Insect and Disease Hazard in Relation to Stand Stability: Waterton Lakes National Park

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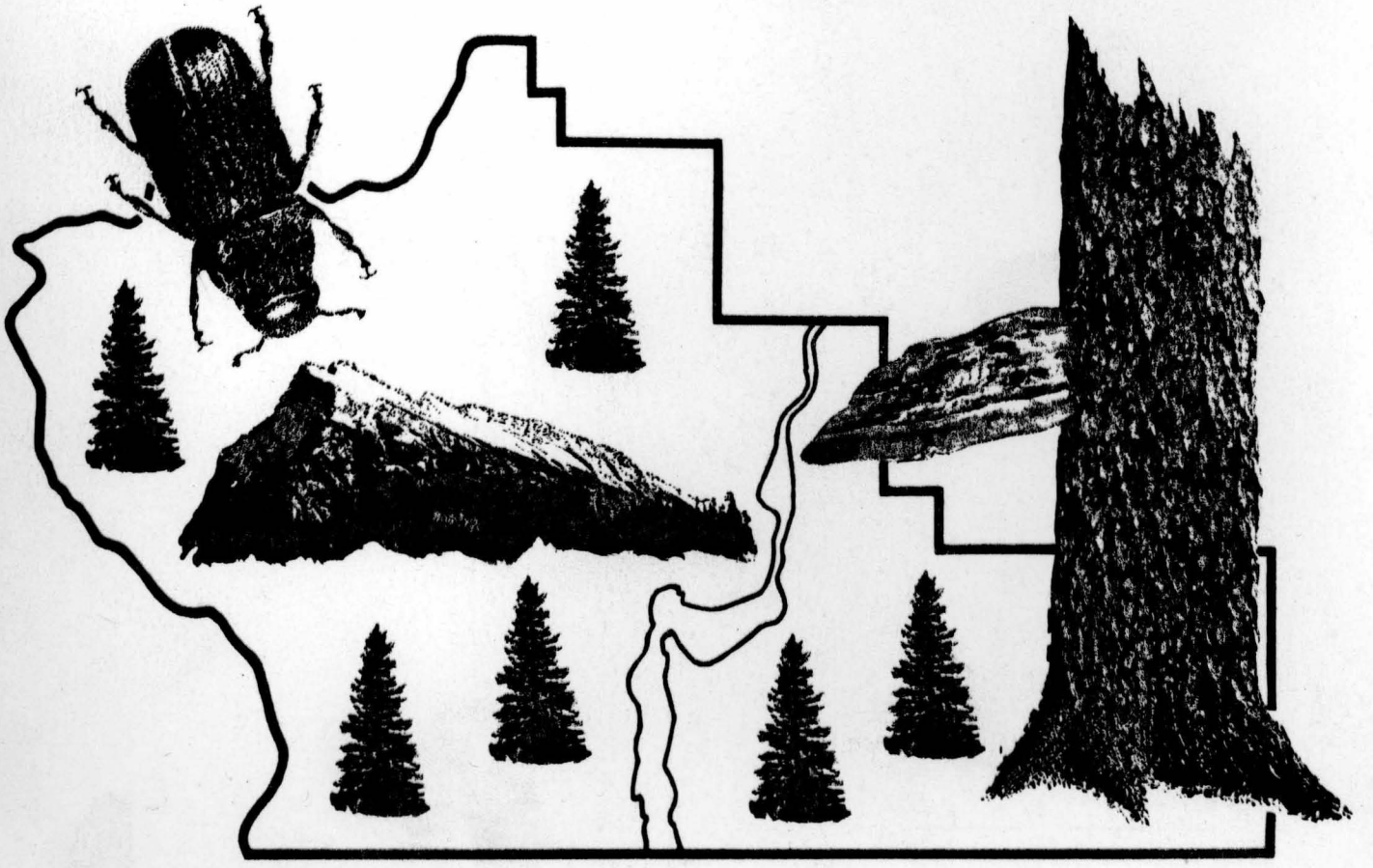

INSECT AND DISEASE HAZARD IN RELATION TO STAND STABILITY: WATERTON LAKES NATIONAL PARK

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NORTHERN FOREST RESEARCH CENTRE

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INTRODUCTION

This report rates the stability of timber stands in Waterton Lakes National Park on the basis of their susceptibility to decimation by insects and diseases. It has been prepared for use by park planners in conjunction with allied reports on cover types, soils, and fire hazard. Color-coded base maps are used to designate the hazard, and ozalid overlays, prepared by the Forest Management Institute, show the stand types. Full scale maps (1:25,000) accompany the master copy of this report. A color photograph of the base map is included in each of the additional reports. The insect and disease hazard ratings are grouped into five categories: very low; low; moderate; high; and very high. Stands rated in any of the first three categories are relatively stable, at least as far as insects and diseases are concerned, and are not likely to suffer major damage. The high hazard stands are considered to be vulnerable to insect and disease attack, and the very high hazard ratings are extremely vulnerable. Stands in either of these categories are not likely to stand additional stress without heavy tree mortality.

