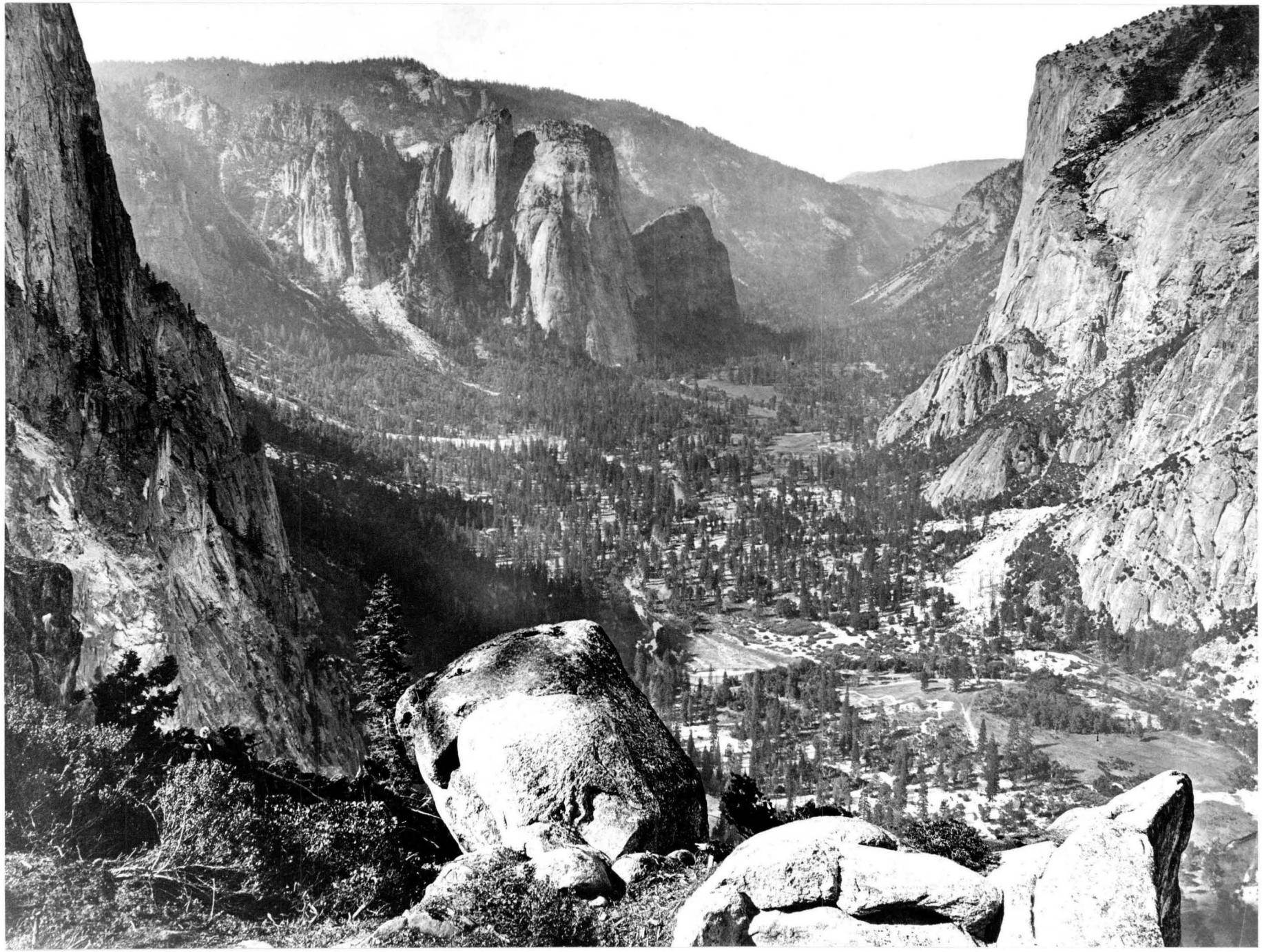
1C

Figure 2A. The lower portion of Yosemite Valley as it appeared from Union Point in 1866. The "arboriferous belt" described by Whitney (1868) is clearly evident at the base of the talus slopes. Photograph taken by C. E. Watkins in 1866. Print from N.P.S. copy negative made by R. H. Anderson.

Figure 2B. The lower portion of Yosemite Valley from Union Point in 1943. The original view was blocked by trees which had grown in the foreground. This vantage point is a short distance to the left of the original one. The old Sewer Farm, a man-made clearing, appears at the top of the foreground tree. The forest has increased remarkably in both extent and density. N.P.S. photograph taken by R. H. Anderson in September, 1943.

Figure 2C. The lower portion of Yosemite Valley from Union Point in 1961. The growth of trees surrounding the old Sewer Farm make it appear smaller and young pine trees have made a remarkable growth within the clearing since 1943. The rock slide appearing at the base of Cathedral Spires (upper left) in 1866 has been nearly obliterated by vegetation. Photograph by R. P. Gibbens in August, 1961.

2A



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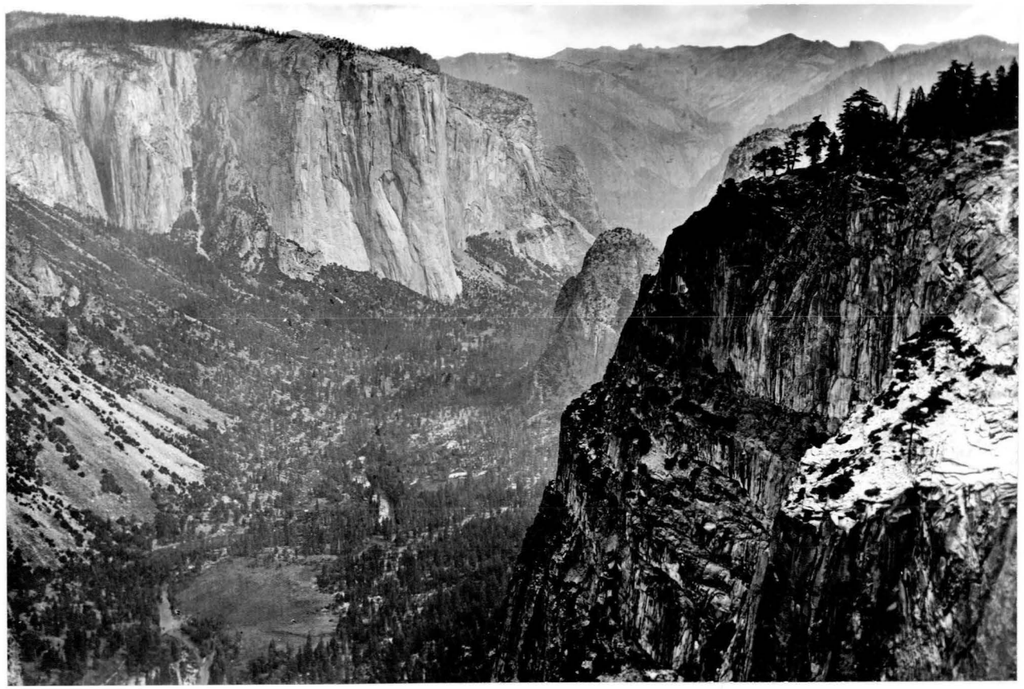


Figure 3A. Lower end of Yosemite Valley as it appeared in 1866 from the point currently called Old Inspiration Point. The large open area in the lower left part of the picture is Bridalveil Meadow. Note the open character of the forest on the north (left) side of the river. Photograph taken by C. E. Watkins in 1866. Print from N.P.S. copy negative made by R. H. Anderson.

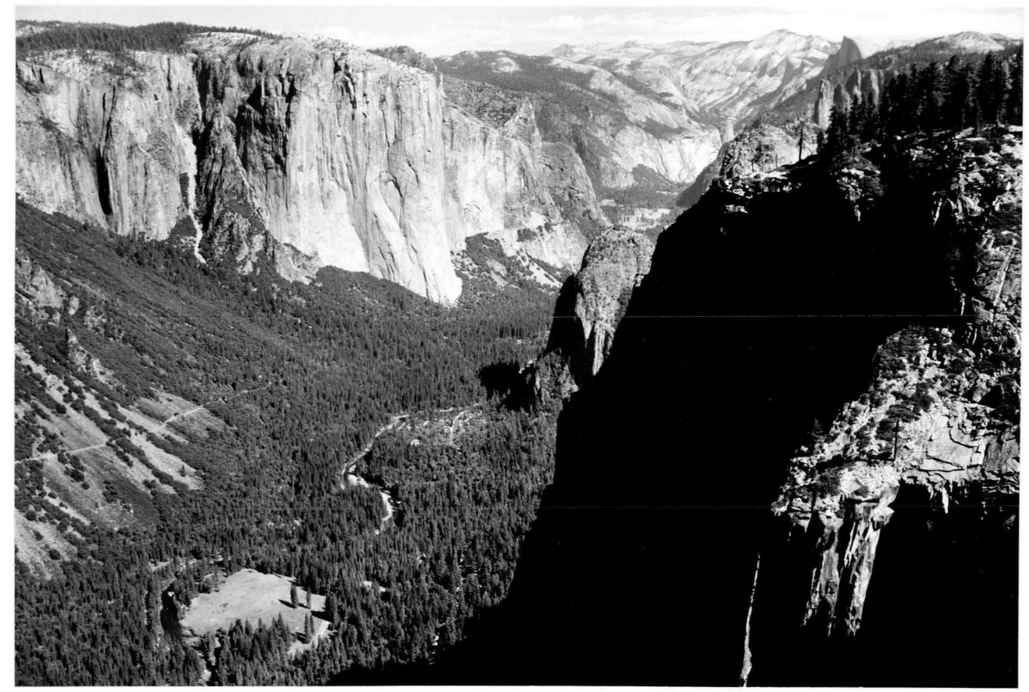


Figure 3B. View of the lower end of Yosemite Valley from Old Inspiration Point in 1961. Bridalveil Meadow has decreased in size and formerly open forest is very dense. The Old Big Oak Flat road can be seen on the talus slope north of the river. There has been considerable increase in cover on the talus slopes. Photograph by R. P. Gibbens, October, 1961.

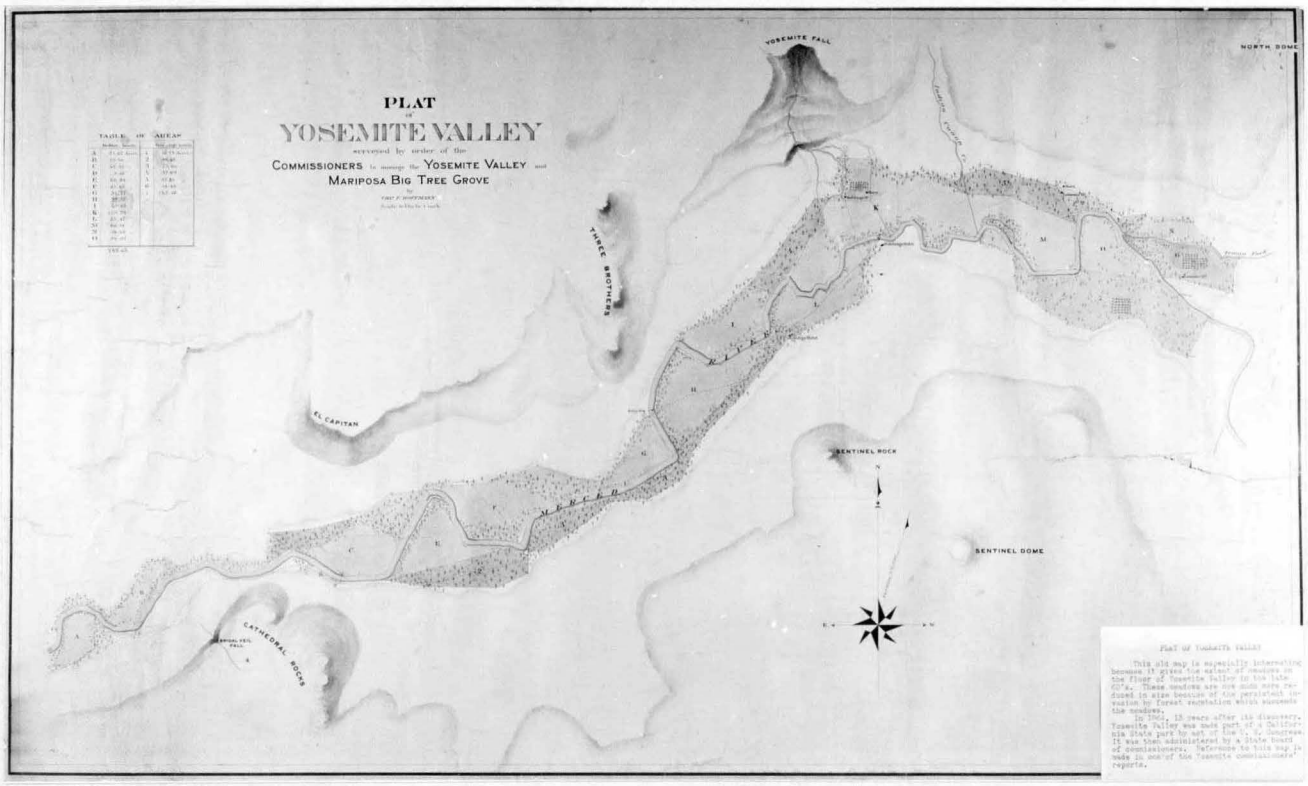
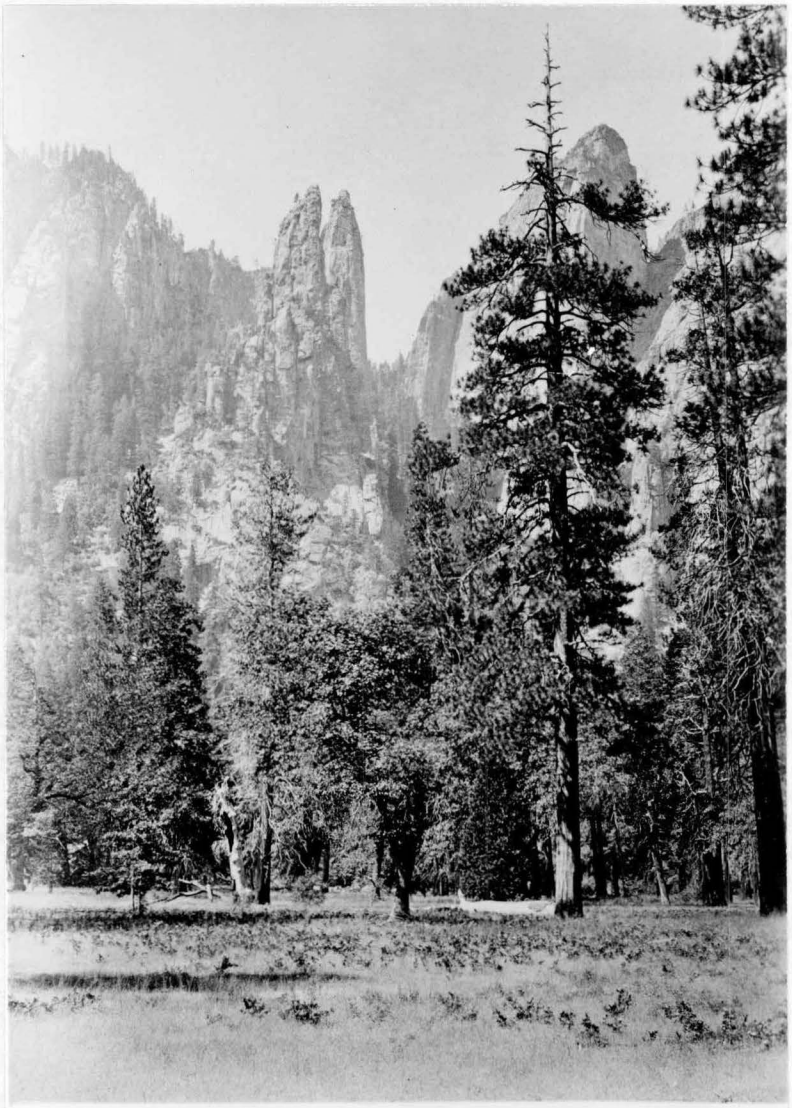


Figure 4. Plat of Yosemite Valley made by Chas. F. Hoffmann, a member of the State Geological Survey party, in 1866 or 1867. According to the Table there were 745.63 acres of meadow land and 395.93 acres of "fern and high lands" on the Valley floor.

Figure 5. Map of the Yosemite Valley region made by C. King and J. T. Gardner, members of the State Geological Survey party, in 1865. This map appears in Whitney's <u>The Yosemite Book</u>. The meadow and forest areas are sketched in and configuration on this map is more realistic than on the plat in Figure 4.



THE CATHEDRAL SPIRES.

Figure 6. A view of the forest or woodland type as it appeared in 1866. This is probably representative of the forest and fern lands described by Whitney (1868). Photograph taken for Whitney by C. E. Watkins in 1866 and used as an illustration in The Yosemite Book. Print from N.P.S. copy negative made by R. H. Anderson.

CHANGES IN THE FOREST

The photographs taken in 1943 and 1961 of the same areas covered by the 1866 photographs show a striking change in the forest cover of the Valley (Figs. 1, 2, 3). The numbers and sizes of conifers, primarily ponderosa pine and incense-cedar, have increased. Former meadow areas and other open ground have been occupied by trees. Areas formerly covered by scattered trees now support a nearly solid stand.

Beginning of Increase in Forest Cover

The 1866 photographs do not show young trees, but those under four or five years of age would probably not be visible. This is evidence that widespread establishment of trees took place after 1860.

The age of the trees is positive evidence of their date of establishment so increment borings were made of trees at various points throughout the Valley. A full range of diameters was included in the samples. Whenever the stump of a recently-cut tree was encountered its rings were counted. The number of years necessary for the tree to reach the height (usually 4.5 feet) at which the ring count was made was estimated and added to the number of growth rings counted.

The age of the oldest trees on former open areas is about 90 years (Fig. 7). Emil Ernst, park forester for many years, stated that he had made hundreds of ring counts on trees removed for insect control, construction, and other reasons (Ernst, 1943a). With the exception of trees obviously very old, he found very few in excess of 70 years. Reynolds (1959) placed the age of most of the trees in the Valley as post-white man. From this evidence the oldest of the trees in the young forest which predominates in the Valley today must have appeared about 1870.

