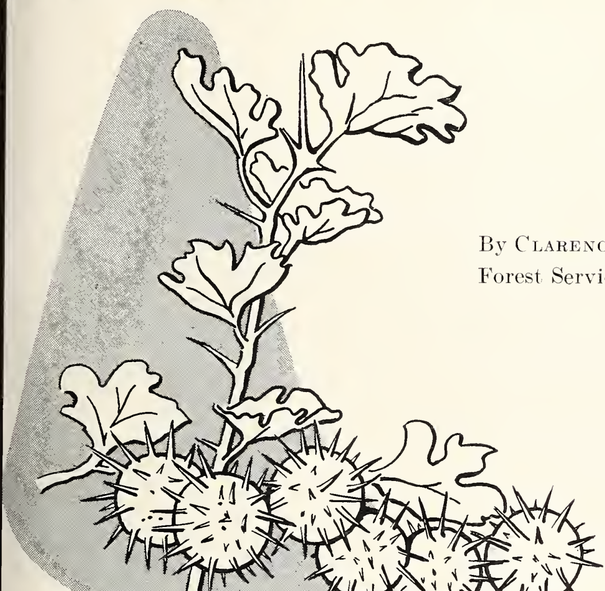
Ecology of the Sierra Nevada Gooseberry in Relation to Blister Rust Control



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CONTENTS

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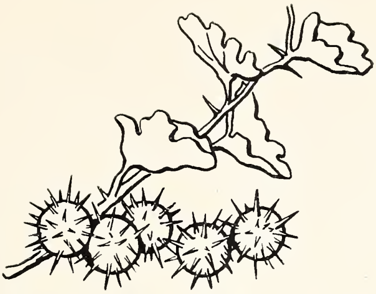
INTRODUCTION

Ecological studies of the genus *Ribes* have been in progress in northern California for more than 20 years. A thorough understanding of the ecology of native ribes in general, and of the Sierra Nevada gooseberry (*Ribes roezli* Regel) in particular, is necessary in connection with the control of the white pine blister rust in California. This disease of five-needled pines, caused by the fungus *Cronartium ribicola* Fischer growing on ribes as its alternate host, threatens to destroy sugar pine (*Pinus lambertiana* Dougl.) on about a million and a half acres of forest land that supports sufficient sugar pine to make rust control economical.

Some of the conclusions from these studies are based on extensive field observations. For the most part, however, they are related directly to analyses of field data collected from several series of plots in California from 1936 to 1949. These plots, selected for sampling the main geographic range of *Ribes roezli*, are distributed from Shaver Lake (Fresno County, Sierra National Forest) on the south to Lake Almanor (Plumas County, Lassen National Forest) on the north.

About 35 species and varieties of the genus *Ribes* L., here construed to include the genus *Grossularia* (Tourn.) Mill., occur in California. A recent taxonomic treatment of gooseberries and currants is given by McMinn (*11*).[1] Several species are commonly associated with sugar pine in the acreages of greatest interest to public and private agencies in California that are in blister rust control units. Approximately 175 million ribes plants were destroyed from 1926 through 1948 for the protection of sugar pine, and of the time and money spent on ribes eradication, perhaps 90 percent was expended on the removal and suppression of one species, the Sierra Nevada gooseberry. In the mixed-conifer forests of the middle altitudes of the Sierra Nevada, on areas suited ecologically to its growth, *roezli* may be found almost everywhere. In favorable sites there may be 3,000 to 5,000 plants per acre.

[1] Italic numbers in parentheses refer to Literature Cited, p. 29.



Ecology of the Sierra Nevada Gooseberry in Relation to Blister Rust Control[1, 2]

By CLARENCE R. QUICK, *Forest Ecologist, Forest Service*

PLANT ECOLOGY IN THE SIERRA NEVADA

Climatology

Precipitation is generally adequate on the western slope of the Sierra Nevada, but it is concentrated in the winter months. On the areas best suited to growth of timber much of the total precipitation is snow. Summer and fall are practically without rain, and the occasional rains are seldom heavy. As a result, soil moisture available to plants during the late summer and fall is scarce. The winter snow pack, when it melts in the spring, frequently saturates the soil mantle. Water then held in the soil constitutes a sort of bank account, to which no appreciable deposit of water is usually made until late fall or early winter. Thus the depth and physical properties of the soil, particularly those relating to maximum water-holding capacity, are of considerable importance in the ecologic niches of sugar pine forests. Although deep, fine-sandy or loamy soils provide outstanding forest sites—especially if favored by some subsurface drainage from higher terrain—shallow, coarse, and rocky soils make arid habitats.

The mountain climates of the Western United States are described by Baker (*2*), and the climates of California by Kesseli (*10*).

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[1] Received for publication August 24, 1953.

[2] Blister rust control investigations at Berkeley, Calif., have been conducted by the Bureau of Entomology and Plant Quarantine in cooperation with the University of California, College of Agriculture, through the School of Forestry. Ribes ecology work was started in California by W. V. Benedict and F. A. Patty in 1927. The author has conducted these studies since 1936. Ecological studies directly concerned with control methods and the silviculture of sugar pine have been aided by operations personnel of the Pacific Coast Blister Rust Control Project and by cooperators in the University of California and the California Forest and Range Experiment Station of the Forest Service. This project has recently been transferred to the Forest Service.

Precipitation records at one station in the Sierra Nevada and at a few stations in other white pine areas are given in table 1.

TABLE 1.—*Percentage distribution of precipitation, by months, at some meteorological stations in white pine areas*[1]

Month	Lake Eleanor, Calif.	Prospect, Oreg.	Bungalow Ranger Station, Idaho	Eau Claire, Wis.	Turner's Falls, Mass.
January	20. 0	15. 9	14. 4	3. 6	8. 5
February	19. 7	12. 6	8. 4	3. 5	6. 8
March	14. 1	10. 0	10. 9	5. 7	8. 5
April	8. 9	8. 1	8. 7	8. 0	8. 0
May	4. 4	5. 9	4. 8	12. 4	8. 4
June	1. 9	3. 7	6. 5	14. 3	9. 0
July	. 3	1. 2	1. 7	10. 8	8. 6
August	. 6	. 7	2. 2	11. 6	9. 5
September	1. 6	4. 1	3. 9	12. 8	9. 9
October	4. 9	7. 8	9. 7	8. 3	6. 9
November	8. 5	15. 7	14. 0	5. 6	8. 3
December	15. 1	14. 2	14. 7	3. 5	7. 6
Annual average precipitation, inches	39. 9	38. 6	41. 8	32. 9	39. 8

[1] Data from the Yearbook of Agriculture.

Because the usual course of storm-track centers is to the north of the Sierra Nevada, and because the circulation of air around low-pressure areas is counterclockwise, air currents there commonly move from southwest to northeast during storms. Better-than-average sites for sugar pine are most often found in localities where air currents during storm periods are forced up steep gradients eastwards towards the top of the range and the Great Basin.

Sierran Montane Forest

A typical Sierran montane forest is a mixture of several coniferous species and of many ages of trees. The most important species are sugar pine, ponderosa pine (*Pinus ponderosa* Laws.), white fir (*Abies concolor* (Gord. & Glend.) Hoopes), Douglas-fir (*Pseudotsuga taxifolia* (Poir.) Britt.), and incense-cedar (*Libocedrus decurrens* Torr.). Jeffrey pine (*Pinus jeffreyi* Grev. & Balf.) and red fir (*Abies magnifica* A. Murr.)often are found in the forest towards the upper altitudinal limits. The Sierran montane forest has been described by Weaver and Clements (*19*, pp. 507–508), and the forest cover types of western North America by the Society of American Foresters (*17*).

The Sierran forest is a complex mosaic of ecologic niches, whose size, species composition, and degree of progression towards the vegetative climax are determined by geology, topography, and climate, modified by such other factors as logging and grazing, and long exposure to intermittent fire. The result is a forest that is most difficult to manage intensively.

