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Manatū Ahu Matua

New Zealand Colony Loss Survey Report – 2016

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Prepared for the Ministry for Primary Industries
by P. Brown, Landcare Research

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Publications Logistics Officer
Ministry for Primary Industries
PO Box 2526
WELLINGTON 6140

Email: brand@mpi.govt.nz
Telephone: 0800 00 83 33
Facsimile: 04-894 0300

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Reviewed by:	Approved for release by:
T. Robertson Economic Analyst Landcare Research	S. Greenhalgh Portfolio Leader, Supporting Business & Policy Landcare Research

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Executive Summary

The 2016 NZ Colony Loss Survey seeks to quantify colony losses over winter 2016. It also seeks to augment the 2015 NZ Colony Loss Survey by providing additional data for monitoring bee health over time and for investigating emerging challenges for the apiculture industry and those industries that rely on pollination services.

The survey questionnaire was adapted from the 2015 questionnaire, which in turn included a core set of questions from a standardised survey that has been conducted in 31 countries. It was programmed and conducted online.

Invitations to participate in the survey were sent to all New Zealand beekeepers who had included email addresses when registering their apiaries with AsureQuality, and participation was widely encouraged in news and specialty media. In addition, personal phone calls were made to beekeepers with 400+ hives registered to encourage participation. In total, 2,179 beekeepers completed the 2016 survey, representing a 37.88% response rate overall and a 50.49% response rate among beekeepers with 400 or more registered hives. Together, these beekeepers reported on 275,356 production colonies as of 1 June 2016, representing 40.25% of all New Zealand production colonies.

The survey is anonymous, and beekeepers are the unit of analysis. Results are aggregated separately by region and by operation size; reporting by region is restricted to beekeepers with more than 250 colonies while reporting by operation size includes the entire sample. The descriptive statistics presented here and on the Landcare Research website are presented as bar charts, pie charts, and/or histograms.

To estimate hive losses at the national level, we multiply the average share of hives lost per beekeeper within each operation size class by the total number of hives reported in each size class in AsureQuality's apiary registry. Using this method, we estimate hives loss rates during winter 2016 to be 9.78%, with a 95% confidence interval of [8.51%, 11.04%]. These national-level losses are statistically indistinguishable from losses during winter 2015. The share of hives lost over winter 2016 is higher in the North Island than in the South Island, and average loss rates are significantly higher for non-commercial beekeepers (as compared to semi-commercial and commercial beekeepers). Nevertheless, there is wide variation in individual loss rates.

Colony losses across apiary registry locations and operation sizes were most frequently attributed to colony death, queen problems, and wasps. Losses to American foulbrood disease, natural disasters, Argentine ants, and theft and vandalism are less common. For colony deaths, starvation (as indicated by dead workers in cells with no food present) was implicated more frequently than exposure to environmental toxins (as indicated by dead bees in and in front of the hive), although both were evident.

Questions pertaining to queen problems, pests and diseases, *Varroa* monitoring and treatment, pollination services, nectar flow, nutrition, and lost and compromised apiary sites were also included in the survey to facilitate further analyses of factors contributing to colony loss. These data also provide useful information on beekeeping management practices.

1 Introduction

Managed bees provide cost-effective pollination services and thus form the backbone of agricultural in temperate climates. In New Zealand, the honey bee (*Apis mellifera*) is the most ubiquitous, abundant, and readily managed of all commercial pollinators and is used in pastoral, arable, and horticultural production (Newstrom-Lloyd 2013). It is now widely recognised that stressors are accumulating and impinging on honey bees, resulting in global declines and increasing threats to bee health (Goulson et al. 2015). As such, honey bee health and threats to pollination services are the subject of increasing scientific scrutiny as well as ongoing commentary in the popular media.

Between March 2015 and June 2016, the number of New Zealand hives reported in AsureQuality's Apiary Registry increased by 20.00%. Between June 2016 and early Janury 2017, hive numbers increased by a further 8.50%. Despite the fact that many countries are seeing rapid increases in the number of managed bee colonies (van der Zee et al. 2012), increasing colony numbers are poor indicators of bee health, the security of pollination services, and the sustinability of honey harvesting. To assess such outcomes, the share of colonies that are lost must be monitored over time (van Engelsdorp et al. 2009).

Weak, unhealthy, and sick bees are less likely to survive wintering, which may lead to the loss of entire colonies. Large-scale and frequent colony losses generate unsustainable expenses for beekeepers; these expenses are eventually passed on to farmers and growers in the form of higher fees for pollination services, thus putting the productive sector at risk in competitive domestic and international markets (Sumner & Boriss 2006). Weak colonies also produce less honey, thereby directly impacting beekeepers' bottom lines and reducing the ability for income earned from honey sales to subsidise pollination services. Understanding colony loss is thus critical to understanding agricultural sustainability and food security.

In temperate regions, low levels of colony loss commonly occur each winter because queens and/or worker bees are too weak to survive the cold or because they are otherwise compromised by pests, diseases, exposures to toxins, lack of food, or poor foraging weather. For example, beekeepers in Canada consider a 15% wintering loss to be sustainable (CAPA National Survey Committee and Provincial Apiarists 2014).

With less severe winters and warmer springs than Canada, the steady state annual loss in production colonies in New Zealand is likely lower. Until 2015, however, New Zealand did not systematically record annual wintering losses. Seeking to fill this critical knowledge gap, the Ministry for Primary Industries and the Bee Industry Advisory Council commissioned Landcare Research to conduct the first NZ Colony Loss Survey survey in 2015. Analysis of those survey data resulted in winter 2014-2015 loss estimates of 10.73%, with a 95% confidence interval of [8.66%, 12.80%] (Brown & Newstrom-Lloyd 2016; see https://www.mpi.govt.nz/document-vault/11512). That report also identified queen problems and colony death as the leading contributors to colony loss in New Zealand over winter 2014/2015.

The Ministry for Primary Industries commissioned Landcare Research to conduct a second NZ Colony Loss Survey in winter 2016 for the purposes of trend analysis and continued investigation of industry challenges and their causes. This report highlights the results of that survey.

2 Project Milestones and Objectives

Deliverable/Milestone	Performance Standards
Milestone 1. **ADVISORY GROUP, SURVEY DESIGN AND COMMUNICATIONS** 1a. Establish a Bee Health Survey advisory group comprised of MPI and beekeeping industry representatives. 1b. Work with advisory group to develop the survey questionnaire based on the 2015 edition and the international standardised survey. 1c. Work with the advisory group to develop communication about the Bee Health Survey.	• Questions are complete and appropriate to New Zealand circumstances. • Provide effective questionnaire delivery mechanisms. • Survey questions programmed into an on-line survey. • A communication package about the Bee Health Survey is available to all relevant organisations.
Milestone 2: **SURVEY DISTRIBUTION** 2a. Complete a web page for the survey which includes FAQs and a link for queries. 2b. E-mail personalised survey URL to target all commercial beekeepers with 400+ hives. 2c. Follow-up with all non-responding target beekeepers at least twice by e-mail and then by telephone. The telephone contact will provide the opportunity for the beekeeper to complete the survey over the phone at that time. 2d. Send a survey link plus a reminder by email to all beekeepers through local bee clubs and national beekeeper mailing lists.	• Survey to go live on the week beginning 22 August 2016. • Target all commercial beekeepers from AsureQuality's AFB database with particular follow-up work with 400+ hive operations. • Response rates to be calculated from the targeted list of commercial beekeepers. • Phone calls to be made to those who have not responded 21 days after the postal survey is sent out. • Work with 6 large beekeepers to complete survey and identify ways to improve the survey for complex beekeeping operations. • Liaise with ApicultureNZ to incentivise uptake of survey utilising $1k of budgeted funds accordingly.
Milestone 3: **BEE HEALTH MONITORING TOOL** 3. Present the monitoring tool to the Bee Health Survey advisory group and then, with the approval of the advisory group, to beekeepers.	• Develop a monitoring tool for beekeepers to assist with record keeping and to facilitate data collection for future surveys. • The tool shall enable beekeepers to calculate and review their accumulated information over a seasonal or annual period.
Milestone 4: **SURVEY COLLATION, ANALYSIS, AND REPORT**	• Build on the baseline of data for future surveys and analysis. • Compare colony loss across geography, enterprise size, and management practices.

4. Submit to MPI a report, an online presentation of results, and all de-identified data in association with the survey.	• The survey findings will be discussed with the advisory group. • Report aggregated data on a webpage, ensuring that no individual identification is possible. This summary information will remain online, and future survey results can be added to facilitate additional analysis over time. • Provide MPI and the beekeeping industry with a finalised report that expands the detail provided online, offers analysis of the data, particularly year-on-year trend analysis, and identifies any issues or improvements for any future survey. • The analysis of the survey will be published in appropriate journals and/or popular press.
Milestone 5: **SURVEY REPORT** 5. Submit to MPI a report, an online presentation of results, and all de-identified data in association with the survey.	• Publication in appropriate scientific journal. • Present survey at the ApicultureNZ conference 2017.

3 Methods

3.1 Survey Design

As with the 2015 survey, the 2016 NZ Colony Loss Survey was administered to beekeepers online. Electronic survey enumeration affords several advantages over alternative data collection methods. In particular, electronic enumeration enables the use of survey logic to deliver a smart, tailored questionnaire to each participant. For example, only beekeepers who indicated that they had new queens in autumn 2016 were asked about the source of those queens. Similarly, only beekeepers who gave their bees supplemental protein were asked which types of protein they gave. In addition, electronic enumeration eliminates data entry error, thereby increasing the accuracy of results.

One criticism levied against online surveying is lack of accessibility, particularly for rural populations. However, approximately 80% of rural New Zealanders had home access to broadband in 2015 (a figure that is rapidly expanding under the government's Rural Broadband Initiative), as do more than 90% of registered New Zealand beekeepers. To reach beekeepers without Internet access, the survey was also made available via telephone interview and via mail.

The 2015 survey questionnaire (Brown 2015; Brown & Newstrom-Lloyd 2015) was based on an annual survey of beekeepers developed by the international COLOSS honey bee research association.[1] Survey topics include the number and nature of over-winter colony losses, queen health and performance, indicators of pests and diseases such as *Varroa* and *Nosema ceranae*, treatment of the *Varroa* mite, supplemental feeding, and colony management. The challenges facing New Zealand beekeepers differ from those facing beekeepers in the northern hemisphere, hence the New Zealand questionnaire was adapted to the local context. For example, the 2015 NZ Colony Loss Survey added questions on competition for apiary sites; losses from American foulbrood, theft and vandalism, natural disasters, and wasps. It also adapted the question on nectar flow to reflect New Zealand plants. In addition, the 2015 NZ Colony Loss Survey included questions pertaining to losses of nucs, splits, and tops to help distinguish these losses from production colony losses.

The 2016 NZ Colony Loss Survey was a refinement of the 2015 survey. While retaining the core international COLOSS questions to facilitate international comparisons, it incorporated feedback from scientists, beekeepers, and industry representatives to increase the relevance and accuracy of information that was collected. In particular, it incorporated three specific suggestions arising from feedback on the 2015 NZ Colony Loss Survey report, namely: 1) it includes new questions on the acquisition and disposal of hives to improve accounting of winter losses; 2) it replaces AsureQuality's Apiary Registry Location, which are poorly understood among beekeepers, with well understood geographic regions; and 3) it was made available to beekeepers as a download before they began the survey.

In addition, several refinements were made to the 2016 NZ Colony Loss Survey. For example, new questions on emerging challenges to apiaries were added to quantify the threats posed by Argentine ants and giant willow aphid (*Tuberolachnus salignus*). Questions on methods for monitoring *Varroa* were also added in the 2016 survey, as were several new methods for treating *Varroa*. The questionnaire also included new questions on beekeeper's estimates of the primary reasons that apiary sites had been lost or compromised and revised questions on the nectar flow of selected native monoflorals.

The 2016 NZ Colony Loss Survey questionnaire was also streamlined significantly compared to the 2015 NZ Colony Loss Survey by removing questions regarding nucs, splits, and tops. This decision was based on the results of the 2015 survey, which showed that the general pattern of results for nucs, splits and tops was so similar to the patterns found for production colonies that they provided little new information.

3.2 Colony Losses

Colony losses in general may be attributed to queen problems (including drone-laying queens, or no queen, etc.), colony death (including starvation and hives that are reduced to a few hundred bees), AFB, natural disasters, theft and vandalism, wasps, and Argentine ants. Argentine ants are an emerging problem for beekeepers in New Zealand, and their inclusion was an important addition to the 2016 questionnaire.

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[1] COLOSS is a non-profit organisation that seeks to improve the well-being of bees at a global level. Its membership includes beekeepers, researchers, veterinarians, extension specialists, and students from more than 75 countries, including several prominent beekeepers from New Zealand. In 2014–2015, the COLOSS survey was administered to more than 23,000 beekeepers in 31 countries. http://www.coloss.org/

Losses due to *Varroa* mite, pesticides or plant toxins, and other pathogens and pests are considerably more difficult to diagnose; hence, following the practice established on international COLOSS surveys, the 2016 NZ Colony Loss Survey does not ask beekeepers to attribute losses to these causes. However, the NZ Colony Loss Survey does ask beekeepers to report on symptoms to help distinguish cases of starvation from those of exposure to toxins or particular diseases such as *Nosema ceranae*. Futhermore, the 2016 NZ Colony Loss Survey is not intended to diagnose specific syndromes such as Colony Collapse Disorder or Colony Depopulation Syndrome because these are multi-causal syndromes and require hive monitoring for specific information not possible in a survey (see Brown and Newstrom-Lloyd 2015).

3.3 Sampling Strategy

Our sampling strategy aimed for inclusiveness while targeting New Zealand's largest beekeeping operations. Thus, we adopted a two-pronged approach to recruiting respondents.

Under the Biosecurity Act of 1993, all New Zealand beekeepers are legally obligated to register their apiaries with AsureQuality and to complete and Annual Disease Return by 1 June. Nearly 90% of New Zealand beekeepers have registered email addresses with AsureQuality. AsureQuality provided these email addresses to Landcare Research for the purpose of conducting the NZ Colony Loss Survey.

Landcare Research sent personalised email invitations to participate in the survey to 5,953 New Zealand beekeepers on 22 August 2016. In total, 93 emails bounced (likely due to invalid email addresses and/or overly aggressive spam filters) and 107 beekeepers asked to be removed from the list of email contacts. Non-respondents received up to five email reminders between 1 September 2016 and 25 October 2016.

Participation was encouraged by presentations at the 2016 ApicultureNZ conference, interviews on television and radio news, articles in newspapers and *The New Zealand BeeKeeper Journal*, and the opportunity to win one of ten $100 vouchers for morning tea. In addition, all 305 beekeepers with 400+ hives registered with AsureQuality were eligible to receive personal phone calls to encourage completion of the survey; phone calls began in early September for northern New Zealand and continued through mid-October for southern New Zealand, targeting beekeepers who had not completed the survey at the time of the call. Members of the NZ Colony Loss Survey advisory group also made personal telephone calls to targeted beekeepers. In addition, team members worked with six large beekeepers to better understand recordkeeping and to facilitate survey completion. Five beekeepers responded to the survey offline.

In total, 2,179 beekeepers completed the 2016 survey, indicating a response rate of 37.88% overall and a five-fold increase in total numbers vis-à-vis the 2015 survey. Eighty-eight beekeepers had either started or stopped over winter 2016, leaving us with complete information on winter losses for 2,091 beekeepers. Among the beekeepers who completed the survey were 154 of the 305 beekeepers with 400 or more registered hives, indicating a response rate of 50.49% among these large, commercial beekeepers.[2] See Table 1 for a breakdown of region and operation size.

Table 1: Number of beekeepers responding to the NZ Colony Loss Survey by region and operation size

Region	Non-commercial (1-50 colonies)	Semi-commercial (51-500 colonies)	Commercial (500-3000 colonies)	Large Commercial (more than 3000 colonies)
Upper North Island	519	47	31	20
Middle North Island	361	66	35	
Lower North Island	352	24	22	
Upper South Island	133	12	11	
Middle South Island	272	20	19	
Lower South Island	168	12	13	
Total	1790	170	117	15

Notes: Large commercial beekeepers are not reported by region to preserve anonymity. Some beekeepers have hives in multiple regions. As such, the total shown in the last row reflects the total number of beekeepers in each size class and is not a column total.

Together, these beekeepers reported on 275,356 production colonies as of 1 June 2016, representing 40.25% of all New Zealand production colonies.

Consistent with international practice, all responses are anonymous. Data access is limited to the survey director (Pike Brown, Landcare Research), and data are stored exclusively on password-protected computers.

4 Survey Questionnaire

The entire text of the survey questionnaire is included below. All core questions from the standardised international COLOSS survey are included verbatim to enable international comparison. Additional questions were added to reflect both the New Zealand context and feedback on the 2015 NZ Colony Loss Survey provided by scientists, beekeepers, and other end users. The survey was available online between 22 August and 20 November 2016.

Consent

1) Please click YES to begin the survey.*
( ) **YES, take me to the survey**
( ) NO, I don't want to do the survey

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[2] We note that the response rate among commercial beekeepers may be slightly overstated because multiple managers completed the survey for a handful of large beekeepers. Even so, the response rates among both commercial and non-commercial beekeepers are extremely high. We believe that they are the result of personalised invitations to non-commercial beekeepers, extensive coverage in the media, direct telephone calls, and other interventions described above. However, we caution against expecting similar response rates in future surveys.

Ownership

2) Which of the following best describes your role in this beekeeping operation?*
( ) Owner/partner
( ) Site manager

3) Do you personally manage all apiaries?*
( ) Yes
( ) No

4) Ideally, managers will complete the survey for the apiaries that they manage. Do you wish to complete the survey yourself or to ask managers to complete the survey?*
If you will report on some apiaries and managers will report on others, please tick "Managers will complete the survey".
( ) I will complete the survey myself
( ) Managers will complete the survey

5) *Please enter the email address of each apiary manager in the box below. We will send a request to complete the survey directly to the manager(s). Enter each address on a new line.*

____

6) Do you wish to report on any apiary sites yourself?*
( ) Yes
( ) No

Apiary location

*7) How many apiary sites did you manage during the first spring round of 2016?**

____

8) In which region(s) were your apiary sites located during your first spring round (spring 2016)?*
Note that Coromandel is listed separately from Waikato and that Wairarapa is listed separately from Wellington.
Tick all that apply.
[ ] Northland
[ ] Auckland
[ ] Coromandel
[ ] Waikato (apart from Coromandel)
[ ] Bay of Plenty
[ ] Gisborne
[ ] Hawke's Bay
[ ] Taranaki
[ ] Manawatu-Wanganui
[ ] Wairarapa
[ ] Wellington (apart from Wairarapa)
[ ] Tasman / Nelson
[ ] Marlborough

[ ] Canterbury
[ ] West Coast
[ ] Otago
[ ] Southland
[ ] Chatham Islands
9) Are all of your apiary sites within 15 km of one another?*
( ) Yes
( ) No
( ) Unsure

Production colonies

10) How many production colonies did you have on 1 June 2016, as per your Annual Disease Return?*
If the exact number of production colonies is not known, please estimate.

____

11) Did you acquire new production colonies after 1 June 2016 but before the first spring round of 2016?*
Examples include purchasing, receiving as a gift, and creating new production colonies from nucs and splits.
( ) Yes
( ) No

12) How many production colonies did you acquire after 1 June 2016 but before the first spring round of 2016?*
If the exact number of production colonies is not known, please estimate.

____

13) Did you sell or give away production colonies after 1 June 2016 but before the first spring round of 2016? *
( ) Yes
( ) No

14) How many of your [####] production colonies did you sell or give away after 1 June 2016 but before the first spring round of 2016? *
If the exact number of production colonies is not known, please estimate.

____

15) How many production colonies did you have during your first spring round this year (spring 2016)?*
If the exact number of production colonies is not known, please estimate.

____

Attribution of losses

16) Of the [####] production colonies that were lost during winter 2016, how many were lost as a result of...?*

________Queen problems (including drone-laying queens, no queen, etc.)
________Colony death (including suspected starvation, toxicity, Varroa/other parasites, Nosema/other infections, etc.)
________American foulbrood (AFB)
________Natural disasters (gale-force winds, flooding, etc.)
________Theft or vandalism
________Wasps
________Argentine ants (ants that attack the brood and honey comb)
________Unsure
________Other

Attribution of other losses

17) Please describe the other cause of losses to your production colonies.

____
____
____
____

Queen health

18) How many of the [####] production colonies that survived winter 2016 were weak but queenright during the first spring round of 2016?*
If an exact number is not known, please estimate.

____

19) In terms of queen problems (such as drone-laying queens, no queen, etc.) how does the 2015-2016 season compare to previous seasons? The 2015-2016 year was...*
( ) Much worse
than normal
( ) Somewhat worse
than normal
( ) About
normal
( ) Somewhat better
than normal
( ) Much better
than normal
( ) Unsure

20) Of the [####] production colonies that you had on 1 June 2016 (the time of your Annual Disease Return), did any have new queens (own queens or commercial source)?*
( ) Yes
( ) No

21) Of the ## production colonies that you had on 1 June 2016, how many had new queens?*
If an exact number is not known, please estimate.

____

22) How many of these new queens were from queen breeder stock?
If an exact number is not known, please estimate.

____

23) How did production colonies with young queens survive winter 2016 relative to production colonies with old queens? Young queens did...*

( ) Much worse than old queens
( ) Somewhat worse than old queens
( ) About the same as old queens
( ) Somewhat better than old queens
( ) Much better than old queens
( ) Unsure

Regions affected by AFB, natural disasters, theft/vandalism, wasps, and/or Argentine ants

24) In which area did AFB have the biggest impact on your production colonies during winter 2016?

( ) Northland
( ) Auckland
( ) Coromandel
( ) Waikato (apart from Coromandel)
( ) Bay of Plenty
( ) Gisborne
( ) Hawke's Bay
( ) Taranaki
( ) Manawatu-Wanganui
( ) Wairarapa
( ) Wellington (apart from Wairarapa)
( ) Tasman / Nelson
( ) Marlborough
( ) Canterbury
( ) West Coast
( ) Otago
( ) Southland
( ) Chatham Islands

25) In which area did natural disasters have the biggest impact on your production colonies during winter 2016?

( ) Northland
( ) Auckland
( ) Coromandel
( ) Waikato (apart from Coromandel)
( ) Bay of Plenty
( ) Gisborne
( ) Hawke's Bay
( ) Taranaki
( ) Manawatu-Wanganui
( ) Wairarapa
( ) Wellington (apart from Wairarapa)
( ) Tasman / Nelson

( ) Marlborough
( ) Canterbury
( ) West Coast
( ) Otago
( ) Southland
( ) Chatham Islands

26) In which area did theft and/or vandalism have the biggest impact on your production colonies during winter 2016?
( ) Northland
( ) Auckland
( ) Coromandel
( ) Waikato (apart from Coromandel)
( ) Bay of Plenty
( ) Gisborne
( ) Hawke's Bay
( ) Taranaki
( ) Manawatu-Wanganui
( ) Wairarapa
( ) Wellington (apart from Wairarapa)
( ) Tasman / Nelson
( ) Marlborough
( ) Canterbury
( ) West Coast
( ) Otago
( ) Southland
( ) Chatham Islands

27) In which area did wasps have the biggest impact on your production colonies during winter 2016?
( ) Northland
( ) Auckland
( ) Coromandel
( ) Waikato (apart from Coromandel)
( ) Bay of Plenty
( ) Gisborne
( ) Hawke's Bay
( ) Taranaki
( ) Manawatu-Wanganui
( ) Wairarapa
( ) Wellington (apart from Wairarapa)
( ) Tasman / Nelson
( ) Marlborough
( ) Canterbury
( ) West Coast
( ) Otago
( ) Southland
( ) Chatham Islands

28) In which area did Argentine ants have the biggest impact on your production colonies during winter 2016?

( ) Northland
( ) Auckland
( ) Coromandel
( ) Waikato (apart from Coromandel)
( ) Bay of Plenty
( ) Gisborne
( ) Hawke's Bay
( ) Taranaki
( ) Manawatu-Wanganui
( ) Wairarapa
( ) Wellington (apart from Wairarapa)
( ) Tasman / Nelson
( ) Marlborough
( ) Canterbury
( ) Otago
( ) Southland
( ) Chatham Islands
( ) West Coast

Dead colonies

29) Of the [####] production colonies that died during winter 2016, please indicate how many...*
If an exact number is not known, please estimate.
________Had many dead bees in or in front of the hive
________Had no or only a few dead bees in or in front of the hive

30) Of the [####] production colonies that died during winter 2016, please indicate how many...*
If an exact number is not known, please estimate.
________Had dead workers in cells and no food present in the hive (signs of starvation)
________Had dead workers in cells while food was present in the hive

31) Did any of your production colonies have a large amount of faeces inside when you first opened them in spring 2016?*
( ) Yes
( ) No

32) Approximately what share of your production colonies had a large amount of faeces inside when you first opened them in spring 2016?*
( ) <10%
( ) 10%
( ) 20%
( ) 30%
( ) 40%
( ) 50%
( ) 60%
( ) 70%
( ) 80%
( ) 90%

( ) 100%
( ) Unsure

33) In which area were colony deaths (including suspected starvation, toxicity, Varroa/other parasites, Nosema/other infections, etc.) during winter 2016 most severe?
( ) Northland
( ) Auckland
( ) Coromandel
( ) Waikato (apart from Coromandel)
( ) Bay of Plenty
( ) Gisborne
( ) Hawke's Bay
( ) Taranaki
( ) Manawatu-Wanganui
( ) Wairarapa
( ) Wellington (apart from Wairarapa)
( ) Tasman / Nelson
( ) Marlborough
( ) Canterbury
( ) West Coast
( ) Otago
( ) Southland
( ) Chatham Islands

Varroa

34) Did you notice bees with crippled or deformed wings in your production colonies during the 2015-2016 season?*
( ) Yes
( ) No

35) Did you monitor your production colonies for *Varroa* during the 2015-2016 season?*
( ) Yes
( ) No

36) What methods did you use to monitor your production colonies for *Varroa* during the 2015-2016 Season? Tick all that apply. *
[ ] Alcohol wash
[ ] Sticky board
[ ] Sugar shake / roll
[ ] Other - Please specify: ____

37) Did you treat *Varroa* during the 2015-2016 season.*
( ) Yes
( ) No

38) Please indicate how you treated *Varroa* during the 2015-2016 season.*
Tick all that apply.
[ ] Flumethrin (e.g. Bayvarol)
[ ] Amitraz (in strips, e.g. Apivar)

[ ] Thymol (e.g. Apiguard, ApilifeVar, ThymoVar)
[ ] Thymol cords
[ ] Tau-fluvalinate (e.g. Apistan)
[ ] Oxalic acid - sublimation (evaporation)
[ ] Oxalic acid - dribbling / trickling
[ ] Drone brood removal
[ ] Formic acid - short term (3 days or less)
[ ] Formic acid - long term (4 days or more, e.g. Mite Away Quick Strips)
[ ] Formic acid - very long term (42-day treatment, e.g. Nassenheider evaporator)
[ ] Complete brood removal (including queen trapping)
[ ] Fogging food-grade mineral and essential oils (e.g. thymol, wintergreen)
[ ] Fogging food-grade mineral oil
[ ] Hyperthermia (heat treatment of brood/bees)
[ ] Other method (1): ____
[ ] Other method (2): ____

Please indicate when you started treatment for *Varroa* during the 2015-2016 season.*
Tick all that apply. For example, if you started one treatment in September and repeated it in December, please tick both September and December. Please tick Unsure if you do not remember.

