M-X-206 Ecological Atlas

Abstract

Defoliation coverages for five major forest insect pests in Canada have been prepared for the first time on a national, ecologically stratified, base map. Reporting in an ecological framework, while satisfying updated reporting needs for international and national requirements, gives greater detail about these insect disturbance events in the form of maps, tables, and histograms, and offers analytical opportunities for several ecosystem health issues, such as climate change. This Forest Health Network report focuses on spruce budworm (Choristoneura fumiferana Clem.), forest tent caterpillar (Malacosoma disstria Hbn.), jack pine budworm (Choristoneura pinus pinus Free.), hemlock looper (Lambdina fiscellaria fiscellaria Gn.), and mountain pine beetle (Dendroctonus ponderosae Hopkins) for the period 1980 -1996.

Introduction

Measuring the area of disturbance caused by insect defoliation and damage provides a very important and significant source of information in the maintenance of sustainable forest ecosystems. Damage from insect pests may limit the economic use of certain tree species and/or render areas of forests unsuitable for recreation and wildlife habitat. The biodiversity of forests may also be affected by insect damage. Improved decision making and sound policy decisions require knowledge of the extent and level of disturbance in Canadian forests. National compilation and reporting of areas of forest insect defoliation have been on a jurisdictional basis (FIDS, 1995), and for good reason. The pests of economic significance are of greatest concern to those agencies responsible for the management of the forest resources, the provinces. However reporting needs have changed.

Canada's view of her forests began to change with Canada's Forest Accord (CCFM, 1992) that considered forest management from a multiple-use perspective - for more than its fiber and timber content. Development of criteria and indicators of sustainable forest management soon followed for Canada (CCFM, 1997) and internationally for temperate and boreal forests (Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests, 1997).

These initiatives represent a change in how we collectively view our forests, how we describe and measure our forests and how we report disturbance factors such as insects and fire. These changing views compel Canada to report data to national and international audiences in ecological rather than jurisdictional frameworks. Currently the National Forestry Database Program reports inventory using the ecological classification of Canada (Ecological Stratification Working Group, 1996), and the Forest Health Network's recently released national forest health report (FHN, 1998) adopts a similar framework.

Aerial defoliation surveys have been conducted by provincial and federal staff and by partnerships of Ministries of Natural Resources to measure year-to-year fluctuations in insect populations for forest management planning. The Canadian Forest Service (CFS) FHN has been mandated to acquire and compile annual provincial and territorial defoliation maps, prepare national coverages of insect defoliation in Canada's forests, and prepare statistics.

Reflecting the changing views of our forests and the reporting needs mentioned above, the FHN, for the first time, presents these national coverages and associated tabulated statistics using ecological classification as the reporting framework. This document reports on five major forest insects that caused moderate and severe defoliation and damage within the 1980 - 1996 period: spruce budworm (Choristoneura fumiferana Clem.), forest tent caterpillar (Malacosoma disstria Hbn.), jack pine budworm (Choristoneura pinus pinus Free.), hemlock looper (Lambdina fiscellaria fiscellaria Gn.), and mountain pine beetle (Dendroctonus ponderosae Hopkins).

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		Lancaster Plateau	13
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		Gulf of Boothia Plain	21
		Borden Peninsula Plateau	22
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		Pangnirtung Upland	26
		Hall Peninsula Upland	27
		Meta Incognita Peninsula	28
		Baffin Upland	29
		Wager Bay Plateau	30
		Northern Ungava Peninsula	31
Southern Arctic	3	Yukon Coastal Plain	32
		Tuktoyaktuk Coastal Plain	33
		Anderson River Plain	34
		Dease Arm Plain	35
		Coronation Hills	36
		Bluenose Lake Plain	37
		Bathurst Hills	38
		Queen Maud Gulf Lowland	39
		Chantrey Inlet Lowland	40
		Takijua Lake Upland	41
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		Back River Plain	43
		Dubwant Lake Plain/Upland	44
		Maguse River Upland	45
		Southampton Island Plain	46
		Central Ungava Peninsula	47
		Ottawa Islands	48
		Belcher Islands	49

Ecozone	No.	Ecoregion	No.
Taiga Plains	4	Mackenzie Delta	50
		Peel River Plateau	51
		Great Bear Lake Plain	52
		Fort MacPherson Plain	53
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Ecozone	No.	Ecoregion	No.
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		Frontenac Axis	133
		Manitoulin-Lake Simcoe	134
		Lake Erie Lowland	135
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Montane Cordillera	14	Skeena Mountains	198
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Appendix II

Lambert Conformal Conic Projection Parameters

Central Meridian	-91.8666
Reference Latitude	63.0000
1st parallel	49.0000
2nd parallel	77.0000
False Easting	6200000
False Northing	2985000

Appendix III

Moderate and Severe Defoliation and Damage by Provincial and Territorial Jurisdiction

Spruce Budworm * (hectares)

YEAR	NF	PE	NS	NB	QC	ON	MB	SK	AB	BC	YT	NT
1980	1412000	0	0	709000	5327000	20841000	99000	0	1000	0	0	2000
1981	579000	0	0	1236000	6652000	19471000	23000	0	>0	0	0	0
1982	55000	15000	127000	1221000	8837000	9091000	105000	6000	3000	0	0	2000
1983	12000	25000	361000	2184000	9247000	10700000	462000	17000	5000	0	0	19000
1984	22000	8000	69000	853000	7482000	10061000	278000	26000	4000	2000	0	107000
1985	3000	67000	308000	1047000	6385000	14606000	399000	30000	16000	0	0	62000
1986	2000	79000	0	953000	2134000	10717000	299000	46000	22000	0	0	189000
1987	5000	0	0	430000	786000	8692000	186000	146000	112000	0	0	190000
1988	>0	0	0	484000	441000	6299000	90000	83000	135000	0	0	166000
1989	2000	0	0	430000	739000	7430000	83000	112000	116000	0	0	302000
1990	1000	0	0	250000	608000	8143000	22000	4000	11000	0	0	291000
1991	2000	0	0	285000	350000	10720000	268000	461000	459000	0	0	1086000
1992	2000	51000	0	87000	21000	11212000	214000	748000	750000	0	0	1549000
1993	0	0	0	0	>0	10900000	21000	202000	81000	0	0	198000
1994	0	6000	0	0	2000	5201000	52000	373000	230000	0	0	888000
1995	0	0	0	0	4000	4141000	51000	1109000	255000	0	0	91000
1996	0	0	0	0	5000	441000	68000	742000	271000	1000	0	328000

Forest Tent Caterpillar * (hectares)

YEAR	NF	PE	NS	NB	QC	ON	MB	SK	AB	BC	YT	NT
1980	0	7000	0	215000	308000	371000	12000	11596000	7226000	0	0	146000
1981	0	13000	8000	1125000	1048000	6000	53000	8781000	12312000	0	0	0
1982	0	18000	11000	1552000	372000	83000	1211000	3368000	14558000	0	0	0
1983	0	83000	45000	1258000	18000	29000	525000	670000	4358000	0	0	0
1984	0	36000	42000	101000	0	135000	492000	55000	2228000	14000	0	0
1985	0	0	24000	16000	188000	153000	77000	597000	2625000	26000	0	0
1986	0	0	>0	0	174000	453000	77000	622000	4094000	33000	0	0
1987	0	0	0	0	593000	1694000	14000	3095000	5780000	17000	0	0
1988	0	0	0	0	0	4101000	181000	4965000	10781000	28000	0	0
1989	0	0	0	0	0	8193000	446000	4342000	6536000	89000	0	0
1990	0	0	0	0	0	9433000	0	0	420000	130000	0	0
1991	0	0	0	3000	0	18925000	0	0	0	72000	0	0
1992	0	0	0	176000	38000	16086000	155000	23000	46000	34000	0	0
1993	0	0	0	194000	7000	724000	4000	0	19000	78000	0	0
1994	0	0	0	392000	4000	168000	9000	23000	141000	85000	0	0
1995	0	0	10000	437000	1000	244000	>0	110000	222000	91000	0	49000
1996	0	0	1000	33000	1000	859000	2000	39000	130000	56000	0	198000
											0	
											0	

Jack Pine Budworm * (hectares)

YEAR	NF	PE	NS	NB	QC	ON	MB	SK	AB	BC	YT	NT
1982	0	0	0	0	0	0	26000	0	0	0	0	0
1983	0	0	0	0	0	68000	481000	0	0	0	0	0
1984	0	0	0	0	0	1316000	3478000	219000	0	0	0	0
1985	0	0	0	0	0	0	5050000	882000	5000	0	0	0
1986	0	0	0	0	0	0	668000	397000	11000	0	0	0
1987	0	0	0	0	0	0	9000	6000	8000	0	0	0
1988	0	0	0	0	0	718000	0	4000	0	0	0	0
1989	0	0	0	0	0	285000	0	0	0	0	0	0
1990	0	0	0	0	0	30000	0	0	0	0	0	0
1991	0	0	0	0	0	138000	0	0	0	0	0	0
1992	0	0	0	0	>0	0	0	0	0	0	0	0
1993	0	0	0	0	1000	316000	0	0	0	0	0	0
1994	0	0	0	0	>0	424000	0	0	0	0	0	0
1995	0	0	0	0	1000	0	0	0	0	0	0	0
1996	0	0	0	0	>0	104000	0	0	0	0	0	0

* all areas rounded to the nearest 1000 hectares

Hemlock Looper (hectares)

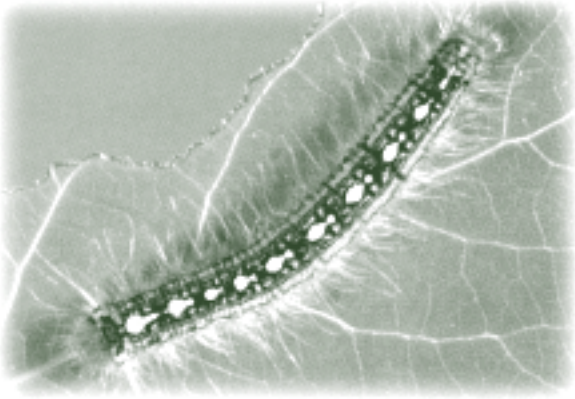
YEAR	NF	PE	NS	NB	QC	ON	MB	SK	AB	BC	YT	NT
1983	>0	0	0	0	0	0	0	0	0	0	0	0
1984	19000	0	0	0	0	0	0	0	0	0	0	0
1985	89000	0	0	0	0	0	0	0	0	0	0	0
1986	70000	0	0	0	0	0	0	0	0	0	0	0
1987	115000	0	0	0	0	0	0	0	0	0	0	0
1988	15000	0	0	0	0	0	0	0	0	0	0	0
1989	7000	0	0	3000	0	0	0	0	0	0	0	0
1990	>0	0	0	4000	0	0	0	0	0	0	0	0
1991	5000	0	0	1000	0	0	0	0	0	0	0	0
1992	4000	0	4000	1000	1000	0	0	0	0	0	0	0
1993	0	0	0	0	>0	0	0	0	0	0	0	0
1994	0	0	0	0	>0	0	0	0	0	0	0	0
1995	0	0	0	0	1000	0	0	0	0	0	0	0
1996	28000	0	0	0	7000	0	0	0	0	0	0	0

Mountain Pine Beetle (hectares)

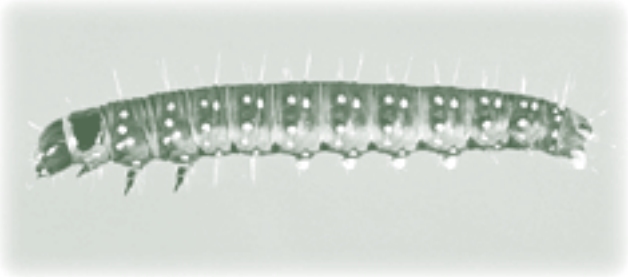
YEAR	NF	PE	NS	NB	QC	ON	MB	SK	AB	BC	YT	NT
1992	0	0	0	0	0	0	0	0	0	27000	0	0
1993	0	0	0	0	0	0	0	0	0	34000	0	0
1994	0	0	0	0	0	0	0	0	0	26000	0	0
1995	0	0	0	0	0	0	0	0	0	18000	0	0
1996	0	0	0	0	0	0	0	0	0	17000	0	0

* all areas rounded to the nearest 1000 hectares

N.B. These tables are calculations of areas of defoliation based on maps and figures submitted by provinces and territories shortly after the defoliation occured and may be subject to revision.



Spruce Budworm



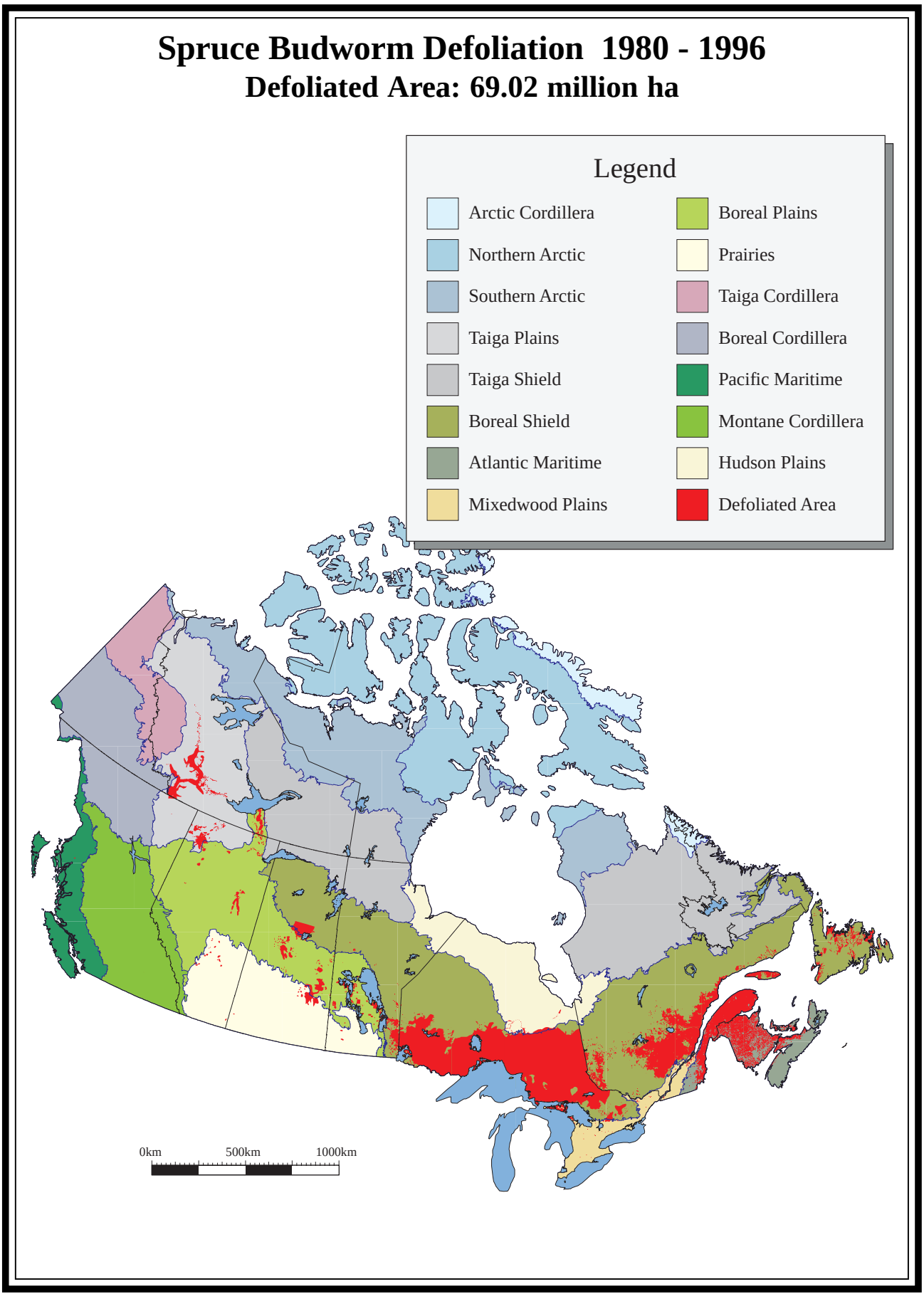
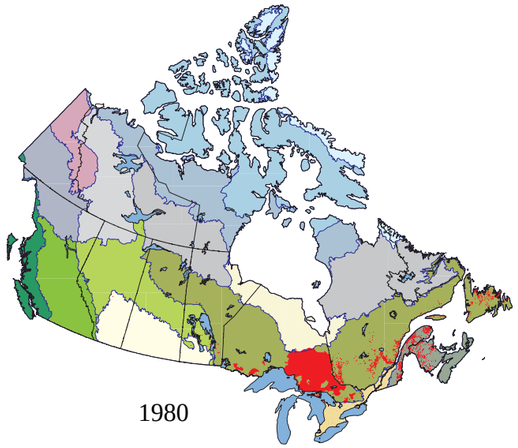


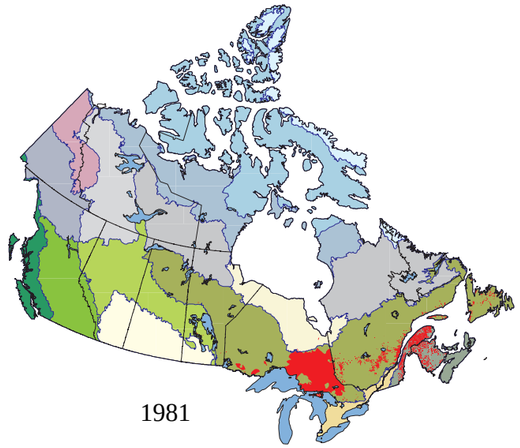
Figure 1. Spruce Budworm Defoliation 1980 - 1996

A Defoliation History Of Spruce Budworm In Canada 1980 - 1996

Legend

- Arctic Cordillera
- Northern Arctic
- Southern Arctic
- Taiga Plains
- Taiga Shield
- Boreal Shield
- Atlantic Maritime
- Mixedwood Plains
- Boreal Plains
- Prairies
- Taiga Cordillera
- Boreal Cordillera
- Pacific Maritime
- Montane Cordillera
- Hudson Plains
- Defoliated Area


1980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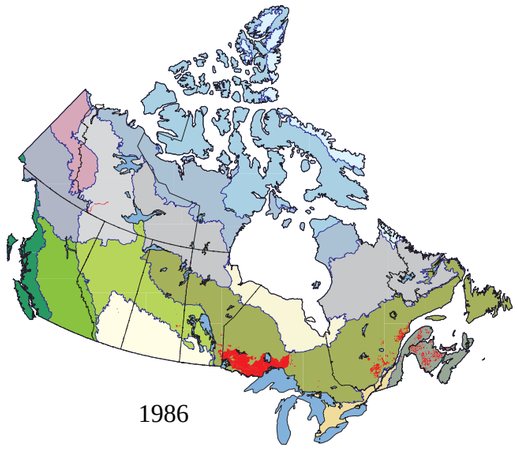
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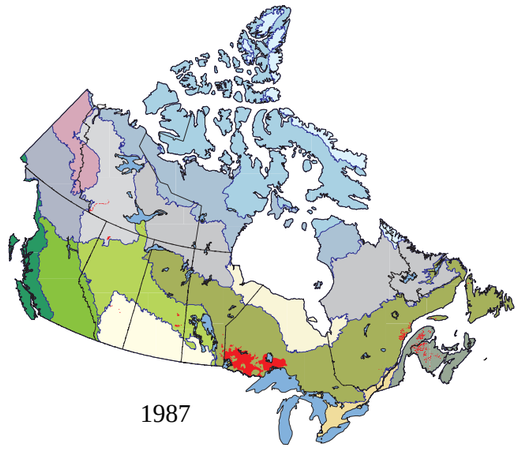
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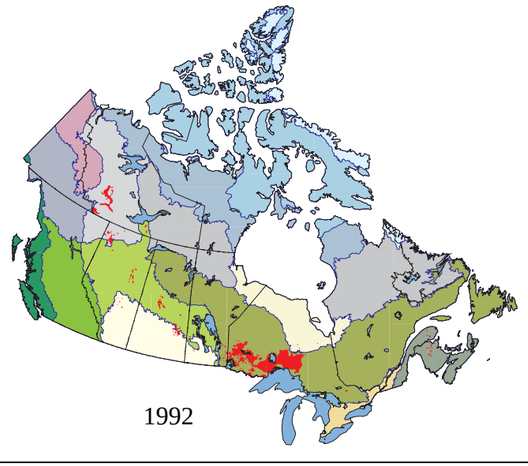
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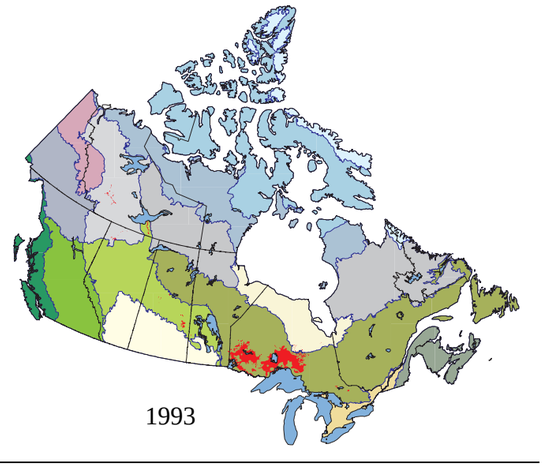
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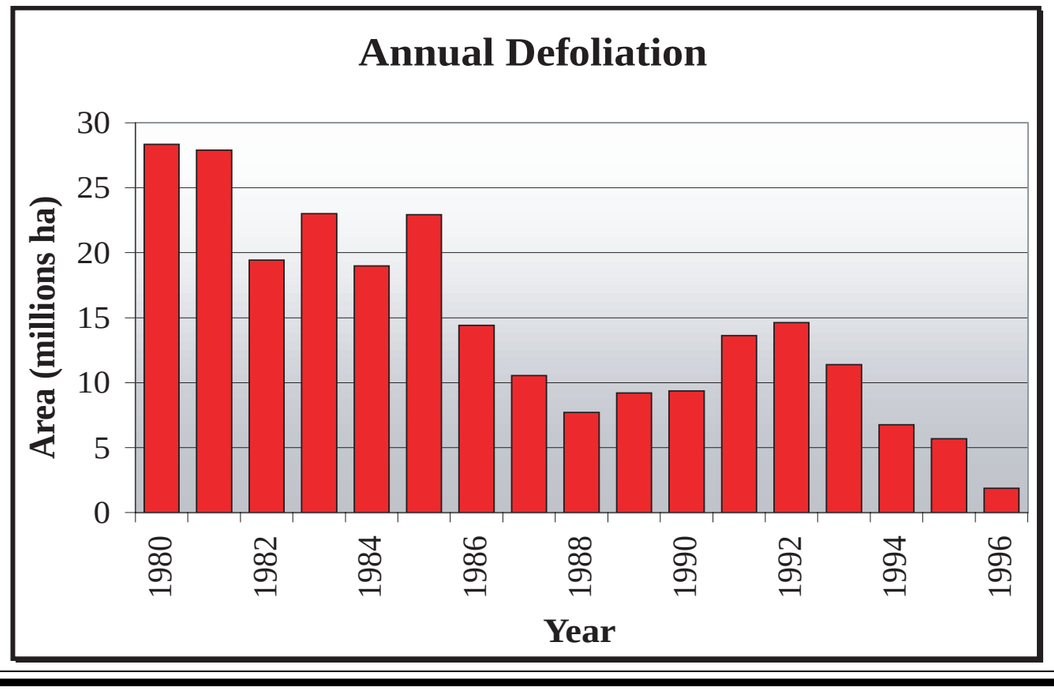
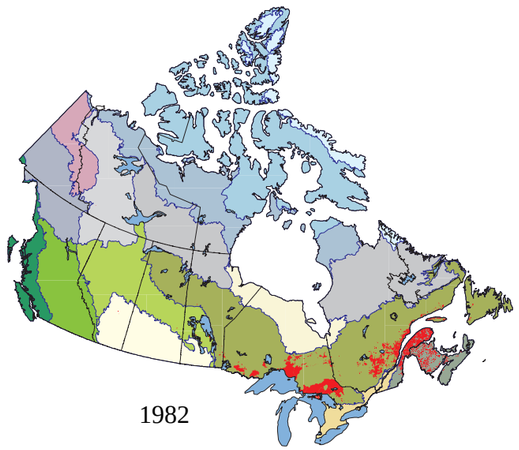
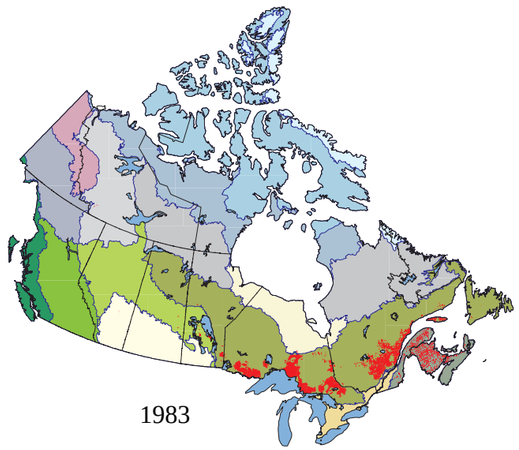


Figure 2. A Defoliation History of Spruce Budworm in Canada 1980 - 1996



1982



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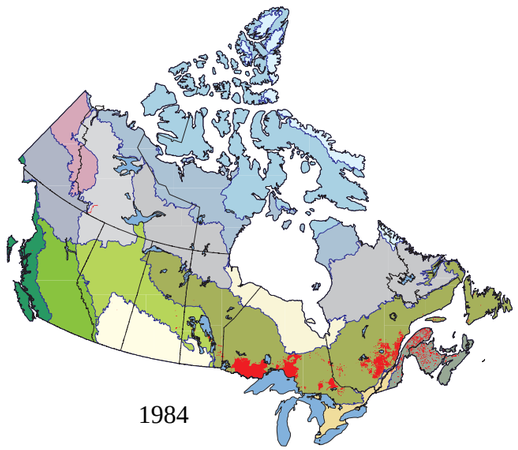

