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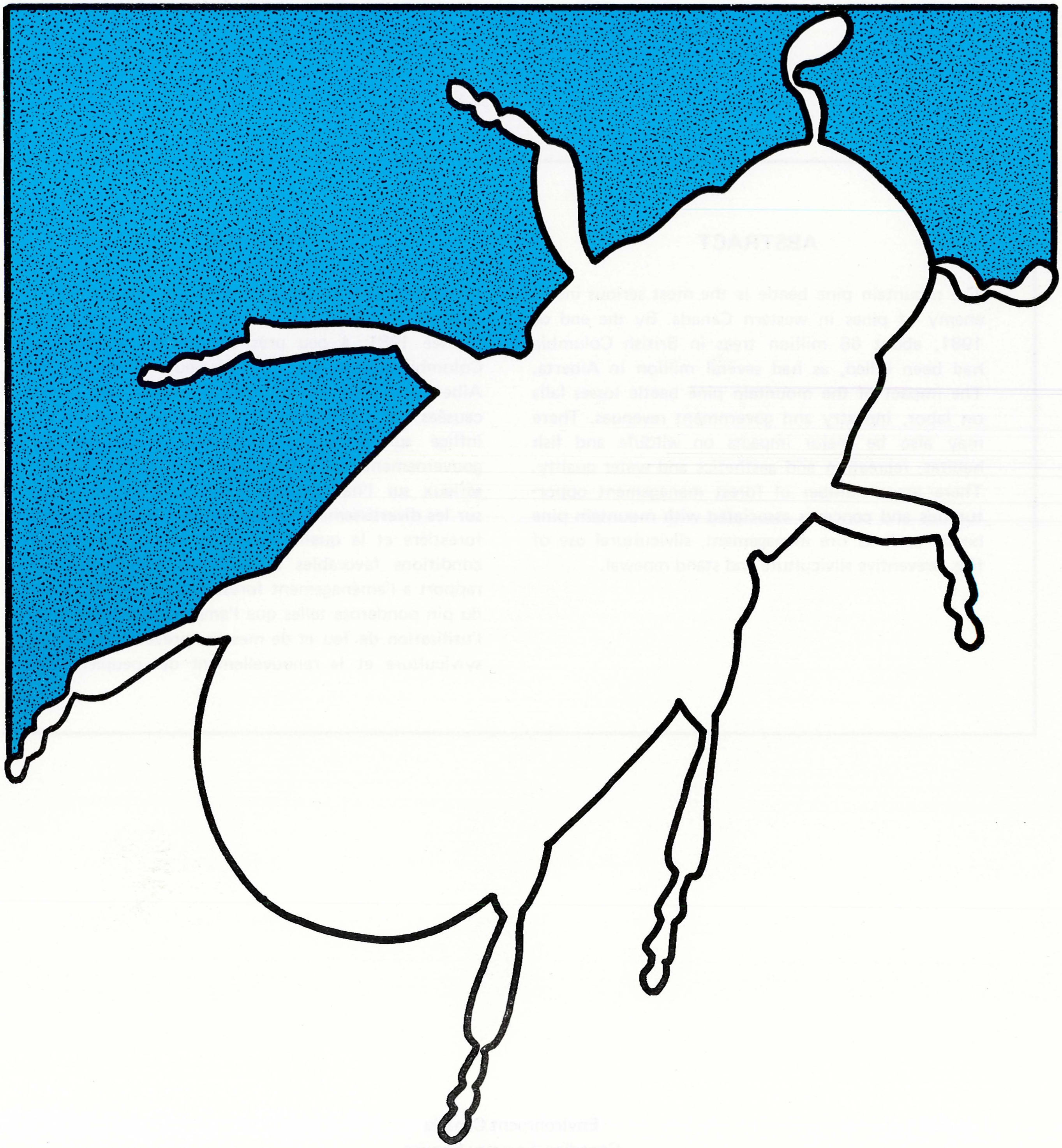

Environment Canada / Environnement Canada

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A Review of Mountain Pine Beetle Problems in Canada

ABSTRACT

The mountain pine beetle is the most serious insect enemy of pines in western Canada. By the end of 1981, about 66 million trees in British Columbia had been killed, as had several million in Alberta. The impact of the mountain pine beetle losses falls on labor, industry and government revenues. There may also be major impacts on wildlife and fish habitat, recreation and aesthetics and water quality. There are a number of forest management opportunities and concerns associated with mountain pine beetle such as fire management, silvicultural use of fire, preventive silviculture and stand renewal.

RESUME

Le dendroctone du pin ponderosa est l'insecte le plus nuisible des pins dans l'ouest du Canada. Au bout de l'année 1981, à peu près 66 millions d'arbres en Colombie-Britannique, et plusieurs millions en Alberta, avaient été détruits. L'impact des pertes causées par le dendroctone du pin ponderosa est infligé sur le travail, l'industrie et les revenus gouvernementaux. Il peut aussi y avoir des impacts sérieux sur l'habitat des poissons et de la faune, sur les divertissements et l'esthétique d'une ambiance forestière et la qualité de l'eau. Il existe certaines conditions favorables et certaines inquiétudes par rapport a l'aménagement forestier lié au dendroctone du pin ponderosa telles que l'aménagement des feux, l'utilisation de feu et de mesures préventives dans la sylviculture et le renouvellement des peuplements.

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PREFACE

Following the joint Canada/U.S.A. Workshop on Mountain Pine Beetle-Related Problems, the senior management of the Canadian Forestry Service requested the preparation of a paper on mountain pine beetle problems in western Canada. This paper is the result of that request.

The discussion paper, in addition to evaluating the potential physical, economic, and social impacts of the current mountain pine beetle outbreak, suggests possible management and research strategy to deal with the problems.

As part of the effort to acquaint more people with the seriousness of the mountain pine beetle problem, this paper is being generally distributed. The paper was prepared by G.H. Manning, L. Safranyik, G.H. Van Sickle, R.B. Smith, W.A. White, and E. Hetherington of the Pacific Forest Research Centre, Canadian Forestry Service, Victoria, British Columbia. The following members of the staff of the Northern Forest Research Centre, Canadian Forestry Service, Edmonton, Alberta, contributed to the report: H. Cerezke, W.D. Holland, D. Dube, L. Brace, R.H. Swanson, and T. Williamson. In addition, Mr. R.L. Morley, B.C. Ministry of Environment, Victoria, British Columbia, contributed to the section on wildlife habitat considerations.

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OBJECTIVES

1. The objective of this paper is to update and expand upon "Position Paper on Mountain Pine Beetle Problems, With Special Reference to the Rocky Mountain Parks Region," released March 19, 1981. This update treats mountain pine beetle problems in western Canada, including physical impacts through the summer of 1981, economic impact, and impacts on recreation, tourism, wildlife, water and soils. Specific opportunities are identified for managing the lodgepole pine component of western Canada's forests to reduce losses.

BACKGROUND

2. The mountain pine beetle, a native pest, is the most serious insect enemy of mature pines in western Canada. The beetle attacks trees in midsummer by chewing through the outer bark and by cutting vertical egg galleries (tunnels) in the inner bark region of the main stem. Eggs are laid along the galleries. Upon hatching, the larvae feed circumferentially on the soft tissues of the inner bark and then usually overwinter, becoming pupae the spring after attack. Pupae transform into young adult beetles by late spring-early summer and, upon maturation 2 to 3 weeks later, emerge to attack new trees. Thus, the life cycle is normally 1 year. The beetles carry a number of microorganisms, including blue stain fungi, which quickly infest and kill living cells in the bark and sapwood. Within a few weeks of being infested, trees usually begin dying from the action of the blue stain fungi and the girdling of the living bark by the beetles.

3. Mountain pine beetle activity has been recorded in British Columbia since 1910, with major outbreaks at irregular intervals in various geographic locations. Outbreaks are persistent; on average, they last 8 to 9 years and severely deplete the pine component of forests, particularly the larger-diameter (greater than 25 cm) trees. Groups of trees in the younger age classes (40 to 80 years) may also be attacked and killed, because of the pressure of the beetle population. Other effects of the mountain pine beetle are a hastening of forest succession, a change in age and diameter distribution of the pine component of forests, a reduction in aesthetic values and an increase in fire hazard. Each of these effects can force changes in management plans. Additionally, marketing problems may result from the unplanned necessity to quickly cut large volumes of dead timber.

4. Because outbreaks usually develop in mature to overmature forests, especially in lodgepole pine, large reserves of these forests pose a constant hazard in areas climatically favorable for the beetle. Thus, "storing" mature or overmature trees on the stump should be discouraged.

5. Serious outbreaks are located in a number of areas in British Columbia, in southwest Alberta and adjacent to the United States. In British Columbia, major infestations may be found in the East Kootenays from the United States border north to Mica Reservoir, in the Fraser River drainage from Lytton to Quesnel and westward through the Cariboo, in the Okanagan Region and in the Skeena drainage from Hazelton to Vanderhoof.

6. Owing to the destructive nature of mountain pine beetle outbreaks, the biology and management of this insect has been intensively researched in Canada (mostly by the Canadian Forestry Service) and the United States.