In addition to the insect and disease hazard rating maps, this report presents a brief history of various organisms within the Park (Appendix A) and a tabular listing of the numerical values of the hazard ratings for each stand type (Appendix B).

Three factors were considered when deriving the insect and disease hazard rating: (1) the organism and its effect on the tree; (2) the tree and its susceptibility to attack; (3) stand composition. Additional factors, such as regenerative potential, and stress, either natural or man-made, are worthy of consideration. They were not included in the present report because of lack of data.

METHODS

The first step in establishing a hazard rating was to determine the important insects and disease organisms in the Park and the extent of their damage. Much of the information was extracted from national punch-card files established by the Forest Insect and Disease Survey and from the Annual District Reports of that organization for the past 25 years.

The forest cover maps of Waterton Lake National Park, prepared by the Forest Management Institute, were used to select 25 different stand types. A detailed survey of these stand types was made in October, 1970, to obtain information on insects and diseases, their abundance, distribution and extent of damage. Increment borings of major tree species indicated their general vigor, and observations on regeneration and stress were made in each stand examined.

Numerous insect and disease pests have been recorded in the Park since examinations first began. Many of these have been of minor importance, as they cause little or no damage and pose no threat to the trees. The criteria used to select organisms which affect stand stability were: (1) those common enough to cause appreciable damage; (2) those which were well established and perennial (some disease organisms); and (3) those with a history of causing damage in other parts of the region and capable of doing so in Waterton Lakes National Park.

HAZARD RATING

For each selected organism, a numerical value was provisionally assigned to each of the following factors: damage caused by an organism; stand composition; and susceptivility to attack.

Damage caused by an organism - The portion of the tree affected and the types of damage caused by an organism were categorized and a simple numbering system assigned. The numbers range from $\frac{1}{4}$ for damage that has very little effect on the tree to 8 for injury that causes death to part or all of the tree (Table I).

Stand Composition - Because of the method of calculating the rating, mixed stands would automatically receive a higher rating than pure stands unless stand composition was given a weighting factor. A factor of 10 was therefore assigned to pure stands and a 6:4 ratio was assumed for mixed stands, the larger number being assigned to the major species. In this way, mixed and pure stands were placed on a comparable basis.

Stand susceptibility - The susceptibility of stands to attack by organisms is not constant. Stands of mature or over-mature spruce often contain heart rot which weakens the stems and makes the stands subject to blowdown. Bark beetle populations build up in the blowdown and then move to standing trees in the vicinity. This is an example of increased hazard due to high susceptibility to attack. On the other extreme, dwarf mistletoe is an example of decreased hazard. The rate of spread for mistletoe is slow, and since it has been recorded in only one area of the Park, the hazard throughout the remainder of the Park is reduced.

Numerical values ranging from $\frac{1}{4}$ to 2 (low to high) were assigned to susceptibility to attack, using 1 as an average.

Calculation of the hazard rating - The hazard ratings for each stand type were obtained by calculating the products of the three numbers assigned to the factors for each organism affecting the stand and summing these values

TABLE I

Damage factors assigned to various types of injury to trees

CROWN			
Damage to foliage -			
No loss of foliage	(a)	injury to a portion of the leaf- leaf able to continue photosynthesis.	0.5
Loss of foliage	(a)	early in the season - tree able to refoliate and carry on photosynthesis.	1
deciduous	(b)	late in the season - photosynthesis has been carried out for most of the season.	1
	(c)	loss of needles other than current year.	1
coniferous	(d)	loss of current years' needles only.	2
	(e)	loss of current and older needles.	4
Damage to buds and twigs -			
	(a)	Twigs deformed no mortality.	0.5
	(b)	Buds or twigs killed, no mortality of tree but individual branchlets killed, some deformity of tree.	1
	(c)	Buds or twigs killed, mortality of regeneration - important when stand composition changed.	2

Table I continued.

Damage affecting crown mass -		
	(a) damage on branches causing deformities and mortality.	2
	(b) damage affecting major portion of the crown mass; structural weakness sometimes result and tree mortality can occur.	4
STEM		
Damage to wood -		
	(a) loss of heartwood, weakens tree structurally in main stem & large branches (usually associated with mature to overmature trees).	2
	(b) loss of sapwood same as (a) above.	
Damage to the cambium -		
	(a) damage in limited areas of cambium causing deformities and some structural weakness.	2
	(b) damage on main stem causing girdling of tree and mortality of host.	8
ROOT		
Damage to root system -		
	(a) damage to root system causing structural weakness.	4
	(b) damage to root collar causing mortality by girdling.	8

for all organisms in the stand. For example, the hazard of 190 for lodgepole pine 1-3 (Appendix B) equals the sum of these products for diseases (4 x 10 x .25 + --- 1 x 10 x 1) plus those for insects (1 x 10 x 1 + 1 x 10 x 1). These numerical ratings were then grouped to give five categories of hazard rating ranging from very low to very high, which are presented on the color coded base maps (Fig. 1). The numerical values are presented in Appendix B.