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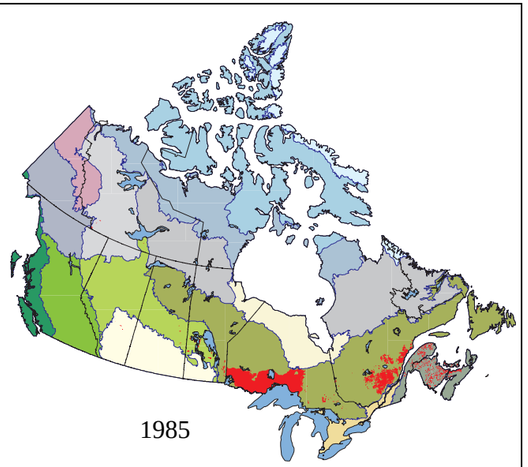
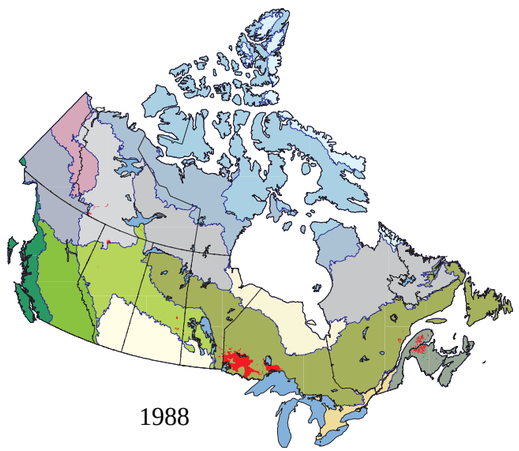
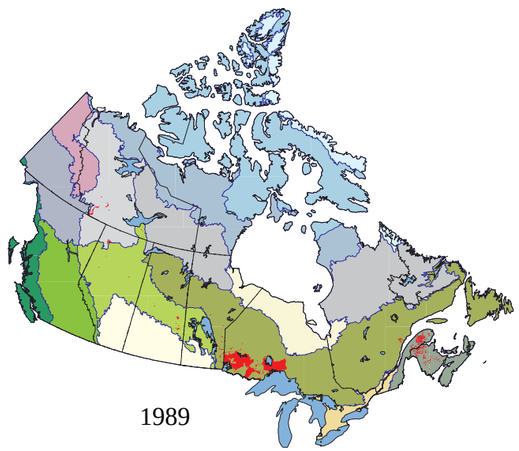


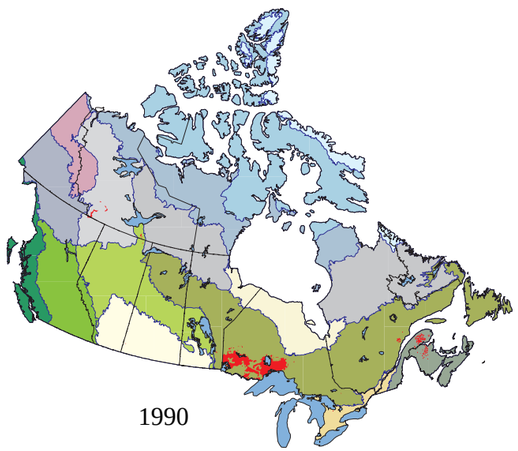
1985



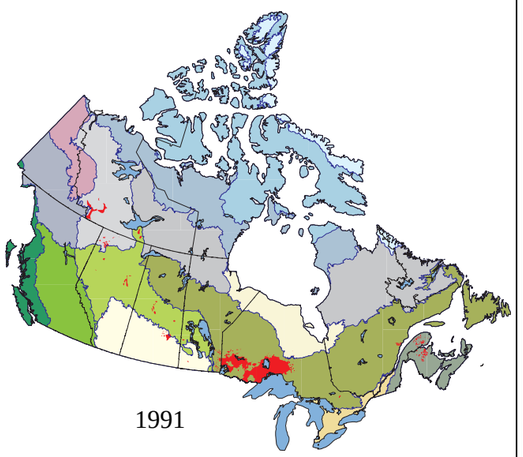
1988



1989



1990



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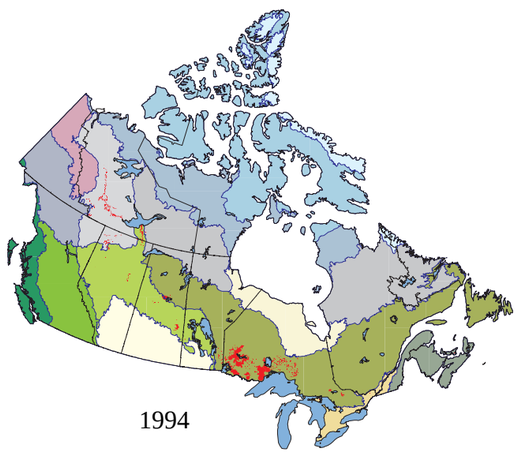

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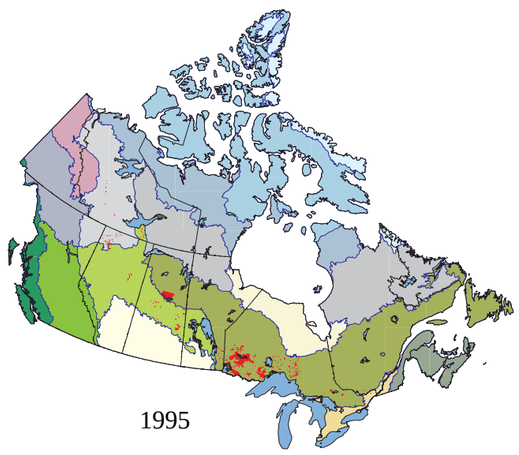

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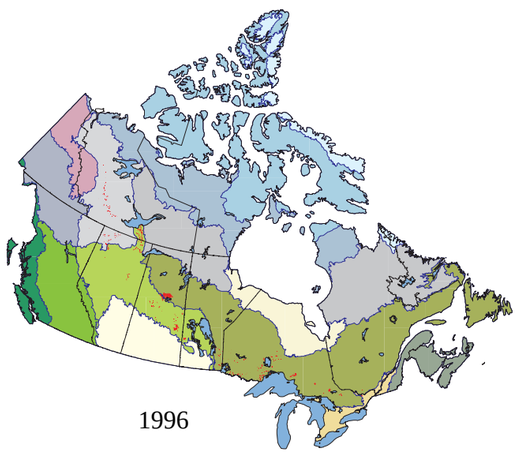
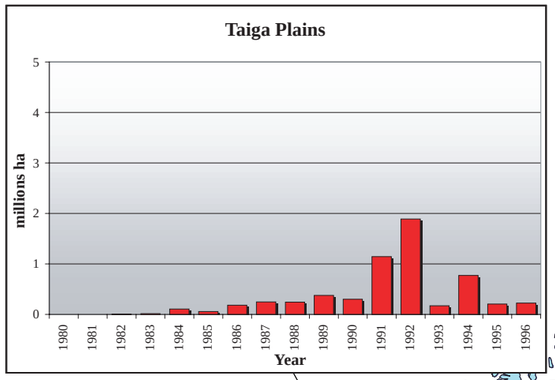
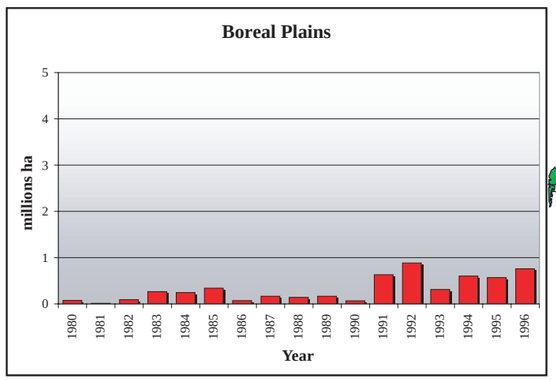


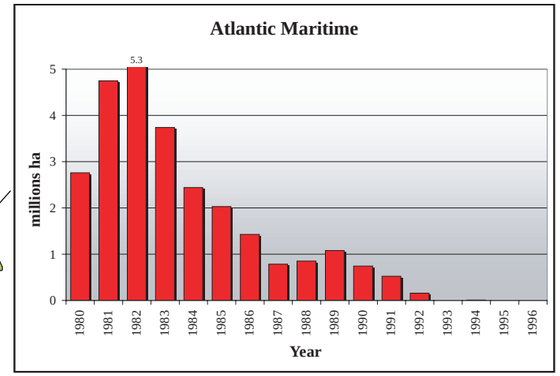
1996

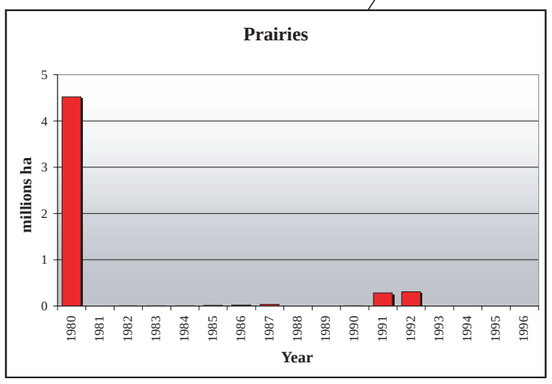
Spruce Budworm Defoliation In Canada By Ecozone 1980 - 1996

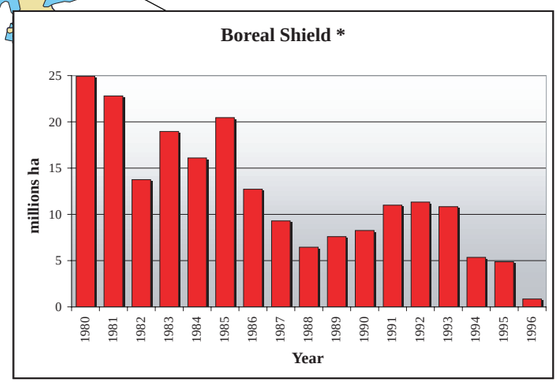
This sequence displays only the ecozones that had more than 500,000 hectares of defoliation in any of the years from 1980 – 1996.











* Note: The range of the y-axis is increased to accommodate the greater amounts of defoliation in this ecozone.

Legend

- Arctic Cordillera
- Northern Arctic
- Southern Arctic
- Taiga Plains
- Taiga Shield
- Boreal Shield
- Atlantic Maritime
- Mixedwood Plains
- Boreal Plains
- Prairies
- Taiga Cordillera
- Boreal Cordillera
- Pacific Maritime
- Montane Cordillera
- Hudson Plains

Figure 3. Spruce Budworm Defoliation in Canada by Ecozone

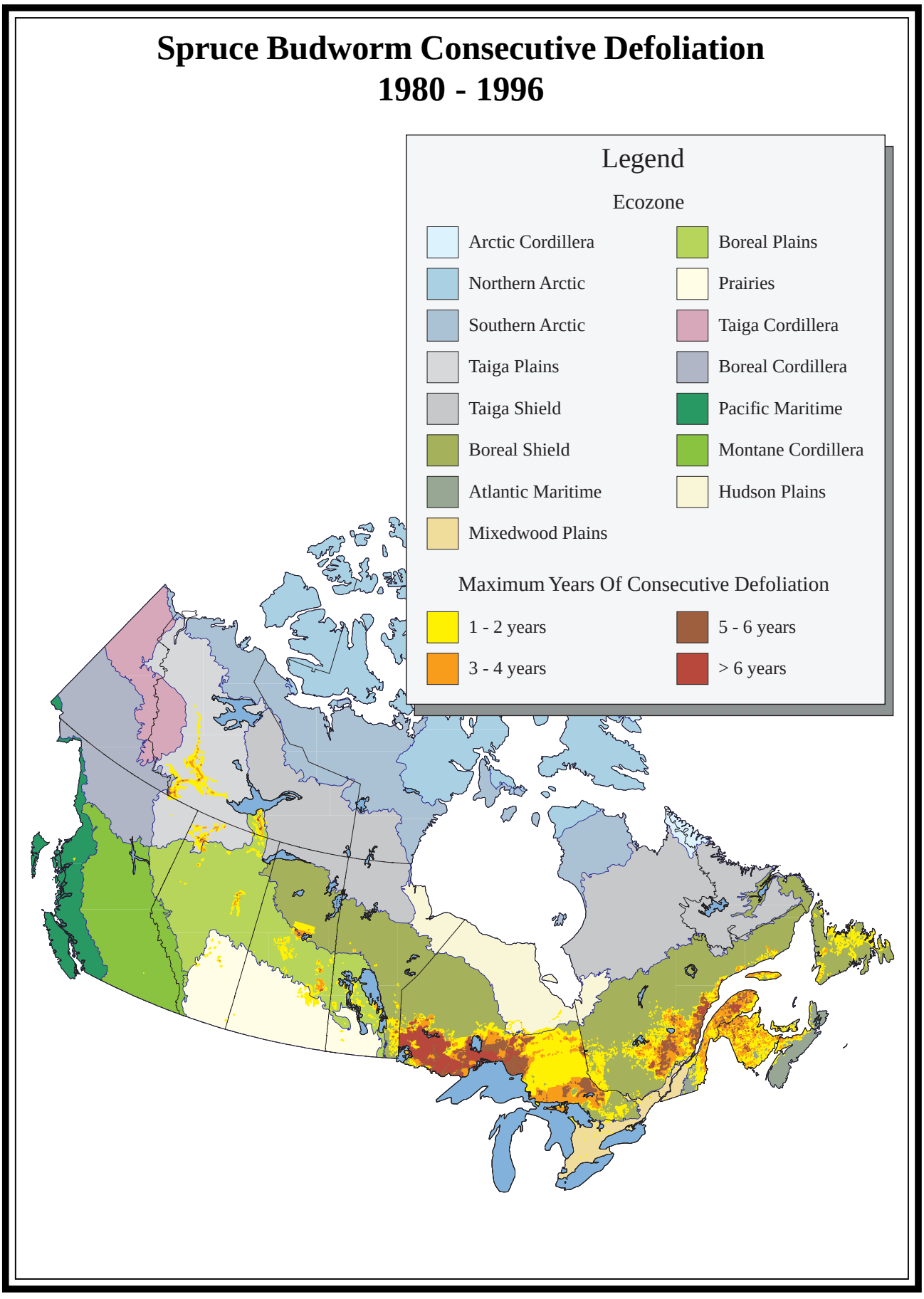
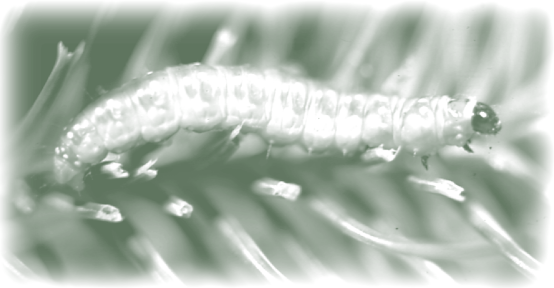
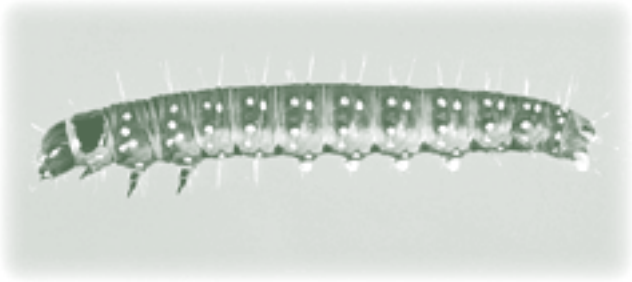


Figure 4. Spruce Budworm Consecutive Defoliation 1980 -1996



Forest Tent Caterpillar



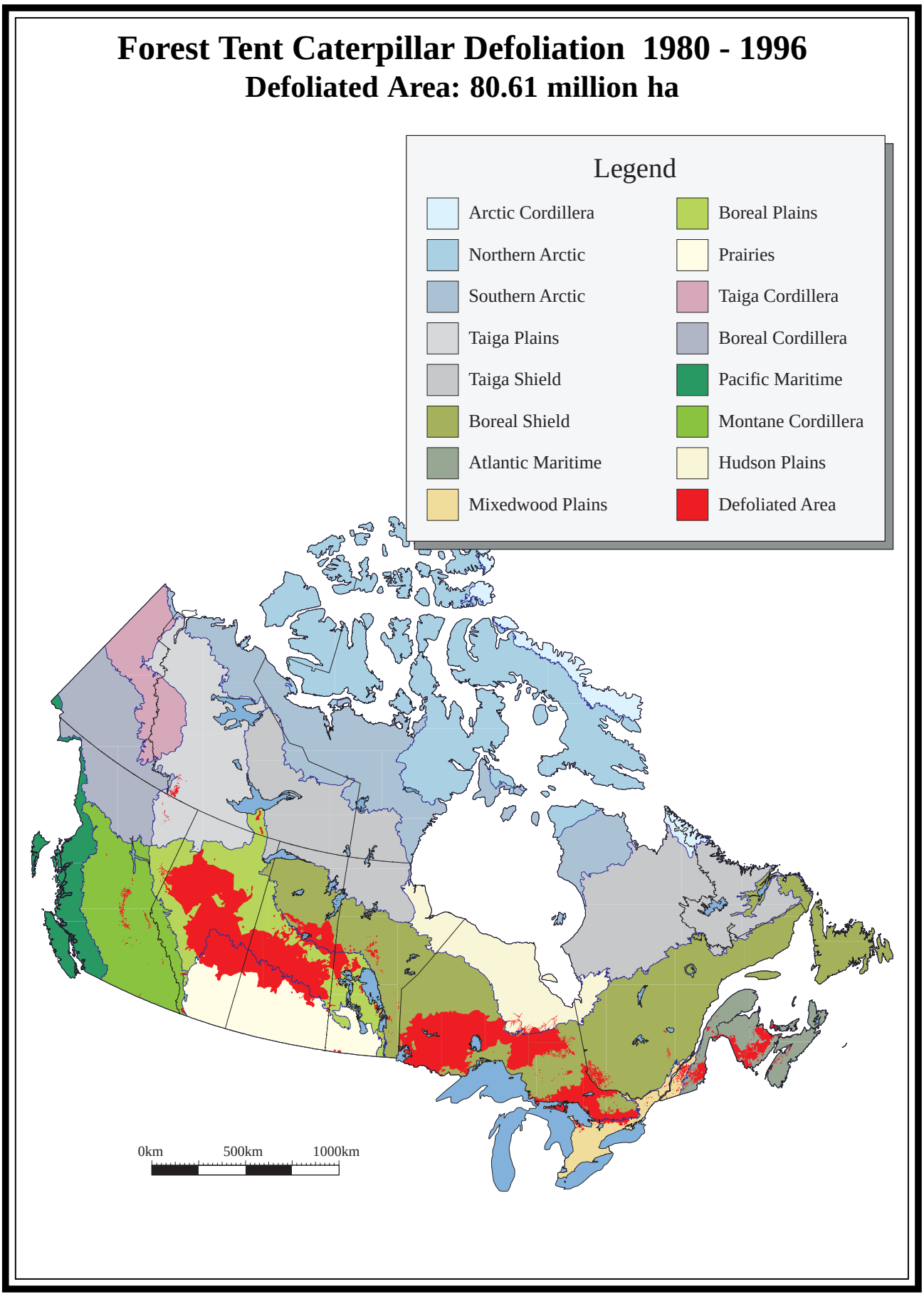
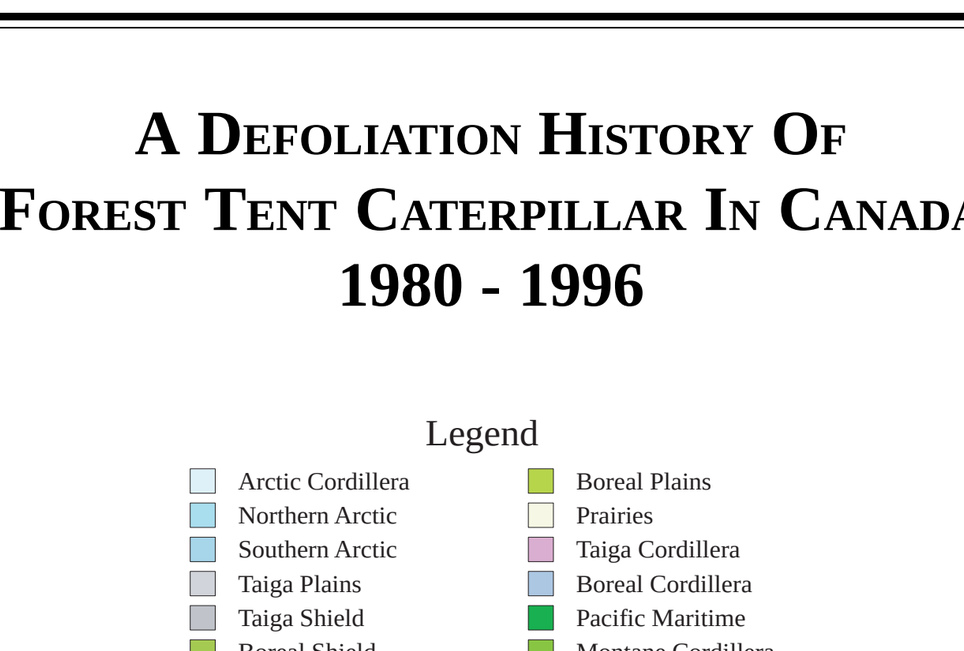


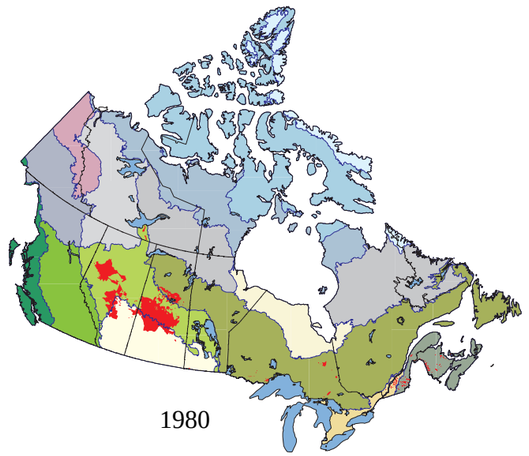
Figure 5. Forest Tent Caterpillar Defoliation 1980 - 1996

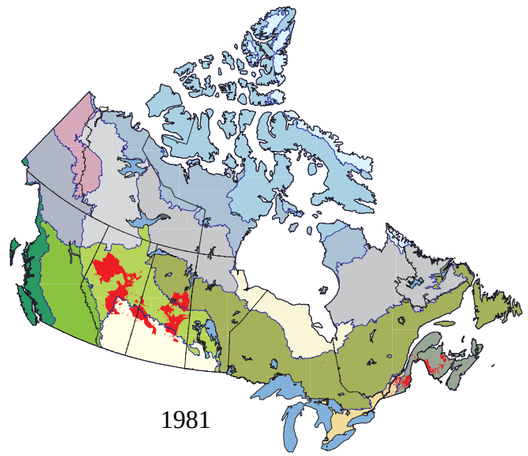
A Defoliation History Of Forest Tent Caterpillar In Canada 1980 - 1996

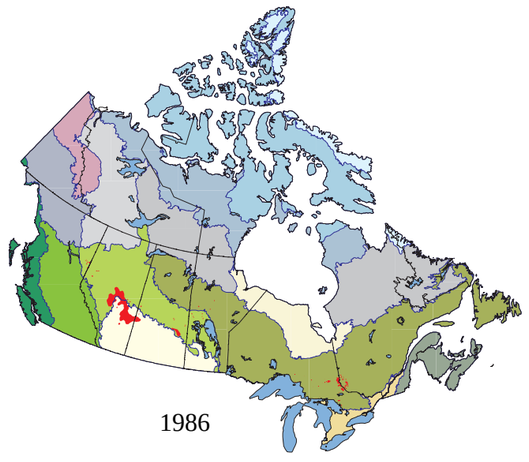
Legend

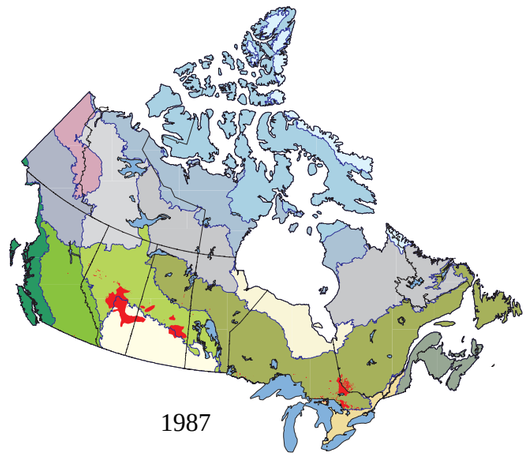
- Arctic Cordillera
- Northern Arctic
- Southern Arctic
- Taiga Plains
- Taiga Shield
- Boreal Shield
- Atlantic Maritime
- Mixedwood Plains
- Boreal Plains
- Prairies
- Taiga Cordillera
- Boreal Cordillera
- Pacific Maritime
- Montane Cordillera
- Hudson Plains
- Defoliated Area




1980


1981


1986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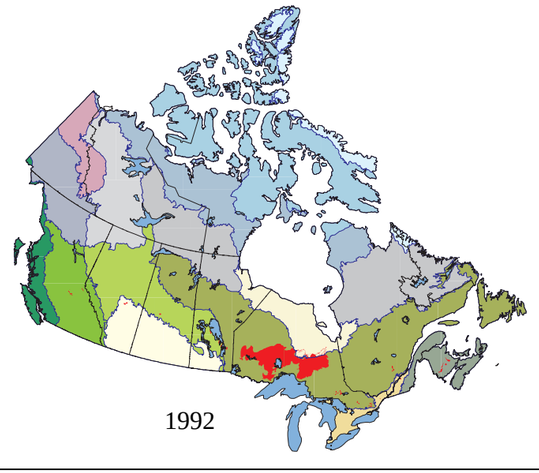

