THESIS

on

RELATION OF RIBES LACUSTRE TO MANAGEMENT OF WESTERN WHITE PINE

Comparison with other species of Ribes in areas invaded by White Pine Blister Rust.

Submitted to the
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MASTER OF SCIENCE

by

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Western white pine (Pinus monticola D. Don) is considered one of the most valuable timber trees occurring in western North America (1,6). The stand of this species in the western states has been estimated at 22 billion board feet and valued at $165,000,000, and in addition to this merchantable timber there is a large acreage of young trees (2). The main commercial range of western white pine is in the Inland Empire region (northeastern Washington, northern Idaho and western Montana), and here the lumber industry is largely dependent upon this tree for its existence (8,6).

In the conservation of such resources, the problem of forest management is of utmost importance. Forest management plans include such items as fire control and suppression methods, control of insect infestations, and control of disease. The latter mentioned phase of the management plans has recently become of especial importance for western white pine forests. This has come about by the introduction of the destructive foreign plant disease white-pine blister rust (Cronartium ribicola Dietr.) into western North America in 1910 from Europe (8). As a result this valuable timber stand has been menaced and its perpetuation threatened (1,2,5).

Forest management for the control of this disease, however, is known to be feasible (2,16,4). This is ac-
complished by the removal of Ribes—the alternate host plants of the rust—from the white pine areas (16, p.86).

In this connection, advantage has been taken of the significant features in the life history of C. ribicola which are as follows: Spores, aeciospores, are produced in the spring on the diseased portions of the pines. These are blown about by the winds. Spores of this type are not known to infect other pines, but are capable of infecting currant and gooseberry leaves. Here, spores of a different type, the urediniospores, are developed in early summer on the underside of the leaves which can infect only other currant and gooseberry leaves. Later in the summer, and also on the underside of diseased leaves, spores of another stage are developed, the teliospores, which do not infect other leaves but which give rise to still another type of spore—the basidiospores or sporidia. These spores when blown to a pine tree can infect it. The separation of the two hosts of the rust (pines and Ribes), therefore, prohibits it from completing its life cycle (16).

The importance of complete or nearly complete eradication of any species of Ribes, in the management of an area of western white pine, will depend on the degree to which its presence is a source of danger. One of the

1 The genus name Ribes is used in this paper to include both currants and gooseberries.
3.

The commonest species in this region is the prickly currant, *Ribes lacustre* (Pers.) Poir., which is known to occur generally throughout the commercial range of western white pine in the Inland Empire (2). This species is very frequent and widely distributed over the Inland Empire, particularly the northern part. It occurs generally in the forested region but is not confined to any particular site condition (19). In connection, therefore, with forest management for the protection of this territory from white pine blister rust damage, it becomes important to know how dangerous *R. lacustre* actually is, as a carrier of the disease, in comparison with other species of *Ribes* found in the region.

Results of studies on *C. ribicola* in the West during the period 1922 to 1932 inclusive have given, together with other data, considerable information on the relative susceptibility and teliospore-producing capacity of several *Ribes* species to this rust (8,13,14,10). During the course of these studies it has been found that *R. lacustre*, when compared with other *Ribes* species, is a variable host not only in respect to susceptibility and teliospore-producing capacity, but also in respect to the period in which teliospores may be produced.

The studies reported herein on *R. lacustre* were taken up principally from this latter standpoint and consider the prickly currant of importance both in the control of the rust and in the development of that portion of the manage-
ment plans of western white pine involving protection from disease.

PREVIOUS STUDIES OF RIBES LACUSTRE

Some studies have already been made on Ribes lacustre in connection with general investigations on Cronartium ribicola and in these its variable behavior was early noted. Spaulding (16,p.19) in 1922 classified the species as subject to a medium degree (xx) of infection under greenhouse conditions and to slight infection (x) when tested out of doors in the East. Also, in a discussion on variations in appearance on Ribes leaves, he gives (16,p.53) the following for R. lacustre: "Dead spots formed early on infected leaves; sori sparse and diffuse, irregular spots; telia rather scattered." Investigations by York in New Hampshire and reported by Spaulding (16,p.56) on the period of time, urediniospores were produced on nine different species of Ribes, revealed, that urediniospore production continued the longest time (185 days) on R. nigrum and the shortest time (65 days) on R. lacustre. Hahn (5,p.680) states that the species produced a moderate number of telia when tested in the greenhouse. Lachmund (8,10), in reporting the results of his large scale studies, conducted in British Columbia, on the four species of Ribes (R. petiolare Dougl., R. inerme (Rydb.) Coville and Britton, R. viscosissimum Pursh and R. lacustre) which are most important numerically
as associates of the main bodies of western white pine in the Inland Empire region, states that the latter species is generally comparatively low in susceptibility to the rust and in the production of teliospores. It appears that Mielke and Hansbrough (6) first applied the term "variable host" to R. lacustre. This was offered as an explanation of certain results obtained in some tests conducted out of doors in the West, to account for the variation in amount and character of rust infection occurring on this host in different seasons, when compared with some other tested Ribes growing nearby.

The results of the studies made by these investigators indicate that the Ribes species in question displays some variation both in degree and character of the rust infection and in ability to produce certain spore stages. In the literature, however, the factors responsible for this variation have been only briefly mentioned and no reference has been made the time teliospores are produced. A discussion mainly of this phase of the subject together with its importance in the management of western white pine is given in later paragraphs.
6.

THE PRESENT STUDIES

General Observations

During the past several years the writer has been engaged in investigations of Cronartium ribicola in the West. In the course of this work, it became evident through observation that this rust frequently developed somewhat differently on Ribes lacustre than on other species of Ribes growing in association with it. The majority of the observations were made in British Columbia in connection with relative susceptibility and teliospore-producing capacity tests and studies of several Ribes species (R. petiolare, R. inerme, R. viscosissimum, R. lacustre and R. bracteosum Dougl.) that are associates of Pinus monticola.

In the course of these observations, the following differences in behavior of the rust on R. lacustre were noted:

1. Urediniospores were produced more or less luxuriantly during most of the summer season on all species studied except R. lacustre. On this host this spore stage was often difficult to find generally by the latter part of July.

2. Intensification of the rust on R. lacustre by urediniospores was generally relatively poor when compared with that on the other Ribes species.

3. The rust appeared to "die-out" or lose its viability on R. lacustre, but generally developed normally until the end of summer on the other species.

4. Uredinia sometimes failed to develop normally and

Investigations being conducted by the Division of Forest Pathology, Bur. of Pl. Industry, U.S.D.A., Portland, Ore.
instead of their usual mealy appearance they looked more like tiny blisters. Apparently the epidermis of the leaves had become toughened, so that the uredinia did not burst through it, as they naturally do, but pulled it loose from the inner leaf tissues and in this way actually formed small blisters. The urediniospores never broke through it. These blisters, which were also observed by the writer in a few instances on *R. inerme* in British Columbia, were usually 3 to 6 times as large as the normal uredinial sori. Spaulding (16, p. 51) reports these blisters as rare in the East but does not mention their occurrence on either of these hosts.