Plant species that usually occur only in the initial stages of vegetative successions are known as pioneer species. Such plants are said to be intolerant to shade, and may be contrasted with the tolerants—the shade-tolerant plants. The theory of vegetative succession as it applies to forests is concisely reviewed by Baker (*1*, pp. 244–257).

Smallness of plant body handicaps a species in competition with larger, particularly taller, plants. Small seedling-origin plants of ponderosa pine, snowbrush (*Ceanothus cordulatus* Kell.), and the Sierra Nevada gooseberry appear to be about equally intolerant to shading and to competition. If seedlings of these three species begin growing at the same time—for example, immediately after a fire—dense mature snowbrush often will suppress the gooseberry after 10 to 20 years, and ponderosa pine may eventually suppress the snowbrush. This progressive suppression seems to be due largely to the relative size of the mature specimens of these three species. Rate of early growth and the period needed to reach maturity and produce seed are inversely related to size at maturity.

Pioneer plants may be loosely classed as primary or secondary, depending upon the type of vegetative succession in which they are most commonly found (Weaver and Clements *19*, pp. 78, 79, 107, 113–115). A secondary plant succession develops upon a more nearly mature soil profile than a primary plant succession. In other words, although most of the vegetation is removed at the start of a secondary succession, the soil profile approaches a condition comparable to that under climax vegetation. Vegetative-cover development is usually much slower through primary than through secondary successions, and development through secondary successions is slower on poor than on good sites. Site has been considered in general by Baker (*1*, pp. 190–200). Dunning (*5*) has prepared a site classification for the mixed-conifer Sierran forest. Because of recurrent fire and logging, secondary successions in the Sierran forest are frequent and of outstanding ecologic importance.

AUTECOLOGY OF THE SIERRA NEVADA GOOSEBERRY

The Sierra Nevada gooseberry is a pioneer species. It will tolerate the severe site conditions of a primary succession, but grows most abundantly in secondary successions—*i. e.*, on denuded areas. It is a low shrub. In dense brush it may send some branches 4 or 5 feet into the air, but in the open it grows as a low rosette, or mound. On open, burned, and destructively logged areas the species grows with a vegetative and reproductive vigor that is remarkable.

This gooseberry apparently is nitrophilous, and therefore survival and early growth of seedling-origin gooseberry bushes may often be favored by association with snowbrush and other species of *Ceanothus*, all of which apparently harbor nitrogen-fixing bacteria in nodules on their roots. This relationship has been studied and discussed by Quick (*15*).

Morphology

The Sierra Nevada gooseberry, in common with other native gooseberries of pioneer habitats, regularly forms no terminal buds, and therefore has an indeterminate growth. Such species grow vigorously throughout the season until lack of soil water, lack of space, or low temperatures terminate growth. In contrast, many native ribes, including the shade-tolerant Sierra Nevada currant (*Ribes nevadense* Kell.), develop terminal buds late in the summer, often when conditions for growth still appear to be favorable.

Many of the native gooseberries, including *roezli*, have marked woody enlargements, or crowns, between roots and stems which bear numerous adventitious buds around the canes arising from the crown (fig. 1). Any fragment of crown attached to an undisturbed root can

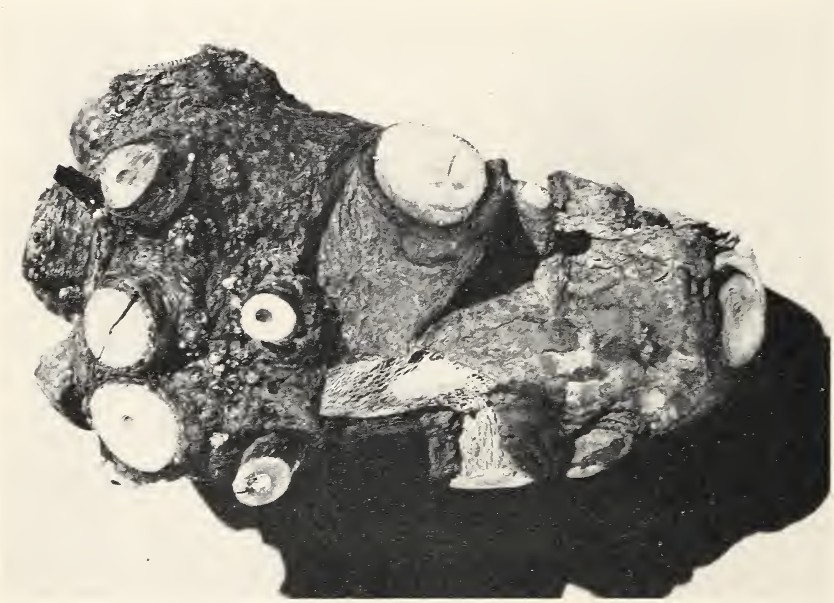

FIGURE 1.—Crown of a young *Ribes roezli* plant, showing numerous adventitious buds among the cane bases. Stems and roots have been removed.

regenerate a plant with surprising rapidity, but *roezli* roots do not form foliage buds. Root cuttings fail to produce plants, but stem cuttings can be rooted easily. Gooseberry stems attached to living plants and in contact with the ground frequently layer, and the crowns of large, old open-grown plants with canes that have been repeatedly flattened against the ground by snow, often are surrounded by numerous auxiliary crowns in various stages of development.

Diseases

Leaf anthracnose and downy mildew are common diseases of gooseberries. The leaves and fruits often drop prematurely, and although the plants are weakened, they are seldom if ever killed. These and other diseases thereby favor competing species, but appear to be of no general importance in gooseberry ecology or in ribes control problems.

The fungus *Cronartium ribicola* sometimes defoliates *roezli*. However, the importance of defoliation is outweighed by the fact that rusted gooseberry leaves on the ground are much less likely to spread the disease back to white pines than are similar leaves borne on canes some distance above the ground. Thus the persistence or nonpersistence of severely rusted leaves is a factor in the rust-hazard rating of the various *Ribes* species.

A troublesome complication of rust morphology on native ribes bushes is the confusion in the field between the white pine blister rust fungus and the pinyon rust fungus (*Cronartium occidentale* Hedgcock, Bethel and Hunt). Positive differentiation of these two rusts is a matter of microscopic examination of teliospores stained under carefully controlled conditions of time, temperature, and pH.

A general review of literature on white pine blister rust has been given by Boyce (*4*, pp. 206–225). A summary on the rust in western North America has been prepared by Mielke (*12*).

Seeds and Distribution

Seeds of the Sierra Nevada gooseberry are small, brown, and subglobose, or somewhat angular. They average from 500 to 650 per gram, or 225,000 to 295,000 per pound. Seeds extracted from mature fruits and stored air-dry for 2 months or more are easily conditioned for immediate germination by stratification (continuous moist aerated storage at 36° F. for 14 to 16 weeks, or at 32° F. for 18 to 20 weeks). However, seeds cultured as soon as extracted from fresh ripe fruits cannot be conditioned for immediate germination by such stratification. Seed viability is normally high; when seed samples are properly aged and conditioned by stratification, germination often is as high as 90 to 95 percent.

When properly stored, gooseberry seeds are longlived. In 1931 Frank A. Patty packed some ripe fruits in fine sand and buried them in inverted quart milk bottles in the forest floor under a mixed stand of sugar pine and white fir. Seeds periodically recovered from these caches were highly viable. Seeds extracted from fruits collected in 1936 and stored airdry in corked vials at 36° F. had lost about half of their viability in 1948. However, most of the seeds from the same collection stored in seed envelopes in a greenhouse cabinet had lost most of their viability within 3 years.

Viable gooseberry seeds have been recovered repeatedly from samples of duff and soil collected from sugar pine stands where no gooseberry plants were then growing and where, from an ecologic point of view, none might be expected to grow. Some of these seeds had certainly been in the forest floor for many years.