EXTENT AND HISTORY OF MOUNTAIN PINE BEETLE OUTBREAKS IN BRITISH COLUMBIA

7. Historically in British Columbia, damage has been greatest in the southcentral and southeastern interior, in the Chilcotin and in an area between Hazelton and Stuart Lake. Infestations in British Columbia have expanded dramatically since 1974, when a total of only 3 300 ha at 35 scattered locations were affected. In 1981, infestations numbered almost 5 000 and encompassed 158 000 ha of mature lodgepole and other pine stands. Based on Canadian Forestry Service surveys, it is estimated that the 1979 attacks alone killed more than 14 million trees in British Columbia, with a gross volume of 7.7 million m^3; an additional 19.6 million trees were killed by the 1980 attack and an estimated 32 million during 1981. The volume of timber on the area currently under attack was 18.5 billion m^3.

8. The cumulative potential loss, considering the extent and volume of mature, susceptible stands, is many times greater. As two-thirds of the infestations mapped presently cover less than 20 ha each and another 17% are less than 50 ha, the potential for expansion is considerable. Also, two-thirds of the area mapped was judged to be lightly or moderately infested (i.e., less than 30% of the susceptible host trees were recently attacked); consequently, the potential is high for continued intensification of attacks within these stands.

9. The attached maps and table of area or tree counts (Attachment 1) are based on newly faded trees, most of which were attacked the year preceding the annual aerial survey. Recently killed trees that are still green or trees killed in earlier years are not reflected in the annual data. Results from 48 ground cruises, performed by the Canadian Forestry Service this year, clearly indicate the following conditions: in individual stands, from 0% to 47% of the trees were recently killed, with red foliage still evident; from 0% to 72% were currently attacked and still green; and from 1% to 87% of the trees had been dead for 2 or more years. In some stands, which had been infested for as few as 4 years, less than 10% of the trees were still alive.

10. Mortality of lodgepole pine, caused by the 1980 beetle attack over more than 158 000 ha in the province from the Flathead River drainage in the southeast corner through the Kamloops and Cariboo Regions to the Nass River in the Prince Rupert Region, was sketchmapped during 1981 aerial surveys (see map, Attachment 1). More than 19.6 million trees were killed—most of them in the Nelson and Cariboo Regions (Table 1, Attachment 1). Scattered mortality also continued in the Nelson and Cariboo Regions on an additional 59 000 ha, on which most of the pine had been previously killed. Exclusion of this area containing more than 8 million m^3 of pine and salvage logging in some infested stands have slightly reduced the current area of infestation reported, despite the continued expansion and intensification of infestations since the early 1970s.

11. Generally, there was a considerable increase in the number of trees attacked in 1981 compared with 1980, particularly in the Cariboo Region, where, in the Chilcotin, an average of 55% of the trees were currently attacked. In the Prince Rupert Region, current attacks more than doubled. Based on limited prism cruises in representative stands, it is estimated that more than 32 million trees were attacked in 1981, of which the largest percentage was in the Cariboo Region. This, combined with large, healthy beetle populations in attacked trees, points to the continued increase and expansion of infestations in mature lodgepole pine stands.

12. In the Nelson Region, an estimated 10.5 million lodgepole pine trees, totalling 3.3 million m^3, were killed in 2 424 separate infestations on 58 700 ha (Table 1, Attachment 1). In addition, western white pine trees were killed on 9 000 ha in 78 separate locations. Major expansions occurred in Kootenay and Yoho National Parks, in the Cranbrook District in the Caven-Bloom-Ward Creeks drainages, in the Invermere District from Findlay Creek north along the west side of the Columbia and Windermere Lakes and the Columbia Valley to Golden, and in the White River drainage. In four stands cruised north of the Flathead

drainage, current attacks occurred on 14% of the trees (13% in 1980), although the range was from 3% to 22%. However, in the Flathead Valley, where mainly immature trees remain, the beetle populations have declined as a result of reduced brood production and poor survival in smaller trees, and the current attack dropped to less than 2%, from 35% in 1980. In the West Kootenays, where infestations are not nearly as concentrated, mortality continued and increased slightly in the Kettle River drainage at Trapping Creek, between Grand Forks and Mt. Morrissey near Christina Lake, and in scattered small pockets north of the international boundary from Gilpin to Bitter Creek. At the south end of Slocan Lake, infestations are active in Springer, Chapleau and Lemon Creeks. Western white pine mortality occurs in groups on both sides of the Upper Arrow Lake, north of Nakusp.

13. In the Cariboo Region, the widespread infestations showed no signs of abating, except where most mature pine had been killed, such as 36 000 ha in the Klinaklini River-Clearwater Lake area. More than 6 million recently killed trees, totalling 2 million m^3, were mapped at 1 716 locations over 73 200 ha (Table 1, Attachment 1). The most widespread and severe infestations occurred west of Williams Lake in the Chilcotin area. In 15 stands, the proportion of trees currently attacked averaged 33% (range from 2% to 72%). The highest current attack occurred in the Alexis Creek District, where an average of 55% of the lodgepole pine were newly infested. At Vert and Tatlayoko Lakes, current attacks had declined because of a shortage of host material; less than 30% of the lodgepole pine were healthy. In the Williams Lake Timber Supply Area, all of the logging of lodgepole pine is being done in beetle-killed stands. Recreational sites in severely infested areas are closed to the public because of both the increased fire hazard from the sudden increase in available dead fine fuels and the public hazard presented over the longer term by standing dead trees.

14. In the Kamloops Region, more than 2.7 million pine trees were killed by 1980 beetle attack on 19 500 ha, mostly in the Goldbridge and Downton-Carpenter Lakes area near Lillooet (Table 1, Attachment 1). In addition, there are 2.7 million "grey" previously killed trees in the Gun and Carpenter Lakes area. Based on 2 675 trees examined on 15 quarter-hectare plots in the Goldbridge-Downton Lake Areas, 21% were currently attacked (range from 4% to 50%), 23% were red, and 23% were grey. In the Okanagan Valley, 46 000 recently killed trees were recorded on 2 000 ha, primarily along the Trout-Hayes, Mission-Belgo, and Lambly Creeks and the Okanagan Mountain Park. The widespread tree mortality has resulted in increased harvesting of pine stands in the Lillooet area.

15. In the Prince Rupert Region, 190 000 recently killed lodgepole pine occurred in 332 infestations on 5 740 ha (Table 1, Attachment 1). The largest and most serious outbreak continued in the Harold Price Creek drainage, where it has been active since 1972, with new small outbreaks toward the headwaters. Significant outbreaks occurred in the Kispiox, Nass, and Bulkley River Valleys and in Tweedsmuir Park. In six stands cruised, the current attack averaged 36%, the most severe being 58% in the Kispiox River Valley and 48% at Van Dyke on the Nass River. At Woodcock, on one permanent study strip, 95% of the pines were killed over a 3-year period, while at three other locations, 67% of the pines were killed over a 4-year period.

16. In the Prince George Region, small infestations, totalling 6 300 trees, occurred at 84 locations on 900 ha in the McNaughton Lake and Takla-Stuart-Trembleur Lakes areas. The large infestation near Valemount declined because of logging and a lack of host material.

17. In the Vancouver Region, lodgepole pine stands are not extensive; however, infestations occurred on 500 ha at Haylmore Creek, on 130 ha at Specht Creek near Pemberton, and on 130 ha at Eastgate near the eastern entrance to Manning Park. Stand examinations indicate continuing tree mortality will occur in these areas in 1982. At Haylmore and Specht Creeks, the potential for spread is not as great as at Eastgate, where extensive stands of mature pine adjoin the active infestations. Examination of this stand showed the current attack in the area cruised increased from 4% of the stems in 1980 to 30%, in 1981.

EXTENT AND HISTORY OF MOUNTAIN PINE BEETLE IN THE PRAIRIES AND NATIONAL PARKS

18. Mountain pine beetle infestations reported in 1980 showed little expansion into new areas in 1981 but did intensify in most of the areas mapped. The total forested area affected by beetle-killed trees increased little in 1981. However, the total number of beetle-killed trees increased by an estimated factor of 1.5. Significant new infestations were reported in Kootenay and Yoho National Parks (see Map, Attachment 2) and in localized stands in the Cypress Hills; a general reinvasion and/or local buildup occurred in the provincial forest north of Blairmore.

19. The main forested area of current mountain pine beetle outbreak in Alberta extends from the United States border north about 120 km and includes Waterton Lakes National Park and the Bow-Crow Provincial Forest (see map, Attachment 2). In the area from the border to the Crowsnest Pass area at Blairmore, beetle infestations developed rapidly since first detected in 1977. By 1979, the outbreak was essentially beyond control and plans for salvage were considered.

20. The number of 1980-attacked trees was not estimated; however, the Alberta Forest Service estimated that, up to 1981, a cumulative total of 283 000 m^3 of lodgepole pine had been killed by the beetle between Blairmore and Waterton Lakes National Park. Of this, about 37% was salvaged for lumber and other wood products in 1980-1981. Much of the remainder was unsalvageable because of deterioration, inaccessibility, unmerchantability, and environmentally sensitive areas. Aerial photography taken in 1981 by the Alberta Forest Service will provide a more complete assessment of losses.