Unsure	Aug2015	Sep2015	Oct2015	Nov2015	Dec2015	Jan2016	Feb2016	Mar2016	Apr2016	May2016	Jun2016	Jul2016	Aug2016	Sep2016

Colony management

39) How many production colonies did you have at the start of your last spring round (spring 2015)?
This question will help us to track trends over time. Again, please consider colonies that are queenright and strong enough to provide a honey harvest as production colonies.
Production colonies: ____

40) Did you replace any brood combs with comb foundation during the 2015-2016 season?
( ) Yes
( ) No

41) Approximately what proportion of brood combs did you replace with comb foundation (per colony) during the 2015-2016 season?
( ) <10%
( ) 10%
( ) 20%
( ) 30%
( ) 40%
( ) 50%

( ) 60%
( ) 70%
( ) 80%
( ) 90%
( ) 100%
( ) Unsure

42) During the 2015-2016 season, approximately what share of production colonies were used for pollination, for honey production, and for both pollination and honey production?
Please enter numbers only. For 50%, enter "50". For 0%, enter "0". Total must sum to 100. If you did not use colonies for pollination or honey production (e.g., if they were used only to produce queens), please leave this question blank.
________% for pollination only
________% for honey production only
________% for both pollination and honey production

43) Did you migrate any of your production colonies at least once during the 2015-2016 season?
This question refers to moving production colonies from one apiary site to another.
( ) Yes
( ) No

44) Approximately what proportion of production colonies were migrated during the 2015-2016 season?
( ) <10%
( ) 10%
( ) 20%
( ) 30%
( ) 40%
( ) 50%
( ) 60%
( ) 70%
( ) 80%
( ) 90%
( ) 100%
( ) Unsure

45) In which regions were your apiaries kept at any time during the 2015-2016 season?
Note that Coromandel is listed separately from Waikato and that Wairarapa is listed separately from Wellington.
Tick all that apply.
[ ] Northland
[ ] Auckland
[ ] Coromandel
[ ] Waikato (apart from Coromandel)
[ ] Bay of Plenty
[ ] Gisborne
[ ] Hawke's Bay
[ ] Taranaki
[ ] Manawatu-Wanganui
[ ] Wairarapa

[ ] Wellington (apart from Wairarapa)
[ ] Tasman / Nelson
[ ] Marlborough
[ ] Canterbury
[ ] West Coast
[ ] Otago
[ ] Southland
[ ] Chatham Islands

Nectar flow

46) Did the majority of your bee colonies have a significant flow on one or more of the following plants during the 2015-2016 season?
Tick all that apply.
[ ] Mānuka
[ ] Kānuka
[ ] Mixed mānuka and kānuka
[ ] Clover / pasture
[ ] Kamahi
[ ] Willow honey (spring)
[ ] Willow honeydew (summer-autumn)
[ ] Rewarewa
[ ] Citrus
[ ] Borage / Vipers bugloss
[ ] Rata
[ ] Pohutukawa
[ ] Tawari
[ ] Beech honeydew
[ ] Thyme
[ ] Nodding thistle
[ ] Ling heather
[ ] Native bush blend
[ ] Urban floral and garden
[ ] Other: ____

47) During the 2015-2016 season, approximately what share of the mānuka flow came from plantation mānuka?
( ) 0%
( ) 10%
( ) 20%
( ) 30%
( ) 40%
( ) 50%
( ) 60%
( ) 70%
( ) 80%
( ) 90%
( ) 100%
( ) Unsure

48) How was the nectar flow from kamahi in 2015-2016 compared to 2014-2015? The 2015-2016 nectar flow from kamahi was...
( ) Much better
( ) Somewhat better
( ) About the same
( ) Somewhat worse
( ) Much worse
( ) Not sure

49) How was the nectar flow from rewarewa in 2015-2016 compared to 2014-2015? The 2015-2016 nectar flow from rewarewa was...
( ) Much better
( ) Somewhat better
( ) About the same
( ) Somewhat worse
( ) Much worse
( ) Not sure

50) How was the nectar flow from rata in 2015-2016 compared to 2014-2015? The 2015-2016 nectar flow from rata was...
( ) Much better
( ) Somewhat better
( ) About the same
( ) Somewhat worse
( ) Much worse
( ) Not sure

51) How was the nectar flow from pohutukawa in 2015-2016 compared to 2014-2015? The 2015-2016 nectar flow from pohutukawa was...
( ) Much better
( ) Somewhat better
( ) About the same
( ) Somewhat worse
( ) Much worse
( ) Not sure

52) How was the nectar flow from tawari in 2015-2016 compared to 2014-2015? The 2015-2016 nectar flow from tawari was...
( ) Much better
( ) Somewhat better
( ) About the same
( ) Somewhat worse
( ) Much worse
( ) Not sure

Supplemental feeding

53) Did you give any of your colonies a supplemental sugar feed during the 2015-2016 season?

Supplemental sugar feeds include sugar solution, invert sugar, raw sugar, white sugar, and honey.
( ) Yes
( ) No

54) What type of sugar did you use as supplementary feed during the 2015-2016 season?
Tick all that apply.
[ ] Sugar solution
[ ] Invert sugar solution
[ ] Raw sugar
[ ] White sugar
[ ] Honey
[ ] Other: ____

55) How many litres of solution did you give to each production colony, on average?

____

56) How many KGs of dry sugar (raw and/or white) did you give to each production colony, on average?

____

57) How many frames of honey did you give to each production colony, on average?

____

58) How much [sugar type] did you give to each production colony, on average?
Please specify units, e.g. KGs, or litres.

____

59) Did you give any of your colonies protein supplements during the 2015-2016 season?
Proteins supplements include FeedBee, MegaBee, dry pollen, and homemade supplements.
( ) Yes
( ) No

60) What type of protein supplement did you use during the 2015-2016 season?
Tick all that apply.
[ ] FeedBee
[ ] MegaBee
[ ] Dry pollen
[ ] Homemade protein supplement
[ ] Other: ____

61) How many kg of supplement (dry matter) did you give to each production colony, on average?

____

62) How much [protein type] did you give to each production colony, on average?
Please specify units, e.g. KGs, or litres.

____

Lost and compromised apiary sites

63) Between the first spring round of 2015 and the first spring round of 2016, did you lose one or more entire apiary sites?
Possible causes include being overtaken by other beekeepers, overcrowding, lost pollen and nectar sources, and effects of giant willow aphid.
( ) Yes
( ) No

64) Between the first spring round of 2015 and the first spring round of 2016, was one or more of your apiary sites compromised?
Possible causes include overcrowding, lost pollen and nectar sources, and effects of giant willow aphid.
( ) Yes
( ) No

65) Which of the following caused you to lose one or more entire apiary sites between the first spring round of 2015 and the first spring round of 2016?
Tick all that apply.
[ ] Overtaken by another beekeeper
[ ] Overcrowding (too many hives close to your apiary sites)
[ ] Pollen and nectar sources were removed without replacement
[ ] Effects of giant willow aphid
[ ] Other - Please describe: ____

66) Which of the following caused one or more of your apiary sites to be compromised between the first spring round of 2015 and the first spring round of 2016?
Tick all that apply.
[ ] Overcrowding (too many hives close to your apiary sites)
[ ] Pollen and nectar sources were removed without replacement
[ ] Effects of giant willow aphid
[ ] Other - Please describe: ____

67) Approximately how many of your apiary sites were entirely lost between the first spring round of 2015 and the first spring round of 2016 for each of the following reasons?

68) Approximately how many of your apiary sites were compromised between the first spring round of 2015 and the first spring round of 2016 for each of the following reasons?

69) In which area were problems associated with apiary sites being entirely lost or compromised between the first spring round of 2015 and the first spring round of 2016 most severe?
Please select from the list below even if only one region is shown.
( ) Northland
( ) Auckland
( ) Coromandel
( ) Waikato (apart from Coromandel)
( ) Bay of Plenty
( ) Gisborne
( ) Hawke's Bay
( ) Taranaki
( ) Manawatu-Wanganui

( ) Wairarapa
( ) Wellington (apart from Wairarapa)
( ) Tasman / Nelson
( ) Marlborough
( ) Canterbury
( ) West Coast
( ) Otago
( ) Southland
( ) Chatham Islands

Qualitative responses

70) Please describe how your 2015-2016 season was compared to your 2014-2015 season.

____
____
____
____

71) What are the key challenges facing New Zealand beekeepers? Are there other problems that we should monitor in future surveys?

____
____
____
____

72) What are the key opportunities facing New Zealand beekeepers?

____
____
____
____

73) Were any parts of this survey difficult to answer? Please let us know so we can improve the questionnaire for the future.

____
____
____
____

Experience

74) Approximately how many years of beekeeping experience do you have?

____

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5 Figures

Results of the 2016 NZ Colony Loss Survey – which are also available on the Landcare Research website – are presented as bar charts, pie charts, and histograms. The latter are useful for showing the distribution of survey responses, particularly as zeros are included separately, a new feature in the reporting for 2016. Averages are also noted in the histograms.

Most information from the NZ Colony Loss Survey is reported according to an aggregated area (hereafter, called "region"). Specifically, beekeepers recorded the political regions corresponding to their AsureQuality Apiary Registry Locations; these political regions were then aggregated and categorised into six regions: "Upper North Island", "Middle North Island", "Lower North Island", "Upper South Island", "Middle South Island", or "Lower South Island" (Fig. 1).

Most information is also reported by the total number of hives comprising each beekeeping operation as of 1 June 2016. In all figures, operation size is categorised into four size classes as of 1 June 2016: "non-commercial" for those with 1–50 hives; "semi-commercial" for those with 51–500 hives; "commercial" for those with 501–3,000 hives; and "large commercial" for those with more than 3,000 hives.[3]

Because 5.43% of New Zealand beekeepers operated 86.88% of production colonies as of 1 June 2016, figures reported by aggregated region restrict the sample to beekeepers with more than 250 hives (unless noted). Figures reported by operation size include all respondents.

Highlighted results follow in Section 6.

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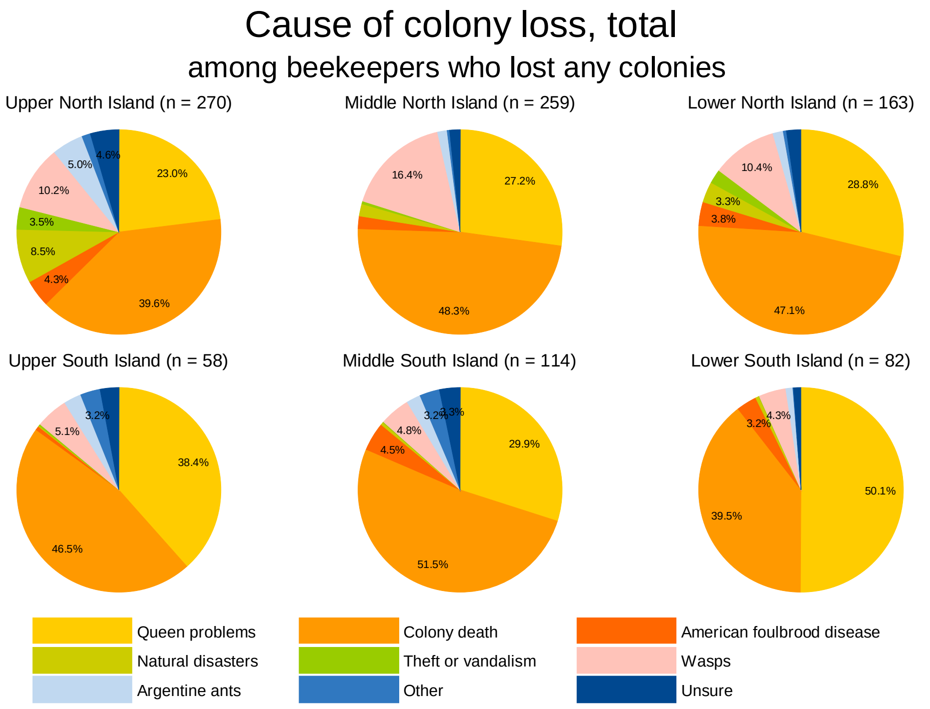
[3] The 2015 NZ Colony Loss Survey report described beekeepers in five size classes (0-50 colonies; 51-250 colonies; 250-500 colonies; 500-1000 colonies; and more than 1000 colonies). They are changed in the 2016 report to simplify the presentation of results and to better highlight differences across operation size.

Figure 1: Reference map for reporting by region. Legend shows the number of colonies in each region. Includes all respondents in all operation size classes.

Figure 2: Estimated total colony losses by region. Includes all respondents in all operation size classes.



Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 3: Share of total colony losses over winter 2016 attributed to various causes based on reports from respondents who lost any colonies, by region.

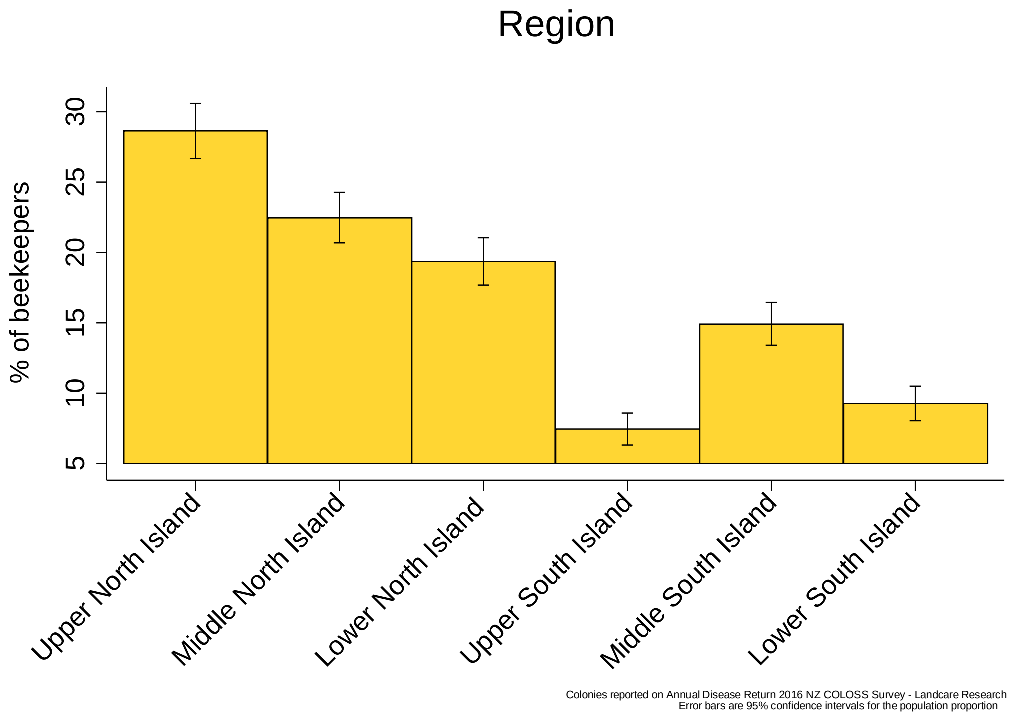


Figure 4: Share of respondents who operate in each region. Includes all respondents in all operation size classes.

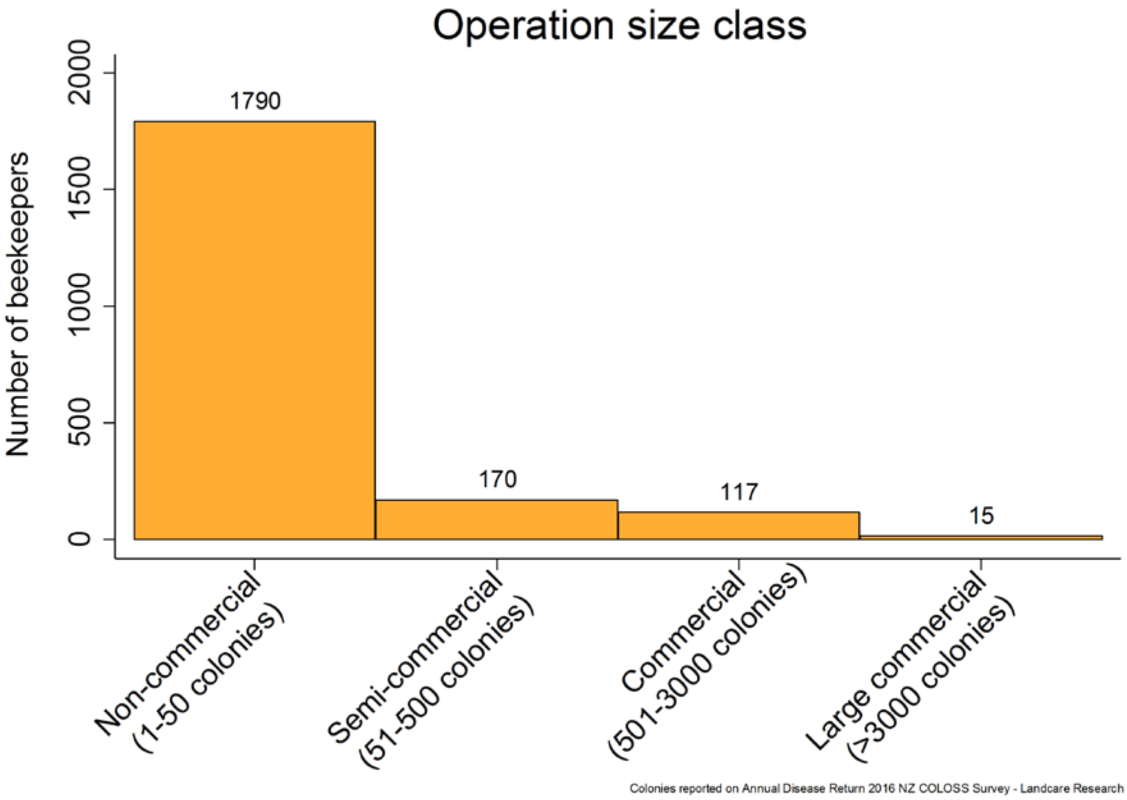


Figure 5: Operation size of respondents grouped into four size classes.

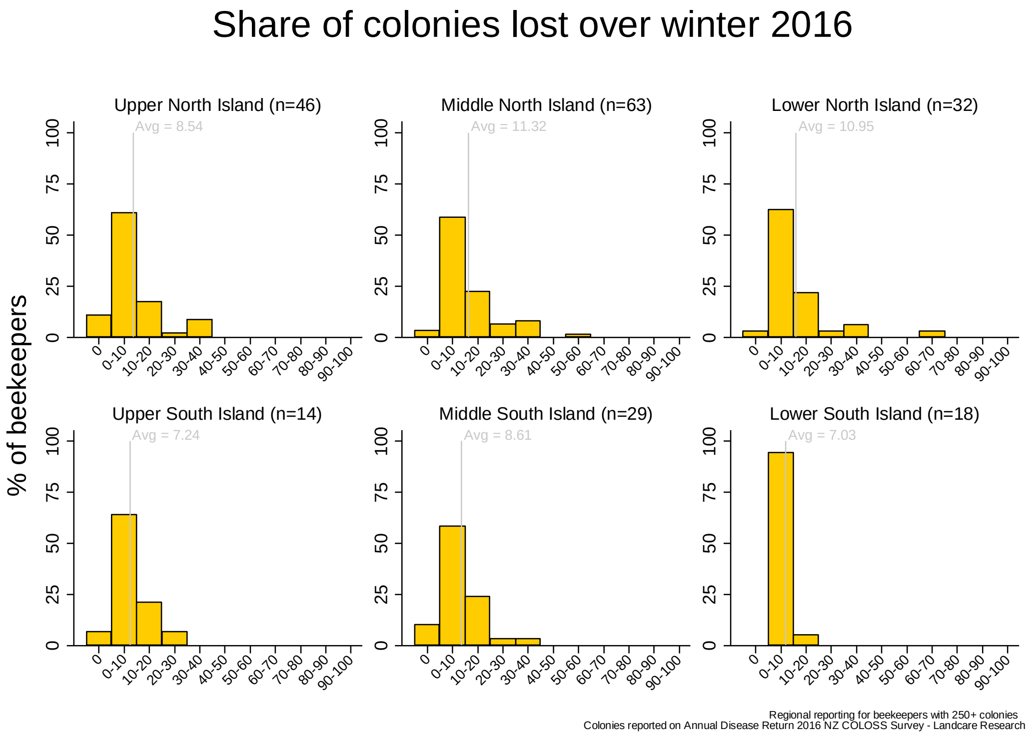


Figure 6: Winter 2016 colony losses as a share of total colonies on 1 June 2016 based on reports from respondents with more than 250 colonies, by region.

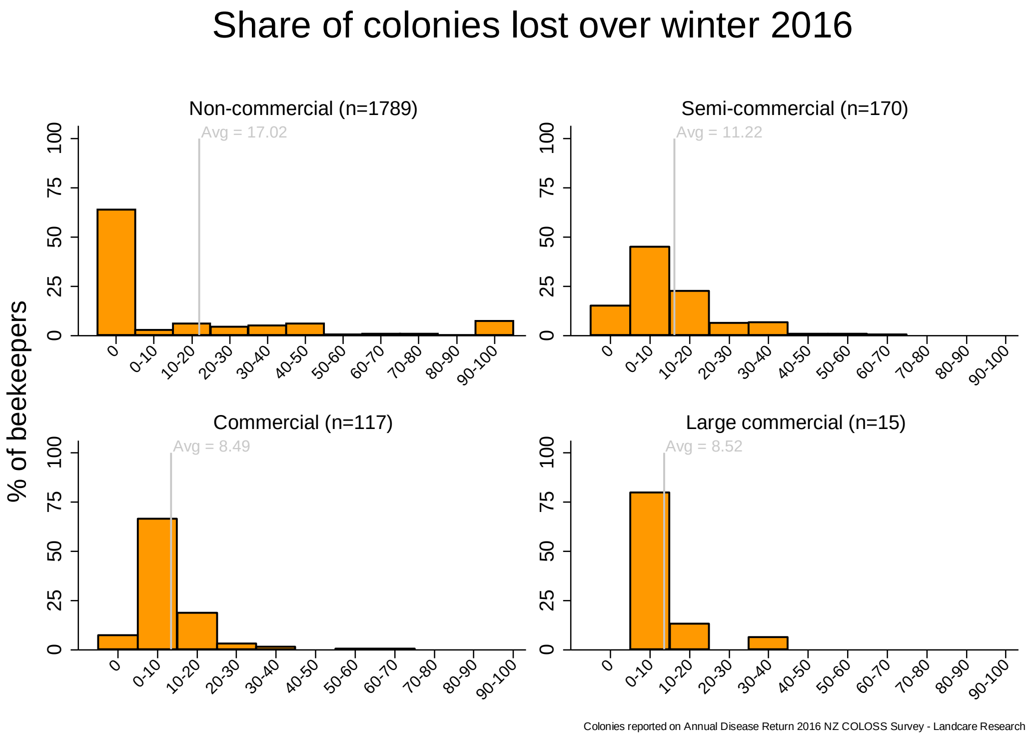
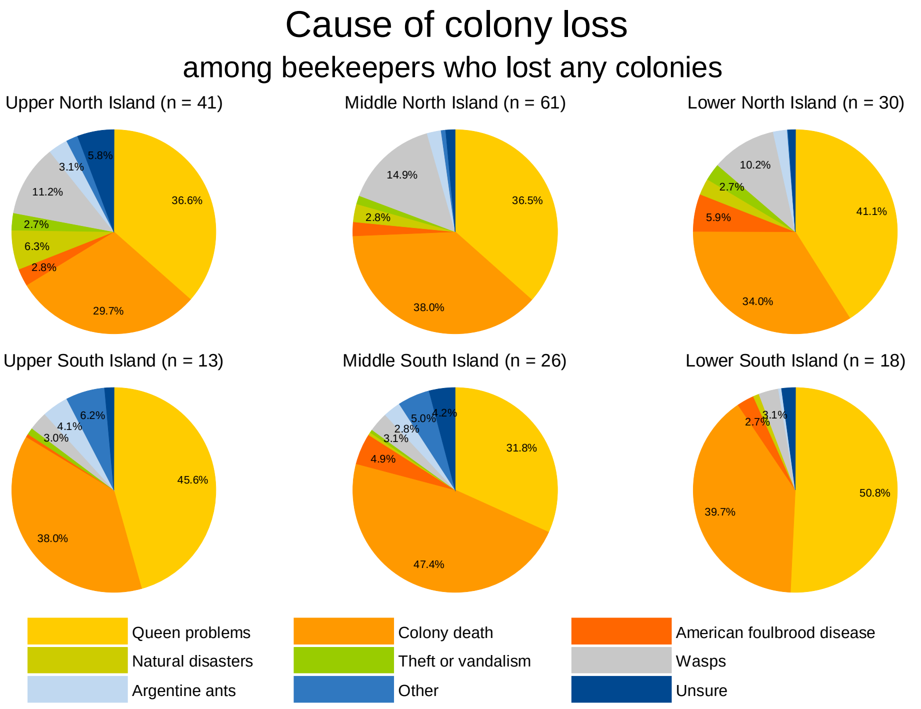
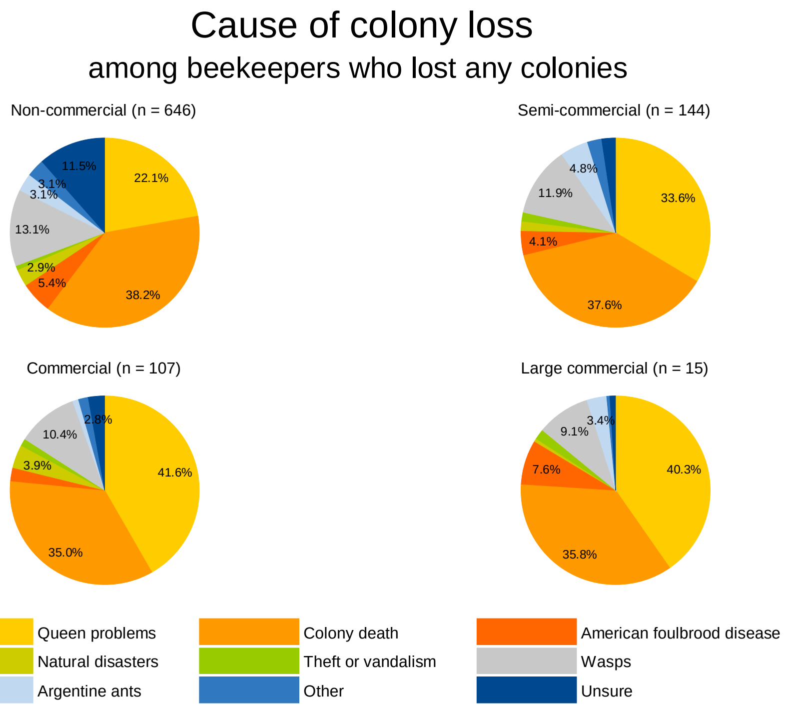


Figure 7: Winter 2016 colony losses as a share of total colonies on 1 June 2016 for all respondents, by operation size.



Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 8: Share of colony losses attributed to various causes based on reports from respondents with more than 250 colonies who lost any colonies, by region.



Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 9: Share of colony losses attributed to various causes based on reports from respondents who lost any colonies, by operation size.

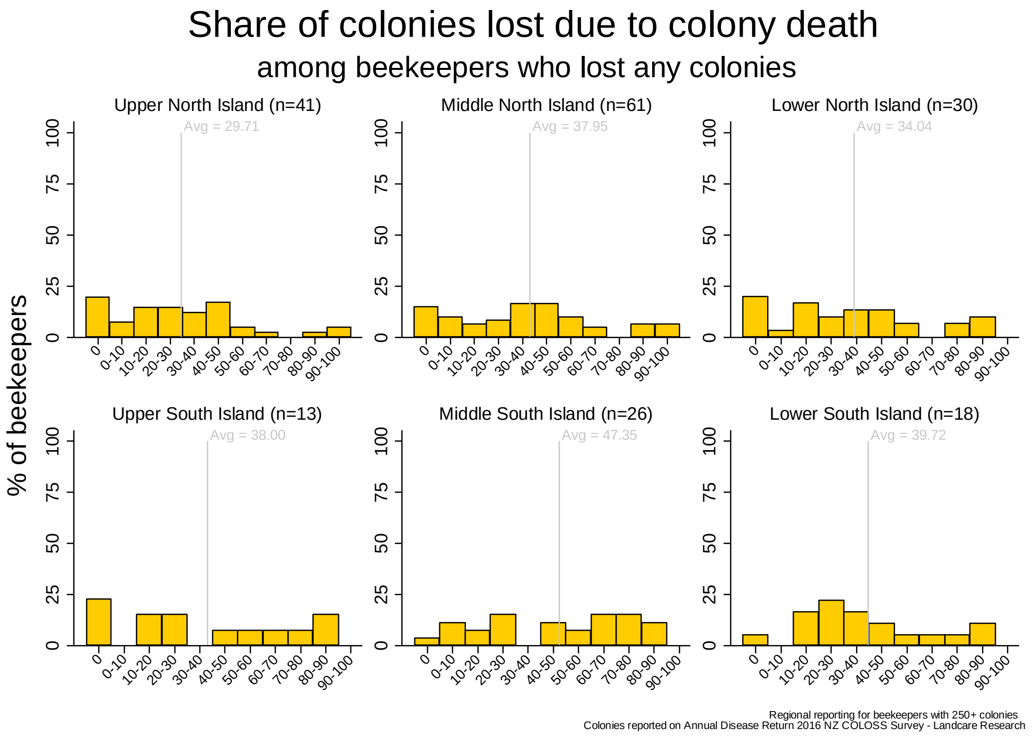


Figure 10: Winter 2016 colony losses that resulted from colony death based on reports from respondents with more than 250 colonies who lost any colonies, by region.

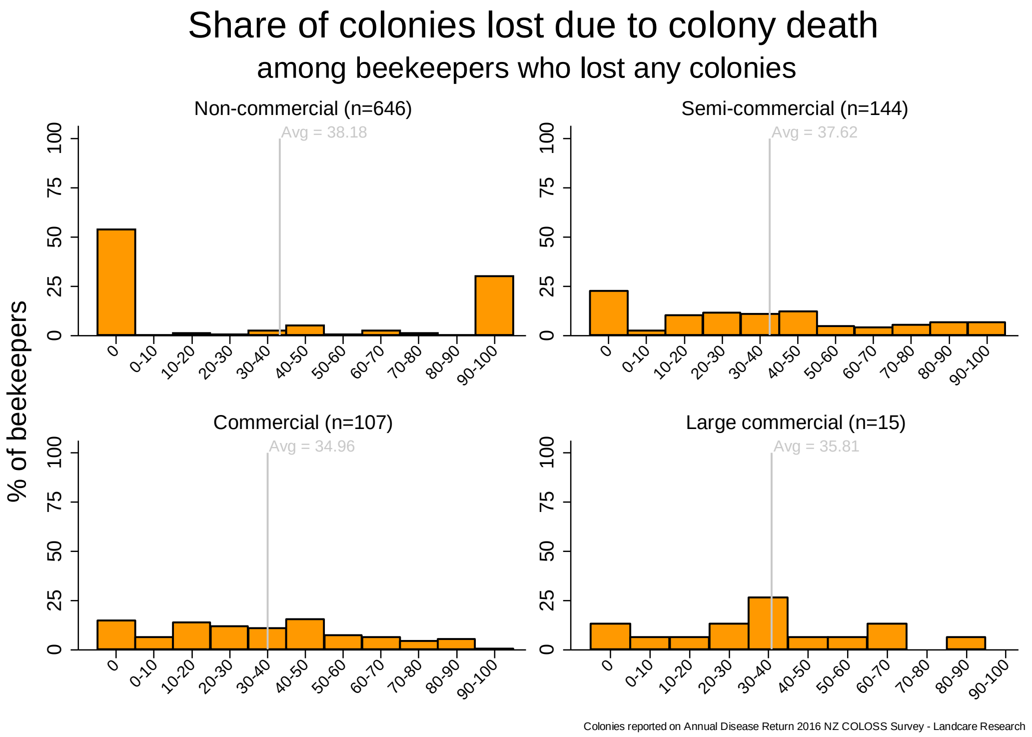


Figure 11: Winter 2016 colony losses that resulted from colony death based on reports from all respondents who lost any colonies, by operation size.

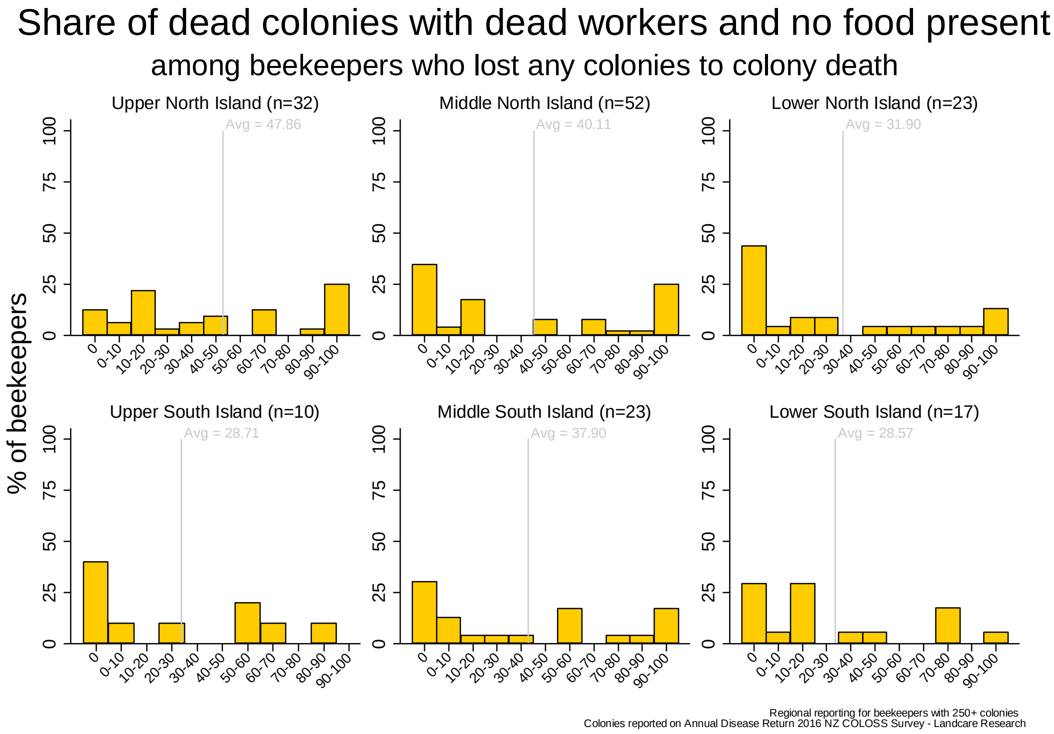


Figure 12: Share of dead colonies that had dead workers and no food present among respondents who had any dead colonies after winter 2016 based on reports from respondents with more than 250 hives, by region.

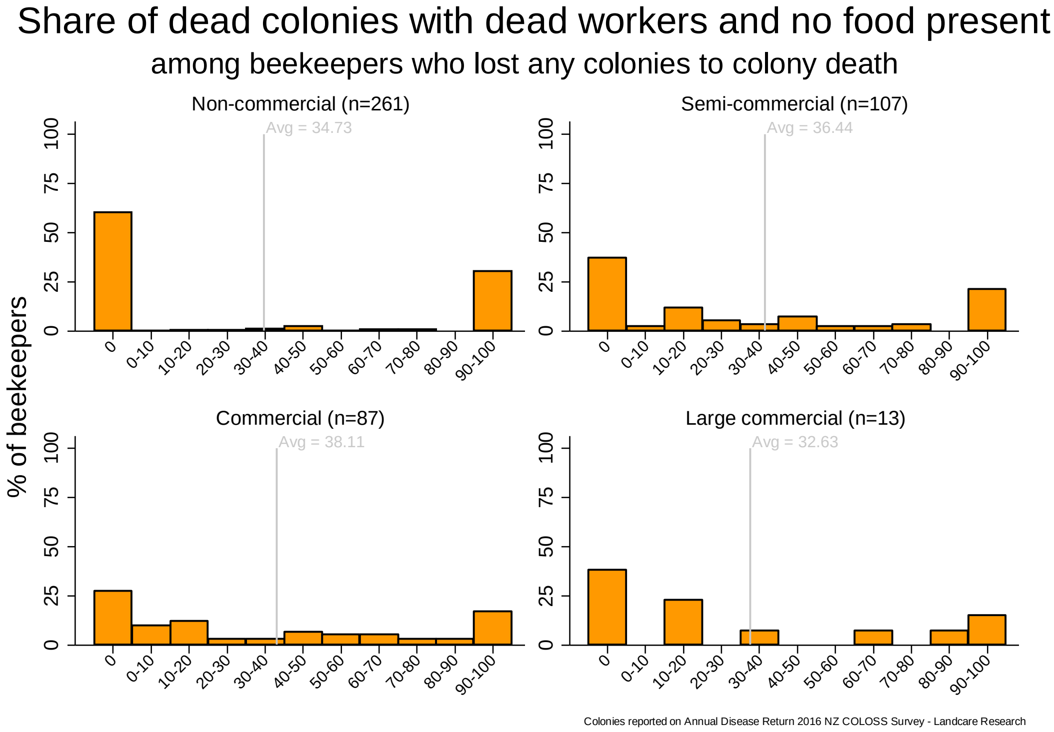
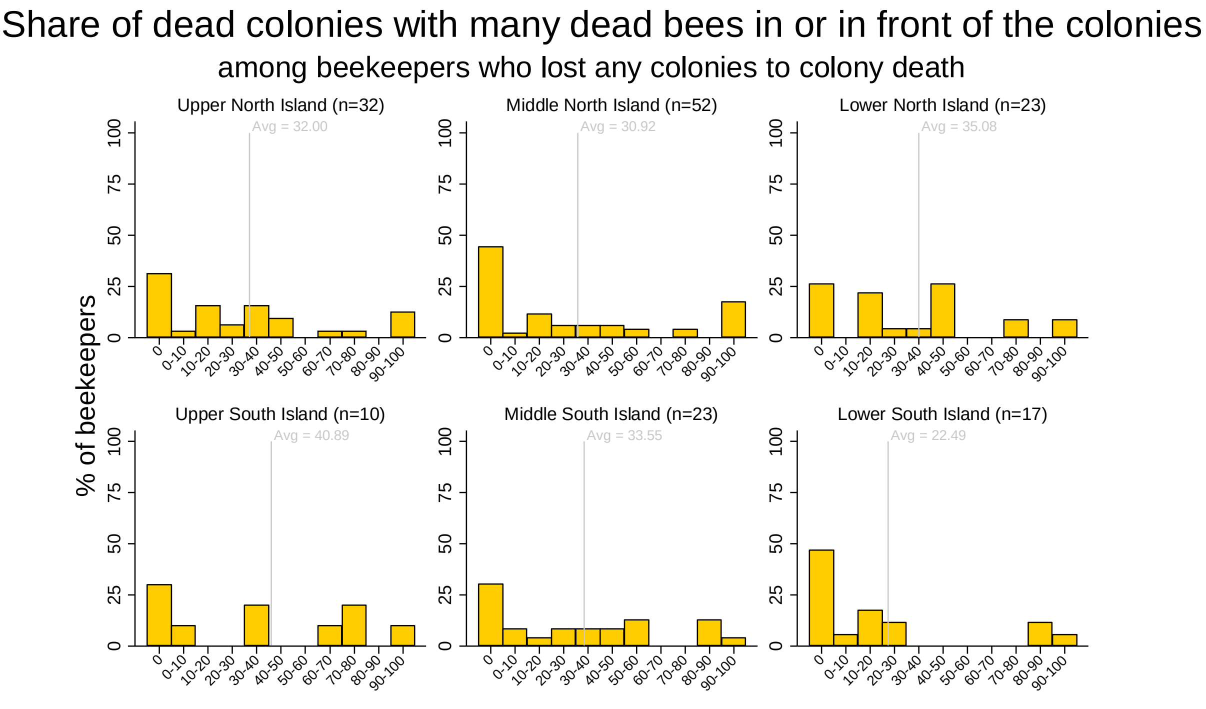
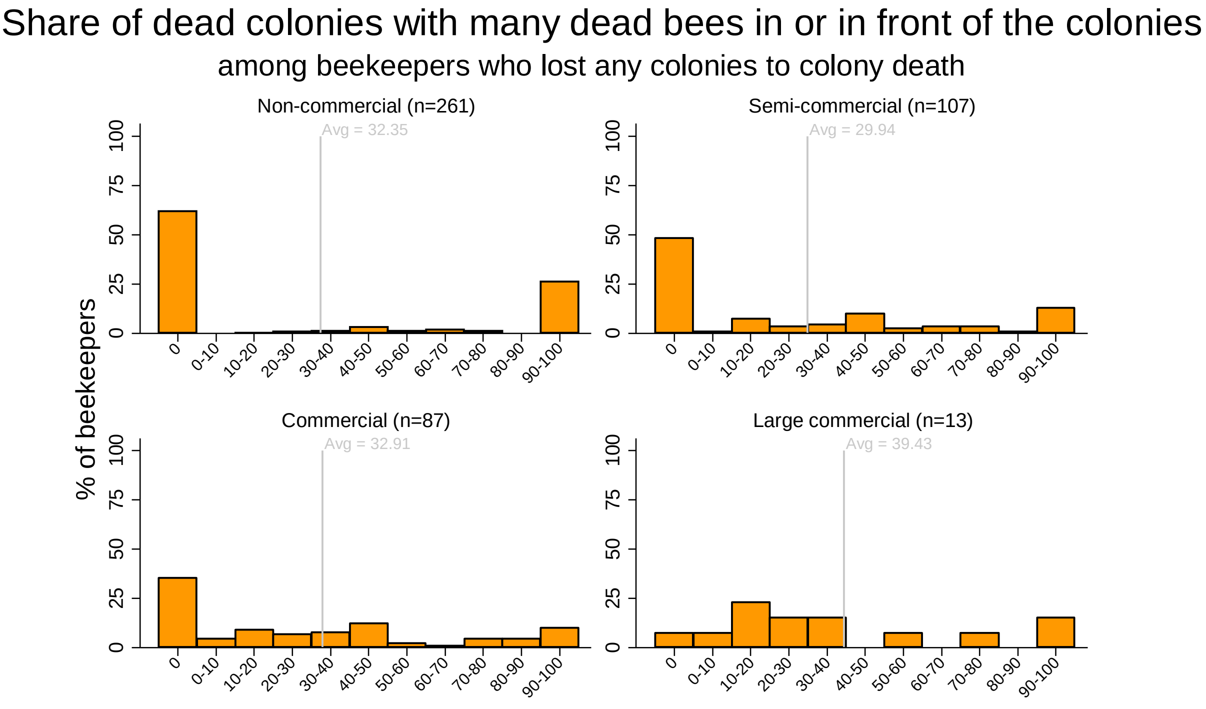


Figure 13: Share of dead colonies that had dead workers and no food present among respondents who had any dead colonies after winter 2016 based on reports from all respondents, by operation size.



Regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 14: Share of dead colonies that had many dead bees in or in front of the colonies among respondents who had any dead colonies after winter 2016 based on reports from respondents with more than 250 hives, by region.



Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 15: Share of dead colonies that had many dead bees in or in front of the colonies among respondents who had any dead colonies after winter 2016 based on reports from all respondents, by operation size.

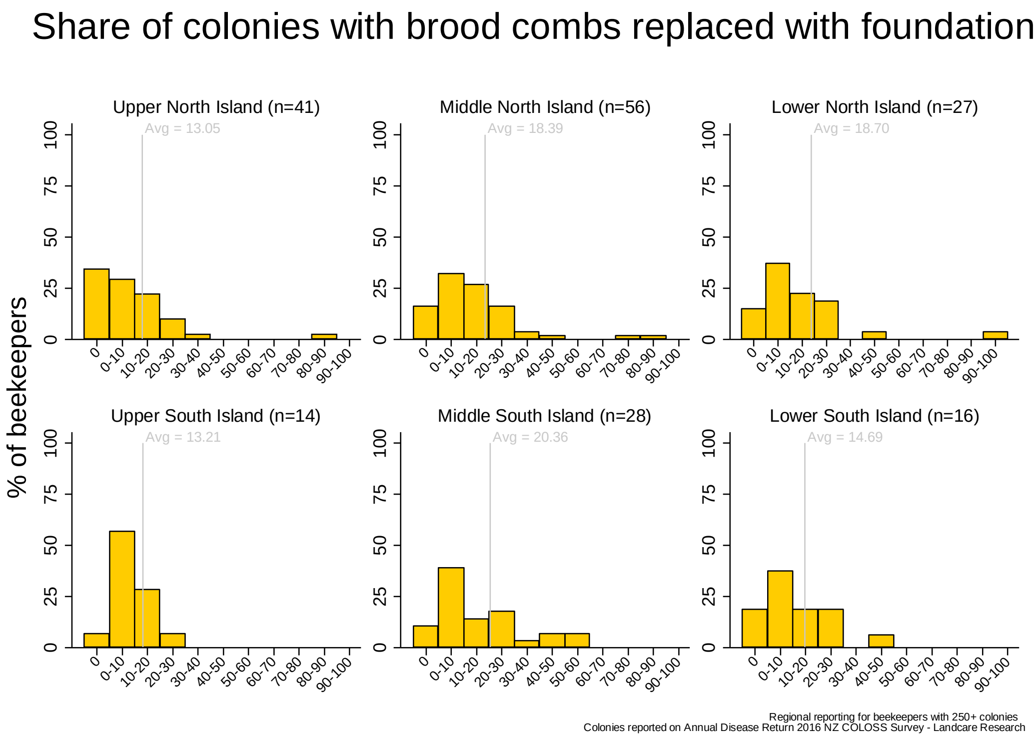


Figure 16: Share of brood combs replaced by comb foundation (per colony) during the 2015/2016 season based on reports from respondents with more than 250 colonies, by region.

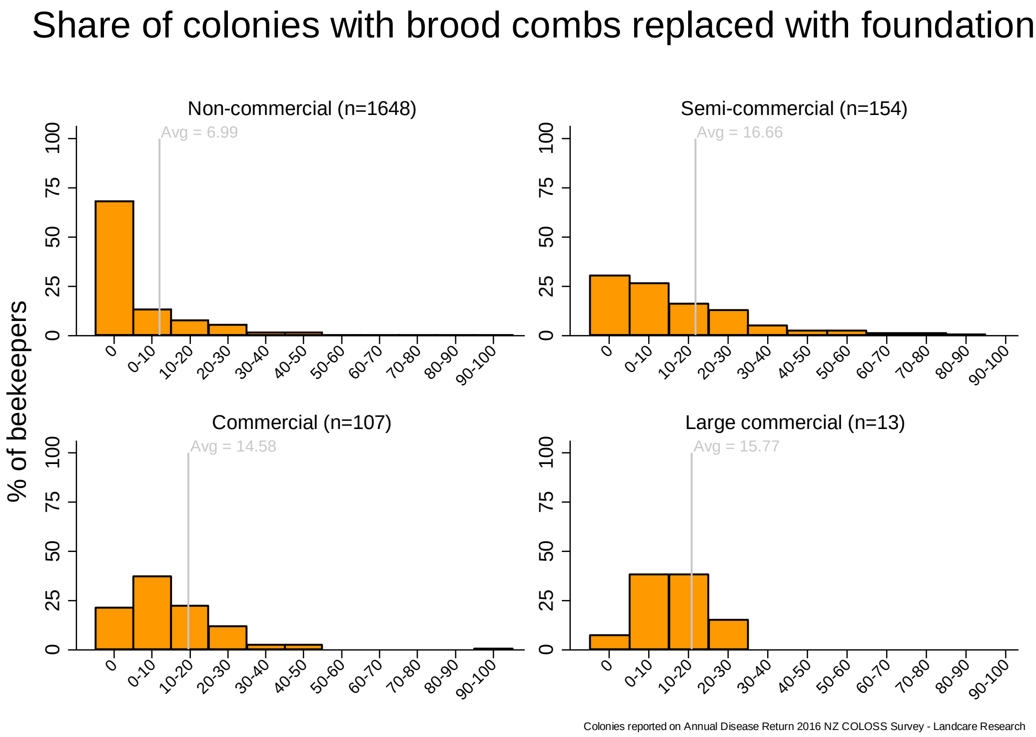
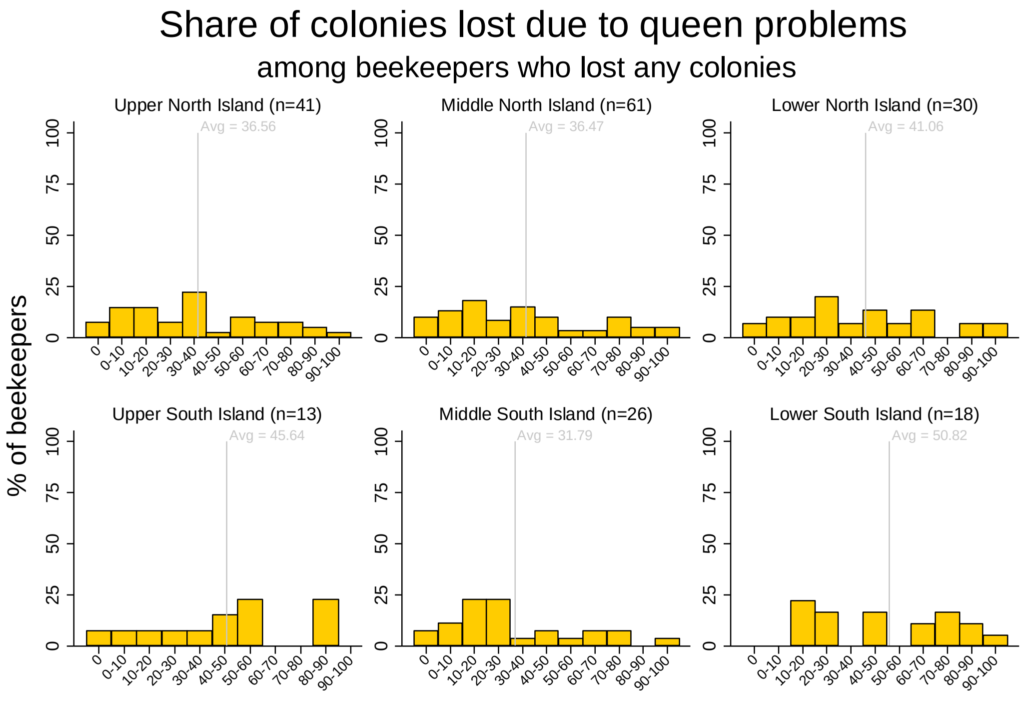
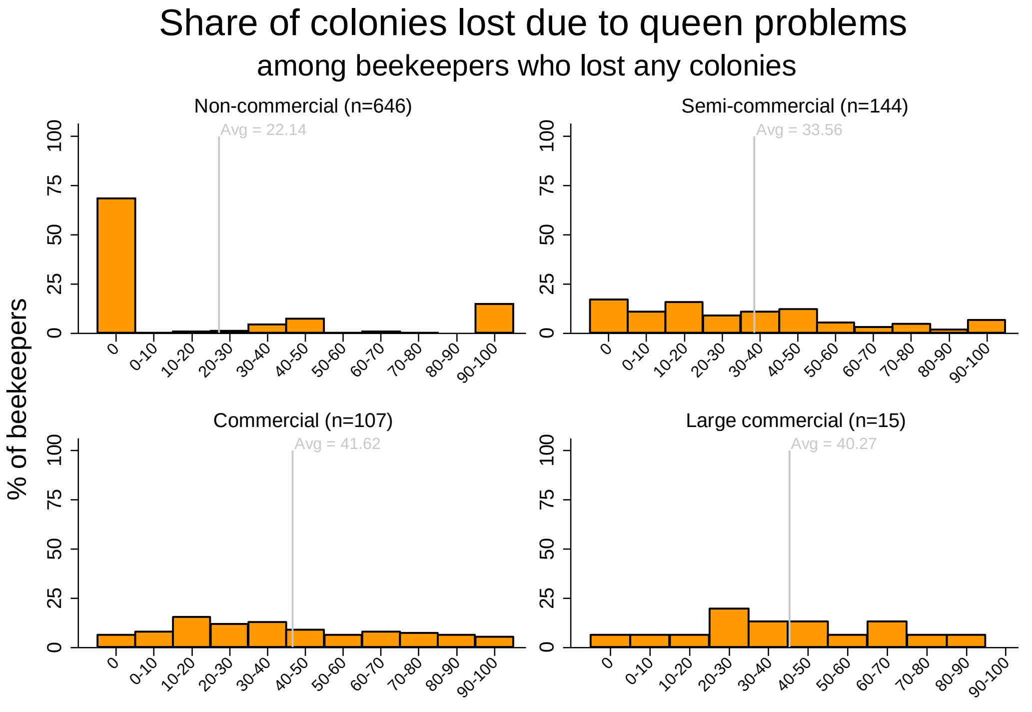


Figure 17: Share of brood combs replaced by comb foundation (per colony) during the 2015/2016 season based on reports from all respondents, by operation size.



