UNIVERSITY OF CALIFORNIA PUBLICATIONS.

COLLEGE OF AGRICULTURE.

AGRICULTURAL EXPERIMENT STATION.

THE VALUE OF OAK LEAVES FOR FORAGE.

By W. W. MACKIE.

SIGNAL PEAK, IN EASTERN MENDOCINO COUNTY.

Slopes covered with low-growing *Quercus garryana*, and open places where covering has been killed by sheep. In the foreground is False Hellebore (*Veratrum*), an indication of moist ground.

BULLETIN No. 150.

(Berkeley, April, 1903.)

SACRAMENTO:

W. W. SHANNON, : : : : SUPERINTENDENT STATE PRINTING.

1903.

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THE VALUE OF OAK LEAVES FOR FORAGE.

The exploration in the course of which the data and samples forming the basis of this bulletin were gathered, was originated by the Bureau of Forestry of the Department of Agriculture, with a view to a study of the forest resources of the region in question. At my request, Mr. Mackie paid some attention to the pasture conditions existing there, to serve as a complement to the previous exploration of Mr. Joseph Burtt Davy in northwestern California, the results of which were published in Bulletin No. 12, of the Bureau of Plant Industry of the Department. Mr. Mackie found somewhat unexpectedly that a large part of the actual nourishment of stock in the region was obtained by browsing on the various oaks, and on his return I suggested to him, as an interesting subject for his graduating thesis, an examination of the chemical composition and nutritive value of the several kinds of oak leaves usually eaten by stock. The results of this work, carried out in the Station laboratory, together with the general information obtained regarding the importance of browsing forage as against the rapidly deteriorating grass range, form the subject of this paper.

E. W. HILGARD.

During the summer and fall of 1902, while experting a forest reserve in the northern Coast Ranges, the writer noticed with surprise and interest the eagerness with which leaves of certain oaks were eaten by live stock. Having this fact in mind, many observations were made in regard to the forage value of each species of oak occurring in the Coast Ranges. These observations, while confined more especially to the extent to which each species was eaten by stock, included also the range or distribution, altitude, and mode of occurrence.

Later in the year, in order to ascertain, if possible, whether these observations indicated fully the real value and significance of these oaks for forage, a chemical analysis was undertaken covering six species of oaks and one of poison oak. Only those species were chosen which occur on hills, ridges, and mountains where tillage is impossible; and the object kept continually in mind was the forage value of the leaves of the different species.

It is the purpose of this paper to give in full the results of both observation and analysis, and to discuss the harmony or lack of harmony between the two.

The ranges covered by the investigation are those situated in Lake County, in eastern Mendocino north of Ukiah to Humboldt County, in the western parts of Colusa and Glenn counties, and in southwestern

Tehama County. These northern Coast Ranges are broken up into many ridges, all running northwest and southeast. Between them are small, narrow, gravelly valleys, with very little cultivable soil. The mountains and slopes are composed of shales or loose soft rocks, often volcanic in formation. The soil formed by decomposition of these rocks on ridges is very shallow and poor—seldom as deep as four feet and commonly two or less. The decomposition of these shales is hastened by the growth of chaparral, herbs, and grasses, and on these poor, shallow, rocky soils the browsing oaks are found. In the sedimentary or alluvial, or even the colluvial soils washed from these mountains, none of the browsing oaks are found. These oaks, therefore, are good indicators of poor, shallow, and rocky soils.

This area is typical of all the northern Coast Ranges, and, in regard to oaks, may be taken also as a type of the southern Coast Ranges. Thus the browsing areas of the Coast Ranges alone cover about one third of the State. Adding to these those areas of the lower foothills of the Sierra Nevada, which are occupied in part by many of these same species of oaks, we have, as the entire region enriched in many places by browsing oaks, about one half the State area.