21. North of Blairmore, numerous small scattered infestations were identified in 1980, and a control program was immediately implemented by the Alberta Forest Service to attempt containment and to prevent northward spread. About 1 600 pocket infestations and about 16 000 trees were removed. Destruction of the beetle broods was by log-burning, by bark-peeling, or by processing the logs into lumber and chipping the slabs. In 1981, the control program was continued with a further removal of over 3 000 infestation pockets and about 26 000 beetle-attacked trees. Tree removal was augmented in difficult terrain by helicopter lift. The infestation pockets removed in late 1980 and 1981 were widely distributed throughout the Porcupine Hills and the Livingstone Range (see Map, Attachment 2) and are believed to have resulted both from reinvasion from the west and southwest and from local buildup.

22. During 1981, control operations were extended into the Peigan Indian Reserve, immediately south of the Porcupine Hills, where over 700 trees were removed. In the Blood Indian Reserve, east of Waterton Lakes National Park, further intensification of infestations occurred, but no control action was taken.

23. Aerial surveys were conducted in Banff and Jasper National Parks, but no infestations were observed. However, some 55 infestations were mapped in Yoho National Park, with an estimated 1 500 or more 1980-killed trees. Main areas of infestation were along the Emerald, Amiskwi, Otterhead, and Kicking-horse Rivers and on Tocher Ridge, Horne Ridge, Mt. Burgess, and Mt. Hunter.

24. In Kootenay National Park, similar increases in infestations occurred in the southern area of the park northward to Kootenay Crossing. About 54 infestations were mapped, with an estimated 2 400 1980-killed trees. Most infestations are distributed along the valley adjacent to the Kootenay River, near the confluence of the Vermilion River, and near Radium. One large infestation at the north end of the outbreak near Kootenay Crossing is slated for control action by selective tree removal and has had 245, 94, and 79 trees attacked, respectively, during 1981, 1980 and prior to 1980.

25. In Waterton Lakes National Park, tree mortality increased considerably over that reported in 1980; the most notable increases were above the Waterton Park townsite, along Cameron

Creek Valley, adjacent to Blackiston Creek, and in the Belly River Valley. At least 85% of the pine component has been killed in some stands. Ground surveys of beetle survival and attacked trees in 1981 indicate a declining trend developing generally in the park, which is expected to continue in 1982. A similar trend seems likely in the forested area northward to the Crowsnest Pass. However, in Kootenay and Yoho National Parks, a continued expansion of the outbreak is expected in 1982.

26. New infestations were reported in the provincial parks, most notably in the Cypress Hills in both the Saskatchewan and Alberta portions (see Map, Attachment 2) and in Beauvais Provincial Park, Alberta. In the central and western Cypress Hills blocks of Saskatchewan, 132 red trees were mapped in 82 infestations. A control program underway since 1980 has resulted in the removal of over 500 beetle-attacked trees.

27. On the Alberta portion of the Cypress Hills, over 1 000 red trees (mostly 1979-1980-attacked) were identified in 365 infestations. The general trend of the outbreak for 1981-1982 is static to slightly increasing. However, the current control program is expected to significantly reduce this trend in 1982.

28. The prairie zone of southern Alberta and southwestern Saskatchewan was also surveyed to determine the extent and pattern of beetle dispersal into nonforested areas. Locations surveyed included park areas, campgrounds, urban centres, farm shelterbelts, cemeteries, and other areas of planted pine. Some 38 locations were identified with beetle-killed and/or beetle-attacked trees (see Map, Attachment 2), indicating a long-range dispersal potential of 200 km to 300 km from the nearest major population source. Much of the dispersal appears to have occurred in 1979, possibly assisted by the late summer prevailing wind-flow pattern from the west and southwest. The most common tree affected was the Scots pine, with a few lodgepole pine and one mugho pine. Most mortality occurred on trees older than 20 to 25 years and with stem diameters greater than 6 to 8 cm.

ECONOMIC IMPACT OF MOUNTAIN PINE BEETLE OUTBREAKS IN BRITISH COLUMBIA

29. Lodgepole pine represents a major portion of the forest resources of British Columbia, amounting to 1 120 million m^3, or 14% of the standing coniferous inventory. Other species susceptible to mountain pine beetle attack constitute an additional 3% of the inventory. The importance of the resource at risk varies from region to region in the province. For example, lodgepole pine constitutes 42% of the coniferous inventory in the Cariboo Region; 28%, in the Prince George Region; and less than 1%, in the Vancouver Region.

30. The importance of lodgepole pine to the forest industry in the province is evident from recent harvest figures. In 1972, harvest of lodgepole pine was about 7 million m^3, or 12.7% of the province's harvest. The lodgepole pine harvest expanded to 14.4 million m^3 in 1980, or 19.3% of the annual harvest. This increase was partially the result of expanded salvage of beetle-killed pine and was also the result of the expansion of harvesting into uninfested areas where lodgepole pine is the predominant species.

31. The potential economic impact of mountain pine beetle attack on these resources was outlined in "Position Paper on Mountain Pine Beetle Problems, With Special Reference to the Rocky Mountain Parks Region". A potential industry income loss of more than $35 per cubic metre and various government revenue losses were identified in the report. A direct employment impact of 1.87 person years per thousand cubic metres and an industry multiplier of two give a total employment impact of 3.75 person years per thousand

cubic metres sawn by the lumber industry. This latter becomes important in light of an estimated 35 one-mill forest industry towns that depend, in a significant way, on the pine resource. The major processing centres of Prince George, Quesnel, Williams Lake, and Vanderhoof are also highly dependent on the pine resource. A British Columbia Ministry of Forests Task Force reported that, in the Quesnel Timber Supply Area, if all of the mature pine were lost, 50% of the total volume would disappear. This would force an accelerated salvage for 5 to 10 years, followed by a very substantial mill closure for 20 to 30 years. Other Timber Supply Areas might be similarly affected.

32. As noted, government revenues (both federal and provincial, but especially the latter) are strongly influenced by the health of the forestry sector. Revenues from the forestry sector vary with value of production. For example, in 1975 when market demand was weak, the federal government received $1.28 per cubic metre of wood scaled, while the provincial government collected $1.78 per cubic metre of wood scaled in tax revenues and $1.13 per cubic metre in fees and royalties (including stumpage). By contrast in 1979 (a year of strong demand), the federal government collected $2.93 per cubic metre of wood scaled and the provincial government collected $2.41 per cubic metre and $4.81 per cubic metre in taxes and fees and royalties, respectively (the figures are in 1975 dollars).

33. The current mountain pine beetle infestation has resulted in extensive salvage and control operations taking place in British Columbia. These operations are made up of:

    a. The harvesting of beetle-killed timber.

    b. The harvesting of infested or soon-to-be-infested areas.

    There are many factors involved in determining the actual stumpage paid on salvage timber. These include the percentage of dead trees in a stand, how long they have been dead, the type of sale, the cost of preparing an area for sale (e.g., roads), and the existing market demand for wood products. For example, a stand of lightly infested or soon-to-be-infested pine sold by competitive bid, during a time of strong markets and tight timber supply, would result in relatively high stumpage. But a pine stand with 20% to 100% mortality not sold through competition, during poor market times, may bring only one-quarter of the minimum stumpage rate. This is the minimum rate at which timber is offered, and some stands cannot be sold even at this price.

34. Losses in stumpage revenues, because of the mountain pine beetle, vary throughout the province. In the Cariboo Forest Region, where many areas were harvested before the beetle attacked or before the condition of trees had deteriorated and where many sales fell under the Small Business Enterprise Program, little or no loss in stumpage resulted in 1981. By contrast, in the Nelson Forest Region, where the infestation is older and many areas have not been sold by competitive bid, average pine stumpage has been running at little better than one-quarter of the minimum rate.

35. Additional processing may be required to prepare salvaged wood for export markets to ensure the beetle is not transported with the lumber. As well, chips from salvaged wood require additional bleaching, as a result of blue stain, before being used in pulp. Where these additional costs are not met by reduced stumpage levels, corporate profits and government tax revenues are affected.

36. When volume losses attributable to mountain pine beetle infestations affect allowable cut, as suggested previously for some areas, further stumpage and tax revenue losses will occur because of a smaller forest industry. Such losses could be as high as $3.70 per cubic metre for the federal government and $9.00 per cubic metre for the provincial government. In times of weaker markets (which are now being experienced), the losses would not be as great.

37. Because mountain pine beetle infestations reduce the flow of revenues from the forest industry to the government, an increased level of government services is required to measure and minimize the impacts of infestations, namely:

    a. Surveying to detect and map, and to measure the impact of, infestations.