5. The first development of teliospores and main period of production thereof frequently occurred much earlier on *R. lacustre* than on the other *Ribes* species studied.

Of the above mentioned differences, the latter one is here considered to be of greatest significance, for as previously stated, this spore stage gives rise to the pine-infecting spores. A better knowledge of the time that these spores are produced on the prickly currant is believed, therefore, to be an important factor in connection with the control of the rust. Accordingly it was considered pertinent to obtain more definite information on *R. lacustre*, in comparison with other *Ribes* species, regarding the period of teliospore production, the frequency of occurrence of any variation in this period, and the factors responsible there-to, if any. Other investigations on the rust gave added information on the subject.
8.

Special studies and experiments

Special studies were first made of certain available field data previously secured by the Division of Forest Pathology in connection with other investigations of the rust on which the writer was engaged. Before the above outlined behavior of Cronartium ribicola on Ribes lacustre was noted, studies (8,14,10) had already been conducted on the relative susceptibility and teliospore-producing capacity of several western Ribes species including R. lacustre. Incidental to these studies a considerable amount of field data were secured that have been used in the present study. It was necessary, however, to make special compilations, computations, and tabulations of a large volume of these field data and these have been used as a portion of the information in the present paper.

Additional data on C. ribicola secured over a wider range of territory were essential, however, for the completion of the study. From other and more recent experiments on the rust in which the writer was in charge, additional information on the present problem was secured. These experiments included additional inoculations of

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3 The author was in charge of some of these studies, which were carried on over a period of several years, and worked under the direct supervision of Mr. H. G. Lachmund, Pathologist in charge of the Division of Forest Pathology, Bur. of Pl. Industry, U.S.D.A., Portland, Oregon, to whom he is indebted for many helpful suggestions and much stimulating criticism in connection with the present study.
Ribes lacustre and R. viscosissimum, and a study of naturally infected R. lacustre.

These experiments and studies are described later in this paper.

LOCATION AND DESCRIPTION OF FIELD PLOTS

With the exception of one study plot at Rhododendron, Oregon, in the Mt. Hood National Forest, the remainder were located in British Columbia. Location of the plots in British Columbia was essential in order to study the rust under natural conditions, for as previously stated, this disease was introduced into that country from Europe. It was not until the past few years that it has been prevalent enough south of the International Boundary in the western states to conduct most of the studies mentioned herein.

From a comparison of tables I and II it will be seen that the rainfall in the summer months in the Interior section of British Columbia is fairly comparable to that obtaining in the north Idaho section, which contains the main body of western white pine in the Inland Empire region. Moisture in the form of rainfall during the summer months is considered the most important factor in the infection of Ribes and pines by the rust (15,p.603). The results of these studies should, therefore, be of practical application in the Inland Empire region.

The locations (see map,p.16) and descriptions of the
MONTHLY AVERAGES OF RAINFALL
(In inches)

Northern Idaho*

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<tr>
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<td>Avery</td>
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<td>1.98</td>
<td>.95</td>
<td>1.11</td>
<td>1.74</td>
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<td>.51</td>
<td>.67</td>
<td>1.42</td>
<td>1.62</td>
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<td>Kellogg</td>
<td>2.66</td>
<td>2.02</td>
<td>.94</td>
<td>1.07</td>
<td>1.78</td>
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<td>Pritchard</td>
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<td>1.97</td>
<td>.72</td>
<td>1.11</td>
<td>1.84</td>
<td>2.87</td>
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<td>Gibbs</td>
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<td>.69</td>
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<td>1.67</td>
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<td>St. Maries</td>
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<td>1.50</td>
<td>.79</td>
<td>.86</td>
<td>1.30</td>
<td>1.99</td>
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<td>Priest River Exp. Sta.</td>
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<td>1.79</td>
<td>.85</td>
<td>1.27</td>
<td>1.82</td>
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<td>Sand Point</td>
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<td>1.67</td>
<td>.75</td>
<td>1.21</td>
<td>1.77</td>
<td>2.27</td>
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*U. S. Weather Bureau records.
MONTHLY AVERAGES OF RAINFALL
(In inches)

Interior of British Columbia*

Table II

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<tr>
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<td>Revelstoke</td>
<td>2.24</td>
<td>2.63</td>
<td>2.13</td>
<td>2.22</td>
<td>2.77</td>
<td>3.79</td>
<td>29</td>
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<td>New Denver</td>
<td>2.36</td>
<td>2.48</td>
<td>1.08</td>
<td>1.66</td>
<td>1.80</td>
<td>2.67</td>
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<tr>
<td>Nelson</td>
<td>2.23</td>
<td>2.61</td>
<td>1.51</td>
<td>1.47</td>
<td>1.85</td>
<td>2.30</td>
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</tr>
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<td>Fauquier</td>
<td>2.13</td>
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<td>Kaslo</td>
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<td>2.14</td>
<td>0.87</td>
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<td>1.99</td>
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<td>Perry Siding</td>
<td>1.86</td>
<td>2.27</td>
<td>1.05</td>
<td>1.34</td>
<td>1.78</td>
<td>2.22</td>
<td>17</td>
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<td>Rock Creek</td>
<td>1.24</td>
<td>1.90</td>
<td>1.06</td>
<td>1.05</td>
<td>1.10</td>
<td>0.87</td>
<td>18</td>
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<td>Kelowna</td>
<td>0.80</td>
<td>1.06</td>
<td>0.55</td>
<td>0.87</td>
<td>0.97</td>
<td>1.02</td>
<td>16</td>
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*British Columbia Department of Agriculture weather records.
11.

field study plots follow:

British Columbia

Coastal section

Garibaldi (formerly Daisy Lake)⁴

Located about 50 miles north of Vancouver along the line of the P.G.E.R.R., in the narrow valley of the Cheakamus River. Drainage is to the south. The soil is mainly sand and gravel with a thin layer of sandy loam and silt covering portions of the area. Humus is moderate in amount.

Some of the Ribes studied occurred in the shade of an uneven-aged stand of mixed conifers and broad-leaves composed of western white pine, western hemlock, Douglas fir, cottonwood, willows and alders, mainly the latter.

The elevation is 1125 feet.

The Ribes studied here were *R. lacustre* and *R. bracteosum*.

Interior section

Canyon Creek (near Kelowna in the Okanagan Valley)

The study plot was situated 12 miles southeast of Kelowna in a narrow, rocky canyon drained by a small, rapidly-flowing mountain stream known as Canyon Creek.

⁴The name of this station on the P.G.E.R.R. has recently been changed.
Drainage was to the north. The open (sun) form Ribes were on well drained, sandy, and gravelly soil with very little humus. The shade plants were situated close to the open plants also on sandy and gravelly soil but with some sandy loam covered by a thin layer of humus. The shade was supplied by mixed coniferous and hardwood growth composed of birch, cottonwood, dwarf maple, Douglas fir, Engelmann Spruce and western red cedar which formed a moderately dense canopy over the Ribes plants.