Of the six species of oaks chosen from this browsing area for investigation and here discussed, three are peculiar to California. The remaining three species (*Quercus garryana*, *Q. californica*, and *Q. chrysolepis*) range north into Oregon, as also does the Poison Oak, a species of sumach. Each of these oaks varies in range according to temperature. altitude, and humidity; and the value of each species as a "browse" increases almost directly with the altitude, except when modified by exposure to the direct rays of the sun. Beginning on the lower hills. the six species succeed one another upward in nearly distinct zones or ranges, as follows: Blue Oak (*Quercus douglasii*), Scrub Oak and Curlleaf Scrub Oak (*Q. dumosa* and its variety, *bullata*), Cañon Live Oak (*Q. wislizeni*), Maul Oak (*Q. chrysolepis*), Black Oak (*Q. californica*), and White Mountain Oak (*Q. garryana*). In addition to these, the Poison Oak (*Rhus diversiloba*) is found commonly everywhere, on hills, slopes, and by streams.

In the following description we will attempt to characterize each individual species in the above order, as regards form, mode of occurrence, range, and the forage value as indicated by the stock feeding upon it.

BLUE OAK (*Quercus douglasii*).

The Blue or Rock Oak reaches, in favored localities, a height of 20 feet, but is commonly found as a small tree about 12 feet high, or as a shrub from 4 to 6 feet in height. It is oval or round in appearance, and is covered densely with dark bluish leaves. The leaves are obovate to oblong, with lobes commonly increasing in size toward the apex. In

young trees and shrubs the leaves are inclined to become spinescent. The acorns, borne in shallow cups, are oval to ovate-acute, and are about 1 to 1½ inches long.

In altitude, this oak is limited to the low foothills and dry valleys where the soil is hard and rocky, and never ranges upward to the higher slopes and valleys. It is found most abundantly in the dry foothills of

PLATE I. QUERCUS DOUGLASII. (BLUE OAK.)

the inner Coast Ranges, but extends from Mendocino County and the upper Sacramento Valley through the Coast Ranges and Sierra Nevada to Tejon Pass, in Kern County, from whence stunted individuals extend to the margin of the Mojave Desert. In the southern Coast Ranges it reaches its maximum height of fully 30 feet.

On account of the dryness of its leaf, only goats and sheep browse on the Blue Oak; but the acorn mast, which is plentiful and quite certain, is excellent feed for hogs, cattle, sheep, goats, and often for horses.