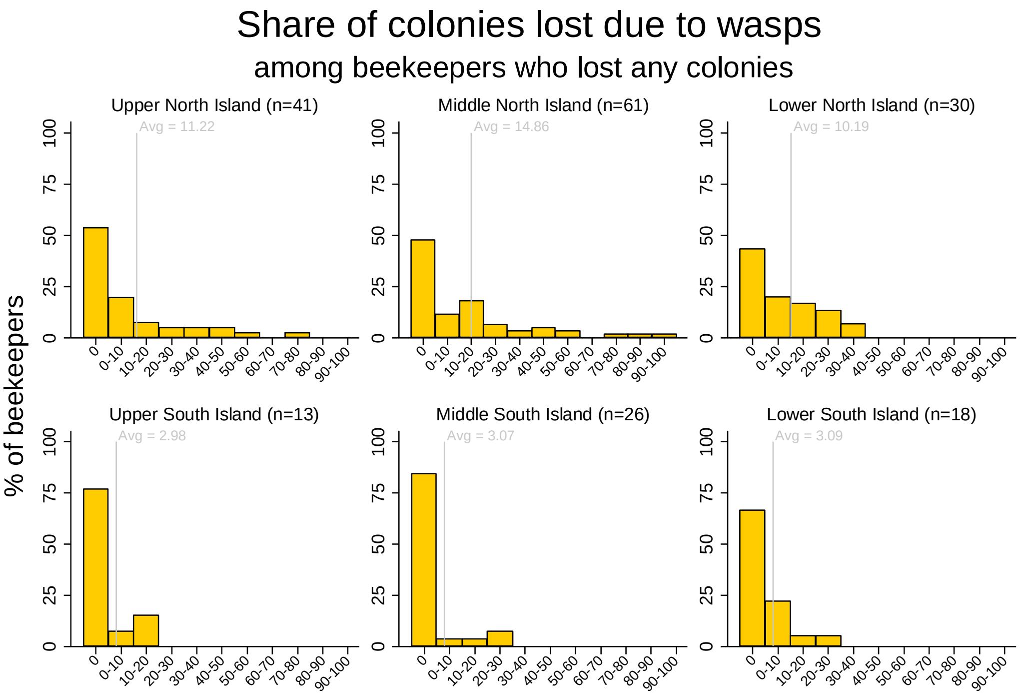
Regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 18: Winter 2016 colony losses that resulted from queen problems (including drone-laying queens and no queen) based on reports from respondents with more than 250 colonies who lost any colonies, by region.



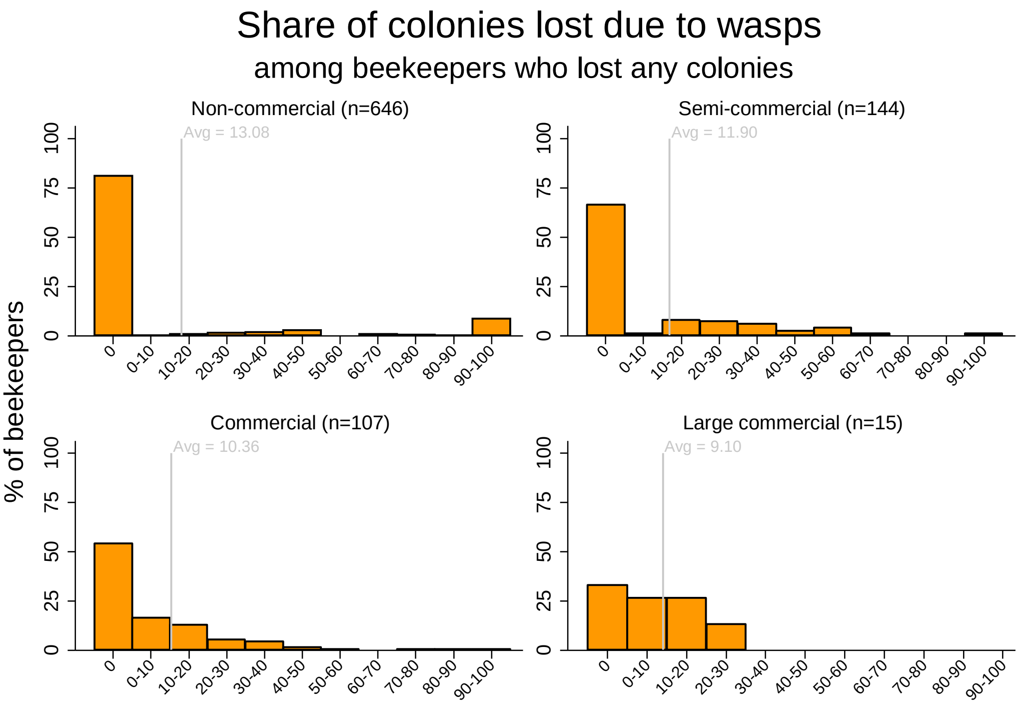
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 19: Winter 2016 colony losses that resulted from queen problems (including drone-laying and no queen) based on reports from all respondents who lost any colonies, by operation size.



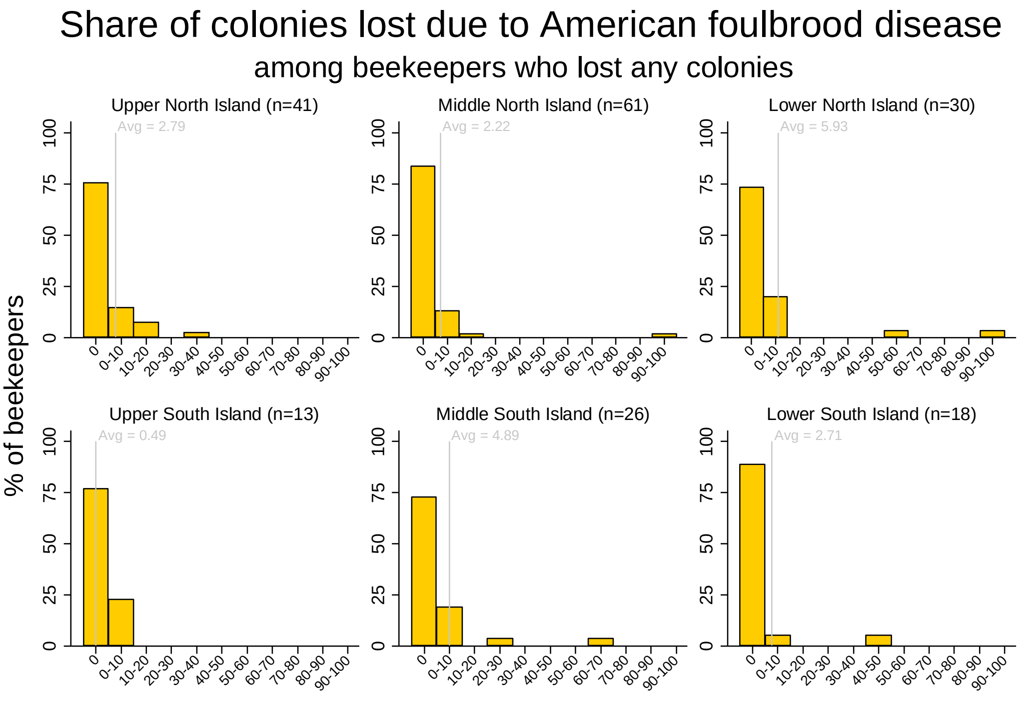
Regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 20: Winter 2016 colony losses that resulted from wasp problems based on reports from respondents with more than 250 colonies who lost any colonies, by region.



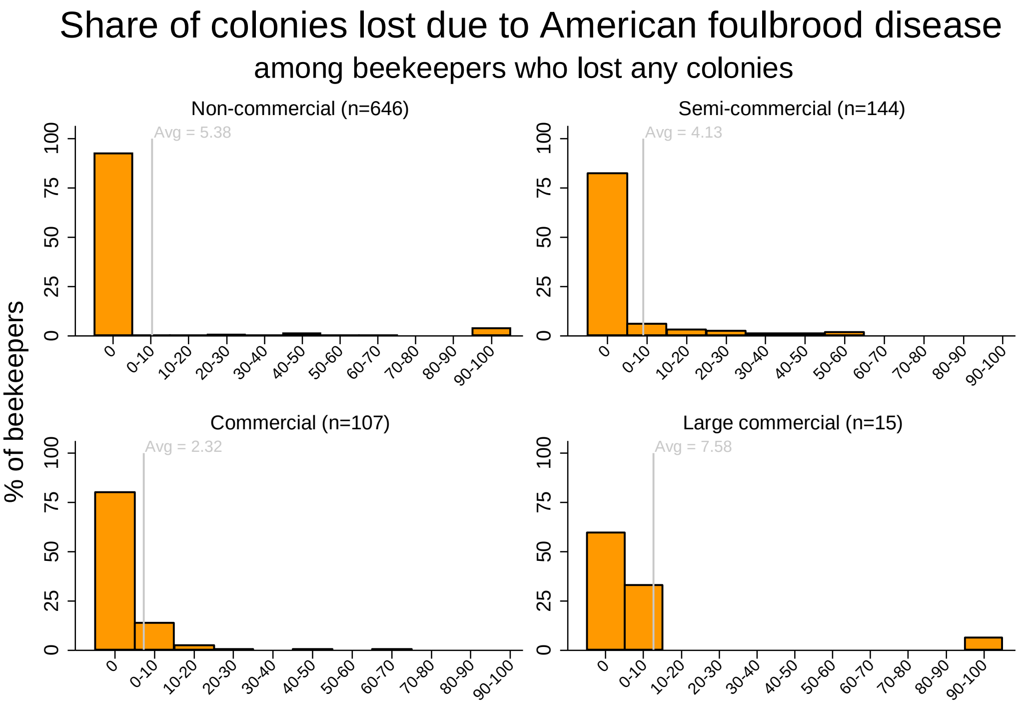
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 21: Winter 2016 colony losses that resulted from wasp problems based on reports from all respondents who lost any colonies, by operation size.



Regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 22: Winter 2016 colony losses that resulted from AFB based on reports from respondents with more than 250 colonies who lost any colonies, by region.



Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 23: Winter 2016 colony losses that resulted from AFB based on reports from all respondents who lost any colonies, by operation size.

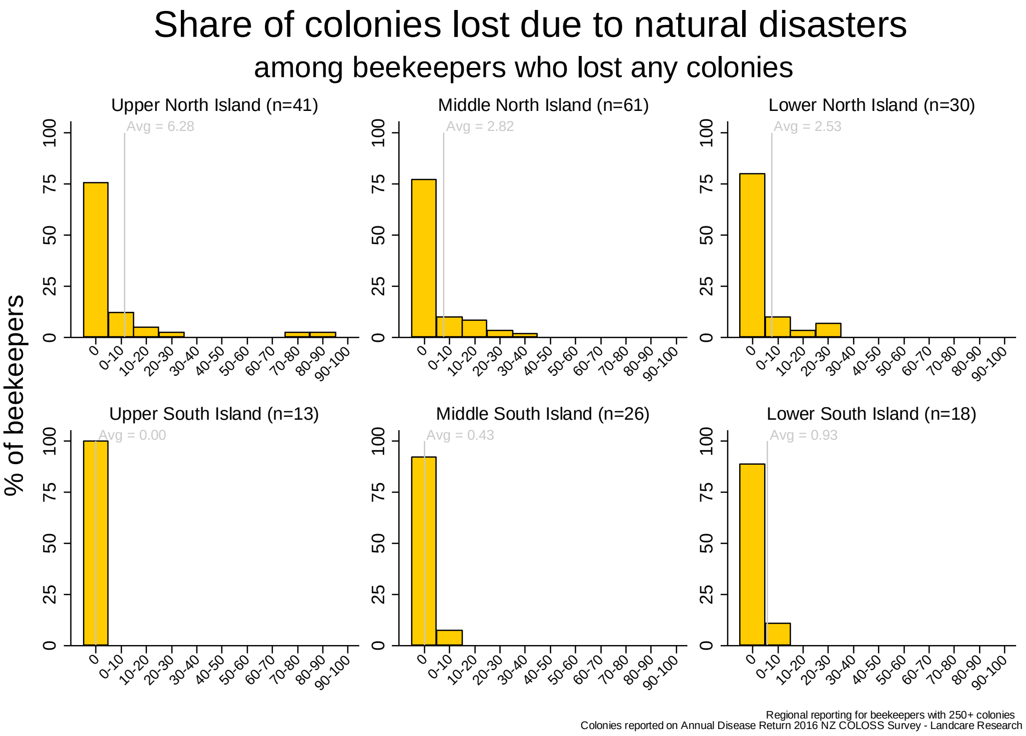


Figure 24: Winter 2016 colony losses that resulted from natural disasters based on reports from respondents with more than 250 colonies who lost any colonies, by region. Natural disasters include gale force winds, flooding, etc.

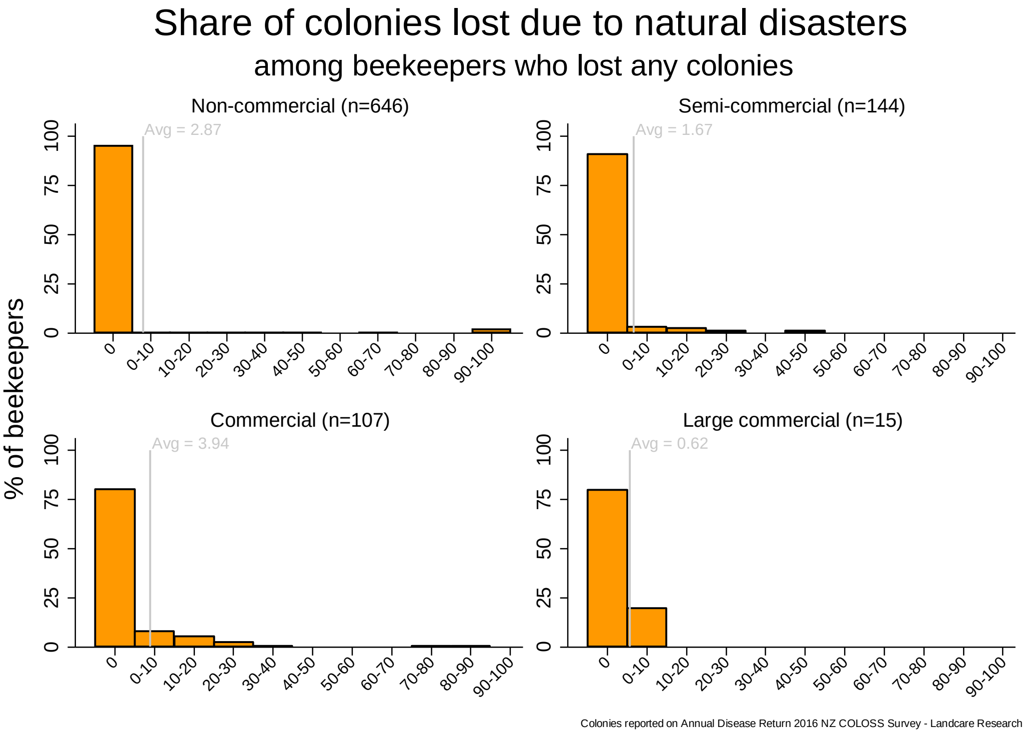
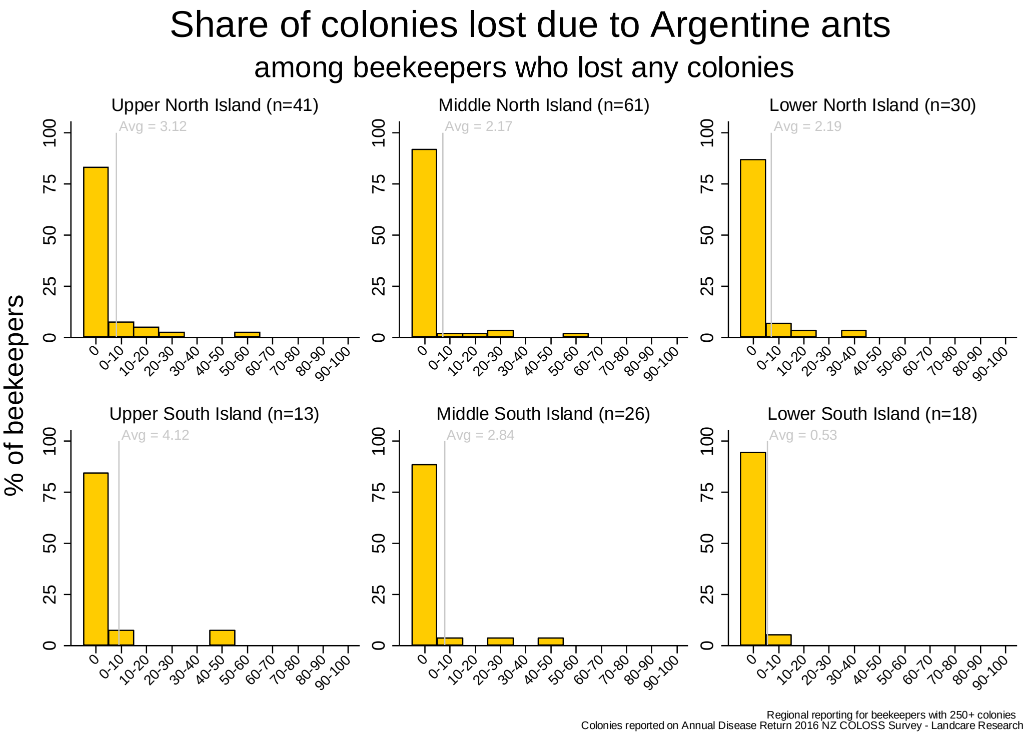


Figure 25: Winter 2016 colony losses that resulted from natural disasters based on reports from all respondents who lost any colonies, by operation size. Natural disasters include gale force winds, flooding, etc.


Share of colonies lost due to Argentine ants

among beekeepers who lost any colonies

Upper North Island (n=41)

Middle North Island (n=61)

Lower North Island (n=30)

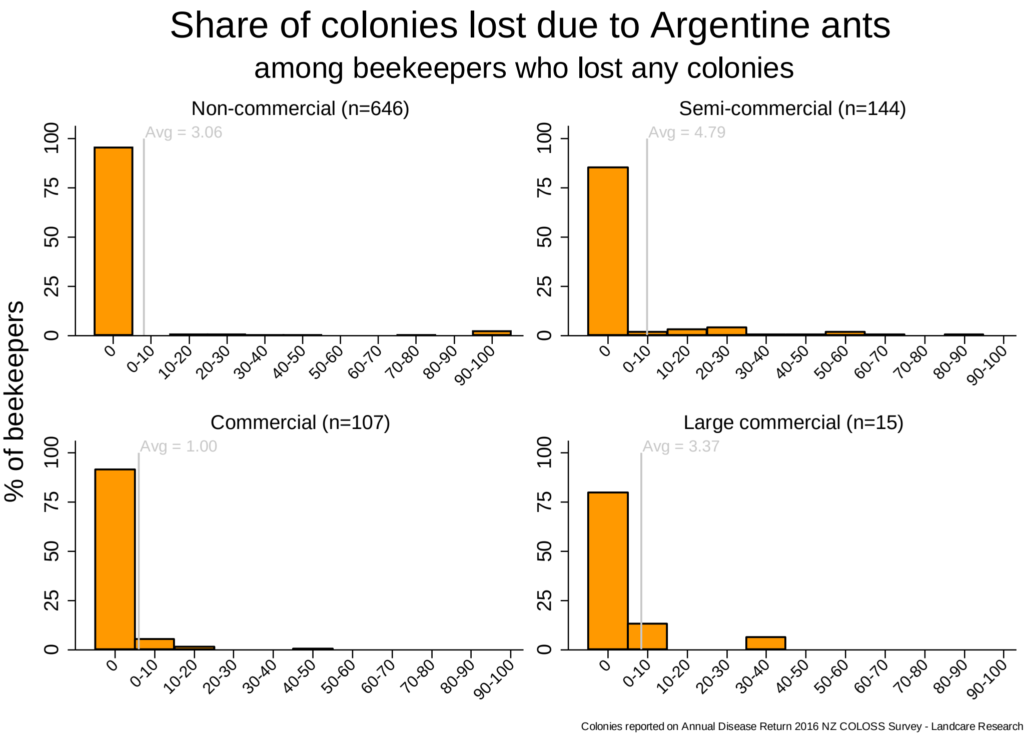
Upper South Island (n=13)

Middle South Island (n=26)

Lower South Island (n=18)

Regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 26: Winter 2016 colony losses that resulted from Argentine ant problems based on reports from respondents with more than 250 colonies who lost any colonies, by region.


Share of colonies lost due to Argentine ants

among beekeepers who lost any colonies

Non-commercial (n=646)

Semi-commercial (n=144)

Commercial (n=107)

Large commercial (n=15)

Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 27: Winter 2016 colony losses that resulted from Argentine ant problems based on reports from all respondents who lost any colonies, by operation size.

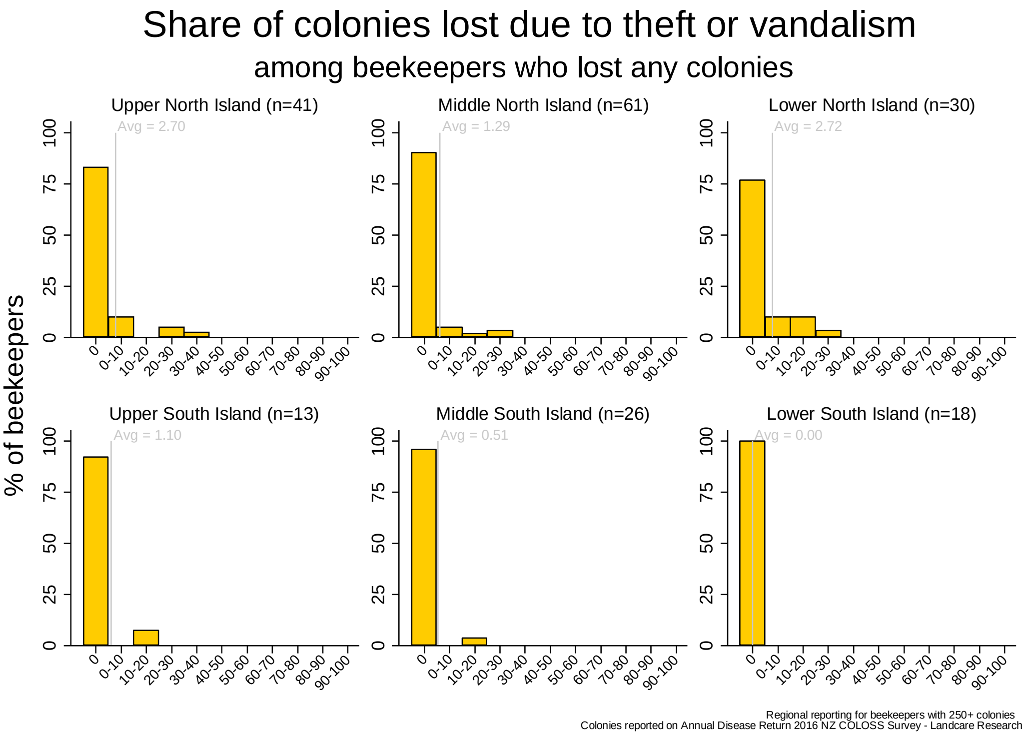


Figure 28: Winter 2016 colony losses that resulted from theft or vandalism based on reports from respondents with more than 250 colonies who lost any colonies, by region.

