Alberta Beekeepers Over-Wintering Loss Survey 2007

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Executive Summary

In the spring of 2007, Alberta beekeepers found higher than average winterkill losses in over-wintered bee colonies. To determine the extent of winterkill, Alberta Agriculture and Food conducted a survey of 112 beekeepers with 400 or more colonies.

Survey results show that 30 percent of Alberta bees were killed in the 2006 / 2007 winter. This reported winterkill is twice the long-term average in Alberta but is in line with this year's Canadian average (29 percent). The survey also reveals that 15 percent of the surviving colonies were weak with less than 3 frames covered with bees. The survivorship and production of these weak colonies in 2007 is questionable.

The winterkill plus weak colonies percentage was lowest in region 1 (southern Alberta), followed by central regions 2, 3 and 4, and region 5 (Peace River area) was the highest. Overall in the province, 50 percent of the beekeepers reported losing about half of their productive hives in 2007 due to winterkill and weak colonies.

The responses in this survey indicate that disappearance or starvation were not major factors in the higher overwinter losses in Alberta. The data also reveals that loss rates cannot be attributed the Colony Collapse Disorder (CCD) currently in the United States.

Over-winter losses in Alberta during 2006 / 07 may be attributed to a combination of several potential causes:

- The unusual weather conditions during the 2006 bee season encouraged the retention of summer bees and reduced the production of winter bees.
- The late arrival of spring in 2007 prolonged winter stress and delayed availability of spring forage.
- Varroa mites unexpectedly developed resistance to applied miticides. Consequently, mite populations were higher than normal in bee colonies and damaged winter bees.
- The early onset of winter made it difficult to treat varroa with alternative products to protect winter bees.
- The late treatments also increased the stress on hives, making them more vulnerable to winterkill factors.
- In spring 2007, beekeepers reported higher than normal incidence of Nosema-like symptoms. The percentage infection with Nosema-like symptoms was positively correlated with winterkill and winterkill plus weak colonies. Though beekeepers feed medicated sugar syrup in the fall to control Nosema, the chemotherapy did not work well in some cases. The failure of treatment is under investigation.
- Viruses and other pathogens were often present as a secondary infection and this added stress to over-wintering colonies.

The potential causes for overwinter losses outlined in this survey are in agreement with reports from other provincial apicultural specialists.

Introduction

In the spring of 2007, Alberta beekeepers were finding high winterkill losses in over-wintered bee colonies. To determine the extent of winterkill damage, Alberta Agriculture and Food conducted a survey of 112 beekeepers with 400 or more colonies. This bee loss and management survey (Appendix 1) containing approximately 40 questions was conducted by the Ag-Info Centre in May, 2007. Eighty-six responses were received (77% response rate). The responses represent 164,000 colonies, which is two-thirds of all colonies in Alberta. The data is summarized by five agricultural regions (Appendix 2). Regions 2 and 3 have a limited number of beekeepers and responses and their data is considered weak in comparison to the other regions. Statistical differences were determined by t-tests.

Results

From the descriptive statistics in Table 1, there were differences in the over-wintering methods in the various regions. Beekeepers in central regions 2, 3 and 4 primarily over-wintered hives outdoors in Alberta. In the south region, the majority of hives were over-wintered outdoors in Alberta, but there were also a significant portion (25%) of hives over-wintered indoors. In region 5 (Peace River region), most (46%) hives were over-wintered indoors, with the remainder equally divided between over-wintered outdoors in Alberta and British Columbia.

Table 1. Beekeeper Respondent Descriptive Statistics of Owned Colonies and Wintering

Descriptive Statistics	Regions					Overall
	1	2	3	4	5	
Total over-wintered Alberta colonies in fall 2006						
# of cases	16	5	10	24	31	86
# of colonies	47814	11869	13803	37839	52728	164053
% of total colonies	29	7	8	23	32	
Average colonies	2988	2374	1380	1577	1701	1908
Median colonies	1743	2375	968	817	1287	1090
Over-wintered colonies outdoor in Alberta						
# of cases	13	5	10	23	19	70
# of colonies	34004	11169	12547	32119	14441	104280
Average colonies	2616	2234	1255	1397	760	1490
Median # of colonies	1300	2375	740	807	550	788
Over-wintered colonies indoor in Alberta						
# of cases	4	1	2	4	16	27
# of colonies	12010	700	1256	5720	24263	43949
Average colonies	3003	N/a	628	1430	1516	1628
Median colonies	950	N/a	628	260	1287	1050
Colonies from Alberta over-wintered outdoors in British Columbia						
# of cases	2	0	0	0	8	10

# of colonies	1800	-	-	-	14024	15824
Average colonies	900	-	-	-	1753	1582
Median colonies	900	-	-	-	1300	1250

Ignoring the few cases in region 2, the largest beekeeper operations (average and median colonies) were in the south region, followed by region 5. In most regions, averages are skewed by a few large beekeeping operations, and thus the median (value where half the cases are higher and half are lower) better represents the “middle” or central value.

<u>2006 crops for bee forage</u>

Almost all responses indicated that 2 or more crops were the source of bee forage. Honey produced in Alberta is mainly multifloral. Overall beekeeper responses, the percentage of times various crops were indicated: canola (92%), clover (81%), hay (78%) and other (27%). Other crops were mainly alfalfa or borage.