For example, in the fall of 1947, 66 samples of duff and soil were collected from the forest floor under a virgin stand of mixed conifers in the NW ¼ sec. 26, and in the NE ¼ sec. 27, T. 4 N., R. 18 E., Stanislaus National Forest. Each sample represented 1 square link of surface—*i. e.*, 0.00001 acre. The total depth of collection varied among the samples, but in general all material down to fairly solid and undisturbed mineral soil was collected at each site. By various processes each field sample was reduced separately to a seed concentrate. These concentrates were visually inspected, and then cultured for germination of viable seeds.

Table 2 summarizes the numbers of seeds found in the 66 samples, which represent a total area of only ⅔ milacre. Seeds and very young seedlings of *Ceanothus parvifolius* were not distinguished from those of *cordulatus*, and the data for it are included. Seedlings developed from all but 3 samples.

TABLE 2.—*Number of viable seeds recovered, and seedlings produced, from 66 samples of duff and soil collected under a virgin stand of mature mixed conifers in the Stanislaus National Forest, Calif., 1947*

Species	Seeds recovered	Seedlings produced	Samples producing seedlings
Ceanothus cordulatus and *parvifolius*	2, 660	[1] 1890	48
Ceanothus integerrimus	250	188	28
Arctostaphylos spp.	87	14	3
Ribes spp.	66	191	30
Other dicotyledons	715	571	33
Grasses and sedges	(2)	184	8
Total	3, 778	[1] 3, 038	
Mean per sample	57	46	

[1] Not all *Ceanothus* seeds were cultured for germination.
[2] Included, if observed, with data for other dicotyledons.

Gooseberry seeds are disseminated by rodents and bears, by water and gravity, especially during periods of spring runoff, and probably also by birds, deer, and cattle. Small rodents are usually hungry. Chipmunks (*Eutamias speciosus*), probably also mice and ground squirrels (*Citellus beecheyi* and *C. callospermophilus lateralis*), eat many gooseberry fruits and destroy large numbers of seeds in the process. Several experiments with temporarily caged chipmunks have shown that all ingested gooseberry seeds are destroyed. It has been observed, however, that rodents frequently leave one or more viable seeds in the skin of fruits. Thus rodents disseminate, as well as destroy, gooseberry seeds. Chipmunks also cache seeds in small holes that they have dug in the forest floor (Ingles *9*, pp. 110, 111). Groups of 20 to 80 current-season gooseberry seedlings are occasionally found early in the spring in open forested areas. Careful excavation of these seedling groups has usually disclosed no fruit pulp, skin, or spines. Gooseberry seeds are therefore presumed to be one kind of seed that chipmunks cache and sometimes forget.

Robins (*Turdus migratorius* subsp.) and other thrushes often eat *Ribes nevadense* fruits. Chickadees (*Penthestes gambeli* subsp.) have been observed eating fruits of the wax currant (*R. cereum* Dougl.). Some skins and seeds of fruits eaten by birds are regurgitated; others apparently are defecated. In germination tests recovered seeds of both kinds have shown a high rate of viability. Although birds have not been observed feeding on *R. roezli* fruits, they probably do so and could disseminate the seeds widely.

The writer once collected part of a scat of bear (*Euarctos americanum*) that consisted largely of skins, spines, and seeds of ripe gooseberry fruits. Other similar bear scats have been observed. Several thousand seeds subsequently recovered from the one collection were from 75 to 85 percent viable in germination tests.

Deer (*Odocoileus columbianus*) have been observed eating gooseberry fruits. Range cattle also probably eat them, and both these grazing animals may occasionally disseminate viable seeds.

Seedling Occurrence

Gooseberry seedlings are found in considerable abundance after a fire. As evidenced by scars on trees 400 to 600 years old and by many patches of fire-type brush developing back towards vegetative climax, fire was obviously common in sugar pine forests long before the arrival of the white man. This long history of recurrent fire, with subsequent appearance, growth, and fruiting of sizable gooseberry populations, is presumed to be the major reason why viable seeds may still be found almost anywhere in the soil and duff of sugar pine forests.

Most of the gooseberry seedlings that develop after a fire appear the first spring after the burn, and few or no seedlings appear after the second or third spring. For example, about 1.5 acres of mature uncut, relatively undisturbed, mixed-conifer forest near Cow Creek Guard Station, Stanislaus National Forest, burned accidentally in the fall of 1936. Several hundred current-season seedlings were counted on the area in July 1937; about 80 additional seedlings appeared in 1938, and about 20 more in 1939. After 1939 no new seedlings resulting from the burn were observed. This germinative response of the Sierra Nevada gooseberry has been confirmed by data from several other similar plots. On some severe burns no new seedlings appeared after the first spring subsequent to the fire.

Current-season seedlings also occur abundantly on logged and unburned areas, but they continue to appear over long periods of time. Results from a 1.6-acre plot established by Patty bear on this point. The plot lies at an altitude of about 6,250 feet just south of Cow Creek, a tributary to the Middle Fork of the Stanislaus River, in the Stanislaus National Forest. The plot area, which was almost completely disturbed by logging in 1925, is crossed by a logging railroad spur and includes a donkey landing that once was much used but has long since been deserted. When the plot was established in 1930, the *Ribes* population had already grown to 1,450 plants of *roezli*, 23 plants of *nevadense*, and 1 plant each of *cereum* and *viscosissimum* Pursh. These *ribes* bushes were all removed in September 1930. The eradicated *roezli* bushes bore an estimated 37,800 mature fruits—*i. e.*, about 1.5 million seeds. The bushes of the other *Ribes* species were not fruiting.

Since 1930 this plot has been inspected frequently. Table 3 records the ribes seedlings and seedling-origin plants removed from 1 acre of this area from 1937 to 1946. Current-season seedlings were estimated at each inspection, but were not removed from the plot until the following inspection. Thus, barring errors of age determination, of the estimated 7,015 current-season seedlings observed but left on the plot in 1937, the following were found and removed: 4,100 one-year-old seedlings in 1938, 755 two-year-old plants in 1939, 77 three-year-olds in 1940, and 8 four-year-olds in 1941. Estimates of current-season seedlings are believed to have been somewhat low.

By 1940 the plot was almost completely covered with snowbrush and for the last several years many of the ribes bushes have been growing slowly. Numerous 2- to 5-year-old bushes removed at recent

TABLE 3.—*Number of ribes seedlings of different ages removed from a 1-acre plot near Cow Creek, Stanislaus National Forest, Calif., 1937–46*

Date inspected	Current season seedlings [1]	Seedlings removed, by indicated age								
		1 year	2 years	3 years	4 years	5 years	6 years	7 years	8 years	Total
June 14, 1937	7, 015	5, 260	628	103	21	4	0	[2] 1	0	6, 017
15, 1938	6, 150	4, 100	277	39	7	2	1	0	0	4, 426
20, 1939	4, 440	6, 204	755	78	18	3	1	0	[3] 1	7, 060
25, 1940	1, 690	1, 491	398	77	15	3	1	1	0	1, 986
23, 1941	1, 165	308	147	61	8	1	1	0	0	526
July 1, 1942	3, 470	777	94	46	13	4	0	0	0	934
June 29, 1943	1, 100	1, 010	131	39	22	4	2	1	0	1, 209
July 4, 1944	1, 030	485	103	27	4	5	2	1	0	627
June 28, 1945	815	727	143	69	10	0	1	1	1	952
18, 1946	900	475	119	40	19	5	1	1	0	660
Total	27, 775	20, 837	2, 795	579	137	31	10	6	2	24, 397

[1] Not removed from plot.
[2] This 7-year-old *cereum* plant had about 6 inches of live stem
[3] An 11-year-old nonfruiting *roezli* bush.

inspections had only a few inches of live stem per bush, but some bushes were large and vigorous. In June 1937 a characteristic group of current-season seedlings of *roezli* was found under the edge of the crown of a large snowbrush plant (fig. 2).

FIGURE 2.—Current-season seedlings of *Ribes roezli* growing under the edge of the crown of the snowbrush.