DISCUSSION

In this report, numerical ratings for stand hazard attributable to insects and disease have been derived. The various stands could have been rated on a purely qualitative basis, but this would not have been subject to easy modification as subsequent data became available.

The hazard in this report refers to the present stands. If information on reproductive potential for the different stands becomes available this can be included as another factor which could substantially change the ratings. For example, most aspen stands reproduce readily by suckers, if they have sufficient light and are allowed to develop. Consequently, although a high hazard rating has been assigned to aspen stands, which is realistic for the present trees, the reproductive potential for most of these stands is probably such that regeneration will replace the trees as they die out. However, if campsites are established in aspen stands, for example, the combination of compaction and sucker damage or removal would probably prevent most of the suckers from reaching tree size. Once the existing trees died out there would be nothing to replace them.

One other point should be stressed. The hazard that has been derived is based on a relatively short history of infestations, or lack

of them. There is always the distinct danger that some organism that has not been included, because it has not been recorded in Waterton National Park, could become a major threat if conditions changed. For example, the mountain pine beetle is a major problem in Montana and British Columbia, but has not been a problem in the park. The ecological factors responsible for this are obscure, but might change sufficiently to allow the beetle to reach outbreak proportions. For this reason, park wardens should always be alert for new or unusual pests. They may be innocuous, but they may also be a major threat.

In conclusion, it must be borne in mind that this is a first attempt to provide such a rating. Any suggestions that users of this report may have are welcome, so that improvements or modifications can be made in the ratings to agree with the known facts. Only by having a feed-back from the users will it be possible to improve the ratings and thus make them more useful. Also, if there are major changes in stand types the maps should be updated. There is little point in having a hazard rating for a stand that may have been destroyed by a fire for example. This updating does not need to be done annually, but should be undertaken periodically, in order that the maps do not become seriously outdated.

APPENDIX A

Brief histories of a number of insect and disease pests found in Waterton Lakes National Park.

INSECTS

THE BLACK-HEADED BUDWORM, Acleris variana Fern., is a defoliator of spruce and fir that feeds on the current years foliage. Severe defoliation in successive years could cause growth loss, although there has been no record of high populations in this area. It has caused some light defoliation in limited areas in past years. Injury to infested trees is light and the danger to stands is low.

THE LARGE ASPEN TORTRIX, Choristoneura conflictana Wlk., is an aspen defoliator that is capable of completly defoliating trees. Defoliation occurs in spring and early summer and stripped trees releaf in 3-5 weeks. There has been a history of periodic outbreaks along the east side of the Park. Severe infestations rarely last more than 2 or 3 years and the overall damage is no more than slight growth loss. The effect is mostly aesthetic. Injury to infested trees is light, and the danger to stands is low.

THE SPRUCE BUDWORM, Choristoneura fumiferana Clem., is a defoliator of spruce and fir feeding on the buds and new foliage. Defoliation for several consecutive years can cause growth loss and tree mortality. There has been no record of permanent injury in the Park although low populations of budworms have been present for several years. There have been small areas along the mountains north of the Park where severe defoliation has occurred recently. Injury to infested trees is light, and the danger to stands is low.

A BUDWORM, Choristoneura lambertiana Busck, is a defoliator of the 5-needle pines that feeds on the current year's foliage. Severe defoliation in successive years could cause growth loss. Although this budworm has caused light defoliation in past years, there has been no history of severe damage in the Park. Most of the white pine is at higher elevations and appears to be unfavorable for establishment of these insects. Injury to infested trees is light and the danger to stands is low.

THE LODGEPOLE NEEDLE MINER, Coleotechnites starki Free., feeds inside the needles of lodgepole pine causing needle drop. It usually feeds in 2 and 3 year old needles and in severe infestations can cause notable needle loss and some growth reduction. It has been present in low numbers but there is no record of high populations. North of the Park severe infestations have caused notable stand discoloration which has had a detrimental effect aesthetically but apparently not physically. Injury to infested trees is light and the danger to stands is low.

THE SPRUCE BARK BEETLE, Dendroctonus obesus Mann., attacks mature and overmature spruce and feeds under the bark on the main stem cutting off the food supply to and from the roots. Infested trees usually die. There has been considerable mortality to overmature spruce recently at several locations in the Park. This outbreak, which peaked in 1968, has subsided at present but danger will be high as long as overmature stands are present. Injury to infested trees is high and the danger to stands is high.

THE AMERICAN POPLAR BEETLE, Gonioctena americana Schaef., feeds on aspen poplar, particularly regeneration and saplings. It is capable of causing severe defoliation but is unlikely to cause permanent injury of the trees.