1992

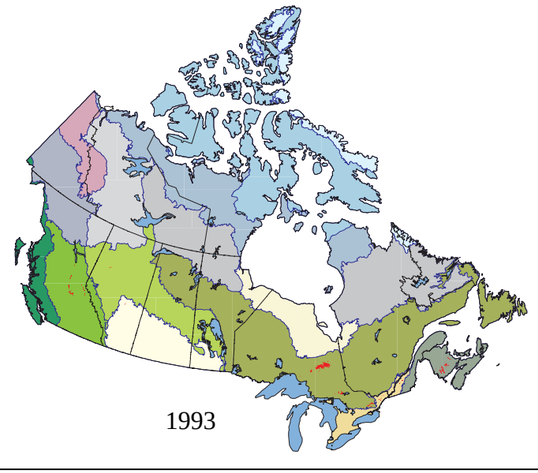
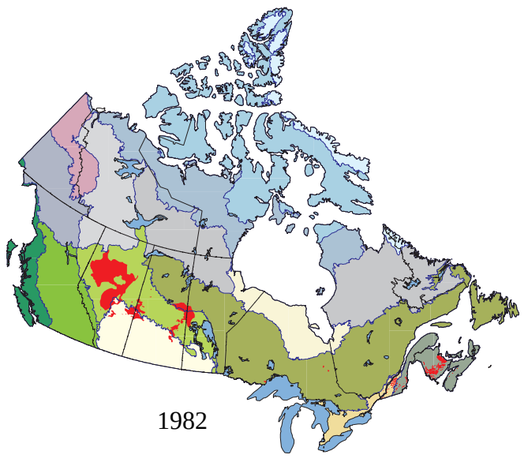
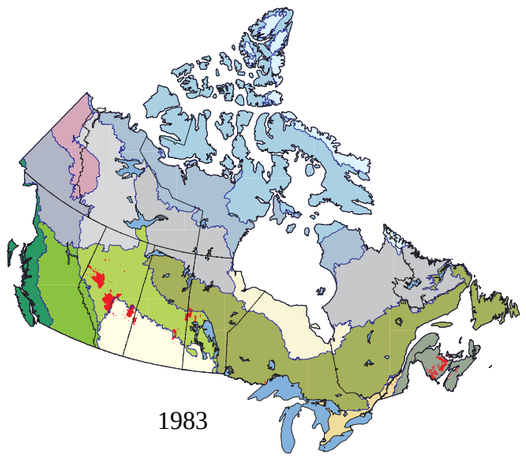

1993

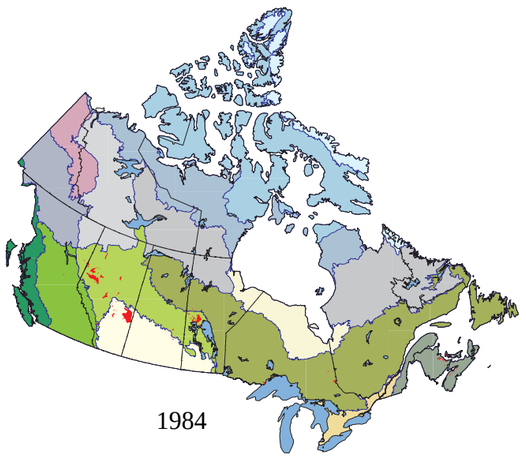
Figure 6. A Defoliation History of Forest Tent Caterpillar in Canada 1980 - 1996



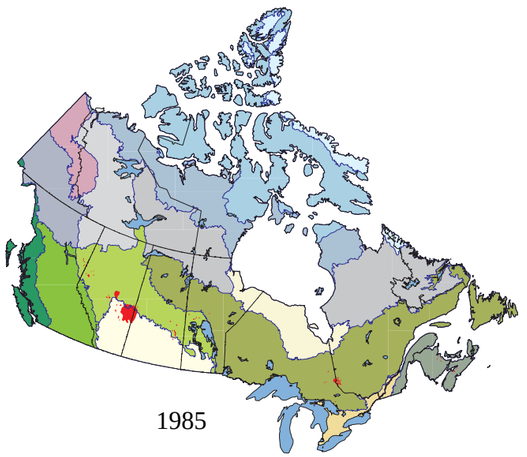
1982



1983



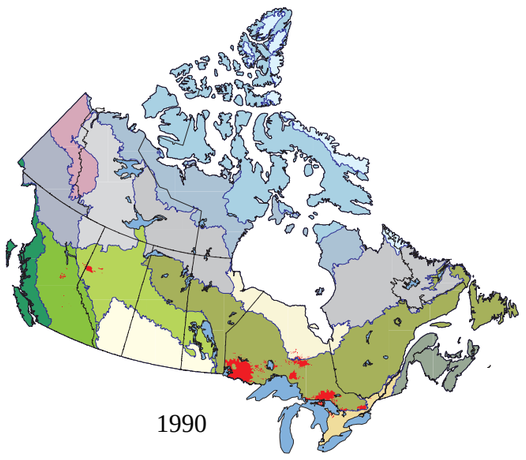
1984



1985

1988

1989



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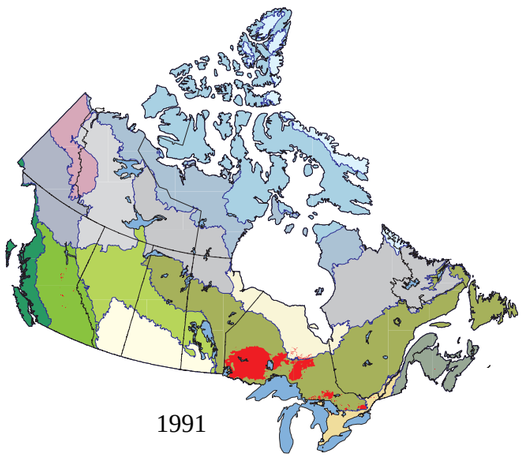

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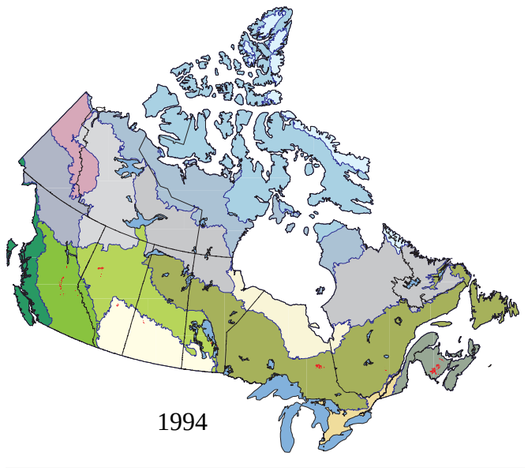
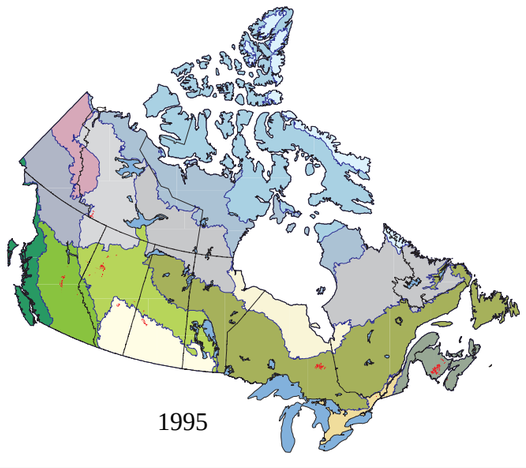
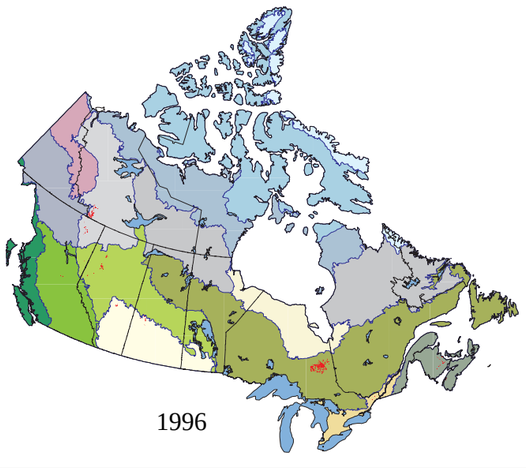


1994



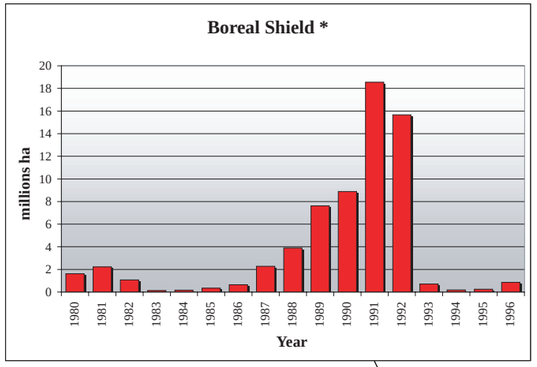
1995



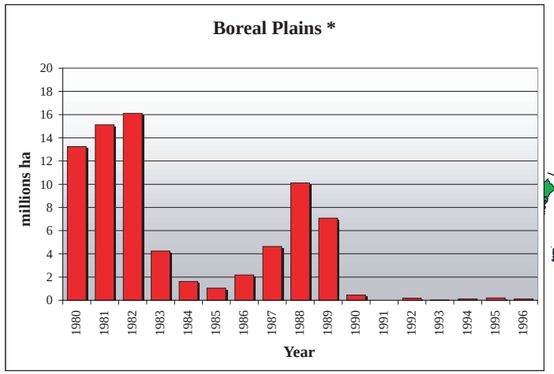
1996

Forest Tent Caterpillar Defoliation In Canada By Ecozone 1980 - 1996

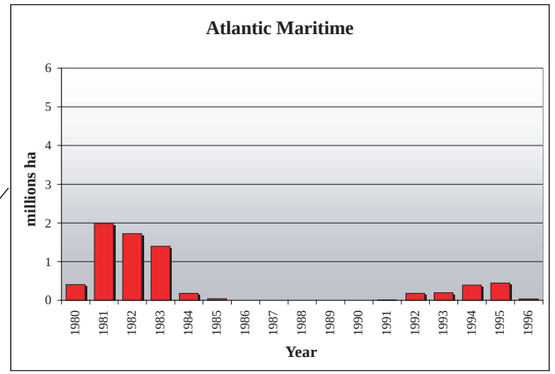
This sequence displays only the ecozones that had more than 500,000 hectares of defoliation in any of the years from 1980 – 1996.

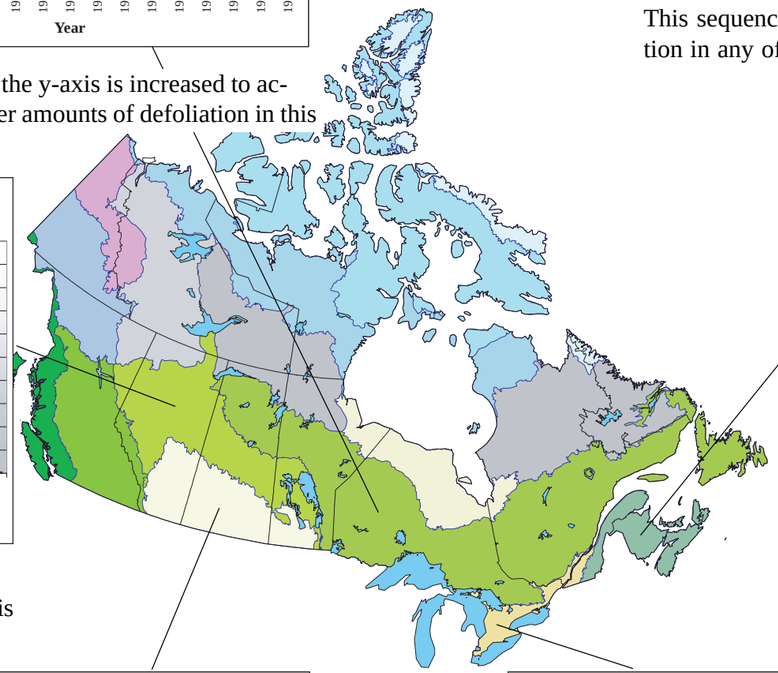


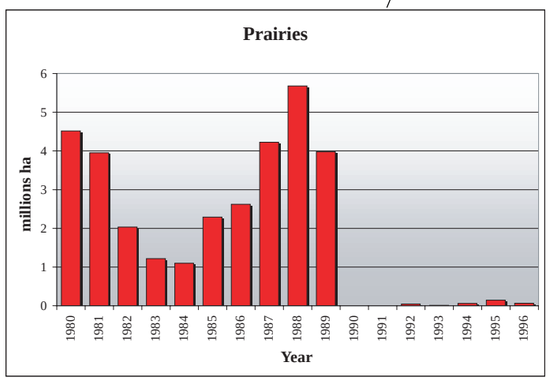
* Note: The range of the y-axis is increased to accommodate the greater amounts of defoliation in this ecozone.

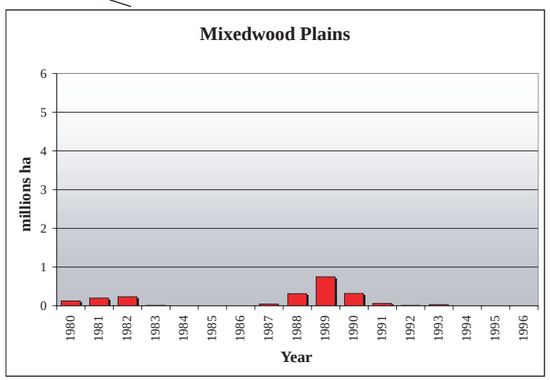


* Note: The range of the y-axis is increased to accommodate the greater amounts of defoliation in this ecozone.









Legend

- Arctic Cordillera
- Northern Arctic
- Southern Arctic
- Taiga Plains
- Taiga Shield
- Boreal Shield
- Atlantic Maritime
- Mixedwood Plains
- Boreal Plains
- Prairies
- Taiga Cordillera
- Boreal Cordillera
- Pacific Maritime
- Montane Cordillera
- Hudson Plains

Figure 7. Forest Tent Caterpillar Defoliation in Canada by Ecozone 1980 - 1996

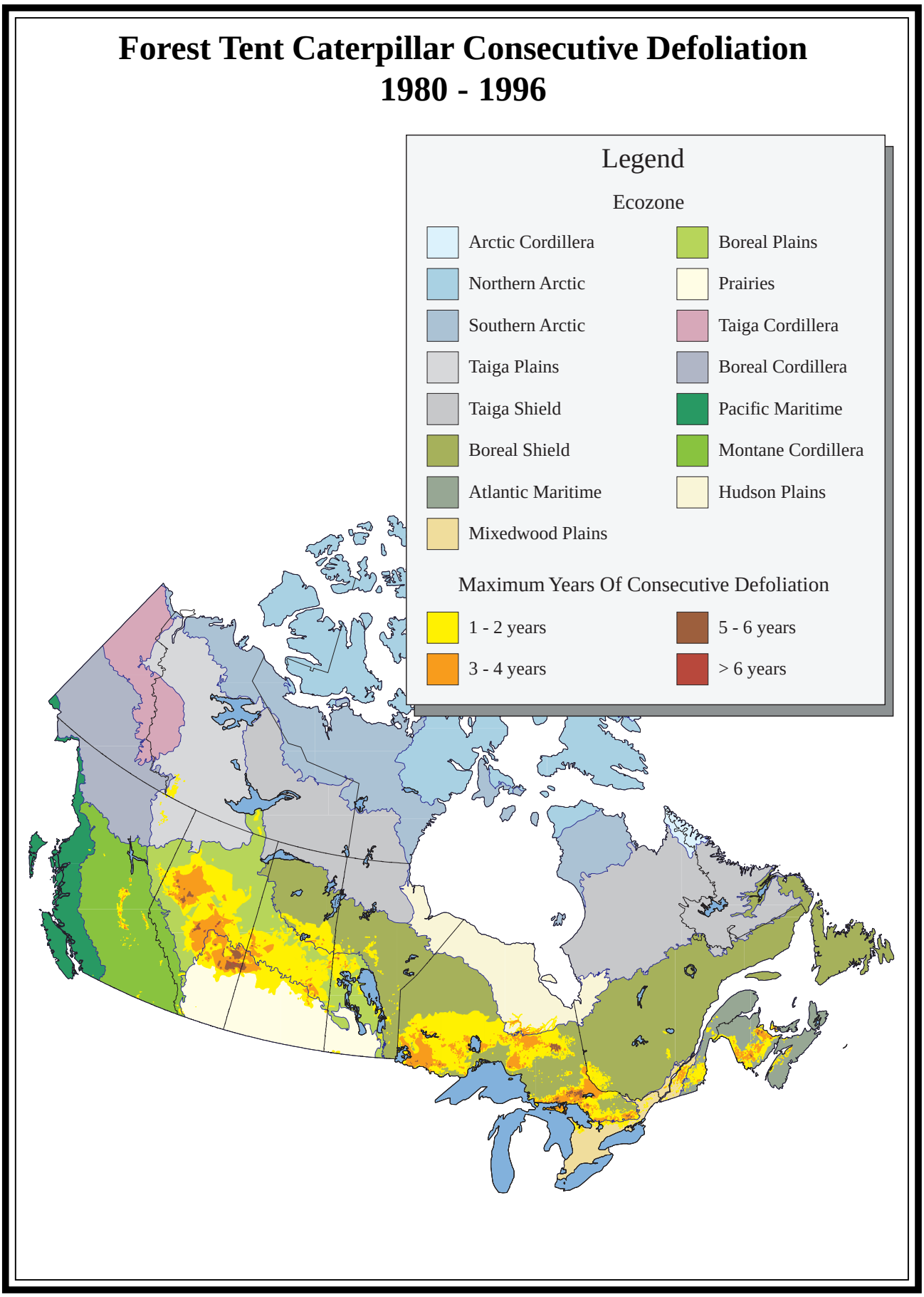
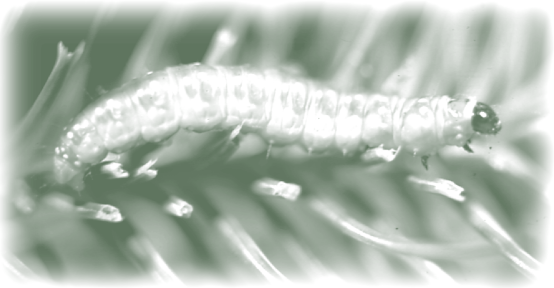
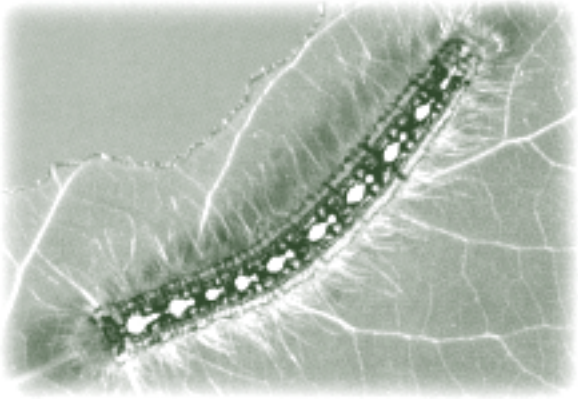


Figure 8. Forest Tent Caterpillar Consecutive Defoliation





Jack Pine Budworm

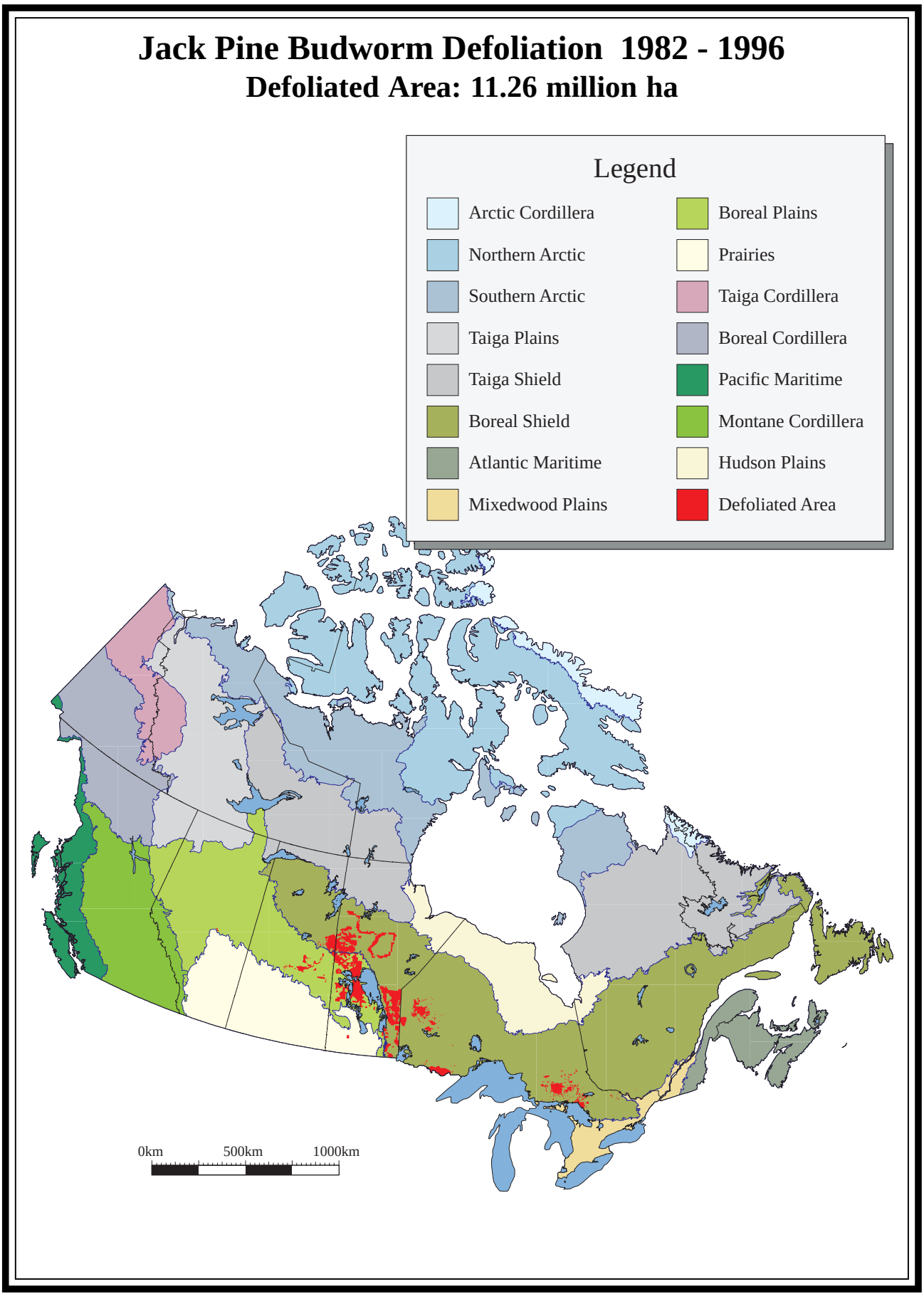
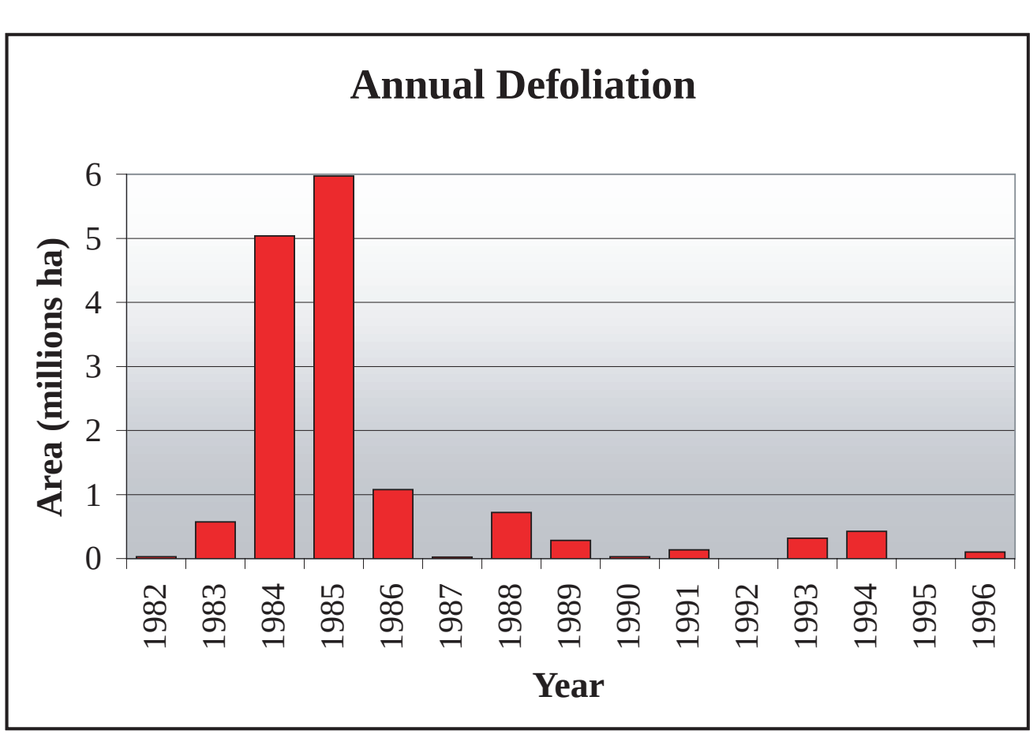


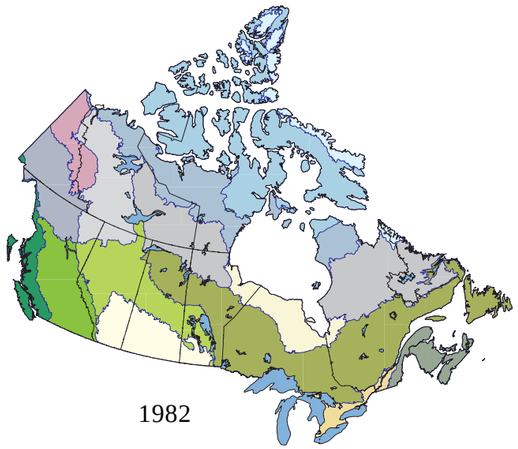
Figure 9. Jack Pine Budworm Defoliation 1982 - 1996

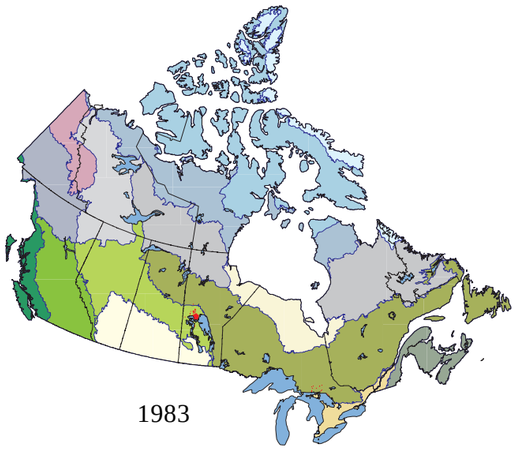
A Defoliation History Of Jack Pine Budworm In Canada 1982 - 1996