Table 4 presents a breakdown by size of bush for 180 ribes seedlings found in 1949 on subplot 2 (0.2 acre) of this plot. The numerous small bushes that were not found for several years indicate the extreme difficulty of finding them in dense brush. Data from several additional plots, similar to those shown in table 3, indicate that, once a crop of gooseberry seeds has been permitted to mature on an area after a major disturbance, complete suppression of this plant is likely to be a long and expensive undertaking.

TABLE 4.—*Number of ribes bushes, by age and length of live stem, found in June 1949 on a 0.2-acre subplot near Cow Creek, Stanislaus National Forest, Calif.*

Estimated year of seedling origin	0–4.9 inches	5–11.9 inches	12–35 inches	3–5.9 feet	6–11.9 feet	12–24.9 feet	More than 25 feet	Total
1948	37	1						38
1947	30	22	10	3				65
1946	11	14	20	11	3	3		62
1945	1		2	2	3	1	1	10
1944			2	1		1		4
1942 [1]				1				1
Total	79	37	34	18	6	5	1	180

[1] No bushes of 1943 origin were found.

The duration and intensity of gooseberry regeneration from seed after a combination of fire and logging have not been thoroughly defined by plot data. It is assumed that whichever disturbance takes place first will set the pace for the subsequent ecologic reactions. If fire follows logging, seedling regeneration will resemble the pattern of logging rather than of fire. If logging follows fire, as in salvage operations on a burn, the pattern of seedling incidence will approximate the pattern following fire alone, unless the salvage operations take place before the first crop of seedlings appears in the spring after the fire.

Indications are that gooseberry seedlings will be suppressed more rapidly, more easily, and more cheaply on unburned logged areas, where no gooseberry fruits have been permitted to mature subsequent to logging, than on areas where a single crop of seed has matured.

Seedling Survival and Growth

Seed germination with the resultant appearance of seedlings is the first stage in the important ecologic process of colonization. A more critical stage in colonization by pioneer species, including the Sierra Nevada gooseberry, is survival and establishment of seedlings. Little importance need be attached to small, slow-growing gooseberry seedlings, which are barely able to become established in the vegetation.

Many variations of seedling survival and establishment have been observed in collected data. The suitability of a specific niche for the establishment and growth of gooseberries, although depending largely upon the ecologic development of associated vegetation, also seems to be dependent upon the time elapsed after logging or other disturbance.

An open area 10–15 years after logging is not so favorable a gooseberry habitat as an equally open area just subsequent to logging.

A plot of 21 milacres, established in June 1937 along Cow Creek near the 1.6-acre seedling-occurrence plot previously described, illustrates the loss of vigor of gooseberry seedlings that survive after logging. Some of the data from this plot are summarized in table 5. Both occurrence and persistence of seedling-origin bushes have run down rather rapidly since the plot was established. However, in 1945, 20 years after logging and 12 years after the initial bushes had been removed, 3,500 current-season seedlings were found per acre. The rate of growth had diminished greatly. This is not shown in table 5, but was apparent in the assembled data.

TABLE 5.—*Number of seedling-origin ribes bushes of different ages surviving on a 21-milacre plot near Cow Creek, Stanislaus National Forest, Calif., 1937–49*

Date of inspection	Current-season seedlings	1 year	2 years	3 years	4 years	5 years	6 years	Total
June 23, 1937	2, 598	200	33	5	3			2, 839
July 11, 1938	1, 073	816	87	25	5	1		2, 007
June 9, 1939	957	839	401	72	14	5		2, 288
22, 1940 [1]	270	107	567	471	93	16	8	1, 532
19, 1941	279							279
20, 1942	279	50						329
23, 1943	104	18	35					157
22, 1944	201	14	10	18				243
26, 1945	73	42	5	4	13			137
14, 1946	50	18	26	5	2	11		112
July 9, 1947 [1]	31	13	15	22	4	2	9	96
9, 1948	2							2
June 18, 1949	185							185

[1] All ribes bushes were removed at these inspections.

A marked decrease in the suitability of a site for seedling survival and growth of gooseberries is illustrated in figure 3. The vegetative cover practically precludes survival and establishment of seedlings.

The vigor and growth of gooseberry bushes on newly disturbed areas are directly proportional to the available space and the soil moisture. Rapid rates of growth have been observed on moist, high-quality sites denuded by logging or fire. An example of rapid growth is a 4-year-old bush taken in August 1938 from a recently logged area in the Devil's Gulch, Chowchilla Mountain, Sierra National Forest. The lengths of live stem on this bush, by years of growth, were as follows: 1934, 0.4 foot; 1935, 0.9 foot; 1936, 6.2 feet; 1937, 51.6 feet; and 1938, 193.8 feet; a total of about 253 feet for 5 years of growth. Figure 4 pictures a 2-year-old seedling of rapid growth observed in the same general area.

Another example of rapid growth, and of the great size attained by some gooseberry bushes in favorable niches, is the record taken in June 1936 of a bush growing on the practically denuded Stinchfield

FIGURE 3.—*A*, A small, mechanically denuded area 2 years after logging, showing vigorous gooseberry regeneration among scattered seedling-origin manzanita and *Ceanothus* plants. *B*, Same area 5 years later, when snowbrush has overgrown the area. Gooseberry seedlings would have little chance of becoming established under the dense brush.

Figure 4.—A 2-year-old gooseberry seedling of rapid growth on an area practically denuded by logging.

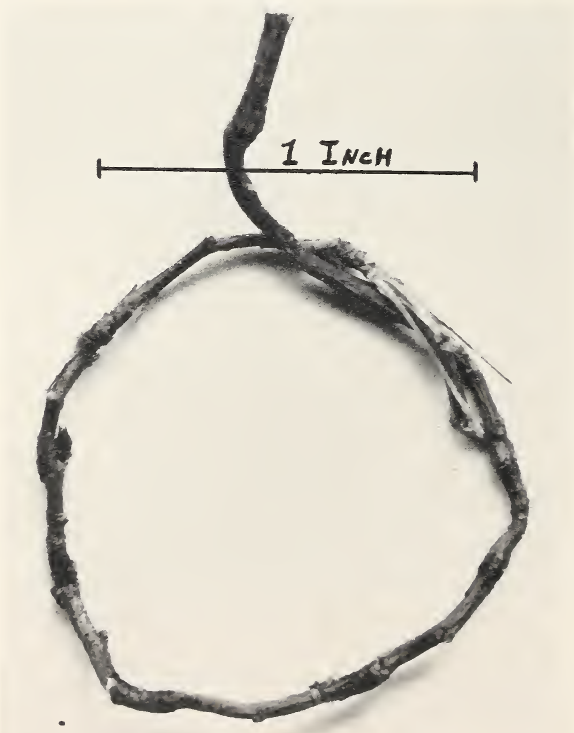

Figure 5.—Coiled stem of a small gooseberry plant of very slow growth suppressed by dense mixed brush. At least nine annual increments of growth are evident on the stem.

Slash, Strawberry area, Stanislaus National Forest. The lengths of live stem on this bush, by years of growth were as follows: 1928,0.2 foot; 1929, 0.3 foot; 1930, 0.3 foot; 1931, 11.2 feet; 1932, 53.4 feet; 1933, 103.1 feet; 1934, 32.0 feet; 1935, 301.0 feet; and 1936, 103.5 feet; a total of 605 feet.

Towards the other extreme of growth are severely repressed bushes, occasionally found in well-advanced stands of timber or in dense brush, which average only an inch or so of live stem per year of age. Figure 5 pictures the dry stem of a small, slow-growing bush which, when collected at an age of 9 to 12 years, had only about 5 inches of live stem.

Fruit Production

Because of the fruiting characteristics of *Ribes roezli* (fig. 6), one prime objective of many local control efforts is the prevention of reseeding once eradication work has been started. Seedling-origin gooseberry bushes may produce quantities of fruit in 3 or 4 years, and enormous numbers in 5 to 8 years. Patty found an average of 40 seeds in 2,000 fruits collected in September 1930 from bushes growing along Cow Creek at an altitude of about 6,250 feet.