Low populations have persisted in aspen stands in the Park for several years and occasionally moderate to severe defoliation has occurred in small areas. Injury to infested trees is light and the danger to stands is low.

THE BALSAM FIR SAWFLY, Neodiprion abietis Harr., is a defoliator of spruce that feeds primarily on one year old needles, and for this reason it is not likely to cause notable damage. It has been present throughout the Park but there have been no records of high populations. Injury to infested trees is light, and the danger to stands is low.

THE BRUCE SPANWORM, Operophtera bruceata Hlst., is an aspen defoliator that feeds early in the spring. It is capable of causing severe defoliation over large areas but because it feeds early in the year the trees are able to refoliate by the first of July. Severe infestations are usually of short duration. Low populations have been present regularly over past years but there has been no records of severe outbreaks in the Park. Injury to infested trees is light and the danger to stands is low.

THE PINE NEEDLE SCALE, Phenacaspis pinifoliae Fitch, is a sucking insect that derives its nutrients from needles of conifers. Severe infestations can cause loss of foliage and, occasionally, tree mortality. Small pockets of severely infested trees have been recorded along the east slopes of the mountains, and although it is current present in the Park, there has been no record of severe infestations or stand damage. Injury to infested trees is moderate, but the danger to stands is low.

THE YELLOW-HEADED SPRUCE SAWFLY, Pikonema alaskensis Roh., is a defoliator of spruce that usually attacks open growing trees or planted ornamentals. The larvae feed on current year's foliage. There are no records of severe infestations, although it is present in all areas of the Park. Damage is most likely to occur on planted spruce in the townsite. Injury to infested trees is moderate, but the danger to stands is low.

THE ENGELMANN SPRUCE WEEVIL, Pissodes engelmanni Hopk., infests and kills terminals of young spruce trees which results in tree deformity. Open growing young trees are most susceptible to attack. As this species usually attacks scattered, open growing individuals, stands are not likely to be affected. Its presence in the Park has been mainly along roadsides where aesthetic value is more important. Injury to infested trees is light and the danger to stands is low.

THE POPLAR BORER, Saperda calcarata Say, attacks living, non-vigorous aspen trees. It destroys heartwood and enhances the decay process, which often results in stem breakage. Much of aspen approaching maturity is susceptible to borer attack because of low vigor caused by poor site conditions and climatic stress. Infestations are common in all aspen stands in the Park. Injury to infested trees is high, and the danger to stands is also high.

SPRUCE GALL APHIDS, Adelges spp., are sucking insects that cause unsightly galls on the new shoots of spruce. Usually there is no permanent injury to the tree although individual ornamentals may be deformed and the old galls cause unsightliness. They are insignificant except when severe.

Present in all areas but the only area where they may be a problem is on planted trees in the townsite. Injury to infested trees is light, and there is no danger to stands.

THE POPLAR BUTT BORER, Xylotrechus obliteratus Lec., feeds in butts and root crowns of living, predisposed poplar trees of all ages. The insect destroys the heartwood, which results in mortality or blowdown. The presence of this borer in the Park has been established but the extent is not known. Since much of the poplar suffers from stress and poor site, most stands are susceptible. Injury to infested trees is high, and the danger to stands is also high.

DISEASES

A DWARF MISTLETOE, Arceuthobium americanum Nutt., is a parasitic plant whose principal host in this area is lodgepole pine. It is occasionally found on spruce and white bark pine. Once established on a tree, it gradually weakens the tree and causes brooming and sometimes mortality of parts of the tree. Its presence has been detected along the east side of the Park, but because of the slowness of spread it is not likely to present much of a hazard in the rest of the Park for many years. Injury to infested trees is moderate, and the danger to stands is moderate.

ARMILLARIA ROOT DISEASE, Armillaria mellea (Vahl ex Fr.) Kummer, is a rot that attacks the roots and root collar on a great variety of hosts, both coniferous and deciduous. If the trees are thrifty they can very often overcome attack from Armillaria. However, if the trees attacked have been subject to stress conditions they are often predisposed to the

point where serious injury and death result from an Armillaria attack. Root rot is well established in most areas of the Park and notable damage has been evident in some of these. As a primary invader, this disease causes moderate injury to infested trees, but as a secondary invader, the injury is extreme. However, danger to stands is low under normal conditions.

ATROPELLIS CANKER, Atropellis piniphila (Weir) Lohman & Cash., is a disease on lodgepole pine that causes cankers, resin flow and death of cambium in limited areas of the stems and branches. The girdling effect of more than one canker on the main stem of the tree can result in mortality of that tree. Atropellis canker is well established in the Park, and although some mortality has occurred, this has been more beneficial than detrimental, as it has acted as a natural thinning agent. Injury to infected trees is light, and the danger to stands is low.