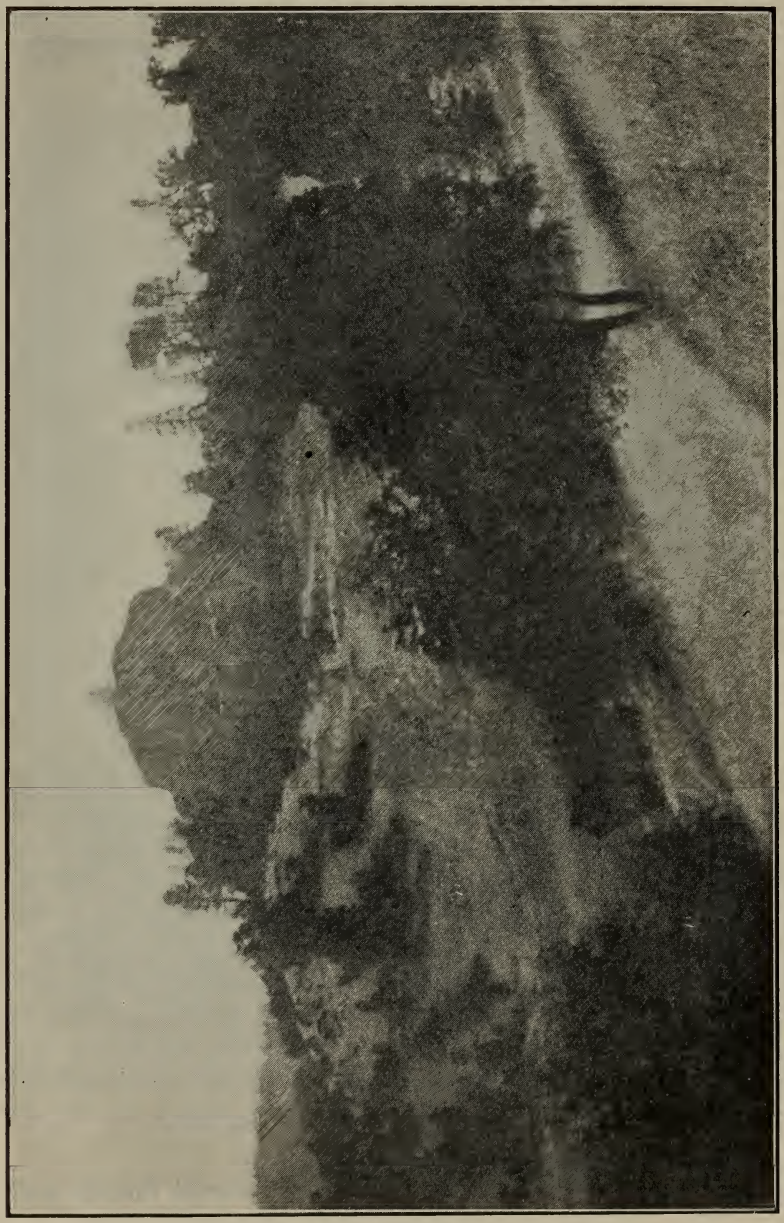

PLATE II. QUERCUS DOUGLASII. (BLUE OR ROCK OAK.)
In its natural range on Eel River, Lake County. Bloody Rock, where the last of the Chumiah Indians perished.

SCRUB OAK (*Quercus dumosa*).

This oak is a round-topped shrub 5 or 6 feet high, consisting of numerous closely tangled branches starting from near the ground. The twigs are usually tomentose, with leaves bunched at the ends. The

leaves are oblong to obovate and entire on the older trees, but are often sinuate-toothed and spinescent in young shrubs. They are pale green in color and pubescent on the lower side. The acorns are oval and

PLATE III. QUERCUS DUMOSA. (SCRUB OAK.)

pointed, from $\frac{1}{2}$ to $1\frac{1}{2}$ inches long, and are contained in shallow cups. The crop is light and very uncertain.

The Scrub Oak is commonly found associated with many other shrubs in the chaparral of the mountains and upper foothill slopes in dry

localities. It ranges from Mendocino County southward through the Coast Ranges to Lower California, and is also found in the foothills of the Sierra Nevada.

This shrub, on account of its low habit of growth, is particularly adapted to browsing, and is one of the best for sheep and goats. Cattle, however, dislike it on account of its harsh, spinescent leaves, but feed on it during the winter when snow has covered the ground, or when from any cause other food is not available.

PLATE IV. QUERCUS DUMOSA, VAR. BULLATA. (CURL-LEAF SCRUB OAK.)

CURL-LEAF SCRUB OAK (*Quercus dumosa*, var. *bullata*).

The Curl-leaf Scrub Oak is a variety with the same habit of growth as the typical species. The leaves differ, however, in having the margins strongly revolute, thus presenting a curled appearance. The under side of the leaf is densely tomentose, and the whole leaf is thicker and rounder than that of the type. The acorns of the variety are similar in size and shape to those of the other, but are contained in even shallower cups.

This oak is seldom found south of San Francisco Bay, and reaches its greatest abundance north of Clear Lake, on the dry eastern slopes of the Coast Ranges bordering on the Sacramento Valley, and extending to Mount Shasta.

The forage value of the variety is apparently the same as that of the type of the species.

PLATE V. QUERCUS WISLIZENI. (CAÑON LIVE OAK.)

CAÑON LIVE OAK (*Quercus wislizeni*).

The Cañon Live Oak when found in the cañons is a tree usually 20 to 40 feet high, but when it passes into the chaparral it is never higher than 8 feet. Here it is an intricately branched shrub with a rounded top. The bark on old trees is rough and thick, but on shrubs it is smooth. The leaves are usually oblong-lanceolate, entire, serrate or dentate, and are lustrous and dark green in color. They are about $1\frac{1}{2}$ inches long and $\frac{3}{4}$ of an inch wide. The nuts ripen in the second season,

and are long, sessile, slender oblong-oval, set in deep scaly cups. The mast is usually scanty.

The shrub is common in the chaparral with *Quercus dumosa*, and ranges with it in altitude. It is well distributed in the Coast Ranges from Mount Shasta to San Diego County, usually at quite a distance

PLATE VI. QUERCUS CHRYSOLEPIS. (MAUL OAK.)
Showing two distinct leaf forms.

from the sea. It also exists, but not commonly, from Mount Shasta through the lower foothills of the Sierra to Tejon Pass.

The leaves of this shrub are sought in preference to those of the Scrub Oak by sheep, goats, and cattle, and it is thus often found stripped of its leaves.