<u>Canola seed pollination</u>

Twelve (14%) of the responses indicated canola hybrid seed pollination, which involved beekeeper operations containing 23% of all Alberta hives. Most (9 /12) of these were from region 1 and this represented more than 1/2 of the hives in that region. Two producers indicated only canola as the crop source. Most beekeepers move hives to another crop after hybrid seed pollination is completed. The canola hybrid seed industry in southern Alberta required about 45,000 hives in 2006, and 60,000 hives are estimated for 2007 (industry data provided to Dr. Nasr). There were 18434 rented hives in 2006, all in the south. These are used for the hybrid canola seed pollination industry in southern Alberta.

<u>Honey production</u>

Honey production in 2006 by these commercial beekeepers was generally quite high (Table 2). The previous 5 year honey production average in Alberta has been between 110 and 134 lb / hive (Alberta Agriculture Statistics Yearbook, 2005). Honey production in region 1 is lower, partly due to high stocking rates needed for hybrid canola seed pollination.

Table 2. Beekeeper Respondent 2006 Honey production lbs / hive

Descriptive statistics	Region					Overall
	1	2	3	4	5	
# of cases	15	5	10	24	29	83
Average lbs per hive	160	250	219	251	173	203

<u>2006 precipitation</u>

The survey asked beekeepers to rate their summer and fall precipitation (low, medium or dry). In the regions 1 to 4, the majority of beekeepers rated summer and fall moisture conditions as medium. In the Peace region 5, the majority rated the summer and fall as dry. This generally agrees with the Alberta precipitation map for September through October of 2006 (appendix 3). However, the Alberta precipitation map for May through August shows that drier conditions than normal were experienced in regions 1 and 4 as well as the Peace region 5 (Appendix 4). The dry summer and fall probably explains the lower honey production in the Peace region compared to central regions.

Winterkill and weak colonies

There is trend for winterkill to increase from south to north in Alberta – region 1 has the least, followed by region 2, then regions 3 and 4, and the Peace region is the highest (Table 3). The winterkill is generally similar within a region between the various wintering methods. The value of 13% for indoors in region 3 is based on only 2 responses and thus is of limited credibility. However, the winterkill indoors in region 5 is lower than the other wintering methods in that region (p=0.03). The winterkill percentage was not statistically related to weak colonies. Weak colonies appeared higher in regions 3 and 5.

The winterkill plus weak colonies percentage was lowest in region 1, followed by central regions 2, 3 and 4, and region 5 was the highest. Overall in the province, 50% of the beekeepers reported losing about half of their productive hives in 2007 due to winterkill and weak colonies. The Peace region suffered the highest losses. Although the Peace region reported more dry summer and fall conditions, there was not a difference in winterkill between the dry and medium groups in that region. The higher winterkill in Peace is likely due to a combination of many weather and management factors, some of which will be discussed later in this report.

Table 3. Beekeeper Respondent Winterkill and Weak Colonies

Descriptive statistics	Region					Overall
	1	2	3	4	5	
Winterkill 2006/2007						
Average % winterkill outdoor AB	17	32	22	33	47	32
Average % winterkill indoor AB	17	30	13	31	34	29
Average % winterkill outdoor BC	17	-	-	-	45	40
Average winterkill % in region	17	32	22	33	39	31
Median winterkill % in region	15	30	20	29	35	30
Winterkill in previous 5 years						
Average % winterkill previous 5 yr	14	17	17	17	22	18
Weak colonies in spring 2007						
Average weak colonies %	9	13	21	11	21	15
Winterkill and weak colonies in 2006/2007						
Average % winterkill + weak colonies	27	45	43	43	60	46
Median % winterkill + weak colonies	22	50	39	41	60	48
Estimated number of hives out of production in 2007 due to winterkill and weak colonies from this survey	14624	5103	6118	18027	31979	75852

Bee disappearance and starvation

The majority of responses did not report disappearance (63%) or starvation (72%) as shown in Table 4. Overall, winterkill tended to be higher in the group that reported disappearance (not statistically significant, p=0.10), and region 1 had a statistically significant difference (15% winterkill in no versus 23% in yes group, data not shown). There were no statistically significant differences in the starvation response groups for winterkill. The responses in this survey indicate that disappearance or starvation were not major factors in the higher over-winter losses in Alberta and that colony collapse disorder (as described in the USA) was not prevalent in Alberta.

Table 4. Bee disappearance and starvation responses.

Descriptive statistics	Region					Total	Overall Winterkill (%)
	1	2	3	4	5		
Disappearance:	Numbers of responses						
# of No responses	11	2	3	15	19	50	29
# of Yes responses	5	3	6	7	8	29	34
Starvation:							
# of No responses	7	4	9	19	23	62	31
# of Yes responses	9	1	1	5	8	24	32

<u>Nosema</u>

The majority (76%) of responses indicated that Nosema-like infection symptoms were noticed in the spring of 2007, and there were no large differences by region. The symptoms of Nosema infection include disjointed wings, distended abdomens and fecal materials on combs. The particular symptom of fecal materials on combs is often correlated with dysentery. When dysentery occurs, the disease is aggravated and effectively spread in the colony and the colony deteriorates beyond help. Microscopic confirmation was not conducted, but samples from dead colonies are being processed to confirm finding Nosema spores. Therefore, infection is referred to in this report as Nosema-like infection. The winterkill percentage was not statistically different ($p=0.15$) between the no and yes groups overall. However, the yes group in region 1 reported statistically higher winterkill compared to the no group (data not shown).