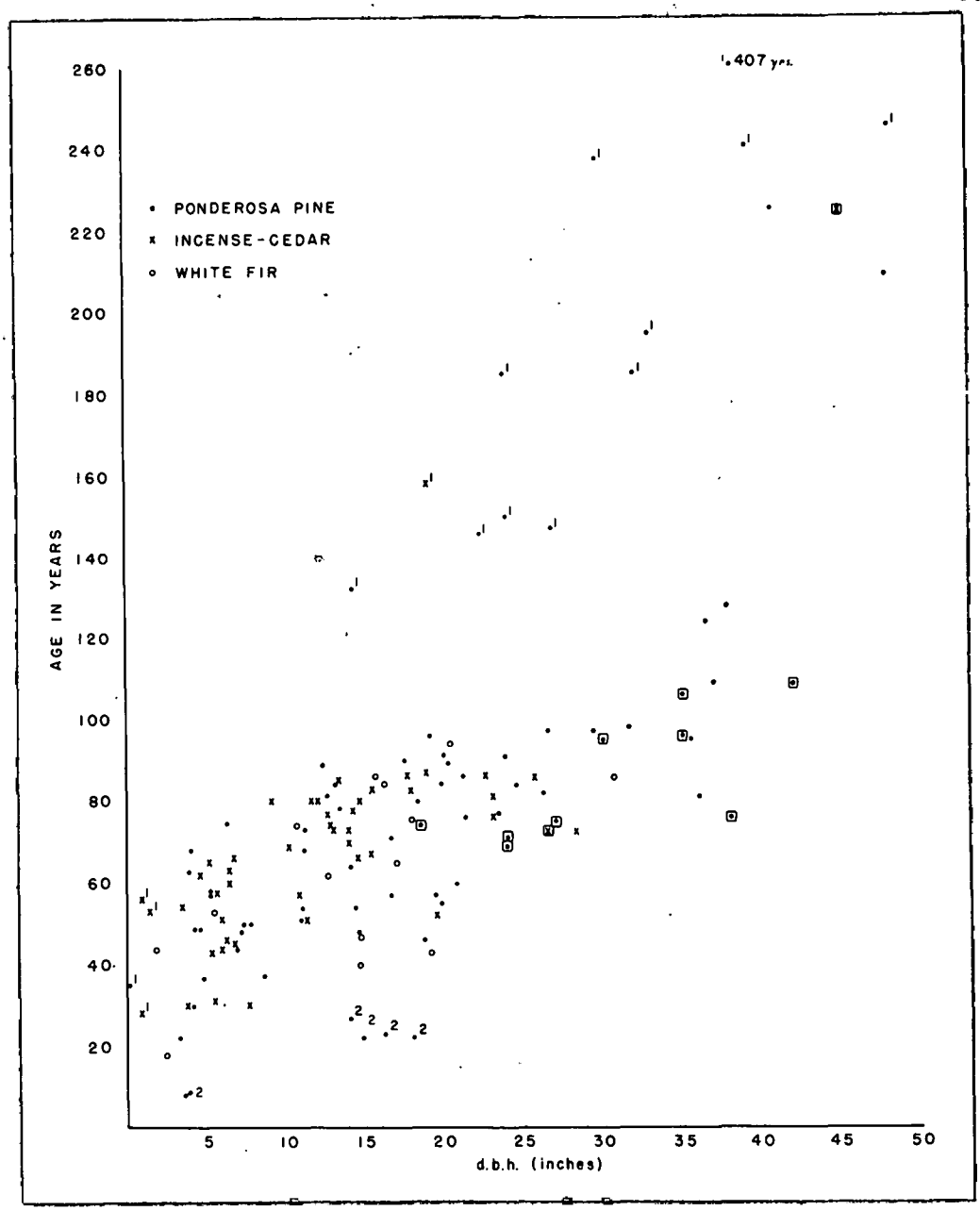


Figure 7. Total age of trees as estimated from increment cores. The range of d.b.h. classes was sampled at several sites on the Valley floor. Symbols enclosed in a square represent stumps whose diameter is larger than the d.b.h. The diameter of the trees is closely correlated with age but this correlation is influenced by the site. For example, the trees marked with a "1" are from dry sites at the base of the talus slopes and are much older than trees of comparable diameters from the level portions of the Valley floor. Trees on very favorable sites, such as the old Sewer Farm (2) have a large d.b.h. in relation to their age. Understory trees, many of which are less than 10 inches d.b.h., are quite old. Since most of the samples were taken from trees on former meadow areas the invasion of trees appears to have started approximately 90 years ago.

Historical reports substantiate this evidence. J. M. Hutchings, in the Guardian's Report for 1880, makes the following statement:

> A dense growth of underbrush, almost from one end of the Valley to the other, not only offends the eye and shuts out its magnificant views but monopolizes and appropriates its best land, to the exclusion of valuable forage plants and wild flowers.

A statement in the Commissioners' Report of 1882 indicates the "underbrush" contained large numbers of small trees.

> In our brief report of 1880, we called attention to the rapidly increasing breadth of underbrush and second growth pines, and need not restate our convictions with respect to the importance of counterworking this spreading infestment. While the Indians held possession, the annual fires kept the whole floor of the valley free from underbrush, leaving only the majestic oaks and pines to adorn the most beautiful of parks.

The above statements confirm that the spread of trees took place between 1866 and 1880. Although 1880 is ten years after the date established by the tree ring counts, the time lag necessary for the trees and shrubs to attain sufficient stature and density to attract attention is about what one would expect.

Extent of Increase in Forest Cover

Photographs furnish evidence of the widespread invasion of trees and their rapid growth. A photograph taken from Eagle Peak and dated 1870, but believed to be of a later date because of structures visible, shows the upper portion of the Valley (Fig. 8A). Young trees and shrubs in former meadows and open areas are clearly visible, particularly around the site now occupied by the Yosemite Lodge. A remarkably clear photograph taken in 1899 shows the extent and growth of trees approximately 30 years after the invasion started (Fig. 9A). Small trees dot areas which were meadows in 1866 (Fig. 1A).

The photographs show that the establishment of trees occurred throughout the Valley; on talus slopes, sandy delta remnants, dry meadows, and wet meadows. Although Ernest (1961) states that the area of wet meadow has remained about the same, evidence from the photographs indicates that very wet sites were invaded at an early date. Whitney (1868) refers to the meadows as "swampy". The dark color in area A on Figure 1A suggests wet meadow. The building of a board walk across this meadow (Hutchings, 1868) is a further indication that inundation by overflow was common and swampy conditions prevailed during at least part of the year. Trees became established on this wet meadow (Fig. 8A, 9A).

Another example of invasion of a wet habitat is Black Spring, shown in Figure 10. This area was an open spring-fed drainageway in 1866. J. M. Hutchings, in the Guardian's Report for 1882, described road building activities across the Black Spring area as follows:

> From the Phono Bridge we followed up our work on the northern side of the Valley to Black Springs. This is a wet and swampy place, which required ditching on both sides for nearly two hundred feet, and three rock-covered culverts for drainage.

The road may have altered the drainage and created drier conditions but the age of the trees now growing in the area shows that some of them became established before the road was built. Since this spot was a favorite for early photographers, beginning in 1863, many pictures are available. In the 1870's and 1880's young trees were well established, even in the center of the drainageway where the ground was the wettest. Other examples of forest encroachment on what must have been wet sites are found throughout the Valley.

Dry habitats in the Valley were also readily invaded by trees. In Figure 1A area B shows a bare, sandy site which is now covered by a

stand of ponderosa pine and incense-cedar. The increase in the number of trees along the base of the talus slopes is clearly evident in Figure 2. The increase in density was not confined to the Valley floor. Canyon oak has increased in number and size on the talus slopes (Figs. 1, 2, 3).

Ponderosa pine and incense-cedar were the primary, but not the only, woody plants which increased on the Valley floor. Post-white man stands of white fir are found in certain areas. Willows and wild roses (Rosa spp.) are listed as invaders of open fields in the Commissioners' Report for 1880. Galen Clark (1894) noted that willows and cottonwoods of four or five years growth were becoming so thick on the meadows that little clear ground was left. Only a few of these plants, evidently once abundant, have survived.

Growth of the trees which became established in the 1870's and 1880's was very rapid (Fig. 9). Growth rings up to 3/8 of an inch in width were found at the center of these trees. Ernst (1943A) says that his early interest in ring counts was aroused by the very wide growth rings. The rapid growth is also indicated by the large diameters attained (Fig. 7). Although the diameter of the trees is closely correlated with age, the site has considerable influence. Trees growing at the base of the talus slopes have a smaller d.b.h. than trees of comparable age on the level floor of the Valley (Fig. 7).

The increase in density of the ponderosa pines and incense-cedars and their rapid growth has completely changed the appearance of the forests in the Valley. Many areas which were formerly a black oak woodland are now dominated by conifers (Fig. 11). Some of the black oaks are still present but they are overtopped and no longer dominate.

The increase in density has been a continuing process outside the campground areas. Dense understory stands of young incense-cedars occur in many parts of the Valley floor (Fig. 12). Young ponderosa pines are also abundant and are often very dense on dry sites near the base of the talus slopes (Fig. 13). The growth of this understory reproduction is slow as can be seen by the ages of trees with a small d.b.h. in Fig. 7. Outside the campgrounds there is often a continuum of tree ages and sizes in the stands, extending from seedlings to the pre-white man elements. Recent tree establishment has not been confined to the forest stands. Young trees are found on the meadows (Fig. 14) and other open areas (Fig. 15).

The 1943 and 1961 photographs of the same areas in Figures 1, 2, 3, 8, and 9 show that there have been no extensive changes in the forests during the past 20 years. Some trees have been removed for construction, vista clearing or other purposes. A few areas have been invaded by trees. The size of individuals has increased and changes have occurred in the understory.

Causes of Increase in Forest Cover

The portion of the 1882 Commissioners' Report previously quoted contains the most common contemporary explanation of the cause of the invasion of woody plants--ceasing of burning by the Indians. This was undoubtedly a contributing factor but perhaps not the only cause. Another hypothesis was postulated by Wm. Ham. Hall, the State Engineer who visited the Valley in 1881 (Hall, 1882).

> The use of the valley itself by the constant travel and the grazing of animals upon it, is beginning to tell upon the character and extent of its vegetable productions. The finer forage grasses are being thinned out; the coarser and more robust or hardy grasses and weeds, able to withstand the trampling and cropping, are taking their places; and the area of meadow is decreasing, while young thickets of forest or shrub growth are springing up instead. . . . The cause is alleged to be the abolition of the old practice of burning off the thickets, which practice formerly made new clearings almost every year for grass growth. Doubtless this clearing had its effect in this way, but another cause, and perhaps a more potent one, is to be found in the continued cropping of the grass and trampling of the ground by horses. The finer grasses are cropped off, pulled up, trampled under foot into soft meadow ground, while coarser growths are avoided by browsing animals and permitted to flourish. The soil and the subsoil of the meadows is becoming compacted, and percolation of waters therein is arrested, so that they dry out earlier each year; the change in character of their forage vegetation results, and the thicket growths encroach upon their borders.

Hall was not the only person to note the impact of grazing on the vegetation during this period. The Commissioners' Report for 1885-1886 states in part:

> During the season now closing--with its list of visitors largely in excess of former years--the utmost resources of the valley were drawn upon and exhausted for pasturage. Any increase of demand must be met by a timely increase of meadow land area, and the Commission has no choice but to appeal to the State on this behalf. The truth is that, under the strain of over-pasturage, the best meadow lands are being injured, while all of them show narrowing lines from the encroachment of brambles and thickets of young pines, willows, and cottonwoods, and some of them are so entirely overgrown as to have passed out of a pasturage classification into that of woodland.

It seems safe to assume that overgrazing, although not inciting comment until the 1880's, was a factor in 1870 when the spread of trees began. The year 1869 saw a doubling in the number of visitors to the Valley (Table I). Such an increase means that the meadows in the Valley, already grazed by the livestock of residents, were subjected to grazing by a large number of additional animals. The 1870 date marks only the approximate beginning of the wide-spread increase in trees. Many became established in the late 1870's and early 1880's when grazing was very severe.

Hall (1882) made an analysis of the grazing factors which contributed to the spread of trees that still stands as an accurate one. Heavy grazing allows seedlings to become established by reducing the competition of grasses, sedges, and herbaceous plants. The trampling creates drier conditions by compacting the soil and, in very wet areas, by forming a rough, ridged surface which increases evaporation and drying. Exposure of mineral soil provides an excellent seedbed. With conditions favoring seedling establishment, the absence of fire allows the trees and shrubs to develop. Even if occasional fires do occur their effectiveness as a killing agent is greatly lessened because herbaceous fuel is scarce.

The sudden and widespread appearance of trees was perhaps partly due to the production of the first big seed crop for several years. An abundant seed crop followed by a series of seasons favorable for seedling establishment and growth may be one of the reasons the tree invasion occurred when it did.

There is no evidence that the early spread of trees in the meadows was facilitated by a lowering of the water table which created drier, more favorable conditions for tree growth. The blasting of the rocks in the river channel at Bridalveil in 1879 was the first recorded event which might have caused an appreciable lowering of the water table (Commissioners' Report, 1879). This was 10 years after the start of tree invasion. Ernst (1961) has suggested the possibility of a lowering of the water table by natural processes coincident with white man's arrival. Such a possibility exists but it cannot be substantiated. Evidence already presented indicates that tree invasion was not prevented

in wet habitats. In addition, willows and cottonwoods, adapted to very wet conditions, were not abundant when the white man arrived. They increased after his arrival.

The fact that the Indians had to use cultural practices to maintain the open woodlands and the presence of the intermediate aged stand of trees which developed when the Indians were absent about 1800 are indicators that plant succession was toward a forest cover prior to white man's arrival. The succession is direct from meadow to forest, as shrub stages, although they may occur, are not essential. The moisture regime of the habitat appears to have little influence as only marshes appear to be too wet for the establishment of a coniferous cover and no soil habitat is too dry.

Since trees have become established in meadow areas after grazing ceased (Fig. 14) one can only conclude that fire was the major factor in suppressing them before the arrival of the white man. Heavy grazing, which coincided with the first widespread establishment of trees, was more an accelerating than an initiating factor. The drying influence of the trees and the possible lowering of the water table did not influence the early spread because they became operative at a later date.

Effect of White Man on Forest Cover

The pre-white man forests and woodlands must have been thinned during the early days of settlement. Both cabin logs and firewood were, of necessity, obtained from the immediate vicinity. With the creation of the Yosemite Grant it was unlawful to "cut down or carry off any wood, underwood, tree, or timber, or girdle or otherwise injure any tree or timber, . . ." without permission of the Commissioners

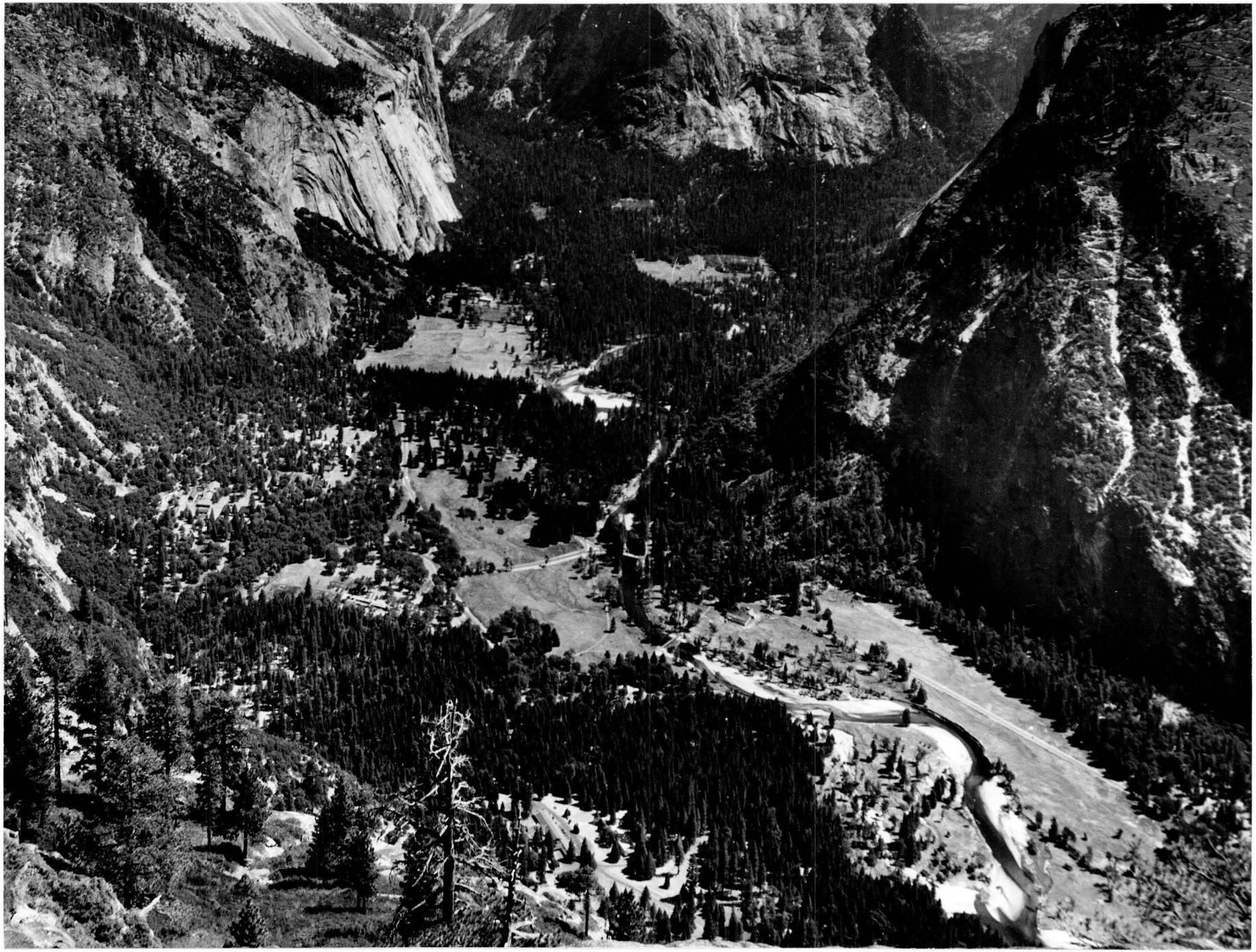
Figure 8A. View of Yosemite Valley from Eagle Peak, probably in the late 1870's. The Cosmopolitan Walk (constructed in 1870 - the straight white line in lower right), the Four Mile Trail to Glacier Point (1871), and the Sentinel Hotel (1876) can be seen in the picture. Note the open nature of the present site of the Yosemite Lodge, occupied at this time by Black's barn and corral. Young trees or brush are visible in many of the meadow areas. Black oak predominates in the upper end of the Valley. Detail of a picture by an unknown photographer. Print from N.P.S. copy negative made by R. H. Anderson.

Figure 8B. Yosemite Valley as it appeared from Eagle Peak in 1943. Many of the areas which were open ground are covered with a dense stand of trees. Detail of N.P.S. photograph taken by R. H. Anderson in September, 1943.

Figure 8C. Yosemite Valley from Eagle Peak in 1961. Numerous changes in roads and building locations have occurred since 1943. Some of the trees formerly present on the Ahwahnee Meadow have been removed. Photograph taken by R. P. Gibbens in September, 1961.