This involves both the federal and provincial governments.

b. Producing information publications for both internal and public use. Again, this affects both levels of government.

c. Continuing to negotiate with representatives of countries desirous to keep the mountain pine beetle from entering their countries on lumber imported from Canada.

d. Building access roads into infested areas to facilitate survey, control, and salvage. The provincial government will spend $11.4 million over two years—$7 million in 1981-1982 and the remainder in 1982-1983 (some of this will be recovered in stumpage). Other areas will be sanitation logged.

e. Increasing fire protection services; drying dead trees represent an increased fire hazard.

The impact on services will be even greater if the infestations force a real decline in allowable cut. This would have serious effects on employment and would require increased manpower services and increased unemployment and welfare costs.

ECONOMIC IMPACT OF MOUNTAIN PINE BEETLE OUTBREAKS IN ALBERTA

38. Mountain pine beetle in Alberta must be considered from two perspectives:

a. Impact on areas hardest hit at present.

b. Impact on areas not presently under attack.

These are evaluated from two points of view: impact on industry, including expansion plans; and government revenues.

39. The area presently under the greatest beetle pressure is the Bow-Crow Forest. About 52% of the total volume of the Bow-Crow Forest is lodgepole pine, while about 33% of the pine in the forest is sawlog-size (greater than 25 cm DBH) and therefore highly susceptible to mountain pine beetle attack. In absolute terms, the Bow-Crow Forest contains approximately 53 million m^3 of merchantable timber (based on a utilization standard of 10 cm DBH), 27.5 million m^3 is pine, and 9 million m^3 is sawlog-size lodgepole pine.

40. An estimate of the commercial value of susceptible trees within the Bow-Crow Forest is around $341 million, while the value-added from this total revenue is $193 million. If it can be assumed that this value-added is distributed largely to local labor, capital, and raw materials, then it represents an estimate of the true economic value of the resource to the region.

41. It is difficult to establish what constraints to future industrial expansion will exist as a result of mountain pine beetle attacks in southern Alberta. As D. Fregran[1] suggests: "Faced with the unpredictability of the beetles' future in C3 (a management unit in the Bow-Crow Forest) at this time, it is difficult to determine an accurate timber supply analyses." He does, however, suggest the following: "The beetle has decimated this predominately pine unit to the point where few mature and overmature stands exist. In fact, we can safely predict that the long-term allowable cut may be depressed for a number of decades due to this lack of merchantable timber in the short term." This

[1] Quotes from Mountain Pine Beetle Symposium at Coleman, Alberta, February 6-7, 1981.

statement suggests there will be a constraint to industrial expansion, at least in that management unit.

42. There is an obvious effect on the potential for industrial expansion in the area. Because it is difficult to predict the direction and intensity of future infestations and to ascertain what effect the mountain pine beetle will have on future timber supply, a climate of uncertainty is created in the area. Uncertainty may have an as great or greater effect in limiting industrial expansion than actual timber supply deficits.

43. Questions such as:

a. When will the current outbreak stop?

b. How far north will it spread and intensify?

c. What are the long-term consequences for local industry?

invite further questions from equity investors, including:

d. How much annual volume will we have to cut?

e. What will the size of allocated timber be?

f. How long can an operation exist in the area?

44. From an industrial utilization standpoint, the worst possible (though unlikely) consequence of the mountain pine beetle in the Bow-Crow Forest would be the closing down of the two major processing facilities that operate within the southern portions of the Bow-Crow Forest. The cut in manufacturing activity associated with the forest industry in this area of the province could result in an annual decrease in lumber production worth an estimated $6 million and a value-added loss of $3.4 million. The result would be a direct loss of 163 jobs and an indirect loss of 326 jobs—a total loss of 489 jobs. A total income loss of about $7.5 million (average income of $15 500 per employee) would follow.

45. If the assumption were made that the mountain pine beetle could not be controlled, the result could be elimination of mature and overmature pine stands in Alberta. This is an extreme assumption; however, it does provide a point of reference and it does reflect the values at risk.

46. The effect of mountain pine beetle constraining industrial expansion in Alberta as a whole may be demonstrated by describing the decreased allowable cut resulting from an all-encompassing pine beetle attack. Should the pine beetle eliminate the sawlog pine component of Alberta's forests, the reduced growing stock would result in a 38% decline in allowable cut from 6.6 million m^3 to 4.0 million m^3. In addition, some of this remaining allowable cut is economically inaccessible, thereby further reducing the available resource. In 1978, total lumber production in Alberta consumed about 4.15 million m^3 of roundwood. From these figures, the limits to expansion of the industrial base processing forest products becomes obvious. In fact, the figures imply that there would be not only a considerable constraint to growth but also some decline in industrial activity, in order to maintain sustained yield-use policies. Of course, about 113 million m^3 of salvageable pine would be available for product conversion, but it is doubtful that the necessary factors of production or market access could be marshalled to fully utilize this mortality.

47. The possible impact of mountain pine beetle on government, in terms of reduced industrial activity, could be measured by eliminating all current production (1978) attributable to the processing of pine. The total lumber production of sawmills producing greater than 2 000 m^3 per year in Alberta in 1978 was 1.71 million m^3. In the unlikely event that the pine component of final output were eliminated, output would fall to 1.18 million m^3. This would result in a tax and stumpage loss of $9.2 million per year.

48. The two major kraft pulp mills presently operating in Alberta depend on pine for over 50% of their wood inputs. Without pine, they would very likely be unable to continue operating. However, since the mills can and do utilize small-diameter wood (which is less

susceptible to attack), the mills could possibly survive a large-scale epidemic attack throughout the Alberta foothills, although with higher costs.

49. The following potential economic impacts are based on the assumed destruction of the sawlog pine component of Alberta's forest resource. Any effects on pulpwood supply would incur additional economic impacts. The impacts include reduced annual sales of $48 million, a reduced annual value-added of $27 million, a decline in direct wages and salaries paid of $14.7 million, and a loss in stumpage revenue of $700 000.

POSSIBLE IMPACT OF MOUNTAIN PINE BEETLE ON TOURISM AND RECREATION

50. The impact of the mountain pine beetle on tourism (other than consumptive activities) may largely come about, indirectly, through changes in the aesthetic value of landscapes, denudation of campsite and picnic areas, and forest closures for fire protection.

51. The impact of the mountain pine beetle and timber salvage on the aesthetics of the forest landscape will be a contentious issue as the infestations spread. This is especially true in the Rocky Mountain Parks Region (East Kootenays) and the adjoining provincial crown land.

52. There is rich research literature on ways in which landscapes are viewed and on landscape preferences. In evaluating the problem, Litton and Twiss[2] emphasize that, "The sightseer or generalized user unquestionably sees the forest in a different way from the forester who is influenced by specific and technical responsibilities." The landscape preference literature emphasizes the preference for natural systems that are not overtly disturbed by man's works. There is little, however, on the relation of landscape preference to natural phenomena such as insect attack.

53. Four factors of landscape analysis are repeated consistently throughout the literature: (1) distance, (2) light, (3) topographic form and contrast, and (4) spatial definition. These are the general basis of the British Columbia Ministry of Forests' "Forest Landscape Handbook"[3], which delineates their recommended approach to landscape design in forest management activities.

54. The major impact of the mountain pine beetle on important landscape resources will likely occur in the Rocky Mountain National Parks. The resources in danger are in Jasper, Banff, Yoho, Kootenay and Waterton Lakes National Parks. In Waterton Lakes National Park, the majority of the mature lodgepole pine has already been killed.

55. Parks Canada's general philosophy, and indeed its expressed policy, is to maintain the physical environment in as natural a state as possible. This implies managing with minimal interference to natural processes to ensure the perpetuation of naturally evolving environments.

56. In manipulation of naturally occurring processes (such as fire, insects, and disease), control may take place—only after it has been demonstrated that there will be serious adverse effects on neighboring lands; when health and public safety is threatened; or for a number of ecological reasons.

[2] Litton, R.B. and R.H. Twiss. 1966. The Forest Landscape: Some Elements of Visual Analysis. Proc. of the Soc. Am. For. Annual Meeting, Seattle, Washington.

[3] British Columbia Ministry of Forests. 1981. Forest Landscape Handbook. Victoria, British Columbia.

57. For the first reason, Parks Canada has agreed to establish a control line, beyond which mountain pine beetle infestations will be attacked. Control attempts have already started as of the winter of 1981-1982. It is not known whether such attempts will be successful.

58. Some have expressed the opinion that the effects of the mountain pine beetle on visitors' reactions will likely be neutral. According to Parks Canada, visitor reaction to the Kootenay Park fire was even positive in the short run. The short-run visitor reaction to massive mountain pine beetle-caused mortality in National Parks is unknown, but may not be positive. However, in the long run, an increased landscape diversity, caused by the release of climax vegetation, may result in a positive reaction from recreationists and tourists.

59. If there is an adverse impact on tourism and recreation in National Parks and their surrounding provincial crown land, there could be direct and indirect consequences to the national and regional economy. The Rocky Mountain national parks in British Columbia and Alberta registered more than 11.3 million visitors in 1980-1981. Visits to provincial parks in mountain pine beetle-affected areas added more than 5 million visitors to that total. Available statistics suggest an average visitor expenditure of more than $15 per day. Recreation and tourism are significant employers, especially of seasonal employees such as high school and university students. An impact on employment could have obvious downstream consequences on other economic sectors.