MAUL OAK (*Quercus chrysolepis*).

The Maul Oak (*Q. chrysolepis*), when found growing on well-watered and protected slopes, is a tree 40 to 60 feet in height, with large sweeping branches. On exposed slopes, however, and on the upper ridges and peaks, it becomes a gregarious shrub with *Q. garryana*. The leaves are oblong, acute or cuspidate, entire on old trees but spinose-dentate on young ones and on shoots. They are pale and glaucous above, with

PLATE VII. QUERCUS CALIFORNICA. (BLACK OAK.)

golden tomentum below. The acorn is usually solitary, ovate or oval, ½ to 2 inches long, and borne in a shallow cup. The crop of mast is uncertain and is often ruined by the larvæ of moths.

The range of this oak extends from southern Oregon through the Coast Ranges and Sierra Nevada, and on through the San Bernardino Mountains to Lower California. It often reaches an elevation of 9,000 feet.

Maul Oak is used as a "browse" by sheep and goats, and sparingly by cattle.

BLACK OAK (*Quercus californica*).

The Black Oak is a tree 18 to 30 feet high, usually with several large erect branches. It is generally found near coniferous trees, and apparently occupying the same belt. Young trees often occur in dense growth, and, when in this condition or when overshadowed by other trees, grow slowly, thus enabling stock to browse on them. The leaves of young trees are covered with a dense gray tomentum below, and are pubescent above. On older trees the leaves are glabrous with little tomentum. They vary

PLATE VIII. QUERCUS GARRYANA. (MOUNTAIN WHITE OAK.)

from oblong to broadly ovate in outline, and each is parted into about seven broad lobes. The nut is broadly ovate, one inch in length, and ripens in the second season. The crop is scanty and unreliable.

The range of the Black Oak extends from the Mackenzie River in Oregon through the Coast Ranges and Sierra, and through the San Bernardino Mountains to Lower California. This oak often reaches elevations of 7,000 to 8,000 feet. It is scarce near the coast.

The flexible texture of the leaves of this oak allows it to be easily eaten by cattle and horses as well as by sheep and goats.

WHITE MOUNTAIN OAK (*Quercus garryana*).

Two forms of this species, differing only in range and height of individuals, may be distinguished. The typical form is a tree from 30 to 70