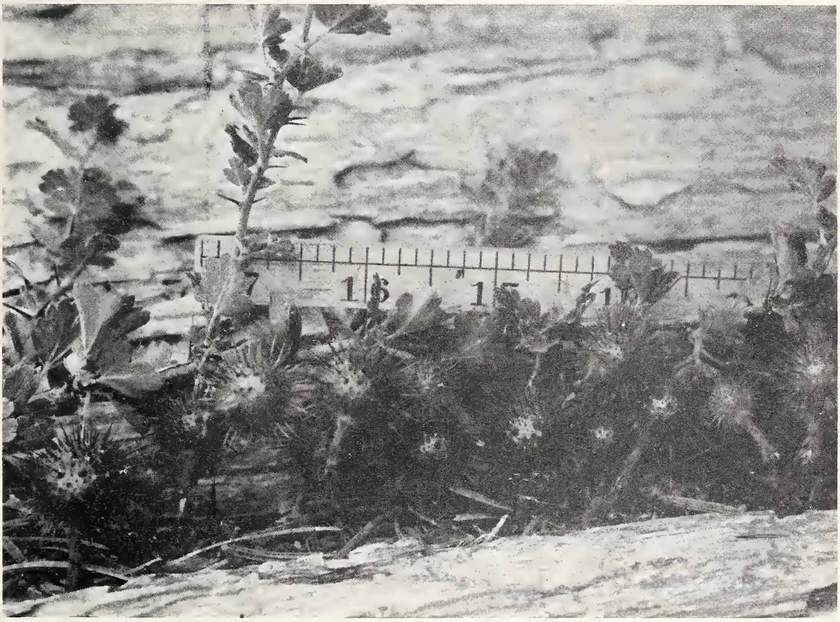

FIGURE 6.—Small branch of *Ribes roezli* with mature fruits. Each berry contains about 40 seeds.

After initial eradicative work has been done on any area, there may remain one or more of the following types of gooseberry bushes: (1) Crowns of incompletely removed bushes, (2) small layers from the large old bushes with multiple crowns so frequently found on initial work areas, and (3) small seedling-origin bushes. These types differ considerably in growth and fruiting characteristics. The following data, collected in 1937 from selected bushes on Chowchilla Mountain from an area that had been given an initial working in 1935, illustrate this point. Bushes from resprouting crowns averaged 8.9 feet of live stem per plant and bore 4.5 fruits per foot of 1936-origin live stem, bushes from small layers averaged 11.8 feet of stem and bore 7.2 fruits per foot of 1936 stem, and selected seedling-origin bushes of exceptional vigor averaged 19.7 feet of stem but bore no fruits.

When small populations of vigorous gooseberries are surrounded by undisturbed vegetation—as for example on a small burn in well-developed forest—or when only a few bushes are fruiting in a waning population in well-developed vegetation, rodents may destroy practically all the seeds that are produced. Such an instance has been studied on a small burn of about 1.5 acres in near-virgin timber close to the Cow Creek Guard Station (table 6). The burn occurred late in the summer of 1936, and large numbers of seedlings had become established by 1939. In 1941, the first year that bushes of postburn origin bore fruits, the number of fruits had changed from 1,206 (May 20–31) to 25 (August 11–20), largely through destruction by rodents. Records for 1942–46 show comparable reductions in fruit production. At the inspection closest to June 15 of each year, the numbers of bushes bearing fruits were as follows: 1941, 15 bushes; 1942, 28 bushes; 1943, 57 bushes; 1944, 106 bushes; 1945, 81 bushes; and 1946, 123 bushes. It is believed that during this period no fruits and only small numbers of seeds escaped the rodents.

TABLE 6.—*Destruction of gooseberry fruits by rodents on 1.5 acres of timber burned in 1936, as shown by the number of fruits collected at various inspection periods during the season. Cow Creek Guard Station, Stanislaus National Forest, Calif., 1941–46*

Inspection period	1941	1942	1943	1944	1945	1946
May 20–31	1, 206	-------	-------	-------	-------	-------
June 1–10	429	-------	-------	-------	-------	-------
11–20	114	-------	1, 254	3, 934	2, 102	3, 862
21–30	-------	423	1, 206	1, 173	1, 758	-------
July 1–10	-------	-------	1, 157	-------	-------	-------
11–20	42	-------	-------	983	-------	3, 023
21–31	-------	-------	958	-------	1, 452	-------
Aug. 11–20 [1]	25	252	67	-------	-------	-------
21–31	-------	198	-------	-------	12	589
Sept. 1–10	-------	-------	-------	191	-------	-------
11–20	-------	None	-------	15	-------	-------

[1] No inspections made August 1–10.

Offord *et al.* (*13*) have shown that individual ribes plants are self-sterile and that under most conditions viable seeds result only from cross-pollination. As eradication progresses, and as sizable mature bushes become fewer and farther apart, fewer seeds are produced by a comparable number and size of bushes.

Decline of Populations

The quality of a forest site has a great deal to do with the rate at which an area develops through the succession of pioneer stages toward climax vegetation. There are many degrees of "pioneerness" and of tolerance. Some pioneer species may be crowded out of vegetation in which other pioneers persist, but old and well-established individuals of a pioneer species may persist long after the establishment of new seedlings of the same species has practically ceased.

The all-age mixed-species forest in which gooseberry and sugar pine normally grow in association often is not of marked overall density, and even a small opening is big enough to encourage gooseberry growth. Consequently, mature bushes are seldom completely crowded out of sugar pine forests. However, pioneer bushes are suppressed by competing vegetation, and their complete disappearance with forest development is quite possible.

A good example of the exclusion of gooseberries from a developing forest was observed from 1939 to 1947 in the NW ¼ sec. 14, T. 10 S., R 25 E., Blue Canyon, Shaver Lake area, Sierra National Forest. This area is said to have been logged in the fall of 1914, and to have been burned deliberately by a slow-creeping fire late that fall. A vigorous stand of sugar pine and white fir poles developed after the logging and fire. Very few mature trees, mostly culls, remained on a 1-acre plot. In 1939 many gooseberry bushes on this plot consisted of rosettes of dead canes around dead or decadent crowns (fig. 7).

FIGURE 7.—A large old gooseberry bush crowded out of the vegetation and killed by a well-stocked stand of coniferous poles.

Each of the bushes had once supported several hundred feet of live stem. If ecologic signs are correctly interpreted, coniferous reproduction killed the gooseberries on this plot largely by competition for soil moisture or for soil nutrients rather than by competition for light.

Gooseberries and the Fauna

Dissemination and destruction of gooseberry seeds by animals, especially rodents, have already been discussed, and the effects of grazing by domestic stock will be considered under grazing as a disturbance. There remains to be considered a few ecologic relations of the gooseberry to the fauna.

Two ground-dwelling birds, the fox sparrow (*Passerella iliaca* subsp.) and the green-tailed towhee (*Oberholseria chlorura*), are abundant in open sugar pine forests. These birds forage in the duff and soil under the crowns of snowbrush and other shrubby plants, and dig numerous holes an inch or so deep and 2 or 3 inches across. Considered collectively, these scratchings cause an appreciable shallow disturbance to the forest floor and thus favor the occurrence of gooseberry seedlings. These birds are seed eaters, however, and may well destroy the seeds they find.

Mice occasionally become abundant in brushy forested areas, and then may cause extensive damage to the above-ground parts of gooseberry plants. In an area of cutover forest near the Cow Creek Guard Station during the winter of 1944–45, the stems of most of the large gooseberry plants growing in mixed snowbrush, deerbrush (*Ceanothus integerrimus* H. & A.), and manzanita (*Arctostaphylos patula* Greene) were severly damaged by small rodents. The animals, presumed to be meadow mice (*Microtus* sp.), apparently had holed up for the winter under the snow at the ground surface in the partial protection of these plants. Frequently much of the bark and cambium of the stems, along with the wood of many smaller twigs, was consumed before more suitable food became available in the spring. However, few large gooseberry plants were killed. Growth of the 1945 current-season stem on debarked plants, particularly that of crown sprouts, was unusually vigorous, but the retarding and weakening effects of debarking were obviously hindrances in their competition with *Ceanothus* and manzanita, neither of which was eaten by the mice.

