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Spruce Weevil Damage

ECOLOGICAL BASIS AND HAZARD RATING FOR VANCOUVER ISLAND

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The spruce weevil (*Pissodes strobi* Peck) was once known as three separate species: the Sitka spruce weevil (*P. sitchensis* Hopkins), the Engelmann spruce weevil (*P. engelmanni* Hopkins), and the white pine weevil (Smith and Sugden, 1969). Although white pine weevil is the name associated with the correct scientific name, it is referred to here as the spruce weevil because it does not attack western white pine (*Pinus monticola* Dougl.). In the west, it is found primarily on Sitka (*Picea sitchensis* (Bong.) Carr.), white (*P. glauca* (Moench) Voss) and Engelmann (*P. engelmannii* Parry) spruce. The insect is a serious pest of regeneration Sitka spruce in British Columbia (Silver, 1968), Washington and Oregon (Wright, 1960), but has never been found on the Queen Charlotte Islands. The weevil is a potential pest on white and Engelmann spruce as regeneration acreages of these species increase.

ABSTRACT

Various ecological factors, particularly the effect of summer heat, associated with damage caused by spruce weevil are discussed. A map outlining general areas of low damage hazard is included.

RÉSUMÉ

L'auteur discute de divers facteurs écologiques, notamment l'effet de la chaleur estivale sur les dommages causés par le Charançon du Pin blanc. Il présente un carton montrant les régions de danger peu élevé.

The weevil attacks and kills the year-old leader; consequently, the current year's growth dies as well. The first gross evidence of damage occurs when the new shoot begins to wilt and droop, usually in July (Fig. 1). The needles eventually discolour, turn red, and drop by fall or the following spring (Fig. 2). The damage results in multiple and crooked stems, loss of height growth and general bushiness (Fig. 3).

The seasonal history was described by Silver (1968) and Wood and McMullen (1971). The adults deposit eggs in the phloem of the leader during May and June. The larvae burrow downward in the phloem and, when nearly mature, form cavities in the woody tissue of the leader. The cavities, usually on the surface but sometimes in the pith, are covered with wood fibres and are commonly called "chip cocoons". The larvae pupate in these cocoons and emerge as young adults in late August and September. The adults feed throughout the tree crown and then overwinter in the duff or in the tree crown (Gara *et al.*, 1971; McMullen and Condrashoff, 1973). Some adults may live up to 4 years, reproducing each year (McMullen and Condrashoff, 1973).

A survey of weevil damage on Vancouver Island (Harris *et al.*, 1968) indicated that, in general, the west coast area of the Island suffered the least damage, but variation was high. This report covers further examination of ecological factors associated with weevil damage and provides a map showing areas of low hazard of damage.

ECOLOGICAL FACTORS ASSOCIATED WITH DAMAGE

An initial examination of 122 plots of approximately 50 trees each at 62 locations on Vancouver Island attempted to associate weevil damage with various ecological criteria, such as site (as determined by ground cover), associated tree species, spruce growth characteristics, deciduous overstory, distance from the open sea, and elevation. Of these criteria, only tree height, deciduous overstory, and distance from the sea appeared to influence the incidence of damage.

TABLE I.
Distribution of trees and percentage damaged by spruce weevil by height classes

	Height class (m)						
	0-1.2	1.2-2.1	2.1-3.0	3.0-6.1	6.1-9.1	9.1+	Total
Number of trees	736	1439	1010	1792	761	552	6290
Damage (%)	0.4	3.7	11.4	27.0	17.5	12.1	12.9

The incidence of attack was greatest in the 3.0- to 6.1-m (10-to 20-ft) height class (Table I), similar to the results of Harris *et al*. (1968) and Silver (1968). Only stands averaging over 1.8 m (6 ft) in height and with more than 10% over 3.05 m (10 ft) were attacked. Stands not meeting these height requirements were deleted for examination of effect of deciduous overstory and distance from the sea. Those stands within 6.4 km (4 miles) of the open sea and those with deciduous overstory (maple and/or alder) suffered the least damage (Table II). The major exception to these generalizations occurred in the class 19.3 to 25.7 km (12 to 16 miles) from the sea. Of the four plots, two were in a valley bottom frequently subjected to fog, and two were on northern Vancouver Island which had a general low incidence of weevil damage.

EFFECT OF TEMPERATURE

Since the incidence of damage was relatively low within 6.4 km (4 miles) of the open sea and on northern Vancouver Island, and absent on the Queen Charlotte Islands, temperature was suggested as an important factor. Two ways in which temperature might affect the behavior of the insect are through its effect on oviposition activity and on rate of brood development.