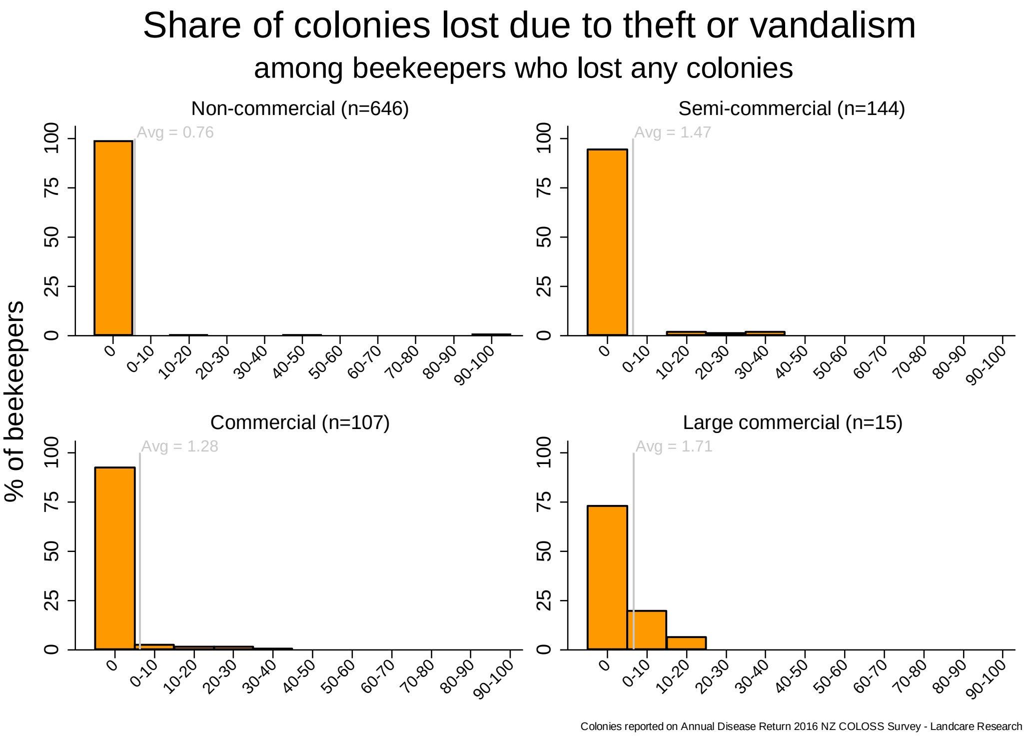


Figure 29: Winter 2016 colony losses that resulted from theft or vandalism based on reports from all respondents who lost any colonies, by operation size.

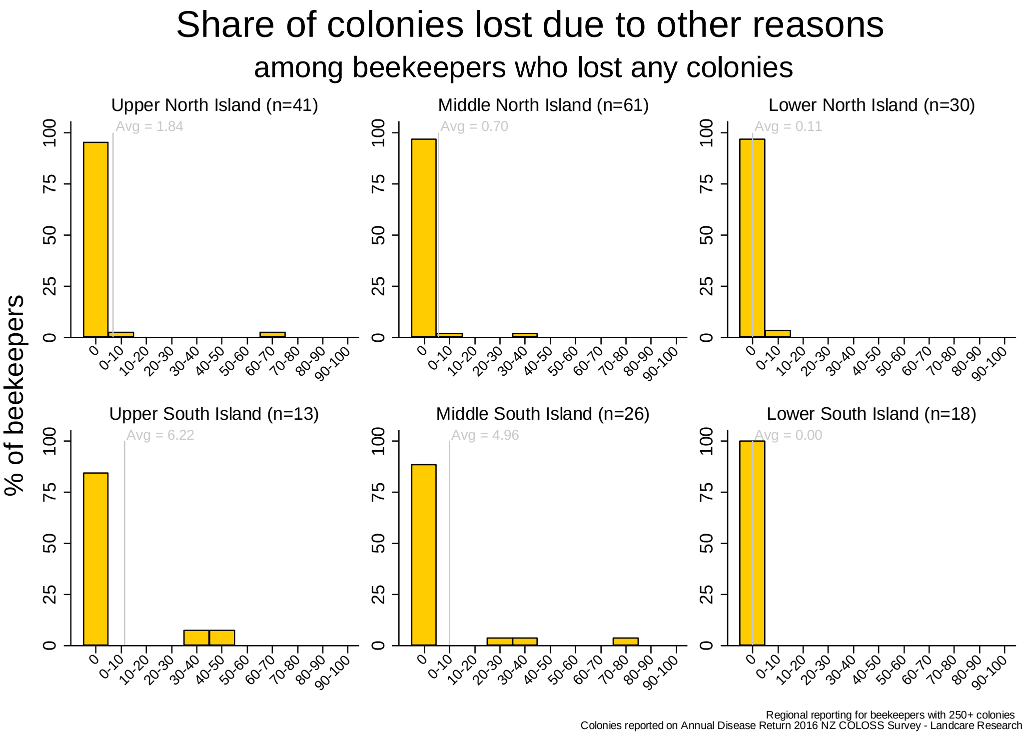


Figure 30: Winter 2016 colony losses that resulted from other problems based on reports from respondents with more than 250 colonies who lost any colonies, by region.

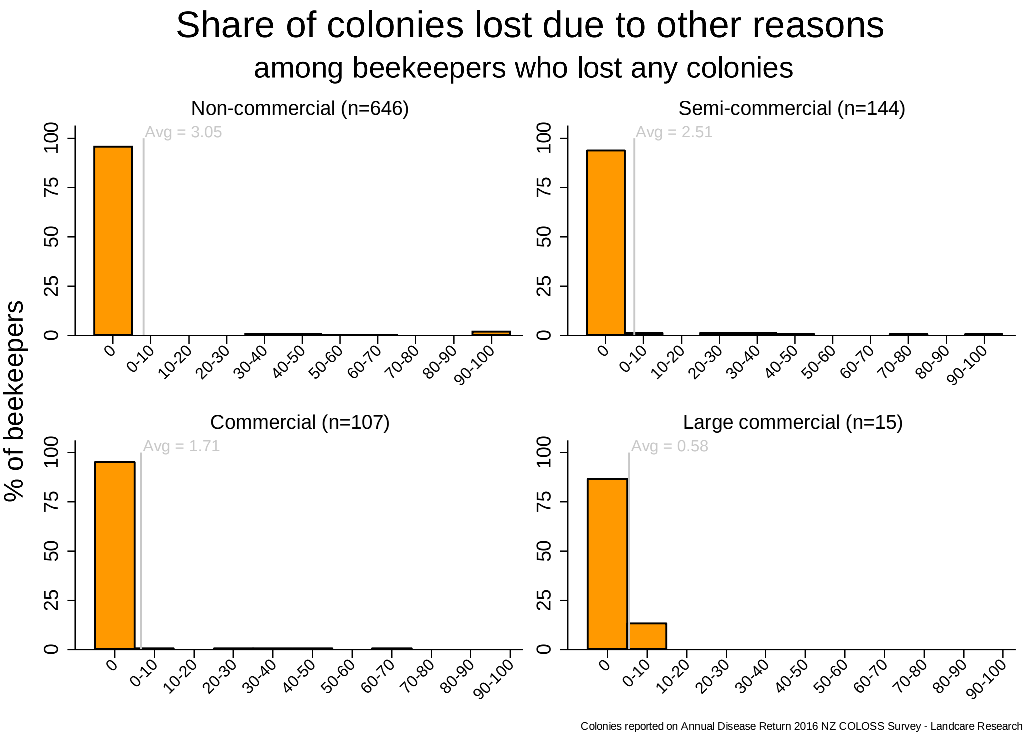
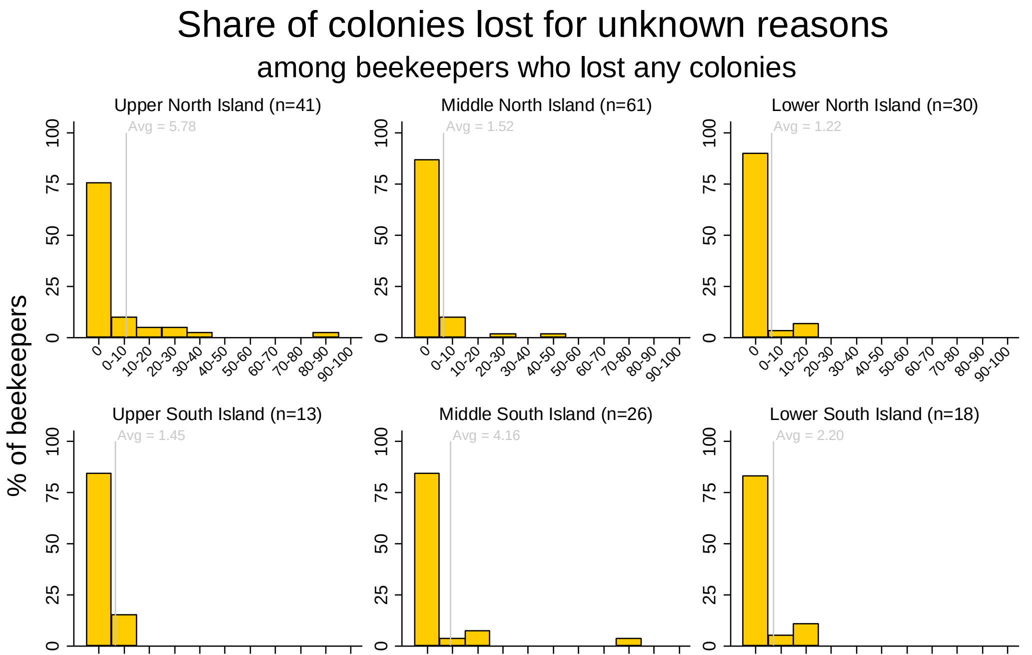
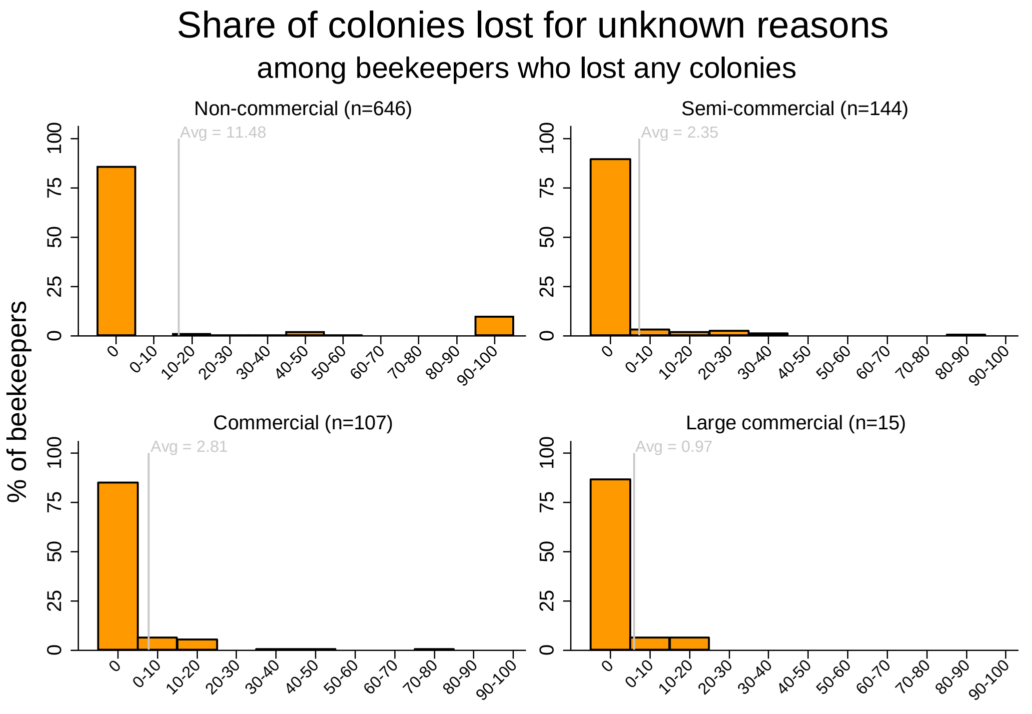


Figure 31: Winter 2016 colony losses that resulted from other problems based on reports from all respondents who lost any colonies, by operation size.



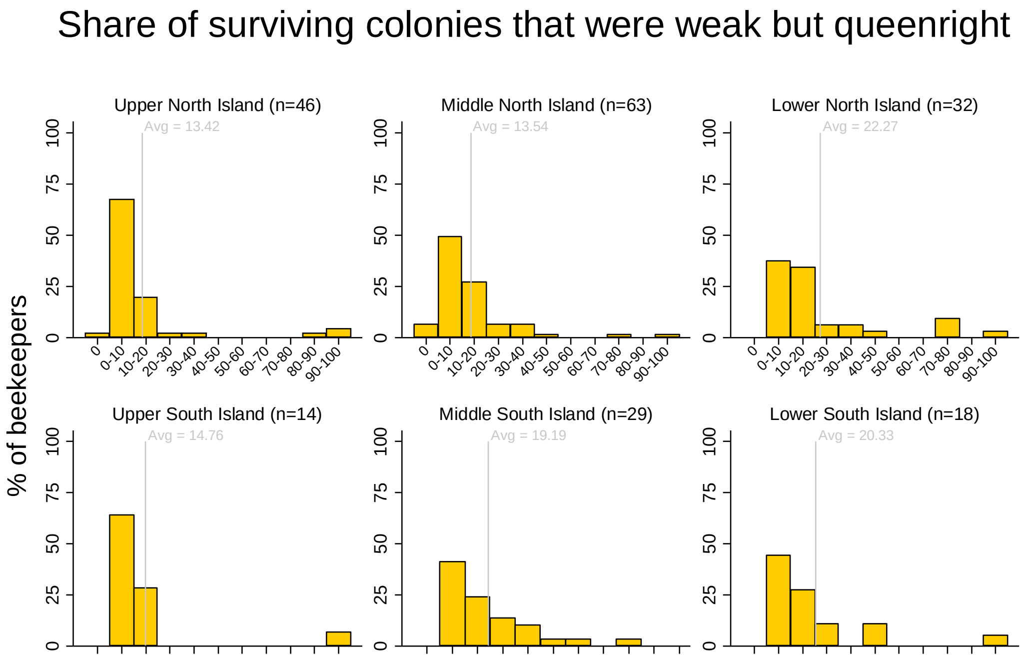
Regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 32: Winter 2016 colony losses that resulted from unknown reasons based on reports from respondents with more than 250 colonies who lost any colonies, by region.



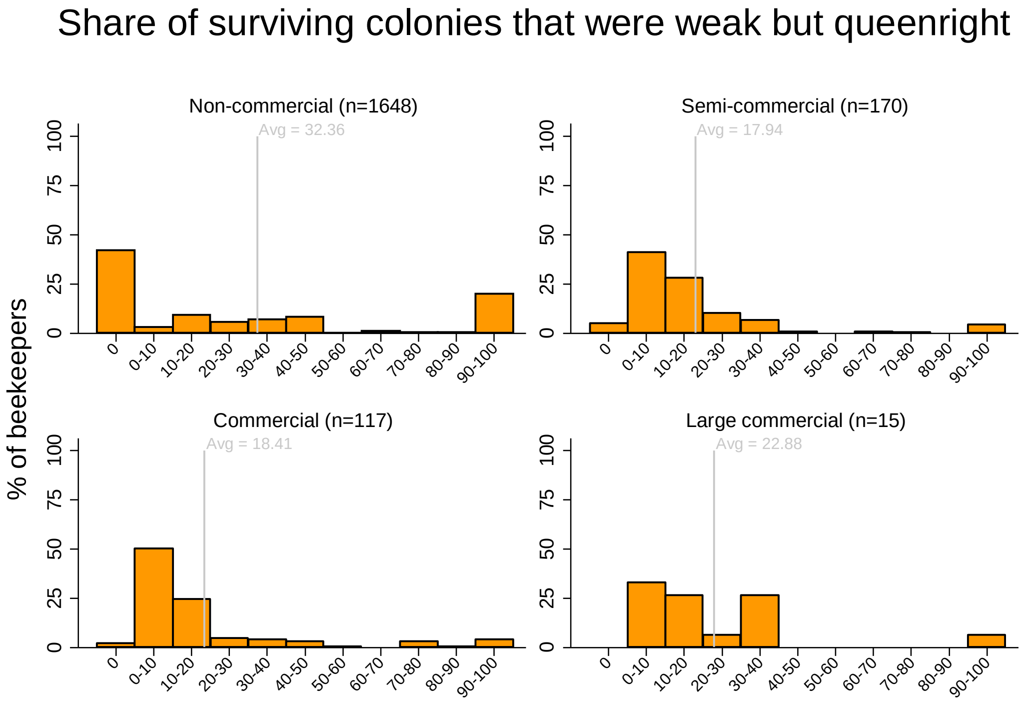
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 33: Winter 2016 colony losses that resulted from unknown reasons based on reports from all respondents who lost any colonies, by operation size.



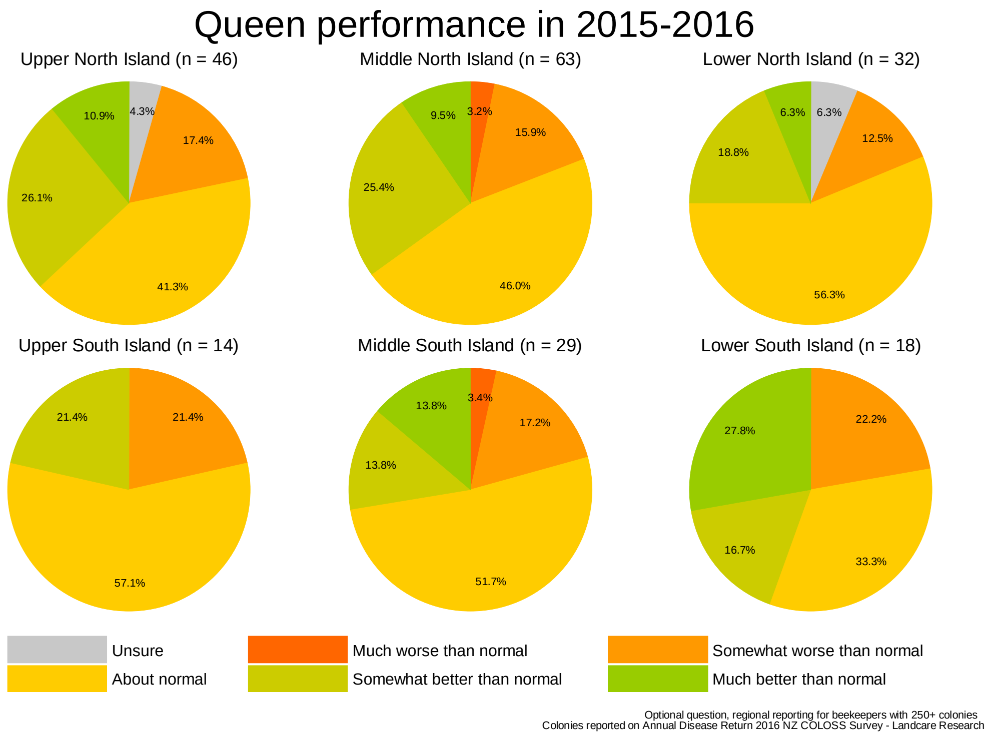
Regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 34: Colonies that survived winter 2016 and that were weak but queenright based on reports from respondents with more than 250 colonies, by region.



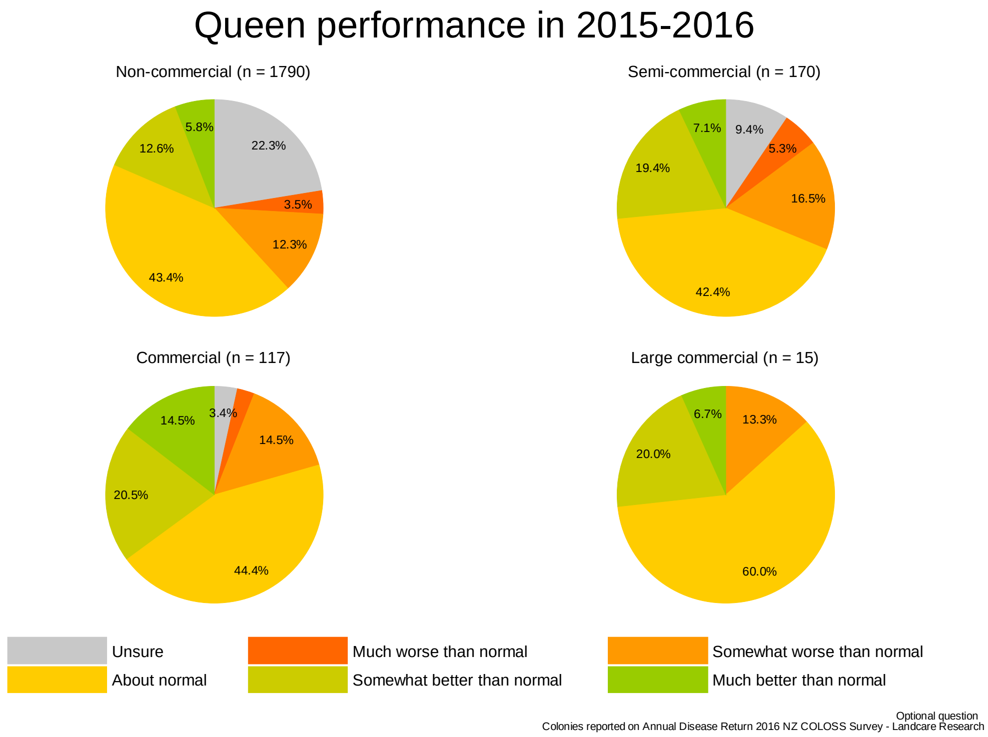
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 35: Colonies that survived winter 2016 and that were weak but queenright based on reports from all respondents, by operation size.



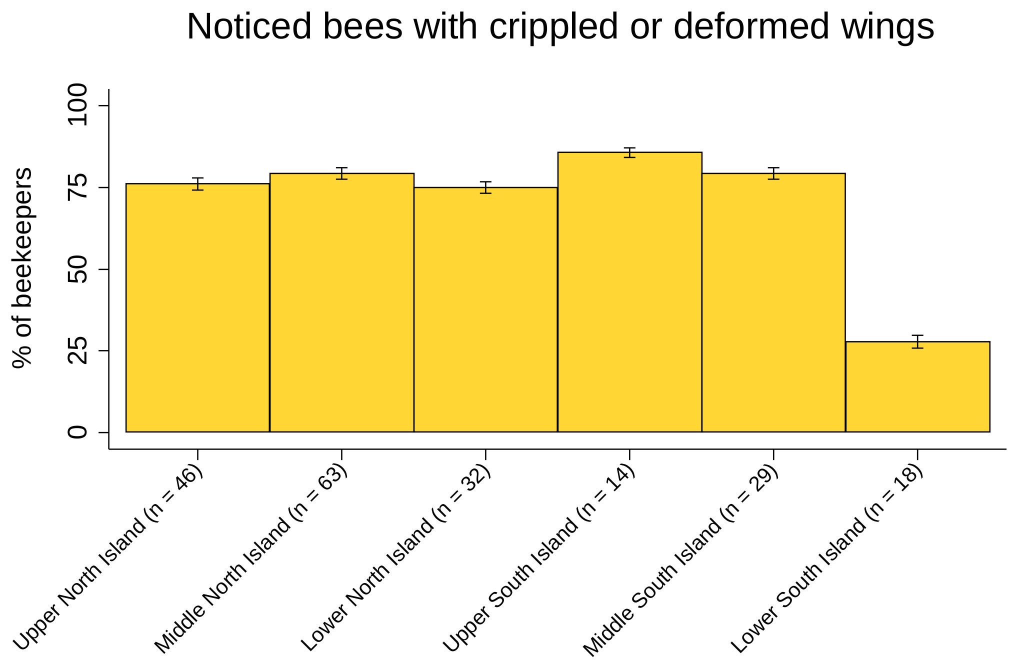
Optional question, regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 36: Queen performance during 2015/2016 compared with previous years for respondents with more than 250 colonies, by region.



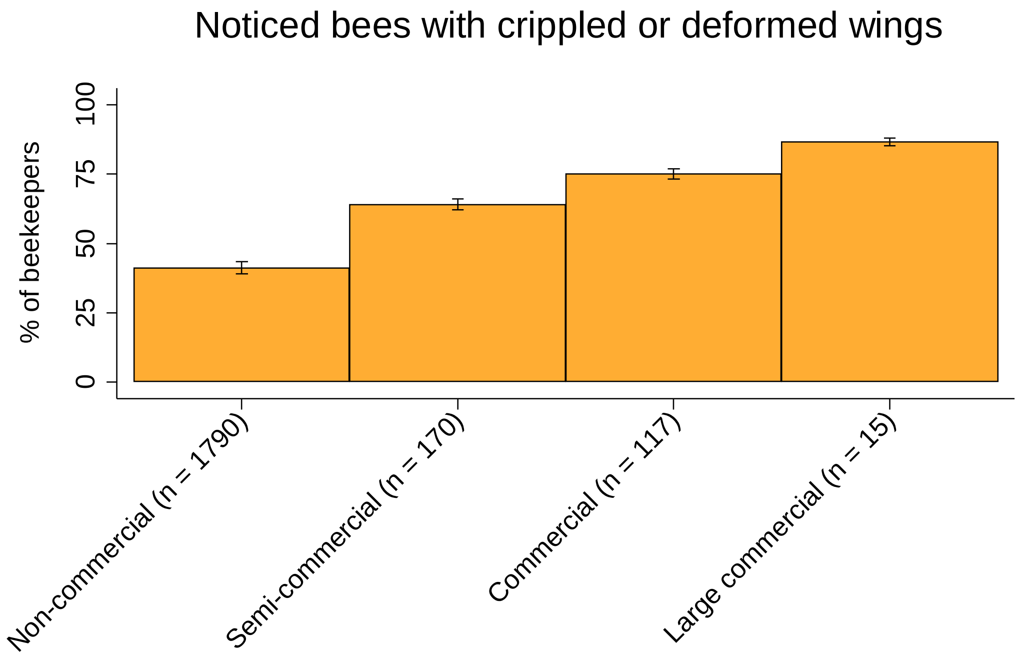
Optional question
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 37: Queen performance during 2015/2016 compared with previous years for all respondents, by operation size.