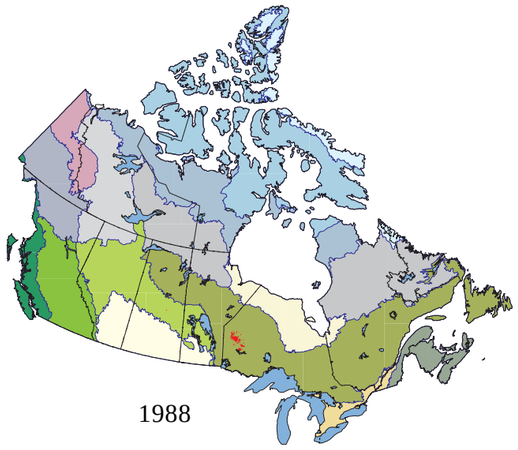
Legend

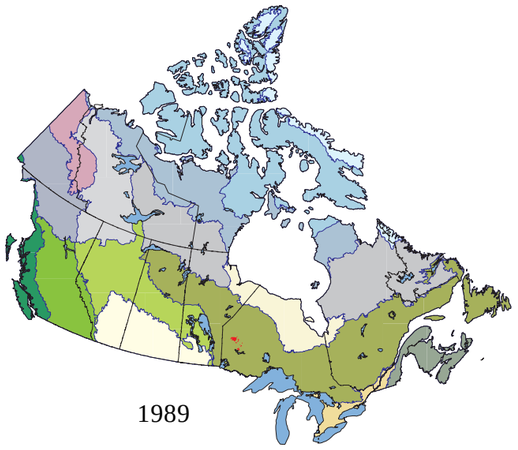
- Arctic Cordillera
- Northern Arctic
- Southern Arctic
- Taiga Plains
- Taiga Shield
- Boreal Shield
- Atlantic Maritime
- Mixedwood Plains
- Boreal Plains
- Prairies
- Taiga Cordillera
- Boreal Cordillera
- Pacific Maritime
- Montane Cordillera
- Hudson Plains
- Defoliated Area

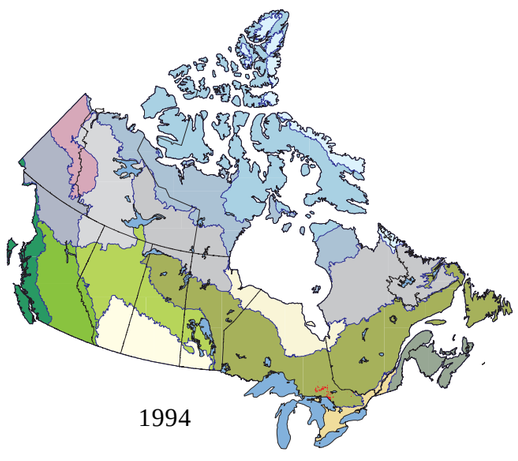












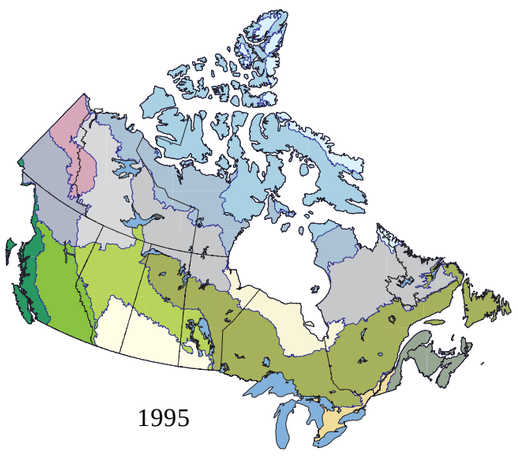
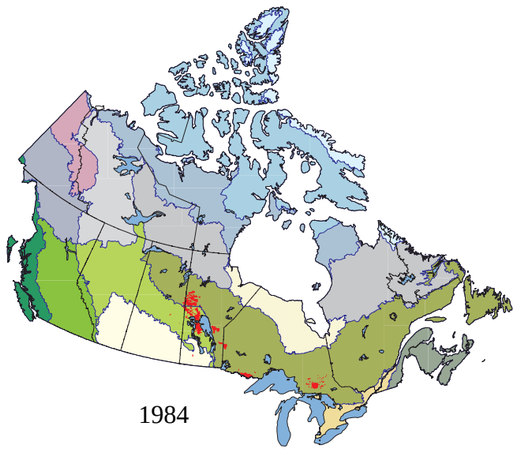
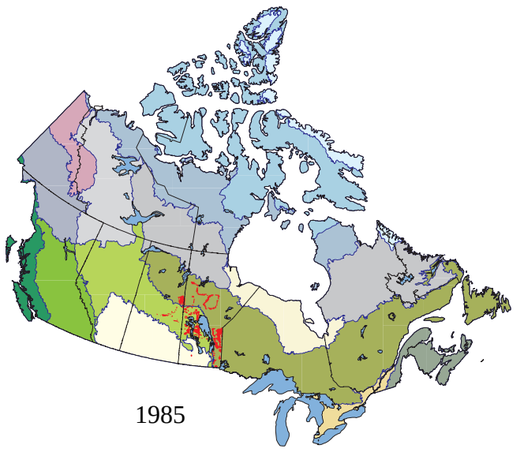


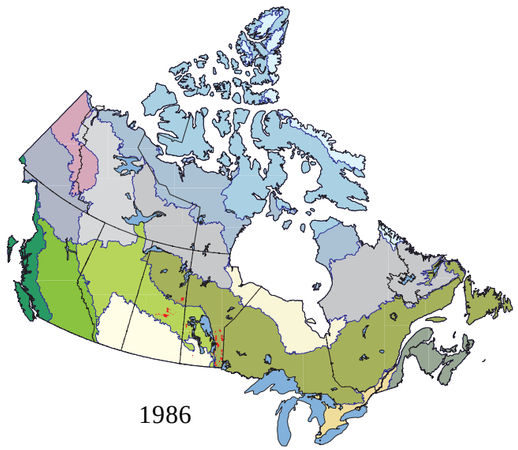
Figure 10. A Defoliation History of Jack Pine Budworm in Canada 1982 - 1996



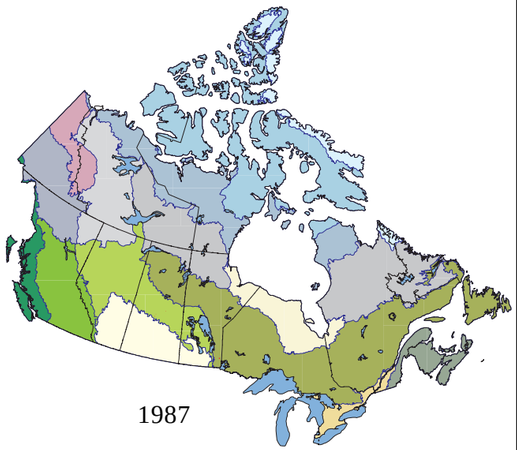
1984



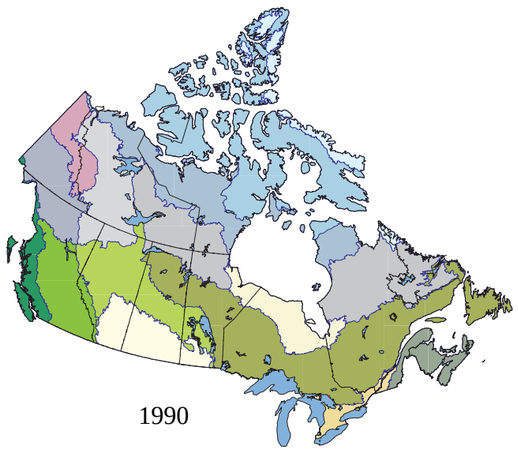
1985



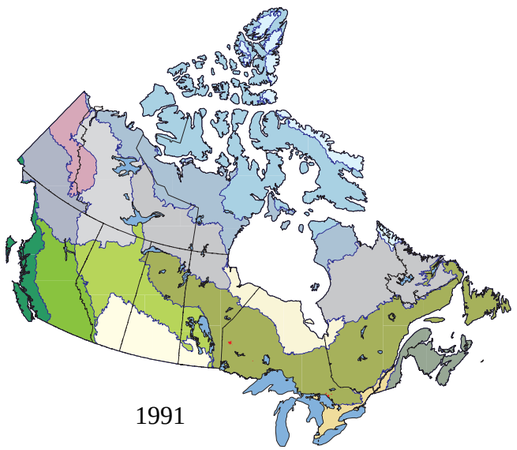
1986



1987



1990



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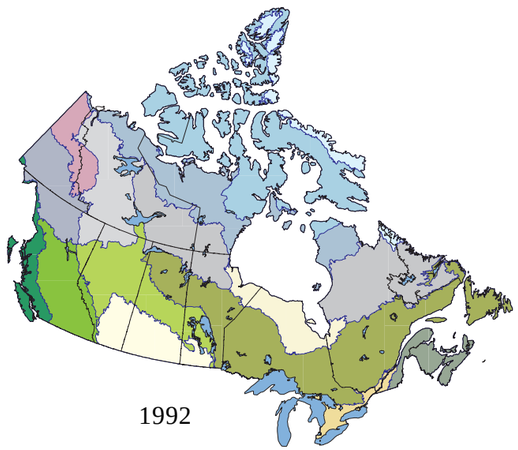

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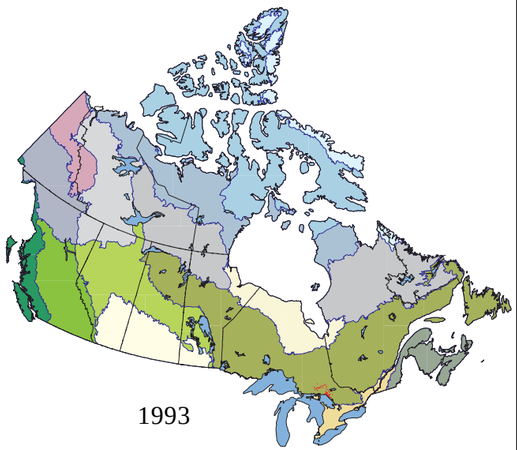
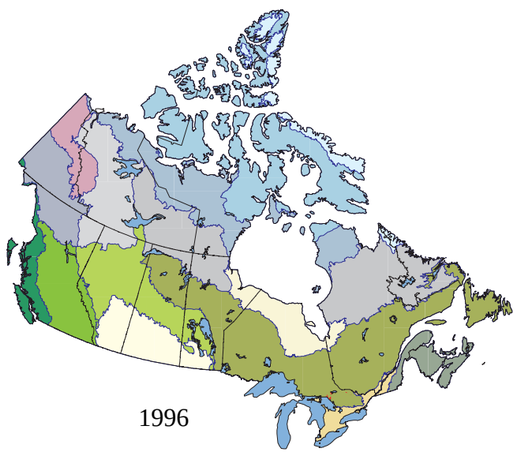


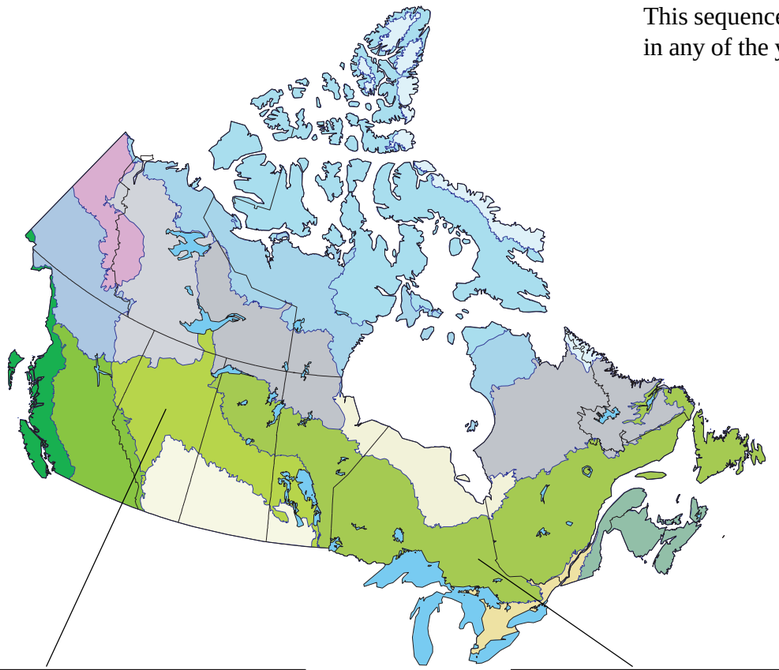
1993



1996

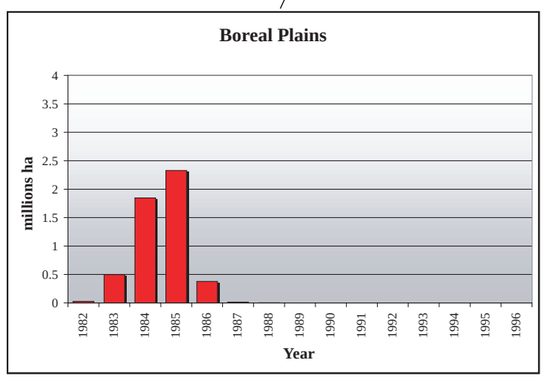
Jack Pine Budworm Defoliation In Canada By Ecozone 1982 - 1996

This sequence displays only the ecozones that had more than 25,000 hectares of defoliation in any of the years from 1982 – 1996.



Legend

- Arctic Cordillera
- Northern Arctic
- Southern Arctic
- Taiga Plains
- Taiga Shield
- Boreal Shield
- Atlantic Maritime
- Mixedwood Plains
- Boreal Plains
- Prairies
- Taiga Cordillera
- Boreal Cordillera
- Pacific Maritime
- Montane Cordillera
- Hudson Plains



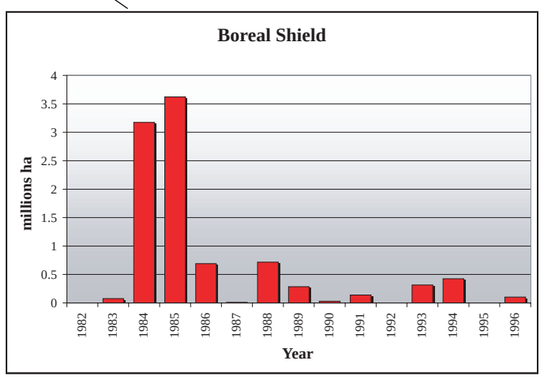


Figure 11. Jack Pine Budworm Defoliation in Canada by Ecozone 1982 - 1996

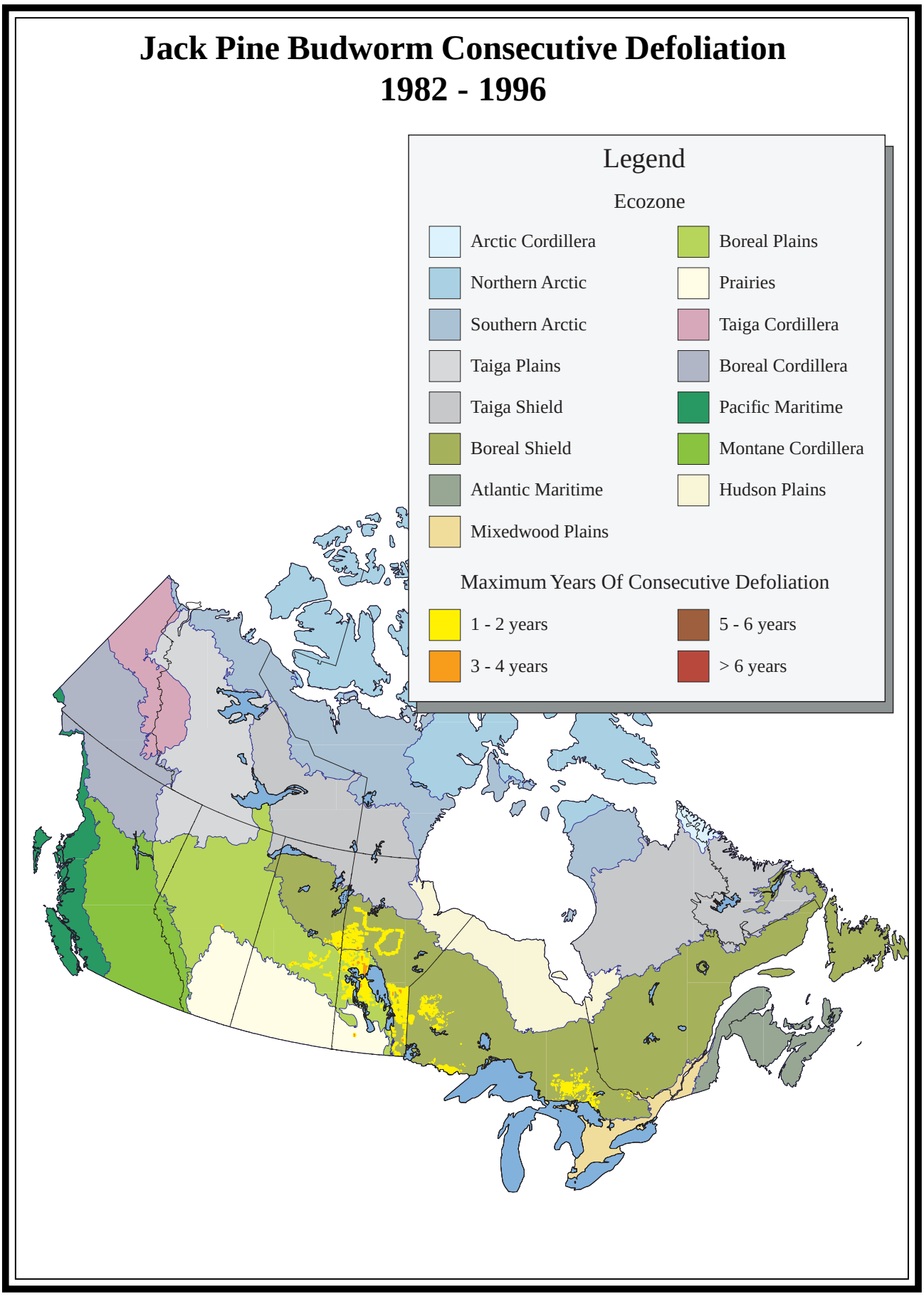
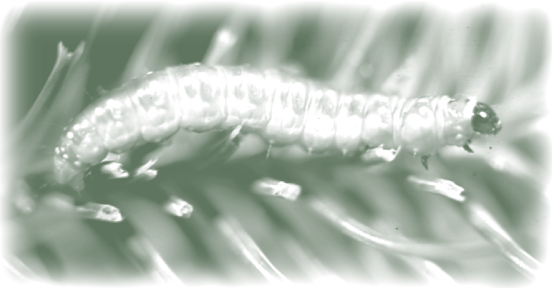
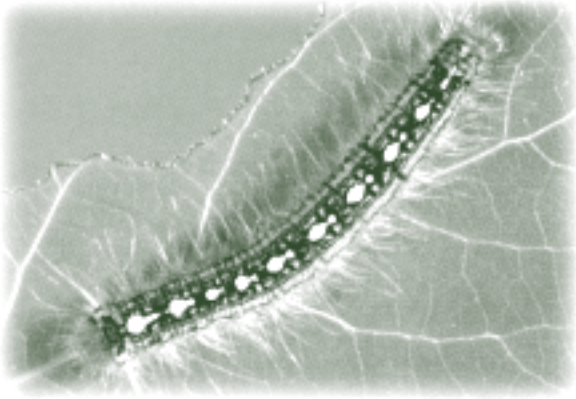
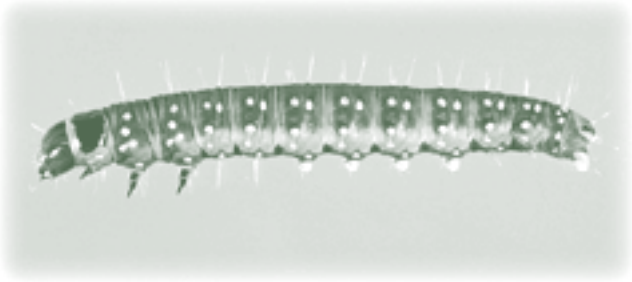


Figure 12. Jack Pine Budworm Consecutive Defoliation 1982 - 1996





Hemlock Looper



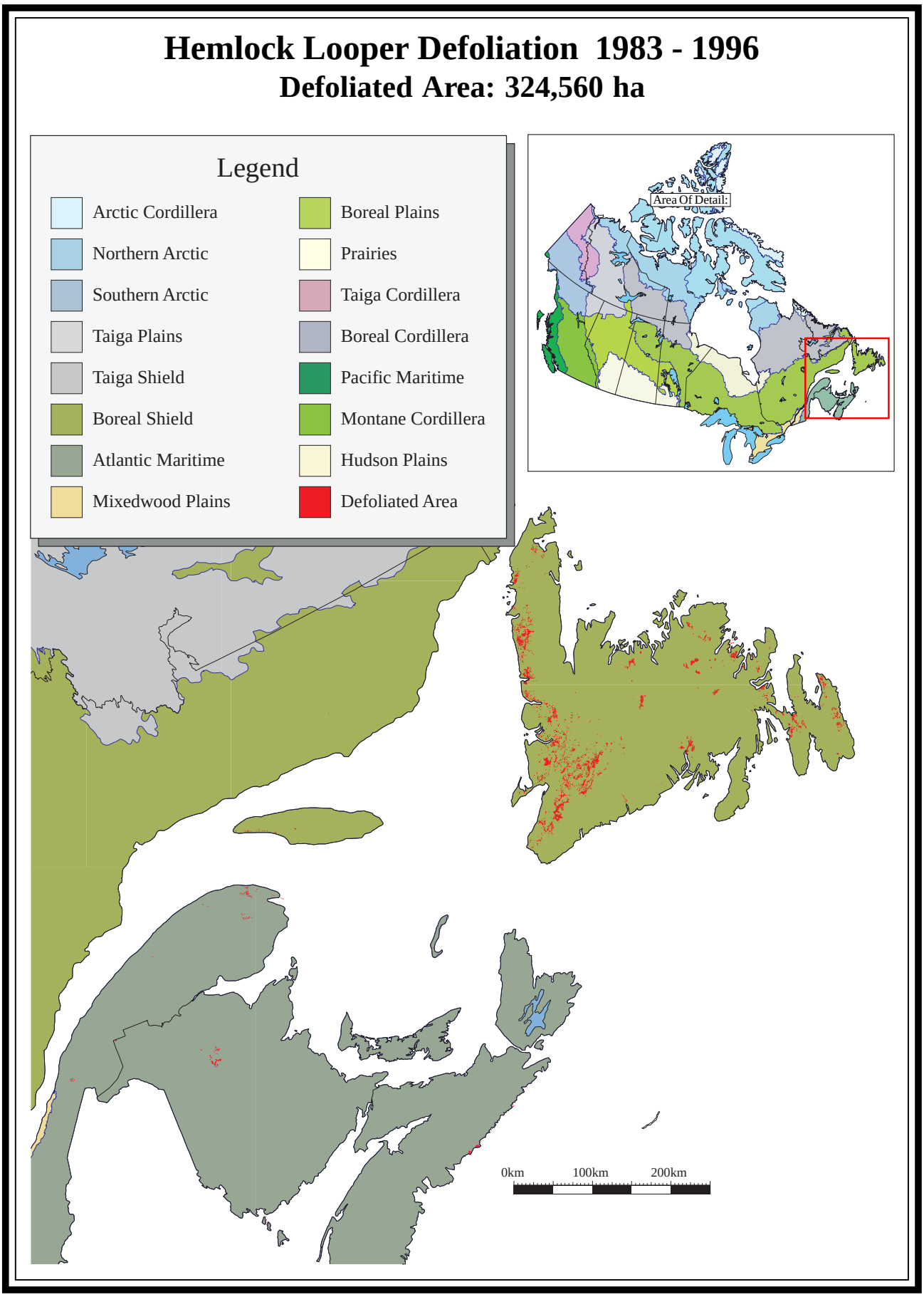
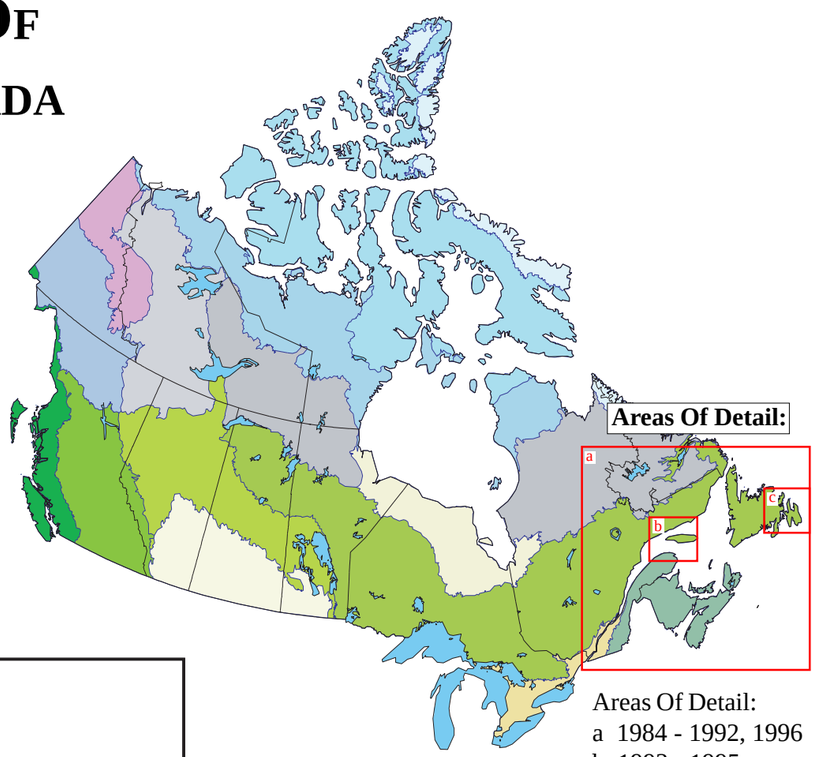


Figure 13. Hemlock Looper Defoliation 1983 - 1996

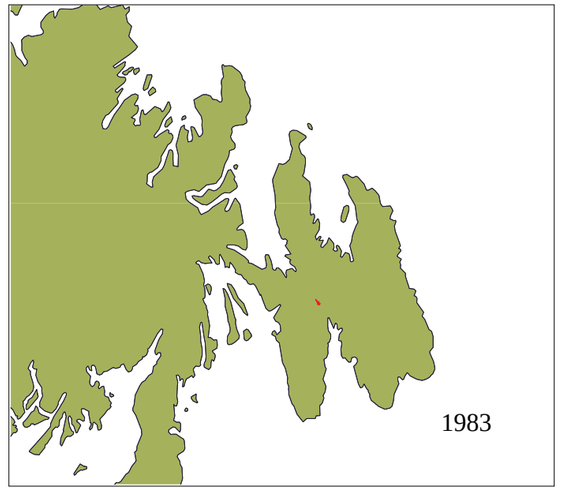
A Defoliation History Of Hemlock Looper In Canada 1983 - 1996