SPRUCE NEEDLE RUSTS, Chrysomyxa spp. Unger., infect the needles of spruce. Depending on the species, they may attack current year's needles or one year old needles and cause loss of infected foliage and hence possible slight growth reduction of trees heavily infected for successive years. They would probably be more important from the aesthetic standpoint than from any loss to the stand. Endemic infections persist throughout the Park and occasionally small areas of moderate infection have been recorded. Injury to infested trees is light and the danger to stands is low.

THE PINE NEEDLE RUST, Coleosporium asterum (Diet) Syd., infects one year old needles of lodgepole pine. Heavy infections can cause notable needle drop and possibly slight growth reduction. As with spruce needle rusts,

the aesthetic value is decreased in years of high infection. This needle rust could probably be found in all areas where host occurs. A high incidence on regeneration has been recorded in the northwest section of the Park. Injury to infested trees is light, and the danger to stands is low.

THE PINE STEM RUST, Cronartium comandrae Pk , infects branches and main stems of lodgepole pine and occasionally, white bark pine. Cankers develop and girdling of the host at the infection area causes mortality above the cankers. Often rodents chew out the canker but in so doing may girdle the tree and cause mortality. It requires an alternate host to complete the life cycle. Infections have been recorded in the Park but no severe injury has been seen. Injury to infected trees is moderate, but the danger to stands is low.

STALACTIFORM BLISTER RUST, Cronartium coleosporioides Arth., causes cankers on stems and branches of lodgepole pine. On regeneration and on branches girdling by cankers will cause mortality. On larger trees the cankers elongate and deformities occur. It requires an alternate host to complete the life cycle. Low incidence of infection has been reported from widely separated areas. Regeneration is more likely to suffer from infections, deformities of larger trees could present aesthetic problems. Injury to infested trees is light, and the danger to stands is low.

THE WHITE PINE BLISTER RUST, Cronartium ribicola Fisch., is an important rust fungus that attacks limber and white bark pines. The cankers develop on branches and on the main stem and cause girdling and eventual mortality. Several species of 5-needle pines have been threatened with extinction by

this important disease. It requires an alternate host to complete the life cycle, and is found throughout the Park with a high incidence rate and notable mortality in many areas. Injury to infested trees is severe, and the damage to stands is high.

CYTOSPORA CANKER, Cytospora chrysosperma Fr., usually attacks the bark of poplar and willow, but it becomes parasitic if the host is weakened by drought, frost or fire, or is growing on an unfavourable site, or under stress. Cankers form on the main stem and larger branches and mortality results after girdling. Cytospora canker is well established in most poplar stands in the Park. Injury to infested trees is moderate, although the damage to stands is low.

THE INDIAN PAINT FUNGUS, Echinodontium tinctorium Ell. & Ev., is a brown stringy rot of the heart wood of Alpine fir and, rarely, Engelmann spruce. This rot does not kill a tree but it weakens the stem to the extent that wind damage occurs, and this presents a major physical hazard in areas designated for campsites, etc. It is well established in stands of mature and overmature fir throughout the Park. Injury to infected trees is moderate, but the danger to stands is low.

THE WESTERN GALL RUST, Endocronartium harknessii (J.P. Moore) Y. Hiratsuka, causes globose swellings on the branches and stems of lodgepole pine. Often regeneration and branches of larger trees are killed as a result of the galls girdling them. This rust does not require an alternate host to complete its life cycle. It has been reported in all areas of the Park but

nowhere are infection levels high, although some mortality in regeneration has been evident. Injury to infect trees is light, and the damage to stands is low.

THE WHITE TRUNK ROT, Fomes ignarius (L. ex Fr.) Kickx , occurs in the heartwood of mature and overmature poplars. It does not kill trees but weakens them structurally to the extent that they are susceptible to blowdown. Infections are present in poplar stands where they occur in the Park. Some breakage and windthrow of infected trees is evident. This damage would be important in areas used for camping, etc. Injury to infected trees is light to moderate, and danger to stands is low.

THE RED RING ROT, Fomes pini (Brot. ex Fr.) Karst., is a destructive wood decay fungus that attacks most species of conifer and is common on mature and overmature spruce, pine and Douglas fir in the Park. It does not kill the trees but weakens them making them subject to blowdown and it is in these trees that bark beetle populations build up. Decay caused by this fungus is prevalent in mature and overmature stands containing the preferred hosts in all areas of the Park. Injury to infected trees is moderate, and the danger to stands is low to moderate.

HYPOXYLON CANKER OF POPLAR, Hypoxylon mammatum (Wahl) Miller, causes cankers on living aspen poplar. Cankers are mainly on the main stem and enlarge to the extent that the tree is girdled, causing mortality. Trees subject to wounds or under stress are highly susceptible in this area. It is presently well established in all aspen stands in the Park. The percentage of infected trees is higher in those stands that have been subject to stress. Injury to infected trees is high and the danger to stands is moderate.