Maximum oviposition activity occurred at 29.4°C (85°F) on Sitka spruce in Washington (Carlson, 1971), similar to that on eastern white pine (*Pinus strobus* L.) in Ontario (Sullivan, 1960). On both hosts, very little oviposition occurred below 20°C (68°F) in the field. In the San Juan Valley, oviposition activity was maximum between 25 and 30°C (77 and 86°F), but with some oviposition as low as 11.1°C (52°F). Laboratory studies (McMullen, unpublished) indicated a gradual increase from 10°C (50°F) to a maximum at 26°C (78.8°F), but with much variation. Carlson (1971) found a gradual increase from 15.6°C (60°F) to 29.4°C (85°F) under laboratory conditions. Nevertheless, oviposition progressed rapidly in the San Juan Valley when few days exceeded 18.3°C (65°F) and the weather records suggest that during May and June enough days for oviposition to be successful would occur even where cooler near the coast.

Accumulated heat, measured in degree-days above a threshold temperature, can be used to determine the development of the brood in the leader. The accumulated heat required for brood development from egg to emergence is 888 degree-days above 7.2°C (1600 degree-days above 45°F) (McMullen,

TABLE II.
Percentage of trees damaged by spruce weevil over 3 years by distance from the open sea and presence or absence of deciduous overstory.

Distance from sea (km)	Overstory present		Overstory absent		Total	
	n[1/]	%	n	%	n	%
0 - 6.4	4	0	12	1	16	1
6.4-12.9	2	11	16	14	18	14
12.9-19.3	0	—	4	10	4	10
19.3-25.7	0	—	4	2	4	2
25.7-32.2	2	7	6	30	8	24
32.2+	13	16	33	32	46	27
Total	21	12	75	20	96	18

1/ n = number of plots.

unpublished). The number of degree-days can be determined from field weather records (Baskerville and Emin, 1969) by summing the degree-days contributed by each day as the average of the maximum and minimum temperature less 7.2°C (45°F) (the threshold temperature for development of the insect) when the minimum is above the threshold. A small modification, made when the temperature drops below the threshold, is given by a chart.

The date of the first occurrence of developmental stages in the Nitinat Valley in 1962 (Silver, 1968) and 1963 (Silver, unpublished) provide confidence in the use of the amount of heat required by the insect. Weather records taken at the site (supplemented by Cowichan Forestry records to fill in missing data in 1963) were used to calculate heat accumulation and estimate the time of first occurrence of the developmental stages (Table IV).

The incidence of weevil damage in the San Juan Valley increased from zero near the coast to over 20%, 12 km (7½ miles) inland. Five weather stations, spaced at intervals inland 12 km from the coast, operated during 1969 and 1970 showed, for the period May through September, a general gradual increase in temperature and heat accumulation as distance inland increased. Temperature and heat accumulation at the inland station and maximum differences among the five stations are shown in Table III. The accumulated heat exceeded 888 degree-days C in 1969 at all five stations, but only at the most inland station in 1970. Weather records

FIGURE 1. Drooping current year's shoots, an early symptom of attack by spruce weevil.

obtained from British Columbia Forest Products Ltd. for Port Renfrew for 1964 to 1970 indicated that 1969 was relatively warm and 1970 relatively cool. Only 4 of the 7 years provided the 888 degree-days required by the insect, suggesting that the coastal area at Port Renfrew is marginal for development of the insect.

The number of degree-days, May through September, for 1964 to 1970 was calculated from weather records for three stations on the Queen Charlotte Islands and nine on northern and western Vancouver Island (Table V, Fig. 4). Records from stations further inland and on the east coast of Vancouver Island (e.g. Port Alberni and Campbell River) were not examined in detail because they were obviously much warmer than the west coast stations.

These heat accumulation records indicate that the west coast of Vancouver Island is marginal for development of weevil broods. A few locations such as Zeballos and Quatsino indicate that the limits placed on the insect by accumulated heat are confined to a narrow belt along the coast. On northern Vancouver Island, Port Hardy and Alert Bay, records suggest that the hazard of damage by the weevil would be low over much of the area. The weather records from the Queen Charlotte Islands suggest that the weevil would not survive there.

Records of weevil damage obtained from various sources, such as those of Harris *et al.* (1968), Forest Insect and Disease Survey, the survey referred to in this report, and other miscellaneous observations, generally support the conclusions drawn from the weather records. Thus the weather records provide a basis to estimate areas on Vancouver Island which

TABLE III.
Temperature (°C) and heat accumulation, May through September, at weather station 12 km inland and maximum differences among five stations situated from the coast inland during 2 years San Juan Valley.