60. Trees killed as a result of mountain pine beetle attack represent a hazard in campgrounds, townsites, and other public areas. These trees must be removed to protect the public. The cost of this removal may be directly attributed to the mountain pine beetle. A further, but unmeasurable loss may be attributed to a change in use patterns caused by aesthetic changes in these areas.

61. Standing dead trees in public areas also increase the fire hazard because of increased flammability of both crown and surface fuels. It will be necessary to remove these trees or to increase fire prevention and suppression funding. In undeveloped areas, removal is probably impractical.

STREAM WATER AND FISHERIES RESOURCE IMPACTS OF MOUNTAIN PINE BEETLE

62. The influence of mountain pine beetle infestations on water and fisheries resources will be directly related to the severity, extent and location of the infestation and type of control or rehabilitation treatment. The actual killing of trees will modify the hydrologic regime of a watershed by changing snowmelt and evapotranspiration patterns. Treatment of infested areas by control measures such as logging, plus associated rehabilitation practices, can further affect streamflow regimes and water quality. These changes, in turn, have the potential to affect fisheries values.

63. The killing and/or removal of trees will result in increased annual water yields. Sample calculations, applicable to southwestern Alberta and probably applicable to the western slopes of the Rockies in British Columbia, indicate increased water yields of 16% to 20% for forested areas with total kill and trees left standing. Potential water yield increases range up to 34%, depending on the cutting pattern and the extent of forest cover. Most of the increased runoff occurs during the snowmelt period. The effect on streamflow regime will depend on the aspect of the watershed and on the location of the affected areas. Because salvage logging tends to result in larger clearcuts and faster rates of cut, changes in water yield and flow regime will tend to be more accentuated.

64. Any impacts on water quality will depend on the type and extent of treatment. On the

east slopes of the Rockies in Alberta, the potential impacts of mountain pine beetle salvage would appear to be minor and of little consequence. Studies of sediment levels following logging have revealed only minor increases, as soils are generally coarse and resistant to excessive erosion. Changes in nutrient or chemical composition of stream water should also be minimal, particularly since prescribed broadcast slash-burning is not generally practiced. The biggest potential change in water chemistry would occur in the case of a large, intense wildfire, and even here, peak changes in nutrient concentrations would be short-lived and minor. Pesticides, if applied, would be used mostly on a single-tree basis and should not reach water courses and, therefore, would not pose a water quality problem.

65. In British Columbia, there should likewise be no detrimental impacts on the water quality in relation to nutrient levels or pesticide input. There may, however, be a problem in relation to sediment production and salvage logging, particularly east of the Rocky Mountain Trench, where fine-textured soils occur. With salvage logging, road construction is accelerated and the use of roads occurs sooner than under normal logging practice. Accelerated road construction will likely result in increased sediment production. Fisheries officers have already noted increased siltation in the Flathead and White River drainages following the onset of logging activity.

66. Stream sportfishing is an important resource-use activity in both Alberta and British Columbia. Mountain pine beetle infestations and the resulting control treatments can affect the stream environment and its fisheries resources. The main problem is with changes in fish habitat, as direct detrimental impacts on the fish themselves are unlikely to occur. Increased sediment input can smother streambeds and can reduce spawning habitat, more so in British Columbia than Alberta. Increased streambank erosion, which degrades both the spawning and rearing of habitat, could result from increased peak flows. Except for sediment, potential water quality changes and pesticide use should not adversely affect the fisheries resource.

67. Logging can also affect the fisheries resource by direct impacts on the stream environment itself. The removal of trees adjacent to stream channels can result in debris input, reduction in terrestrial foods for fish, increased stream temperature, and channel alteration, but the amount of pine, in relation to other species, is low along main channel margins. Careful logging practices will minimize debris input and channel impacts, although tributaries from steep side slopes could contribute some debris. There is little available information on which to judge whether tributary flow from logged areas or main channel forest cover removal will result in detrimental stream temperature changes.

68. Accelerated construction of road systems into previously relatively inaccessible areas may indirectly affect fisheries. Improved access in the East Kootenay region is already beginning to result in over-fishing of some streams, causing the provincial Fish and Wildlife Service to enforce rotational stream closures to preserve fish stocks.

POTENTIAL SOIL EROSION PROBLEMS ASSOCIATED WITH SALVAGE LOGGING OR HAZARD ABATEMENT

69. Soil erosion is generally classified as surface erosion or as mass-wasting (landslides, flows, slumps, etc.). The extent of surface erosion is strongly influenced by soil texture and structure, rainfall and snowmelt rates, slope gradient, and most particularly by the presence or absence of a protective organic mat. Mass-wasting is much less governed by organic mat characteristics than by soil moisture and depth, slope gradient, bedrock configuration, intensity and duration of rainfall, and the incidence of deep-rooting plants, particularly trees.

70. Stands, even with most trees killed, retain an intact organic mat and, in fact, a mat which would be supplemented as dead trees lose their needles. Thus, surface erosion would not be expected to be significantly greater in infested (but not salvaged) stands than in healthy ones, even in the face of an anticipated increase in the rate of snowmelt. The killing of trees will, however, reduce evapotranspiration and allow a longer period of high soil moisture at depth than would occur with a healthy stand. This longer duration of saturated soil, coupled with deterioration of the killed trees' root systems, would tend to decrease soil strength and increase natural mass-wasting. Banks already oversteepened by old river erosion are especially susceptible to this action. Fortunately, a large proportion of these valley-bottom sites support mixed stands which would be only partially destroyed.

71. The construction of haul roads and the yarding and skidding activities associated with salvage logging will initiate soil erosion, particularly in the moderately fine-textured silt loams of southeastern British Columbia. The magnitude of erosion will probably exceed that resulting from normal harvesting operations, as in the following hypothetical scenarios.

a. **Due to the urgency for salvage, the planning and conduct of harvesting is under severe time constraints.**

i. Haul roads may be subjected to heavy traffic too soon after construction, i.e., before natural settling of the roadbed. The result may be increased slumping of fillslopes, damage to drainage structures such as culverts, surface erosion, and puddling of roadbeds.

ii. Unstable slopes and sites, with especially erodible soil sensitive to gouging and displacement, may have to be harvested when ground conditions are less than optimum (e.g., wet soil, no snow cover, unfrozen soil).

iii. Skidroad layout may be hastily planned, resulting in more and steeper skidroads than usual, thus increasing the potential for surface erosion.

b. **Salvage operations are carried out below an infested, but nonmerchantable or nonoperable, stand.**

i. Higher snowmelt rates on the upper area may overload drainage structures in the salvaged area that were designed for normal runoff.

c. **Timber is salvage-logged before it reaches its normal harvestable size.**

i. Closer spacing of skidroads will be required than for timber with greater average height. This increase in the density of skidroads will increase the magnitude of surface soil erosion and reduce site productivity by increased exposure of subsoil.

ii. Cable yarding is often an environmentally more suitable logging system than ground skidding on sensitive sites, but small log size will tend to make it economically infeasible.

72. Infested stands that have not been salvage-logged may require special rehabilitation by mechanical means or prescribed burning. Mechanical rehabilitation on sloping ground will result in mineral soil exposure and may include scalping, compaction, and soil displacement. It differs from normal site preparation operations in that standing dead trees must be pushed over. This exposes erodible subsoil and increases the potential for surface soil erosion. Prescribed burning is often not performed on lodgepole pine clearcuts. Unless expertly managed to fit site and weather considerations, the practice could significantly increase surface erosion on sloping terrain.

WILDLIFE HABITAT CONSIDERATIONS

73. Insectivorous birds and mammals increase in numbers with a lag phase behind that of the insect population. Barring other environment-limiting factors such as weather, other predator outbreaks, and the influences of man, this is the general sequence of events. Then, following the peak of the insect infestation, a decline phase can also be expected to occur in predator species. In fact, the insectivorous species can influence the timing of the decline of a pest species.

74. In shorter-lived outbreaks such as that of the Douglas-fir tussock moth, these ecosystem reactions are much compressed and probably of less significance. However, in protracted insect outbreaks, which in parts of the East Kootenays have continued for two decades, various animals have become adapted to, and are dependent upon, these high levels of prey organisms. Thus, cavity-nesting birds have increased in numbers, along with some insectivorous mammals. Also to be expected are more subtle changes such as the opening of the tree canopy and a corresponding increase in forbs and shrubs. On a site-specific basis, these changes can enhance certain grazing/browsing species such as elk and deer.

75. From a wildlife point of view, one must put the mountain pine beetle problem in perspective, by considering it in a historical sense. It is generally acknowledged that the present outbreak situation is the result of vast areas of basically even-aged stands of lodgepole pine. This situation goes back to the early development of British Columbia, where vast areas were burned off for mining and general land-clearing or burned by uncontrolled accidental wildfires. Somewhat later, wildfires were seen as a danger to managed forests, and massive fire protection efforts greatly reduced the role of fires in providing varied species and age-class structures of the East Kootenay forests. These human influences have resulted in reduction in the area of pine/spruce climax forests in which wildlife populations have evolved over the millenia.