The elevation is 1900 feet.

The Ribes species are *R. lacustre* and *R. viscosissimum*.

9-Mile Creek (12 miles east of Osoyoos)

The study plot was situated in a shallow small valley or canyon with a bottom 150 to 200 feet wide and sides rising some 100 to 200 feet. Exposure is southeast by east.

The Ribes grew mainly in the vicinity of a rather slowly flowing creek in rich mineral soil containing some sandy loam and silt. Bordering the creek were a few small swampy spots.

The creek was bordered mainly by alders, willows, mountain maple and Engelmann spruce. Nearby on the hillsides the timber stand was composed principally of western yellow pine, western larch and Douglas
The elevation is approximately 3200 feet.

The Ribes studied here were *R. petiolare*, *R. lacustre*, and *R. inerme*.

**Revelstoke**

The plot is located 10 miles north of Revelstoke in the Columbia River valley. The valley is narrow and with comparatively steep mountain sides. Exposure of this study area is west. Most of the Ribes occur along a small rapidly flowing creek.

The soil is mainly sand and fine gravel with a mixture of rich mineral earth and clay covered by a thin layer of humus. A moderately dense growth of western white pine reproduction 1 to 35 feet in height occupies the area in association with birch, cottonwoods, scrub alder, hemlock and western red cedar.

The elevation is 2000 feet.

*R. lacustre* is the only Ribes species occurring on the plot or in its vicinity.

**Hunters Siding**

The plot is located about 20 miles east of Nakusp near the head of Slocan Lake in a rather narrow valley bordered by steep and high mountains. The valley lies in an east and west direction with drainage
to the east. Five study plots are located at this place and all are on the valley floor and within a few to several hundred yards of each other.

Western white pine, in the reproduction stage, is the principal tree species on the plots and occurs in admixture with birch, cottonwoods, dwarf alder, western hemlock and western red cedar.

A light and thin layer of rich mineral soil often mixed with sand occurs over most of the area. The humus layer is generally thin.

The elevation is approximately 2000 feet.

Ribes lacustre occurs on three of the plots and R. viscosissimum on the other two.

Apex and Hall

Three plots are at these places, two of which are near Hall and the other one near Apex. These plots, which are located about 10 miles south of Nelson in the Salmon River Valley, are so similar in character that their descriptions are here combined.

White pine, in the reproduction stage, occurs over the areas in an admixture with birch, aspen, dwarf alder, willow and western hemlock.

The soil is mainly of a light fine sandy mixture containing some mineral earth and wood ashes. The humus layer is thin. Rocky outcroppings occur over the areas.
R. *viscosissimum* is the only Ribes species on the plot near Apex. The two plots near Hall are about 200 yards apart and *R. lacustre* occurs on one of them and *R. viscosissimum* on the other. The Hall and Apex plots are about three quarters of a mile apart. Elevations of both plots are approximately 3100 feet.

Oregon

Rhododendron (on the Mt. Hood National Forest)

The plot is located about one-quarter mile south-east of the townsite and is situated on the valley floor in the vicinity of a small sluggish creek that flows into the Zig Zag River nearby.

The soil is mostly sandy loam containing a high percentage of decayed mineral matter. The Ribes studied are *R. lacustre* and *R. bracteosum* and they occur under a fairly dense canopy of mixed hardwoods and conifers—principally alder, willow, Douglas fir and western hemlock.

The elevation is approximately 1600 feet.
LOCATIONS OF STUDY PLOTS

- Study plots.
- Other places.
- Range limits of western white pine.
METHODS AND FREQUENCY OF TAKING RECORDS

Selection and establishment of study areas

In practically all cases, selection of the study areas were confined to localities where at least two species of Ribes were found growing in close association so that direct comparisons could be made on the behavior of the rust on different host species under identical conditions. On one area studied three different Ribes species occurred in association. Only in one case—the Revelstoke plot—was there but a single species and this one was Ribes lacustre which is of principal concern in this study.

The number of bushes of each species in each group varied from several to about a hundred. In most instances, however, there were a bases of twenty-five or fifty bushes. Permanent tags were placed on all bushes so that the identical ones were used throughout the studies.

Growth conditions of the Ribes were taken into consideration, that is, sun form plants were distinguished from those growing under a shade canopy of taller plants, generally trees. Partially shaded plants were also considered as a separate group. In all cases the Ribes of these different growth habitats are treated separately in the study.
Inoculations

For the majority of the Ribes studied, it was necessary to inoculate these plants with the rust because in most instances they either occurred in sections of the country free from the disease or it was not present in sufficient abundance to cause general infection of all of them. On two of the plots rust infection of the Ribes was so general and abundant that inoculations were not necessary. In a discussion of the graphical presentation of the data which appears later in this paper a statement is made as to whether the Ribes in each group were inoculated or studied under natural infection conditions.

In the spring of the year shortly after the young Ribes leaves had made their appearance each plant was inoculated, when this procedure was necessary, with aeciospores taken from cankers on western white pine. The inoculum, used each year to infect the Ribes on the Canyon Creek and 9-Mile Creek plots, was all secured at Garibaldi and that for the Hunters Siding, Apex and Hall plots at Arrow Park. Inoculations were essential so as to insure infection of all of the bushes, for infected pines did not occur nearby. The Revelstoke and Garibaldi plots are located within areas of heavy pine infection, and inoculations of the Ribes were not necessary because they became infected by natural means. The Rhododendron plot is also within an infection area, but heavily infected pines do not occur close enough to the
plot to insure abundant and uniform infection of all of the Ribes, so inoculations were resorted to, using for this purpose cankers, collected in the near vicinity.

A simple but effective inoculation method was employed --sporulating cankers were placed in large paper bags which were used in bellows fashion to shower the leaves with spores. The inoculating was done just prior to a rain storm and in the event that the Ribes leaves did not remain wet for at least twelve hours the inoculations were repeated when favorable weather conditions again occurred.

Rainy periods must here be taken into consideration because spores need moisture for germination. Consequently, all the inoculations could not be made on the same date in any one season, or could they all be made on the same dates every year because the time Ribes leaves begin to develop is correlated with the advent of spring which generally varies annually. The earliest inoculations were made on April 25 and the latest on June 5, but generally they were made between about May 5 and 20.

Examinations of Ribes and recording data

Examinations of the Ribes for degree and character of rust infection were generally made at approximately monthly intervals and in some cases oftener, starting a few weeks after the inoculations and continuing until mid-September or early October. Regular examinations such as at monthly
or semi-monthly intervals were impossible because too many areas were studied and travel between them involved considerable time. Also, intensification of the rust on Ribes during the season does not occur by a steady increase in amount thereof, but is in the form of more or less definite waves correlated with indefinite periods of rainfall. An attempt was made, therefore, to time the examination dates so that they occurred at about the peak of development of each wave of intensification or telial production. Such procedure was not possible at all times but was adhered to in the majority of cases.