8A

8B



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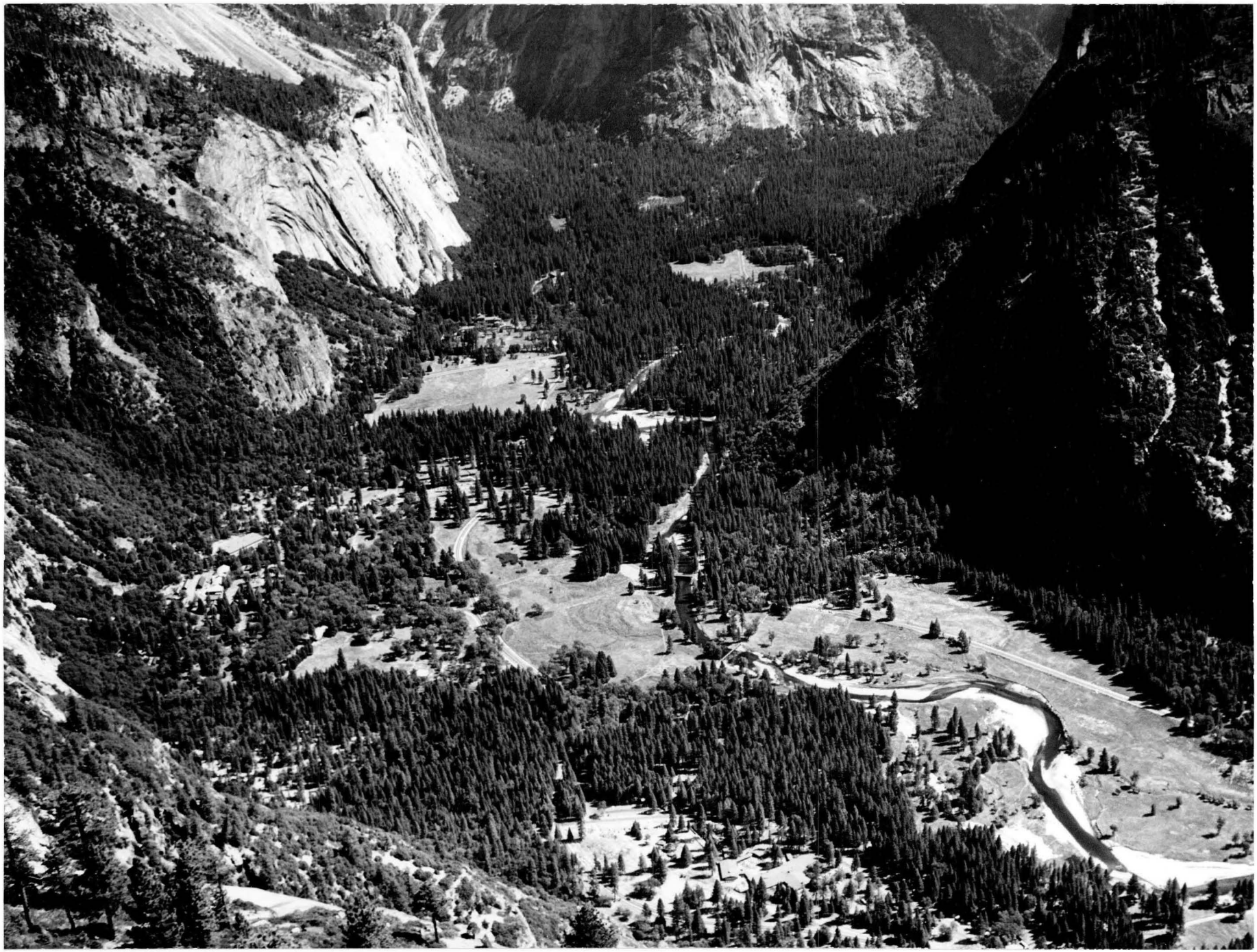


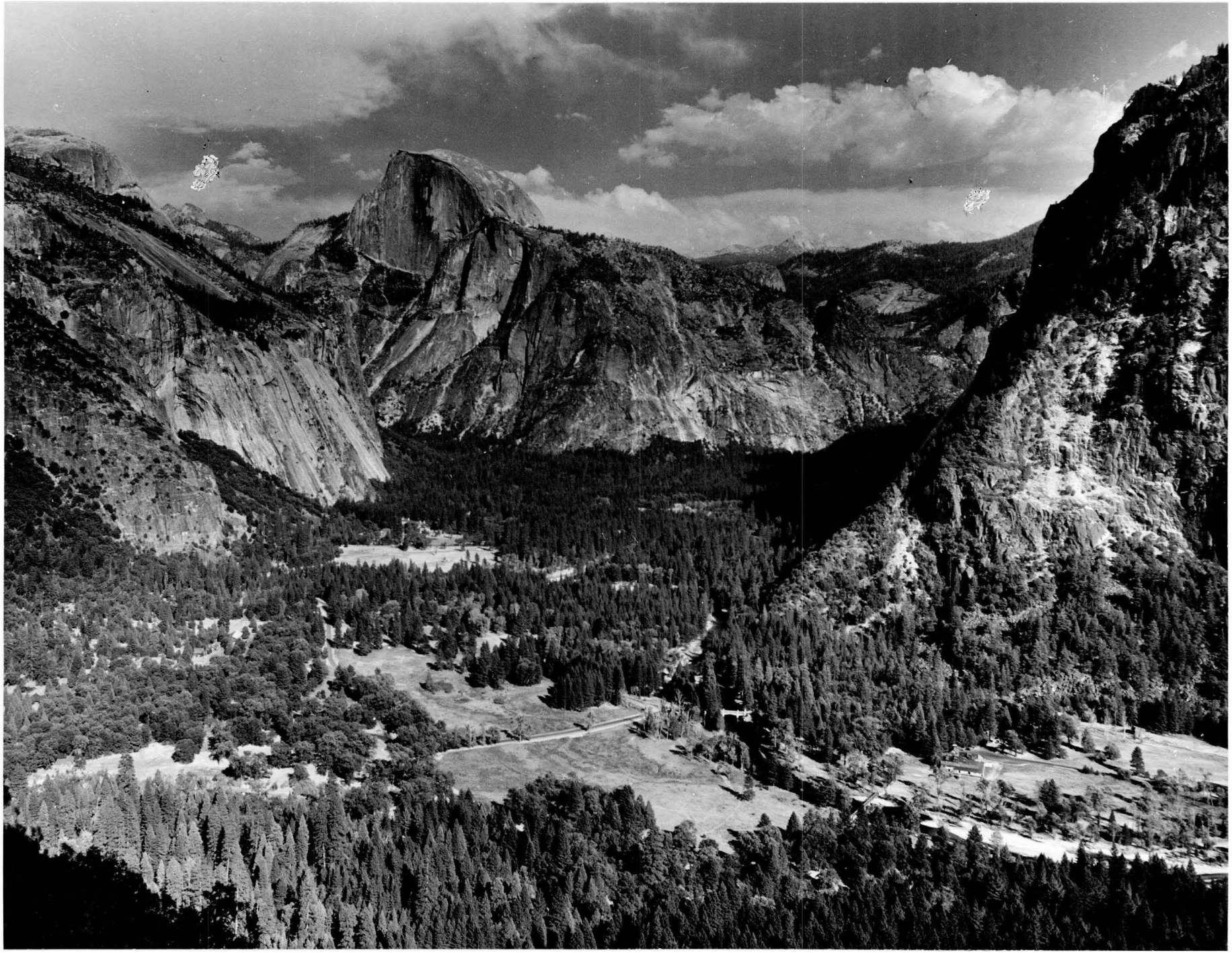
Figure 9A. A remarkably clear photograph taken from Columbia Point in 1899. Young trees dotting the meadows are clearly visible as are fences enclosing portions of the meadows. The pre-white man conifers are plainly visible above the stands of black oak and young trees. Photograph by H. G. Peabody. Print from N.P.S. copy negative made by R. H. Anderson.

Figure 9B. The upper end of Yosemite Valley as it appeared from Columbia Point in 1943. Note the complete change in the character of the forest, from open oak stands to a dense ponderosa pine - incense-cedar type in the upper end of the Valley. N.P.S. photograph taken by R. H. Anderson in September, 1943.

Figure 9C. The view from Columbia Point in 1961. The size of the oak trees around Yosemite Village have increased considerably since 1899. Growth of trees since 1943 is also evident. Photograph taken by R. P. Gibbens in September, 1961.

9 A

9B



9C

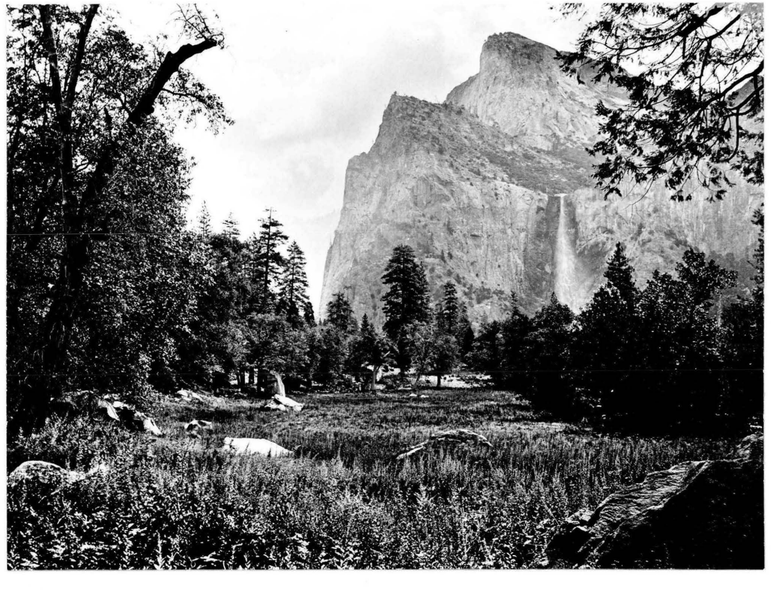


Figure 10A. The Black Spring area as it appeared in a photograph taken by C. E. Watkins in 1866. Original print copied by R. P. Gibbens.

Figure 10B. The same view as in Figure 10A as it appeared in 1943. A small rock has rolled against the larger one since the 1866 photograph was taken. N.P.S. photograph taken by R. H. Anderson in November, 1943.

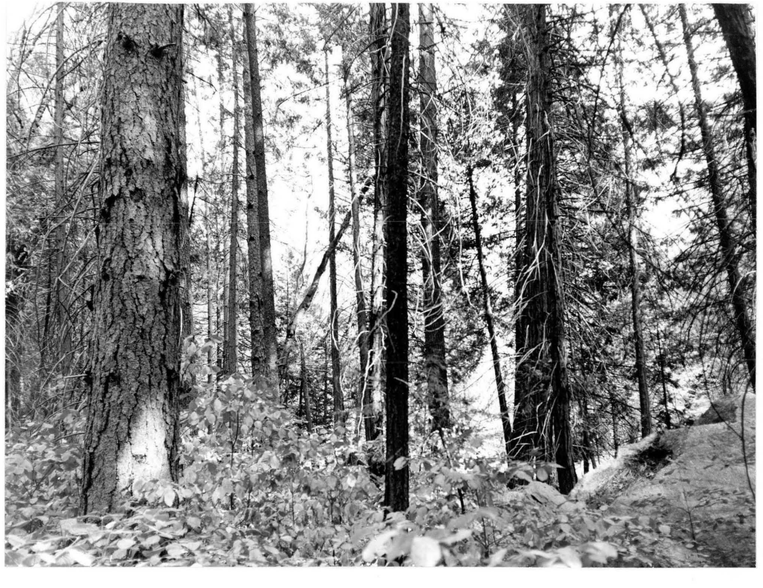


Figure 10C. Same view as preceding photographs in 1961. The tree in the left foreground is about 73 years old. The small incense-cedars in the center of the picture are 65 to 70 years of age. Flowering dogwood (Cornus nuttallii) has become established since 1943. Photograph taken by H. F. Heady in October, 1961.

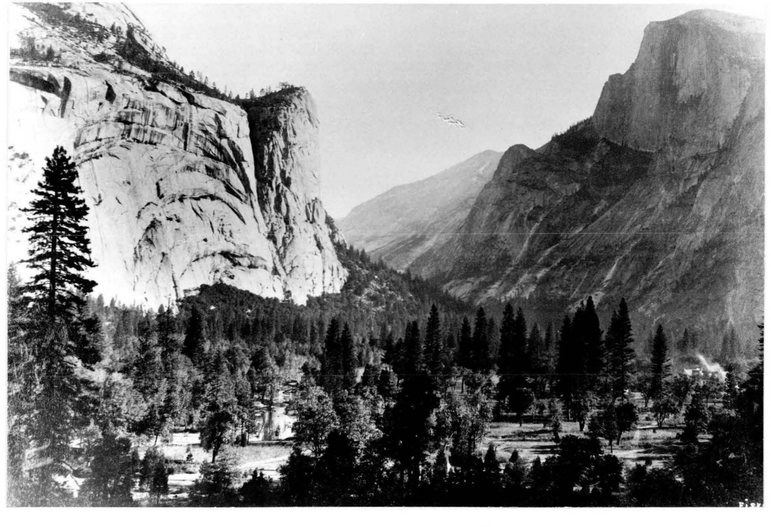


Figure 11A. The eastern end of Yosemite Valley as it appeared when the Stoneman House, visible on the right, existed - between 1887 and 1896. Young conifers are visible among the black oaks which predominated. Photograph taken by George Fiske. Exact date unknown. Print from N.P.S. copy negative made by R. H. Anderson.

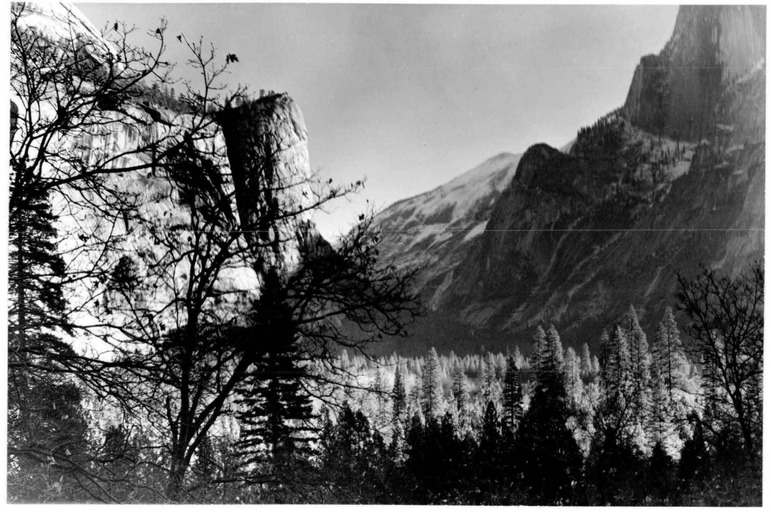


Figure 11B. The same view shown in Figure 11A as it appeared in 1943. The black oaks have been overtopped by post-white man ponderosa pine and incense-cedar. Foreground trees are beginning to block the view. N.P.S. photograph taken by R. H. Anderson in November, 1943.

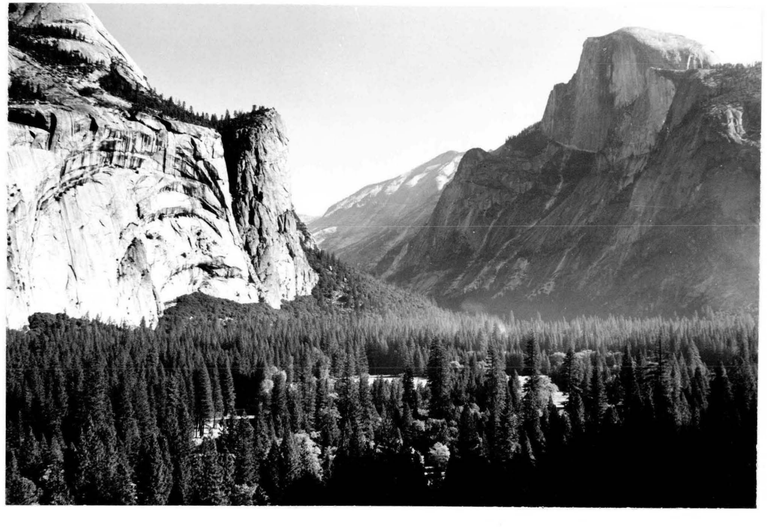


Figure 11C. View of the same area covered by Figures 11A and B but taken from a ledge above the original point to avoid the screening trees. Only a few of the black oaks are visible, the rest have been overtopped and obscured by the rapidly growing conifers. Photograph taken by R. P. Gibbens in October, 1961.

Figure 12. A dense understory of incense-cedar such as the one shown above is often found in forested areas in the Valley. The trees grow very slowly and may take over 20 years to reach a height of six feet. Photograph taken by R. P. Gibbens in January, 1962.

Figure 13. Young ponderosa pines which often occur in great abundance in small openings in the forests on the dry sites at the foot of the talus slopes. A "young" oak tree probably 40 to 50 years old is also shown. Photograph taken by R. P. Gibbens in September, 1961.

Figure 14. Young ponderosa pine, 4 to 6 years old, growing in Stoneman Meadow. This is an example of the invasion of meadow areas which has been going on for many years. The young trees are well removed from the surrounding trees. Photograph by R. P. Gibbens taken in October, 1961.

Figure 15. Dense stand of young ponderosa pines growing along the edge of a torrent channel between Cathedral Rocks and Sentinel Rock. Establishment of trees in open areas such as this has led to the dense stands now found in the Valley. Photograph taken by R. P. Gibbens in September, 1961.

(Commissioners' Report, 1877). This rule was not rigorously enforced and in any case permission was easy to obtain if logs were needed for building or firewood.

John Muir, among others, operated a sawmill for J. M. Hutchings about 1870 (Bade, 1923). Most of the logs were obtained from a large windfall and it is doubtful if large quantities of standing timber were cut. Cutting of mature trees did take place. In the Guardian's Report for 1880, J. M. Hutchings stated: "Growing trees, of great size and beauty, have been felled, contrary to law and the order of your honorable Board." Evidently no action was taken and the cutting of trees continued. An article in the San Francisco Examiner (Hutchings, 1888) brought the "timber slaughter" to public attention. According to the article a three acre grove of cottonwoods, a number of large oaks, and assorted other "noble" trees had fallen to the axe in 1887. Further evidence of tree cutting, primarily around the Stoneman House, was contained in an article in the San Francisco Examiner for November 29, 1888. These cutting operations were concentrated in the upper part of the Valley and probably significantly reduced the number of pre-white man trees.

The spread of trees and shrubs after 1870 was influenced by the activities of white man. Areas which were plowed or mowed were kept free of young trees. The loss of valuable grazing land led to clearing efforts. Galen Clark (1894) said that during the seasons of 1891 and 1892, men were employed to thin some of the thickets of young pines and cedars and clean up combustible material. About 150 acres were partially reclaimed. More clearing was done during 1897 or 1898

(Commissioners' Report, 1897-1898). Practically every annual report during the early years of the Army administration mentions the need for clearing in the Valley but little seems to have been done until 1911. "Gradual progress is being made in removing the undergrowth and clearing the thickets that have spread so extensively over Yosemite Valley" (Acting Superintendent's Report, 1911).

The 1914 Report of the Acting Superintendent stated in part:

> The clearing of thickets is a very important part of the work on the floor of the valley and becomes necessary to safeguard the growing trees both from fires and natural destruction of its own, caused by rapid and dense growth.
>
> There were approximately 150 acres cleared this season on the floor of the valley, and the work continues in connection with wood-cutting, . . .

In 1915, 1,500 cords of wood were cut in connection with clearing operations (Superintendent's Report, 1915). The objective of the clearing and thinning operations was set for the National Park Service in 1919. The report of the landscape engineer (Punchard, 1919) appointed by Stephen T. Mather to study landscaping problems in the National Parks, stated as follows:

> Generally it was concluded that the present growth was greatly in need of attention and that thinning on the floor of the valley should be undertaken for two reasons - first, to preserve the health of the larger trees and as a protection against serious fires, and, second, that thinning and clearing of the meadows would tend to open up and develop very interesting open spaces and vistas on the valley floor. It is not the intention to do this work in a drastic manner and reclaim the floor of the valley entirely and thus reproduce the conditions which existed at the time of the Indians, but to confine the work to such lines as will make the woodlands safer from the standpoint of fires and also produce a pleasing landscape effect.

The vista clearing concept, although perhaps first called such, was not new to the Valley. J. M. Hutchings had cut a lane through the trees so his guests would have a clear view of Yosemite Falls (Paden and Schlichtmann, 1955).

During the 1920's wood and pole cutting was used as a means of opening vistas and thinning stands in campground areas (Superintendent's Monthly Reports, 1924 to 1930). An indeterminate number of trees were cut but the 1,000 stumps blasted along the roads in 1930 indicates that large numbers were removed (Superintendent's Monthly Report, December 1930). The thinning of trees and cleanup of dead brush and timber reached a peak during the CCC days. Most of the Valley floor was affected. Such activities have been continued to a lesser degree to the present day. In addition to vista clearing, snags and unsound trees, such as black oak trees which characteristically decay in the center, are pruned or removed for public protection. With the exception of small areas such activities have had little effect on the extent of the forest. The constant thinning has influenced the composition of the stands, particularly in the campground areas.