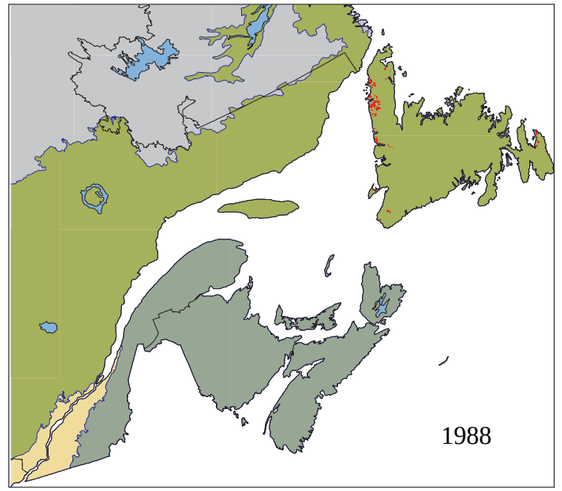
Legend

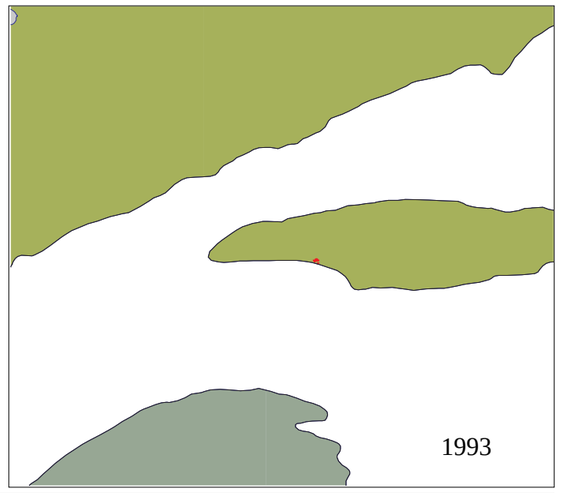
- Arctic Cordillera
- Northern Arctic
- Southern Arctic
- Taiga Plains
- Taiga Shield
- Boreal Shield
- Atlantic Maritime
- Mixedwood Plains
- Boreal Plains
- Prairies
- Taiga Cordillera
- Boreal Cordillera
- Pacific Maritime
- Montane Cordillera
- Hudson Plains
- Defoliated Area



Areas Of Detail:
a 1984 - 1992, 1996
b 1993 - 1995
c 1983







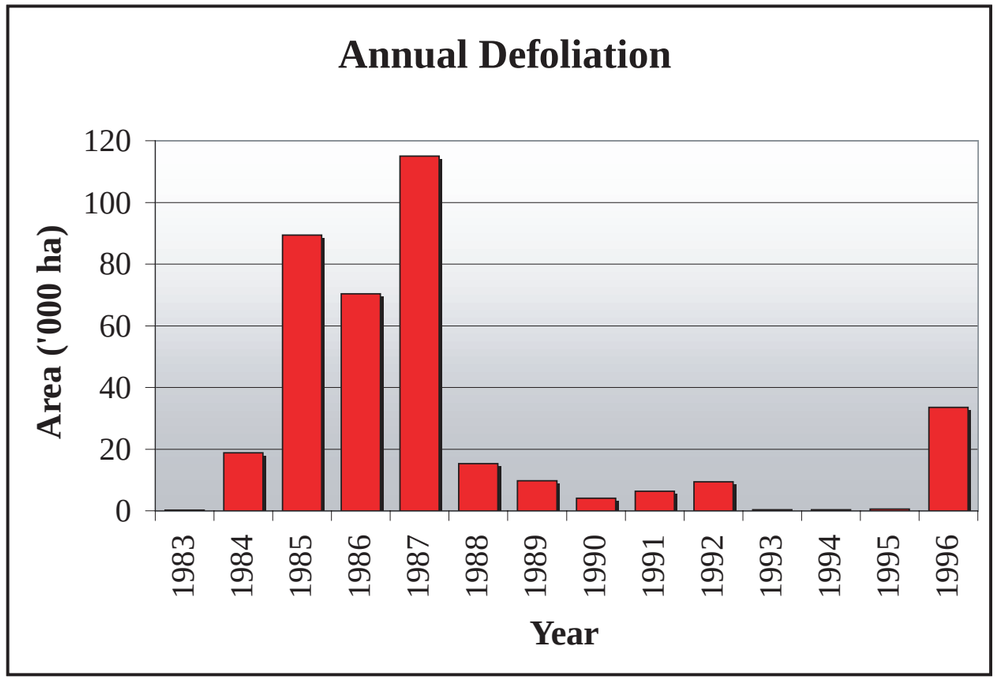
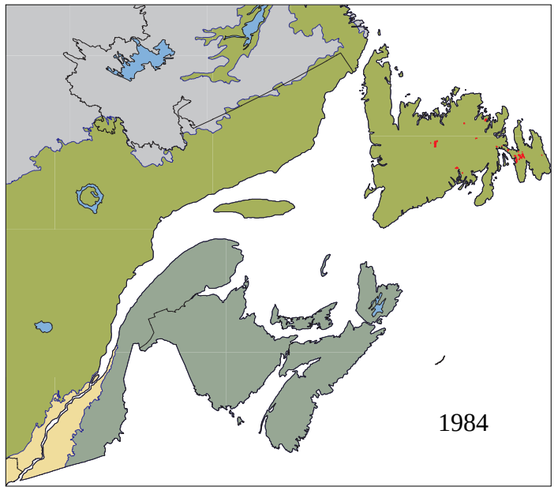
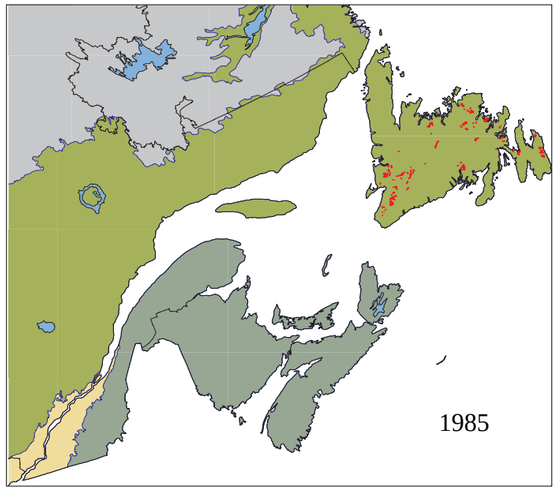
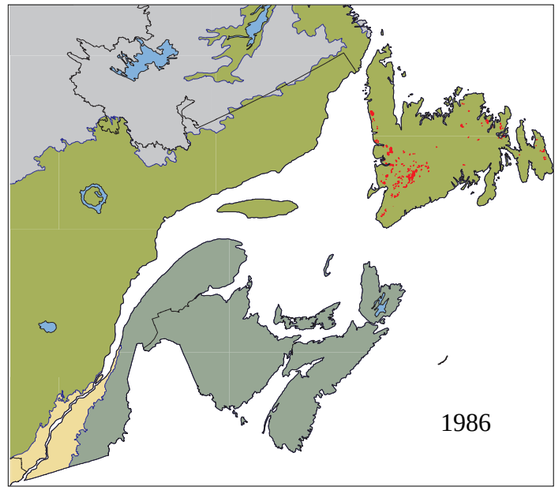
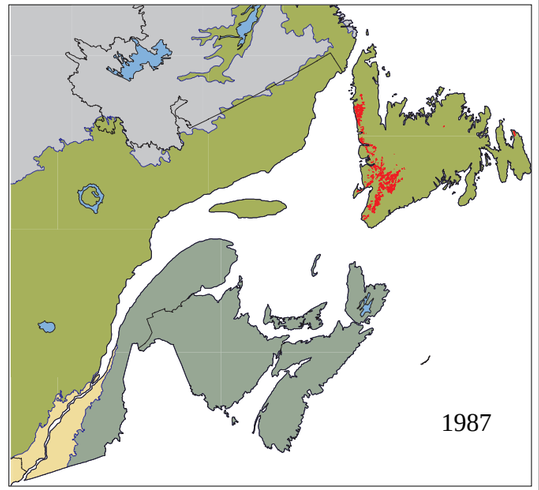


Figure 14. A Defoliation History of Hemlock Looper in Canada 1983 - 1996


1984


1985


1986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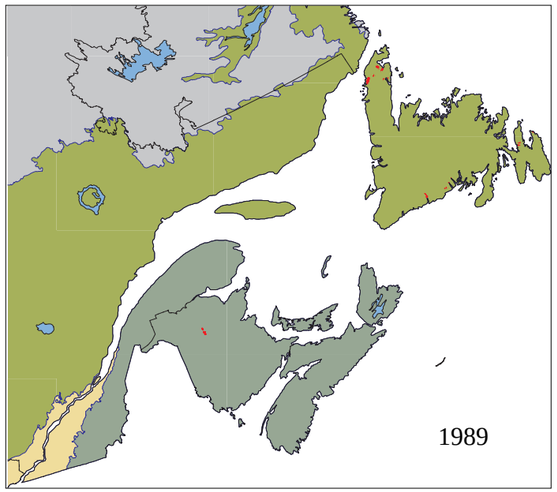
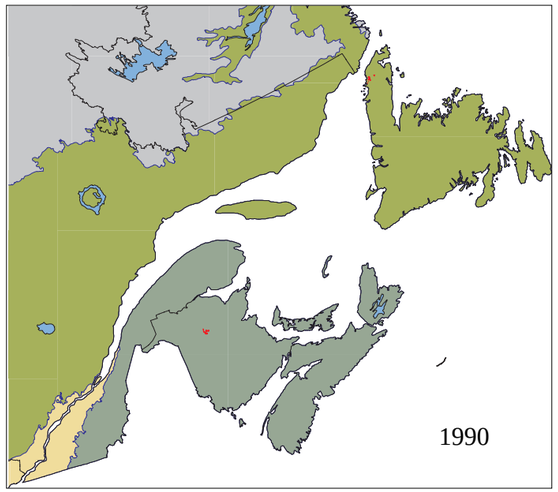
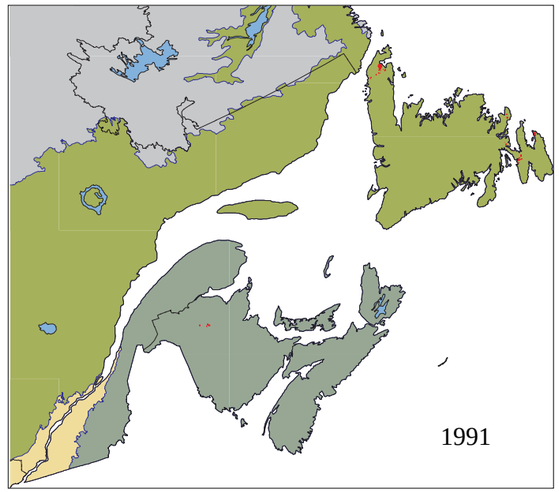
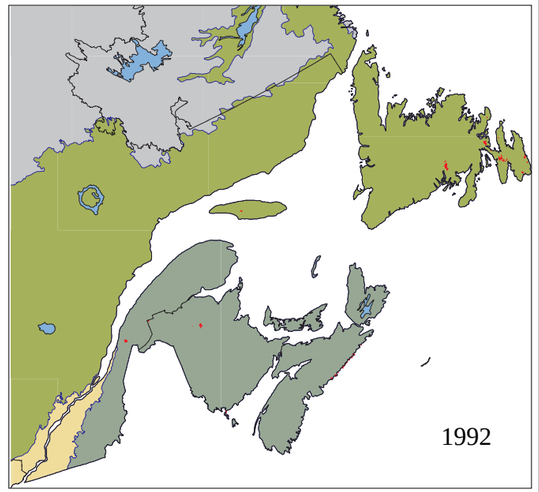
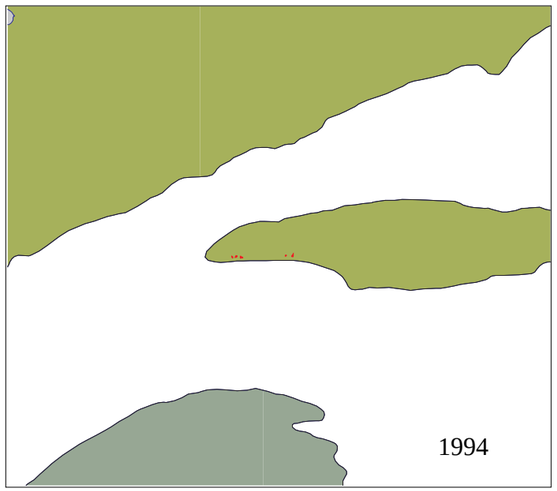
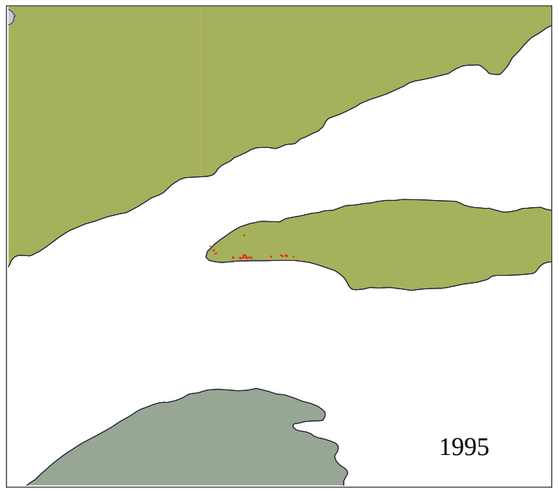

1989

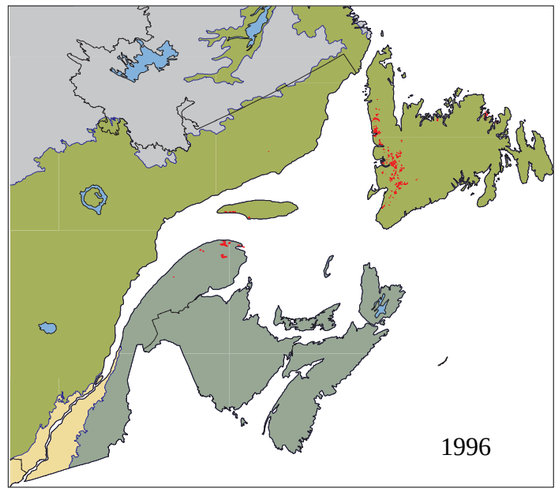

1990


1991

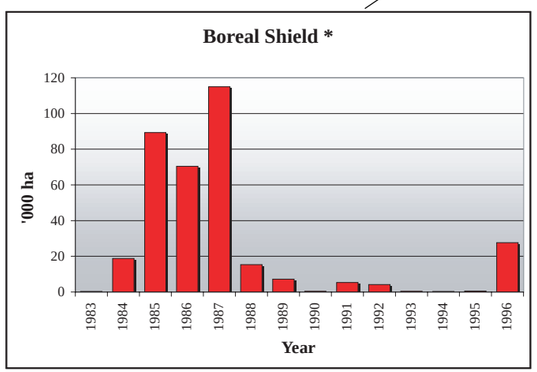

1992

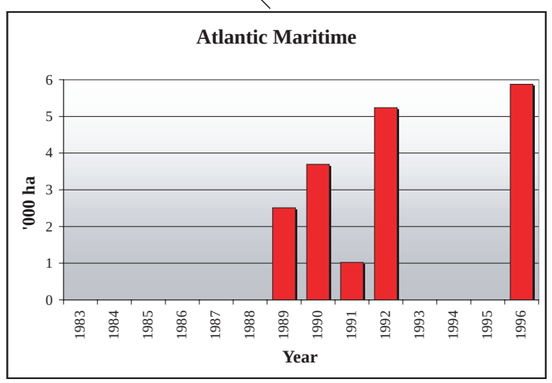

1994


1995


1996

Hemlock Looper Defoliation In Canada By Ecozone 1983 - 1996





* Note: The range of the y-axis is increased to accommodate the greater amounts of defoliation in this ecozone.

Figure 15. Hemlock Looper Defoliation in Canada by Ecozone 1983 - 1996

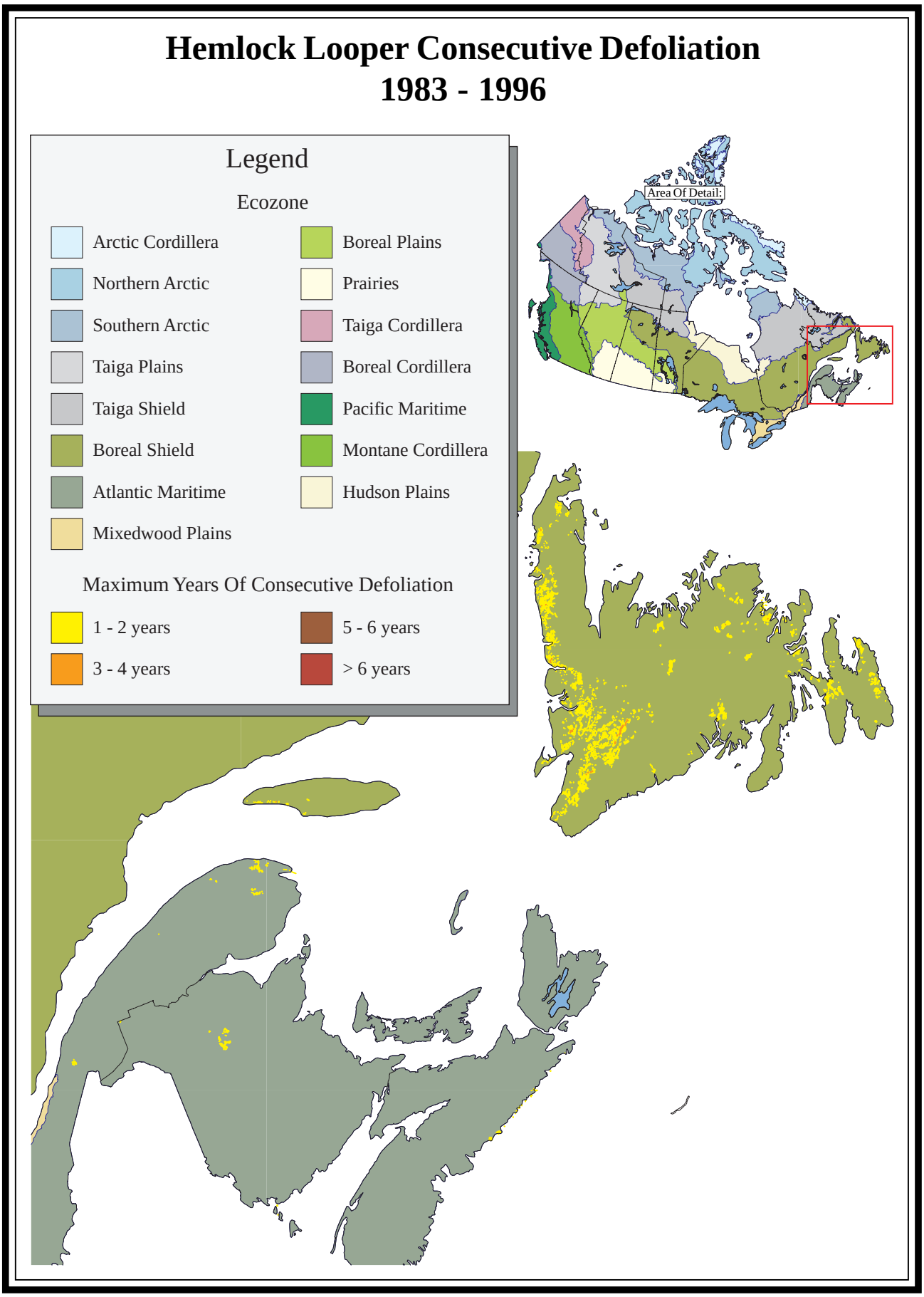
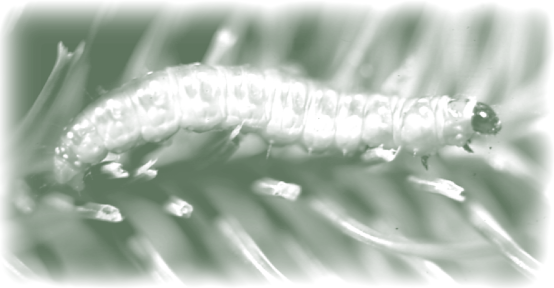
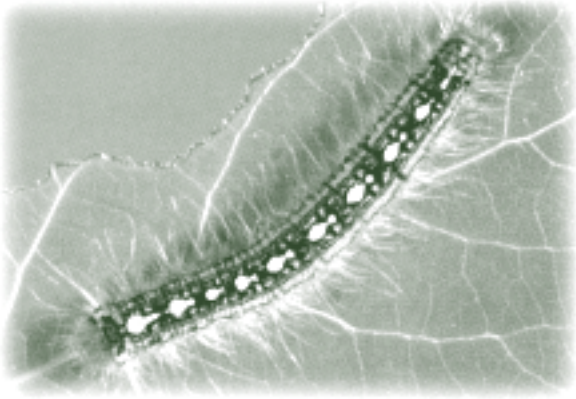
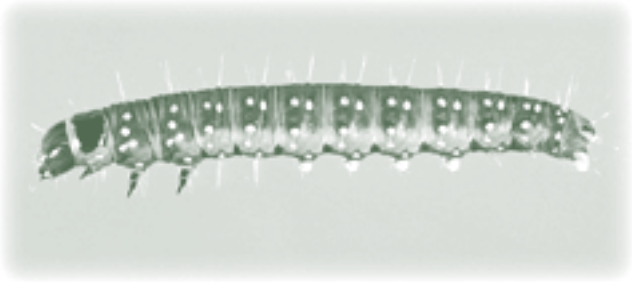


Figure 16. Hemlock Looper Consecutive Defoliation 1983 - 1996





Mountain Pine Beetle



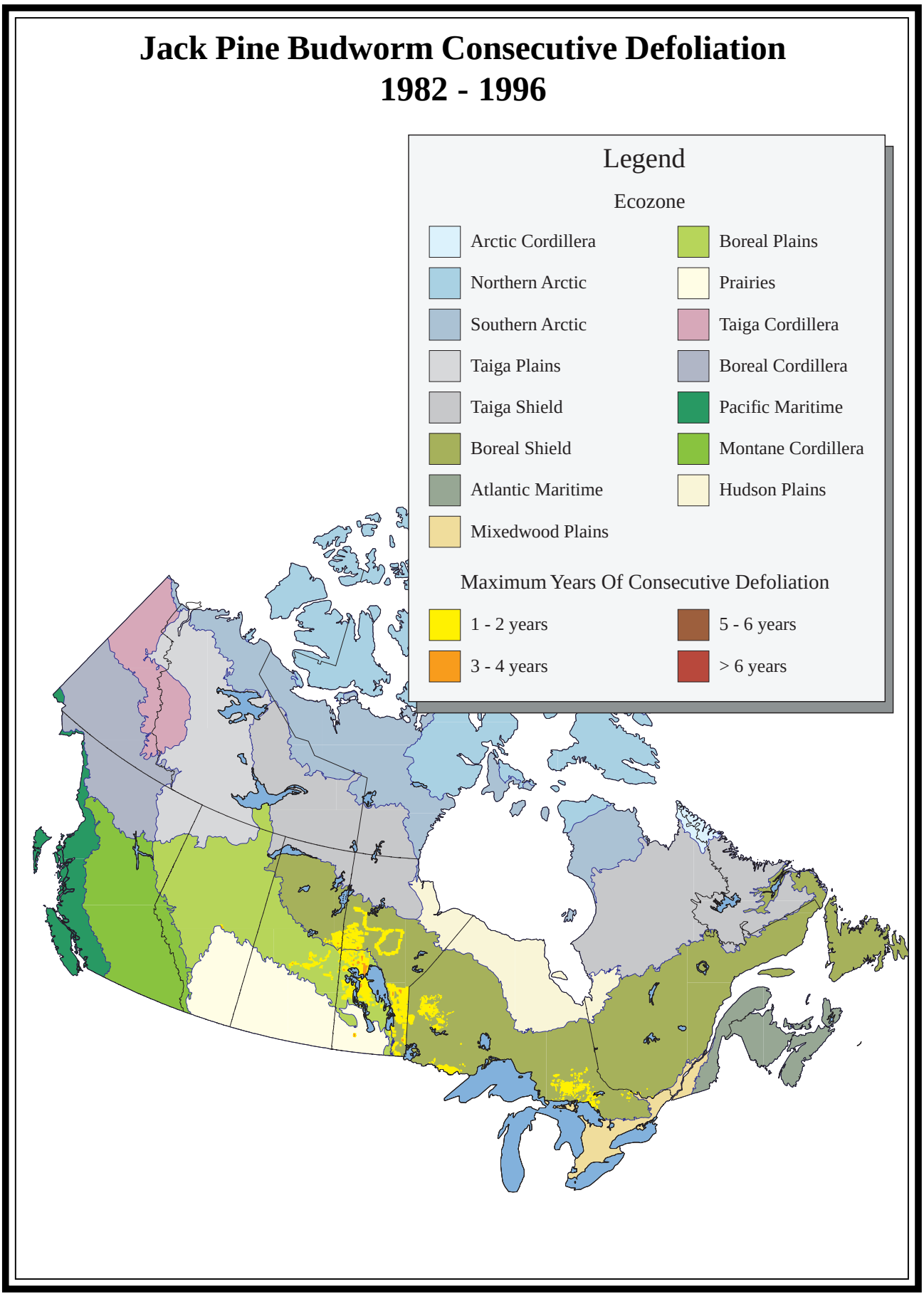
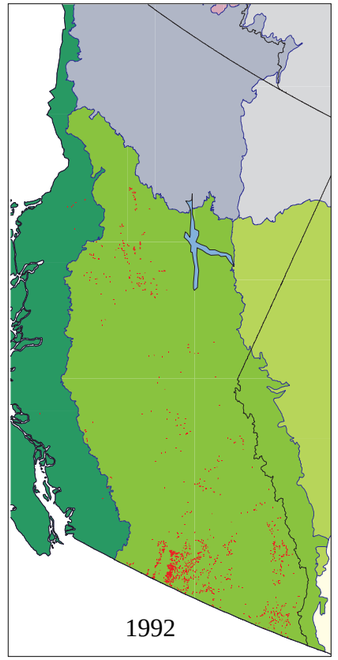