FIR NEEDLE RUSTS - There are two species of rust fungi that infect the needles of alpine fir in this area. One infects the current year's needles and the other infects one year old needles, both cause the loss of needles. Needle rusts have been present in many areas of the Park but there has been no severe infections. Injury to infected trees is very light and the danger to stands is very low.

PINE NEEDLE CASTS - There are several species of needle casts which infect and kill needles of lodgepole pine and, to a lesser degree, white bark and limber pines. One species, Elytroderma deforams Darker, is a perennial, systemic disease that causes deformation and reduces growth, and infections in small trees can cause mortality. Other species infect one or two year old needles causing discoloration and needle drop. Some growth loss could result but aesthetic damage is most notable. Infections have been present periodically and in some localized areas the incidence has been high. Injury to infected trees is light and the danger to stands is low.

WHITE FLAKEY WOOD DECAY, Pleurotus ostreatus (Fr.) Kummer, as its name implies, causes a white, flakey rot of the heartwood and sapwood of mature and overmature poplar species and occasionally spruce. As with other heart rots the tree is weakened and subject to breakage and windthrow, which could present a hazard in areas utilized by the public. It has become established in some areas of the Park but the extent is unknown. Injury to infected trees is moderate and the danger to stands is low.

POPLAR LEAF DISEASES - A number of different fungi infect the leaves of poplar, causing discoloration and premature leaf drop. Successive years of severe infection could cause growth loss, but leaf diseases mainly affect the aesthetic value of the trees. Noticeable discoloration has occurred in limited areas from time to time, and all poplar in the park is subject to infection. Injury to infected trees is light and the danger to stands is low.

THE BLACK CANKER OF SPRUCE, Retinocyclus abietis (Crouan) Groves & Wells, enters a mechanical wound on branches and stems of young spruce and fir. Cankers are usually formed and kept open by the fungus. Some top killing could result in deformities of the tree. It has been collected in the Park but at present is not a problem. Areas where mechanical injury is likely would be subject to the infection. Injury to infested trees is moderate and the danger to stands is low.

A DOUGLAS FIR NEEDLE CAST, Rhabdocline pseudotsugae Syd., infects all except newest needles of young Douglas fir causing them to die and drop off, and severe infections can cause mortality of younger trees (up to about 30 years old). More common in seasons of high humidity and heavy rainfall, and it has been present in all stands of Douglas fir. Infections occasionally are severe but no mortality attributable to needle cast has been noted in the Park. Injury to infected trees is moderate and the danger to stands is also moderate.

APPENDIX B

Insect and disease hazard ratings for 25 stand types in Waterton Lakes National Park (the numbers following some species are the height classes given on the Forest Management Institute cover type maps).

Very Low		
	Alpine larch	0
	Alpine fir - larch	84
Low		
	Alpine fir - white bark pine	108
	Whitebark pine - alpine fir	116
	Alpine fir	140
	Spruce 1-3	155
Moderate		
	Douglas fir - alpine fir	170
	Alpine fir - spruce	174
	Lodgepole pine - alpine fir	176
	Douglas fir	176
	Douglas fir - lodgepole pine	188
	Lodgepole pine 1-3	190
	Lodgepole pine 5-7	190
	Lodgepole pine - Douglas fir	192
	Lodgepole pine 9	200
High		
	Lodgepole pine - poplar	234
	Douglas fir - spruce	246
	Spruce - alpine fir	249
	Lodgepole pine - spruce	254
	Spruce - Douglas fir	273
Very High		
	Poplar 1-3	280
	Poplar - spruce	300
	Poplar 5-9	300
	Spruce 5-7	325
	Spruce 9	335