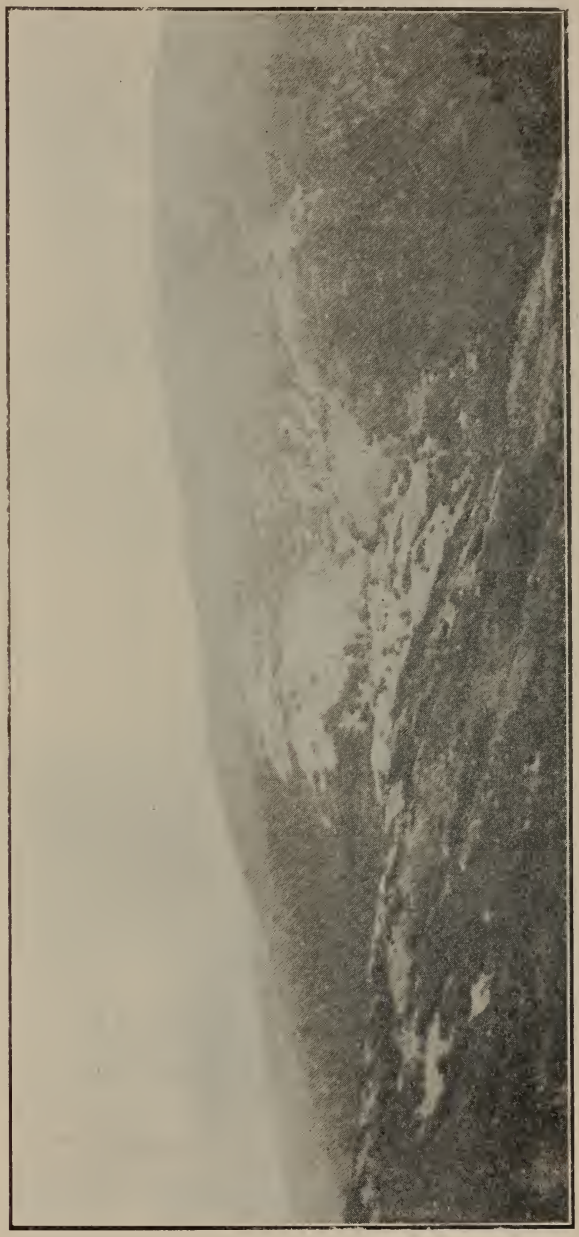

PLATE IX. SANHEDRIN MOUNTAIN, IN WESTERN MENDOCINO COUNTY.
Showing *Quercus garryana* pastures and bare places and erosion, the result of trampling and over-pasturing with sheep.

feet in height, with erect rigid branches. Its leaves are oblong to obovate, 4 to 6 inches long, with coarse lobes. The acorns are sessile or

shortly peduncled, oval to slightly obovate, about 1 to 1¼ inches in length, contained in a shallow cup.

It ranges from Vancouver Island southwestward through western Washington, Oregon, and the Coast Ranges of California, to Santa Cruz. It is the only oak used for lumber on the Pacific Coast, and furnishes the oak lumber for the furniture factories of West Berkeley.

The other form of this species is a mere shrub from 2 to 6 feet high, but identical with the larger form in every other particular.

Its range begins in an exposed portion of western Washington, where apparently it is stunted by the severe sea-breezes. Passing along the western slopes of the Cascades in Washington and Oregon, its elevation continually increases until in California it is found only on the highest ridges and peaks. Its southernmost range is Snow Mountain in Lake County.

The entire range of this oak is swept by cold driving north winds, which apparently serve to keep the temperature and other conditions uniform throughout.

It is to this form of *Q. garryana* that stockmen turn when seeking "browse" in their mountain pasture. It is gregarious over hundreds of acres on the ridges, peaks, and higher slopes in the most exposed places of the northern Coast Ranges. It forms thickets to the exclusion of everything else except the Maul Oak (*Quercus chrysolepis*), and occasionally Wild Cherry (*Cerasus demissa*).

This species, almost unaided, supplies pasture for thousands of sheep and goats as well as cattle and horses, and not only keeps them up, but actually fattens them. The stock keep whole ranges of it eaten down often to within less than two feet of the ground. Aside from the value of the leaves, the acorn, which is quite sweet, forms a rich diet for stock. The mast is usually sure and abundant.

POISON OAK (*Rhus diversiloba*).

The Poison Oak (*Rhus diversiloba*) is usually a small shrub from 2 to 5 feet high, but occasionally it ascends the trunks of trees as a vine, to a height of 15 or 20 feet. The leaflets are orbicular to ovate, glaucous, with distinct venation. They contain an irritating and poisonous volatile oil, which poisons many persons by simple contact or even by diffusion in the air. The fruit is pale, about three lines thick, and quite abundant.

Rhus diversiloba is everywhere common through the hilly portions of California.

On the ranges the leaves and berries are readily eaten by sheep, goats, and horses, but not by cattle, as far as could be ascertained by observation and numerous inquiries. Many of the bushes are stripped entirely of leaves long before they would naturally drop them.

VALUE OF CALIFORNIA OAKS FOR BROWSING PURPOSES.

In summing up the value of these California oaks, the common classification into "live," or evergreen, and deciduous will be made. The former class includes Scrub Oak and Curl-leaf Scrub Oak (*Quercus dumosa* and variety *bullata*), Cañon Live Oak (*Q. wislizeni*), and Maul

PLATE X. RHUS DIVERSILOBA. (POISON OAK.)

Oak (*Q. chrysolepis*). The deciduous oaks consist of Blue, or Rock Oak (*Q. douglasii*), Black Oak (*Q. californica*), and Mountain White Oak (*Q. garryana*). The Poison Oak (*Rhus diversiloba*) is also deciduous.

The live oaks, as seen in the previous descriptions, occupy the brush areas on the slopes and ridges, and, except for a few isolated specimens

of *Quercus chrysolepis*, never grow within the timbered, or coniferous, belt. These live oaks, therefore, occupy a continuous belt of country which is free from snow except for occasional short periods. This belt, for this reason, is used as a winter range for holding-over stock when feed is scarce in the valleys and deep snows cover the mountains. Sheep and goats are kept in good condition on these live oaks, but cattle and horses do not eat them to any extent until other food can not be obtained. Then this "browse" keeps them in feed until other kinds are available.