Noticed bees with crippled or deformed wings

Optional question, regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research
Error bars are 95% confidence intervals for the population proportion

Figure 38: Share of respondents who observed crippled or deformed wings during the 2015/2016 season based on reports from respondents with more than 250 colonies, by region.


Noticed bees with crippled or deformed wings

Optional question
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research
Error bars are 95% confidence intervals for the population proportion

Figure 39: Share of respondents who observed crippled or deformed wings during the 2015/2016 season based on reports from all respondents, by operation size.

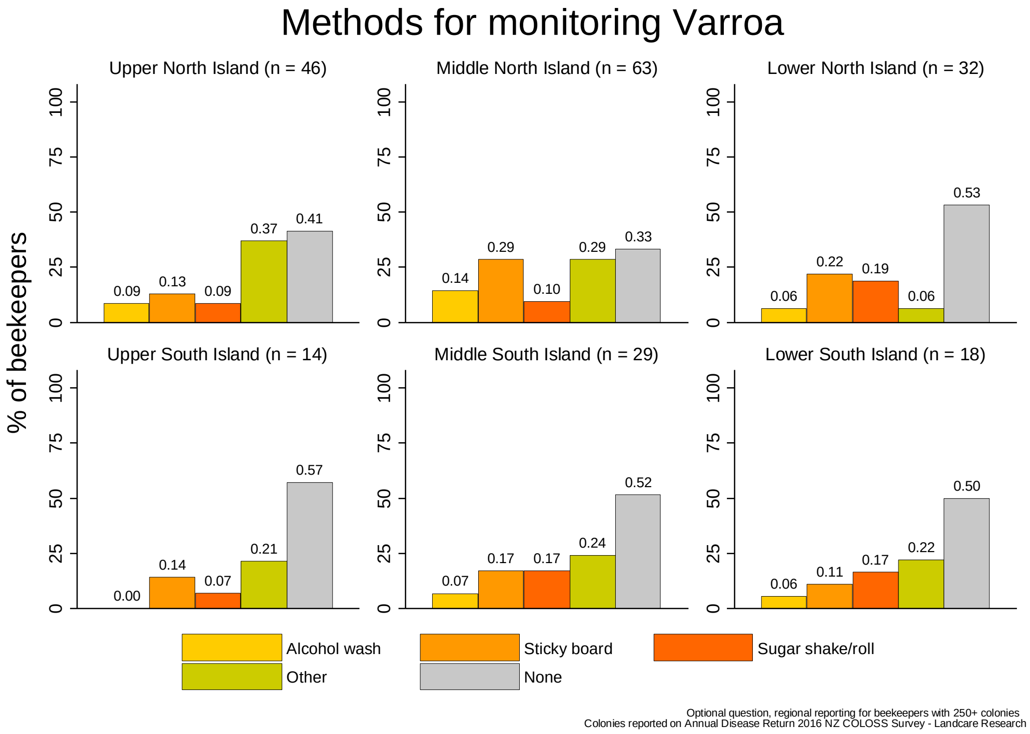


Figure 40: Methods for monitoring *Varroa* during the 2015/2016 season based on reports from respondents with more than 250 colonies, by region.

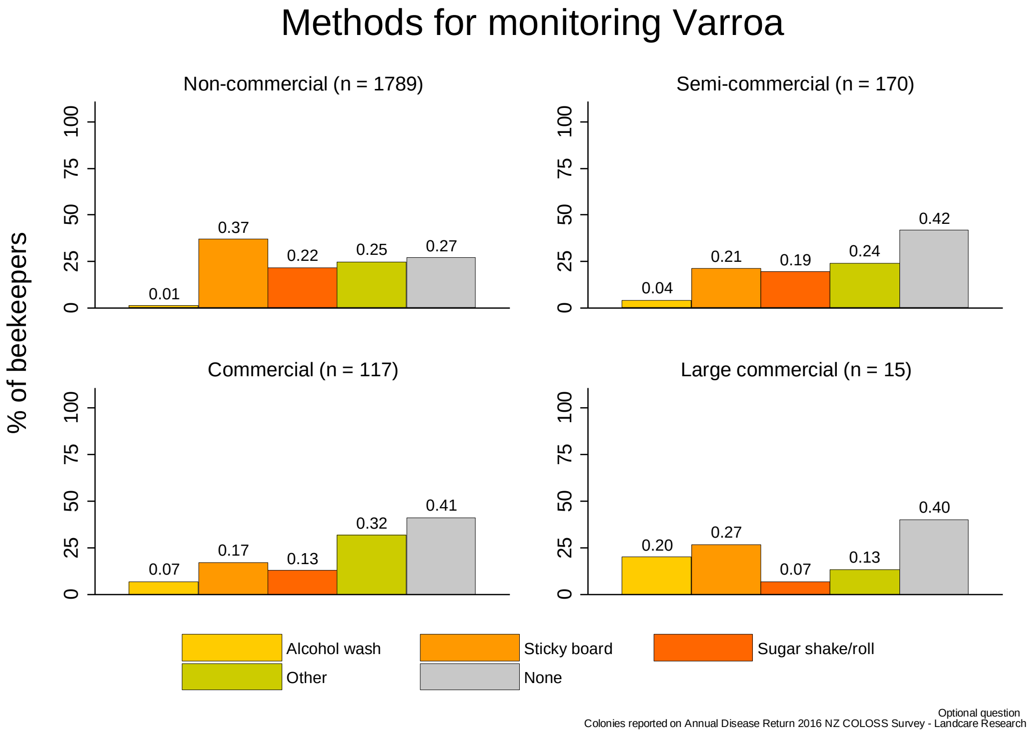
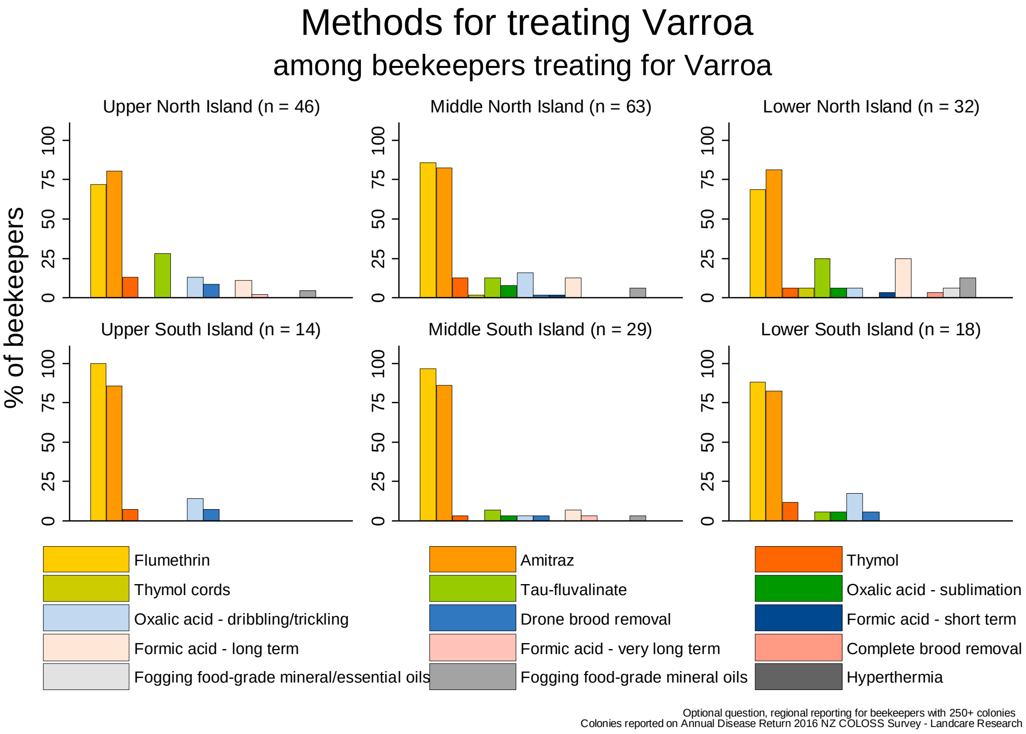
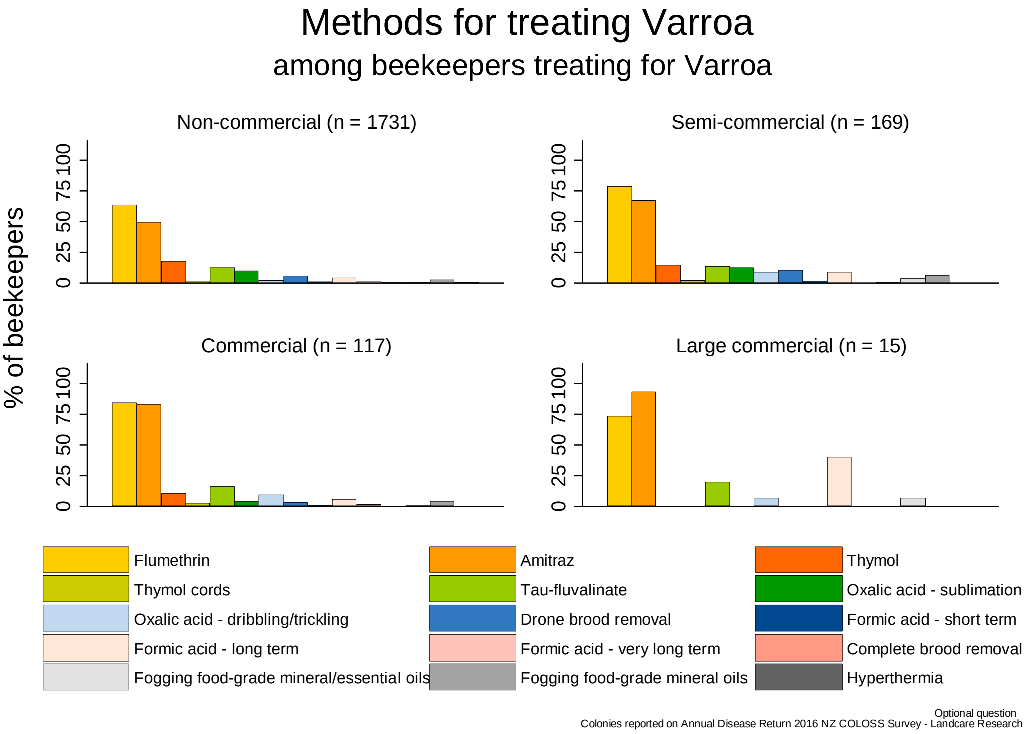


Figure 41: Methods for monitoring *Varroa* during the 2015/2016 season based on reports from all respondents, by operation size.



Optional question, regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 42: *Varroa* treatment methods during the 2015/2016 season based on reports from respondents with more than 250 colonies, by region.



Optional question
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 43: *Varroa* treatment methods during the 2015/2016 season based on reports from all respondents, by operation size.

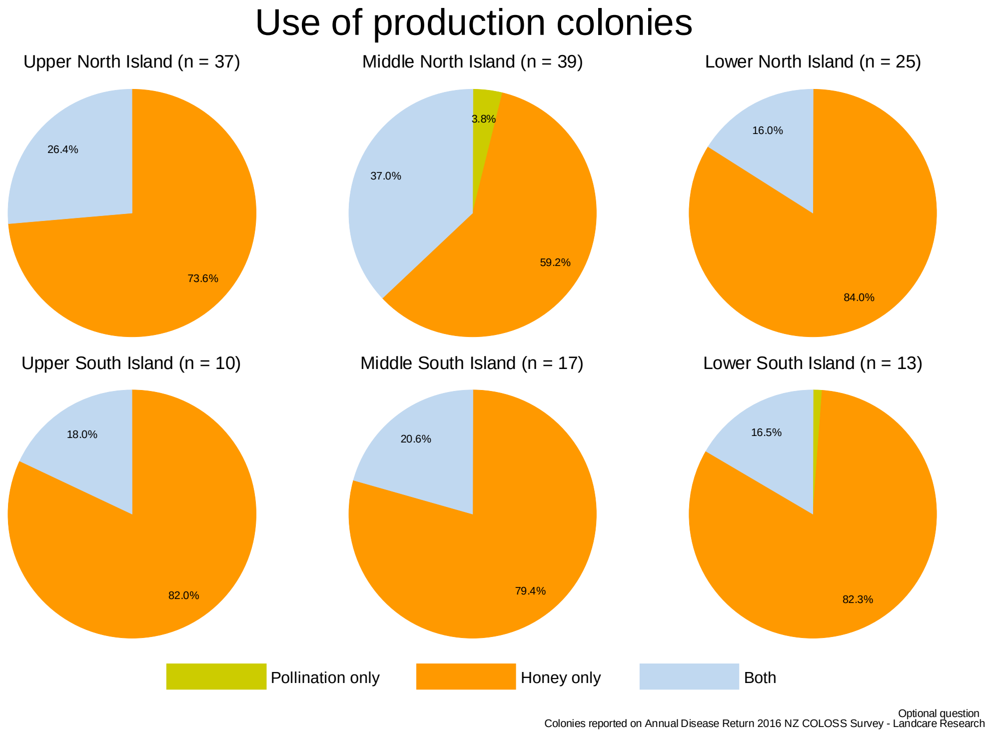


Figure 44: Use of production colonies during the 2015/2016 season based on reports from respondents with more than 250 colonies, by region.

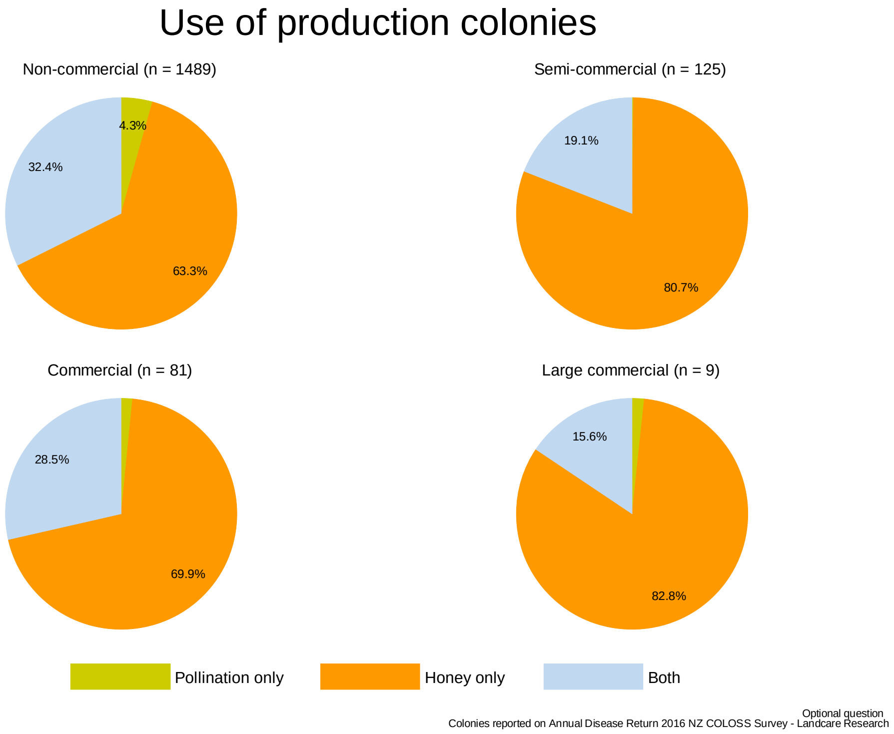


Figure 45: Use of production colonies during the 2015/2016 season based on reports from all respondents, by operation size.

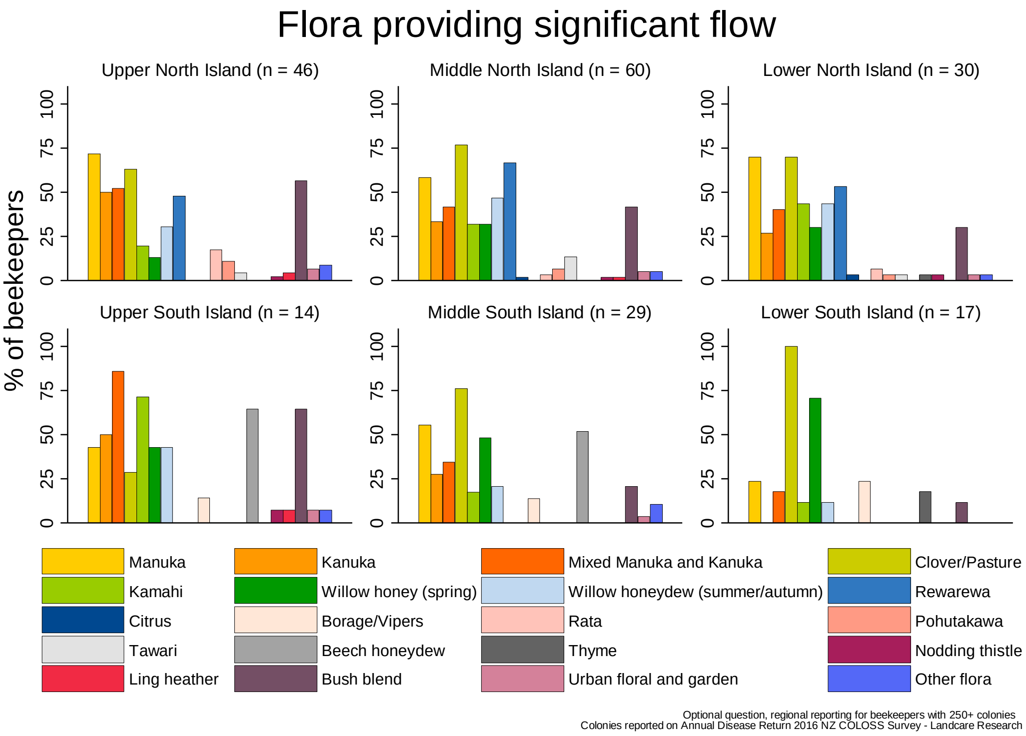


Figure 46: Sources of significant flow during the 2015/2016 season based on reports from respondents with more than 250 colonies, by region.

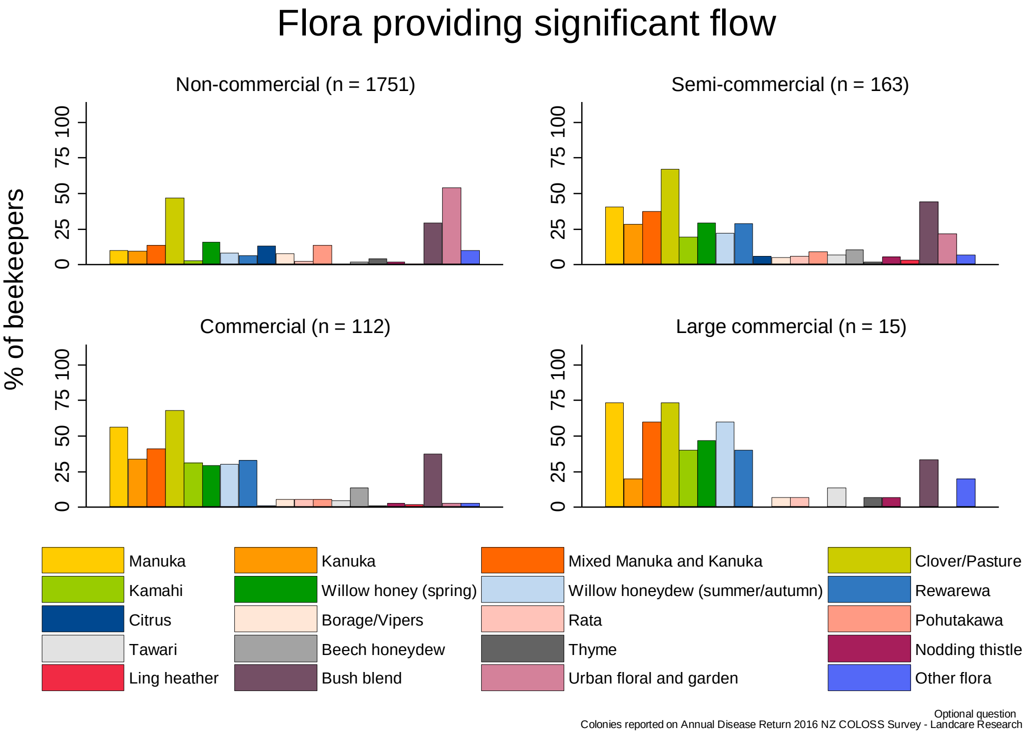
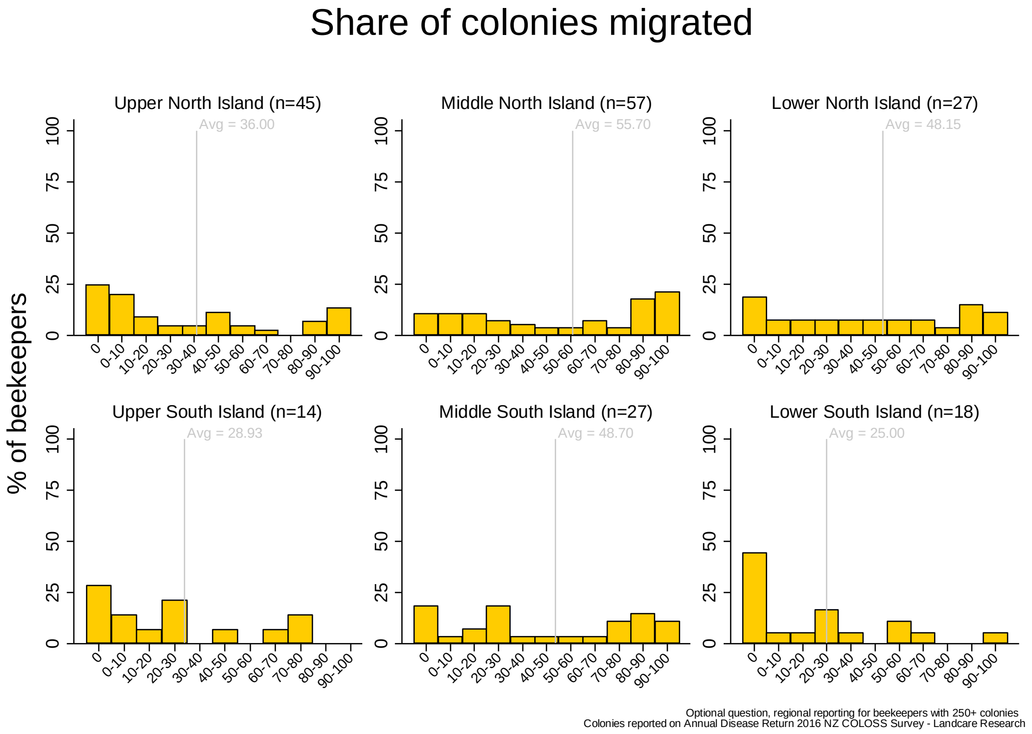
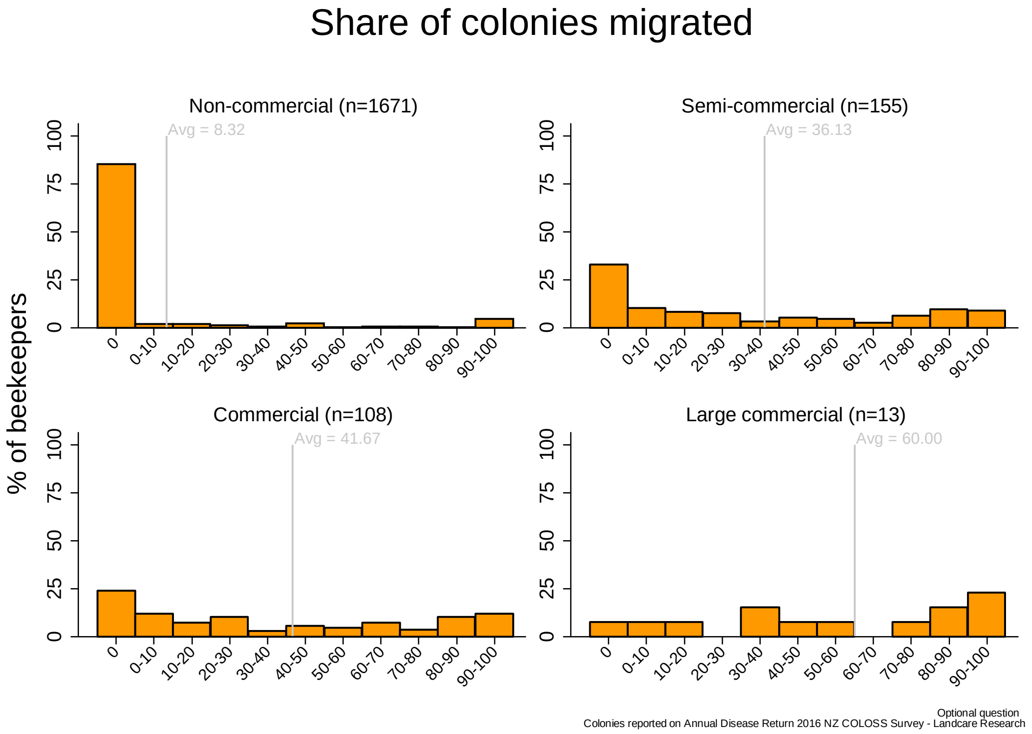


Figure 47: Sources of significant flow during the 2015/2016 season based on reports from all respondents, by operation size.