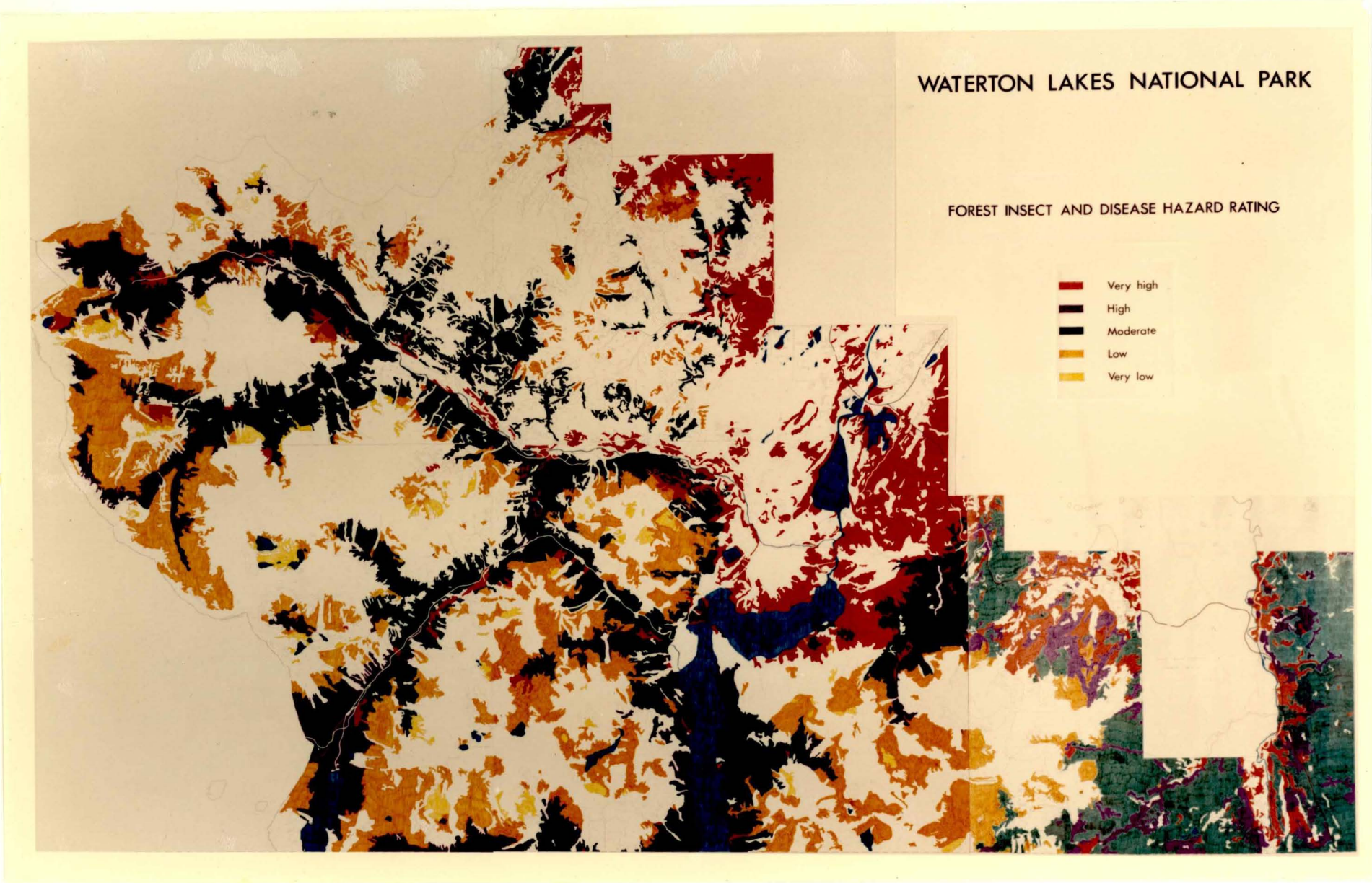

Fig. 1. Forest insect and disease hazard ratings for timber stands in Waterton Lakes National Park. (See Appendix B for numerical values)

Contributions of disease organisms to the hazard ratings for 25 stand types in Waterton Lakes National Park

(See Page 3 for explanation of column entries)

DISEASE	Lp pine 1-3	Lp pine 5-7	Lp pine 9	Lp pine Spruce	Lp pine A fir	Lp pine D.fir	Lp pine Poplar	A fir	A fir Spruce	A fir W pine	A fir Larch	Spruce 1-3	Spruce 5-7	Spruce 9	Spruce A fir	Spruce D fir	Poplar 1-3	Poplar 5-9	Poplar Spruce	W pine A fir	D fir	D fir Lp pine	D fir Spruce	D fir A fir	Larch
Arceuthobium americanum dwarf mistletoe	4/10/25	4/10/25	4/10/25	4/6/25	4/6/25	4/6/25	4/6/25															4/4/25			
Armillaria mellea Armillaria root rot	4/10/1	4/10/1	4/10/1	4/10/1	4/10/1	4/10/1	4/10/1	4/10/1	4/10/1	4/6/1	4/6/1	4/10/1	4/10/1	4/10/1	4/10/1	4/10/1	4/10/1	4/10/1	4/10/1	4/4/1	4/10/1	4/10/1	4/10/1	4/10/1	
Atropellis piniphila Atropellis canker	2/10/1	2/10/1	2/10/1	2/6/1	2/6/1	2/6/1	2/6/1															2/4/1			
Chrysomyxa spp. spruce needle rusts				1/4/1					1/4/1			1/10/1	1/10/1	1/10/1	1/6/1	1/6/1			1/4/1				1/4/1		
Coleosporium asterum pine needle rust	1/10/1	1/10/1	1/10/1	1/6/1	1/6/1	1/6/1	1/6/1															1/4/1			
Cronartium coleosporioides stalactiforme blister rust	2/10/1	2/10/1	2/10/1	2/6/1	2/6/1	2/6/1	2/6/1															2/4/1			
Cronartium comandrae pine stem rust	2/10/1	2/10/1	2/10/1	2/6/1	2/6/1	2/6/1	2/6/1															2/4/1			
Cronartium ribicola white pine blister rust										4/4/2										4/6/2					
Cytospora chrysosperma Cytospora canker							2/4/1										2/10/1	2/10/1	2/6/1						
Endocronartium harknessii western gall rust	2/10/1	2/10/1	2/10/1	2/6/1	2/6/1	2/6/1	2/6/1															2/4/1			
Echinodontium tinctorium Indian paint fungus					2/4/1			2/10/1	2/6/1.5	2/6/1.5	2/6/1.5				2/4/1.5					2/4/1.5			2/4/1	
Fomes igniarius white trunk rot							2/4/1										2/10/1	2/10/1	2/6/1						
Fomes pini red ring rot	2/10/1	2/10/1	2/10/1.5	2/10/1.5	2/6/1.5	2/10/1.5	2/6/1			2/4/1			2/10/1	2/10/1.5	2/6/1.5	2/10/1.5				2/6/1.5	2/10/1.5	2/10/1.5	2/10/1.5	2/10/1.5	
Hypoxylon mammatum Hypoxylon canker							8/4/1.5										8/10/1.5	8/10/1.5	8/6/1.5						
Pucciniastrum spp. fir needle rusts					1/4/1	1/4/1		1/10/1	1/6/1	1/6/1	1/6/1				1/4/1	1/4/1				1/4/1	1/10/1	1/6/1	1/6/1	1/10/1	
Pine needle casts	1/10/1	1/10/1	1/10/1	1/6/1	1/6/1	1/6/1	1/6/1															1/4/1			
Pleurotus ostreatus white flakey wood decay							2/4/1											2/10/1	2/6/1						
Poplar leaf diseases							1/4/1										1/10/1	1/10/1	1/6/1						
Rhabdocline pseudotsugae Douglas fir needle cast						4/4/1										4/4/1					4/10/1	4/6/1	4/6/1	4/6/1	