At the time of each examination the number of infected leaves was determined by actual counts or estimates or a combination of both, or, instead, an estimate was made of the percentage of leaves infected for the entire group of bushes after an examination of each individual bush. The total number of leaves for each bush or group of bushes was secured by actual counts and estimates made of the individual bushes. Estimates were also made of the percentages of area infected of the infected leaves and percentages of infected area bearing telia. A record of the infection at each examination date for each bush or group of bushes was thus secured. The identical bushes were examined on each of the examination dates for, as previously mentioned, all of them were tagged at the time of establishment of the study areas.
By using numerical values instead of symbols to denote the amount of infection and the portion of it which bore telia, it was possible to compute the data so that they could be presented in graphic form. Reasonably reliable estimates of the amount of rust infection might at first thought appear difficult or even impossible to make, but their reliability was proven in the field. With a little practice, estimates of assistants working independently compared very favorably between assistants and with those made by the writer. At any rate, numerical values are possible of comparison while symbols used by one investigator are impossible of comparison with the same symbols used by another research worker. For example, it is impossible to know that one individual's conception of heavy infection, which might be designated by the symbol "XXX", is comparable to that which is considered to be heavy infection by another individual.

It is recognized that the numerical values herein used of the amount of infection and amount of telia produced were obtained from estimates. These estimates, however, are believed to be within a reasonable degree of accuracy and at maximum do not in any case represent an error—plus or minus—greater than ten percent. In favor of the system is the fact that errors in this type of study should tend to compensate each other.

General notes were used in a few instances to record
field observations. This method was resorted to only when a more detailed study was impossible for various reasons, or to augment data secured during the course of the systematic studies. A complete set of general notes, however, of important phases on development and character of rust infection was always secured in connection with the regular data obtained at the time of the periodic examinations. These are essential for complete interpretation of the systematic data.

**Computations of the field data**

Computations of the data were possible, since the amount of infection and the portion of it developing into the telial stage had been given numerical values in the field at the time each examination of the Ribes was made. The figures were available for the total number of leaves, the total number of infected leaves, the percentage of rust-bearing area on the latter, and the percentage of infected leaf area bearing telia. It was, therefore, possible to calculate the percentage of total leaf area infected and percentage of total leaf area bearing telia.

The values (percentages) of total infection and total telial production, shown in the following graphs, were obtained by further calculations. Of the total amount of rust infection developed on a particular group of Ribes
during the course of the season, certain percentages of this total had developed prior to the different examination dates. These percentages were obtained by simple calculations. This same procedure was also followed in determining the percentages of the total telial production present at the time of each of the examination dates.

Not all rust infection occurring on the Ribes during the course of a season finally develops into the telial stage. Consequently, the data would have to be treated in a different manner to show these relationships between total infection and total telial development. This paper is not concerned with the amount of infection or amount of telia produced during the season, but primarily with the time telial development occurs and the percentage of telia produced at the time the different examinations of the Ribes were made. The percentages of the total infection developed are included herein, however, to show the trends in seasonal development of the rust on the different Ribes species studied when compared with the telial development. The trend in seasonal development of the rust is also of importance and will be discussed later.
RESULTS

The results of the studies on the Ribes are here presented in graphical form so that comparisons may be readily made of the seasonal progress of telial development on the different species. Together with the telial development data there are included data on the rust development. The total rust developed, or in other words, the total leaf area finally covered by infection includes all infected area regardless of the character of the infection. As previously mentioned, this paper is not concerned with the total amount of rust or telia developed, but primarily with the time the telia are produced. The rust development data are included for showing the general progress in the seasonal development of total infection as compared with one phase of it—the telial production.

The uredinial stage of the rust is the first one to develop after initial infection of the Ribes occurs. Following this by a few to several weeks the telial stage makes its appearance. This explains why there are generally few or no telia shown on the graphs at the times of the first or sometimes later examinations of the Ribes.

A consistent order of arrangement of the data has been used throughout the graphs. The percentage of the total rust and percentage of total telial development at the time of any examination date are always shown together, with the
former first in order of presentation. The words "none" and "trace" have been frequently used. When the word "none" is used, it signifies, for the particular case involved, that either no rust development or no telial production is recorded for that particular date. When the word "trace" is used, the amount in either case is less than one per cent and cannot, therefore, be adequately shown in the graphs. Generally this amount is considerably less than one-half of one per cent and in most cases means that only a very few telia were observed.

The study plots were not abandoned after one season's use thereof. In many cases, the same group of Ribes on a particular plot were studied for three different years. This was essential so as to secure data on the influence, if any, of varying seasonal climatic conditions on the production of telia.

The graphical data follow:

Canyon Creek Plots

The first tests of Ribes on these plots were made in 1925 (figs. 1 and 2). In comparing the data on the sun-form plants of Ribes lacustre and R. viscosissimum (fig.1), it will be observed that by June 24 the rust was well established on both of them. Only a trace of telia was noted at this time, indicating that this stage was very little in amount and just starting. By July 10, telial production was fairly well started on R. lacustre, but still only a
COMPARISONS OF
TOTAL RUST AND TELIAL DEVELOPMENT
1925

1925 SERIES
SUN FORM BUSHES
CANYON CREEK PLOTS

R. lacustre

R. viscosissimum

PERCENTAGES

INTervals OF EXAMINATIONS

Fig. 1

Percentage of total season's infection observed June 24 and developing at subsequent intervals.

Percentage of total season's telial production observed June 24 and developing at subsequent intervals.

R. lacustre, 49 bushes, 12,438 leaves.
R. viscosissimum, 50 bushes, 6,082 leaves.

Inoculations May 18 and 29.
COMPARISONS OF
TOTAL RUST AND TELIAL DEVELOPMENT
1925
1925 SERIES
SHADE FORM BUSHES
CANYON CREEK PLOT

R. lacustre
R. viscosissimum

PERCENTAGES

<table>
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<th>INTERVALS</th>
<th>EXAMINATIONS</th>
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<tr>
<td>Aug. 14 - Sept. 1</td>
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</tr>
</tbody>
</table>

Fig. 2

Percentage of total season's infection observed June 26 and developing at subsequent intervals.

Percentage of total season's telial production observed June 26 and developing at subsequent intervals.

R. lacustre, 50 bushes, 5,680 leaves.
R. viscosissimum 50 bushes, 4,201 leaves.
Inoculations May 18 and 29.
trace in amount on *R. viscosissimum*. By July 31, all of the telia that were developed during that season on *R. lacustre* had been produced. Telial production on *R. viscosissimum*, however, was attaining only a fair start at this time, being only 7 per cent of the total, and was not noted in considerable amount until August 19. On August 12 it was noted that a new crop of telia were just making their appearance on this host. On *R. lacustre* there was no increase in total development of the rust after July 31. On *R. viscosissimum*, however, the rust continued to increase in amount until the first part of September and telia continued to develop until the middle of that month.