Parameter	1969		1970	
	Inland station	Difference	Inland station	Difference
Mean temperature	13.7	0.8	12.6	0.6
Mean maximum temperature	19.7	2.6	18.9	3.2
Degree-days above 7.2°C	1034	134	907	141

FIGURE 2. Dead leader resulting from attack by spruce weevil.

FIGURE 3. Bushy Sitka spruce attacked for several years by spruce weevil.

TABLE IV.
Date of first occurrence of developmental stages in the field, estimated date based on degree-days, and degree-days above 7.2°C required for development to stage.

Stage		1962 first occurrence	1962 estimated date	1963 first occurrence	1963 estimated date	Degree-days required
Instar	1	May 29	June 7	1/	—	142
	2	June 18	June 17	June 3	June 6	210
	3	June 25	June 25	June 10	June 15	283
	4	July 9	July 7	June 24	June 21	369
Pupa		July 30	July 28	July 22	July 19	568
Young adult		Aug. 20	Aug. 13	Aug. 12	Aug. 5	736
Emergence		Sept. 25 2/	Aug. 29	Aug. 26	Aug. 20	888

1/ Eggs and first instar found on same date.
2/ Date inaccurate due to too few examinations.

TABLE V.
Average annual accumulated heat (Degree-days above 7.2°C), May through September, 1964 to 1970, at 12 weather stations on the Queen Charlotte Islands and Vancouver Island.

	Year							
Location	1964	1965	1966	1967	1968	1969	1970	Average
Tasu Sound	627	821	664	867	828	831	619	751
Sandspit	699	812	748	894*	830	826	706	788
Port Clements				926*	848	861	698	833
Alert Bay	751	779	831	1007*	890*	897*	796	850
Port Hardy	700	720	758	912*	796	808	696	770
Quatsino	849	989*	929*	1114*	994*			975
Zeballos Iron Mines		1180*			1222*			1201
Tofino	783	812	841	1036*	909*	921*	790	870
Bamfield East	766	799	821	972*	888*	916*	782	849
Pachena Point	693	681	710	849	789	799	662	740
Port Renfrew	785	893*	842	1122*	1087*	1061*	833	946
Jordan River	836	848	903*	1051*	937*	936*	853	909

* exceeded 888 degree-days

have a low hazard of weevil damage (Fig. 4). The line delimiting the zone of low hazard, in general, follows contour lines between records, but it also takes into account expected influence of topography to the west.

On northern Vancouver Island, the boundary of the area extends from Quatsino Sound to Holberg Inlet before going east, primarily on the basis of the high heat accumulation at Quatsino. Although a record of high weevil damage occurred north of Rupert Inlet, the boundary extends eastward essentially along the 152 m (500 ft) contour to Beaver Cove. The record of high weevil damage on a south slope may have been due to local conditions. Although no damage occurred at Angler and Bonanza Lakes, nearby Nimpkish Lake has a history of damage.

The area of low hazard described (Fig. 4) coincides closely with the biogeoclimatic Fog Western Hemlock/Sitka spruce Subzone described by Packee (1972), except that the low weevil hazard area is more extensive than the Fog Subzone on northern Vancouver Island.

CONCLUSION

The information contained in this report suggests that accumulated heat is an important factor associated with damage caused by the spruce weevil. Sitka spruce could be planted in the areas of Vancouver Island where accumulated heat is less than 888 degree-days above 7.2°C (1600 degree-days above 45°F) with little risk of serious damage from the weevil. The insect has never been found on the Queen Charlotte Islands and weather records suggest that it would not survive there. On the coastal mainland, one would expect that damage would, in general, be severe east of Vancouver Island, but that there would be a narrow coastal strip north of Vancouver Island that would have a low hazard of damage. As the insect in the interior of British Columbia develops faster (McMullen, unpublished), caution would be necessary in applying the information there.

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(Enclosed)

FIGURE 4. **VANCOUVER ISLAND:** Areas of low hazard of damage by spruce weevil, weather stations with summer accumulated heat (degree-days C), and damage records.