Contributions of insect pests to the hazard ratings for 25 stand types in Waterton Lakes National Park

(See Page 3 for explanation of column entries)

INSECT	Lp pine 1-3	Lp pine 5-7	Lp pine 9	Lp pine Spruce	Lp pine A fir	Lp pine D fir	Lp pine Poplar	A fir	A fir Spruce	A fir W pine	A fir Larch	Spruce 1-3	Spruce 5-7	Spruce 9	Spruce A fir	Spruce D fir	Poplar 1-3	Poplar 5-9	Poplar Spruce	W pine A fir	D fir	D fir Lp pine	D fir Spruce	D fir A fir	A Larch
Acleris variana black-headed budworm				2/4/1	2/4/1	2/4/1		2/10/1	2/4/1	2/6/1	2/6/1	2/10/1	2/10/1	2/10/1	2/6/1	2/10/1			2/4/1	2/4/1	2/10/1	2/6/1	2/10/1	2/10/1	
Choristoneura conflictana large aspen tortrix							1/4/1										1/10/1	1/10/1	1/6/1						
Choristoneura fumiferana spruce budworm				4/4/1	4/4/1	4/4/1		4/10/1	4/4/1		4/6/1	4/10/1	4/10/1	4/10/1	4/10/1	4/10/1			4/4/1	4/4/1	4/10/1	4/6/1	4/10/1	4/10/1	
Choristoneura lambertiana pine budworm										2/4/1										2/6/1					
Coleotechnites starki lodgepole needle miner	1/10/1	1/10/1	1/10/1	1/6/1	1/6/1	1/6/1	1/6/1															1/4/1			
Dendroctonus obesus spruce bark beetle				8/4/2					8/4/2				8/10/2	8/10/2	8/6/2	8/6/2			8/4/2				8/4/2		
Gonioctena americana American aspen beetle							1/4/1										1/10/1	1/10/1	1/6/1						
Neodiprion abietis balsam fir sawfly				1/4/1					1/4/1			1/10/1	1/10/1	1/10/1	1/6/1	1/6/1			1/4/1				1/4/1		
Operophtera bruceata Bruce spanworm							1/4/1										1/10/1	1/10/1	1/6/1						
Phenacaspis pinifoliae pine needle scale	1/10/1	1/10/1	1/10/1	1/6/1	1/6/1	1/6/1	1/6/1															1/4/1			
Pikonema alaskensis yellow-headed spruce sawfly				2/4/1					2/4/1			2/10/1	2/10/1	2/10/1	2/6/1	2/6/1			2/4/1				2/4/1		
Pissodes engelmanni Engelman spruce weevil									1/4/1			1/10/1							1/4/1				1/4/1		
Saperda calcarata poplar borer							2/4/1										2/10/1	2/10/1	2/6/1						
Spruce gall aphids				.5/4/1					.5/4/1			.5/10/1	.5/10/1	.5/10/1	.5/6/1	.5/6/1			.5/4/1				.5/4/1		
Xylotrechus obliteratus poplar butt borer							2/4/1										2/10/1	2/10/1	2/6/1						