During the period from about 1914 to 1924 at least some of the meadows were intentionally burned (Ernst, 1943A). This would have killed many small trees and brush plants. In 1930, 9,170 small pines were cut from El Capitan meadow (Superintendent's Monthly Report, March, 1930). "During 1943, 2,758 small trees were removed from El Capitan meadow and 1,938 trees from other meadows, including the Leidig, Cook, Ahwahnee, and Stoneman meadows" (Ernst, 1943A). It is quite likely that other trees were removed during the early days of CCC activities. A photographic record for the 1943 clearing activities (Figs. 16A, 16B) shows the open woodland in El Capitan meadow before and after the clearing operations. This clearing did not end the problem of tree invasion because they were present again in 1961 (Fig. 16C).

Figure 16A. A view of the woodland in El Capitan meadow in 1943. Young ponderosa pines are abundant. N.P.S. photograph taken by R. H. Anderson in November, 1943.

Figure 16B. View of El Capitan meadow after the pine seedlings were removed by CCC personnel. N.P.S. photograph taken by R. H. Anderson in October, 1944.

Figure 16C. View of the same area shown in Figures 16A and 16B as it appeared in 1961. Young ponderosa pines are once again present in large numbers. Photograph taken by R. P. Gibbens in September, 1961.

Not all of white man's activities have resulted in the removal of trees. The first settlers, J. C. Lamon and J. M. Hutchings, planted orchards. Through the years a large number of trees and shrubs, including apple (Malus sylvestris), American elm (Ulmus americana), cherry, (Prunus cearsus), pear (Pyrus communis), black locust (Robinia pseudoacacia), sugar maple (Acer saccharum) and lilac (Syringa vulgaris) have been planted (Lillard, 1948). Although apple trees have naturalized to some extent, these introduced plants do not constitute a significant element of the vegetation outside the orchards.

Trees native to the Sierra region were also planted at various times. October 30, 1913 was an "Arbor Day" when sequoia (Sequoia gigantea) and sugar pine were planted along several roads (Acting Superintendent's Report, 1913). The planting was unsuccessful. In the CCC days, native species, primarily incense-cedar, were transplanted to screen campgrounds and comfort stations. Many of these trees still survive. The number of planted trees is small, but recording their origin prevents one from attributing their presence to natural processes.

Effect of Insects on Forest Cover

Insect damage to trees in the Valley was first noted by the Commissioners' Report in 1903-1904. Felling and burning of insect infested trees was reported by the Superintendent in 1915. The Superintendent's Monthly Report for May 1929 states that 29 infested yellow pines were found in a survey from Happy Isles to Pohono Bridge. The same source for October, 1929, mentions that 30 white fir trees, infested and killed by the engraver beetle, were cut and burned. An outbreak of bark beetles coincided with the abundance of labor in the 1930's

and control activities were extensive. The forests in the Valley received considerable attention but the numbers of trees cut was reported for the Park as a whole and the number destroyed in the Valley is not known. Pictures of crews in action and occasional logs found in the Valley indicate that the pre-white man forest elements sustained the greatest losses.

Oyster shell scale has taken a toll of cottonwoods and willows in the Valley. The damage was very heavy in 1928, when a survey was made by the Forest Insect Laboratory, Stanford University (Walker, 1945).

Understory Changes Within the Forest

Development of the dense canopy of trees has altered the environment within the forest types. Reduction of insolation, litter accumulation, and changes in soil factors have created conditions favorable for the establishment of shade-loving species. The high shade tolerance of incense-cedar accounts for its abundance as an understory in the dense stands. Young trees and seedlings of two other shade tolerant species, white fir and Douglas-fir, have appeared in the dense stands of ponderosa pine and incense-cedar. The change in environment has enabled plants other than trees to occupy sites formerly unfavorable for them. Flowering dogwood (*Cornus nuttallii*), for example, has become established in the Black Spring area since 1943 (Fig. 10C). The abundance of plants favored by open tree canopy has been reduced. Bracken fern (*Pteridium aquilinum* var. *lanuginosum*) which reaches its best development in the woodland types is probably much less abundant than when Whitney described the "fern lands".

FOREST TYPES

The quarter method was used to sample seven forest areas on the Valley floor. The sampling sites are shown in Figure 17. The species composition varied considerably between sites (Table II). The basal area of each of the 100 trees measured on a site was calculated from its d.b.h.. By addition, the total basal area of each species was determined; by dividing the total for each species by the total for all species the percent of the total basal area contributed by each species, or the relative dominance, was determined (Table III). Six of the areas have essentially the same type of cover. Area 7, where white fir is dominant, differed significantly from the others. The major forest type on the Valley floor is designated as ponderosa pine - incense-cedar. Black oak is hardly abundant enough to warrant inclusion in the type designation. Area 7 is a white fir - ponderosa pine - incense-cedar type. The abundance of species in the ponderosa pine - incense-cedar type was essentially the same on plots sampled by Bryant (1957).

Time limitations prevented the sampling of other forest stands, most of which are various mixtures of the species listed above. There are relatively few areas where a single species occurs in a pure stand. Other major types are canyon oak and Douglas-fir - canyon oak. Species such as alder, broadleaf maple (Acer macrophyllum), and black oak are dominants in relatively small areas.

A vegetation type map was prepared (Figure 18). The limits of the forest types were determined by estimating the dominance of species. Aerial photographs taken in 1960 were used in conjunction with field notes in drawing the map. The amount of reproduction by estimate in

each type was put into one of five abundance classes: 1, rare; 2, occasional; 3, frequent; 4, abundant; 5, very abundant. The abundance estimates for the major species are shown in Figure 18.

A vegetation type map for Yosemite National Park was made in the period from 1930 to 1937. The forest types in Yosemite Valley are shown. On this map single species types were designated where one species occupied 80 percent or more of the cover. Mixed types had two or more species with no one species occupying as much as 80 or less than 20 percent of the cover. Areas with less than 20 percent cover were classed as bare. The types were based on trees of 8 inches d.b.h. or larger. In preparing the map shown in Figure 18 the same cover limits were used. Trees smaller than 8 inches d.b.h. were considered because young, replacement elements of the stands are important features.

The 1937 map has over 30 forest types in the Valley. This seems to be an unnecessary splitting. The quarter point sampling showed that stands on the Valley floor where ponderosa pine and incense-cedar are intermixed are very similar. The seven areas sampled, where only two types were found, crossed through five types on the 1937 map. Consequently, the type designations are broader than those used in 1937.

A number of forested areas were sampled by the modified step-point method. This is far from the best method to use in a forest because two entirely different life forms - trees and herbaceous plants - are intermixed. The method was rapid and furnished a measure of the relative abundance of different species. However, it is not an efficient method in sampling mixed stands of trees and herbaceous plants. The closest rooted plant was sometimes a tree which was recorded as mature, young

Table II. Relative density of trees with a d.b.h. of 2 inches or more on seven sites located on the Valley floor. Site locations are given in Figure 17.

Site number	1	2	3	4	5	6	7
Species							
Pinus ponderosa	40	45	54	56	26	59	12
Libocedrus decurrens	53	39	29	37	56	28	20
Quercus kelloggii	4	11	14	2	16	8	7
Abies concolor	3	4	1	5	1	5	54
Quercus chrysolepis		1	2				2
Pseudotsuga menziesii					1		4
Cornus nuttallii							1

Table III. Relative dominance of trees with a d.b.h. of 2 inches or more on seven sites located on the Valley floor. Site locations are given in Figure 17.

Site	1	2	3	4	5	6	7
Species							
Pinus ponderosa	64.2	68.0	54.2	62.3	54.4	86.5	33.3
Libocedrus decurrens	29.1	20.0	29.3	29.9	35.4	10.7	17.7
Quercus kelloggii	6.5	9.4	16.3	3.1	8.9	1.6	9.4
Abies concolor	0.2	2.5	0.1	4.7	0.9	1.2	31.4
Quercus chrysolepis		0.1	0.1				1.1
Pseudotsuga menziesii					0.4		7.0
Cornus nuttallii							0.1

(under 4" d.b.h.), or seedling (1 and 2 years old for conifers, under 1 foot for oaks). The seedling designation for oaks was used merely to distinguish fairly recent reproduction.

The species composition on the 10 areas sampled are presented in Table IV and the location is marked on the map (Fig. 17). Most of the areas were in the ponderosa pine - incense-cedar type. Areas A, B, and C are on the first floodplain level where overflow is frequent. The understory vegetation in this habitat is dense and is characterized by bracken fern, western raspberry (Rubus leucodermis), and wild-rye (Elymus spp.) (Fig. 19). Areas D, E, and F are on the level floor but are higher and drier than the first floodplain. The herbaceous understory is varied, containing bracken fern and other species characteristic of the floodplains. The density of the herbaceous plants is characteristically sparse. This habitat often has a very high density of young incense-cedar. Area F had a high proportion of annuals due to the presence of dry washes bisecting the sampling route. A heavy accumulation of pine needles was often limiting to herbaceous growth in the dense forest stands. Due to washing and deposition of silt the effect of needle accumulation was less noticeable on the low flood plains.

Areas G and H lie at the base of the talus slopes and are much drier than the level portion of the Valley floor. Poa scrabella, Carex multicaulis, Sitanion hystrix, and Lupinus greyii are commonly abundant in these areas along with a wide variety of annuals and other plants associated with dry habitats. The tree cover is usually interrupted and the herbaceous layer has a low foliar density (Fig. 20).

The rocky outwash fans (area I and J) have a very sparse herbaceous cover and suffrutescent species such as Brickellia californica and

Table IV. Percentage composition of plants on ten forest areas. See Figure 17 for location of areas.

	A	B	C	D	E	F	G	H	I	J
Number of points	150	150	150	150	150	150	150	150	150	150
Carex spp.	4.0	0	10.0	1.3	4.0	3.3	13.3	0	0	0
Elymus spp.	14.0	11.3	48.0	1.3	2.0	15.3	5.3	4.7	6.0	4.0
Bromus marginatus	0	0	0	2.0	0	1.3	0	1.3	0	0.7
Stipa elmeri	0	4.7	0	1.3	0	3.3	0.7	0	0	0
S. californica	0	0	0	4.6	0	4.0	4.7	9.3	0	0.7
Poa scrabella	0	0	0	0	0	2.6	8.6	0.7	22.0	14.6
Sitanion hystrix	0	0	0	0	0	0	4.7	0.7	0	0
Bromus tectorum	0	1.3	0	0	0	24.0	8.0	0	7.3	7.3
Other grasses	4.7	2.1	0	0.7	0.7	0.7	0.7	2.7	1.4	2.0
Pteridium aquilinum var. *lanuginosum*	26.6	18.0	10.6	9.3	26.0	0	0	7.3	0.7	0.7
Galium spp.	0	10.6	3.4	1.3	0.7	2.0	5.3	2.0	4.6	2.7
Osmorhiza brachypodia	10.0	8.7	3.3	0	14.6	0	0	0	0	0
Kelloggia galioides	2.6	2.0	1.3	22.0	0.7	0	0	0	0	0
Rumex acetosella	3.3	4.7	0	0	0	0	0	0	0	1.3
Asarum hartwegii	0	0.7	0	0.7	0	0	0	0	0.7	0
Artemesia douglasiana	0.7	0.7	5.3	0	0	0.7	0	0	0	0
Draperia systyla	0	0	0.7	0	1.3	0.7	0	0	0	0.7
Gayophytum nuttallii	0	0	0	0.7	0	1.3	1.3	0	0	1.3
Strepthanthus tortuosus	0	0	0	0	0	0	0.7	0	0	12.0
Erigeron breweri	0	0	0	0	0	0.7	1.3	0	0	0
Lupinus greyii	0	0	0	0	0	0	21.3	6.0	0	0
Lessingia leptoclada	0	0	0	0	0	2.0	6.7	0	0	0
Brickellia californica	0.7	0	0	0	0	0.7	0	0	7.3	6.6
Penstemon laetus	0	0	0	0	0	0	0	0	0.7	5.3
Eriophyllum confertiflorum	0	0	0	0	0	0	0	0	0	0.7
Other forbs	2.1	2.0	4.0	4.8	2.1	6.1	10.7	4.8	5.3	0
Rubus leucodermis	0	12.6	3.3	0.7	4.0	0	0	0	0	0
Rhamnus rubra	0.7	0	0.7	0.7	0	0	0	9.3	0	0.7
Lonicera interrupta	0	0	0	0	0	0	0	1.3	2.7	0.7
Ribes roezlii	0	0	0	0	0.7	0	0.7	0	0.7	0.7
Philadelphus lewisii	0	0	0	0	0	0	0	0	4.0	0
Arctostaphylos mariposa	0	0	0	0	0	0	0	7.3	0	1.3
Other shrubs	0.7	1.3	0.7	0	0	0	0	0	0	0.7

(continued on next page)

Table IV. (Continued)

Area	A	B	C	D	E	F	G	H	I	J
Libocedrus decurrens										
Mature	1.3	2.7	0.7	1.3	4.6	6.7	0	0	2.0	0.7
Young	4.6	4.0	0.7	21.3	25.2	7.3	1.3	0	10.6	2.6
Seedling	6.0	4.7	0.7	3.3	9.3	2.6	0	2.0	0	0
Pinus ponderosa										
Mature	2.6	3.3	0	0	2.0	0	2.6	4.0	0	12.0
Young	0.7	0	1.3	6.0	0.7	1.3	0.7	12.0	0	1.3
Seedling	0.7	1.3	3.3	0.7	0.7	0	0	4.0	0	10.0
Quercus kelloggii										
Mature	0.7	0	0	0	0	0.7	0	2.0	1.3	2.0
Young	10.0	0	0	3.3	0	0	0.7	6.7	0	0.7
Seedling	0	3.3	0	0.7	0.7	0.7	0	1.3	0	1.3
Abies concolor										
Young	1.3	0	0.7	9.3	0	2.0	0.7	0	1.3	0.7
Seedling	0	0	0	0.7	0	4.7	0	0	0.7	0
Quercus chrysolepis										
Mature	0	0	0	0	0	0	0	1.3	1.3	0
Young	2.0	0	0	0	0	0	0	7.3	6.0	4.0
Seedling	0	0	0	0	0	0	0	2.0	0.7	0
Pseudotsuga menziesii	0	0	0	0.7	0	0	0	0	0.7	0
Umbellularia californica	0	0	0	1.3	0	0	0	0	10.6	0
Acer macrophyllum	0	0	1.3	0	0	5.3*	0	0	0.7	0
Alnus rhombifolia	0	0	0	0	0	0	0	0	0.7	0

*All seedlings

Penstemon laetus are common. *Poa scrabella* and annual grasses are also characteristic.

Reproduction of the tree species is abundant on all of the areas (Table IV). Incense-cedar and ponderosa pine were the most abundant. Small black oaks like the one shown in Figure 21 were occasional to frequent. Seedlings and young plants of white fir were frequent to abundant as were young canyon oaks. The number of trees recorded indicates their relative proportion in the total vegetation.

CHANGES IN THE MEADOWS

History of Use

The meadow land in the Valley is divided into several more or less distinct areas which have had names loosely applied to them from the earliest times. Since the character and extent of the meadows has been influenced by various practices, a history of each of them is given. The location of the meadows is shown in Figure 17.

Bridalveil Meadow

This meadow, lying at the western end of the Valley, was the first meadow reached by travelers to the Valley and was often used as a campsite. Such use commenced with the Mariposa Battalion which camped here in March 1851 (Bunnell, 1911). From 1891 to 1906 troops stationed at Camp A. E. Wood camped on the meadow when visiting the Valley. (Sovulewski, 1937). The meadow was used for the pasturage of stock and and was fenced at an early date. A photograph taken by Joseph LeConte

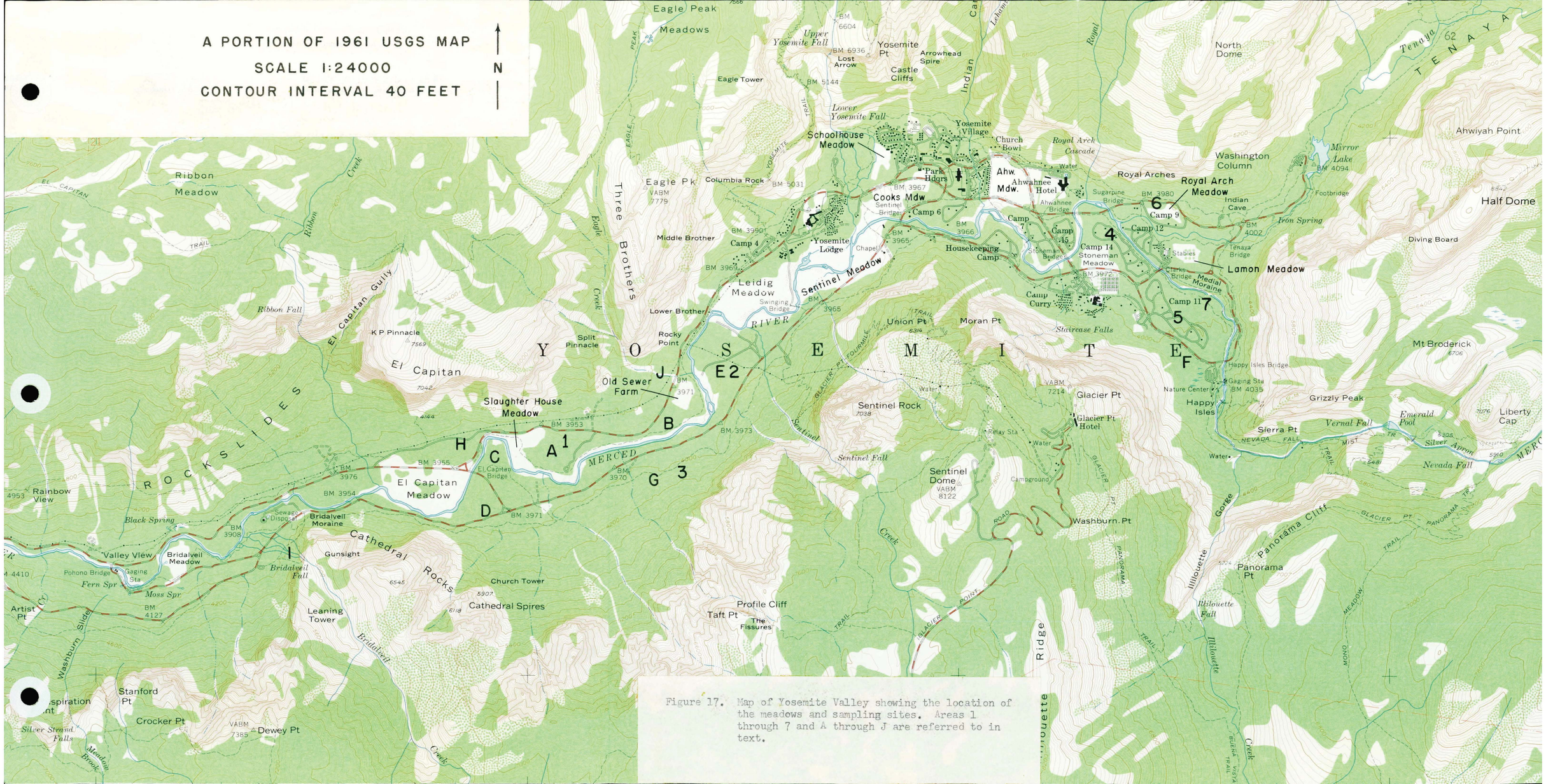


Figure 17. Map of Yosemite Valley showing the location of the meadows and sampling sites. Areas 1 through 7 and A through J are referred to in text.