In the yes group reporting Nosema-like infection, the percentage of colonies infected differs between regions: the south is the least, and the Peace region is highest. The distributions are skewed by a few high estimates since the average is much higher than the median value.

Table 5. Nosema-like infection responses.

Descriptive statistics	Region					Total	Overall Winterkill (%)
	1	2	3	4	5		
Nosema-like symptoms noticed	Number of responses						
# of No responses	6	0	1	5	8	20	34
# of Yes responses	10	4	9	19	23	65	30
Yes group only	% colonies with Nosema-like symptoms						
Average	13	33	15	36	45	33	
Median	5	18	4	25	33	15	
% using fall fumagillin	63	0	60	75	81	69	

Associations between the percentage of Nosema-like infection and winterkill or weak colonies were as follows:

1. Assuming all the No responses to the question about symptoms noticed in spring have 0% Nosema infected colonies, then the correlation between % Nosema and % winterkill was not statistically significant (r^2=0.03, p=0.11). However, a positive correlation between Nosema and winterkill + weak colonies was statistically significant (r^2=0.10, p=0.003). This low r^2 value shows that Nosema does not explain much of variation in winterkill + weak colonies.
2. Using only the Yes responses to Nosema symptoms noticed in the spring, positive correlations between Nosema and winterkill or winterkill + weak colonies were both statistically significant (r^2=0.11, p=0.01 and r^2=0.14, p=0.003, respectively). Again, these low r^2 values show that Nosema does not explain much of the winterkill variation.
3. Using only region 5 data (highest Nosema and highest winterkill), there was not a significant correlation of percent colonies infected with Nosema and winterkill percentage (p=0.61), or weak colonies (p=0.15) or winterkill plus weak colonies (p=0.08).

Overall, Nosema infection in the spring of 2007 is associated with slightly higher winterkill and weak colonies. In northern climates, Nosema is considered as a silent killer of honey bees, and an infection often will increase winterkill and weak colonies in the spring. Although most (69%) of the beekeepers in this survey fed Nosema medication (fumagillin) in their fall feed, the strong honey flow in the fall and early onset of winter decreased the take-up of the medication and thus efficacy was poor. The group that fed fumagillin in the fall of 2006 reported slightly lower incidence of Nosema symptoms in the spring of 2007 than the group that did not fall treat (data not shown, 71% versus 88%). However, the percentage of colonies infected by Nosema was not statistically different (p=0.31) between the fall fumagillin treated and untreated groups overall.

<u>Varroa mites</u>

The majority of respondents (58%) found varroa mites in the spring of 2007 (Table 6) in spite of most (81%) beekeepers having treated in the fall of 2006 (Table 9). The efficacy of fall varroa mite treatments appears limited. In the fall untreated group, 69% reported varroa the next spring, compared to 49% in the treated group. The most popular varroa spring 2007 treatment was Apistan (Table 7) whereas formic acid was the most popular in the fall of 2006 (Table 9). In the spring of 2006, the most popular varroa treatment was untreated. Beekeepers apparently are treating more for varroa, and rotating varroa mite control products to avoid or deal with resistance. While 42% of the respondents did not report finding varroa in the spring of 2007, only 22% did not treat in the spring of 2007. The winterkill or winterkill plus weak colonies percentages were similar between the no / yes groups for varroa presence in the spring 2007 (p=0.52 and 0.14 respectively).

Table 6. Varroa mites found in spring of 2007

Descriptive statistics	Region					Total	Overall winterkill %
	1	2	3	4	5		
# of No responses	7	3	4	11	11	36	31
# of Yes responses	9	2	6	13	20	50	32

Table 7. Varroa spring 2007 treatments.

Treatment method	Responses
A	26
A,F	7
A,F,O	1
A,O	3
C	13
C,A	2
C,A,F	1
C,F	2
C,O	1
F	6
N	18
N,F	1
O	4
Total	85

Percentage of responses that included treatment:				
None	Apistan	CheckMite	Formic	Oxalic
22	47	22	21	11

A – Apistan; C - CheckMite; F - Formic acid; N – none; O – oxalic acid.

Table 8. Was there enough time to treat for varroa mites in the fall 2006?

Descriptive statistics	Overall	Overall winterkill %
# of No responses	23	31
# of Yes responses	60	32

Table 9. Varroa fall 2006 treatments and effects on winterkill and weak colonies.

Treatment method	Responses
A	9
A,F	6
A,O	5
C	15
C,F,O	1
C,O	3
F	26
F,O	1
N	16
O	3
Total	85

Percentage of responses that included treatment:				
None	Apistan	CheckMite	Formic	Oxalic
19	24	22	40	14
Percentage winterkill in treatments:				
24	36	38	30	44
Percentage weak colonies in treatments:				
18	14	13	13	23

A – Apistan; C – CheckMite; F -- Formic acid; N – none; O – Oxalic acid.

The majority of respondents (81%) treated for varroa mites in the fall of 2006, and formic acid was the most popular treatment. The majority (72%) of beekeepers had enough time to treat for varroa mites in the fall of 2006 after harvesting honey (Table 8). There was no difference in winterkill between these no and yes groups.