76. Reacting to these changes were the populations of elk, deer, grizzly bear, etc. If anything, the mountain pine beetle outbreaks are taking these animals back to a predevelopment type of ecosystem. That is a situation with a greater mix of forest ecotypes which, in general, is more beneficial to "wildlife". However, it is not very useful to talk to generalities when, in fact, there will be many exceptions to such predictions on a site-specific basis. Such is the case when one comes to the consideration of control strategies.

77. Presently, salvage logging is used, with the hope of slowing the spread of infestations while extracting the timber which is dead or dying. This can lead to a number of impacts upon wildlife populations.

    a. Increased access to wildlife populations, that previously have been isolated, immediately requires a manager to put additional efforts into protecting them from exploitation. Hunting seasons and bag limits must be readjusted and enforcement efforts redirected. Man's encroachment into such areas, even for nonconsumptive recreation, provides additional stress upon such wildlife.

    b. The size of cut blocks and the method of logging is important to the wildlife manager. In general, opening the forest canopy in a monoculture will benefit wildlife species such as deer, elk, and moose. Such has been the case in the Flathead Valley. However, additional factors such as potential snow depth must be considered in cutting plans, as such areas quickly become unusable when the snow depth prevents movement by such wildlife.

    c. Cavity-nesting birds may suffer when areas are clear-cut and when standing snags are felled because of perceived safety problems.

    d. Regeneration programs should consider the monoculture situation that has led to the present problems and also should recognize that wildlife will benefit most from a varied mix of forest species.

FOREST MANAGEMENT CONCERNS AND OPPORTUNITIES

78. Two of the main concerns of forest management, following mountain pine beetle outbreaks, are increased fire hazard and stand renewal. Fire is an integral part of the ecology of lodgepole pine and, along with the mountain pine beetle, has been responsible for the maintenance of lodgepole pine as a widespread forest type. In lodgepole pine forests, mountain pine beetle infestations may hasten stand succession toward the (spruce-fir) climax stage, and this process is enhanced by the exclusion of fire and even-aged management. Lodgepole pine is a valuable, fast-growing pioneer species and only fire or even-aged silvicultural systems of management can effectively maintain this species.

79. The role of fire, following mountain pine beetle outbreaks in lodgepole pine forest types, should be considered from two viewpoints: (a) increased probability of high-intensity fires resulting from an increase in fuel-loading; and (b) use of fire as a management tool to enhance regeneration of lodgepole pine and to control stocking levels.

Fire Management

80. The strong preference by the mountain pine beetle for large-diameter trees can result in heavy fuel buildup in mature and overmature stands. There are generally three periods of increased fire hazard associated with lodgepole pine stands following mountain pine beetle infestations: (a) the first five years' dead needles and fine branches are retained on the killed trees. The probability of crown fire is high during this period, as only minimal periods of drying weather conditions are required to make dead crown fuels available, and as long as surface fuel conditions permit the carrying of fire, only moderate winds are necessary to sustain crown fire spread. The type and response of understory herbaceous vegetation, following opening up of the crown canopy, will have a significant effect on fire spread and crown fire potential; (b) for a period of about 10 years after the infestation when the bark starts sloughing off; and (c) the worst period occurs after the bulk of the killed trees have fallen and after maximum fuel-loadings. This can occur 20 to 50 years after the outbreak, depending on the attrition of the dead trees. Both snags and fallen trees constitute substantial fire hazard. An Idaho-Montana study indicated that 30% of all fires in lodgepole pine stands originated in snags and 14%, in large, dead, and downed logs. Fires, occurring during drought periods in heavy concentrations of downed woody fuels, produce extreme fire intensities, are damaging to sensitive sites, and are impossible to control. The 1961 Sleeping Child fire in Montana's Bitterroot National Forest illustrated extreme fire behavior in areas of beetle-kill from the 1920s.

81. In western Canada, there is a lack of knowledge on fire behavior in recently killed timber, apparently because no fires have occurred in recent infestations. However, the experience, with the fires of the 1920s and 1930s in the East Kootenays of British Columbia in areas of high beetle hazard, indicates the potential for large, intense wildfires that occur following mountain pine beetle outbreaks.

82. Concern about the increased fire hazard necessitates allocation of additional resources for fire protection and reassessment of fire protection priorities in affected areas. Fire management plans need to put increased emphasis on the following activities:

a. Sanitation and salvage programs to reduce fuel loads in infested stands.

b. New road access in infested areas to enhance fire suppression activities.

c. Development of fire breaks to protect communities, forest resources, and other resource values.

d. Public information on fire prevention.

e. Enforcement of fire prevention regulations.

Silvicultural Use of Fire

83. Owing to a complexity of constraints and concerns such as environmental and multiple-

use considerations and the high costs of logging and control, in most situations large areas of beetle-killed lodgepole pine will remain unsalvaged. For example, in the Flathead Valley in southeastern British Columbia, about 75% of the infested area will not be salvaged. In some situations, such as in pure or nearly pure lodgepole pine stands without advanced regeneration, a program of prescribed burning may serve the dual purpose of reducing fuel-loading and preparing the site for stand renewal.

84. To reduce beetle populations and to prepare seedbeds in infested stands, the use of broadcast fire, in conjunction with perimeter logging, has been tested in the Chilcotin region of British Columbia, with variable results. If a technically feasible procedure for broadcast-burning could be developed in conjunction with salvage logging in merchantable stands, the benefits from the resulting seedbed preparation, seed release from serotinous cones, and sanitation of advanced regeneration would be considerable.

85. Prescribed fire also has some potential as a silvicultural tool in some uninfested, stagnant, unmerchantable lodgepole pine stands which would eventually become susceptible to the mountain pine beetle. Such stands could be burned to establish regeneration, thereby avoiding or delaying beetle problems.

86. In noncommercial forests such as parks, recreation, and wilderness areas, one of the major objectives is the maintenance of natural ecosystems. Often, no action is taken on mountain pine beetle infestations. At the same time, at least some natural fires are suppressed, resulting in fuel accumulation which increases the probability of large, intense fires. In such noncommercial forests, programs of prescribed burning and a policy of allowing some wildfires to burn under prescription and supervision would create mosaics of pine stands of different ages and would help reduce the probability of large, high-intensity fires.

87. To dispose of slash and to prepare the site for regeneration following salvage logging, prescribed fire is used on some sites. Although many foresters and forest entomologists feel that the burning of fresh slash is generally beneficial in reducing populations of damaging bark beetles, there appears to have been very little work on the effects of controlled burning (slash or stand) in regulating insect populations on a large scale.

Preventive Management
and
Stand Renewal

88. The most satisfactory approach to reducing losses from the mountain pine beetle in lodgepole pine forests is through preventive management. The strategy of preventive management is to keep beetle populations below injurious levels by limiting their food base through silvicultural practices designed to maintain or increase tree/stand resistance.

89. In areas of high risk of loss from mountain pine beetle depredations, the following options should be considered: (a) shortened rotation, (b) type conversion, (c) mixed species stands, (d) age and species mosaics, (e) partial cuts, and (f) stocking control. The choice among these management options should be based on silvicultural considerations (including regeneration), resource values, and consideration of other pest problems.

90. Shortened rotation is a viable option when lodgepole pine is the desired species and when a smaller tree size will satisfy the wood product requirements and economics of the operation. Since mountain pine beetle activity usually begins in stands older than 60 years, the harvesting of 60-year-old stands would substantially reduce the losses, although larger-diameter trees would still be susceptible to attack. Other advantages of this management option are that there is no need to create mosaics of different aged lodgepole pine forests or to increase tree/stand resistance through stand-tending practices.

91. Conversion of a stand to another type can be an attractive choice when most of the objectives of management can be equally met by different forest types. For example, most watershed, wildlife, and recreational requirements and even timber objectives could be met with climax associates of lodgepole pine, such as Douglas-fir, spruce, or western larch. Conversion could possibly be done by partial cutting and culturing of the understory or by clearcutting and artificial regeneration.

92. Even though the mountain pine beetle infests mixed stands as readily as pure stands, overall stocking and wood production following an outbreak would be higher in mixed stands than in pure lodgepole pine stands, owing to the presence of nonhost tree species. Mixed stands could be created either through selective cutting of the pine component or through clearcutting and artificial regeneration.

93. Developing a mosaic of age classes and tree species through block clearcutting and artificial regeneration results in a minimum-size, beetle-susceptible stand, making fast removal and/or application of direct control action more feasible. This option takes careful, long-range planning, good roads and markets, and, above all, time.

94. Partial cuts are advantageous under the following conditions: (a) clearcutting is not compatible with multiple-use objectives, (b) combinations of high forest and openings are desired, and (c) regeneration after clearcutting is difficult. This management option is especially attractive when environmental and visual impacts preclude clearcutting. However, increased stand susceptibility to windthrow and increased mistletoe infection could result from such practices. Partial cuts can be achieved through overwood removal and shelterwood and group selection cutting.