The deciduous oaks, not taking into account the *Quercus douglasii*, which is of little forage value, are found in the timber belt or above it. The leaves of the deciduous oaks, in contrast to the harsh spinescent ones of the live oaks, are larger, lobed, and soft. This enables cattle and horses to eat them with ease, as is also true of sheep and goats. They actually fatten on the leaves of the Black Oak and White Mountain Oak of these upper ridges and peaks.

Nutritive Value of the Leaves.—From the observations just recorded concerning these several species of oaks, it would seem that the nutritive value increases with the altitude. To verify this, and to ascertain if possible their relative food values, a chemical analysis of each species was made.

For the purpose of this analysis the leaves were gathered during the month of September, when they were fully mature. Only those which were green and vigorous were taken. These were dried in a room of ordinary temperature, and were then ground to a fine powder.

It would seem that the irritating and poisonous oil of Poison Oak (*Rhus diversiloba*) is volatile at a comparatively low temperature. In gathering the specimen the writer was badly poisoned, even though gloves were worn; yet after drying at ordinary room temperature, and the leaves pressed into the mill with bare hands, no poisoning effects followed.

In the analyses of these oak leaves, the methods for foods, as set forth in Bulletin No. 46, Bureau of Chemistry, U. S. Department of Agriculture, were followed. In this work, however, some errors appeared in the ether extract and in the nitrogen-free extract. These errors were due to certain peculiarities of composition of the oaks.

In the determination of fat, or ether extract, quantities of chlorophyll, the green coloring matter in the leaves, remained in the extract. No quantitative method being known for the extraction of chlorophyll, this, together with the gums and resins which are contained within the leaves or on the tomentum and pubescence of the outside, increased the ether extract beyond its true percentage. After determining the nitrogen-free extract, which consists of sugar, starch, pentosans, etc., the percentage

appeared inexplicably high. The only possible explanation seemed to be that the tannin content, which, by the method of difference, falls in this group, had not been accounted for. It was necessary, then, to make determinations of tannin.

In determining the tannin, the method of Günther was followed; that is, two grams of the substance to be analyzed was taken and the tannin extracted with hot water, in which it is easily soluble, until a dilution of 1 to 400 parts was obtained. This dilution is necessary in order that potassium permanganate may completely oxidize tannin in the presence of indigo-carmine. The oxidizing power of the indigo-carmine was determined by extracting all the tannin by means of animal charcoal and titrating with potassium permanganate. The difference between the two titrations was the tannin oxidized by the potassium permanganate.

With these exceptions in the ether extract and the nitrogen-free extract, the regular official method was followed; and the table below gives the results of the analyses of the different species of oak in an air-dry condition. As a means of exact comparison, these results were calculated first to a water-free basis, and finally, to an alfalfa hay basis. The analyses were all carried out in duplicate and the averages found as follows:

ANALYSES OF OAK LEAVES.

Samples Air Dry.

Species.	Water.	Ash.	Protein.	Fiber.	Tannin.	Nitr'gen Free Extract.	Ether Extract.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Blue Oak	5.21	9.32	8.32	33.35	5.00	34.55	4.25
Scrub Oak	3.90	9.42	9.16	26.79	14.06	31.41	5.26
Cañon Live Oak	3.54	9.66	10.95	29.48	9.62	30.89	5.86
Maul Oak	6.53	9.62	8.32	30.35	10.16	31.52	3.50
Black Oak	5.10	9.35	8.15	19.22	10.62	40.50	7.06
Mountain White Oak	4.59	9.44	15.05	16.26	9.01	40.18	5.47
Poison Oak	5.39	8.66	6.85	25.13	6.42	41.05	6.50
Water-Free.							
Blue Oak		9.83	8.78	35.18	5.28	36.45	4.48
Scrub Oak		9.80	9.53	27.88	14.63	32.69	5.47
Cañon Live Oak		10.02	11.35	30.56	9.97	32.02	6.07
Maul Oak		10.29	8.90	32.47	10.89	33.73	3.74
Black Oak		9.85	8.59	20.25	11.19	42.68	7.44
Mountain White Oak		9.90	15.77	17.04	9.44	42.11	5.73
Poison Oak		9.15	7.24	26.56	6.79	43.39	6.87
Water on Alfalfa Basis.							
Blue Oak	10.95	8.75	7.83	31.32	4.70	32.46	3.99
Scrub Oak	10.95	8.72	8.48	24.83	13.03	29.11	4.87
Cañon Live Oak	10.95	8.92	10.11	27.21	8.88	28.52	5.41
Maul Oak	10.95	9.16	7.92	28.91	9.70	30.03	3.33
Black Oak	10.95	8.77	7.65	18.03	9.96	38.01	6.63
Mountain White Oak	10.95	8.82	14.04	15.18	8.41	37.50	5.10
Poison Oak	10.95	8.15	6.44	23.65	6.04	38.64	6.13
Alfalfa	10.95	6.43	17.60	22.63		39.31	3.08