Varroa mite fall treatment was associated with increased winterkill (p=0.01): the untreated group winterkill was 24% versus 33% for fall varroa treatments. This trend was consistent in each region (data not shown). This association may be due to poor control by the treatments due to weather and resistance, and added stress of the treatments predisposing the colony to other winterkill factors. For example, after noting failure of treatments by Apistan or Check-Mite, some beekeepers then treated with formic or oxalic acid late in the fall, but the early cold onset of winter greatly reduced the efficacy of the treatment yet added stress to the honey bees. The weak colony percent was not statistically different (p=0.47) between the treated and untreated groups.

The majority of respondents treated for varroa mites in the spring of 2006 (Table10). There was no statistically significant difference between the untreated and popular treatments (Apistan, Check-Mite) for winterkill the next winter. In the spring varroa treatments, 50% of the untreated responses were from region 5 in both 2006 and 2007.

Table 10. Spring 2006 Varroa mite treatments.

Treatment method	Responses	Percentage of responses that included treatment:				
A	22	None	Apistan	CheckMite	Formic	Oxalic
C	17	33	27	24	15	8
C,A	1					
C,F	1	Percentage winterkill in treatments containing:				
C,O	1	29	26	35	40	47
F	9					
F,O	3					
N	28					
O	3					
Total	85					

A – Apistan; C – CheckMite; F -- Formic acid; N – none; O – Oxalic acid.

Most of the respondents (73% and 71% respectively) indicated that they did not know if they had varroa resistance to Check-Mite or Apistan. However, these two questions could be interpreted two ways. One interpretation is whether they know if they have resistance (yes could mean they know, and it could be resistant or not). Another interpretation is whether they have resistance to the treatment (yes they have resistance to the treatment; or no they don’t have resistance to the treatment).

<u>Tracheal mites</u>

The majority of respondents do not treat for tracheal mite in the spring (2007,Table 11; 2006 Table 13) whereas the majority (62%) treated for tracheal mites in the fall of 2006 (Table 12). When treating for tracheal mite, most beekeepers use formic acid. Region 5 had a proportionally high amount of untreated responses in every treatment period (spring 2007 – 40%; fall 2006 - 55%, and spring 2005 – 40%). However the fall untreated group in region 5 were predominantly beekeepers that wintered hives indoors, and thus did not experience higher winterkill or weak colonies than the treated group (data not shown).

There was no difference in winterkill between fall tracheal mite treatments and untreated groups (both 31%). In contrast, there was an increase in weak colonies in the group that was not fall treated for tracheal mite (p=0.04). In the group that did not fall treat for varroa mites, they generally (81%) did not fall treat for tracheal mites either. Keep in mind that formic acid can be used to treat for both varroa and tracheal mites, with more applications needed for varroa. Thus if a beekeeper treats for varroa with formic acid, then tracheal mites will also be controlled. There was lower winterkill in the untreated group versus the group of all spring 2006 tracheal mite treatments (p=0.05). There is not a good explanation for this result and it likely is just due to chance.

Table 11. Tracheal mite treatment in spring 2007.

Treatment method	Responses		Percentage of responses that included treatment:			
F	21		None	Formic	Oxalic	Other
N	49		62	28	5	10
N.F	1					
Ot	6					
Ox	1					
Ox,F	1					
Ox,Ot	2					
Total	81					

F- formic acid; N – none; Ot – other treatments; Ox – oxalic acid.

Table 12. Fall 2006 tracheal mite treatments.

Treatment method	Responses		Percentage of responses that included treatment:			
F	41		None	Formic	Oxalic	Other
N	33		38	50	3	10
Ot	9					
Ox	1		Percentage of weak colonies in treatments:			
Ox,F	2		None		All fall treatments	
Total	86		19		13	

F- formic acid; N – none; Ot – other treatments; Ox – oxalic acid.

Table 13. Tracheal mite treatments in spring 2006.

Treatment method	Responses		Percentage of responses that included treatment:			
F	19		None	Formic	Oxalic	Other
N	48		57	26	8	13
Ox,Ot	1					
Ot	10					
Ox	3		% winterkill in treatments containing:			
Ox,F	3		27	34	32	33
Total	84					

F- formic acid; N – none; Ot – other treatments; Ox – oxalic acid.

<u>American foul brood</u>
The majority of respondents treated for American foul brood in the spring of 2007, usually with oxytetracycline (Table 14).

Table 14. American foul brood treatments in spring 2007.

Treatment method	Responses		Percentage of responses that included treatment:		
N	30		None	Oxytetracycline	Tylosin
O	43		36	52	13
O,T	1				
T	10				
Total	84				

N – none; O – oxytetracycline; T – Tylosin.

<u>Fall feed</u>
Nearly all the respondents used sugar syrup as the fall food source (Table 15) and most respondents reported that bees took the fall feed source down in the hive (Table 16).

Table 15. Fall 2006 Bee Feed Source.

Fall Food Source	% of responses
Corn syrup	5
Sugar syrup	94
None	1

Table 16. Observations on bees taking fall food source into hive.

Did bees take feed down	% of responses
No	7
Yes	93

The majority of respondents (62%) reported that brood chambers were plugged with honey, and the winterkill was similar between the no and yes groups (Table 17).

Table 17. Brood chambers filled with honey.