Development of the rust on the shade form plants of both species (fig. 2), was fairly similar to that just described for the sun form plants. Over 65 per cent of the total telia on *R. lacustre* were produced by July 25 and by July 31, practically 85 per cent of them had developed. On *R. viscosissimum* the telia were again slower to develop and by July 25 less than 5 per cent of them were produced. It was not until the middle of August that abundant telial production was in progress on this species and this production continued until about the first of September.

Tests were continued in 1926 within these same groups of *Ribes* but with a somewhat reduced basis in number of
bushes; the remainder being needed for other purposes (fig. 3 and 4). In comparing the data on the sun form plants of both species (fig. 3), it is revealed that total rust development on *R. lacustre* was practically completed by June 16 and that by July 8 all the telia were produced. It was noted that the telia were dark colored and shriveled in appearance on this latter date, indicating that they had reached maturity quite some time before the examination was made. This means that shortly after the first of July no further development of the rust occurred on this species. On *R. viscosissimum*, however, telia did not begin to develop in considerable amount until about the first part of August and continued to develop until the first part of September. There was, therefore, a marked difference in time of development of the telia on both these Ribes species.

On the shade form of these two species of Ribes the same general trend in development of the rust will be noted (fig. 4). The majority of the telia produced on *R. lacustre*, however, were developed by June 16, which was between two and three weeks earlier than on the sun form of this species (fig. 3). They also continued to develop in small amount on the former group until about the first of September. In comparing the data on the shade form plants of both these species (fig. 4), it will be seen that on *R. lacustre* the majority of the telia were developed by June 16, whereas the majority of them on *R. viscosissimum*
COMPARISONS OF
TOTAL RUST AND TELIAL DEVELOPMENT

1926

1925 SERIES
SUN FORM BUSHES

CANYON CREEK PLOT

R. lacustre

R. viscosissimum

PERCENTAGES

INTERVALS

EXAMINATIONS

June 16
June 18
July 8
Aug. 1
Aug. 15
Sept. 3
Oct. 3

TRADE
NONE
NONE
NONE
NONE
NONE
NONE
NONE

Percentage of total season’s infection observed June 16 and developing at subsequent intervals.

Percentage of total season’s telial production observed June 16 and developing at subsequent intervals.

R. lacustre, 29 bushes, 7,153 leaves.
R. viscosissimum, 30 bushes, 4,115 leaves.
Inoculations May 4 and 10.

Fig. 3
COMPARISONS OF
TOTAL RUST AND TELIAL DEVELOPMENT
1926
1925 SERIES
SHADE FORM BUSHES
CANYON CREEK PLOT

R. lacustre
R. viscosissimum

INTERVALS OF EXAMINATIONS

Fig. 4

Percentage of total season's telial production observed June 16 and developing at subsequent intervals.

R. lacustre, 30 bushes, 4,330 leaves
R. viscosissimum, 26 bushes, 2,980 leaves.
Inoculations: May 4 and 10.
were not recorded until August 7, and they continued to develop until the first part of October.

These same groups of Ribes were tested again and for the third time in 1927 (figs. 5 and 6). For the third consecutive season the telial development followed the same general trend on these four different groups of Ribes. Development of the telia in perceptible amount on _R. lacustre_ in 1927 was at least a month earlier than on _R. viscosissimum_.

In summing up the data on these groups of Ribes for the three year period, it has been found that telial development in quantity occurred from two to at least seven weeks earlier on _R. lacustre_ than it did on _R. viscosissimum_. In all cases the telia have appeared in perceptible quantity (more than a trace in amount) earlier on the former than on the latter host of the rust.

It may possibly be suggested that the development of the telia as above discussed is peculiar to the particular bushes tested and might not occur in the same manner on other groups of the same species of Ribes in the near vicinity. Results of tests, however, on other groups of _R. lacustre_ and _R. viscosissimum_ growing nearby substantiate the previously mentioned results.

These other tests were made in 1926 on other bushes of these two Ribes species, which had not previously been infected with the rust (figs. 7 and 8). Here again telial
COMPARISONS OF TOTAL RUST AND TELIAL DEVELOPMENT 1927
1925 SERIES SUN FORM BUSHES
CANYON CREEK PLOT

R. lacustre

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R. viscosissinum

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<td>July 8</td>
<td>TRACE</td>
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<tr>
<td>Aug. 15</td>
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</tr>
</tbody>
</table>

Percentage of total season's infection observed June 15 and developing at subsequent intervals.

R. lacustre, 30 bushes, 9,164 leaves.
R. viscosissinum, 28 bushes, 4,860 leaves.
Inoculations May 16

Fig. 5
COMPARISONS OF
TOTAL RUST AND TELIAL DEVELOPMENT
1927
1925 SERIES
SHADE FORM BUSHES
CANYON CREEK PLOT

R. lacustre
R. viscosissimum

PERCENTAGES

0
20
40
60
80
100

JUNE 15
JUNE 15-
JULY 8
JULY 8-
AUG. 19
AUG. 19-
SEP. 26
JUNE 15
JUNE 15-
JULY 8
JULY 8-
AUG. 19
AUG. 19-
SEP. 26

PERCENTAGES OF TOTAL SEASON'S INFECTION OBSERVED JUNE 15 AND DEVELOPING AT SUBSEQUENT INTERVALS.
PERCENTAGE OF TOTAL SEASON'S TELIAL DEVELOPMENT OBSERVED JUNE 15 AND DEVELOPING AT SUBSEQUENT INTERVALS.
R. lacustre 30 bushes, 3,864 leaves.
R. viscosissimum 30 bushes, 2,895 leaves.
Inoculations May 16.

Fig. 6
COMPARISONS OF
TOTAL RUST AND TELIAL DEVELOPMENT
1926
1926 SERIES
SUN FORM BUSHES
CANYON CREEK PLOT

R. locustre
R. viscosissimum

Percentage of total season's infection observed June 15 and developing at subsequent intervals.
Percentage of total season's telial production observed June 15 and developing at subsequent intervals.
R. locustre: 45 bushes, 18,640 leaves.
Inoculations: May 4 and 10.

Fig. 7
COMPARISONS OF
TOTAL RUST AND TELIAL DEVELOPMENT

1926

1926 SERIES
SHADE FORM BUSHES

CANYON CREEK PLOT

R. lacustre R. viscosissimum

**Fig. 8**
development on *R. lacustre* occurred a few weeks ahead of that on *R. viscosissimum* and practically the same trend in telial development obtained on these bushes when they were again tested in 1927 (figs. 9 and 10).

**9-Mile Creek Plot**

On this plot *R. lacustre* was tested along with two other species of Ribes, the wild black currant (*R. petiolare*) and the smooth-stemmed gooseberry (*R. inerme*). The first tests were here made in 1926. In comparing the data (fig. 11), it is found that telia in abundance were noted a month earlier on *R. lacustre* than on the other two species.

These same bushes were again tested in 1927 (fig. 12) and about the same general tendency in time of telial development was again noted. The difference here is not as great as in 1926, but the results are significant.