Note: *McMullen, unpublished now in press.*

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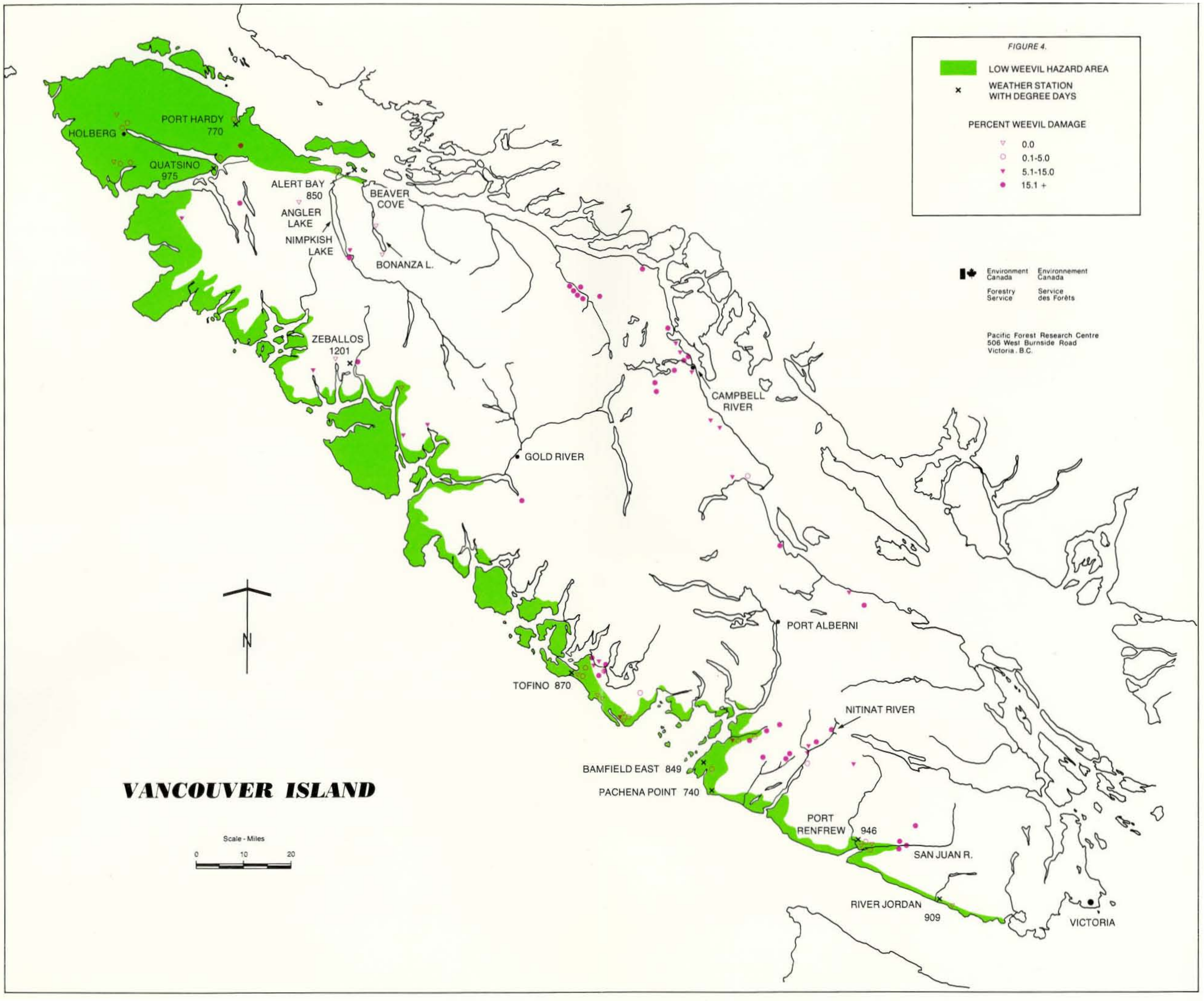
FIGURE 4.
LOW WEEVIL HAZARD AREA
WEATHER STATION WITH DEGREE DAYS
PERCENT WEEVIL DAMAGE
0.0
0.1-5.0
5.1-15.0
15.1 +
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VANCOUVER ISLAND
Scale - Miles
0
10
20
N
HOLBERG
PORT HARDY
770
QUATSINO
975
ALERT BAY
850
ANGLER LAKE
NIMPKISH LAKE
BEAVER COVE
BONANZA L.
ZEBALLOS
1201
GOLD RIVER
CAMPBELL RIVER
PORT ALBERNI
TOFINO 870
NITINAT RIVER
BAMFIELD EAST 849
PACHENA POINT 740
PORT RENFREW
946
SAN JUAN R.
RIVER JORDAN
909
VICTORIA