On Hogan Mountain, Sierra National Forest, along a branch of Laurel Creek, mountain beavers (*Aplodontia* sp.) and oystershell scale (*Lepidosaphes ulmi* (L.)) together thinned an area of dense mixed brush. Before their appearance the brush was dense enough to preclude the establishment of gooseberry seedlings, although a considerable number of long-established bushes had been removed a few years previously. The scales killed a few bushes and weakened many others, thereby thinning the brush cover. The mountain beavers disturbed the soil by digging runways and occasional burrows under the brush. A surprisingly large population of vigorous seedlings sprouted because of this seemingly minor disturbance.

Gooseberry bushes are sometimes killed or severely damaged when their roots are eaten by pocket gophers (*Thomomys* sp.), but such destruction is not significant. Chipmunks also dig small holes in the forest floor similar to those of the ground-feeding birds. Squirrels dig burrows, and gooseberry seedlings have been observed on the mounds of soil, but such seedlings are usually short-lived.

The killing of an occasional forest tree, either singly or in groups, by bark beetles (*Dendroctonus* spp.) and engraver beetles (*Ips* spp.) leave openings in the forest that are favorable to the growth of gooseberries. Sometimes such openings are scattered through timber stands where gooseberry control is approaching maintenance condition.

Considerable defoliation of gooseberries by lepidopterous larvae has been observed twice in the vicinity of the Cow Creek Guard Station—once by the wandering zephyr (*Polygonia zephyrus* (Edw.)) and once by the zipper (*Tharsalea arota* (Bdv.)). A voracious leaf-eating insect with an appetite limited to *roezli*, or to the genus *Ribes*, would be a welcome addition to the insect fauna of the Sierra Nevada.

EFFECTS OF VARIOUS FOREST DISTURBANCES

Ecologic effects of forest disturbances, such as fire, logging, grazing, and soil erosion, vary considerably with the area. The stage of development of total plant cover and the quality of the site before the disturbance affect not only the type and the rate of revegetation but also the subsequent problem of gooseberry suppression. After a disturbance, seedling regeneration is more troublesome on good sites than on poor sites. Although few seedlings are able to persist on poor sites, established seedlings appear intermittently over a long period of years.

The passage of time subsequent to a disturbance, aside from the readily observable effect on plant competition, appears to degrade a site for growth of gooseberries. On comparable sites and in vegetation of similar composition and density, the rate of growth and the vigor of fruiting seem to be inversely proportional to the time since the last major disturbance. This little-studied effect must be due largely to soils factors. Probably of primary importance is a greater-than-expected depletion of mineral nutrients and seasonal supplies of soil moisture in the soil mantle due to a rapid extension of roots around the periphery of the clearing. Leaching of mineral nutrients from exposed mineral soil, changes in physical characteristics of the soil and changes in kind and amount of nitrogen and organic materials may also be important.

Fire

Edaphic factors are perhaps of greatest importance in the effects of fire upon a habitat for gooseberry seeds stored in the duff and soil. The consumption of duff by fire undoubtedly causes an increased aeration of the upper layers of the forest floor. The writer believes that this increased availability of oxygen is the main factor that forces previously dormant seeds into activity and germination. Important changes in soil temperatures are also caused by fire. The necessity for stratification insures the germination of gooseberry seeds in the spring and not after a rain in the fall.

The effect of fire upon vegetation in general, and upon gooseberry bushes in particular, depends on the intensity of the fire. In any burn on forested land, many seeds stored in the duff and soil are destroyed. A slow, creeping fire that incompletely consumes the duff and does not kill mature trees causes the appearance of many gooseberry seedlings. On such a burn these seedlings must compete for soil water, mineral nutrients, space, and light with many other small plants and often with mature trees that predate the fire. Under such circumstances seedling growth is often moderate to slow.

On heavy burns, where all aerial parts of plants have been killed and largely consumed, fewer seeds survive the fire, but conditions for subsequent growth approach the optimum. Ashes from the duff and many small plants greatly enrich the soil with mineral nutrients. In this temporarily enriched soil, and relatively unimpeded in the open burn, the gooseberry seedlings grow astoundingly fast. Furthermore, plant transpiration no longer draws heavily on soil water.

The great quantities of water transpired by trees are considered by Raber (*16*). Increased evaporation from unshaded soil surfaces and transpiration from small pioneer plants do not draw so heavily on the soil water as does a well-developed vegetation. On denuded areas, wherever slow infiltration and rapid runoff do not follow fire, soil moisture adequate for plant growth is available longer into the summer and fall than on comparable forested areas. Any increase of water supply through the dry summer and fall months is of great importance to seedling plants.

On areas devastated by fire these factors sometimes cause unusually rapid growth of *roezli*. Current-season seedlings with two or three orders of branches and 15 to 20 feet of live stem and seedling-origin bushes that fruit the second year after a fire have been observed occasionally. After all fires, however, the seedlings tend to appear in a single crop—that is, the first spring after the burn. Complete suppression of pioneers on heavily burned areas may be laborious, but can be short and simple *if no fruits have been permitted to mature subsequent to the burn.*

Sugar pine itself is somewhat intolerant to shade as compared with white fir (Baker *3*). Conditions for seedling regeneration of sugar pine, in common with other pioneer species, are most favorable on burned or otherwise denuded areas. However, the use of controlled fire as a silvicultural tool does not fit well into the traditional selection type of timber management generally practiced in the past in the all-aged, mixed-conifer forests of the Sierra Nevada. Moreover, fire is very difficult to control in the Sierra Nevada during the dry season, when its use would be most effective for the suppression of ribes and the perpetuation of pine forests. Under certain conditions the judicious use of fire can simplify the subsequent task of ribes suppression. Whether or not the overall objectives of forest management could be best served by controlled burning depends on many technical and psychological elements.

Logging

Many of the problems of gooseberry suppression are increased by logging, somewhat in proportion to the amount of vegetation destroyed and the amount of soil disturbed in the process. The suppression of gooseberries in a mature forest is not at all comparable to the same type of undertaking on recently cutover lands. Marked vigor of gooseberry growth for many years after logging, in combination with long-continued occurrence of seedlings, makes control difficult on many cutover areas.

Several factors bear on the length of time which must elapse after logging before further establishment of gooseberry seedlings is precluded. Perhaps the most important ecologic factors are latitude and altitude, physiographic aspect, and whether or not gooseberry suppression is started immediately after the logging. The period of rapid gooseberry regeneration may be only 3–10 years where a light cut is carefully removed from a forest having a considerable understory of mesophytic broad-leaved plants. However, where a dense forest has been harvested as a single crop, vigorous gooseberry growth may cause trouble for 25–30 years.

The important differences in the timing of seedling occurrence between logged and burned areas presumably are due to the manner in which seeds are distributed in the duff and soil. On burns, little mineral soil is disturbed except on fire lines, and with the consumption of duff by fire, seeds stored in the forest floor tend uniformly to approach the postburn surface. In logging operations uncomplicated by fire, large amounts of soil and duff are pushed around, and mixed and piled, but the duff is not consumed. Some seeds are left near the surface and may germinate soon; others are buried more deeply than before the logging. As years pass and erosion slowly wears down the debris, additional viable seeds approach the soil surface and may germinate.

Soil erosion in spectacular form is infrequent in sugar pine forests. Sheet erosion sometimes occurs and presumably leaves some ribes seeds in a better condition for germination.

Logging landings and logging camp sites often present difficult problems in ribes suppression, presumably because of the continued and complete disturbances that are common in such places. Construction of roads, trails, and logging railroad grades affect ecologic conditions in much the same way as logging disturbance.

Grazing

Grazing cows are present in the pine forests of California throughout the summer and early fall. Although grazing encourages the growth of gooseberries by reducing competition from the favorite browse plants, the cattle may trample out small plants, especially on moderate and steep slopes. Because of the sandy texture of many forest soils, grazing of logged areas often leaves seeds in positions favoring immediate germination.