Figure 18. Vegetation type map of Yosemite Valley

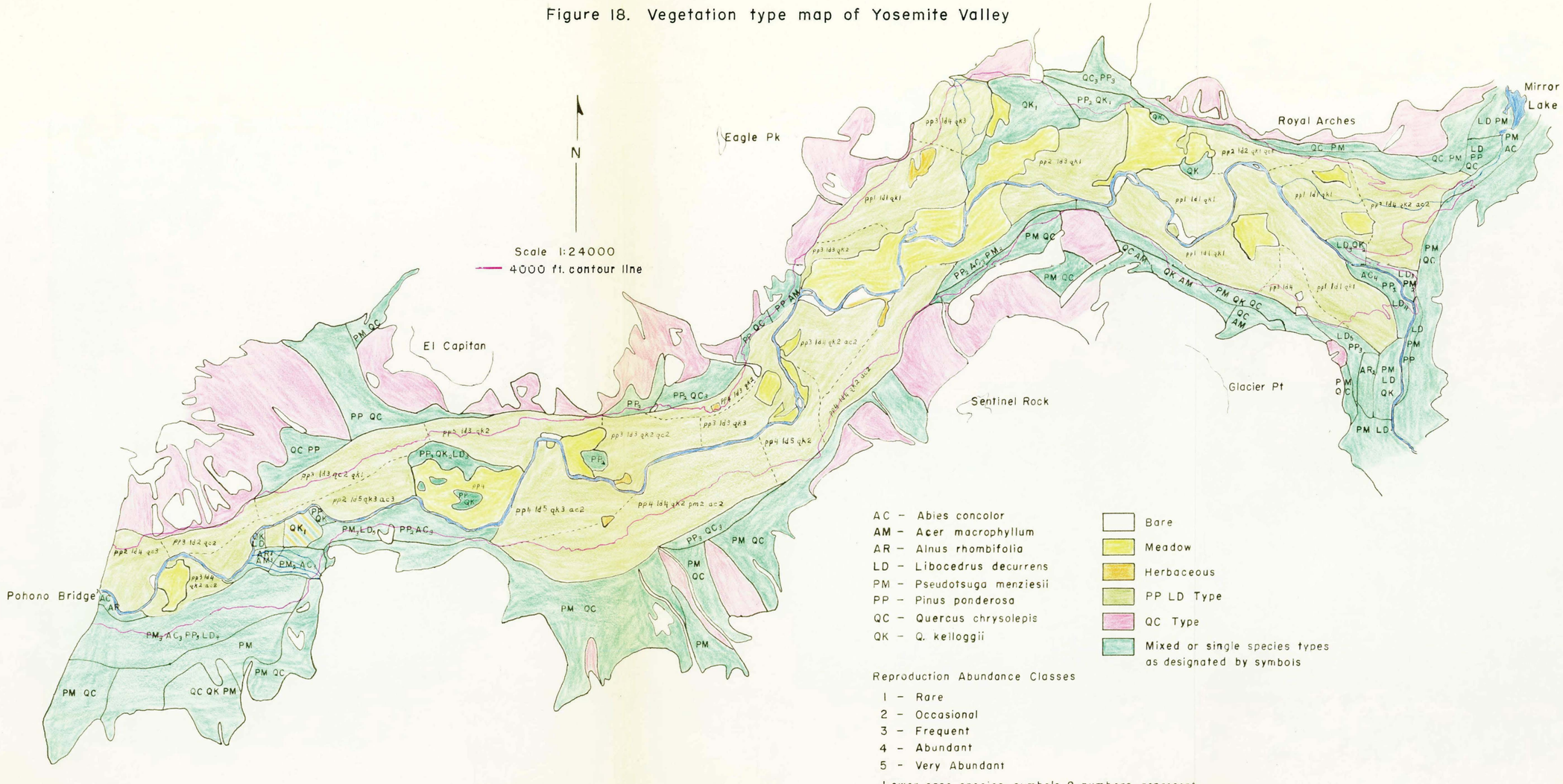


Figure 19. Dense understory of bracken fern and western raspberry which is characteristic of the forest floor on low, wet sites. Photograph taken by R. P. Gibbens in September, 1961.

Figure 20. View of the forested areas found at the base of the talus slopes. Poa scrabella and Lupinus greyii are the principal herbaceous plants. Ground cover is usually sparse and the tree canopy broken by numerous openings. Photograph taken by R. P. Gibbens in September, 1961.

Figure 21. A young black oak is shown to the left of the ponderosa pine trunk. Young trees such as this are 6 to 8 years old and are frequently found in the forests on the Valley floor. Photograph by R. P. Gibbens taken in September, 1961.

in 1896 shows that much of the meadow was covered with brush which is no longer present. Burning is known to have been done intentionally in 1919, 1920, 1921 and 1930 (Ernst, 1943A). Vista clearing has been instrumental in keeping the edge of the meadow across from Valley View free of trees and brush (Superintendent's Monthly Reports, 1924).

El Capitan Meadow

This relatively large meadow was used as pasture by various stage and saddle business operators in the 1870's and 1880's. The Army Engineers Map (Wheeler, 1883), made from data collected by the expeditions of 1878-1879, shows a hay shed in the eastern portion. During this period twenty acres of the meadow were plowed at least once and two tons of timothy seed sown in an unsuccessful hay growing project (Ernst, 1943A).

The Degnan dairy herd used the meadow from 1889 to 1921 during the summer months. A herder was used instead of fences during the later years (Ernst, 1943A). At least part of the area was used as a public campground until 1906 (Sovulewski, 1937). In 1941 small plots in the southwest corner of this meadow received the following treatments: deeply disked; lightly disked; burned; plowed and disked. Native plants were sown in an attempt to reestablish wildflowers (National Park Service File No. 833-01.3). No evidence of the treatments remains.

Slaughter House Meadow

This small meadow lying east of El Capitan Meadow has not had a name associated with it and the one above is merely used for convenience. A slaughter house existed very close to this meadow from at least 1878 until 1892. The Commissioner's Report for 1891-1892 states as follows:

> The slaughtering of sheep and cattle in the valley, always an offensive necessity, has been discontinued, and a supply from the outside has been arranged by furnishing a market house in which it may be stored and sold. This has released El Capitan meadows, necessarily surrendered heretofore for pasture for fat stock brought in for slaughter, and they are now opened to public use. The slaughter house has been removed. . . .

The El Capitan meadow referred to could apply to the large El Capitan meadow, the meadow in question, or to both. The 1883 map shows the slaughter house as being east of this area, and quite removed from the main El Capitan meadow.

In the Superintendent's Monthly Report for May, 1924 the following statement appears:

> Fences around the barnyards were repaired, and some additional fences constructed in the El Capitan Meadow, where extra and idle stock is pastured. The field inside the fence was so nearly devoid of grass that it was necessary to detail a herder to graze the stock outside the fence in the lower El Capitan Meadow during the day, then putting the stock within the enclosure at night.

Since the U. S. Geol. Survey map of 1921 shows a fence around the Slaughter House Meadow and none in El Capitan Meadow it is likely the "field" refers to the former. The reference to the "lower El Capitan Meadow" may be to the present El Capitan Meadow. Use of the areas for grazing was entirely discontinued by 1930.

Leidig Meadow

This large meadow, by virtue of its proximity to the main features of the Valley and early settlements, was heavily used. According to Paden and Schlichtmann (1955), "Fred Leidig had borrowed a bull team from Wawona; grubbed out the willows and planted rye." When this occurred is not clear. The caption on a reproduction of a photograph illustrating Muir's (1890) article in The Century Magazine says in part: " 'Leidig Meadows' plowed in October, 1885, to raise hay . . . ." The meadow was plowed in 1887 when timothy was sown and again in 1888 when wheat was sown (Ernst, 1943A). A reproduction of a photograph showing the plowed meadow appears in the San Francisco Examiner, November 26, 1888.

At least part of the meadow was used as a campground prior to 1906 (Sovulewski, 1937). From 1906 to 1913 troops stationed in the Valley used the meadow as a drill and exercise ground. Fences were probably present from very early days but were removed in 1924 (Superintendent's Monthly Report, April, 1924). The area was grazed by dairy cows during the last years of general use (Fig. 22).

The meadow was used for the Indian Field Days in 1929 and the race track oval is still visible from the cliffs. The meadow was also used as an airplane landing field beginning in 1919. The 1921 map shows a landing strip which is no longer evident.

Sentinel Meadow

Lying between the old Upper and Lower hotels this meadow must have received heavy use from an early date. Photographs indicate that the meadow was fenced in 1887 but when the fences were removed is not known.

The present road bisecting this meadow approximates the location of the Cosmopolitan Walk, a boardwalk constructed across the meadow in 1870.

The meadow was used by the Degnan dairy herd before removal to El Capitan Meadow (Ernst, 1943A). It was occasionally grazed by Army pack stock after 1906 and quite probably hay was harvested from the meadow at various times.

Cook's Meadow

This meadow is bisected by overflow channels and is low and wet. Fences appeared at an early date as they are evident in the 1866 photograph (Fig. 1A) and are also apparent in the 1899 photograph (Fig. 9A). From at least 1888 until 1913 the dairy herd supplying, first the Stoneman House, and then the Sentinel Hotel, used the meadow (Ernst, 1943A). From 1913 to 1921 the area was unfenced but in 1921 the eastern portion was enclosed to hold the herd of Tule elk. The elk used the meadow year-round until 1933 (Borell, 1933).

On the basis of past usage Cook's Meadow may be divided into two parts; the Elk Paddock or eastern portion and the Superintendent's Meadow or western part. The pathway bisecting the meadow (Fig. 1C) approximates the boundary between the two portions.

The meadow was probably burned in the 1920's. The last burning of record occurred in 1930 (Ernst, 1943A).

The Ahwahnee Meadow

Originally used by Lamon, this meadow was later part of the Harris ranch or Royal Arch Farm. Aaron Harris held a lease for the use of the

area from 1876 to 1886 (Ernst, 1943A). The meadow was used for both farming and grazing during this period. At least the eastern portion of the meadow was plowed by Kenny and associates during the late 1800's (Ernst, 1943A). From 1910 to 1914 it was plowed and sown to hay by government employees (Fig. 23) (Ernst, 1943A). The meadow may have been intentionally burned in the early 1900's. It was accidentally burned in 1929 (Michael, 1929).

Stoneman Meadow

The use to which a part of this meadow was put during the early days is plainly evident in the existing apple orchard. According to testimony at the Investigation of the Yosemite Valley Commissioners (1888) the meadow was cleared and plowed in 1887. This meadow was a favorite camping ground after fences were removed (Fig. 24). Surrounded by camping areas, it receives heavy foot traffic today.

Lamon Meadow

This is a relatively small meadow today and much of it is occupied by the apple orchard planted by J. C. Lamon. Probably the remainder of the meadow was cultivated, as remnants of an irrigation ditch running from Tenaya Creek still exist. The area was used by pack stock until the 1940's and a small portion is still contained within the stable complex.

Royal Arch Meadow or Camp 9 Meadow

Little mention is made of this meadow in the early records but it was undoubtedly grazed. In April, 1924 the Superintendent's Monthly Report mentions that 6 acres of the meadow were cleared, presumably of brush and trees. Although this is one of the wettest of the meadows today it is probably much drier than formerly as Ernst (1943A) mentions ditching for mosquito control purposes. Mr. Moe of the park engineering staff revealed in conversation that drainage tiles still exist. Installation of the ditches and tile was probably in the 1920's or 1930's. Ditching of unspecified meadow areas close to Tenaya Creek was done in 1932 (Superintendent's Monthly Report, December, 1932).

The Old Sewer Farm

This is a man-made meadow. In 1866 the area was covered by brush (Fig. 2A) and it probably developed a tree cover during the 70's and 80's. In 1921 it was cleared to provide space for the settling basins of the first centralized sewage system. Appearance of the area in 1925 is shown in Figure 25. With completion of the present sewer plant in 1931 operations ceased and the dikes and tanks were leveled in 1932 (Superintendent's Monthly Report, April, 1932). The vegetation existing on the area today is essentially meadow-like in character although some trees have become established (Fig. 2B, 2C).

Schoolhouse Meadow

Containing the remnants of Hutchings' orchard and being the site of gardening activities by Hutchings as well as Valley residents during World War I and II, this meadow has been intensively used. During the

early days of the Department of Interior, two barns used for the storage of hay were located here (Ernst, 1943A). It is also the former site of the Yosemite Park and Curry Co. warehouses.

From the brief description of the history of the individual meadows, it is apparent that grazing was prevalent until the early 1920's on all of the meadows. This grazing was often severe as the excerpts from Hall (1882) and the Yosemite Valley Commissioners' Report for 1885-1886 indicate. The acreage which was cultivated does not appear to have been large but several meadows were affected. The Investigation of the Yosemite Valley Commissioners (1888) placed the total acreage under cultivation at that time at 150 acres. According to testimony of Galen Clark at the investigation, cultivation was considered a means of "reclaiming" the meadow lands of the Valley. The same investigation established that about 700 acres of land were under fence in 1888.

In the early days of the automobile the meadows received considerable use as picnic and camping areas. Evidently this influence was prevalent between 1924, when most of the remaining fence in the Valley was removed, and 1929. In the Superintendent's Monthly Report for June, 1929, the tourist problem is mentioned.

> Ditches constructed around the meadows on the floor of the Valley have aided materially in protecting these spaces from encroachment by tourists. With autos traversing them constantly, and with daily picnics being held in these meadows, the native flowers and grasses were rapidly becoming a thing of the past.

Construction of these "moral ditches" marked the last general use of the meadow areas. Deer and other wildlife use the meadows today. Foot traffic is also a current use but, with the exception of Steneman Meadow, is not extensive.

Change in Meadow Area

A major change in the meadows has been their decrease in size due to the encroachment of the forest. Whitney (1868) classified 745 acres as meadow land. Russell (1927), using 1922 Yosemite Valley maps (Marshall and Matthes of USGS) placed the meadow acreage at 430 acres. Ernst (1949) measured the meadow area on the 1937 vegetation type map and found 327 acres of meadow land. Based on planimeter readings from aerial photographs taken in 1960 there are approximately 334 acres of meadow.

The remaining meadow areas are largely the product of white man's activities. Plowing, mowing, burning, and probably in some cases severe overgrazing served to keep out encroaching trees. In addition, the clearing activities of the 1890's, 1930's and 1940's have prevented the establishment of woody growth. Although no attempt was made to do so, the boundaries of the present meadows could probably be correlated with the location of fences which delimited activities. The recent invasions by trees (Figs. 14, 16C) shows that only continued efforts will maintain the meadows as open areas.

Composition of Vegetation in the Meadows

Samples were taken on all of the major meadow areas with the exception of the Schoolhouse Meadow. In Table V the percent composition or percent frequency of occurrence of the major species in each meadow is shown.

Sedges (*Carex* spp.) and Kentucky bluegrass (*Poa pratensis*) were the most abundant plants on all of the meadows (Table V). Due to the

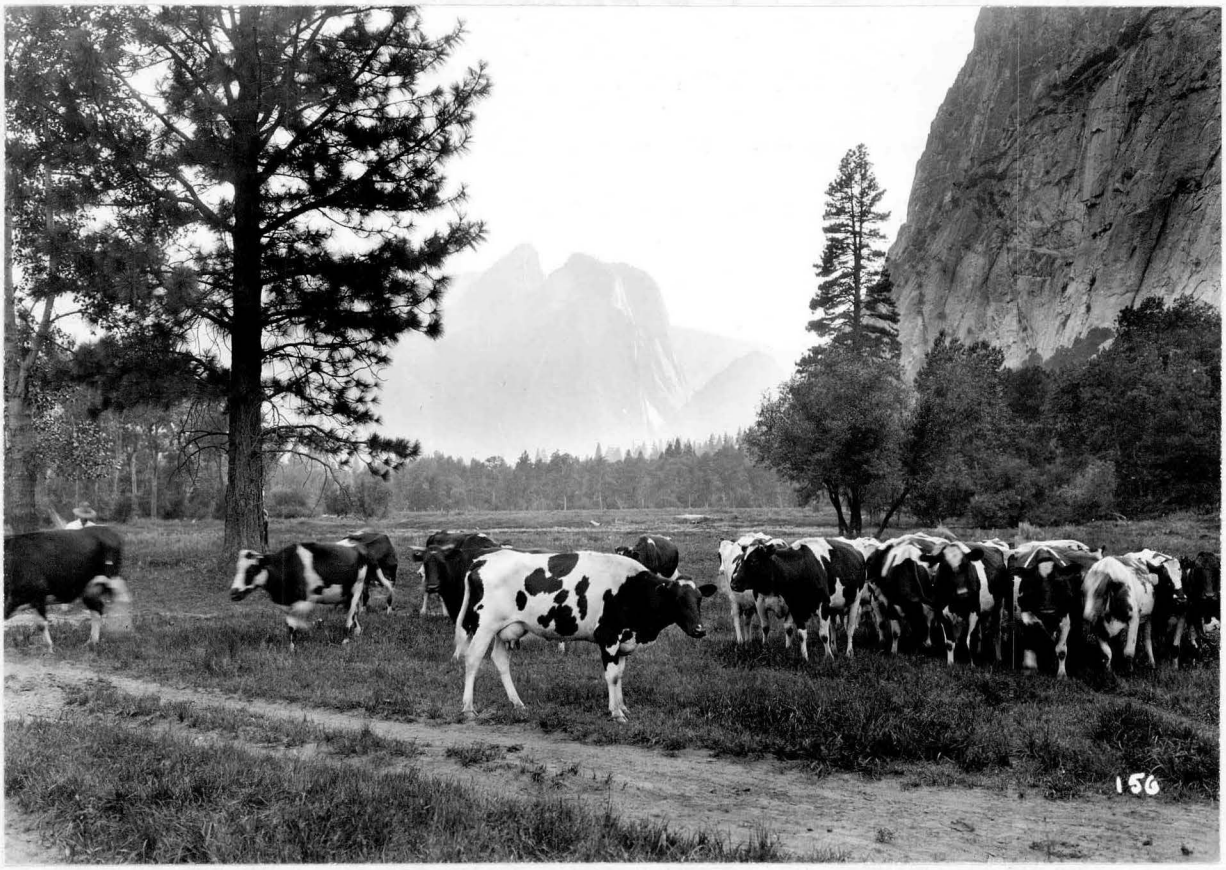


Figure 22. This picture of a dairy herd in Leidig Meadow was taken about 1918. Several meadows in the Valley were used for this purpose until 1924. Grazing by the herds was limited to the summer months. N.P.S. photograph. Photographer unknown.