**Revelstoke Plot**

On this plot the rust's development was recorded for three consecutive years on the same group of 100 *R. lacustre* bushes. There were no other Ribes species nearby on which comparative data could be secured. The data on *R. lacustre* are included, nevertheless, for they were obtained in a location which was widely separated from the two previously mentioned plots and represent results secured under a somewhat different set of climatic conditions. Somewhat more rainfall occurs on this plot than does on the other two
COMPARISONS OF
TOTAL RUST AND TELIAL DEVELOPMENT
1927.

1926 SERIES  JUN FORM BUSHES

CANYON CREEK PLOT

R. lacustre

R. viscosissimum

Percentage of total season's infection observed June 14 and developing at subsequent intervals.
Percentage of total season's telial development observed June 14 and developing at subsequent intervals.

R. lacustre 65 bushes, 20,471 leaves.
R. viscosissimum, 65 bushes, 14,470 leaves.
Inoculations May 16.

Fig. 9
COMPARISONS OF
TOTAL RUST AND TELIAL DEVELOPMENT
1927

1926 SERIES
SHADE FORM BUSHES
CANYON CREEK PLOTS

R.rocustra     R.viscosissimum

PERCENTAGE

PERCENTAGE

0     20   40   60   80   100

June 14  June 14  July 9  Aug. 19  Sept. 19
June 14  June 14  July 9  Aug. 19  Sept. 19

INTERVALS OF EXAMINATIONS

% Percentage of total season's infection observed June 14 and developing at subsequent intervals.
% Percentage of total season's telial development observed June 14 and developing at subsequent intervals.

R.rocustra, 63 bushes, 10,795 leaves.
R.viscosissimum, 63 bushes, 8,342 leaves

Inoculations May 16

Fig. 10
COMPARISONS OF TOTAL RUST AND TELIAL DEVELOPMENT 1926

1926 SERIES   PARTIAL-SHADE FORM BUSHED

9-MILE CREEK PLOT

R. lacustre

R. petiolarë

R. inermë

INTERVALS OF EXAMINATIONS

0  20  40  60  80  100

PERCENTAGES

Percentage of total season's infection observed June 20 and developing at subsequent intervals.

Percentage of total season's telial development observed June 20 and developing at subsequent intervals.

Inoculations May 6 and 12

Fig. 11
COMPARISONS OF
TOTAL RUST AND TELIAL DEVELOPMENT
1927
1926 SERIES PARTIAL-SHADE FORM BUSHES
9-MILE CREEK PLOT

R. lacustre R. petiolare R. inerme

INTERVALS OF EXAMINATIONS.

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Percentage of total season's infection observed June 18 and developing at subsequent intervals.

Inoculations May 17 and June 6
plots and this, as previously stated, favors the development of the rust.

From examination of the data (fig. 13), it will be observed that comparatively little development of the rust or telia occurred after the end of July or first part of August. Here again the trend in rust and telial development is quite comparable to that obtaining on R. lacustre on the other plots.

Hunter's Siding Plots

Ribes lacustre was the only species tested at this place in 1928; the R. viscosissimum plots not being established until 1930, at which time the former species was again tested and comparative data secured. The 1928 data are included, however, so that comparisons may be made of telial development on R. lacustre for the two different years (figs. 14 and 15). From an examination of these graphs it will be observed that from 50 per cent to over 75 per cent of the telial development in 1928 had occurred by the latter part of June. This is here considered early for telia to be produced in amount on R. lacustre and much earlier than on any of the other hosts tested on any of the plots. A similar trend in development of telia on these same groups of bushes was recorded in 1930 (fig. 15).

In comparing the data on R. viscosissimum (fig. 16),
COMPARISONS OF TOTAL RUST AND TELIAL DEVELOPMENT

REVELSTOKE PLOT

R. lacustre Partial shade form bushes

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<tr>
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<th>Interval</th>
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<th>1931</th>
<th>1932</th>
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<tr>
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<td>20%</td>
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Percentage of total season's infection observed June 28, etc., and developing at subsequent intervals.

Naturally infected - not inoculated.
COMPARISONS OF
TOTAL RUST AND TELIAL DEVELOPMENT
1928

1928 SERIES
SUN FORM BUSHES

HUNTERS SIDING PLOTS
R. lacustre

PLOT I
PLOT II
PLOT III

INTervalS
PERCENTAGES

0 20 40 60 80

TRACE NONE

May 23 June 23 July 23 Aug. 28 Sept. 28

May 23 June 23 July 23 Aug. 28 Sept. 28

May 23 June 23 July 23 Aug. 28 Sept. 28

INTERVALS
OF EXAMINATIONS

Percentage of total season's infection observed May 23 and developing at subsequent intervals.

Percentage of total season's telial development observed May 23 and developing at subsequent intervals.

Plot I: 10 bushes 1474 leaves.

Plot II: 5 586

Plot III: 4 9,626

Fig. 14

Inoculations Apr. 25 and May 18, 23 and 28.
COMPARISONS OF TOTAL RUST AND TELIAL DEVELOPMENT

1930

1928 SERIES

HUNTERS SIDING PLOTS

R. lacustre

Plot I

Plot II

Plot III

INTERVALS OF EXAMINATIONS

Percentage of total season's infection observed June 27 and developing at subsequent intervals.

Percentage of total season's telial development observed June 27 and developing at subsequent intervals.

Plot I - 10 bushes, 1,112 leaves.
Plot II - 9 , 1,086
Plot III - 5 , 16,445

Fig. 15

Inoculations May 7, 10 and 11.
COMPARISONS OF TOTAL RUST AND TELIAL DEVELOPMENT
1930

1930 SERIES
SUN FORM BUSHES

HUNTERS SIDING PLOTS

R. viscosissimum

Plot I
Plot II

<table>
<thead>
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<td>TRACE</td>
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- Percentage of total season's infection observed June 29 and developing at subsequent intervals.
- Percentage of total season's telial development observed June 29 and developing at subsequent intervals.

Plot I: 120 bushes, 1,480 leaves.
Plot II: 21 = 1,075
Inoculations: May 7, 10, and 17.

Fig. 16
with that on *R. lacustre* (fig. 15), it will be observed that telial development on the former host was not recorded in amount until the end of July. Practically all of the telial development on *R. lacustre*, however, had occurred by this time. Here again the results are constant, and a wide difference in time of significant telial development on the two different hosts has been recorded.

**Apex and Hall Plots**

These plots were established in 1928, at which time the first tests were made. The comparative results secured here on *R. lacustre* and *R. viscosissimum* are not as striking (fig. 17) as those obtained on most of the other plots, but they do indicate the same general trend in telial development on the two hosts. Over 50 per cent of the telia on *R. lacustre* were observed on June 26 and from general notes recorded July 26 on the stage of development and appearance of the telia at that time, it was evident that most all of them were produced shortly after June 26. Practically all of the telia on *R. lacustre* on this latter date were old and matured. No telia were noted on *R. lacustre* after August 23, whereas their development was just terminating as late as October 2 on *R. viscosissimum*.