Region	1	2	3	4	5	Prov	Overall winterkill %
# of No responses	8	1	7	4	12	32	30
# of Yes responses	8	4	3	19	18	52	32

Time for development of winter bees

The majority of respondents (62%) felt that there was enough time for winter bees to develop in the fall of 2006 (Table 18). There was more winterkill ($p=0.02$) in the group reporting not enough time and this was consistent in each region (data not shown).
The early onset of winter (see November 2006 average temperature departure from normal, appendix 5) contributed to the poor winter bee development in some cases.

Table 18. Was there enough time in the fall for winter bees to develop?

Descriptive statistics	Region					Total	Overall winterkill (%)	Overall weak colonies (%)
	1	2	3	4	5			
	number of responses							
No responses	0	1	2	5	3	11	36	13
Not sure	2	1	3	8	7	21	37	17
Yes responses	14	3	5	11	20	53	28	15

Conclusions

Survey results show that 30% of Alberta bees were killed in 2006 / 2007 winter. The reported winterkill is twice the long-term average in Alberta. It was also reported that 15% of the surviving colonies were weak with less than 3 frames covered with bees. The recovery of these weak colonies was hindered by the cold spring. The survivorship and production of these weak colonies in 2007 is questionable. The winterkill plus weak colonies percentage was lowest in region 1, followed by central regions 2, 3 and 4, and region 5 was the highest. Overall in the province, 50% of the beekeepers reported losing about half of their productive hives in 2007 due to winterkill and weak colonies. The Peace region suffered the highest losses.

Obviously, wintering losses have plagued beekeepers for decades, but this year losses are substantial across various regions in Alberta. Even within the same bee operation one side of the operation suffered from heavy losses, but on the other side the winter mortality was considered average winter mortality.

In Canada, the overall over-winter mortality in 2006 / 2007 appears to be 29%, which is twice the long-term average (15%). Average wintering losses in certain provinces such as New Brunswick (59%, representing only 3% of the country's colonies) and Ontario (37%, representing 11.7% of the country colonies) were very high in 2006-07. The reported high regional losses are of much greater concern across Canada.

This year, losses in Alberta may be attributed to a combination of several potential causes:

1. **The unusual weather conditions during the 2006 bee season and production of winter bees.** Some regions of Alberta suffered from lack of rain in early summer, which affected the canola honey crop and the bee biological cycle. In mid to late summer, good rainfall was reported in several regions that prolonged the nectar flow of clover, especially in the second cut. Beekeepers in the regions of late nectar flow were able to make an above average honey crop. On the other hand, bees were not able to produce winter bees in these regions. The brood chambers plugged with honey caused inadequate room for queens to lay eggs to produce winter bees. This situation combined with the short fall season followed by early winter made it difficult for bees to survive this past winter.

   This unusual climate made the bees cycle out of sync with the season. Consequently, summer bees remained for wintering and not enough winter bees developed for winter. Winter bees, reared from August into October, do not immediately begin hive work. They are physiologically adapted to survive winter and they have a life expectancy of about six months. If summer bees comprise the colony population that goes into winter, as the summer bees get older they die leaving a small cluster of bees. Therefore, the bees lose their ability to thermo-regulate their cluster and the colony dies. In addition, the prolonged winter with no break in the cold weather through late March and early April aggravated the problem in northern and central regions of Alberta. In these regions, honey bees wintered out doors were not able to defecate in early spring. Consequently, high percentages of colonies died or were weakened by high levels of Nosema.

2. **Reported failure of chemical control of varroa mites.** In fall 2006, Alberta bee inspectors who examined bees to issue health certificates for moving bees to winter in British Colombia or for the small hive beetle reported failure of chemical control of varroa mites. Varroa mites unexpectedly developed resistance to applied miticides. Consequently, mite populations were higher than normal in bee colonies and these mites had enough time to damage winter bees. In fact, in some operations, the bee inspectors found that mites survived Apistan and CheckMite applied to bee colonies for several weeks. This has made it very difficult to treat varroa in an acceptable time with alternative products to protect winter bees. The late treatments also increased the stress on hives, making them more vulnerable to winterkill factors. These varroa-infested and treatment-stressed bees could not withstand winter, resulting in increased viral infections in bee colonies and loss of ability to thermo-regulate their cluster.

3. **Nosema.** Nosema is often responsible for winter loss, late winter and early spring dwindling and supersedure. In spring 2007, beekeepers reported higher than normal incidence of Nosema-like symptoms. Assuming Nosema-like symptoms were caused by Nosema, the percentage infection by Nosema was positively correlated with winterkill and winterkill plus weak colonies. Though beekeepers feed medicated sugar syrup in the fall to control Nosema, the chemotherapy did not work. The failure of treatment is under investigation. In addition, prolonged winter with few breaks in the cold weather increased the incidence of Nosema-like symptoms in northern and central regions of Alberta.

4. **Viruses and other pathogens as a secondary infection**. Sac brood and chalk brood were found in weak colonies that survived winter. These colonies could not withstand the 2007 cold spring in Alberta. The population of bees in a large percentage of these colonies continued to decline, queens superseded and eventually died.

The causes of bee losses in Alberta are in agreement with reports from other provincial apicultural specialists. Initial indications suggested that high wintering losses may be attributed to: ineffective control for the parasitic mite *Varroa destructor;* unusual fall and winter weather across the country; and a late, wet spring in most areas prolonging winter conditions for bees and restricting their access to suitable spring forage.