In the discussion of the chemical analysis of these species, alfalfa hay is selected for comparison because alfalfa seems to be the best and commonest forage plant in California. A comparison with this plant, then, naturally sets forth the value of oak leaves for forage to better advantage than a comparison with any other stock food.

Ash Content.—In comparing the ash content of oak leaves and alfalfa, it is noted that the ash of oaks varies but little in various species. This variation is not more than four-tenths of one per cent, while the average ash for all the species is somewhat greater than 8.75 per cent. This percentage is $2\frac{1}{4}$ per cent greater than in alfalfa hay.

As all the mineral, and hence the bone-forming, materials of the plant are in the ash, oak leaves have thus a greater value for growing stock than has alfalfa.

Protein Content.—Proceeding to the protein, or muscle-forming content, greater variations are encountered. The comparison shows alfalfa to contain more than twice as much protein as any of the oaks, with the exception of two species, *Quercus wislizeni* and *Q. garryana*. The former averages 10.11 and the latter 14.04 per cent. *Quercus garryana*, therefore, approaches alfalfa closely. The other species, though falling far below alfalfa, are not poor in protein. The average is nearly 8 per cent, which is one-half of one per cent higher than oat hay—the best of cereal hays.

These analyses indicate that oak leaves are superior in muscle-forming ingredients to non-leguminous hay; that one species (*Quercus wislizeni*) is equal to bur-clover hay; and the best species (*Quercus garryana*) almost equal to alfalfa hay.

Crude Fiber.—In oak leaves the crude fiber is as variable as the protein, ranging from over 30 per cent in *Quercus douglasii* to 15 per cent in *Q. garryana*. With the exception of two of the deciduous oaks, *Quercus californica* and *Q. garryana*, the oak leaves are considerably higher in crude fiber than alfalfa. This crude fiber, or roughage, in oaks tends to produce a wide nutritive ration.

Ether Extract.—The fat, or more correctly speaking, the ether extract, is considerably higher than in alfalfa in all the species, and increases to twice as much in *Quercus wislizeni* and *Q. californica*. This ether extract does not represent pure fat, but includes the chlorophyll, waxes, and resins, which can not be separated from the true fat. These waxes and resins serve to protect the leaves from drying winds and inclement weather, and usually occur in the tomentum or pubescence which cover some leaves. In some cases, as in *Quercus californica*, the waxes and resins are distasteful to stock, thus decreasing their forage value.

Nitrogen-Free Extract.—In oaks the nitrogen-free extract, consisting of starch, sugars, pentosans, etc., does not equal alfalfa in any species, and in Scrub Oak falls as far below as 10 per cent. This fact indicates a lower fattening and heat-producing power than in alfalfa.

Tannin.—Tannin is an astringent principle found in many plants. Aside from its astringent properties, it is acrid, and therefore offensive to the palates of animals. In the stomach, it precipitates the pepsin and peptones, thus preventing the formation of dextrose and hindering digestion. Great thirst and constriction in the digestive tract usually follow an overdose of it. These effects are not so marked in some tannins as in others, for some do not have so great a precipitating power as do others.

In determining the tannins in the oaks, it was found to vary greatly in the different species, but did not serve as an infallible indication of the value of the leaves for forage. For example, *Quercus douglasii*, which is the poorest forage oak analyzed, is lowest in tannin, while *Q. dumosa*, a species preferred by sheep and goats, contains 13 per cent, the largest amount of tannin determined in any one species.