95. Stocking control, a very important practice in pure, even-aged lodgepole pine forests, offers two potential options for reducing losses from the mountain pine beetle, in view of the increasing evidence on the role of tree vigor in host resistance. First, stocking control provides control on phloem thickness and diameter growth and can create and maintain distributions not favorable to the mountain pine beetle. Alternatively, early stocking control and management practices for increasing tree growth (thinning, genetic improvement, fertilization) could raise the vigor of trees so that present age/size limits would not be so restrictive. Since stocking control offers such important, practical solutions, much more intensive research is urgently needed on this subject.

96. Regeneration under unsalvaged stands is a major concern, especially in situations where lodgepole pine has a dominant seral or persistent successional role. In such stands, there is usually not enough advanced regeneration or admixture in the overstory of the successional species for type conversion. Even though there is usually ample lodgepole pine seed in serotinous cones, there is uncertainty as to the establishment of lodgepole pine regeneration in the absence of site preparation. The best seed germination is in full sunlight and the best seedling development is on mineral soil or disturbed duff with no competing vegetation. In beetle-killed stands with a high proportion of serotinous cones, the tendency would be for less pine regeneration than in stands where the majority of cones were nonserotinous. Even if adequate stocking occurred, the increased fuel-loading on the ground would increase the probability of intense crown fires. In view of the lack of related information, field surveys and studies are urgently needed to develop answers to this problem.

97. If not salvaged or rehabilitated, heavily depleted stands of pure or nearly pure lodgepole pine with no significant advance growth of other species will be slow to regenerate and will have low density. Planting in such stands may be feasible in some cases, perhaps on a fill-in basis. In mixed stands with a range of tree sizes and advanced regeneration of species other than pine, the tendency should be toward dominance of nonpine species in the next stand. The new stand, if dominated by less commercially valuable species such as balsam fir, may require treatment and planting to increase the content of commercially valuable species.

FUTURE DEVELOPMENTS

98. Because of the widespread nature and severity of the mountain pine beetle problem and the numerous jurisdictions under which the affected lands are managed, it is not appropriate at this time to propose solutions. One thing is certain—simple solutions will not suffice.

99. Two interagency bodies, in addition to the two provincial forest management agencies, are attempting to find possible solutions to the mountain pine beetle problem. The inter-provincial nature of the problem will be addressed by the Interagency Committee on the Mountain Pine Beetle, which consists of the Canadian Forestry Service, Parks Canada, the British Columbia Ministry of Forests and the Alberta Forest Service. The inter-national aspect of the research, control and rehabilitation of the mountain pine beetle will be addressed through a supplement to the "Memorandum of Understanding for Coordination of Forestry and Associated Range Programs Between the Department of Environment, Canada and the United States Department of Agriculture."

ATTACHMENT 1

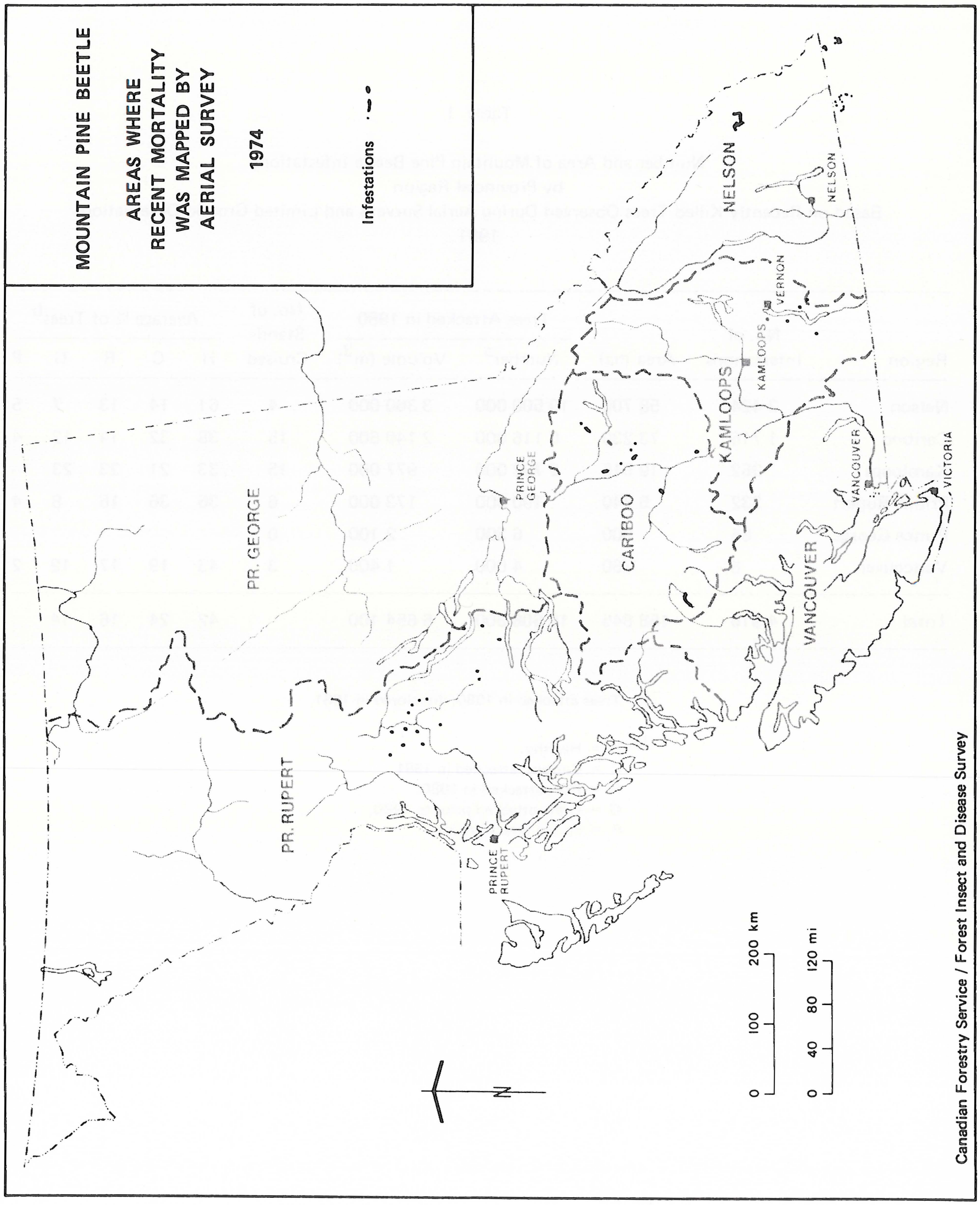
Table 1

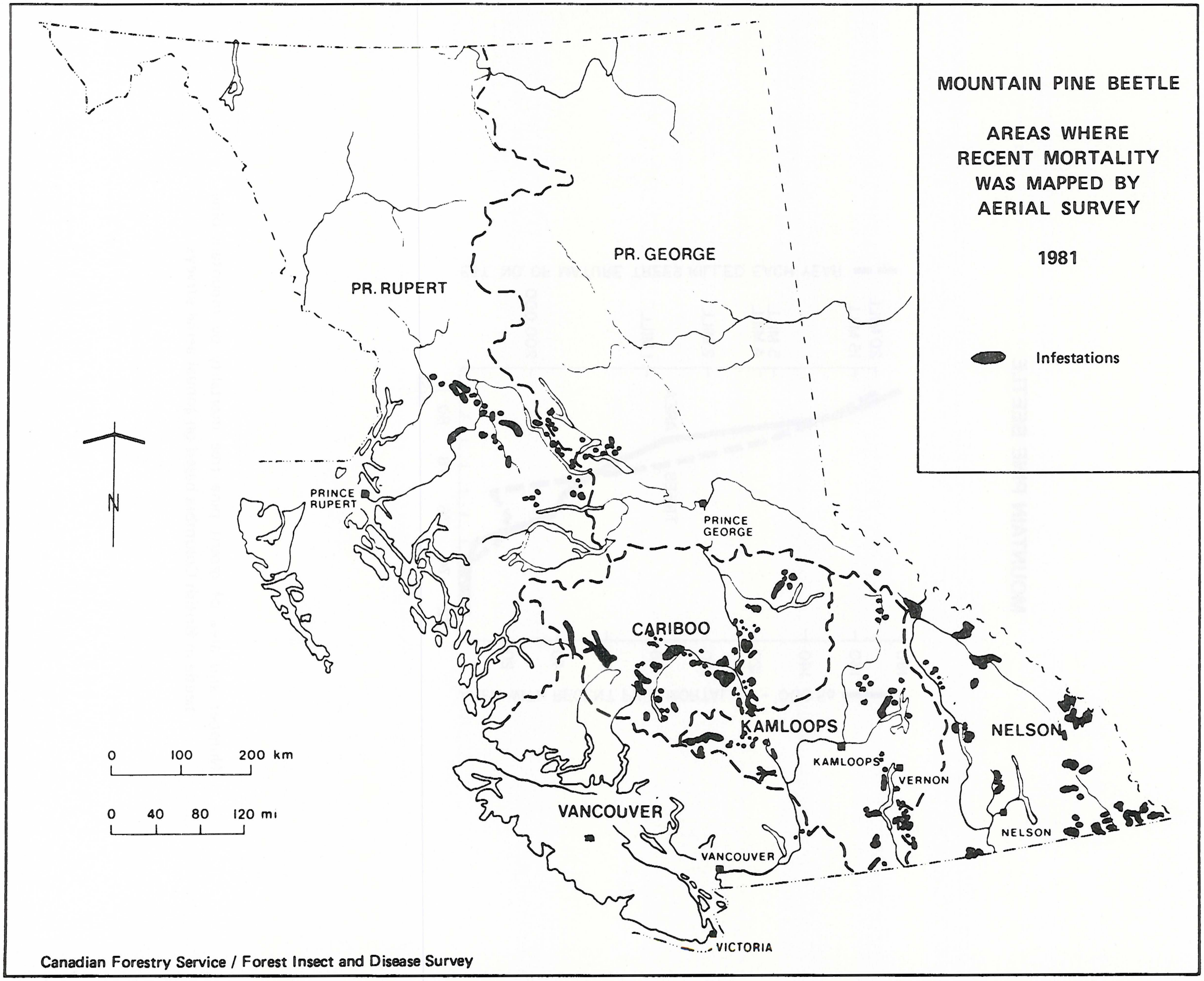
Number and Area of Mountain Pine Beetle Infestations
by Provincial Region
Based on Recently Killed Trees Observed During Aerial Surveys and Limited Ground Observations
1981