Table 7 summarizes data on the growth of gooseberries inside and outside of grazing-exclosure plots that were established in 1940 on Chowchilla Mountain, Sierra National Forest. All gooseberry plants were removed when the plot was established and again in 1947. Both the occurrence and the establishment of seedling plants were reduced faster inside the fence than outside. However, individual plants surviving outside the fence grew to greater size. The total length of live stem per unit area outside the fence greatly exceeded that inside. Table 7 does not show that more, but smaller, bushes fruited inside the fence.

Time and intensity of grazing, topography, type of soil, and type and degree of vegetational development must all be evaluated before the overall effect of grazing may be accurately established. However, reasonable grazing is believed to be no particular handicap in gooseberry suppression.

Hand Eradication

Gooseberry plants are usually removed from control areas with a pick or claw mattock. Whenever they are numerous or large, grubbing disturbs associated plants and soil. Sometimes these disturbances favor gooseberry regeneration and growth, but other factors, such as the general development of the vegetation, often mask this effect of disturbance and determine the extent of gooseberry regeneration after initial eradicative work.

A more serious objection to hand eradication, if not carefully supervised, is the time occasionally lost by overzealous crewmen in digging unnecessarily large holes. Standard instructions tell eradicators to cut off roots 6 inches below the crown.

TABLE 7.—*Growth of* Ribes roezli *bushes inside and outside the fence of exclosure plot, Chowchilla Mountain, Calif., 1941–47. (Figures based on 4 subplots of 1/40 acre each.)*

Year of ribes origin and inspection	Inside fence			Outside fence		
	Known live bushes	Total live stem	Mean live stem	Known live bushes	Total live stem	Mean live stem
Origin 1941:	*Number*	*Feet*	*Inches*	*Number*	*Feet*	*Inches*
1941	638	23	0. 4	408	16	0. 5
1942	197	112	6. 8	112	73	7. 9
1943	172	464	32. 3	117	207	21. 2
1944	167	738	53. 1	117	499	51. 2
1945	170	931	65. 7	116	880	91. 1
1946	159	1, 183	89. 3	109	1, 651	181. 7
1947	192	1, 160	72. 5	114	1, 895	199. 5
Origin 1942:						
1942	94	9	1. 1	283	28	1. 2
1943	33	15	5. 6	88	38	5. 2
1944	25	31	15. 0	118	105	10. 7
1945	25	40	19. 0	103	204	23. 8
1946	30	58	23. 2	92	354	46. 1
1947	34	59	20. 8	99	446	54. 0
Origin 1943:						
1943	43	1	. 8	30	3	1. 3
1944	3	1	3. 3	22	12	6. 4
1945	6	2	4. 6	19	17	11. 0
1946	6	3	6. 7	19	59	37. 5
1947	7	4	6. 7	19	64	40. 0
Origin 1944:						
1944	0	0	0	65	4	. 7
1945	0	0	0	39	11	3. 4
1946	2	2	9. 5	37	17	5. 6
1947	1	2	21. 0	34	24	8. 6
Origin 1945:						
1945	1	0	. 5	24	2	1. 0
1946	2	0	. 8	21	6	3. 4
1947	0	0	0	19	9	5. 9
Origin 1946:						
1946	0	0	0	3	0	1. 0
1947	0	0	0	10	1	. 7

The use of pruning shears by trained men for removing young and early-mature bushes has proved rapid, convenient, and effective, but shears are unsuitable for the eradication of large bushes with multiple root centers. Their effectiveness depends also on the ability of operators to distinguish between roots (which will not sprout) and buried stems (which will sprout vigorously). Except in initial workings in dense gooseberry populations, after the time and energy have been spent in finding a plant, every reasonable effort must be taken to insure that it is eradicated, not just set back in growth for a year or two.

One of the most difficult types of ribes plant to eradicate is the open-grown bush of considerable age (8–20 years), which has been large and vigorous for several years. Recurrent heavy snows mash down old and decadent canes into a rosette around the crown. Debris and duff collect within the periphery of this rosette of stems, and numerous secondary crowns result from the layering of stem tissue in contact with duff and soil. Complete eradication of such a complex bush by the usual hand methods, or by any other method, is difficult and time consuming. Control work should therefore be started before the bushes have attained such an advanced stage.

Chemical Eradication

Ribes roezli may be killed with the herbicide 2,4–D. Since 1946 gooseberry bushes on several thousand acres of high-quality sugar pine land have been treated with this material applied to the foliage and stems, to the basal stems, or to the cutoff root crowns (Offord *et al. 14*). Such use of chemicals, in comparison with hand digging, has saved several man-days for each acre sprayed. Although chemical methods resolve many problems in the control of *roezli* and other highly susceptible species of *Ribes*, their ultimate importance to the control program must be measured in long-range ecologic terms.

Chemicals cannot be expected to kill all gooseberry seeds stored in the duff and soil, and there will be some seedling regeneration on chemically treated areas. However, much less soil is disturbed than on mattock-worked areas, and if this were the only factor involved, immediate seedling regeneration should be less intense. But the lack of soil disturbance may be offset by more important ecologic considerations, such as partial denudation of the associated vegetation by the chemicals. The basal stem and decapitation treatments of ribes plants with 2,4–D and similar herbicides is more selective than foliage sprays and minimizes the killing of vegetation associated with the ribes.

APPLICATION OF ECOLOGY TO CONTROL WORK

Timing of Eradication

In the sugar pine forests of California it is becoming increasingly apparent that there are only two ecologic stages when it is advisable to initiate ribes control.

The best time for undertaking control is immediately after logging or fire. However, especially on burned areas, it is important that nearly all the fruiting bushes be destroyed. Any seedling regeneration will then come from seeds already in the soil at the time of disturbance—that is, from old seeds that can be expected to have lowered viability and shortened life. On the other hand, if eradication is begun after several crops of fruits have been produced, the overall suppression problem will be long and expensive.

Destruction of vegetation and disturbance of soil on logged areas varies greatly with topography, type of forest, and intensity of logging. An individual gooseberry bush occupies little space, and ecologic conditions often change quickly within short distances. Their growth rates vary greatly on any forested area, but particularly on recently logged areas. Therefore, the most advantageously located and most vigorously growing bushes, which usually are the first to fruit, largely determine the permissible interval between reworkings.

For a strict control of seeds, one or possibly two workings of mature timber prior to logging are sometimes desirable. Such procedure prevents rapid growth and vigorous fruiting of long-established but previously suppressed bushes that survive logging. To justify such an initial eradication, however, there must be some reasonable expectation that after the logging there will be sufficient sugar pine regeneration on the area to warrant its protection.

The next best time to start eradication—and perhaps the time when the plants can be suppressed most rapidly, especially in coniferous reproduction of adequate stocking—is when forest vegetation has been undisturbed by fire or logging for many years. Vegetation in general must have occupied the area completely, and the period of active establishment of appreciable numbers of seedlings must have passed. This timing depends upon two conditions—any such delay would not damage sugar pine on the area, and the gooseberry population will have passed through its period of greatest growth.

In undisturbed areas control of gooseberries is based on the advanced development of vegetation and not on the absence or near absence of viable gooseberry seeds. Any disturbance to such areas may suddenly shift the vegetation to more nearly pioneer ecologic conditions, and as suddenly cause loss of gooseberry control. The prevention of fruiting on these areas is not important; probably the soil is already thoroughly contaminated by gooseberry seeds. Suppression is based solely on the inability of the seedlings to become established in advanced stages of the vegetation.

As suppression on any area progresses towards maintenance conditions, and as associated vegetation thickens with development, more time must be spent in finding the few bushes remaining on the area. The proportion and importance of "looking time" to "digging time" increases rapidly with repeated workings. As ribes bushes become fewer, smaller, and more obscured by other plants, difficult problems arise relating to the type and training of labor and the methods and time of working. The solution of these problems will require continued effort for some time to come.