The average of tannin for all the oaks is a little over 10 per cent. In tasting the powdered specimens of the various species, the intensity of acridity perceived coincides with the tannin percentages. In comparison with oak leaves, alfalfa contains an inappreciable amount of tannin.

Water.—Although the water-content of the oak leaves was placed on an alfalfa hay basis, this does not indicate their true comparison when both are green. Green alfalfa contains 80 per cent of water, which is from 10 to 20 per cent higher than that in the various species of oaks. This shows the oak leaves to be a somewhat more concentrated feed in regard to protein, ash, and nitrogen-free extract, than appears in the comparison on an alfalfa hay basis.

Injurious Constituents.—Judging from the results of the chemical analyses of these oak leaves, they would seem to occupy a high place among forage plants. This would be the case were it not for excessive amount of three of the chemical constituents; namely, crude fiber, resins and waxes, and tannin.

The high percentage of crude fiber taken together with the low percentage of nitrogen-free extract produces a coarser and less nutritious feed than leguminous crops.

The resins have pungent and disagreeable flavors, which render them distasteful to stock. A good example of this is seen in the *Quercus californica*, before cited. The leaves of the young trees and shrubs of this species contain no more tannin than those of most of the other species, are only 1⅓ per cent below alfalfa in nitrogen-free extract, have a fair amount of protein, are low in crude fiber, and are large and soft.

These qualities should produce a feed superior to oat hay. This is not the case, however, for stock avoid it to a great extent on account of the resins and waxes in the dense tomentum covering the leaves. These waxes and resins serve as a protection against drying winds and severe weather, and all the oaks have more or less of them.

As compared with the crude fiber and resins, tannin of oak leaves, as before stated, is not only bitter and astringent, but interferes with digestion.

Conclusion.—In summing up the value of the forage oaks, from chemical analyses and observations in the field, the conclusion is reached that the facts observed in the field coincide in most cases with those determined by analysis. For instance, the deciduous oaks possess a higher nutritive value than the live oaks and are, as would be expected, more readily eaten by horses, cattle, sheep, and goats. In some cases, however, certain physical conditions modify these relations. This is true in the case of the live oaks. These contain a sufficiently high proportion of nutrients, and yet only sheep and goats thrive upon them. This is due to the thick, harsh leaves with their spinescent teeth, which prevent horses and cattle from relishing them.

Pasturing Oaks.—Although all stock prefer the deciduous oaks of the higher altitudes, yet indiscriminate pasturing causes much damage to the forests and ground-cover. When sheep and goats are allowed to browse on the deciduous oaks of the timbered area, they kill the seedling conifers by nibbling and trampling, kill the shrubs by over-browsing, and cut up the slopes in trails which become deep gullies during the rainy season. This could be avoided by pasturing the sheep and goats on the "live oaks" of the lower chaparral or brush areas, the only necessary precaution being to prevent too many congregating in one place, thus avoiding too much trampling and gullying.

Since cattle and horses are unable to thrive on the live oaks, and since they do not browse close enough to kill shrubs, never browse on young conifers, nor cut up slopes by trails, they may profitably be pastured on the timbered areas and on the higher altitudes.

Thus, this oak area, comprising half the whole State, can, by a conservative and well-regulated system of browsing, be made to pasture sheep and goats throughout the year, and all stock during the summer months; and also during seasons of drought or when winter conditions make other feed inaccessible.

BIBLIOGRAPHY.

1. Flora of Western Middle California. Jepson.
2. Silva of North America. Sargent.
3. Check List of the Forest Trees of the United States, their Names and Ranges. Bulletin No. 17, Bureau of Forestry. Sudworth.
4. Stock Ranges of Northwestern California. Bulletin No. 12, Bureau of Plant Industry. Davy.
5. Feeding of Farm Animals. Bulletin No. 132, College of Agriculture, University of California. Jaffa and Anderson.
6. Feeds and Feeding. Henry.
7. Official Methods of Analysis adopted by the United States Association of Chemistry. Bulletin No. 46, Bureau of Chemistry, U. S. Department of Agriculture.
8. Plant Analysis. Dragendorff.
9. Chemie der Nahrungs- und Genussmittel. König.