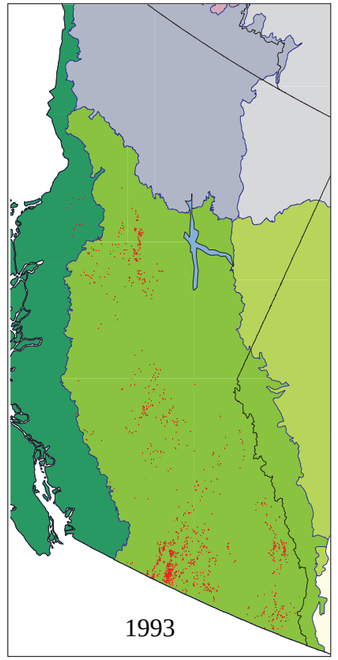
Figure 12. Jack Pine Budworm Consecutive Defoliation 1982 - 1996

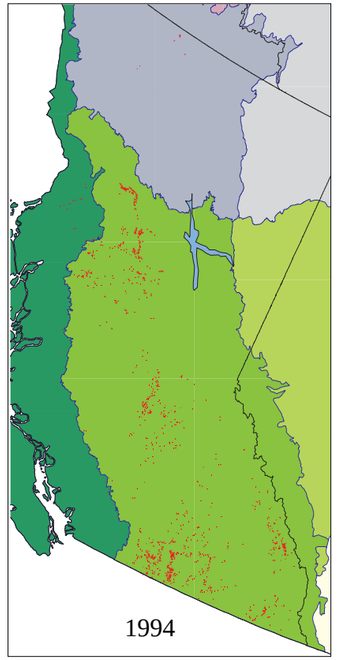
A History Of Mountain Pine Beetle Damage In Canada 1992 - 1996

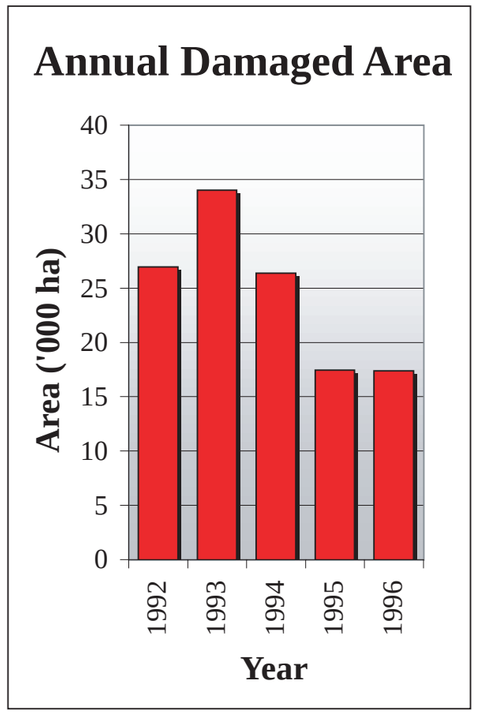
Legend

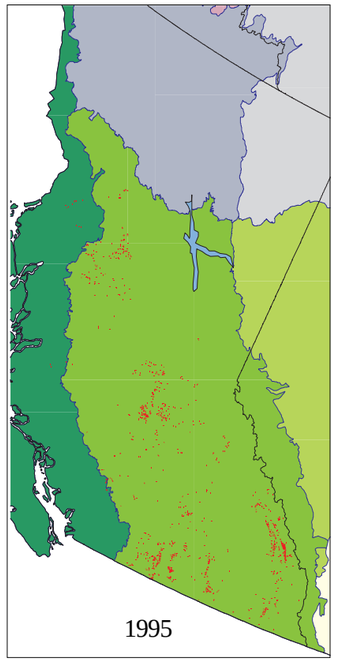
- Arctic Cordillera
- Northern Arctic
- Southern Arctic
- Taiga Plains
- Taiga Shield
- Boreal Shield
- Atlantic Maritime
- Mixedwood Plains
- Boreal Plains
- Prairies
- Taiga Cordillera
- Boreal Cordillera
- Pacific Maritime
- Montane Cordillera
- Hudson Plains
- Defoliated Area











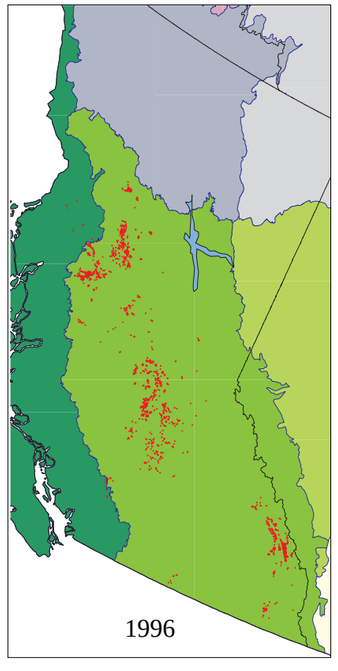
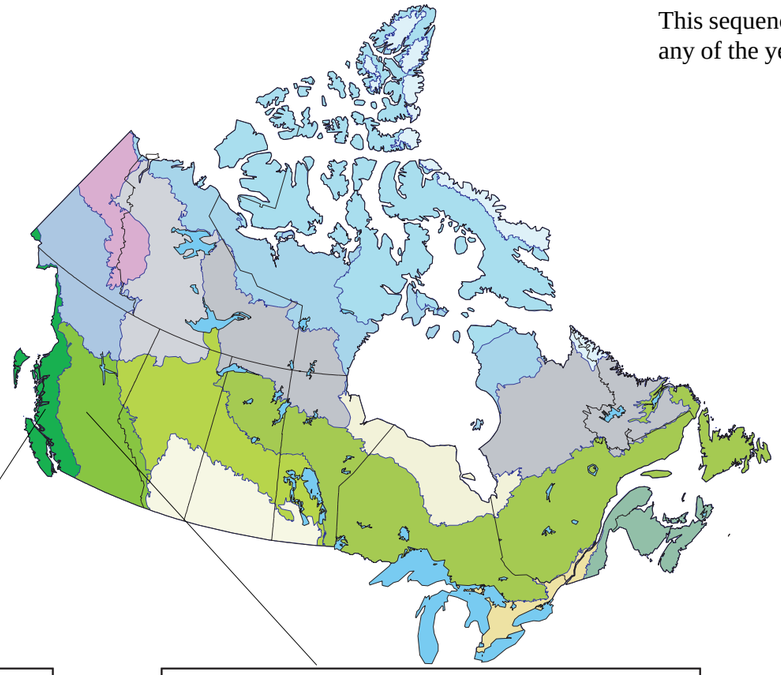


Figure 18. A History Of Mountain Pine Beetle Damage In Canada 1992 - 1996

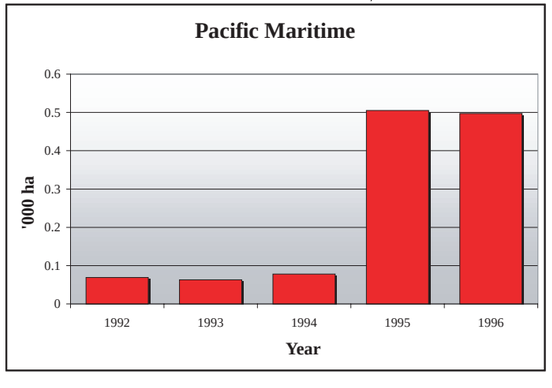
Mountain Pine Beetle Damage In Canada By Ecozone 1992 - 1996

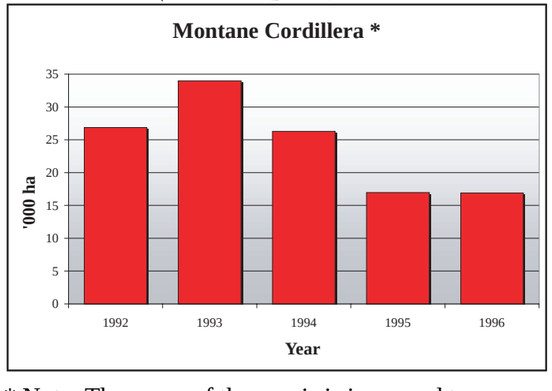
This sequence displays only the ecozones that had more than 500 hectares of affected area in any of the years from 1992 – 1996.



Legend

- Arctic Cordillera
- Northern Arctic
- Southern Arctic
- Taiga Plains
- Taiga Shield
- Boreal Shield
- Atlantic Maritime
- Mixedwood Plains
- Boreal Plains
- Prairies
- Taiga Cordillera
- Boreal Cordillera
- Pacific Maritime
- Montane Cordillera
- Hudson Plains





* Note: The range of the y-axis is increased to accommodate the greater amounts of affected area in this ecozone.

Figure 19. Mountain Pine Beetle Damage In Canada By Ecozone 1992 - 1996

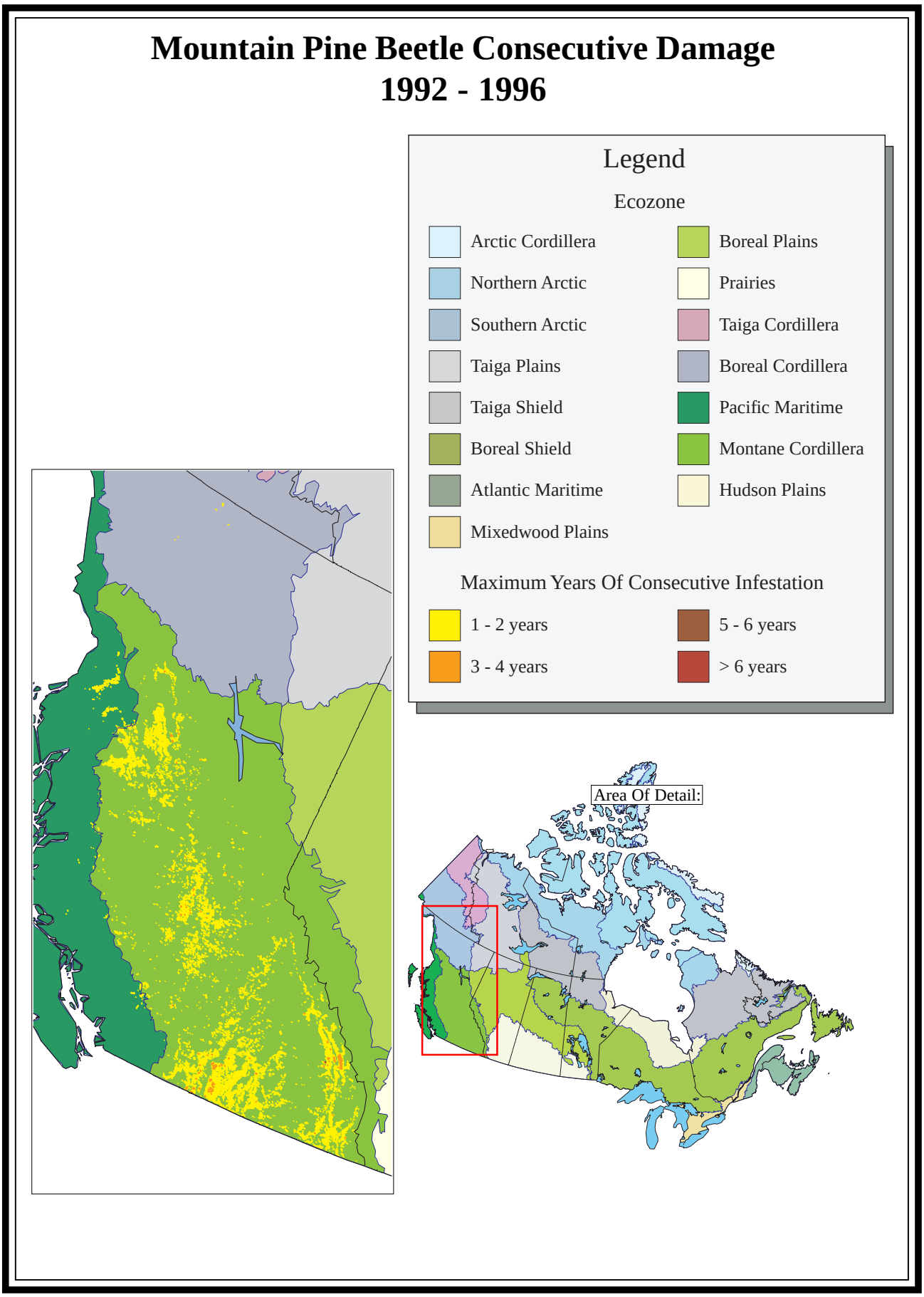


Figure 20. Mountain Pine Beetle Consecutive Damage 1992 - 1996

Table 1. Spruce Budworm Defoliation by Ecozone and Ecoregion 1980 - 1996

ECOZONE	ECOREGION	Year: 1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Arctic Cordillera		no defoliation reported																
Northern Arctic		no defoliation reported																
Southern Arctic		no defoliation reported																
Taiga Plains	Peel River Plateau	0	0	0	0	0	0	0	0	0	0	0	0	67834	0	0	0	0
	Norman Range	0	0	0	0	0	0	0	0	0	0	0	0	60598	0	2325	0	662
	Mackenzie River Plain	0	0	0	0	0	0	0	0	0	0	0	0	46340	6478	48211	1967	9488
	Franklin Mountains	0	0	0	0	0	0	0	0	0	0	0	0	20248	3177	43405	4454	6480
	Great Slave Lake Plain	0	0	0	0	0	0	0	0	0	0	0	0	7952	0	0	0	5562
	Nahanni Plateau	0	0	0	0	0	0	0	0	0	0	0	103721	0	0	6644	0	0
	Sibbeston Lake Plain	0	0	826	3780	5236	1516	8713	20534	21706	35777	9850	181497	133126	6179	60170	6144	10451
	Horn Plateau	0	0	0	0	0	0	0	0	0	0	0	8930	125038	10179	79240	2007	24479
	Hay River Lowland	0	0	1321	13058	48982	14972	106835	160266	160298	224504	51617	605095	1113052	145691	483706	177526	154110
	Northern Alberta Uplands	0	0	0	0	50581	38516	66022	68217	62055	115534	237396	243578	315354	0	47168	12462	12069
	Muskwa Plateau	0	0	0	0	0	1188	0	0	0	0	0	0	0	0	1	0	0
	Ecozone Total:	**0**	**0**	**2147**	**16838**	**104799**	**56192**	**181570**	**249017**	**244059**	**375815**	**298863**	**1142821**	**1889542**	**171704**	**770870**	**204560**	**223301**
Taiga Shield	Tazin Lake Upland	0	0	0	0	0	0	0	0	0	0	0	0	0	7548	9532	5672	11790
	Ecozone Total:	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**7548**	**9532**	**5672**	**11790**
Boreal Shield	Churchill River Upland	1785	7629	6411	10704	6340	0	6049	0	0	0	0	0	0	0	125115	706648	379306
	Hayes River Upland	0	0	0	0	0	0	0	0	0	5034	0	0	0	0	0	0	0
	Lac Seul Upland	20084	1552	13435	53986	118950	808026	1407303	1554708	1524543	1469494	1399247	1594187	2058758	2034259	1532853	1616492	43553
	Lake of the Woods	283243	233044	391023	959442	1464674	2826138	2604199	2310705	2250623	2061883	1667033	1709955	1427148	1715210	1232360	1156282	42230
	Rainy River	0	0	0	0	9944	12873	0	0	0	0	1117	2464	19	1517	8711	23958	9447
	Thunder Bay-Quetico	543541	455548	583271	1689375	2524061	2518379	2426147	1703252	1116280	990412	1024530	1498197	897946	625870	637835	316815	58072
	Lake Nipigon	119640	111931	242102	472987	1875266	4633043	3856135	3265588	1492207	2884939	3781547	5092808	4494103	4155614	1423569	677881	137381
	Big Trout Lake	0	0	0	0	0	0	0	0	0	0	0	67451	164836	291155	1687	1792	1940
	Abltibi Plains	9317905	9192524	2878917	3265900	3094850	3662949	679339	23788	0	81585	260855	914079	2246554	1965194	281282	281317	85383
	Lake Temiscamingue Lowland	7316710	6862893	2268943	2714572	784933	227282	686	0	0	0	0	0	729	6459	592	4954	35314
	Algonquin-Lake Nipissing	3117189	2632206	2441536	1737634	454957	28409	285	0	0	0	2804	13493	33419	44366	113001	89008	61668
	Southern Laurentians	2178913	1892620	2654702	4872310	3943996	4091120	1015524	10378	493	0	0	0	377	385	2032	4316	4686
	Rivière Rupert Plateau	4690	8495	0	0	0	2985	0	0	0	0	0	0	0	0	0	0	0
	Central Laurentians	391502	564962	1836043	2572718	1712433	1642150	717126	403540	71983	88196	115264	111294	1581	0	0	0	0
	Anticosti Island	138616	193468	245354	510337	79211	3336	6166	16214	1505	0	0	0	0	0	0	0	0
	Mecatina Plateau	61641	59422	128568	82381	831	0	0	0	0	0	0	0	0	0	0	0	0
	Northern Peninsula	24360	9623	0	0	0	0	0	3543	0	0	0	0	0	0	0	0	0
	Southwestern Newfoundland	166461	201430	54403	7325	11972	0	1228	997	372	555	885	2240	1935	0	0	0	0
	Long Range Mountains	12474	11619	230	2009	0	0	0	0	0	1226	0	0	0	0	0	0	0
	Long Range Mountains	10664	3765	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Central Newfoundland	723349	253971	298	2466	10041	2937	1159	790	0	0	0	0	0	0	0	0	0
	Northeastern Newfoundland	215419	44927	0	105	0	0	0	0	0	0	0	0	0	0	0	0	0
	Maritime Barrens	257968	53232	0	0	0	0	0	0	0	288	0	0	0	0	0	0	0
	Avalon Forest	1282	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ecozone Total:	**24907436**	**22794861**	**13745236**	**18954251**	**16092459**	**20459627**	**12721346**	**9293503**	**6458006**	**7583612**	**8253282**	**11006168**	**11327405**	**10840029**	**5359037**	**4879463**	**858980**
Atlantic Maritime	Appalachians	2066917	3471320	3738331	1231494	1552740	718507	466043	391006	407705	687666	492033	246676	21859	0	0	0	0
	Northern New Brunswick Uplands	377139	635635	708864	906237	343874	231205	330163	223428	302835	221688	127915	160505	44660	0	0	0	0
	New Brunswick Highlands	48624	65184	73886	228698	125756	80480	78086	88968	131897	88968	104697	93009	37950	0	0	0	0
	Saint John River Valley	46419	78634	68240	70761	22728	8914	24706	1353	0	1353	0	0	0	0	0	0	0
	Southern New Brunswick Uplands	97574	176610	175355	208121	33682	140310	84546	9659	0	9659	0	0	0	0	0	0	0
	Maritime Lowlands	122294	298983	418282	806052	319909	687528	363606	70261	9472	70261	18372	23962	1270	0	0	0	0
	Fundy Coast	1126	19697	32523	95607	6010	22226	1191	1099	0	1099	0	0	0	0	0	0	0
	Southwest Nova Scotia Uplands	0	0	1021	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic Coast	0	0	0	2674	0	0	0	0	0	0	0	0	0	0	0	0	0
	Annapolis-Minas Lowlands	0	0	867	10190	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nova Scotia Highlands	0	0	80178	149926	25585	74614	0	0	0	0	0	0	0	0	0	0	0
	Cape Breton Highlands	0	0	0	4840	0	0	0	0	0	0	0	0	0	0	0	0	0
	Prince Edward Island	0	0	14562	24563	8055	67088	78830	0	0	0	0	0	50501	0	6325	0	0
	Ecozone Total:	**2760093**	**4746063**	**5312109**	**3739163**	**2438339**	**2030872**	**1427171**	**785774**	**851909**	**1080694**	**743017**	**524152**	**156240**	**0**	**6325**	**0**	**0**
Mixedwood Plains	St-Laurent Lowlands	7259	1725	2084	4709	72498	7547	0	0	0	0	0	0	87	529	985	6588	8721
	Manitoulin-Lake Simcoe	346263	276231	268921	0	0	0	0	0	0	0	118	0	715	1728	3347	5557	186
	Lake Erie Lowland	3940	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ecozone Total:	**357462**	**277956**	**271005**	**4709**	**72498**	**7547**	**0**	**0**	**0**	**0**	**118**	**0**	**802**	**2257**	**4332**	**12145**	**8907**
Boreal Plains	Slave River Lowland	2401	0	0	1936	2535	5253	7543	10715	12412	13121	47904	133761	67376	83071	272865	48334	286217
	Clear Hills Upland	0	0	0	0	0	0	0	0	0	0	0	3873	3680	0	0	0	0
	Peace Lowland	0	0	0	0	0	0	0	0	37154	19423	0	51052	54862	16262	37125	42492	37284

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ECOZONE	ECOREGION	Year: 1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
	Wabasca Lowland	0	0	0	0	0	0	0	0	1287	5606	0	141448	152538	358	25944	44542	41883
	Mid-Boreal Uplands	0	0	0	0	0	0	0	0	0	0	0	0	483	0	0	0	0
	Mid-Boreal Uplands	0	0	0	0	0	0	0	0	0	9579	0	177908	342800	28468	108089	215516	168290
	Mid-Boreal Lowland	10920	2560	72013	156477	199080	203903	18923	8367	9786	23110	10939	27342	27471	5086	4315	42262	23481
	Boreal Transition	0	0	0	9627	9222	16641	8178	54103	34335	47275	0	73679	152857	113045	138597	123431	138990
	Mid-Boreal Uplands	0	0	0	0	0	0	0	170	0	16	0	0	0	0	423	0	26
	Mid-Boreal Uplands	0	0	6275	6591	10252	9513	35605	93868	45834	46779	0	0	63576	60617	6231	49591	45174
	Mid-Boreal Uplands	0	0	0	0	0	28450	0	0	0	0	0	20281	18699	4941	6935	1277	20013
	Mid-Boreal Uplands	3180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Interlake Plain	58483	8517	14936	88896	25194	75540	0	0	0	0	7775	0	336	0	0	0	0
	Ecozone Total:	**74984**	**11077**	**93224**	**263527**	**246283**	**339300**	**70249**	**167223**	**140808**	**164909**	**66618**	**629344**	**884678**	**311848**	**600524**	**567445**	**761358**
Prairies	Aspen Parkland	1337	373	1823	3544	3975	12719	14194	26192	143	0	0	277121	298389	0	0	0	125
	Moist Mixed Grassland	0	0	973	973	0	1223	5091	6560	0	0	0	5275	0	0	0	0	0
	Mixed Grassland	0	0	0	0	0	0	0	0	0	0	3947	0	0	0	0	0	0
	Cypress Upland	0	0	0	0	0	0	0	0	0	0	0	0	8384	0	0	0	0
	Lake Manitoba Plain	2198	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ecozone Total:	**3535**	**373**	**2796**	**4517**	**3975**	**13942**	**19285**	**32752**	**143**	**0**	**3947**	**282396**	**306773**	**0**	**0**	**0**	**125**
Taiga Cordillera		no defoliation reported																
Boreal Cordillera	Hyland Highland	0	0	0	0	0	2704	0	3154	3982	3557	0	18163	27090	0	2225	0	11
	Ecozone Total:	**0**	**0**	**0**	**0**	**0**	**2704**	**0**	**3154**	**3982**	**3557**	**0**	**18163**	**27090**	**0**	**2225**	**0**	**11**
Pacific Maritime	Coastal Gap	0	0	0	0	1609	0	0	0	0	0	0	0	0	0	0	0	0
	Ecozone Total:	**0**	**0**	**0**	**0**	**1609**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Montane Cordillera	Columbia Mountains and Highlands	0	0	0	0	210	0	0	0	0	0	0	0	0	0	0	0	0
	Ecozone Total:	**0**	**0**	**0**	**0**	**210**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Hudson Plains	James Bay Lowlands	244953	66110	0	34868	11185	22871	0	0	0	0	0	10520	33849	61785	0	0	0
	Ecozone Total:	**244953**	**66110**	**0**	**34868**	**11185**	**22871**	**0**	**0**	**0**	**0**	**0**	**10520**	**33849**	**61785**	**0**	**0**	**0**
Annual Totals in Canada:		**28348463**	**27896440**	**19426517**	**23017873**	**18971357**	**22933055**	**14419621**	**10531423**	**7698907**	**9208587**	**9365845**	**13613564**	**14626379**	**11395171**	**6752845**	**5669285**	**1864472**

(All defoliation is measured in hectares)

Table 2. Spruce Budworm Consecutive Defoliation by Ecozone and Ecoregion 1980 - 1996