Tests were made on both of the *R. viscosissimum* plots again in 1930. A forest fire destroyed the *R. lacustre* plot in 1929, and as there were no other bushes of this species nearby comparative tests between the two species
COMPARISONS OF TOTAL RUST AND TELIAL DEVELOPMENT
1928

SUN FORM BUSHES

HALL PLOTS

R. lacustre

R. viscosissimum

APEX PLOT

R. viscosissimum

1928 SERIES

PERCENTAGES

INOCULATIONS May 16 and 22.

Fig. 17

Percentage of total season's infection observed June 26 and developing at subsequent intervals.

Percentage of total season's telial development observed June 26 and developing at subsequent intervals.

Hall Plot, R. lacustre, 7 bushes, 625 leaves.

Hall Plot, R. viscosissimum, 5 bushes, 1854 leaves.

Apex = 4 = 3

INTRAVALS OF EXAMINATIONS
COMPARISONS OF
TOTAL RUST AND TELIAL DEVELOPMENT
1930

1928 SERIES
SUN FORM BUSHES

R.viscosissimum

HALL PLOT

APEX PLOT

INTERVALS OF EXAMINATIONS

Percentage of total season's infection observed July 1 and developing at subsequent intervals.

Percentage of total season's telial development observed July 1 and developing at subsequent intervals.

HALL PLOT: 5 bushes, 1688 leaves.
Apex Plot: 4 " 376 "
Inoculations: May 8 and 21.

Fig. 18
were not made. The results of the tests (fig. 18) on *R. viscosissimum*, however, were comparable to those secured on this same species on the several other plots in the different years. As has generally been the case, it was not until the middle to the latter part of July that telial development was of any consequence and the development continued until late in the season—in this instance, the first part of October.

**Garibaldi Plots**

In these tests, which were conducted in 1926 and 1927, *R. lacustre* is compared with *R. bracteosum*—a species not previously mentioned. The results of these tests indicate only a slight difference in the trend of telial development on the two hosts (figs. 19 and 20). Practically all of the telia on *R. lacustre* in 1926 were developed by the latter part of July, but they continued to develop on *R. bracteosum* until the first part of September. In 1927 there was not much of a contrast between the two species (fig. 20), although from the stage of development of the telia on July 5 it was evident that they had appeared earlier on *R. lacustre* than on *R. bracteosum* for they were much farther advanced in development on the former than on the latter host. Both of these *Ribes* grew under dense shade, and it was evident through general observations on *R. lacustre* under such conditions that the rust usually began development somewhat
33.

later in the spring and continued to develop somewhat later in the fall when compared with the sun-form of this species.

During these same two years, 50 bushes of sun form *R. lacustre*, which were growing near the above mentioned groups, were also tested. There were no sun form plants of other Ribes species growing nearby on which comparative tests could be made and for this reason, therefore, graphic results of the tests are not included. It may be stated, however, that the development of the rust and of telia in 1926 was almost completed by June 23 and none occurred after July 19. In 1927 very little rust or telia developed on this group of bushes after the end of July. This was considerably earlier than the development obtaining on the shade form bushes (figs. 19 and 20).

From general observations, made during the course of these studies on *R. lacustre* and several of its Ribes associates in the Coastal section of British Columbia, it was evident that telial development generally occurred somewhat earlier on the former than on any of the latter. The greatest difference in this regard occurred on the sun form of *R. lacustre* when compared with the sun form of the other species, but this trend in development was not as marked when these Ribes grew under shade conditions. Also, development of the uredinia generally terminated somewhat to considerably sooner on *R. lacustre* than on the other, regardless of sun or shade form of the bushes.
COMPARISONS OF
TOTAL RUST AND TELIAL DEVELOPMENT

1926

1926 Series
Shade Form Bushes

GARIBALDI Plot

R. locustra
R. bracteosum

0 20 40 60 80 100

PERCENTAGES

INTERVALS OF EXAMINATIONS

Fig. 19

Percentage of the total season's infection observed May 1 and developing at subsequent intervals.

Percentage of the total season's telial development observed May 1 and developing at subsequent intervals.

R. locustra 75 bushes, 54,123 leaves
R. bracteosum 50 " 7,000 "
Natural infection - No inoculations.
COMPARISONS OF
TOTAL RUST AND TELIAL DEVELOPMENT
1927

1926 Series
Shade Form Bushes

GARIBALDI, B.C.

R. lacustre

R. bracteosum

PERCENTAGES

INTERVALS OF EXAMINATIONS

Percentage of the total season's infection observed June 4 and developing at subsequent intervals.

Percentage of the total season's telial development observed June 4 and developing at subsequent intervals.

R. lacustre - 70 bushes, 10,450 leaves
R. bracteosum - 50 - 2,550 
Natural infection - No inoculations.

Fig. 20
Rhododendron Plot

Tests were conducted on this plot for a period of three years—1930, 1931, and 1932. The species tested were *R. lacustre* and *R. bracteosum*, and the basis of bushes for the former species varied from 13 to 30 and for the latter from 13 to 19. Lack of time prevented systematic studies being carried out on these Ribes, but general notes on the development of the rust and on the telia were recorded.

In 1930 the majority of the telia on *R. lacustre* were developed and producing sporidia by July 4, but on *R. bracteosum* at this time telial development was just starting. A considerable quantity of young telia were noted on the latter mentioned host as late as October 20, but none were observed at this time on the former.

The 1931 results were similar to those of 1930. Telial development was well under way on *R. lacustre* by June 10, but on *R. bracteosum* only a very few telia were noted, and they had practically ceased developing on the former species by July 8 while on the latter they were just beginning. On August 26 development of the telia was practically at its peak on *R. bracteosum*, but no new telia were observed on *R. lacustre*.

In 1932 telial development had started on both hosts by June 14, the time of the first observation. By June 30 telial development had practically reached its peak on *R. lacustre*, while on *R. bracteosum* at this time telial
development was just getting a good start and did not approach culmination until the first part of August.

The development of the rust and telia on the Ribes on this plot followed the same general trend as that recorded in the studies on the other plots. Telia generally develop somewhat sooner on *R. lacustre* than on associated species.