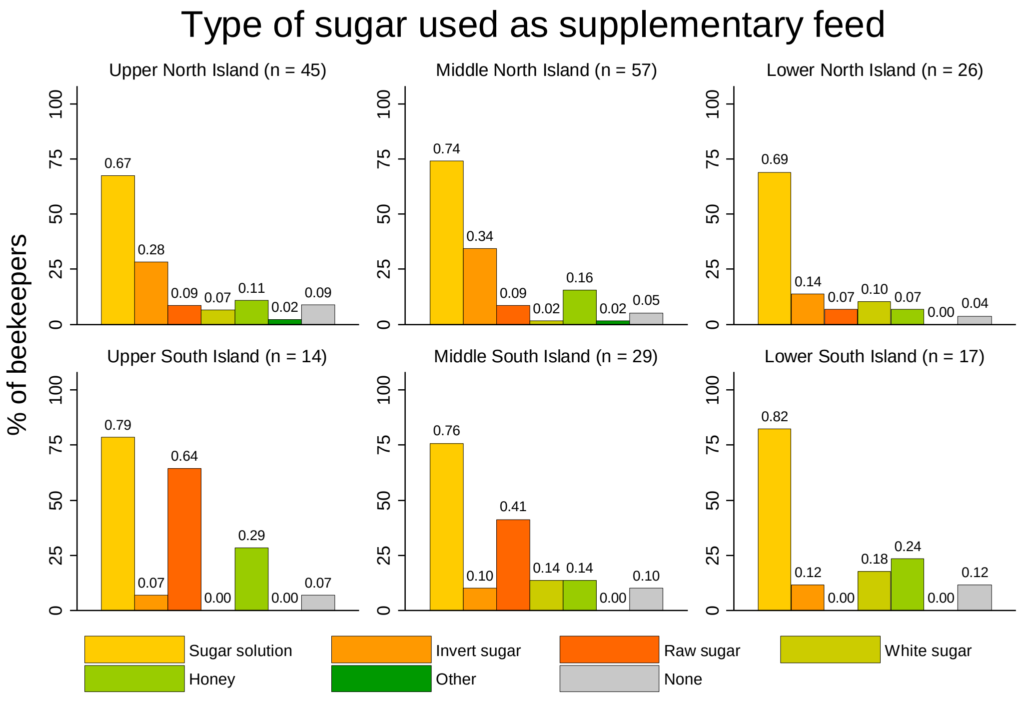
Optional question, regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 48: Share of colonies that were migrated at least once during the 2015/2016 season based on reports from respondents with more than 250 colonies, by region.



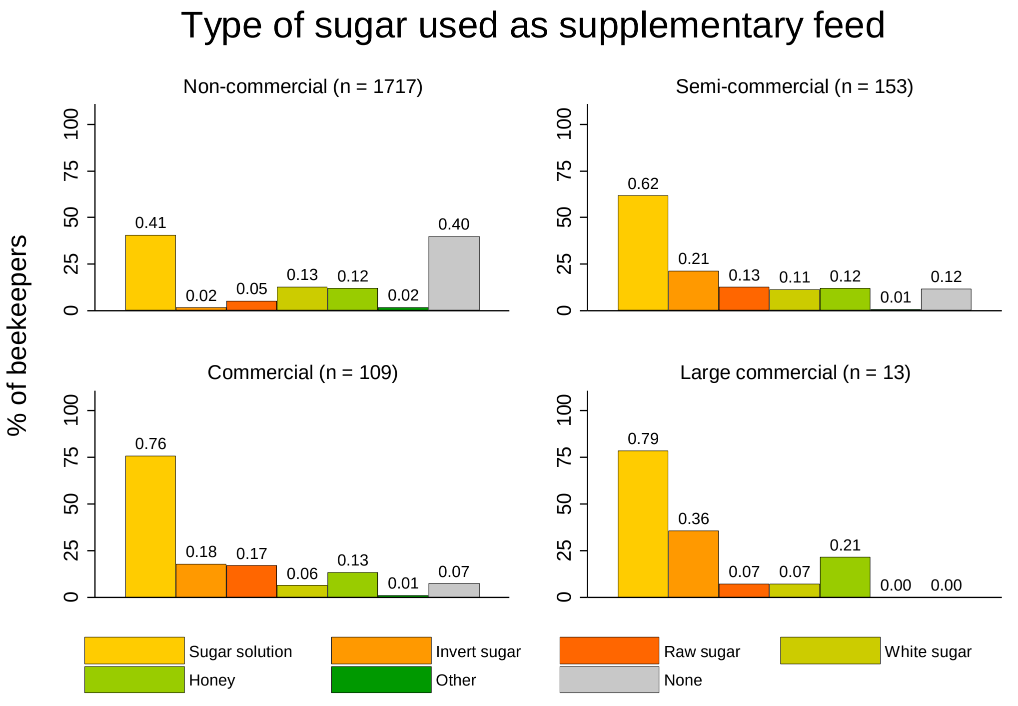
Optional question
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 49: Share of colonies that were migrated at least once during the 2015/2016 season based on reports from all respondents, by operation size.



Optional question, regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 50: Types of supplemental sugar feed provided to production colonies during the 2015/2016 season based on reports from respondents with more than 250 colonies, by region.



Optional question
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 51: Types of supplemental sugar feed provided to production colonies during the 2015/2016 season based on reports from all respondents, by operation size.

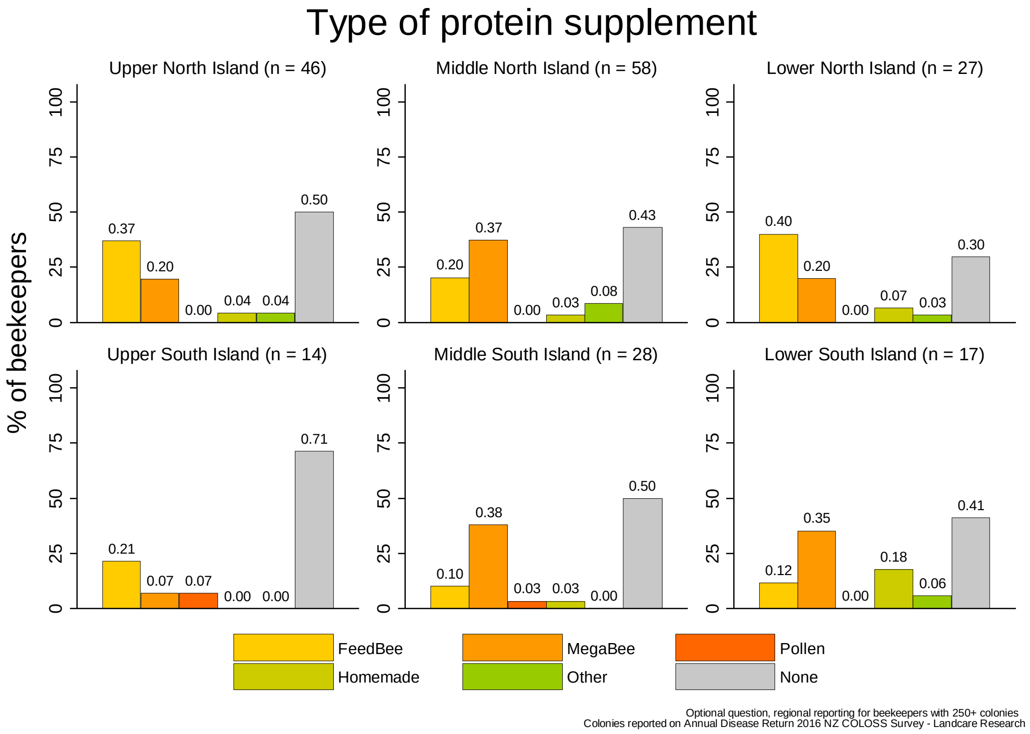


Figure 52: Types of supplemental protein feed provided to production colonies during the 2015/2016 season based on reports from respondents with more than 250 colonies, by region.

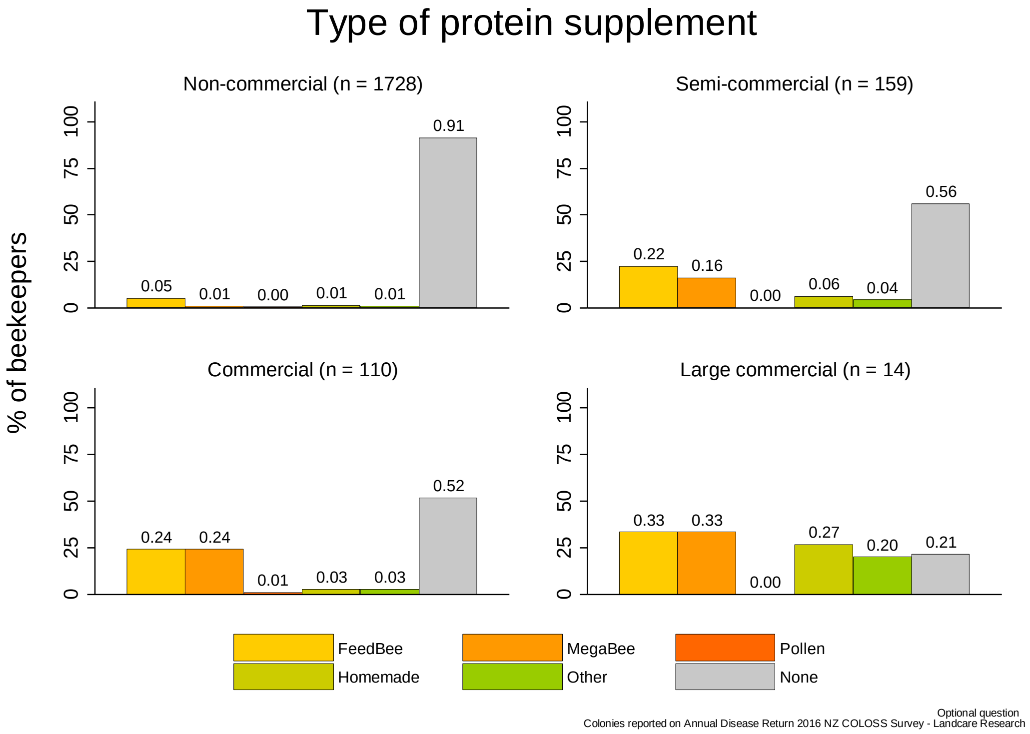


Figure 53: Types of supplemental protein feed provided to production colonies during the 2015/2016 season based on reports from all respondents, by operation size.

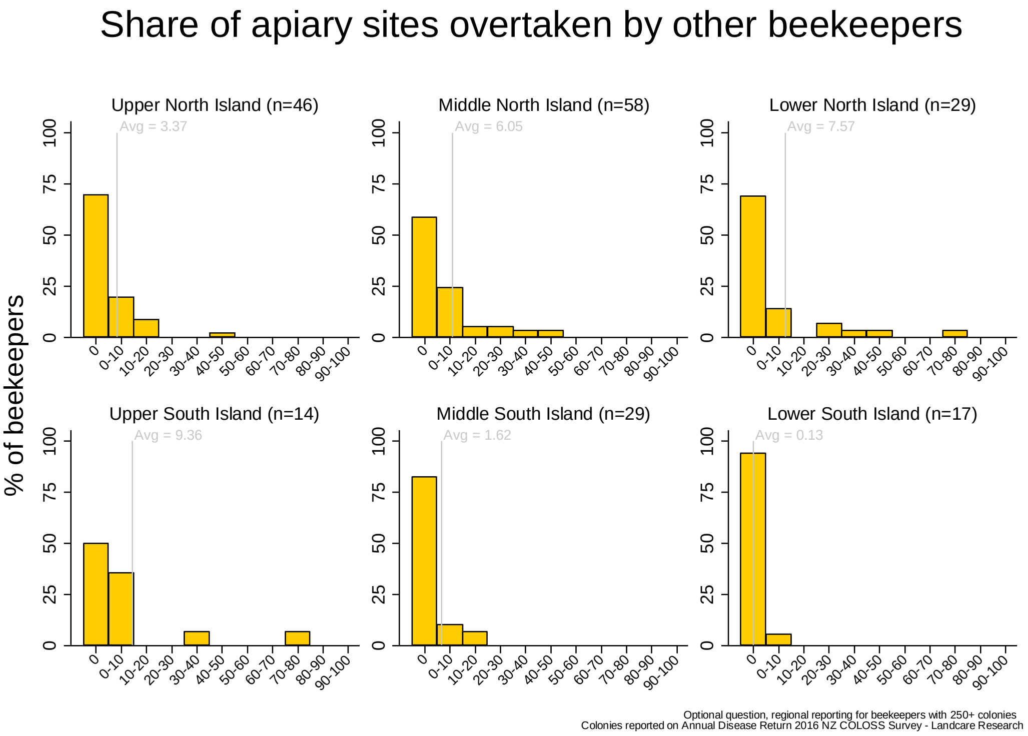


Figure 54: Share of apiary sites lost due to being taken over by other beekeepers during the 2015/2016 season based on reports from respondents with more than 250 colonies, by region.

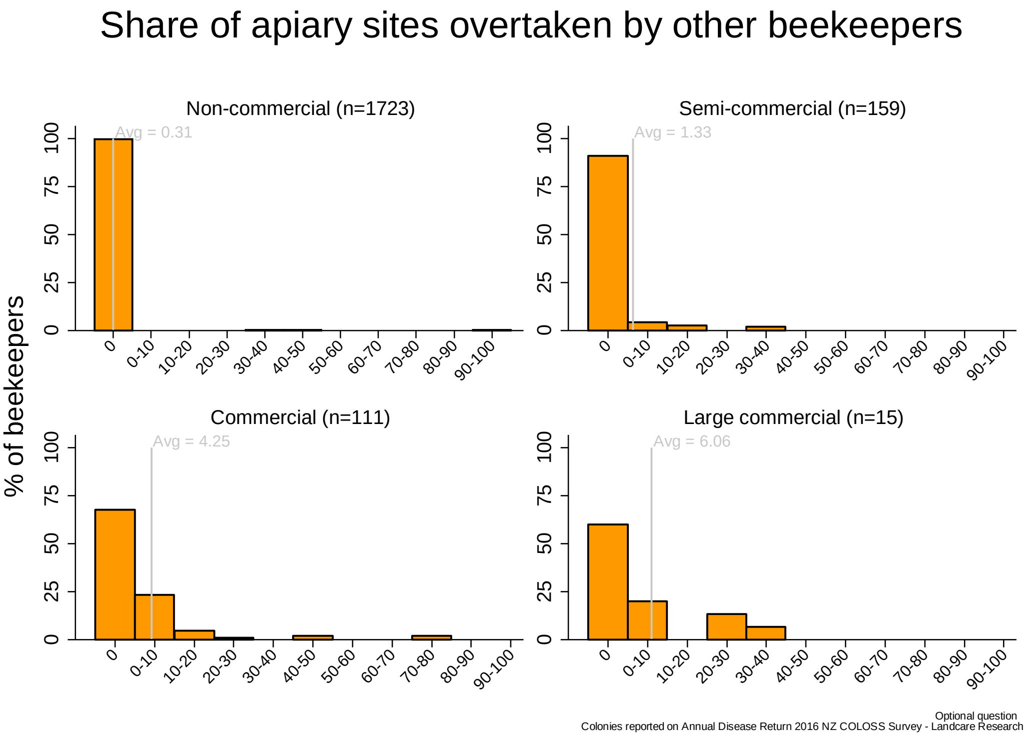
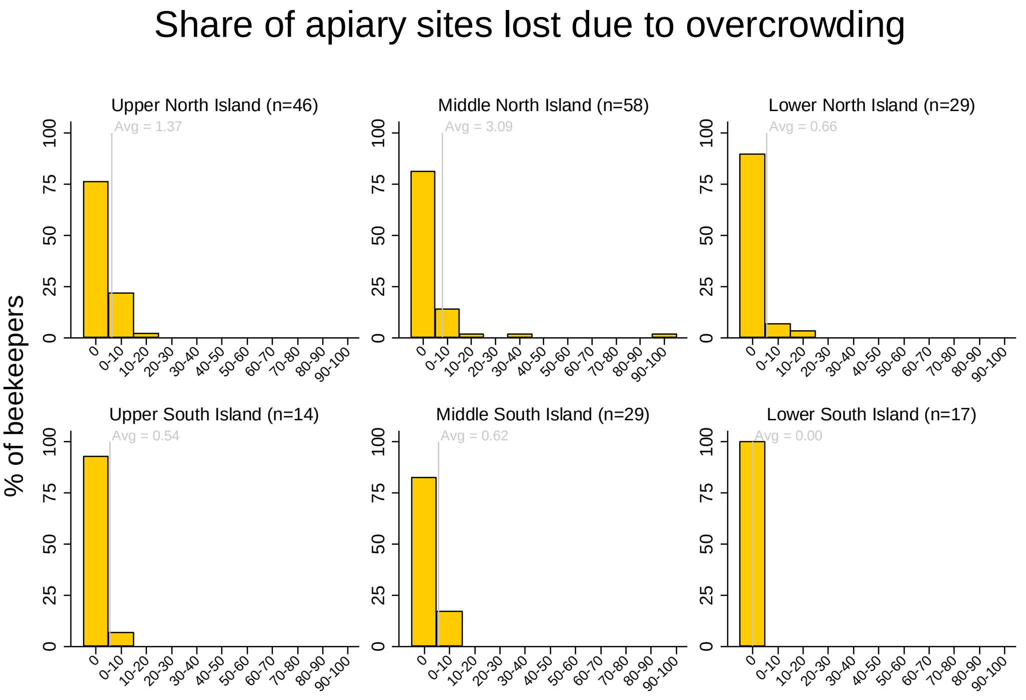
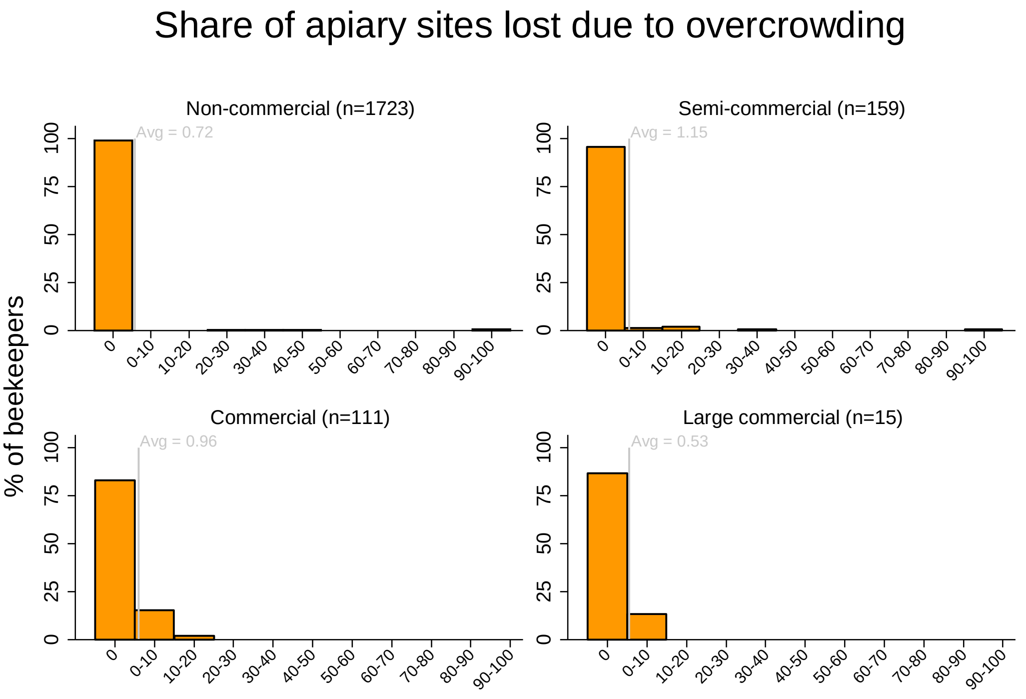


Figure 55: Share of apiary sites lost due to being taken over by other beekeepers during the 2015/2016 season based on reports from all respondents, by operation size.



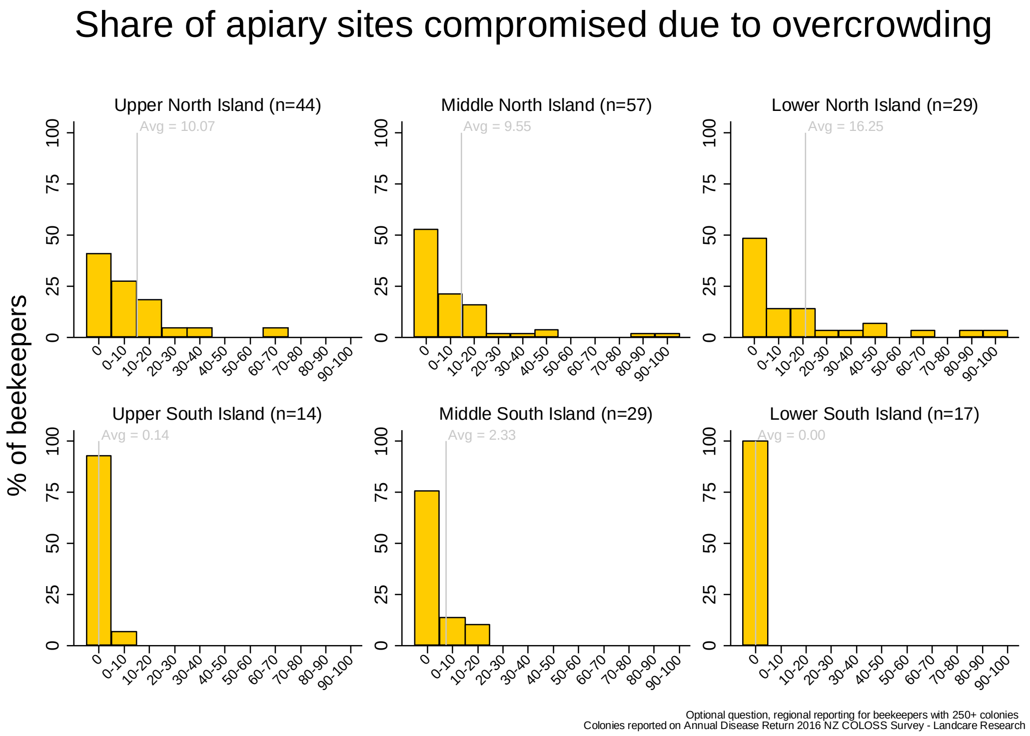
Optional question, regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 56: Share of apiary sites lost due to overcrowding during the 2015/2016 season based on reports from respondents with more than 250 colonies, by region.



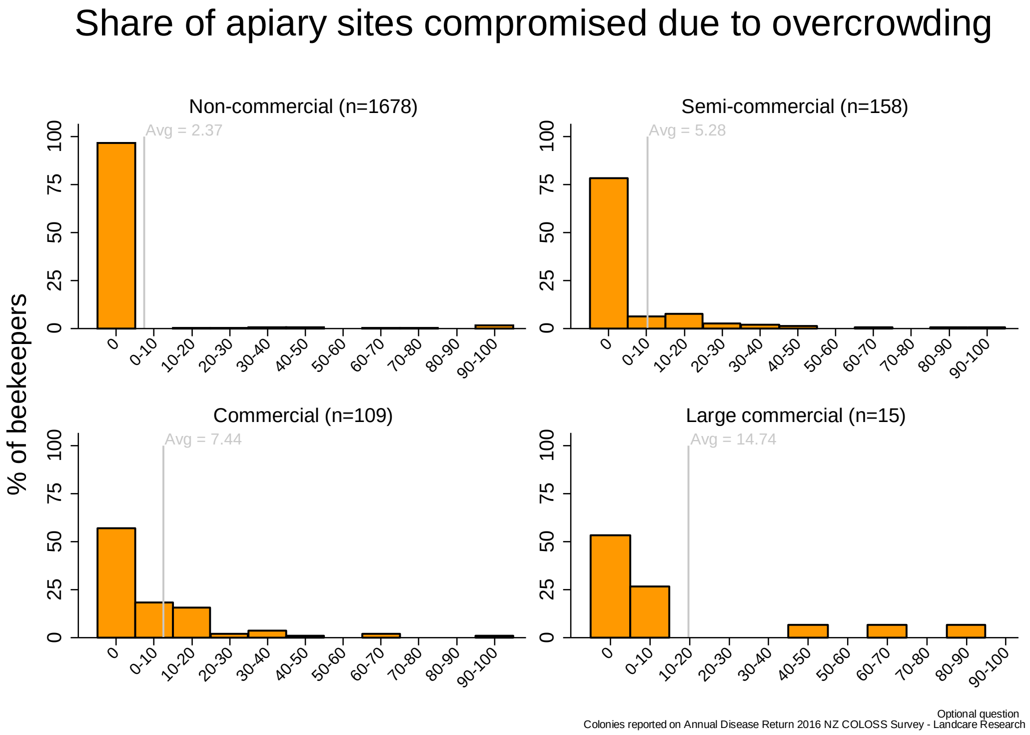
Optional question
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 57: Share of apiary sites lost due to overcrowding during the 2015/2016 season based on reports from all respondents, by operation size.



Optional question, regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 58: Share of apiary sites compromised due to overcrowding during the 2015/2016 season based on reports from respondents with more than 250 colonies, by region.



Optional question
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 59: Share of apiary sites compromised due to overcrowding during the 2015/2016 season based on reports from all respondents, by operation size.