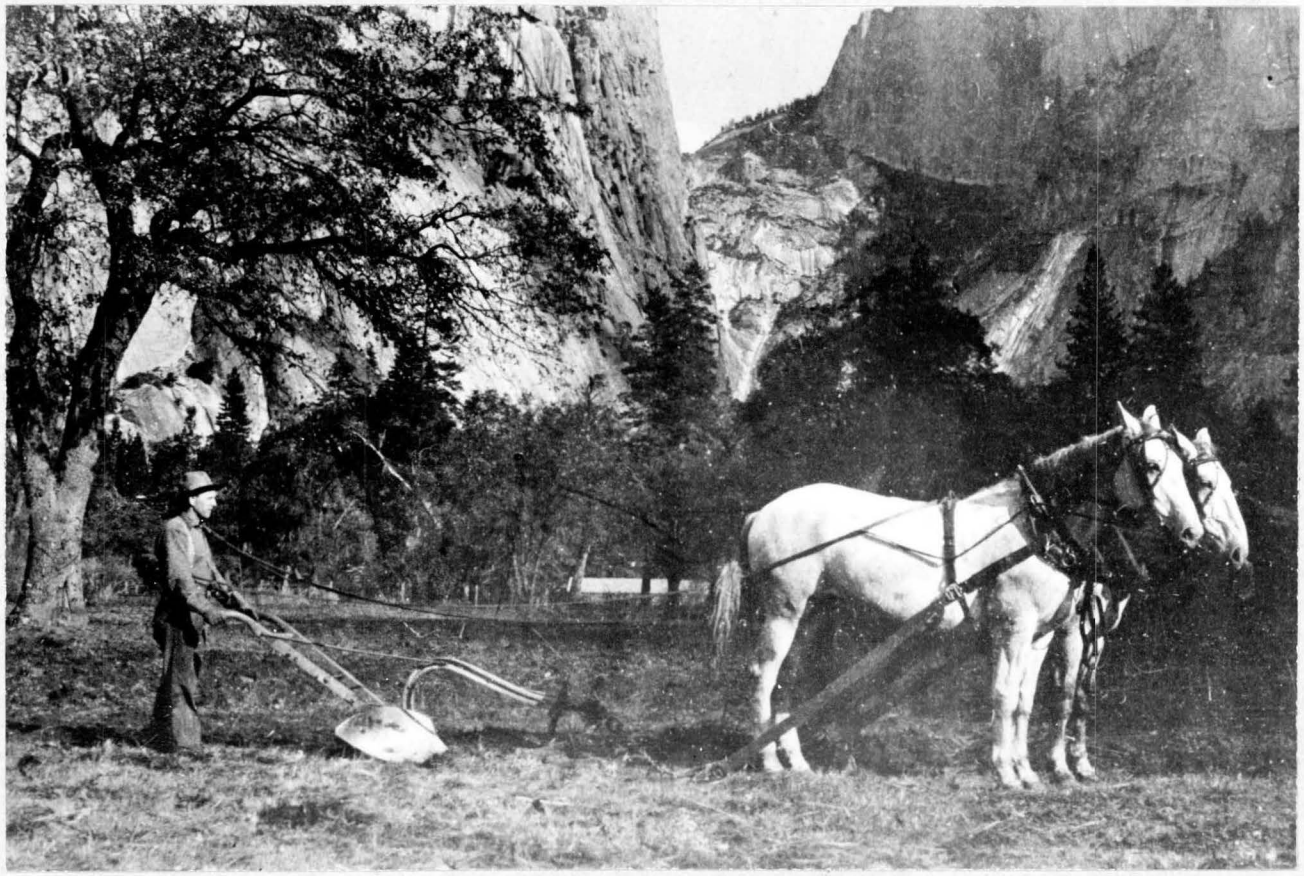


Figure 23. According to Ernst (1943A) this is a picture of Sam Cookson, government electrician, plowing in the Ahwahnee Meadow in 1911 or 1912. At that time civilian employees of the Department of Interior grew hay on this meadow and several others in the Valley. Photographer unknown.

Figure 24. Stoneman Meadow as it appeared in May, 1927. Use of the meadows for picnics and camping was fairly common in the early 1900's. The construction of ditches along the roadways in 1929 brought a halt to such use. N.P.S. photograph taken in May, 1927. Photographer unknown.

Figure 25. One of the first aerial photographs of Yosemite Valley. The settling basins of the old sewer farm are clearly visible in the foreground. Extent of the meadows is much the same as today. Photograph taken in 1925 by Air Force Capt. A. W. Stevens who also took aerial photographs of the Valley in 1923. Print copied by R. P. Gibbens.

scarcity of fruiting bodies and the lack of distinct vegetative differences the species of sedges could not always be distinguished. However, the principal species in approximate order of abundance were Carex barbarae, C. vesicaria, C. feta, and C. kelloggii. Wild-rye (Elymus spp.) was not separated into species due to the intergradation of forms. In general E. triticoides is found in the open areas and E. glauca in wooded areas.

Wild-rye and redtop (Agrostis alba) were often locally abundant but neither was represented in the samples from all of the meadows. Other perennial grasses represented in the samples included: Stipa californica; S. columbiana, Muhlenbergia filiformis, M. rigens, Panicum occidentales, and Calamagrostis canadensis. Cheatgrass (Bromus tectorum) was the most abundant of the annual grasses which also included Bromus commutatus, Festuca reflexa, F. dertonensis, and Deschampsia danthonoides.

The vegetative composition of the meadows only partially fits Whitney's (1886) description which was: "consists chiefly of carices or sedges and a few coarse grasses . . . ." Sedges are still very abundant and it seems safe to assume the species (not given by Whitney) are essentially the same today although their relative abundance may be different. The three "coarse" grasses listed by Whitney - Calamagrostis canadensis, Phragmites communis, and Glyceria nervata - could not be considered characteristic now. Calamagrostis canadensis and species of Glyceria are very rare in occurrence. Phragmites communis was not found nor is it in the Yosemite Museum Herbarium or mentioned in any of the plant lists. Perhaps Whitney mistook it for the common tule (Scirpus acutus). The Royal Arch Meadow is the only one with a stand of tule.

Table V. Percentage composition of plants on the major meadow areas as based on rooted frequency.

	Bridal-veil	El Capitan Open part	El Capitan Wood-land	Slaughter House	Leidig	Sent-inel	Cooks Supt. part	Cooks Elk Paddock	Ahwah-nee	Stone-man	Lamon	Royal Arch	Old Sewer Farm
Number of points	300	300	300	300	300	300	300	300	300	300	150	225	300
Carex spp.	80.1	36.0	17.6	21.0	29.4	47.6	74.2	67.8	51.9	13.0	0.7	78.1	26.6
Poa pratensis	4.0	40.3	35.9	21.3	51.0	22.0	11.0	21.7	27.7	68.3	68.0	10.2	1.7
Elymus spp.	5.3	7.3	10.7	25.3	15.0	26.7	8.0	0	0	0	0	0	38.4
Agrostis alba	0	2.0	7.0	3.3	0	0	0.7	4.0	1.3	8.0	2.0	0.5	0
Other perennial grasses	0	4.3	7.0	1.3	1.0	0	0	0.3	0.3	2.0	0.7	0	0
Bromus tectorum	0	1.0	0	7.0	0.3	0	0	0	15.0	5.4	19.3	0	19.4
Other annual grasses	0	0	0	12.1	1.7	1.0	0	0.3	0	0	5.3	2.7	1.7
Total grasses & sedges	89.4	90.9	78.2	91.3	98.4	97.3	93.9	94.1	96.2	96.7	96.0	91.5	87.8
Juncus effusus	1.0	4.0	5.0	0.7	1.0	0	0	0.3	0	0.7	0	0.5	0.3
J. orthophyllus	1.7	1.3	0	0.7	0.3	1.7	0.7	0.3	1.0	1.0	0.7	0	0
Equisetum laevigatum	0	0.7	2.3	0	0	0	0	0	0	1.0	0.7	0	0
Scirpus acutus	0	0	0	0	0	0	0	0	0	0	0	6.2	0
Iris missouriensis	0	1.8	2.3	1.7	0	0	0	0	0	0	0	0	0
Heleocharis spp.	0	0	0	0	0	0	3.3	1.3	0	0	0	0	0
Solidago spp.	1.6	0	3.0	1.3	0	0	0	0	0.3	0	0	0.5	0
Fragaria californica	0.3	0	1.0	0	0	0	0	0	0	0	0	0	0
Asclepias cordifolia	0	0	0.3	0	0	0	0	0.3	0.7	0	0	0	0
Artemisia douglasiana	0	0.7	1.7	0.7	0	0	0	0	0.3	0.3	0	0	0
A. dracunculus	0	0	0.3	0	0	0	0	0	0	0	0	0	0
Rudbeckia hirta	0	0.3	0	0	0	0	0	0.3	0	0	0	0	2.7
Hypericum formosum	1.0	0	0.3	0	0	0	0	0	0.3	0	0	0	0
Lotus oblongifolius	5.0	0	0.3	0.3	0	0	0	0	0	0	0	0	0
Rumex acetosella	0	0	0	2.4	0.3	0	0	0	0	0.3	0	0	0
Achillea lanulosa	0	0	1.0	0	0	0	0.7	0	0.3	0	0	0	0
Gayophytum nuttallii	0	0	0.3	0	0	0	0	0	0.3	0	0	0	0.3
Lessingia leptoclada	0	0	0	0	0	0	0	0	0.3	0	2.0	0	5.3
Other forbs	0	0.3	4.0	0.9	0	1.0	1.4	3.4	0.3	0	0.6	1.3	3.6

The plants listed as characteristic of the meadows by Whitney are all adapted to very wet habitats. The rarity of Calamagrostis canadensis and Glyceria spp. today leads to the conclusion that the meadows are much drier than formerly. If this is the case, sedges, while still prominent, have probably decreased in abundance. Sedges typically occupy the lower portions of the meadows while Kentucky bluegrass is most abundant on higher and drier sites. Wild-rye is more intermediate in range and often forms an overstory above sedges or Kentucky bluegrass. Redtop occurs in a wide range of moisture gradients but is rarely abundant in the wetest sites. Annual grasses predominate on sandy dikes disturbed by flood waters and other disturbed or very dry sites. The abundance of plants adapted to relatively dry sites further substantiates the deduction that the meadows are, in general, more xeric than when seen by Whitney.

Most of the differences in species composition among the meadows (Table V) are due to differences in moisture supply. The meadows with large amounts of sedges, such as the Bridalveil, Sentinel, Cooks, and Royal Arch meadows, have extensive sloughs, channels, or other low areas where overflow is common. Kentucky bluegrass predominates on high, well drained areas such as the Stoneman and Lamon meadows. Soil factors may also play a part in determining the distribution of species.

El Capitan Meadow was sampled in two parts, the woodland portion and the open part without trees. The woodland portion had a lower percentage of sedges but a greater variety and abundance of forbs than the open meadow. The woodland is probably drier than the open meadow with the more diverse habitat created by the trees favoring a larger number of forbs.

Aside from the shift to plants adapted to a drier habitat there is little evidence of the plowing and heavy grazing of the past. On meadows which were plowed sedges have reestablished themselves wherever moisture conditions permit. The Elk Paddock, one of the most intensively grazed areas, has completely recovered (Fig. 26). If the Elk Paddock and the adjacent Superintendents Meadow, which was not grazed during the same period, are compared in Table V it is evident that only minor differences in species composition exist. The Lamon Meadow, another area of recent heavy use, has the lowest percentage of sedges. This may be due to the compacting and drying action of trampling, but there are few low areas favorable for sedges.

The old Sewer Farm, an area of total and recent denudation, has completely recovered. The southwestern part, where remnants of the old dikes impound water, has a dense cover of sedges with wild-rye surrounding it. The eastern part of the area lies on the Eagle Creek outwash fan where the rapid drainage and occasional deposition of material creates conditions ideal for the abundant annual grasses.

The vegetative cover on the meadow areas is high. On areas dominated by sedges or perennial grasses from 80 to 100 percent of the ground is covered by the tops of the plants. The cover of annual species varies with the stage of development but at the time of maximum foliage cover would rarely be below 75 percent. Forbs such as Solidago, Asclepias and Heracleum, which tend to occur in groups or societies, often have a high foliage cover, usually as an overstory to the shorter sedges and grasses.

Forbs make up only a small part of the botanical composition of the meadows. The most common ones have been included in Table V. Since

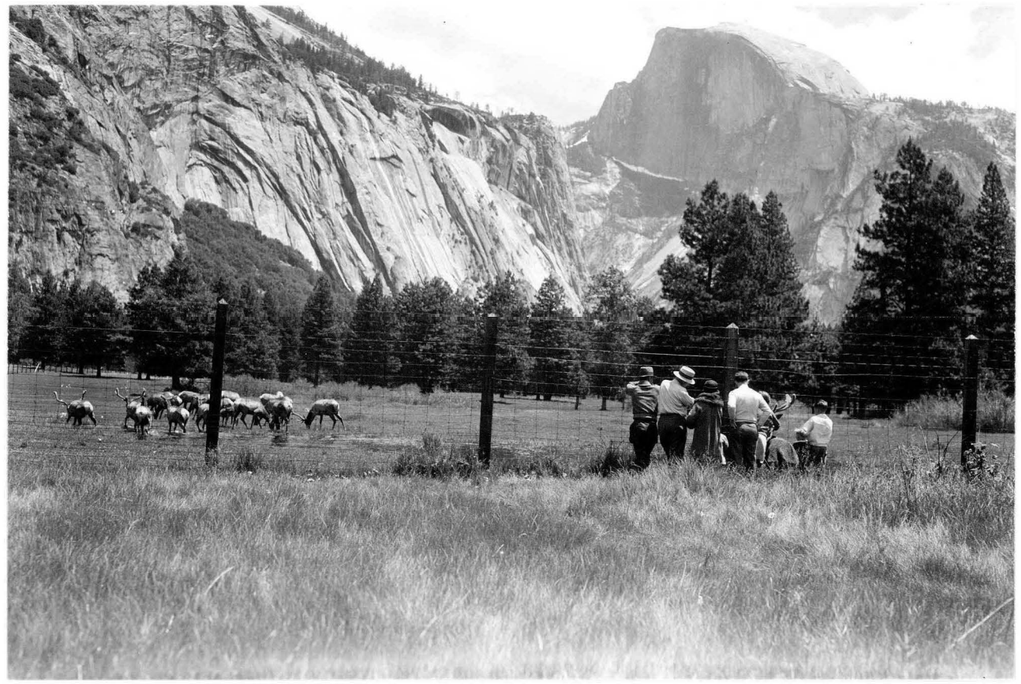


Figure 26A. View of the Elk Paddock portion of Cook's meadow sometime between 1921 and 1933 when the meadow was used for this purpose. Note the heavily grazed condition inside the fence. N.P.S. photograph. Photographer and date unknown.

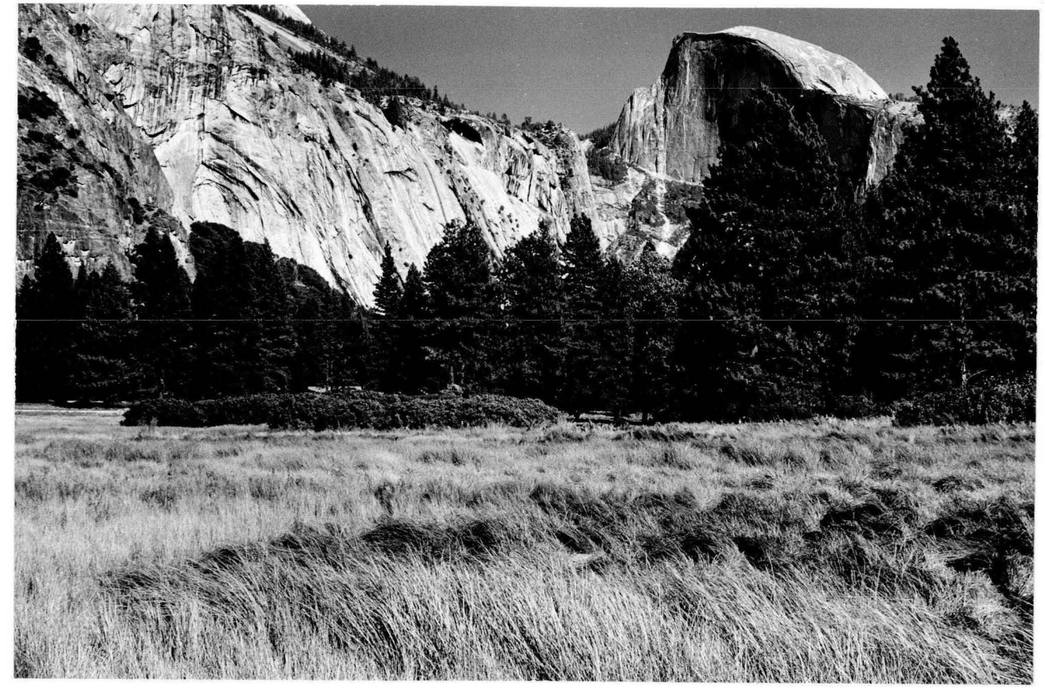


Figure 26B. View of the same area shown in Figure 26A in 1961. The vegetation has completely recovered and no evidence of the former heavy grazing remains. Photograph taken by R. P. Gibbens in September, 1961.

the sampling was not intensive enough to adequately estimate populations of low density, comparisons between the forb elements in the different meadows have little merit.

There are many references through the years to the decreasing numbers of wildflowers in the meadows. Michael (1929) stated: "June of the year 1920 witnessed the last great bloom on the floor of the Valley." She attributed the comparatively small numbers of flowers present in 1927 to the influence of mowing, burning, deer, and people. She did not recognize that these factors were operative prior to 1920. The same author also noted that after being absent or nearly so from 1923 to 1935 various lillies appeared in great abundance. Calochortus venustus was very abundant on Leidig meadow where it had not occurred before in the author's memory (Michael, 1935). Leidig meadow has been established as an area that was plowed. The above examples indicate that it is difficult to determine scarcity or abundance of wildflowers and especially hazardous to guess at the reason. The production of fruiting stalks in abundance by a wide variety of plants common to lower elevations in the Sierra Nevada is assumed to be climatically controlled. The optimum combination of moisture and temperature for abundant flower production in many species occurs only in widely spaced years. This phenomenon must be borne in mind when a visitor to the Valley states that myriads of flowers were seen one year and only a few in another year. To blame the decline on grazing or some other factor is especially hazardous. Valid comparisons need to be based on the actual number of plants present and not on the number of flower stalks produced.

Undoubtedly the mowing, grazing, and plowing of the meadows reduced the population of certain wildflowers. Populations of some rare but

attractive species were decimated by people. Perhaps the establishment of Kentucky bluegrass and wild-rye, both forming a tight sod, prevented the return of wildflowers when mowing, grazing and plowing ceased. Lack of disturbance could decrease the wildflower population. The sedges, abundant in the past, are sod formers and tend to take over a site completely. Certainly, any species favored by burning is less likely to be found today than when white man arrived.

Due to the great variety of species in the category of "wildflowers," it is axiomatic that some will increase with disturbance, some will decrease; some will increase with protection, some will decrease. One can only guess at any changes in the wildflower populations that may have occurred.

INTRODUCED PLANTS

It is quite probable that alien plants began to appear in Yosemite Valley before its discovery by white man. Numberous species were brought to California, both intentionally and accidentally, by the Spaniards as early as the 16th century and many others have arrived since. Some of these plants scattered rapidly and by the middle of the 19th century were widespread and abundant in California (Burcham, 1957). Although the Spaniards rarely penetrated into the Sierra Nevada, the wanderings of the Indians and natural dissemination by wind and animals could have introduced foreign plants to the Valley before white man arrived.

With the entry of white man a great importation of plants began. The fruit trees and ornamental shrubs brought in by the early settlers have been mentioned. A major source of alien plants was the hay and

grain used for horses and the seed for cultivated fields. Besides the hay plants themselves there were undoubtedly many impurities or weeds included. How many kinds of plants were introduced is of academic interest. Only those which become established are significant.

Conditions favorable to the establishment of introduced species were created. Plowing and heavy grazing broke up or weakened the cover of native plants, creating space readily occupied by aggressive introductions. Seeds were widely disseminated over the Valley floor by grazing animals and by man. It was the practice for a number of years to spread manure on "fields and open spaces" (Superintendent's Report, 1915). Old roads and other disturbed areas were often seeded to speed revegetation and plants foreign to the Valley were frequently used.

The introduced plants which have become naturalized constitute a significant part of the herbaceous vegetation in the Valley today. Kentucky bluegrass, although it may be native to the Sierra region, was probably introduced and now is one of the major meadow plants. Redtop was undoubtedly introduced as a hay plant and has spread throughout the Valley. Phleum pratense and Dactylis glomerata, also hay grasses, are found scattered in the meadows. A patch of Bromus inermis exists in the Lamon meadow, obviously originating from hay fed to livestock. Holcus lanatus or velvet grass has become widely established in wet habitats and is something of a pest in the residential areas. Most of the annual grasses are introduced species. They are now a major constituent of the herbaceous vegetation throughout the Valley.

Besides the grasses there are other introduced species, although few are as abundant. Using available sources (Durant, 1927; McDonald, undated; Woodham, 1927; Michael, 1929 & 1935; Goen, 1932; Carlson, 1932;

Table VI. Introduced plants found in Yosemite Valley. List compiled from Durant (1927), McDonald (No date), Woodham (1927), Michael (1929, 1935), Carlson (1932), Goen (1932), Lillard (1948), Bryant (1951), and sheets in the Yosemite Museum Herbarium. Only known transplants from surrounding vegetation are included.