Region	No. of Infestations	Area (ha)	Trees Attacked in 1980		No. of Stands Cruised	Average % of Trees[b]				
			Number[a]	Volume (m^3)		H	C	R	G	P
Nelson	2 424	58 700	10 500 000	3 360 000	4	61	14	13	7	5
Cariboo	1 716	73 230	6 116 000	2 140 600	15	38	32	14	12	4
Kamloops	352	19 515	2 792 000	977 000	15	33	21	23	23	--
Prince Rupert	332	5 740	190 000	173 000	6	36	36	16	8	4
Prince George	84	900	6 300	2 100	0					
Vancouver	8	760	4 000	1 400	3	43	19	17	19	2
Total	4 916	158 845	19 608 300	6 654 100		42	24	16	14	

[a] Trees attacked in 1980, discolored in 1981.

[b] H = Healthy.
C = Current, attacked in 1981.
R = Red, attacked in 1980.
G = Grey, attacked prior to 1980.
P = Partial attack (strip).


MOUNTAIN PINE BEETLE
AREAS WHERE
RECENT MORTALITY
WAS MAPPED BY
AERIAL SURVEY
1974
Infestations
NELSON
NELSON
VERNON
KAMLOOPS
KAMLOOPS
CARIBOO
PRINCE GEORGE
PR. GEORGE
VANCOUVER
VANCOUVER
VICTORIA
PR. RUPERT
PRINCE RUPERT
0 100 200 km
0 40 80 120 mi
N
Canadian Forestry Service / Forest Insect and Disease Survey


MOUNTAIN PINE BEETLE
AREAS WHERE RECENT MORTALITY WAS MAPPED BY AERIAL SURVEY
1981
Infestations
PR. RUPERT
PR. GEORGE
CARIBOO
KAMLOOPS
NELSON
VANCOUVER
PRINCE RUPERT
PRINCE GEORGE
KAMLOOPS
VERNON
NELSON
VANCOUVER
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N
0 100 200 km
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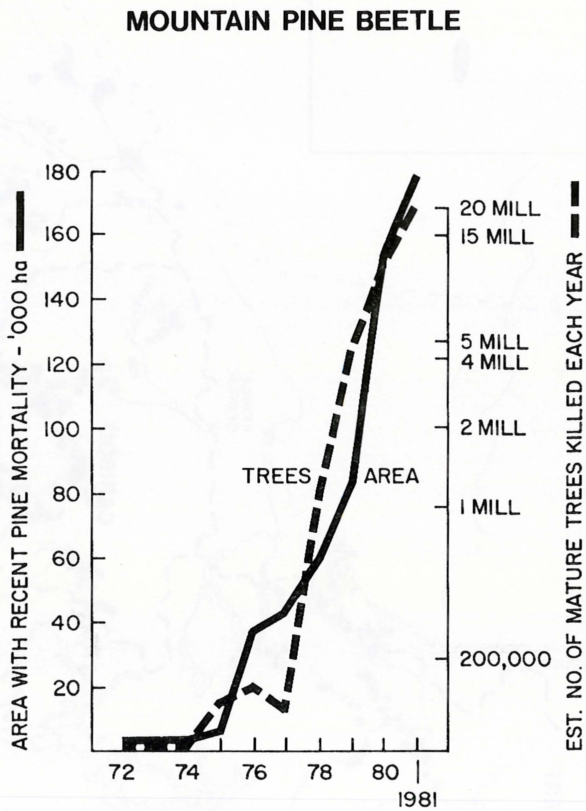
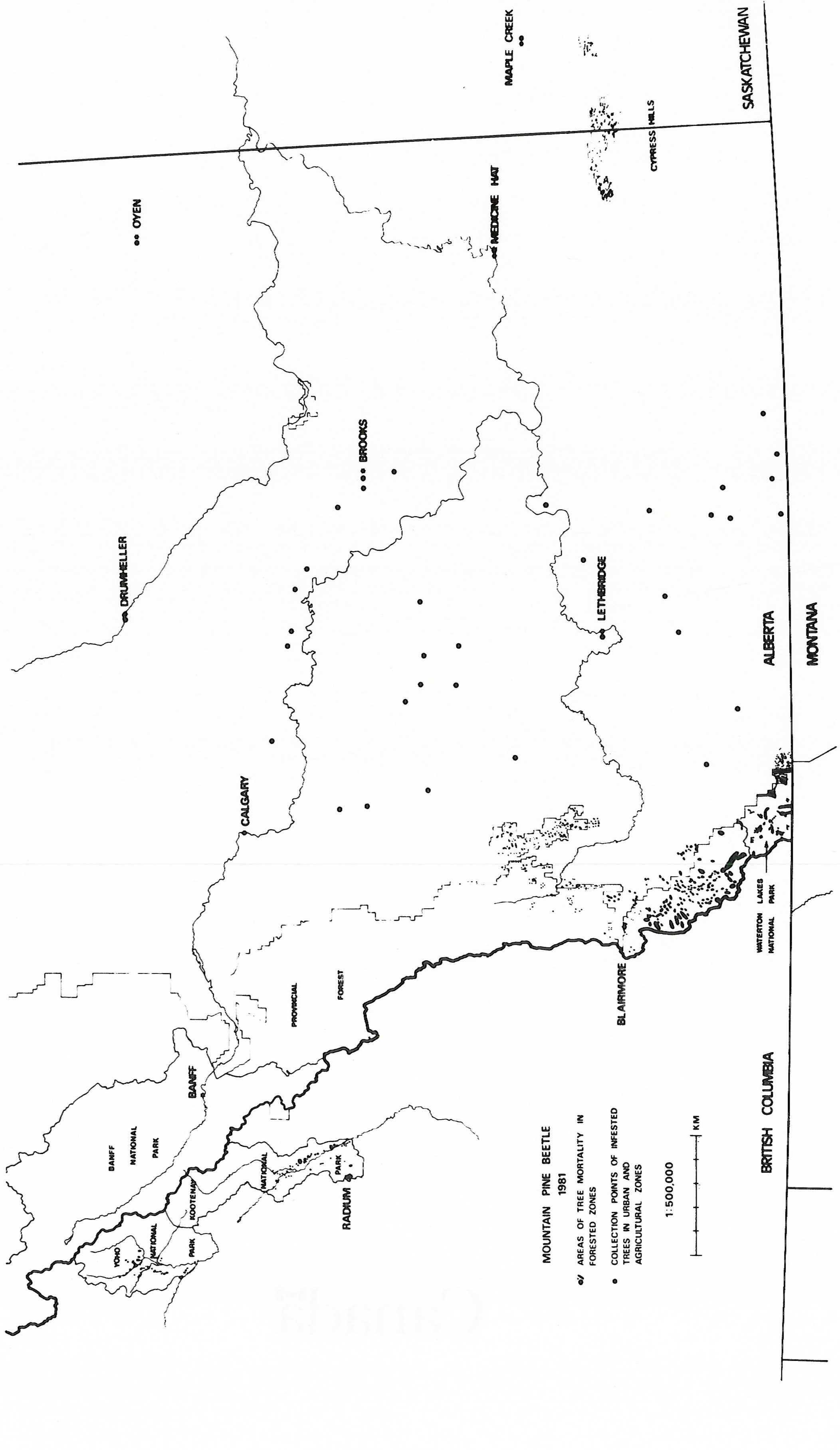
Canadian Forestry Service / Forest Insect and Disease Survey



Number and area of recent pine tree mortality by mountain pine beetle in British Columbia based on annual aerial surveys.

ATTACHMENT 2



Canada