ECOZONE	ECOREGION	Number of Years: 1	2	3	4	5	6	>6	Ecoregion Totals:
Arctic Cordillera		no defoliation reported							
Northern Arctic		no defoliation reported							
Southern Arctic		no defoliation reported							
Taiga Plains	Peel River Plateau	67834	0	0	0	0	0	0	**67834**
	Norman Range	62762	0	0	0	0	0	0	**62762**
	Mackenzie River Plain	85967	3371	3089	254	2	0	0	**92683**
	Franklin Mountains	53460	3304	2528	78	27	0	0	**59397**
	Great Slave Lake Plain	9430	0	0	0	0	0	0	**9430**
	Nahanni Plateau	106808	0	0	0	0	0	0	**106808**
	Sibbeston Lake Plain	274715	37923	11845	3437	102	68	0	**328090**
	Horn Plateau	171544	16648	2996	28	128	0	0	**191344**
	Hay River Lowland	1161516	410376	103843	60344	6530	1922	1815	**1746346**
	Northern Alberta Uplands	351161	121228	45473	30443	9271	6851	99	**564526**
	Muskwa Plateau	1188	0	0	0	0	0	0	**1188**
	Ecozone Total:	**2346385**	**592850**	**169774**	**94584**	**16060**	**8841**	**1914**	3230408
Taiga Shield	Tazin Lake Upland	14299	4254	925	218	0	0	0	**19696**
	Ecozone Total:	**14299**	**4254**	**925**	**218**	**0**	**0**	**0**	19696
Boreal Shield	Churchill River Upland	349623	305676	91570	1573	0	0	0	**748442**
	Hayes River Upland	5034	0	0	0	0	0	0	**5034**
	Lac Seul Upland	772757	258185	299279	261086	101779	49745	1234582	**2977413**
	Lake of the Woods	473791	265360	303204	174559	190667	247567	1735515	**3390663**
	Rainy River	38365	8247	1355	191	0	0	0	**48158**
	Thunder Bay-Quetico	42521	47373	220949	207341	421252	284550	1322240	**2546226**
	Lake Nipigon	956914	290197	976228	793153	1012136	435504	1525432	**5989564**
	Big Trout Lake	191955	73355	57508	1544	142	0	0	**324504**
	Abltibi Plains	1126343	5658411	1044609	281060	240385	1760138	229697	**10340643**
	Lake Temiscamingue Lowland	1068114	4492848	665908	1061716	445875	78617	19	**7813097**
	Algonquin-Lake Nipissing	838128	268730	887846	1062075	367221	21025	362	**3445387**
	Southern Laurentians	2470153	1405029	1224817	1017048	540162	333163	51782	**7042154**
	Rivière Rupert Plateau	13887	1141	0	0	0	0	0	**15028**
	Central Laurentians	962497	879833	479930	545943	223140	173468	74779	**3339590**
	Anticosti Island	284592	111853	78217	72936	8844	0	0	**556442**
	Mecatina Plateau	111107	35213	12281	25183	0	0	0	**183784**
	Northern Peninsula	21956	7785	0	0	0	0	0	**29741**
	Southwestern Newfoundland	143448	104286	23153	599	0	0	0	**271486**
	Long Range Mountains	13963	5985	21	203	0	0	0	**20172**
	Long Range Mountains	7641	3394	0	0	0	0	0	**11035**
	Central Newfoundland	660711	158761	1019	0	0	0	0	**820491**
	Northeastern Newfoundland	188107	36119	0	0	0	0	0	**224226**
	Maritime Barrens	258742	26373	0	0	0	0	0	**285115**
	Avalon Forest	1282	0	0	0	0	0	0	**1282**
	Ecozone Total:	**11001631**	**14444154**	**6367894**	**5506210**	**3551603**	**3383777**	**6174408**	50429677
Atlantic Maritime	Appalachians	1477068	1631279	1449134	253261	130190	48979	53103	**5043014**
	Northern New Brunswick Uplands	1186021	577800	192093	53936	13377	2019	1741	**2026987**
	New Brunswick Highlands	262332	124986	49056	16223	5961	1269	383	**460210**
	Saint John River Valley	143323	37898	10613	3539	330	90	0	**195793**
	Southern New Brunswick Uplands	450160	102307	26054	5864	355	71	0	**584811**
	Maritime Lowlands	1229676	368661	117898	30215	6464	3223	512	**1756649**
	Fundy Coast	126818	16836	1111	167	0	0	0	**144932**
	Southwest Nova Scotia Uplands	1021	0	0	0	0	0	0	**1021**
	Atlantic Coast	2674	0	0	0	0	0	0	**2674**
	Annapolis-Minas Lowlands	11057	0	0	0	0	0	0	**11057**
	Nova Scotia Highlands	179916	49298	4052	1527	0	0	0	**234793**
	Cape Breton Highlands	4840	0	0	0	0	0	0	**4840**
	Prince Edward Island	157647	22548	1587	220	102	0	0	**182104**
	Ecozone Total:	**5232553**	**2931613**	**1851598**	**364952**	**156779**	**55651**	**55739**	10648885
Mixedwood Plains	St-Laurent Lowlands	98465	5433	308	0	0	0	0	**104206**
	Manitoulin-Lake Simcoe	141457	59879	209064	0	0	0	0	**410400**
	Lake Erie Lowland	3940	0	0	0	0	0	0	**3940**
	Ecozone Total:	**243862**	**65312**	**209372**	**0**	**0**	**0**	**0**	518546
Boreal Plains	Slave River Lowland	426114	76248	18456	21479	2040	2904	2472	**549713**
	Clear Hills Upland	7553	0	0	0	0	0	0	**7553**
	Peace Lowland	104448	29205	25436	1255	0	0	0	**160344**
	Wabasca Lowland	132455	92924	14152	198	76	0	0	**239805**
	Mid-Boreal Uplands	483	0	0	0	0	0	0	**483**
	Mid-Boreal Uplands	467795	162014	64777	10285	0	0	0	**704871**
	Mid-Boreal Lowland	418718	124562	23705	11010	97	132	0	**578224**
	Boreal Transition	207049	90773	74306	50940	441	720	0	**424229**
	Mid-Boreal Uplands	599	0	0	0	0	0	0	**599**
	Mid-Boreal Uplands	117416	44557	20000	11578	1986	717	1628	**197882**
	Mid-Boreal Uplands	62518	4447	211	120	0	0	0	**67296**
	Mid-Boreal Uplands	3180	0	0	0	0	0	0	**3180**
	Interlake Plain	223496	22561	2566	0	0	0	0	**248623**
	Ecozone Total:	**2171824**	**647291**	**243609**	**106865**	**4640**	**4473**	**4100**	3182802
Prairies	Aspen Parkland	491466	68857	2295	0	0	0	0	**562618**
	Moist Mixed Grassland	10646	3752	0	0	0	0	0	**14398**
	Mixed Grassland	3947	0	0	0	0	0	0	**3947**
	Cypress Upland	8384	0	0	0	0	0	0	**8384**
	Lake Manitoba Plain	2198	0	0	0	0	0	0	**2198**
	Ecozone Total:	**516641**	**72609**	**2295**	**0**	**0**	**0**	**0**	591545
Taiga Cordillera		no defoliation reported							
Boreal Cordillera	Hyland Highland	35003	5053	260	0	0	0	0	**40316**
	Ecozone Total:	**35003**	**5053**	**260**	**0**	**0**	**0**	**0**	40316
Pacific Maritime	Coastal Gap	1609	0	0	0	0	0	0	**1609**
	Ecozone Total:	**1609**	**0**	**0**	**0**	**0**	**0**	**0**	1609
Montane Cordillera	Columbia Mountains and Highlands	210	0	0	0	0	0	0	**210**
	Ecozone Total:	**210**	**0**	**0**	**0**	**0**	**0**	**0**	210

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ECOZONE	ECOREGION	Number of Years:	1	2	3	4	5	6	>6	Ecoregion Totals:
Hudson Plains	James Bay Lowlands		311007	32440	9877	0	0	0	0	**353324**
	Ecozone Total:		**311007**	**32440**	**9877**	**0**	**0**	**0**	**0**	**353324**
Consecutive Year Totals in Canada:			**21875024**	**18795576**	**8855604**	**6072829**	**3729082**	**3452742**	**6236161**	**69017018**

(All defoliation is measured in hectares)

Table 3. Forest Tent Caterpillar Defoliation by Ecozone and Ecoregion 1980 - 1996

ECOZONE	ECOREGION	Year:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Arctic Cordillera			no defoliation reported																
Northern Arctic			no defoliation reported																
Southern Arctic			no defoliation reported																
Taiga Plains	Sibbeston Lake Plain		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1148	23135
	Hay River Lowland		3780	0	12420	0	0	0	0	0	0	0	0	0	0	0	0	5299	49296
	Northern Alberta Uplands		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	42949	166540
	Muskwa Plateau		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4292
	Ecozone Total:		**3780**	**0**	**12420**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**49396**	**243263**
Taiga Shield			no defoliation reported																
Boreal Shield	Churchill River Upland		1249668	2207324	986572	102520	32216	0	10232	28214	18184	40311	0	0	0	0	0	0	0
	Hayes River Upland		0	0	0	0	0	8976	13494	6658	83256	228353	0	0	0	0	0	0	0
	Lac Seul Upland		0	0	0	0	0	0	0	0	17081	112590	739384	4692710	3337297	0	3919	0	1593
	Lake of the Woods		0	0	0	0	0	0	0	2976	158324	1761903	2509561	2508515	0	0	239	130	0
	Rainy River		0	0	0	0	0	0	0	641	62043	283027	270240	208179	0	0	0	0	0
	Thunder Bay-Quetico		107152	0	39374	27140	43123	1694	440	2907	88619	599319	1313635	1345849	364069	0	0	0	0
	Lake Nipigon		3900	0	0	0	0	0	0	0	505	14249	447748	4794210	5167966	0	0	0	0
	Big Trout Lake		0	0	0	0	0	0	0	0	0	0	118	525073	1294065	0	0	0	0
	Abltibi Plains		157743	6084	43933	1574	8198	9444	14685	12957	0	194531	1353663	3262694	5351510	561160	167524	243041	857241
	Lake Temiscamingue Lowland		30055	0	0	0	83241	310229	393786	679453	406902	642081	524201	158810	1475	878	0	0	0
	Algonquin-Lake Nipissing		72129	0	0	0	0	2746	98034	1129630	3041631	3740756	1735466	1047753	112650	139590	0	0	0
	Southern Laurentians		0	12124	0	0	0	17522	117605	412889	14152	5733	0	0	32019	937	3521	152	0
	Central Laurentians		0	705	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ecozone Total:		**1620647**	**2226237**	**1069879**	**131234**	**166778**	**350611**	**648276**	**2276325**	**3890697**	**7622853**	**8894016**	**18543793**	**15661051**	**702565**	**175203**	**243323**	**858834**
Atlantic Maritime	Appalachians		172069	798596	139202	4106	0	0	0	0	0	0	0	0	0	0	0	0	0
	Northern New Brunswick Uplands		56365	241656	24389	8826	0	0	0	0	0	0	0	0	0	359	0	0	0
	Saint John River Valley		102879	310970	150126	34652	0	0	0	0	0	0	0	0	0	1668	0	0	0
	Southern New Brunswick Uplands		10133	116973	324304	468723	1804	0	0	0	0	0	0	0	9440	31911	64163	99094	410
	Maritime Lowlands		56770	492990	1053124	750838	103835	16293	324	0	0	0	0	2934	166446	160521	327716	337799	32546
	Fundy Coast		0	0	263	1270	2877	4226	0	0	0	0	0	0	0	0	0	352	0
	Southwest Nova Scotia Uplands		0	7892	3337	11485	5173	1645	0	0	0	0	0	0	0	0	0	7946	1033
	Atlantic Coast		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	142	0
	Annapolis-Minas Lowlands		0	0	7134	30116	28344	17219	0	0	0	0	0	0	0	0	0	862	259
	South-central Nova Scotia Uplands		0	0	243	2423	1066	894	0	0	0	0	0	0	0	0	0	0	0
	Prince Edward Island		7426	13357	18085	83451	36275	0	0	0	0	0	0	0	0	0	0	0	0
	Ecozone Total:		**405642**	**1982434**	**1720207**	**1395890**	**179374**	**40277**	**324**	**0**	**0**	**0**	**0**	**2934**	**175886**	**194459**	**391879**	**446195**	**34248**
Mixedwood Plains	St-Laurent Lowlands		124742	199435	232735	8816	0	0	0	293	3225	1343	317	7555	9521	27457	99	2280	2213
	Frontenac Axis		0	0	0	0	0	0	0	0	0	113	80	0	0	197	0	0	0
	Manitoulin-Lake Simcoe		0	0	0	0	0	0	1816	45018	308174	746406	315789	53310	1304	491	0	0	0
	Ecozone Total:		**124742**	**199435**	**232735**	**8816**	**0**	**0**	**1816**	**45311**	**311399**	**747862**	**316186**	**60865**	**10825**	**28145**	**99**	**2280**	**2213**
Boreal Plains	Slave River Lowland		146198	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Clear Hills Upland		38001	491482	667414	642	30278	4238	157	0	0	0	0	0	0	0	0	29951	30193
	Peace Lowland		2084419	3095313	3398777	819112	650781	94655	62726	82813	359386	753144	239189	0	0	8034	107023	123085	62260
	Mid-Boreal Uplands		48330	453111	506337	0	0	0	0	0	0	0	0	0	0	0	0	8295	0
	Mid-Boreal Uplands		0	224870	317886	1492	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Boreal Uplands		0	0	199710	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Wabasca Lowland		407586	1593342	2534224	20574	52040	0	0	0	31053	21029	0	0	0	0	0	0	0
	Western Boreal		181348	236576	524781	630860	171147	4019	3253	6741	0	15117	16003	0	0	0	0	2960	1163
	Mid-Boreal Uplands		1022151	1592136	1896145	54431	17834	57152	207174	352496	1093822	583373	0	0	0	0	0	0	0
	Western Alberta Upland		520479	571186	1048139	537087	51752	6827	59743	277798	1580428	1003282	197563	0	0	0	0	1861	543
	Mid-Boreal Uplands		2956005	1538208	313095	0	0	0	0	72181	741678	908571	0	0	7223	0	0	0	0
	Mid-Boreal Lowland		22591	614623	1522280	590308	467240	63090	56424	7316	145454	182745	0	0	144501	2563	4752	0	77
	Boreal Transition		5200046	4533287	2813581	1452022	167932	698870	1582290	3074976	4956203	3263772	0	0	15641	0	0	15351	13280
	Mid-Boreal Uplands		611969	97813	182411	0	0	11256	12652	367734	656853	271458	0	0	0	0	0	8411	178
	Mid-Boreal Uplands		0	13569	127028	0	0	14765	0	0	222963	37745	0	0	0	0	0	0	0
	Mid-Boreal Uplands		1507	67129	58525	134102	8377	70635	192312	376164	270165	2171	0	0	0	0	0	0	0
	Mid-Boreal Uplands		0	0	0	0	0	0	0	7285	29127	6266	0	0	0	0	0	31	22
	Interlake Plain		0	0	0	1028	0	7133	3478	0	14036	20350	0	0	7040	1266	0	0	0
	Ecozone Total:		**13240630**	**15122645**	**16110333**	**4241658**	**1617381**	**1032640**	**2180209**	**4625504**	**10101168**	**7069023**	**452755**	**0**	**174405**	**11863**	**111775**	**189945**	**107716**
Prairies	Aspen Parkland		3701781	3439530	2033425	1164067	1093962	2249611	2133601	3506608	5335547	3824314	0	0	46003	10949	58467	144118	63352
	Moist Mixed Grassland		812765	483966	0	53757	5415	36202	484371	655220	323274	145937	0	0	0	0	0	213	0
	Fescue Grassland		0	0	0	0	0	0	0	0	16406	5990	0	0	0	0	0	0	0
	Mixed Grassland		0	0	0	0	0	0	0	62261	0	0	0	0	0	0	0	0	0
	Lake Manitoba Plain		0	0	0	0	0	3353	4040	0	0	0	0	0	0	0	0	0	0

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ECOZONE	ECOREGION	Year: 1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
	Southwest Manitoba Uplands	3876	29407	0	0	0	0	0	0	2055	0	0	0	0	0	0	0	0
	Ecozone Total:	**4518422**	**3952903**	**2033425**	**1217824**	**1099377**	**2289166**	**2622012**	**4224089**	**5677282**	**3976241**	**0**	**0**	**46003**	**10949**	**58467**	**144331**	**63352**
Taiga Cordillera		no defoliation reported																
Boreal Cordillera	Hyland Highland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2262
	Ecozone Total:	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2262**
Pacific Maritime	Mass Ranges	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1812
	Lower Mainland	0	0	0	0	0	0	0	0	198	0	0	0	0	0	0	0	0
	Ecozone Total:	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**198**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1812**
Montane Cordillera	Fraser Plateau	0	0	0	0	0	0	0	0	361	2138	2955	10752	19140	29108	18707	14277	0
	Fraser Basin	0	0	0	0	2475	0	175	5935	22852	72763	91222	48519	933	24180	56047	67296	3805
	Columbia Mountains and Highlands	0	0	0	0	0	0	0	435	217	932	1898	4258	8088	14877	4765	1776	0
	Western Continental Ranges	0	0	0	0	0	0	0	0	0	408	1177	2471	1493	50	74	0	0
	Eastern Continental Ranges	0	0	0	0	2957	0	0	0	0	0	0	0	0	0	0	0	0
	Interior Transition Ranges	0	0	0	0	0	0	0	0	0	62	94	0	0	0	0	0	0
	Thompson-Okanagan Plateau	0	0	0	0	0	0	0	46	89	1883	1055	3066	250	0	0	0	0
	Selkirk-Bitterroot Foothills	0	0	0	0	0	0	0	6539	0	0	0	0	0	0	0	0	0
	Southern Rocky Mountain Trench	0	0	0	0	0	0	0	0	285	7214	389	2438	4099	9388	3847	4763	0
	Northern Contlnental Divide	0	0	0	0	36891	0	0	8412	37839	7633	0	0	0	0	0	0	0
	Ecozone Total:	**0**	**0**	**0**	**0**	**42323**	**0**	**175**	**21367**	**61643**	**93033**	**98790**	**71504**	**34003**	**77603**	**83440**	**88112**	**3805**
Hudson Plains	James Bay Lowlands	0	0	0	0	0	0	0	0	0	49692	189397	311117	483309	0	0	0	0
	Ecozone Total:	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**49692**	**189397**	**311117**	**483309**	**0**	**0**	**0**	**0**
Annual Totals in Canada:		**19913863**	**23483654**	**21178999**	**6995422**	**3105233**	**3712694**	**5452812**	**11192596**	**20042387**	**19558704**	**9951144**	**18990213**	**16585482**	**1025584**	**820863**	**1163582**	**1317505**

(All defoliation is measured in hectares)

Table 4. Forest Tent Caterpillar Consecutive Defoliation by Ecozone and Ecoregion 1980 - 1996

ECOZONE	ECOREGION	Number of Years: 1	2	3	4	5	6	>6	Ecoregion Totals:
Arctic Cordillera		no defoliation reported							
Northern Arctic		no defoliation reported							
Southern Arctic		no defoliation reported							
Taiga Plains	Sibbeston Lake Plain	23325	478	0	0	0	0	0	**23803**
	Hay River Lowland	65694	2550	0	0	0	0	0	**68244**
	Northern Alberta Uplands	148215	30637	0	0	0	0	0	**178852**
	Muskwa Plateau	4292	0	0	0	0	0	0	**4292**
	Ecozone Total:	**241526**	**33665**	**0**	**0**	**0**	**0**	**0**	**275191**
Taiga Shield		no defoliation reported							
Boreal Shield	Churchill River Upland	1875362	1315428	31576	806	0	0	0	**3223172**
	Hayes River Upland	259476	33376	394	0	0	0	0	**293246**
	Lac Seul Upland	1602897	3127903	344641	2228	0	0	0	**5077669**
	Lake of the Woods	420804	763253	1455862	136861	1526	0	0	**2778306**
	Rainy River	59747	72635	136257	47163	590	0	0	**316392**
	Thunder Bay-Quetico	535458	1055943	293519	69812	2195	0	0	**1956927**
	Lake Nipigon	1519994	3893319	361552	5964	0	0	0	**5780829**
	Big Trout Lake	793541	512679	118	0	0	0	0	**1306338**
	Abltibi Plains	2204461	2421831	1127674	172836	96050	51	0	**6022903**
	Lake Temiscamingue Lowland	687703	486622	335455	114220	766	0	0	**1624766**
	Algonquin-Lake Nipissing	1210519	1589823	1196644	596042	65316	21690	2189	**4682223**
	Southern Laurentians	390464	96386	6324	92	0	0	0	**493266**
	Central Laurentians	705	0	0	0	0	0	0	**705**
	Ecozone Total:	**11561131**	**15369198**	**5290016**	**1146024**	**166443**	**21741**	**2189**	**33556742**
Atlantic Maritime	Appalachians	614296	229567	13058	0	0	0	0	**856921**
	Northern New Brunswick Uplands	195340	62360	2420	0	0	0	0	**260120**
	Saint John River Valley	128570	170230	36330	4072	0	0	0	**339202**
	Southern New Brunswick Uplands	377389	195438	55466	7684	0	0	0	**635977**
	Maritime Lowlands	470254	429963	314817	92703	8933	1236	0	**1317906**
	Fundy Coast	5613	1128	260	0	0	0	0	**7001**
	Southwest Nova Scotia Uplands	29562	2981	393	0	0	0	0	**32936**
	Atlantic Coast	142	0	0	0	0	0	0	**142**
	Annapolis-Minas Lowlands	42655	11491	3870	506	0	0	0	**58522**
	South-central Nova Scotia Uplands	3098	244	274	0	0	0	0	**3616**
	Prince Edward Island	41221	34303	5561	3530	1743	0	0	**86358**
	Ecozone Total:	**1908140**	**1137705**	**432449**	**108495**	**10676**	**1236**	**0**	**3598701**
Mixedwood Plains	St-Laurent Lowlands	186293	86030	70167	4287	0	0	0	**346777**
	Frontenac Axis	391	0	0	0	0	0	0	**391**
	Manitoulin-Lake Simcoe	485770	254712	115464	21799	3501	0	0	**881246**
	Ecozone Total:	**672454**	**340742**	**185631**	**26086**	**3501**	**0**	**0**	**1228414**
Boreal Plains	Slave River Lowland	146198	0	0	0	0	0	0	**146198**
	Clear Hills Upland	205679	440163	38643	0	0	0	0	**684485**
	Peace Lowland	862523	916549	1763236	380492	113285	88	0	**4036173**
	Mid-Boreal Uplands	61521	404781	48330	0	0	0	0	**514632**
	Mid-Boreal Uplands	91523	226363	0	0	0	0	0	**317886**
	Mid-Boreal Uplands	199710	0	0	0	0	0	0	**199710**
	Wabasca Lowland	1346244	1285682	208174	0	0	0	0	**2840100**
	Western Boreal	164071	207743	134373	158409	23792	0	0	**688388**
	Mid-Boreal Uplands	523044	660450	935619	70314	402	0	0	**2189829**
	Western Alberta Upland	1470483	526681	100958	277795	6733	0	0	**2382650**
	Mid-Boreal Uplands	2637045	1332264	95314	0	0	0	0	**4064623**
	Mid-Boreal Lowland	1905198	703878	76751	6848	1216	0	0	**2693891**
	Boreal Transition	2986160	3525680	1127705	1067865	72434	0	16739	**8796583**
	Mid-Boreal Uplands	139207	332749	175632	6742	2521	0	0	**656851**
	Mid-Boreal Uplands	255227	31753	0	0	0	0	0	**286980**
	Mid-Boreal Uplands	101032	193703	93055	43882	268	0	2686	**434626**
	Mid-Boreal Uplands	38856	0	0	0	0	0	0	**38856**
	Interlake Plain	50141	1726	0	0	0	0	0	**51867**
	Ecozone Total:	**13183862**	**10790165**	**4797790**	**2012347**	**220651**	**88**	**19425**	**31024328**
Prairies	Aspen Parkland	1866498	2679417	1898038	881374	349225	323098	24198	**8021848**
	Moist Mixed Grassland	823691	589855	108553	133005	16223	16	0	**1671343**
	Fescue Grassland	18385	2005	0	0	0	0	0	**20390**
	Mixed Grassland	62261	0	0	0	0	0	0	**62261**
	Lake Manitoba Plain	7393	0	0	0	0	0	0	**7393**
	Southwest Manitoba Uplands	33657	0	0	0	0	0	0	**33657**
	Ecozone Total:	**2811885**	**3271277**	**2006591**	**1014379**	**365448**	**323114**	**24198**	**9816892**
Taiga Cordillera		no defoliation reported							
Boreal Cordillera	Hyland Highland	2262	0	0	0	0	0	0	**2262**
	Ecozone Total:	**2262**	**0**	**0**	**0**	**0**	**0**	**0**	**2262**
Pacific Maritime	Mass Ranges	1812	0	0	0	0	0	0	**1812**
	Lower Mainland	198	0	0	0	0	0	0	**198**
	Ecozone Total:	**2010**	**0**	**0**	**0**	**0**	**0**	**0**	**2010**
Montane Cordillera	Fraser Plateau	43886	14620	5171	996	371	0	0	**65044**
	Fraser Basin	151471	66757	20119	2880	958	70	0	**242255**
	Columbia Mountains and Highlands	20125	5415	1254	252	0	0	0	**27046**
	Western Continental Ranges	1790	871	685	0	0	0	0	**3346**
	Eastern Continental Ranges	2957	0	0	0	0	0	0	**2957**
	Interior Transition Ranges	119	18	0	0	0	0	0	**137**
	Thompson-Okanagan Plateau	3773	707	165	3	0	0	0	**4648**
	Selkirk-Bitterroot Foothills	6539	0	0	0	0	0	0	**6539**
	Southern Rocky Mountain Trench	19199	3107	1187	176	0	0	0	**23669**
	Northern Contlnental Divide	64569	13103	0	0	0	0	0	**77672**
	Ecozone Total:	**314428**	**104598**	**28581**	**4307**	**1329**	**70**	**0**	**453313**
Hudson Plains	James Bay Lowlands	421767	141559	76069	14623	0	0	0	**654018**
	Ecozone Total:	**421767**	**141559**	**76069**	**14623**	**0**	**0**	**0**	**654018**
Consecutive Year Totals in Canada:		**31119465**	**31188909**	**12817127**	**4326261**	**768048**	**346249**	**45812**	**80611871**

(All defoliation is measured in hectares)

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Table 5. Jack Pine Budworm Defoliation by Ecozone and Ecoregion 1982 - 1996

ECOZONE	ECOREGION	Year: 1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Arctic Cordillera		no defoliation reported														
Northern Arctic		no defoliation reported														
Southern Arctic		no defoliation reported														
Taiga Plains		no defoliation reported														
Taiga Shield		no defoliation reported														
Boreal Shield	Churchill River Upland	0	7471	1413305	1092594	117403	0	0	0	0	0	0	0	0	0	0
	Hayes River Upland	0	0	4017	697152	0	0	0	0	0	0	0	0	0	0	0
	Lac Seul Upland	0	0	612670	1494869	391303	0	717515	284773	717	71055	0	0	0	0	0
	Lake of the Woods	0	0	13794	336507	181002	8759	0	0	0	0	0	0	0	0	0
	Thunder Bay-Quetico	0	11878	460857	0	0	0	0	0	0	0	0	0	0	0	0
	Lake Nipigon	0	0	0	0	0	0	0	0	0	2696	0	0	0	0	0
	Lake Temiscamingue Lowland	0	13291	647805	0	0	0	0	0	0	0	0	104186	208296	0	0
	Algonquin-Lake Nipissing	0	42853	20548	0	0	0	0	0	29513	64464	0	211852	216113	0	103071
	Southern Laurentians	0	0	0	0	0	0	0	0	0	0	388	635	352	1228	86
	Ecozone Total:	**0**	**75493**	**3172996**	**3621122**	**689708**	**8759**	**717515**	**284773**	**30230**	**138215**	**388**	**316673**	**424761**	**1228**	**103157**
Atlantic Maritime		no defoliation reported														
Mixedwood Plains	Manitoulin-Lake Simcoe	0	434	112	0	0	0	0	0	0	0	0	0	0	0	0
	Ecozone Total:	**0**	**434**	**112**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Boreal Plains	Mid-Boreal Uplands	0	0	0	0	76581	1594	2177	0	0	0	0	0	0	0	0
	Mid-Boreal Lowland	26428	497358	1589416	1267361	16503	0	0	0	0	0	0	0	0	0	0
	Boreal Transition	0	0	16499	206281	198085	12023	2208	0	0	0	0	0	0	0	0
	Mid-Boreal Uplands	0	0	0	44996	0	0	0	0	0	0	0	0	0	0	0
	Mid-Boreal Uplands	0	0	0	5794	31653	0	0	0	0	0	0	0	0	0	0
	Mid-Boreal Uplands	0	0	0	71305	0	0	0	0	0	0	0	0	0	0	0
	Interlake Plain	0	0	239329	732013	54081	0	0	0	0	0	0	0	0	0	0
	Ecozone Total:	**26428**	**497358**	**1845244**	**2327750**	**376903**	**13617**	**4385**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Prairies	Aspen Parkland	0	0	19575	22510	10867	0	0	0	0	0	0	0	0	0	0
	Ecozone Total:	**0**	**0**	**19575**	**22510**	**10867**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Taiga Cordillera		no defoliation reported														
Boreal Cordillera		no defoliation reported														
Pacific Maritime		no defoliation reported														
Montane Cordillera		no defoliation reported														
Hudson Plains		no defoliation reported														
Annual Totals in Canada:		**26428**	**573285**	**5037927**	**5971382**	**1077478**	**22376**	**721900**	**284773**	**30230**	**138215**	**388**	**316673**	**424761**	**1228**	**103157**