TREES AND SHRUBS

Acer saccharophorum
Cercis occidentalis
Hedera helix
Malus sylvestris
Parthenocissus quinquefolia
Prunus cerasus
Pyrus communis
Robinia pseudocacia
Rubus recurvans
Sequoia gigantea
Syringa vulgaris
Ulmus americana
Vitis spp.

FORBS

Anthemis cotula
Brassica kaber var. pinnatifida
B. campestris
Capsella bursa-pastoris
Cardaria draba
Cerastrium viscosum
C. vulgatum
Chenopodium album
C. botrys
Chrysanthemum leucanthemum
Cirsium vulgare
Cnicus benedictus
Convolvulus arvensis
Conyza canadensis
Digitalis purpurea
Erigeron strigosus
Erodium botrys
E. cicutarium
Galium aparine
Glecoma hederacea
Humulus lupulus
Hypericum perforatum
Ilex aquifolium
Lactuca serriola
Malva parviflora
Mentha spicata
Mullugo vertiticillata
Pimpinella anisum
Plantago lanceolata
P. major
Polygonum aviculare
P. convolvulus
P. lapathifolium
P. persicaria
Portulaca oleracea
Prunella vulgaris
Raphanus sativus
Rudbeckia hirta var. pulcherrima
Rumex acetosella
R. crispus
Sisymbrium altissimum
S. officinale
Taraxacum vulgare
Thlaspi arvense
Trifolium repens
Verbascum thapsus
Veronica serpyllifolia

GRASSES

Agrostis alba
A. alba var. palustris
Avena fatua
Bromus commutatus
B. inermis
B. mollis
B. rigidus
B. rubens
B. secalinus
B. tectorum
Dactylis glomerata
Digitaria ischaemum
D. sanguinalis
Eragrostis megastachya
E. pilosa
Festuca dertonensis
Festuca elatior
Holcus lanatus
Hordeum stebbinsi
Lolium perenne
Phleum pratense
Poa pratensis
Setaria lutescens
S. viridus

Lillard, 1948; Bryant, 1951) and sheets from the Yosemite Museum Herbarium, a list of introduced plants which have been found on the Valley floor and lower portions of the talus slopes was compiled (Table VI). Only a few of the known transplanted species found in the surrounding Sierra Nevada were classed as introduced since they may have become established through natural means. The list is admittedly incomplete as there could have been many species brought in since the collections and studies were made. However, out of 470 species of all kinds in the sources used, 84, or 18 percent, were introduced plants.

The introduced forbs, for the most part, are weeds commonly found on disturbed areas. Some plants, because they detract from the "natural" appearance of the meadows, have been the object of control measures. Klamath weed, (Hypericum perforatum), which became abundant in the meadows about 1946, was eradicated first by hand and then, in 1948, by 2-4D (Ernst, 1948). Bull thistle (Cirsium vulgare) has been the object of eradication efforts in the past (Fig. 27). During the summer of 1961 extensive stands were cut down before seeds had a chance to ripen.

ESTABLISHMENT OF COVER ON DENUDED AREAS

During the past 110 years a great many areas in the Valley have been denuded at one time or another. Changing the routes of roads, tearing down or moving buildings, digging barrow pits and laying pipelines have all created bare areas. Natural agents, such as floods and rockslides have also caused denudation. Although such events have been frequent, little evidence of them remains today due to the rapid reestablishment of native and naturalized plants.

Figure 27. CCC boys pulling thistles (Cirsium vulgare) on the Ahwahnee meadow. This plant has invaded most of the meadows and control measures are used to remove it at the present time. N.P.S. photograph taken by R. H. Anderson in July, 1941.

The site of the Old Village store was sampled to determine the extent of recovery and the kinds of plants found on recently disturbed areas. The store was removed in the spring of 1959. The area had been sown to Festuca rubra; this is now the most abundant plant on the site (Table VII). In addition to the seeded grass, annual weeds, characteristically the first invaders of denuded areas, were very abundant. It is interesting to note that all of the "weeds" in Table VII are introduced plants. Although the area was bared only two years ago the perennials from the bordering meadow have gained a strong foothold. As the wild-rye, Kentucky bluegrass and sedges continue to increase the annual weeds will be gradually eliminated. It is likely that Festuca rubra will be unable to compete with the meadow species and will eventually be replaced.

The development of rhizomes by the dominant meadow plants enables them to move into disturbed areas very quickly. The old road shown in Figure 28 is being invaded from both sides and the annuals which are now abundant will soon be crowded out. Such areas may remain visible for a long time, not because of species differences, but due to differences in plant size or color. The high gravel content of the soil and its compaction make such areas drier than their surroundings.

On very sandy, or other dry sites, the succession of herbaceous plants may end with annual grasses which are better adapted to the short period of available moisture than are perennials. Trees may become established on denuded areas and develop concurrently with the herbaceous vegetation. Once established, trees will become the dominant vegetation. On rock slides woody plants are often the primary invaders. A large rock slide at Rocky Point which occurred in 1923 was studied

Table VII. Percentage composition of plants based on rooted frequency on the site of the Old Village store.

Number of points	150
Festuca rubra	31.3
Elymus spp.	22.7
Poa pratensis	10.7
Agrostis alba	1.3
Sitanion hystrix	0.7
Carex spp.	1.3
Bromus rigidus	1.3
B. tectorum	0.7
Sisymbrium altissimum	22.7
Lactuca serriola	1.3
Capsella bursa-pastoris	0.7
Chenopodium botrys	0.7
C. album	1.3
Rumex acetosella	1.3
Artemesia douglasiana	0.7
Unidentified	1.3

Figure 28A. View showing the road skirting the north side of the Elk Paddock in the late 1920's or early 1930's. Print from copy negative made by R. P. Gibbens. Date and photographer of original unknown.

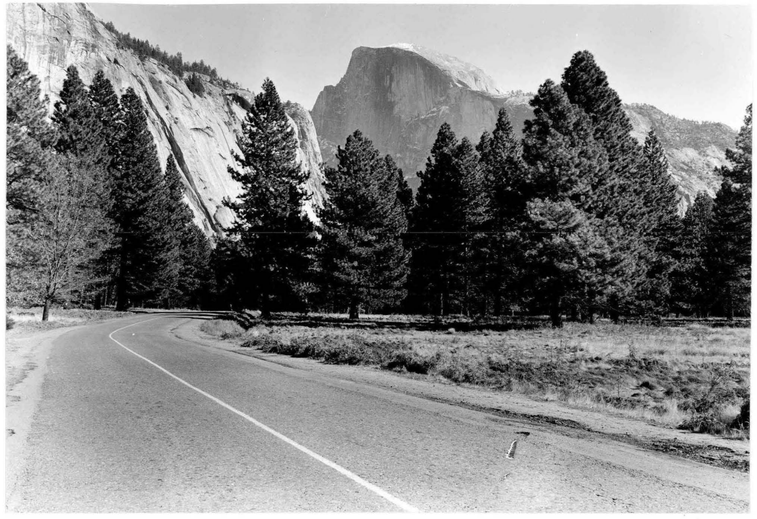


Figure 28B. The same area shown in Figure 28A as it appeared in 1943. Improvement in the condition of the road and the vegetation are obvious. N.P.S. photograph taken by R. H. Anderson in November, 1943.

Figure 28C. View of the area shown in preceding photographs as it appeared in 1961. Site of the old road (torn up in 1953) is being rapidly occupied by sedges and grasses. Annual plants such as the Lessingia leptoclada in the foreground are still fairly abundant. Photograph taken by R. P. Gibbens in October, 1961.

nine years later (Carlson, 1932). Shrubs and suffrutescent plants including Brickellia californica, Eriodictyon californica, and Penstemon breviflorus, had become well established. Young trees were numerous with ponderosa pine being the most abundant. Thus, on the talus slopes shrubs and trees quickly invade denuded areas. Herbaceous plants also move in but are not an essential stage in secondary succession.

CAMPING INFLUENCES

Camping has been a popular pastime in Yosemite Valley for decades. In the early days campers could pick a favorable spot and pitch their tent. When large portions of the Valley were fenced this freedom of choice was restricted. Full restriction came with the designation of specific areas for camping by the Park Service and the delimiting of the campground areas by rails and other devices in the 1930's. Since their establishment the present campgrounds have received the full impact of a steadily mounting stream of campers. In 1958 there were 8,800 to 12,000 campers per night in the Yosemite Valley campgrounds from June 20 to Labor Day(National Park Service File No. A3015).

The campgrounds are all in forested areas, yet, with so many people moving about, the ground is devoid of herbaceous plants and young trees (Figure 29). Ernst (1947) lists only two plants, miner's lettuce (Montia perfoliata) and false Solomon's seal (Smilacina amplexicaulis) which appeared year after year in the campground areas. Miner's lettuce produces seed before the peak of camping activity and false Solomon's seal produces stems from underground rootstalks. Even adapted plants such as these can survive for only a short period each year.

Another influence of the campers is soil compaction from continual walking and weight of vehicles. This compaction, measured by a soil penetrometer, was found to be significantly higher than in immediately adjacent areas (Table VIII). Sandy loam soils were highly compacted and even soils which were almost pure sand were compacted slightly. The compaction dropped off very sharply at the campground boundaries, even though adjacent areas receive foot traffic. Compacted soils have reduced air space, lowered water infiltration rate, and increased runoff; all conditions unfavorable to plant growth.

The litter and duff layers characteristic of forest floors are reduced by campers. Pine needles, which are the principal constituents of the litter and duff layer, make excellent kindling for fires and are removed each year. In Camp 14 the litter collected from 25 random square foot quadrats was equivalent to 2.5 tons of oven-dry material per acre. Under a stand of trees similar in size and age, where camping was not an influence, the litter and duff from 25 square foot quadrats was equivalent to 17.4 tons per acre. Of this amount 9.8 tons was duff, or largely decomposed organic matter, a layer that was non-existent in the campground. Larger debris, like pine needles, has been removed for fuel from the campgrounds and from the upper end of the Valley in general.

The constant removal of the litter is a loss of nutrients which are normally re-cycled by the breakdown of organic matter. The leaching of campfire ashes and the addition of material through spilled foodstuffs may partially offset this loss in nutrients. However, the organic matter, important in maintaining soil structure, and nitrogen, is not replaced.

Table VIII. Degree of soil compaction inside and outside of campgrounds as measured by a soil penetrometer. The larger the value of the means the greater the degree of compaction. Differences between the means of samples from inside and outside of the campgrounds were highly significant.

Location	East end of Camp 14		Central part of Camp 14			West end of Camp 14	
Soil type	Sandy-loam		Sandy-loam			Sandy	
Area	Inside	Outside	Inside	Inside	Outside	Inside	Outside
Use	Heavy	Moderate	Heavy	Heavy	Moderate	Heavy	Moderate
Number of samples	39	10	47	40	38	50	50
$\bar{x}$	2.82	1.16	2.58	2.34	1.40	1.35	0.48
s	0.96	0.44	0.89	0.71	0.66	0.16	0.32
$s_{\bar{x}}$	0.15	0.14	0.13	0.11	0.11	0.02	0.04

Location	Southwest corner of Camp 11		East of Yellow Pine Beach	North of El Capitan Beach
Soil type	Sandy-loam		Sandy	Sandy to sandy-loam
Area	Inside	Outside	Forest	Forest
Use	Heavy	Moderate	Very light	Very light
Number of samples	50	50	50	50
$\bar{x}$	2.78	1.24	0.55	0.60
s	0.85	0.45	0.25	0.45
$s_{\bar{x}}$	0.01	0.06	0.04	0.06

The trampling influence of campers, and visitors in general, is not confined to the campgrounds. Because the river bisects the campground area and is a focal point of activity its banks are trampled bare (Fig. 30). Figure 31 shows that before the campgrounds were established the river banks supported a good cover of shrubs and herbaceous plants. Today the herbaceous plants are gone and the few remaining azalea clumps have been broken by people. River banks at favored bathing beaches and picnic areas also show the effects of trampling. Outside the areas of high human concentration the effects of trampling are largely confined to paths along the river.

An indication of what would happen in the present campgrounds if people were excluded was furnished by the closing of campgrounds 7 and 15 during 1943, 1944, and 1945 (Ernst, 1947). Largeleafed maple germinated in great abundance in portions of Campground 7. The seed came from a relatively few mature trees. Favorable moisture conditions and direct contact of the seeds with the soil permitted the high germination rate. Herbaceous plants recovered rapidly, especially near protected spots and guard rails at the camp boundaries where the seed source was located. Today, the results of this rest period are absent.

On campgrounds which have been abandoned for many years there is no evidence of past trampling. Soon after 1906 the following camps were abandoned for sanitary reasons: Camp 1, El Capitan Meadow; Camp 2, Bridalveil Meadow; Camp 3, in trees at west end of Sentinel Meadow; portions of Camp 4, Leidig Meadow and Yosemite Lodge grounds; Camp 5, east of Yosemite Creek bridge; Camp 10, near Iron Spring on Tenaya Creek (Sovulewski, 1937). Trampling probably was not as severe on the above areas as in the present campgrounds. With the long period of non-use the vegetation has completely recovered.

Figure 29. View of a portion of Camp 14 showing the complete absence of tree reproduction and herbaceous cover. The heavy litter layer normally found under similar stands of trees is absent. Photograph taken by R. P. Gibbens in October, 1961.

Figure 30. Denuded and trampled river bank at the west end of Camp 14. The pile of rocks is one of the many efforts made to halt cutting of the stream banks by the river. Photograph taken by R. P. Gibbens in October, 1961.

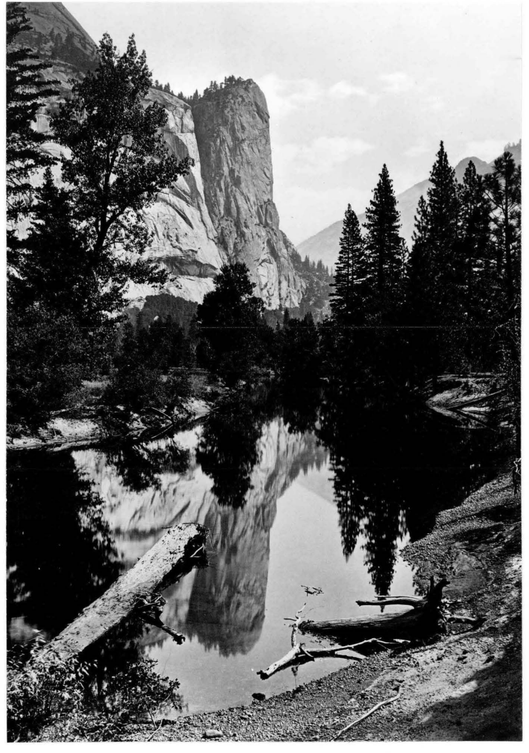


Figure 31A. This photograph of an unknown but very early date shows the appearance of the river banks below the present site of the Stoneman Bridge. Photographer unknown. Print from a N.P.S. copy negative made by R. H. Anderson.

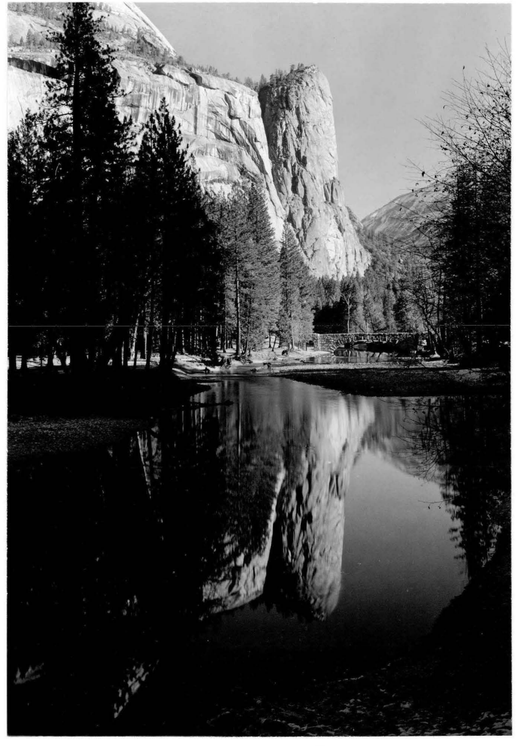


Figure 31B. This view of the area shown in Figure 31A was taken in 1943. The river bank on the left borders Camp 7 and the shrubs and herbaceous plants formerly present have been trampled out by campers. Trees are much more abundant than when the first picture was taken. N.P.S. photograph taken by R. H. Anderson in November, 1943.

Figure 31C. This view of the river below Stoneman Bridge was taken in 1961. No attempt was made to match the view and artistry of the preceding photographers. The picture does show that considerable erosion of the banks has occurred and that they are still in a denuded condition as far as shrubs and herbaceous plants are concerned. Photograph taken by R. P. Gibbens in October, 1961.

INFLUENCE OF PHYSICAL IMPROVEMENTS

Buildings and roads are an integral part of white man's use of Yosemite Valley. The loss of vegetation on the space occupied by these improvements is insignificant but surrounding vegetation may be affected. Buildings serve as focal points of human activity and trampling often creates disturbed areas around them. Extensive walks and paved areas have reduced trampling but the runoff from such non-absorptive surfaces influences the vegetation on adjacent areas.

The roads in the Valley have a broader influence. With the exception of the Lamon Meadow, all of the meadows are skirted or bisected by major roads. The fill and ditches of the roads have had considerable influence on drainage patterns and have, no doubt, changed soil moisture conditions. A small swamp supporting a stand of Thypa latifolia has been formed in the Black Spring drainageway by the damming action of the highway. This swamp lies beyond the screen of trees shown in Figure 10C. The influence of roads is seldom as marked as this, the shift usually being from a wet to a dry meadow type or vice versa. The shoulders and embankments of roads constitute a very dry habitat and are often a haven for weedy annuals.

The opening of the forest canopy for power lines, installation of pipelines, collection of gravel from the river bed, and diversion of springs for water supplies are other items that have caused changes in plant cover. These are, like buildings and roads, necessary in Park management and are part of the over-all influence of white man on the vegetation.

WILDLIFE INFLUENCES

With the arrival of the white man, wildlife assumed a new role in the Valley. No longer was it a source of food, and kept at low population levels. It became an intrinsic part of the natural scene to be protected. As a result, wildlife reached levels of abundance never before attained.

Deer did not become a problem until after the creation of Yosemite National Park. This action, of course, gave protection to deer over a large tract surrounding the Valley. The Acting Superintendent's Report for 1912 mentioned that game was increasing, indicating a buildup of populations. During the early 1920's the outbreak of hoof-and-mouth disease led to widescale destruction of deer in the park and elsewhere. The deer present in the Valley were not destroyed but were confined to an exclosure (Superintendent's Monthly Report, June, 1925). Evidently they were released as soon as the hoof-and-mouth disease scare had abated.

According to the Superintendent's Monthly Reports deer were numerous during 1930 when 93 were corralled and removed from the Valley. Deer were also removed in 1931 and 1941. This practice of removing excessive resident animals continues today. The history of the deer population has been one of fluctuating numbers with controls being applied at times of population peaks.

The population records are too sketchy to evaluate the past influence of deer on the vegetation. At the present, young white fir trees are often hedged by browsing, greatly slowing their growth. Rhamnus rubra, another favorite browse plant, is usually hedged. Evening primrose

(Oenothera hookeri), a relished herb, is said to be greatly restricted by deer. Other herbaceous plants are probably affected. Browse plants are not abundant on the Valley floor so forbs and grasses must furnish the principal food.