It should be emphasized that there is a time when it is particularly unfavorable to initiate gooseberry control. From 4 to 15 years after logging or fire the number of bushes per acre is large, and individual plants are large and growing rapidly. Fruits are often being produced in great profusion; control of fruiting has been lost. The soil already contains many seeds, and the "wearing out" of viable seed stored in duff and soil will take a long time. Seedlings will become established in large numbers after initial and subsequent workings. General development of the vegetation is such that plant competition has little slowing effect on gooseberry growth. Under such conditions the problem of control, if demanded by pathologic developments, may be expected to be difficult and expensive.

Estimation of Gooseberry Potential

An estimate of gooseberry potential on specified areas is an important prerequisite to an effective plan for its suppression. Such an estimate may be desired for an area on which no suppression work has been done, or on one where partial control is already established. On any extensive area such an estimate is obviously a broad generalization, and requires adequate data from a representative number of subareas of different kinds.

Most of such data are obtained when areas are systematically sampled for the sugar pine and gooseberry populations prior to eradication. Methods of sampling and uses of collected data are described by Harris (7). Three types of sampling or checking of populations are usually undertaken—advance, regular, and post checks. The advance check is made before any crew work is undertaken. The species, number, size, and location of gooseberry plants are determined and mapped. Frequently the approximate age of each bush, and whether or not it is producing fruit are also recorded. Data concerning general vegetation are taken concurrently. Other sources of forest-management information—such as aerial photographs, logging and fire records, timber-type maps, cruise data, and timber-management plans—are considered whenever available. After each working of an area it is sampled by a regular check to see whether control standards have been met. Then at planned intervals after each regular check—the interval depending upon the degree of gooseberry suppression—the area is given a post check to see whether additional control work is needed.

Thus, as eradication progresses towards complete suppression, this series of checks (inspections) provide data from which the future course of gooseberry regeneration and suppression can be determined with considerable accuracy. In recent years a system of keeping eradication records—principally of the species and the approximate number of plants removed—by small blocks of 1 to 5 acres has added great ecologic value to routine eradication data. These data, when combined with the checking data, present an adequate and reliable picture of gooseberry ecology on control areas, provided no new disturbance upsets the ecologic trends.

One good indication of the potential of gooseberry regeneration, particularly in secondary successions, is the overall development and density of vegetation compared with the probable maximum density as determined by site capacity. Certain species of plants, themselves pioneers, indicate conditions favorable to gooseberry development, and may offer an important supporting estimation of gooseberry potential. Such species, largely easily identified plants normally expected on good sugar pine sites, include snowbrush, deerbrush, sweet birch (*Ceanothus parvifolius* Trel.), bull thistle (*Cirsium lanceolatum* (L.) (Hill), mountain dogwood (*Cornus nuttalii* Aud.), hazel brush (*Corylus californica* (A. DC) Rose), gayophytum (*Gayophytum diffusum* T. & G.), swale lupine (*Lupinus latifolius* Agardh.), common phacelia (*Phacelia heterophylla* Pursh), Nuttall willow (*Salix scouleriana* Barr.), blueberry elder (*Sambucus glauca* Nutt.), and common mullein (*Verbascum thapsus* L.). As with all indicator plants, the relative abundance and vigor of a species is of more value than its mere presence.

Timber Management

Timber-management and forest-research groups have long recognized the need for an understanding of the long-range aspects of gooseberry suppression and of the objectives and economics of sugar pine management in relation to blister rust control. Since a vigorous, fully stocked stand of coniferous reproduction will rapidly suppress gooseberries, the timber-management objectives of maintaining high productivity and of controlling gooseberries are served simultaneously. Areas scheduled for application of measures to suppress gooseberry should produce the largest possible quantity and the highest quality of sugar pine stumpage so that the cost of ribes control per thousand feet of sugar pine lumber may be kept at a minimum.

A general description and brief history of the pine and mixed-conifer forests of California and the major problems and possibilities of intensive timber management are presented by Hughes and Dunning (*8*). A logging experiment designed to assure adequate sugar pine regeneration after the harvest cut of mature timber is described by Dunning (*6*). Many of the bases and field techniques for broad-scale intensive management of the mixed-conifer forest also have been presented by Dunning. Economic aspects of intensive management of sugar pine, particularly with respect to the economics of blister rust control, have been reported upon by Vaux (*18*).

The various types and intensities of management practiced in sugar pine forests and the intolerance of sugar pine as a species have important bearings on the selection of control areas, and on the cost and difficulty of gooseberry suppression. Sierran mixed-conifer forests, managed intensively for frequent light cuts on a strict tree-selection basis, offer little encouragement to the shade-intolerant gooseberry. Under such conditions the approximately full stocking would prevent vigorous gooseberry regeneration and growth, except in disturbed spots. However, this type of management would eventually exclude practically all the sugar pine from many forest stands. The true firs, because of their tolerance to shade, would benefit greatly. If adequate stocking of sugar pine and other coniferous regeneration would follow heavy cuts of virgin sugar pine, the gooseberry seedlings developing after logging operations could be controlled rather easily and promptly by eradication and suppression. However, after the logging of overmature mixed stands in the past, adequate reproduction has been the exception and not the rule. Management of sugar pine stands on a periodic clear-cut, burn-and-plant sequence likewise would ease problems of gooseberry suppression. But in general Sierran forests have been considered mixed-age forests, and are not particularly well suited to this type of treatment, at least until after they are converted into more intensively managed forests.

As knowledge and experience in sugar pine silviculture is accumulated, and as forest management becomes more intensive, the problem of gooseberry suppression in sugar pine stands will become progressively less acute.

SUMMARY

The autecology of the Sierra Nevada gooseberry (*Ribes roezli* Regel) has been studied in California for the last 20 years. Because this species is an alternate host to the white pine blister rust (*Cronartium ribicola* Fischer), a serious fungus disease of sugar pine (*Pinus lambertiana* Dougl.), it is being removed from selected pine stands.

The long summer drought in the Sierra Nevada is of outstanding importance in any consideration of the ecology of the region.

The Sierra Nevada gooseberry is widespread and abundant in sugar pine forests. It occurs most frequently on logged, burned, or otherwise disturbed areas; it may best be classed as a secondary pioneer. On areas denuded of vegetation it grows and fruits with remarkable vigor.

Gooseberry seeds are small, but surprisingly longlived. Apparently they can remain dormant and viable in the forest floor for many years. Various rodents eat gooseberry fruits and destroy many seeds. The seeds are scattered by animals, and by water and gravity.

On burned areas practically all gooseberry seeds germinate the first spring after the fire. On logged areas new seedlings continue to appear for many years.

Perhaps the weakest point in the life cycle of the pioneer gooseberry is seedling establishment. The summer drought and competition of other larger or less pioneer plants in well-developed vegetation prevent survival of great numbers of gooseberry seedlings and slow the growth of plants that do become established.

Under near optimum conditions gooseberry bushes produce fruit in 3 or 4 years from origin as seedlings, the time depending principally upon the quality of the soil mantle, the amount of soil moisture, and the degree of openness of the habitat. Because prevention of fruiting is often a major objective in control programs, the most vigorous bushes often determine the permissible interval between eradicative workings.

As vegetation develops, the establishment of gooseberry seedlings slows down and then stops. Later the growth and fruiting of established bushes reach a peak and thereafter decline. The species may be completely crowded out of well-stocked stands in the pole stage, but such natural suppression occurs only on small areas, because the typical second-growth Sierran forest is open and brushy.

All disturbances in the forest, especially by fire and logging, favor an increase in the number of gooseberry bushes and the vigor of their growth. They can be suppressed most advantageously by initiating control before any fruits have matured subsequent to a major disturbance, and by not permitting the seeds to mature on the area after eradication. Another favorable time is several years after a severe disturbance, when, because of the advanced stages of the vegetation, gooseberry seedlings are no longer able to become established in appreciable numbers.

Gooseberry suppression for the control of blister rust in California is merely one aspect of sugar pine management. The problem of gooseberry control will become progressively less acute as forest management becomes more intense.

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