Appendix 1

Survey questions

Alberta Bee Winter Kill in 2006/2007
Alberta Agriculture and Food – Agriculture Research Division

All information collected is protected and confidential.

a. Beekeeper Name: ________________________________
b. City/Town: _________________________
c. Telephone _________________________
d. Number of colonies wintered in fall of 2006: ___________________
e. Percentage winter-killed colonies found in spring 2007: ___________%
f. Number of colonies wintered outdoors in Alberta in fall of 2006: ___________________
g. Percentage winter kill for outdoor wintered colonies in Alberta: _________%
h. Number of colonies wintered indoors in Alberta in fall of 2006: ___________________
i. Percentage winter kill for indoor wintered colonies in Alberta: _________%
j. Number of colonies wintered outdoors in B.C. in fall of 2006: ___________________
k. Percentage winter kill for outdoor wintered colonies in BC: ____________%
l. Percentage of weak colonies with cluster 3 frames or less of bees in spring 2007: _____%
m. Percentage of colonies with cluster between 4-8 frames of bees in spring 2007: ________%
n. Percentage of colonies with cluster above 8 frames of bees in spring 2007: _______%
o. 2006 crops in your area: Canola (__) Clover (__) Hay (__) others (_______________)
p. Average 2006 honey production: ________________lb /hive
q. Rain in summer 2006: Heavy ____ Moderate ____ Dry ____
r. Rain in fall 2006: Heavy ____ Moderate _______ Dry ______
s. Average percentage winter mortality in the previous 5 years: _____%
t. Do you pollinate canola seed fields commercially: Yes (___) No (___)
u. Number of colonies rented in 2006 (___)

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Spring 2007 management and observations:

v. Did bees disappear: Yes (___) No (___)
w. Did bees starve: Yes (___) No (___)
x. Did you see any Nosema infection symptoms: Yes (___) No (___)
y. Percentage of colonies with Nosema infection signs:____%
z. Did you see varroa mites in spring 2007: Yes (___) No (___)
aa. Varroa treatment in the spring 2007:
None (___) CheckMite (___) Apistan (___) Formic Acid (___) Oxalic acid (___)
ab. Tracheal mite treatment in Spring 2007:
None (___) Formic Acid (___) Oxalic acid (___) Others (____________________)
ac. American Foul Brood Treatment: None (___) Oxy tet (___) Tylosin (___)

Fall 2006 management and observations:

ad. What did you feed bees in the fall:

Nothing (___) Sugar syrup (___) Corn syrup (___)

ae. Did the bees take the feed down: Yes (___) No (___)
af. Did you feed Fumagillin in the fall of 2006: Yes (___) No (___)
ag. Were brood chambers plugged with honey in the fall of 2006: Yes (___) No (___)
ah. Do you think your bees had enough time to produce winter bees for 06/07 winter:
Yes (___) No (___) Not sure (___)
ai. Did you have enough time to treat for varroa after harvesting honey in 2006: Yes (___) No (___)
aj. Varroa treatment in the fall of 2006:

None (___) CheckMite (___) Apistan (___) Formic Acid (___) Oxalic acid (___)

ak. Do you know if your varroa has resistance to CheckMite: Yes (___) No (___)

al. Do you know if your varroa has resistance to Apistan: Yes (___) No (___)

am. Tracheal mite treatment in the fall of 2006:

None (___) Formic Acid (___) Oxalic acid (___) Others (____________________)

Spring 2006 management:

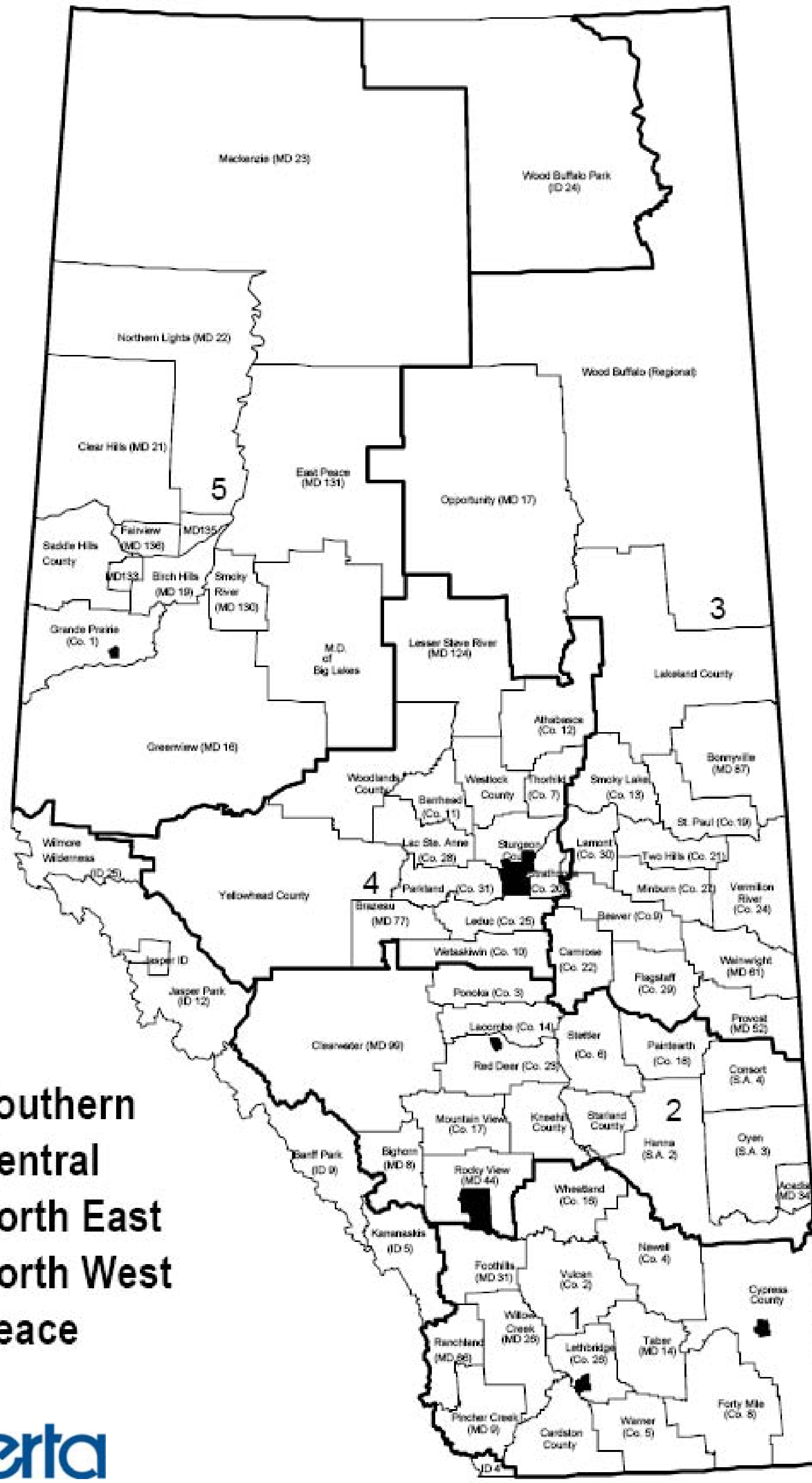
an. Varroa treatment in the spring of 2006:

None (___) CheckMite (___) Apistan (___) Formic Acid (___) Oxalic acid (___)

ao. Tracheal mite treatment in the spring of 2006:

None (___) Formic Acid (___) Oxalic acid (___) Others (____________________)

Appendix 2



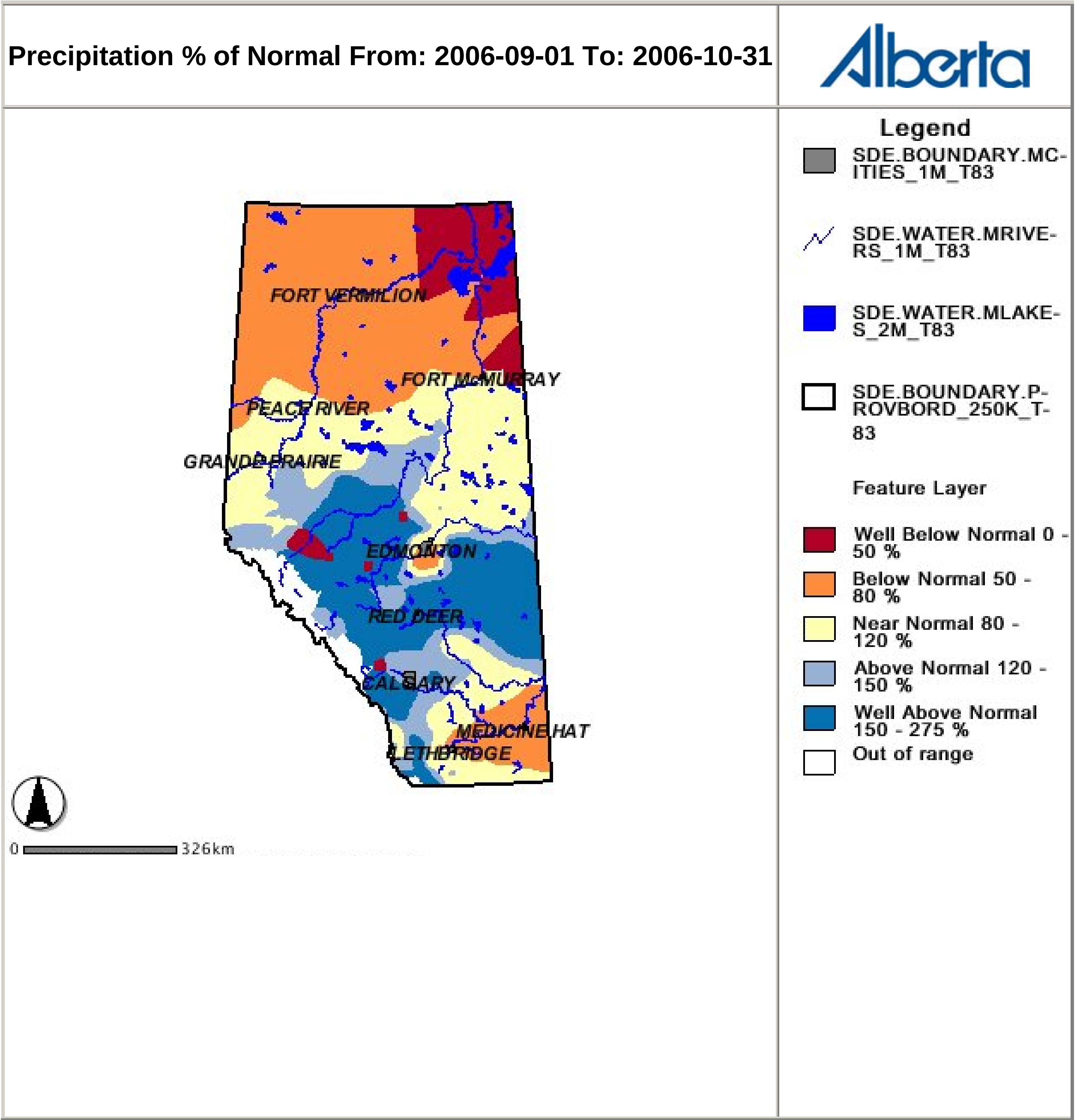
1 Southern
2 Central
3 North East
4 North West
5 Peace