Three exclosures were erected on the floor of the Valley in 1935 to determine the effect of browsing and grazing by deer (Superintendent's Monthly Report, 1935). Two of the exclosures are at the foot of the talus on the north side of the Valley where mariposa manzanita (Arctostaphylos mariposa) is the principal shrub. Since this manzanita is not a preferred browse plant, the exclosures show little except that deer have had a minimum of influence on the vegetation. The exclosure located in Bridalveil meadow indicates that Rubus parviflorus is subjected to heavy browsing as it is definitely more abundant within the exclosure. All of the exclosures have serious drawbacks in that they are small and no record of vegetation on open, control plots was made.

Limited reproduction of black oak in the Valley, particularly in the grove surrounding Yosemite Village, has been attributed to deer. The relatively deer proof Ahwahnee Hotel grounds by the tennis courts revealed a few, small black oaks less than a foot tall. One was also found outside the fence. As the grounds have been fenced since 1929 one would expect a larger number of young oaks and a number of different age groups if deer were the only factor involved. Perhaps the plants were removed periodically. Young black oaks are more numerous in the lower part of the Valley where deer densities are lower but they are typically found on the forest floor, a different habitat from the open oak grove around Yosemite Village.

From the evidence at hand it is not possible to determine the reason for the scarcity of black oak reproduction. Consumption of acorns

may be a factor but deer are not the only acorn users present. Any one of a number of factors, including competition, disease, insects, viability, and climatic factors, may also be involved.

Oak seedlings have appeared in large numbers at least once in relatively recent times. Payne (1938), commenting on the exceptionally large crop of acorns produced in 1936, states: "With the lapse of a year since the sprouting of the acorns, we find a great host of these seedling oaks growing most vigorously." Unfortunately no further information was recorded.

Rodents may have played a part in the early spread of trees in the Valley. During population peaks rodents, by consuming seeds and girdling young trees would be a restrictive influence in tree establishment. At a low rodent population level more seed would be available. In addition, the bare soil of gopher workings in meadows would make an excellent seedbed and seeds buried in caches would be a source of seedlings. It is not known if factors such as these were operative during the early invasion of trees but the possibility exists.

The rodent populations in the Valley, particularly ground squirrels, have been subjected to control measures since 1912 (Superintendent's Report, 1912). Large numbers of the animals have been killed by trapping and poisoning. Too little is known about the rodent populations to evaluate their effect on the vegetation but the control measures have certainly reduced their influence.

INFLUENCE OF FLOODS AND ROCKSLIDES

Forces not attributable to man, such as floods, rockslides, avalanches, and lightening caused fires are phenomena which have a

catastrophic effect on the vegetation. Lightening fires have been contained by man but floods and rockslides have occurred during the historical period and will undoubtedly occur in the future.

Major floods occurred in 1867, 1890, 1919, 1937, 1950 and 1955. Hutchings (1886) described the flood of 1867 as follows:

> On December 23, 1867, after a snow fall of about three feet, a heavy down-pour of rain set in, and incessantly continued for ten successive days; when every little hollow had its own particular water-fall, or cascade, throughout the entire circumference of the Valley; each rivulet became a foaming torrent, and every stream a thundering cataract. The whole meadow land of the Valley was covered by a surging and impetuous flood to an average depth of nine feet. Bridges were swept away, and everything floatable was carried off.
>
> Immense quantities of talus were washed down upon the Valley during this storm, - more than at any time for scores, if not hundreds, of years, judging from the low talus ridges, and the timber growth upon them. After this rain-storm had ceased, a wind sprung up and blew down over one hundred trees. In one spot of less than seven acres twenty-three large pines and cedars were piled, crosswise, upon each other.

Major floods, such as the one described above, inundate large areas normally not flooded by spring runoff. The flood of 1950 covered 55 percent of the nearly level floor of the Valley (Engineer's Report, 1950). The flood of 1955 covered an even larger area (Engineer's Report, 1955). The floodwaters do not stand long enough to cause wholesale drowning of plants but either by erosion or deposition and changing of the river channel they can influence the abundance and growth of plants. Bare areas so created may be occupied by vegetation different from that previously existing.

The erosive force of the Merced River, even in years of normal water levels, has long been a matter of concern. Since 1879 there has been a continuing struggle to confine the river to its channel and to

halt the cutting of banks. The changes in the channel evident in Figures 1, 9, and 31 indicate that these efforts have not been entirely successful. Both meadow areas and trees have been undermined and swept away by the river.

Efforts to contain the river may have caused a deepening of the channel. If this is the case, overflow is lessened, drainage is quicker, and the water table lowered. These in total, indicate that the low lying ground may be drier during the summer than it was when the Valley was discovered. Such effects would be minor during periods of high rainfall and major floods.

Rockslides shear off or bury plants in their path. Several have occurred within the historical period. The fall of Eagle Rock in the earthquake of 1872, which John Muir (1912) described so rapturously, snapped off huge firs and covered a large area with a rubble pile many feet thick. Much of this area is still bare of vegetation. Slides of lesser proportions, like the one at Rocky Point in 1923, are not so long lasting in their effect.

RECOMMENDATIONS FOR FUTURE STUDIES

There are many problems in Yosemite Valley which merit investigation. Due to the complexity of vegetational relationships the determination of cause and effect is often difficult. However, planning and management can be most effective if predictions of changes can be made. Ability to make predictions requires a thorough knowledge of the ecological relationships of the vegetation. Such knowledge can be best acquired through planned investigations which yield objective, verifiable

information. The following list includes a few of the many possibilities for future study.

1. The sketchy nature of climatic data during the 1800's makes interpretation of vegetational changes difficult. There are trees in the Valley which predate this period and individuals are removed from time to time. If sections near the bases of these trees were preserved, along with notations on the sites on which they were growing, a study of the growth rings could furnish a good indication of climatic conditions over the past 100 or 200 years. Trees from dry sites would show the climatic pattern best.
2. The careful study of burn scars on such tree sections and on stumps in the Valley might also shed some light on the fire history of the Valley. Were all of the fires light ground fires or did occasional major fires literally sweep the Valley clean? Have the talus slopes remained relatively free of fire or have they also been burned? Such knowledge might aid in interpreting the rather incongruous forest stands existing during aboriginal times. There were scattered trees. How did they get started if periodic burning was the custom?
3. Pollen profiles could be taken in the sedimentary soils of meadow and marsh areas to determine the species present in the past and their relative abundance.
4. The study of deep soil profiles in conjunction with pollen counts would show the layers of sediment and the presence or absence of charcoal and buried soil profiles.

5. Mapping of the soil types on the Valley floor would be an invaluable aid in vegetation studies and also for management decisions. Since parent materials are uniform and the cover has changed from grass to trees on many areas excellent opportunities exist for studying the role of vegetation in soil formation.

6. The influence of people on the soil characteristics of the campgrounds needs much more investigation. Soil Ph, fertility level, and organic matter content need to be measured on heavily used and non-used soils of the same type to determine if serious alteration of soil characters has taken place.

7. Permanent, inconspicuously marked, open quadrats in and near areas of high human concentration would be a good means of determining which plants are best adapted to withstand heavy use. There is a possibility of discerning "trampling" ecotypes of species such as Poa pratensis. Similar plots which were protected could furnish valuable information on the rate of vegetation recovery.

8. Further sampling of the meadow and forest types on a percent cover as well as a species composition basis in areas of use and non-use would aid in determining the effects of current use and provide a basis for measurement of future changes. Such studies need to be done early in the season, or perhaps at intervals throughout the season so all aspects of the vegetation will be sampled.

9. The establishment of permanent plots in meadow and forest areas could yield valuable information on the rate of tree seedling establishment, growth, and mortality.

10. Factors governing the distribution of the various species in both meadows and forests need investigation. Soil moisture, exposure, and soil factors could be measured to see what correlations exist

between these influences and the presence or absence of particular species.

11. The influence of wildlife on black oak reproduction needs clarification. Although exclosures might in time furnish some evidence, the experimental planting of acorns in different sites might yield more rapid results. The percentage loss of acorns to wildlife could be determined by counts of acorns on protected and unprotected plots.

12. The food habits of the very tame deer in the Valley could be easily determined by observation. Data on time spent browsing or grazing different species, plant parts taken, season of use, etc. would supply the information necessary to evaluate their influence on the vegetation.

13. Taxonomic studies of wild-rye need to be made. There are many forms present which do not fit descriptions of current species.

14. The information which can be acquired from old photographs has by no means been exhausted. The unusually large number of existing photographs of Yosemite Valley offer a unique opportunity which should be exploited to the fullest extent.

DISCUSSION

Since aboriginal times there have been extensive vegetational changes in Yosemite Valley. It is only natural that interpretations of good or bad are placed on changes which have occurred. However, evaluation of change must be based on the present and future use of the Valley, not on the aboriginal use. Plants present today should be judged on the

position they occupy in the present vegetation and not on their scarcity or abundance during aboriginal times.

The abundance of introduced species in the meadows might be interpreted as detracting from their "natural" scenic values. However, Kentucky bluegrass is ideally suited to withstand heavy trampling and maintain a pleasing appearance. The more robust sedges quickly show the effects of trampling. The annual grasses cover disturbed areas and furnish a cover of vegetation not possible in their absence. Since the annual cover is transitory on all but the driest sites it serves a useful function while more permanent vegetation becomes established.

The meadows are dominated by a few well adapted species which have been able to reoccupy the multitude of areas disturbed in the past. Thus these species are ideal candidates for revegetation purposes. The use of other species may be successful temporarily but more often than not they will be replaced by the "natives". The *Festuca rubra* on the old Village Store site, being a bunch grass, has little chance of successfully competing with the aggressive sod formers. It will probably persist in small amounts for years as another species in the long list of introduced plants. Revegetation efforts should include local species that are used according to site capabilities.

Certain of the introduced plants, such as thistles, are undesirable weeds because they detract from scenic values. Abundance of such species has made them the object of control measures and such action will probably be necessary for a long time. New introductions which will fall in the weed class are likely to occur. Application

of controls before such species become firmly established will increase the efficiency and effectiveness of control measures. There will probably be "population explosions" of certain species in the Valley from time to time. If the species involved are undesirable, controls may be in order. However, the abundance may be due to favorable climatic conditions and the population increase only a temporary one.

The trees which became established in the 1870's serve a useful function in the Valley. By their abundance and stature they screen the extensive campgrounds and physical improvements. In addition, being a young and vigorous stand, they are less hazardous to campers than the old, mature pre-white man specimens. On the other hand the abundance of trees, by obscuring views, is undesirable in the tourists eyes. The degree to which vista clearing is employed is, of course, a management decision. The successional trend toward a forest cover does show that suppression of trees will be a continuing problem.

The methods used to control tree reproduction must be based on present conditions. Fire, as used by the aboriginals, is no longer practical because of the high risk to the immense investment in improvements. The structure of the forest stands, with a continuum of tree sizes, is entirely different from the open forest in which aboriginal burning was conducted. Selection of tree control methods must also take into account the effect on associated vegetation. Alteration of soil Ph, for example, might keep out trees but cause undesirable changes in herbaceous species.

The abundance of tree reproduction throughout the Valley means that any desired density and extent of forest types may be maintained.

The black oak grove at Yosemite Village is one exception. The lack of reproduction and the very slow growth of this species calls for efforts to determine the limiting factors involved if perpetuation of the grove is desired. Another exception is the campground areas. Here the lack of reproduction has placed a time limit -- the life span of the existing trees -- on the forest if use remains at the present level.

The effect of people in the campgrounds is minimal because of the preponderance of very sandy soils. However, soil factors have been altered and may affect the present tree cover. The soil changes are probably more serious than the botanical changes since they are less readily reversible. The recovery of vegetation in the campgrounds closed during World War II and on the many formerly denuded sites in the Valley show that the vegetation has great recuperative power.

The day when the vegetation of Yosemite Valley could be preserved or returned to its "natural" or aboriginal state is long past. "Preservation" must now take the form of manipulation to achieve desired objectives. Manipulation of plants requires a thorough understanding of their ecological relationships. With such knowledge man can select, initiate, guide, and arrest the changes which will result in the vegetation type best suited to his goals.

SUMMARY

The first white men to enter Yosemite Valley in 1851 described the vegetation as being "parklike". Descriptions by early visitors and photographic evidence from the 1860's establishes that the Valley was at that time occupied by extensive meadow areas and very open forests and woodlands with a minimum of understory brush and reproduction. There is evidence that fires, set intentionally and accidentally by the aboriginals and originating from natural causes, were a major reason for the presence of large meadows and open woodlands. Another influence was the use of brush for fuel and hand pulling of young trees and shrubs by the aboriginals.

A successional trend toward a forest cover existed before the white man made his appearance. The fact that it was necessary for the aboriginals to use fire and hand eradication to maintain the open meadows and woodlands suited to their needs attests to the existence of this trend. Further evidence is furnished by the presence of an intermediate aged stand of trees which became established about 1800, during a period when the aboriginals were absent or at least used the Valley very little.

The arrival of white man marked the end of the aboriginal culture as a dominant factor in the Valley. Occupation by the white man was very rapid with year-round residence beginning in 1862. The large number of visitors attracted to the Valley, even when it could be reached only by a long and arduous horseback journey, is amazing. The livestock necessary for transportation caused grazing, never an important factor in aboriginal times, to become a major influence which continued until the 1920's.

The present age of post-white man trees in the Valley indicates that widespread establishment began about 1870. Factors that contributed to the increase in woody cover included the halting of intentional burning, the control of natural fires, and heavy grazing. Grazing, by reducing the vigor of herbaceous plants and causing compaction and drying of the soil, created conditions ideal for tree and shrub establishment. Grazing cannot be considered a basic cause of the spread of trees because seedlings became established in meadow areas after grazing ceased. Drying influences were not necessary to permit tree establishment as is evident from the early invasion of Black Spring and other very wet habitats. This leaves replacement of the aboriginal practices as the major cause of tree spread. Heavy grazing and accompanying drying influences merely accelerated the process. Timing of the widespread establishment of trees may have been influenced by climatic factors which resulted in abundant seed crops and seasons favorable for seedling survival. The extensive nature of the tree invasion is evident from the decrease of open ground. In 1864 there were 750 acres of meadow; today there are only 334 acres.

The widespread establishment of trees and shrubs on meadow lands during the 1800's was adverse to the current land usage, grazing and hay growing. Efforts were made to keep at least a part of the meadow areas free by clearing the young growth. Besides direct removal by clearing, plowing and mowing kept many meadow areas free of trees. It is not unlikely that in some of the grazed meadows, use was so severe that even brush and young trees were killed. Some intentional burning of meadows during the early 1900's and more recent hand eradication

have prevented the encroachment of trees. Thus, the meadow areas which remain in the Valley today exist largely because they have been kept free of trees by manipulation. On these areas the white man has continued the influence of the aboriginal. Only the method has changed.

On the level portion of the Valley floor the present character of the forests is derived from the trees which became established about 1870. Ponderosa pine and incense-cedar were the principal invaders and are dominants over much of the Valley today. Once established, growth of these trees was very rapid. Today they overtop the black oaks which were a prominent feature of the Valley in the early days of white man's occupancy. The black oaks still make up part of the forest cover and seem scarce only by comparison to ponderosa pine and incense-cedar. The abundance of young oaks indicates they will maintain their position for many years, except, perhaps, in the major black oak grove at Yosemite Village where reproduction is lacking.

Reproduction of incense-cedar forms a dense understory in many of the forest stands on the Valley floor. Ponderosa pine reproduction is also abundant, being thickest in dry areas with interrupted cover. These understory trees are growing very slowly and will continue to do so until released by the death of existing dominants. Seedlings of white fir and Douglas fir are also found and, being very shade tolerant, are able to grow fairly rapidly. It is entirely possible that white fir will in time become a codominant with ponderosa pine and incense-cedar. The presence of an abundance of tree reproduction insures perpetuation of a forest cover over most of the Valley, barring catastrophic destruction.

The development of a closed forest canopy in former open areas or woodland types has caused many changes in the herbaceous understory. As the forests mature, micro-environmental changes will occur, accompanied by further changes in the herbaceous plants. Sampling of the herbaceous understory showed that there is a great deal of difference in both density and species composition between wet and dry habitats even though the composition of the forest cover is essentially the same.

The vegetation of the meadows has changed a great deal. As described by Whitney in 1868 the meadow vegetation consisted primarily of sedges and a few grasses adapted to a very wet habitat. Sampling of the meadows showed that while sedges are still abundant the species of grasses formerly listed as characteristic are very rare. Introduction of a wide variety of hay grasses and other alien species of grasses and forbs coincided with extensive disturbance of the native plants by grazing, mowing, and plowing. The meadows are now dominated by sedges in the wetter portions and by Kentucky bluegrass on drier sites with wild-rye and redtop occupying intermediate sites. Redtop and probably Kentucky bluegrass are introduced species and wild-rye a native species which has increased in abundance.

Annual grasses are abundantly present on dry or frequently disturbed sites. They represent a group of introduced plants that are ideally suited to the Mediterranian-type climate. This insures them a place in the vegetative cover.

A vast number of forbs, both annuals and perennials, have been introduced. Some of these are able to compete successfully with sedges and grasses. They detract from the appearance of the meadows. These

weeds have been the object of control measures for many years. The majority of the introductions are present in small numbers and become abundant only in pioneer stages on disturbed areas. With their characteristically long-lived seeds these plants will remain as a potential, if not active, part of the vegetation. Abundance will fluctuate widely with climatic conditions and the creation of suitable habitats by disruption of the more stable meadow type. With vehicles arriving from every state in the Union it is to be expected that new introductions will continue to appear.

There is little doubt that extensive mowing, plowing, grazing, and removal by humans has caused a reduction in the population of some of the native forbs or wildflowers. However, there is no objective data which can be used to measure the reduction. The abundance of flowers is probably climatically based and, as in the past, will continue to fluctuate greatly from year to year.

Although the meadows have had a long history of disturbance, they appear healthy today. Meadow plants have reestablished themselves on areas of recent heavy grazing such as the Elk Paddock and on areas of complete denudation like old roads and the old Sewer Farm. The present distribution of species on such areas reflects moisture gradients and soil factors - not the type of disturbance. The type of disturbance is reflected only if soil and moisture relations were altered and in the time necessary for recovery, complete denudation taking the longest.

The abundance of plants adapted to relatively xeric habitats indicates that the Valley floor is drier than when first seen by white man. The period since such temporary drying influences as plowing and grazing has been sufficient to allow reestablishment of mesic types if

conditions permitted. This has not occurred on many areas. The reason must be that the necessary moisture is no longer available. Since the late 1800's there have been many efforts to halt the cutting of river banks. The channel has been cleared of obstructions which may have accelerated the downward cutting of the river. If the channel has been deepened overflow is less and of shorter duration, the ground water level is lower, and the floor of the Valley consequently drier. Extensive building of roads has also been a drying factor in at least local areas. Raised roadways with their ditches tend to concentrate surface runoff. Subsurface drainage may also be affected. The damming action of roadways has created wetter habitats, such as the small swamp above the highway at Black Spring. Some of the meadows were drained for mosquito control, a direct drying influence.

Most of the influences of white man which have caused vegetational changes are historical. However, the influence of the current million-plus visitors a year is very obvious. The campgrounds, adjacent river banks, picnic areas, and beaches are virtually devoid of understory vegetation due to continuous trampling during the summer months. This suppression of plant growth will continue as long as use of the areas continued at the prevent intensity.

The influence of people is not confined to physical destruction of vegetation in the areas of high concentration. Litter layers are largely removed and the soil is compacted. Infiltration is reduced, internal water storage capacity restricted, and surface runoff and erosion increased. The preponderance of sandy soils which do not compact easily has kept these serious changes to a minimum.

The vegetation as it existed during aboriginal times has been used as a basis for measuring changes which have occurred. It has been established that vegetational changes have been extensive and that white man has been an accelerating or causative factor for most of them. However, evaluation of changes must be made on the basis of the present use of the Valley, not on the basis of aboriginal use.

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