**DISCUSSION AND CONCLUSIONS**

The studies described included tests on five different species of Ribes and were conducted over a period of seven years—1925 to 1928 and 1930 to 1932 inclusive. The study plots were established in seven different localities, which were widely separated and represent a variety of weather and other ecological conditions. A summary of the different Ribes tested follows:

<table>
<thead>
<tr>
<th>Ribes species</th>
<th>No. Localities</th>
<th>No. Groups</th>
<th>No. Bushes</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>R. lacustre</em></td>
<td>7</td>
<td>13</td>
<td>over 500</td>
</tr>
<tr>
<td><em>R. viscosissimum</em></td>
<td>3</td>
<td>8</td>
<td>over 230</td>
</tr>
<tr>
<td><em>R. petiolare</em></td>
<td>1</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td><em>R. inerme</em></td>
<td>2</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td><em>R. bracteosum</em></td>
<td>2</td>
<td>2</td>
<td>over 60</td>
</tr>
</tbody>
</table>

In most cases *R. viscosissimum* was tested with *R. lacustre* because these two species are common associates in the Inland Empire section. The former did not occur at all of the study localities, however, so other species were included in the tests. This procedure permitted the studies to be conducted over a wide range of territory representing a variety of environmental conditions.
Regardless of these varying conditions, it was found as a result of the studies that telia generally began developing earlier (from two weeks to almost two months) on R. lacustre than on the other species tested, and especially does this appear to be the case when compared with R. viscosissimum. Also, development of the uredinia generally ceases a few to several weeks sooner on the prickly currant than on the other species. This shorter period of uredinial production on the prickly currant when compared with other Ribes species has also been reported from New Hampshire (16, p. 56), but no explanation of the cause was given.

It is evident that environment is not the factor responsible for the manner of development of the rust and telia on R. lacustre as compared with other species of Ribes. If this were the case the results could not be so constant. The factor here believed to be responsible for the above outlined behavior of the rust on this currant is an inherent characteristic of the species, namely, the time of maturity of its leaves. Observations and records made in this connection during the course of the studies revealed that on this species the leaves reach maturity sooner than they do on the other species. Generally by July 1, and often before that time, the leaves of the prickly currant become hardened and leather-like. This is especially the case on the sun form of the species but was
not noticeable to any extent on the other Ribes.

This hardening of the leaves may be accompanied by physiological changes within them which retard development of the rust and limit seasonal infection increases. Commenting on rusts in general, Arthur (3, p. 241) states that maturity of the tissues has a marked effect upon the development of the rust. However, little is known about the underlying causes. Often with the maturing of the tissue the development of the rust takes place much more slowly, and while producing a mycelium may not reach a condition of sporulation. Sometimes, even infection is prevented. At other times, although infection takes place, yet the development of the mycelium is slow and only a weak sporulation occurs. That the chemistry of a plant changes markedly as it ages is well known. In these changes doubtless will be found the explanation of some of the differences noted in the development of the rusts in tissues of different maturity.

Lachmund (11) found that the very young leaves of *R. lacustre* are much more susceptible to blister rust than those a few weeks older. He also found (10) that this species is relatively low both in susceptibility and telial production when compared with the other three Inland Empire Ribes species. According to Arthur's comments mentioned above, it would appear that early maturity of the leaves of *R. lacustre* is an important factor in the behavior of the
There is constant danger of infection of pines at any time after telia form (16, p. 26). Before the infection can take place, however, humid weather conditions are necessary. Generally these conditions obtain during periods of rainfall and high relative humidity. It has been found that infections of pines may take place in a period of 18 to 36 hours depending upon the weather conditions (17, p. 15).

According to Spaulding, conditions necessary for pine infection, however, must be peculiar and not occur very often (17, p. 15). Observations of the disease in all the outbreak areas of North America by many different workers show that the amount of infection of pines which has occurred is not uniform in different years. A large amount of the infection in a given locality has started in a certain year or in a few scattered years. Relatively few scattered infections have taken place in the intervening years. Pennington (15) found that an average of one season in every four years has been favorable for general spread of the rust along the coast of British Columbia, and the writer has observed that the average in this regard is one season in every five years in the interior section of this same country. The former found a correlation between summer precipitation and infections of pines.

Considering that every season is not favorable for the occurrence of pine infection apparently because of low
humidity conditions, it would appear evident that the necessary and favorable weather conditions in this regard may vary within a season. It has been shown herein that telia generally develop somewhat earlier on *R. lacustre* than on the other Ribes species compared with it. Weather conditions being favorable, pine infection may occur from the first telia that develop on this prickly currant. The remainder of the season may be unfavorable for pine infection to take place, and the remainder of the telia developing on *R. lacustre* and those which did not begin their development until later on other Ribes species may never cause infection of the pines for this reason. There is also the possibility that there might occur in a given season two favorable periods for the infection of pines—-one during early summer and the other late in the fall. In such an event a greater amount of pine infection might take place than would occur if only one Ribes species were present. Also, the danger period during which pine infection may take place is somewhat lengthened when *R. lacustre* is present with other species. It would seem, therefore, that wherever the prickly currant is in association with any of the other Ribes species considered in this paper, a greater frequency of the occurrence of pine infection is possible.

Telia are known to remain viable under certain conditions for practically three months (18). Early development of the telia on *R. lacustre* as compared with the other
species is, therefore, not a particular detriment for with favorable weather conditions obtaining later in the season pine infection from the old prickly currant telia may then take place.

It was thought possible at one time to leave uneradicated certain areas in the white pine stands where \textit{R. lacustre} occurred rather sparsely (9). The reason for this belief was that this species was then known to be relatively low in susceptibility to the rust and in the production of telia when compared with the three other important Inland Empire Ribes, and might, therefore, cause very little infection of pines. Recent studies (13), however, have shown that from but a few small diseased bushes of the prickly currant abundant infection of nearby pines occurred.

From a consideration of the foregoing, the prickly currant must be regarded as an important blister rust host in connection with the control of this disease and consequently with the management of western white pine. As brought out in these studies, this Ribes species must be considered an especial source of danger to the pines whenever it is found in association with them and should be destroyed.
SUMMARY

The studies here reported were made to determine the importance in the management of western white pine forests of certain native species of currants and gooseberries (Ribes spp.) with particular reference to *R. lacustre*, the prickly currant.

These currants and gooseberries, as alternate hosts of the white pine blister rust, are potential carriers of this destructive disease of the pine. Where the species of Ribes are numerous and highly susceptible to the rust, they must be eradicated as a part of the forest management program in order to protect the pine trees against the disease.

The importance of *R. lacustre*, although widely distributed over much of the western white pine area, has hitherto been questioned. The species has also been considered a variable host of the rust.

In order to establish the relative behavior and importance of this species as a potential source of rust infection on the pine, studies were conducted over a period of years, comparing this species with other species of Ribes occurring throughout the commercial western white pine stands of the Pacific Northwest.

The species studied were *Ribes bracteosum*, *R. petiolare*, *R. inerme*, *R. viscosissimum* and *R. lacustre*. 
The study plots were situated in seven different localities - one in the coastal section and five in the interior section of British Columbia, and one in Oregon on the Mt. Hood National Forest.

The results of these studies clearly show that the telia, from which the pine-infecting spores form, generally begin to develop from about two weeks to almost two months earlier on *R. lacustre* than on the other species considered.

As a result of the earlier development of the telia on *R. lacustre* the season during which pine infection may take place is lengthened, and the chances for the occurrence of pine infection are increased.

Accordingly, *R. lacustre*, the prickly currant, is regarded as of especial importance in the control of blister rust and, consequently, must be given particular consideration in that phase of forest management of western white pine which aims at permanent protection against this disease.
LIST OF LITERATURE CITED