Alberta

eMapGIS 2004(c) 02/09/2004

Appendix 3

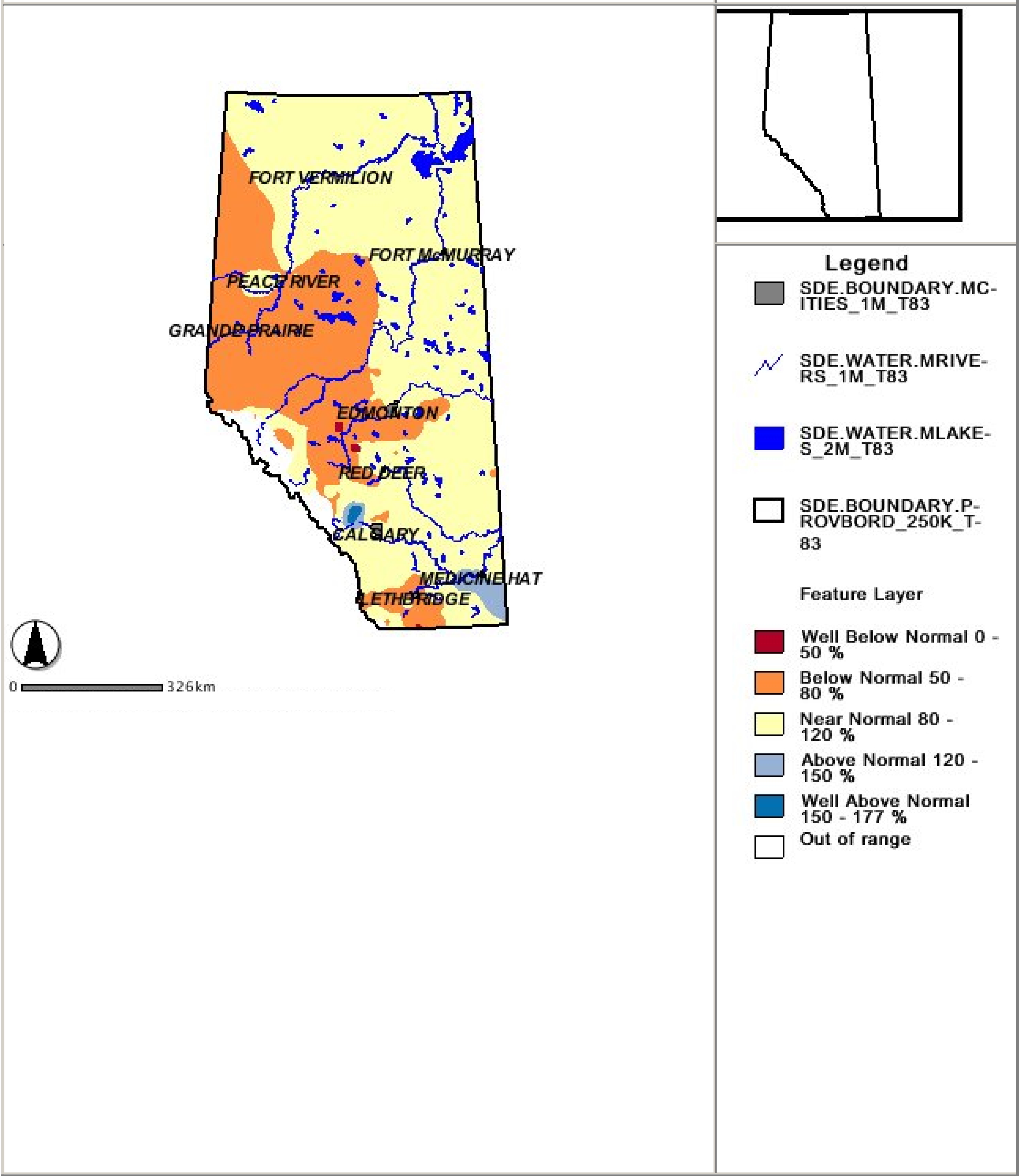
Precipitation % of Normal From: 2006-09-01 To: 2006-10-31



Appendix 4

Precipitation % of Normal From: 2006-05-01 To: 2006-08-31

Alberta



Appendix 5

Average Daily Temp. Departures From: 2006-11-01 To: 2006-11-30