(All defoliation is measured in hectares)

Table 6. Jack Pine Budworm Consecutive Defoliation by Ecozone and Ecoregion 1982 - 1996

ECOZONE	ECOREGION	Number of Years: 1	2	3	4	5	6	>6	Ecoregion Totals:
Arctic Cordillera		no defoliation reported							
Northern Arctic		no defoliation reported							
Southern Arctic		no defoliation reported							
Taiga Plains		no defoliation reported							
Taiga Shield		no defoliation reported							
Boreal Shield	Churchill River Upland	1851382	378397	7280	0	0	0	0	**2237059**
	Hayes River Upland	701169	0	0	0	0	0	0	**701169**
	Lac Seul Upland	2022521	745332	18491	0	0	0	0	**2786344**
	Lake of the Woods	306004	104411	8412	0	0	0	0	**418827**
	Thunder Bay-Quetico	449131	11802	0	0	0	0	0	**460933**
	Lake Nipigon	2696	0	0	0	0	0	0	**2696**
	Lake Temiscamingue Lowland	703320	77906	0	0	0	0	0	**781226**
	Algonquin-Lake Nipissing	201094	138046	0	0	0	0	0	**339140**
	Southern Laurentians	1580	282	79	18	0	0	0	**1959**
	Ecozone Total:	**6238897**	**1456176**	**34262**	**18**	**0**	**0**	**0**	**7729353**
Atlantic Maritime		no defoliation reported							
Mixedwood Plains	Manitoulin-Lake Simcoe	546	0	0	0	0	0	0	**546**
	Ecozone Total:	**546**	**0**	**0**	**0**	**0**	**0**	**0**	**546**
Boreal Plains	Mid-Boreal Uplands	74986	1514	80	0	0	0	0	**76580**
	Mid-Boreal Lowland	1228151	816960	130076	21222	0	0	0	**2196409**
	Boreal Transition	182034	122277	2530	0	0	0	0	**306841**
	Mid-Boreal Uplands	44996	0	0	0	0	0	0	**44996**
	Mid-Boreal Uplands	26890	5279	0	0	0	0	0	**32169**
	Mid-Boreal Uplands	71305	0	0	0	0	0	0	**71305**
	Interlake Plain	514552	255436	0	0	0	0	0	**769988**
	Ecozone Total:	**2142914**	**1201466**	**132686**	**21222**	**0**	**0**	**0**	**3498288**
Prairies	Aspen Parkland	8329	12868	6208	0	0	0	0	**27405**
	Ecozone Total:	**8329**	**12868**	**6208**	**0**	**0**	**0**	**0**	**27405**
Taiga Cordillera		no defoliation reported							
Boreal Cordillera		no defoliation reported							
Pacific Maritime		no defoliation reported							
Montane Cordillera		no defoliation reported							
Hudson Plains		no defoliation reported							
Consecutive Year Totals in Canada:		**8390686**	**2670510**	**173156**	**21240**	**0**	**0**	**0**	**11255592**

(All defoliation is measured in hectares)

Table 7. Hemlock Looper Defoliation by Ecozone and Ecoregion 1983 - 1996

ECOZONE	ECOREGION	Year: 1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Arctic Cordillera		no defoliation reported													
Northern Arctic		no defoliation reported													
Southern Arctic		no defoliation reported													
Taiga Plains		no defoliation reported													
Taiga Shield		no defoliation reported													
Boreal Shield	Anticosti Island	0	0	0	0	0	0	0	0	0	341	378	356	539	940
	Mecatina Plateau	0	0	0	0	0	0	0	0	0	0	0	0	0	91
	Strait of Belle Isle	0	0	0	0	0	880	4527	298	1586	0	0	0	0	0
	Northern Peninsula	0	0	0	8027	18111	8846	947	134	324	0	0	0	0	7928
	Long Range Mountains	0	0	0	653	4339	1751	0	0	0	0	0	0	0	7594
	Southwestern Newfoundland	0	0	17268	22788	34224	2369	0	0	0	0	0	0	0	7880
	Long Range Mountains	0	0	10225	4368	32197	0	0	0	0	0	0	0	0	685
	Long Range Mountains	0	0	1085	1522	1388	0	0	0	0	0	0	0	0	434
	Central Newfoundland	0	7425	35865	28329	23092	0	0	0	7	85	0	0	0	1056
	Northeastern Newfoundland	0	426	1408	142	0	0	0	0	0	0	0	0	0	999
	Maritime Barrens	269	10948	23496	4554	1630	1485	1722	0	3422	3195	0	0	0	0
	South Avalon-Burin Oceanic Barrens	0	0	0	0	0	0	0	0	0	534	0	0	0	0
	Ecozone Total:	**269**	**18799**	**89347**	**70383**	**114981**	**15331**	**7196**	**432**	**5339**	**4155**	**378**	**356**	**539**	**27607**
Atlantic Maritime	Appalachians	0	0	0	0	0	0	0	0	0	1155	0	0	0	5877
	New Brunswick Highlands	0	0	0	0	0	0	2512	3693	1022	1008	0	0	0	0
	Atlantic Coast	0	0	0	0	0	0	0	0	0	3075	0	0	0	0
	Ecozone Total:	**0**	**0**	**0**	**0**	**0**	**0**	**2512**	**3693**	**1022**	**5238**	**0**	**0**	**0**	**5877**
Mixedwood Plains		no defoliation reported													
Boreal Plains		no defoliation reported													
Prairies		no defoliation reported													
Taiga Cordillera		no defoliation reported													
Boreal Cordillera		no defoliation reported													
Pacific Maritime		no defoliation reported													
Montane Cordillera		no defoliation reported													
Hudson Plains		no defoliation reported													
Annual Totals in Canada:		**269**	**18799**	**89347**	**70383**	**114981**	**15331**	**9708**	**4125**	**6361**	**9393**	**378**	**356**	**539**	**33484**

(All defoliation is measured in hectares)

Table 8. Hemlock Looper Consecutive Defoliation by Ecozone and Ecoregion 1983 - 1996

ECOZONE	ECOREGION	Number of Years: 1	2	3	4	5	6	>6	Ecoregion Totals:
Arctic Cordillera		no defoliation reported							
Northern Arctic		no defoliation reported							
Southern Arctic		no defoliation reported							
Taiga Plains		no defoliation reported							
Taiga Shield		no defoliation reported							
Boreal Shield	Anticosti Island	1907	239	38	0	0	0	0	**2184**
	Mecatina Plateau	91	0	0	0	0	0	0	**91**
	Strait of Belle Isle	5479	829	20	0	0	0	0	**6328**
	Northern Peninsula	35690	3764	200	0	0	0	0	**39654**
	Long Range Mountains	12087	1023	0	0	0	0	0	**13110**
	Southwestern Newfoundland	71006	3824	288	0	0	0	0	**75118**
	Long Range Mountains	34164	2382	297	0	0	0	0	**36843**
	Long Range Mountains	4081	7	0	0	0	0	0	**4088**
	Central Newfoundland	65546	11537	2200	0	0	0	0	**79283**
	Northeastern Newfoundland	2613	181	0	0	0	0	0	**2794**
	Maritime Barrens	45199	2119	0	0	0	0	0	**47318**
	South Avalon-Burin Oceanic Barrens	534	0	0	0	0	0	0	**534**
	Ecozone Total:	**278397**	**25905**	**3043**	**0**	**0**	**0**	**0**	**307345**
Atlantic Maritime	Appalachians	7032	0	0	0	0	0	0	**7032**
	New Brunswick Highlands	6153	1041	0	0	0	0	0	**7194**
	Atlantic Coast	3075	0	0	0	0	0	0	**3075**
	Ecozone Total:	**16260**	**1041**	**0**	**0**	**0**	**0**	**0**	**17301**
Mixedwood Plains		no defoliation reported							
Boreal Plains		no defoliation reported							
Prairies		no defoliation reported							
Taiga Cordillera		no defoliation reported							
Boreal Cordillera		no defoliation reported							
Pacific Maritime		no defoliation reported							
Montane Cordillera		no defoliation reported							
Hudson Plains		no defoliation reported							
Consecutive Year Totals in Canada:		**294657**	**26946**	**3043**	**0**	**0**	**0**	**0**	**324646**

(All defoliation is measured in hectares)

Table 9. Mountain Pine Beetle Damage by Ecozone and Ecoregion 1992 - 1996

ECOZONE	ECOREGION	Year: 1992	1993	1994	1995	1996
Arctic Cordillera		no damage reported				
Northern Arctic		no damage reported				
Southern Arctic		no damage reported				
Taiga Plains		no damage reported				
Taiga Shield		no damage reported				
Boreal Shield		no damage reported				
Atlantic Maritime		no damage reported				
Mixedwood Plains		no damage reported				
Boreal Plains		no damage reported				
Prairies		no damage reported				
Taiga Cordillera		no damage reported				
Boreal Cordillera	Liard Basin	0	0	2	0	0
	Ecozone Total:	**0**	**0**	**2**	**0**	**0**
Pacific Maritime	Nass Basin	14	18	21	73	12
	Mass Ranges	49	12	9	11	14
	Coastal Gap	0	0	16	3	24
	Pacific Ranges	6	32	30	416	446
	Ecozone Total:	**69**	**62**	**76**	**503**	**496**
Montane Cordillera	Skeena Mountains	2	10	12	147	11
	Omineca Mountains	2514	5020	9162	408	2933
	Central Canadian Rocky Mountains	52	0	0	0	0
	Bulkley Ranges	5	258	333	305	322
	Fraser Plateau	162	592	1873	3456	6564
	Fraser Basin	2650	4990	4114	1070	1815
	Chilcotin Ranges	113	86	26	23	1
	Columbia Mountains and Highlands	1586	2403	770	1519	630
	Western Continental Ranges	967	1382	1102	2877	4124
	Interior Transition Ranges	6	23	125	234	86
	Thompson-Okanagan Plateau	14874	14031	6619	3456	69
	Okanagan Range	1295	1761	1041	1168	0
	Okanagan Highland	872	758	243	0	0
	Selkirk-Bitterroot Foothills	1188	2182	666	1755	0
	Southern Rocky Mountain Trench	350	386	177	513	324
	Northern Contlnental Divide	236	79	21	16	10
	Ecozone Total:	**26872**	**33961**	**26284**	**16947**	**16889**
Hudson Plains		no damage reported				
Annual Totals in Canada:		**26941**	**34023**	**26362**	**17450**	**17385**

(All damage is measured in hectares)

Table 10. Mountain Pine Beetle Consecutive Damage by Ecozone and Ecoregion 1992 - 1996

ECOZONE	ECOREGION	Number of Years: 1	2	3	4	5	6	>6	Ecoregion Totals:
Arctic Cordillera		no damage reported							
Northern Arctic		no damage reported							
Southern Arctic		no damage reported							
Taiga Plains		no damage reported							
Taiga Shield		no damage reported							
Boreal Shield		no damage reported							
Atlantic Maritime		no damage reported							
Mixedwood Plains		no damage reported							
Boreal Plains		no damage reported							
Prairies		no damage reported							
Taiga Cordillera		no damage reported							
Boreal Cordillera	Liard Basin	2	0	0	0	0	0	0	**2**
	Ecozone Total:	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**2**
Pacific Maritime	Nass Basin	138	0	0	0	0	0	0	**138**
	Mass Ranges	97	0	0	0	0	0	0	**97**
	Coastal Gap	44	0	0	0	0	0	0	**44**
	Pacific Ranges	654	138	0	0	0	0	0	**792**
	Ecozone Total:	**933**	**138**	**0**	**0**	**0**	**0**	**0**	**1071**
Montane Cordillera	Skeena Mountains	185	0	0	0	0	0	0	**185**
	Omineca Mountains	15622	1760	68	0	0	0	0	**17450**
	Central Canadian Rocky Mountains	52	0	0	0	0	0	0	**52**
	Bulkley Ranges	689	85	30	35	0	0	0	**839**
	Fraser Plateau	11714	366	17	0	0	0	0	**12097**
	Fraser Basin	12440	772	139	0	0	0	0	**13351**
	Chilcotin Ranges	249	0	0	0	0	0	0	**249**
	Columbia Mountains and Highlands	5951	388	14	2	0	0	0	**6355**
	Western Continental Ranges	7451	1076	106	16	0	0	0	**8649**
	Interior Transition Ranges	359	48	6	0	0	0	0	**413**
	Thompson-Okanagan Plateau	31157	3286	234	2	0	0	0	**34679**
	Okanagan Range	3995	448	34	34	0	0	0	**4511**
	Okanagan Highland	1659	80	16	0	0	0	0	**1755**
	Selkirk-Bitterroot Foothills	5468	117	8	0	0	0	0	**5593**
	Southern Rocky Mountain Trench	1653	32	1	0	0	0	0	**1686**
	Northern Contlnental Divide	345	7	0	0	0	0	0	**352**
	Ecozone Total:	**98989**	**8465**	**673**	**89**	**0**	**0**	**0**	**108216**
Hudson Plains		no damage reported							
Consecutive Year Totals in Canada:		**99924**	**8603**	**673**	**89**	**0**	**0**	**0**	**109289**

(All damage is measured in hectares)

Data Sources and Methods of Analysis

National insect defoliation coverages are compilations of aerial survey data collected by CFS and the provinces and territories of Canada for the review period 1980 – 1996. Historically, provincial defoliation coverages were submitted as maps or digital coverages to the regional CFS centres for use in regional reports. The regional coverages were ultimately compiled by CFS to produce national statistics and reports. The national insect defoliation coverages are maintained by the Forest Health Network in a geographic information system (GIS) library using ESRI ArcInfo ® . The GIS resides on a Sun Sparc Ultra II ® running on a Solaris ® operating system housed at the FHN GIS Laboratory, Atlantic Forestry Centre.

The base maps used to illustrate and analyze insect defoliation are:

1. The geographic outline of Canada, a composite created from provincial and territorial maps. It incorporates the political boundaries and major lakes. Projection: Lambert Conformal Conic. Scale varies among the different geographic areas. (Appendix II.)
2. Terrestrial Ecozones and Ecoregions of Canada 1996. Digital map produced by Agriculture and Agri-Foods Canada, Centre for Land and Biological Resources Research, Canada Soil Information System (CanSIS), Ottawa (Ecological Stratification Working Group, 1996). Projection: Lambert Conformal Conic. Scale 1: 7,500,000.

Insect defoliation coverages for the reporting period have been submitted over the years from the NRCan - CFS research centres across Canada. The centres and their provinces of responsibility are as follows:

1. CFS -Atlantic Forestry Centre, Fredericton, New Brunswick. Area of responsibility: Newfoundland, Nova Scotia, New Brunswick, and Prince Edward Island.
2. CFS - Laurentian Forestry Centre, Sainte-Foy, Quebec. Area of responsibility: Quebec.
3. CFS - Great Lakes Forestry Centre, Sault Ste. Marie, Ontario. Area of responsibility: Ontario.
4. CFS - Northern Forestry Centre, Edmonton, Alberta. Area of responsibility: Manitoba, Saskatchewan, Alberta, and Northwest Territories.
5. CFS - Pacific Forestry Centre, Victoria, British Columbia. Area of responsibility: British Columbia and the Yukon.

The datasets are transferred in digital ArcInfo export format from the regional forestry centres in various map projections. The regional map projections are converted to a standard national projection, Lambert Conformal Conic. The national coverages of insect defoliation are displayed 9 99 99 on an ecostratification base map with political boundaries. Analyses show the extent of defoliation for each of the forested ecozones and ecoregions. A complete listing of the terrestrial ecozones and ecoregions of Canada are listed in Appendix I.

Annual regional and provincial coverages of insect defoliation are joined to produce a national coverage of defoliation for each insect by year. National coverages are then overlaid with Canada’s ecostratification base map to produce statistics and graphs that quantify the amount of defoliation within each of the affected ecozones and ecoregions.

Area totals of insect defoliation were calculated for the whole country and for each of the affected ecozones and ecoregions by year. Only moderate and severe defoliation categories were selected for analysis and illustration in maps, graphs, and tables. Moderate damage is defined as 30-69% and severe damage is defined as 70% or greater defoliation to a tree or stand. The analysis was done using the ArcInfo statistics function. A table of areas of moderate and severe insect defoliation and damage by provincial and territorial jurisdiction is presented in Appendix III. These areas have been previously reported in the annual 'Grey Reports' (Forest Insect and Disease Conditions in Canada).

The annual defoliation maps for each insect were overlaid to produce information on consecutive years of defoliation. Moderate and severe levels of defoliation over various time periods result in growth loss and mortality (Piene et al., 1981). Areas of consecutive years of defoliation were calculated by overlaying year-one defoliation coverage with the next chronological year of defoliation to create a new coverage and this was done for each successive year over the 17-year study period. The processes were automated using ArcInfo macro programming language (AML). The final coverage was analyzed to extract area totals where defoliation had occurred in consecutive years and data were categorized by 1 - 2 years, 3 - 4 years, 5 - 6 years, and more than 6 years. Summaries and totals, as well as figures and graphs, were prepared using spreadsheet software.

The insect defoliation coverages for the period (1980 to 1996 inclusive) are complete for spruce budworm, forest tent caterpillar, jack pine budworm, and hemlock looper. The mountain pine beetle coverages for 1992 to 1996 inclusive are complete for British Columbia but, although data from other regions are known to exist, they were unavailable at time of publishing.

The data must be treated with caution as the basic information varies greatly from one place to another. Researchers and forest managers try to use the most up-to-date methods of data collection and analysis and every effort is made to ensure that the data represents the actual forest conditions. However, sketch-mapping techniques are often imprecise and standards of data collection and processing vary among organizations. The area within which moderate and severe defoliation or damage occurs may also include non-forested areas such as roads, cultivated land, small lakes, and burned areas. In addition, some areas of defoliation or damage may be missed in the surveys.

The coverages and statistics are based on the best available data at time of reporting. The regional and national GIS libraries of insect coverages may be updated as a result of quality assurance checks or as additional maps become available that broaden the historical timeline for some of their insects.

Results

The defoliation maps for each insect show the extent of moderate and severe defoliation for their respective review period (Figs. 1, 5, 9, 13, and 17).
Spruce budworm defoliation (Fig. 1) extended from coast to coast and is present in all of

Canada's forested ecozones, covering a total area of 69.0 million hectares over the 17-year period.

Forest tent caterpillar defoliation (Fig. 5) spanned all of the forested ecozones except the Taiga Shield. A total area of 80.6 million hectares was defoliated over the 17-year period.

Jack pine budworm (Fig. 9) defoliated a total area of 11.3 million hectares in the central provinces of Canada, in the Boreal Plains, and in the central and western portion of the Boreal Shield.

Hemlock looper (Fig. 13) defoliated over 325 000 hectares from 1983 - 1996 in eastern Canada, in the Atlantic Ecozone and in the eastern part of the Boreal Shield.

Mountain pine beetle (Fig. 17) damage is found in western Canada, in the Montane Cordillera and to a lesser extent in the Pacific Maritime ecozone. Damage extends over a total area of 109 000 hectares for the 1992-1996 reporting period. Mountain pine beetle damage is known to be present in the Boreal Plains, but data were not available in digital format for inclusion in this report.

Figures 2, 6, 10, 14, and 18 present a temporal map sequence of defoliation for each insect, illustrating overall trend and fluctuation in defoliation in the forested ecozones across Canada.

Figures 3, 7, 11, 15, and 19 depict insect defoliation by ecozone, with histograms showing the area and trend in defoliation by year over the review period 1980 - 1996.

Over the 17-year study period, the spruce budworm defoliation trend in Canada has declined from 28 million hectares in 1980 to 1.8 million hectares in 1996 (see histogram in Fig. 2 and details in Table 1). The ecozones with the greatest defoliation are the Boreal Shield and Atlantic Maritime, with both ecozones showing a dramatic decline over the 17 years (Fig. 3).

Forest tent caterpillar defoliation declined from a peak of 23 million hectares in 1981 to 6.9 million hectares in 1984 (Fig. 7, Table 3). This was followed by a sharp increase to 20 million hectares of defoliation in 1988; it dropped off again to 1 million hectares in 1993. Since 1994, there has been a slight increase to 1.3 million hectares in 1996. There was a shift in distribution of defoliation between ecozones from Boreal Plains to Boreal Shield over the study period (Fig. 7).

Jack pine budworm defoliation peaked at 5.9 million hectares in 1985 (Table 5 and Fig. 11). It declined in 1986 and remained relatively low but persisted throughout the remainder of the period (Fig. 10).

Hemlock looper defoliation peaked in 1987 in Eastern Canada (Table 7 and Fig. 15) in the Boreal Shield. There was an increase from 1984 to 1987 and then a sharp decline in 1988. This insect first showed up in the Atlantic Maritime ecozone in 1989.

Mountain pine beetle infestation and damage was persistent throughout the 5-year reporting period and showed a decline from 34 000 hectares in 1993 to 17 000 hectares in 1996 (Table 9 and Fig. 19).

The maps of consecutive years of insect defoliation illustrate areas that have been moderately or severely defoliated in consecutive-year classes (Figs. 4, 8, 12, 16, and 20). Consecutive-year defoliation analysis was done to determine which areas were defoliated for several consecutive years. The analysis of consecutive defoliation reflect areas that were defoliated for 1 - 2 years, 3 - 4 years, 5 - 6 years and >6 years. It should be noted that year 1 is the first year of defoliation for an area. In addition to providing data on cumulative damage, this analysis illustrates trends of insect movement as indicated by new areas (year 1) of defoliation.

Consecutive-year analysis shows that, of the 96 million hectares defoliatied by spruce budworm over the 17 years, 9% was defoliated for more than 6 consecutive years (Table 2).

Forest tent caterpillar consecutive-year analysis shows that, of the 80.6 million hectares defoliated over the 17 year period, 21.2% was defoliated for 3 or 4 years consecutively. Consecutive-year defoliation for forest tent caterpillar was minimal over 4 years (Table 4).

Jack pine budworm consecutive-year data show that, of the 11.2 million hectares defoliated over the 15 year period, 23.7 % was defoliated 2 years consecutively and only 5.7% was defoliated for more than 2 years consecutively (Table 6).

Hemlock looper consecutive-year defoliation shows that, of the 0.32 million hectares defoliated over the 14-year period, 8.3% was defoliated for 2 consecutive years and areas defoliated consecutively for more than 2 years were minimal (Table 8).

The mountain pine beetle is not a true defoliator but attacks the tree through its vascular system, with mortality occurring after 1 or 2 years of attack (van Sickle, 1995). Mountain pine beetle data describe areas within which trees have been killed by the beetles. Data indicate that there are areas where the mountain pine beetle has been detected for 4 consecutive years (Table 10). This inconsistency is thought to be a result of survey methods whereby areas or stands having damage are reported; it does not necessarily mean that the damage reported each year is to the same trees within that area.

It should be noted that survey methodology varies by region and province in the intensity of the surveys relative to the size of the land mass and areas of defoliation to be surveyed, the level of detail needed for forest and pest management planning, and available resources. These factors weigh heavily on the outcome of data analysis and on consecutive-year analysis in particular, as any discrepancies will be compounded when overlaid.

Discussion and Future Direction

The Forest Health Network GIS is an important reference tool for measuring and visualizing insect disturbance in Canada's forested ecosystems. What was previously reported nationally on a jurisdictional framework is now presented on an ecosystem basis. This facilitates the reporting of forest health and related issues that transcend political and institutional boundaries. The difference and main advantage to an ecologically based hierarchical format of analysis is that it adds dimension not possible with jurisdictional reporting.
The selected pests are generally the most significant forest insect pests that defoliate or damage trees and can cause mortality in our forests over vast areas. The analyses presented in this report conform to a new and improved way of meeting national and international reporting needs for insect disturbance statistics, but also demonstrate the analytical advantages of an ecological classification framework. A list of only five insect pests with associated data over a relatively narrow time frame limits long-term analyses, but the methodology demonstrates an approach for producing cartographic products and numerical statistics for these and other insect pests. The goal will be to expand these datasets historically for as far back in time as aerial survey data can be compiled and to append annual coverages as they become available in future years.

While much of this report created fundamental forest insect defoliation statistics on an ecological classification framework, the overlays of consecutive years of defoliation provide a relative measure of the impact of these insects on our forested ecosystems. Depletion estimates are no longer analyzed and reported by CFS in partnership with the provinces.

Defoliation data as structured and shown in this report have greater interpretive value and analytical potential for other issues of concern in the forest science community. As the ecological datasets for these insects are expanded historically, their interpretive value increases; for example, long-term trend analyses correlated with climate change scenarios, multiple stress analyses on forests at the ecozone level, or pest outbreak frequency or length of outbreak episode relative to atmospheric pollution or forest management practices.

The following objectives are proposed to expand the use of insect defoliation data held in the National Forest Health GIS and to explore development of its full potential as an indicator of the health of Canada's forested ecosystems:

1. The FHN will continue to manage the development and growth of forest insect defoliation data for Canada, given the continued participation and support by provinces and territories through the acquisition and incorporation of insect defoliation coverages.

2. The FHN will develop the FHN GIS through acquisition of insect defoliation coverages that broaden the historic timeframe and geographic range for the major forest insects as well as those of a more regional concern or limited distribution.

3. The FHN will further develop and maintain metadata for the insect defoliation coverages and make them more accessible to interested organizations.

4. The FHN will promote the use and development of the insect defoliation coverages through partnerships with other organizations and collaborators at CFS research centres.

5. The FHN will encourage all agencies to standardize survey and recording methodologies that will facilitate data integration and analyses.

6. The FHN will develop the FHN GIS through acquisition of coverages of forest diseases, and anthropogenic and abiotic forest conditions.

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CFS - Northern Forestry Centre, Edmonton, AB
CFS - Pacific Forestry Centre, Victoria, BC

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