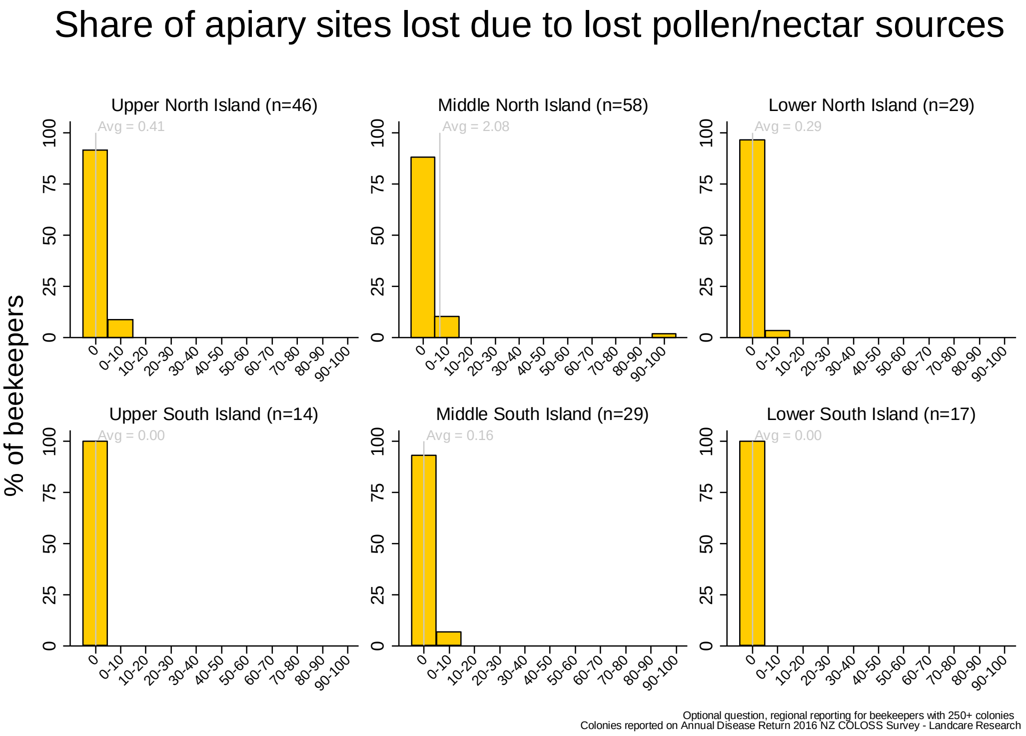


Figure 60: Share of apiary sites lost due to sources of pollen and nectar being removed during the 2015/2016 season based on reports from respondents with more than 250 colonies, by region.

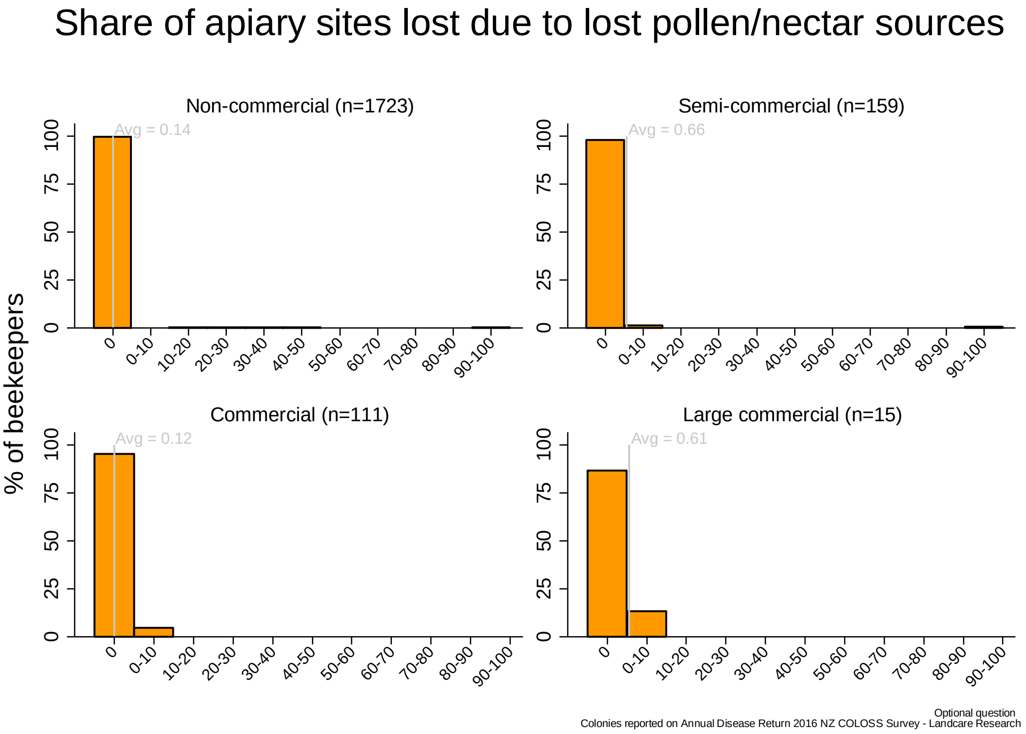
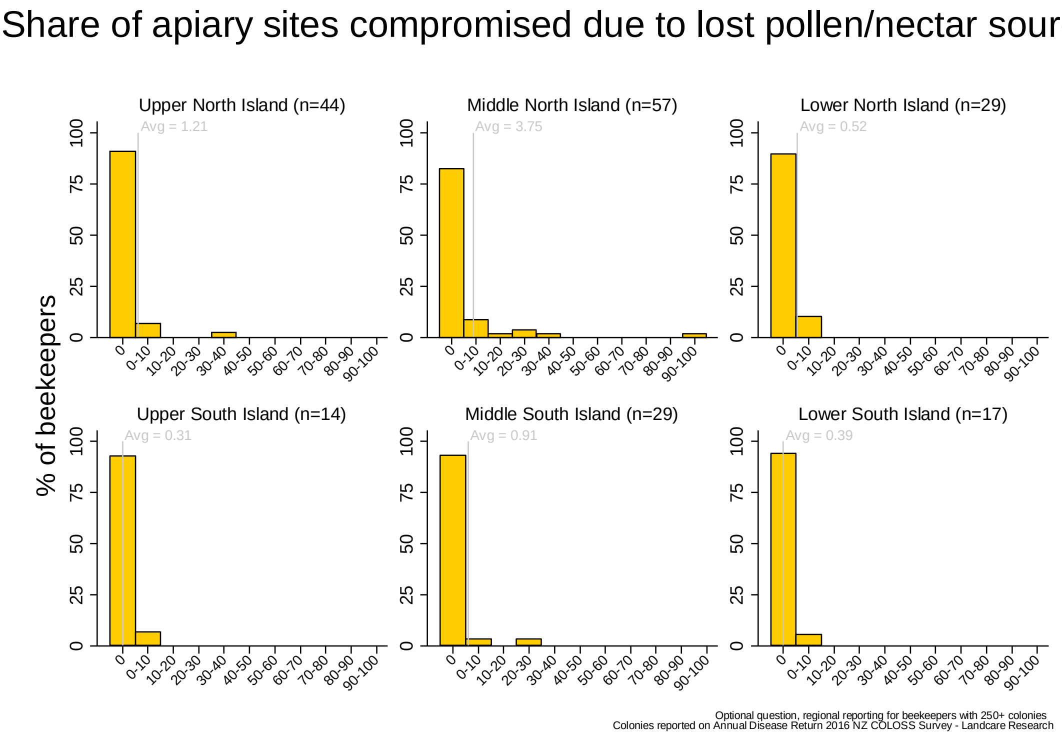
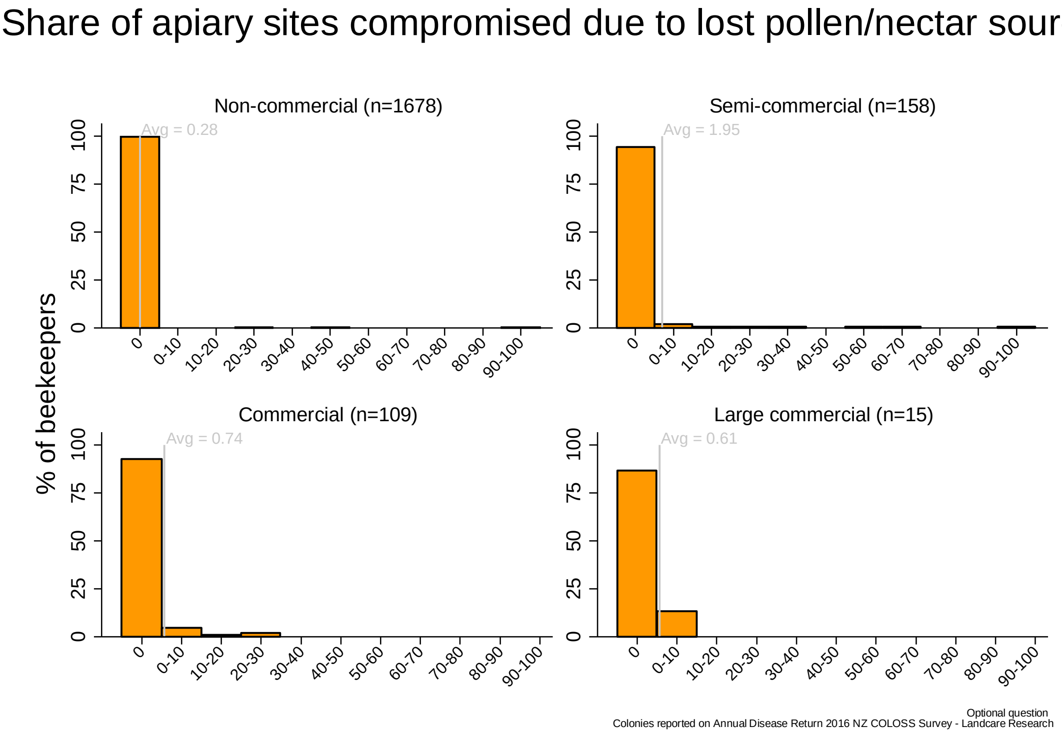


Figure 61: Share of apiary sites lost due to pollen and nectar sources being removed during the 2015/2016 season based on reports from all respondents, by operation size.



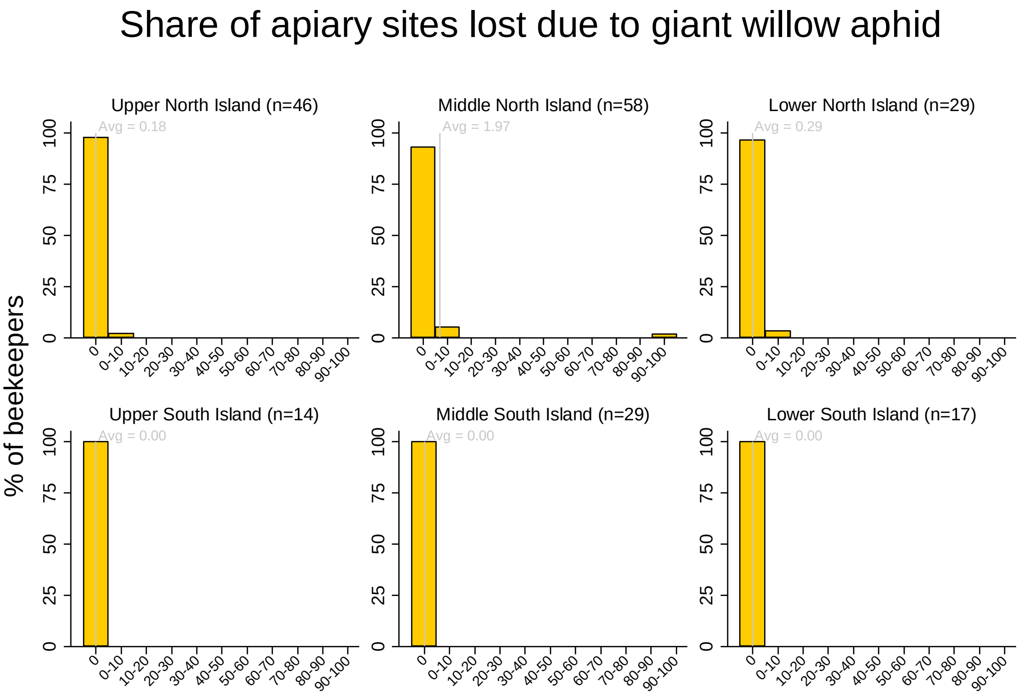
Optional question, regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 62: Share of apiary sites compromised due to pollen and nectar sources being removed during the 2015/2016 season based on reports from respondents with more than 250 colonies, by region.



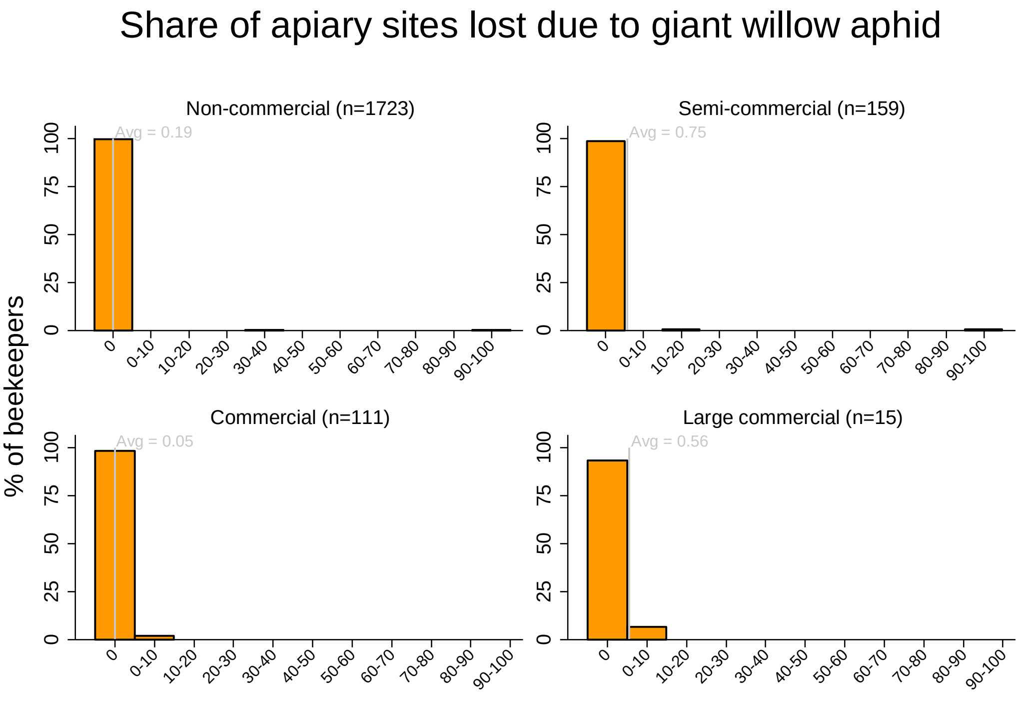
Optional question
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 63: Share apiary sites compromised due to pollen and nectar sources being removed during the 2015/2016 season based on reports from all respondents, by operation size.



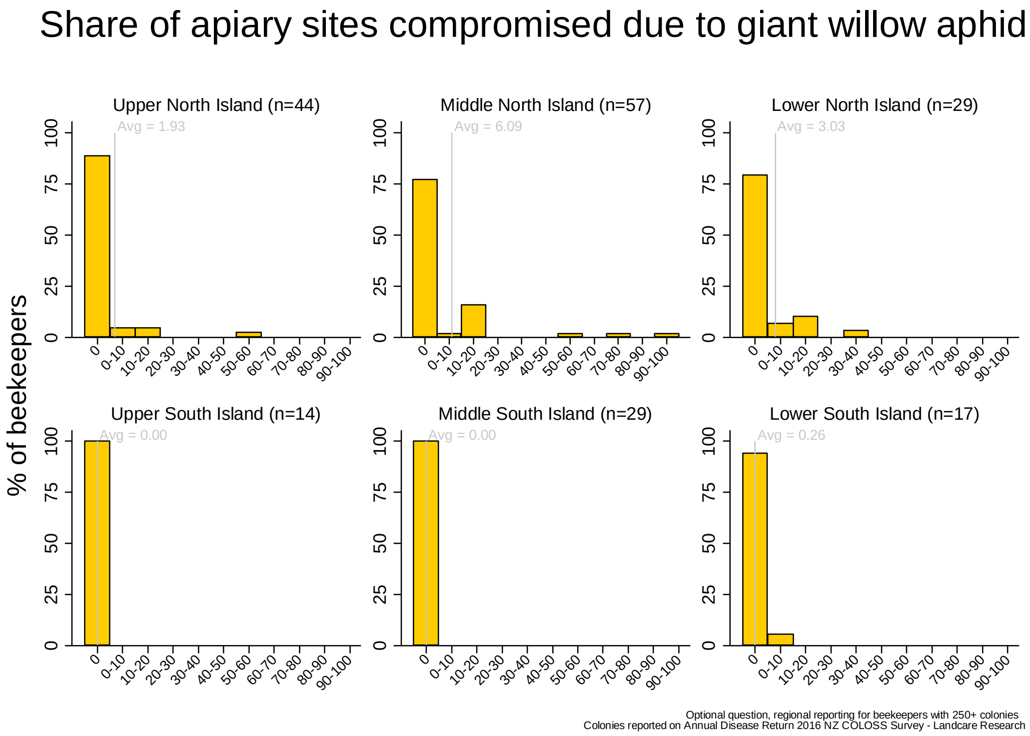
Optional question, regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 64: Share of apiary sites lost due to giant willow aphid during the 2015/2016 season based on reports from respondents with more than 250 colonies, by region.



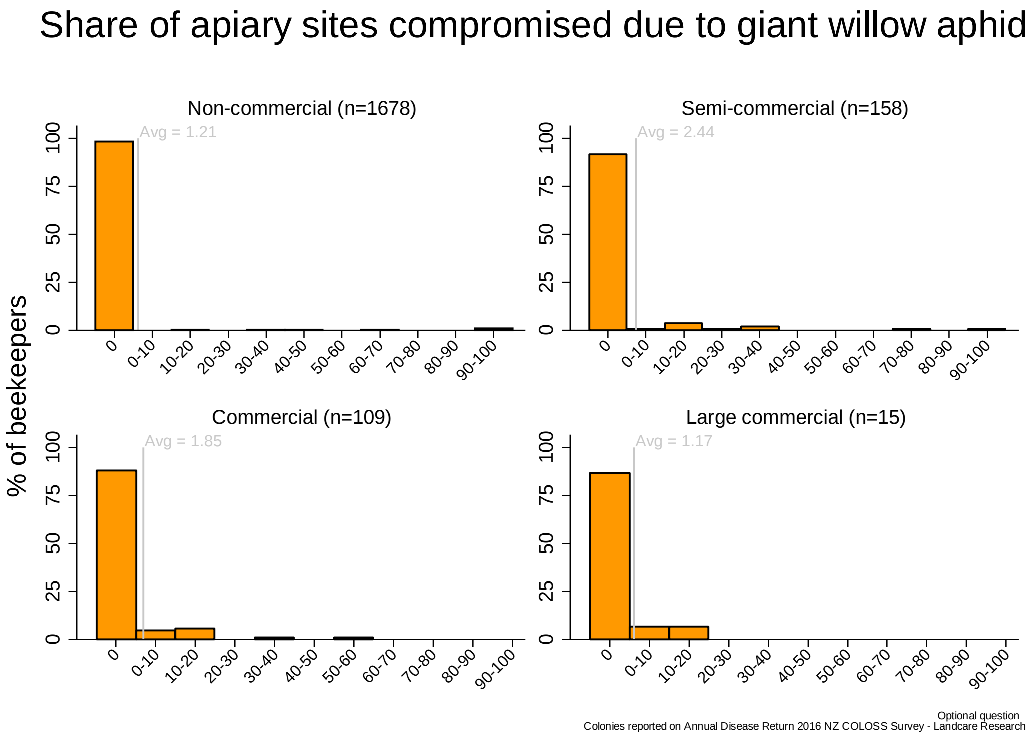
Optional question
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 65: Share of apiaries lost due to giant willow aphid during the 2015/2016 season based on reports from all respondents, by operation size.


Share of apiary sites compromised due to giant willow aphid

Optional question, regional reporting for beekeepers with 250+ colonies
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 66: Share of apiary sites that were compromised due to giant willow aphid during the 2015/2016 season based on reports from respondents with more than 250 colonies, by region.


Share of apiary sites compromised due to giant willow aphid

Optional question
Colonies reported on Annual Disease Return 2016 NZ COLOSS Survey - Landcare Research

Figure 67: Share of apiary sites compromised due to giant willow aphid during the 2015/2016 season based on reports from all respondents, by operation size.

6 Highlighted Results

6.1 National-Level Estimates of Colony Losses during Winter 2016

Each respondent's colony losses for winter 2016 is defined as the number of production colonies that he/she had on 1 June 2016 less the number that were alive when he/she opened the colonies in spring, typically between August and October. To estimate colony losses for winter 2016 at the national level, we multiply the average share of colonies lost per beekeeper within each operation size class in AsureQuality's apiary registry by the total number of colonies reported in each size class. The 95% confidence interval (which may be interpreted as the true value falling within this range 95% of the time in which we draw a new sample of beekeepers from the population) is calculated using the generalised linear model quasi-binomial error distributions outlined in McCullagh and Nelder (1989).

Our national-level estimate of colony losses during winter 2016 based on the NZ Colony Loss Survey is 9.78%, with a 95% confidence interval of [8.51%, 11.04%].

In the winter 2015 NZ Colony Loss Survey, colony losses using this method were estimated to be 10.73% [8.66%, 12.80%]. **As the confidence intervals overlap, the shares of colonies lost in winter 2016 is statistically indistinguishable from the share lost in winter 2015.**

For robustness, we estimated national-level colony losses for winter 2016 in two alternative ways. First, we calculate the average share of colonies lost per beekeeper in each size class in AsureQuality's apiary registry and multiply this figure by the number of beekeepers in each size class in the registry. Using this method, our national-level estimate of colony losses during winter 2016 based on the NZ Colony Loss Survey is 9.67% [8.41%, 10.93%] (cf. 2015 estimates of 10.68% [8.61%, 12.75%]).

As a second alternative, we divide the total number of colonies lost during winter 2016 by the total number of colonies on 1 June 2016 as reported in the NZ Colony Loss Survey. Using this method, our national-level estimate of colony losses during winter 2016 is 9.56% [8.31%, 10.82%] (cf. 2015 estimates of 8.37% [6.30%, 10.44%]).

Estimated colony loss shares over winter 2016 by region (as defined above and shown in Fig. 1) are shown in Figure 2. Using the method described in the previous paragraph, we estimate total winter losses of 8.19% [6.00%, 10.39%] in the Upper North Island, 10.66% [7.87%, 13.46%] in the Middle North Island, 11.94% [8.77%, 15.11%] in the Lower North Island, 5.54% [1.92%, 9.16%] in the Upper South Island, 7.24% [4.36%, 10.13%] in the Middle South Island, and 7.36% [3.67%, 11.06%] in the Lower South Island.[4]

The share of total losses attributed to colony death, queen problems, wasps, American foulbrood disease (AFB), natural disasters, Argentine ants, theft or vandalism, and other causes is shown in Figure 3. Overall, 45.12% of total colony losses were attributed to colony death, 29.27% were attributed to queen problems, and 10.46% were attributed to wasp

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[4] For beekeepers who operate across regions, colony losses are estimated according to the population-wide share of colonies wintered in each region.

problems. AFB was cited as the cause of 4.30% of total colony losses in the Upper North Island, 3.8% in the Lower North Island, 4.50% on the Middle South Island, and 3.20% in the Lower South Island. Natural disasters and Argentine ants respectively represented 8.50% and 5.00% of winter colony losses in the Upper North Island.

6.2 Region and Operation Size

Figure 4 shows the region(s) in which the 2091 beekeepers who completed the survey and who reported having hives in both autumn and spring 2016 registered their hives. Because beekeeping operations may span multiple political regions, 43 beekeepers are included in more than one region, and hence the total share exceeds 1. 95% confidence intervals are also depicted in the figure.

Figure 5 shows the operation size reported by each respondent as of 1 June 2016. "Non-commercial beekeepers" (1–50 colonies) comprise 85.6% of the sample; semi-commercial beekeepers (51–500 colonies) comprise 8.1% of the sample; commercial beekeepers (501–3,000 colonies) comprise 5.6% of the sample; and large commercial beekeepers (3,000+ colonies) comprise 0.7% of the sample.

6.3 Average Share of Colonies Lost over Winter 2016

From this point on, numbers reported in figures are interpreted as averages within groups. For example, whereas Figure 2 shows losses as a share of all colonies within each region, Figure 6 reports the average losses across beekeepers within each region.[5] More precisely, Figure 6 reports the entire distribution of colony loss rates over winter 2016 across beekeepers with more than 250 colonies in each region who reported having any colony losses.

These beekeepers with more than 250 colonies experienced modest levels of colony loss over winter 2016. The mean reported colony loss among this group was 9.07%, although one operator in the Middle North Island reported losing 50-60% of his/her colonies and one operator in the Lower Middle Island reported losing 60-70% of his/her colonies. The average shares of colonies lost among beekeepers with at least 250 colonies in the North Island and South Island were 9.68% and 7.81%, respectively, with the highest average losses in the Middle North Island at 11.32%.

Notably, 10.87% of beekeepers in the Upper North Island and 10.34% of beekeepers in the Middle South Island reported no colony losses. Similarly, 7.14% of beekeepers in the Upper South Island, 3.17% of beekeepers in the Middle North Island, and 3.13% of beekeepers in the Lower North Island experienced no colony losses. All 18 beekeepers in the Lower South Island reported losses.

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[5] For example, consider a region that consists of two beekeepers, one with 500 colonies and one with 5,000 colonies. Assume that the smaller beekeeper loses 8% of his/her colonies and that the larger beekeeper loses 12% of his/her colonies. Losses amount to 11.64% of total colonies in the region, but the average loss per beekeeper in the colony is 10.00%.

Figure 7 shows the distribution of hive losses by operation size, including those with fewer than 251 colonies. Non-commercial beekeepers lost the highest share of colonies, on average, at 17.02%, although 63.89% of non-commercial beekeepers reported having no losses. Semi-commercial beekeepers lost 11.22% of their colonies, on average, with 15.29% reporting no losses. Beekeepers with more than 500 colonies lost 8.49%, on average (cf. 8.81% in 2015). Some 92.31% of those with between 501 and 3,000 colonies and 100% of those with more than 3,000 colonies reported colony losses over winter 2016.

6.4 Colony Losses

Among beekeepers with more than 250 colonies, 93.85% reported experiencing colony losses over winter 2016. Figure 8 and Figure 9 report the total share of hives lost to colony death, queen problems, wasps, American foulbrood disease (AFB), natural disasters, Argentine ants, theft or vandalism, and other causes by region for beekeepers with more than 250 regions and by operation size, respectively, among beekeepers who experienced losses. For example, 38.2% of all losses among non-commercial beekeepers were attributed to colony death, as were 37.6% of all losses among semi-commercial beekeepers. Overall, colony death and queen problems together account for at least two-thirds of colony losses among beekeepers with at least 250 colonies in all regions and among all size classes except non-commercial beekeepers. Wasps were the third most frequent cause of colony losses overall. Losses attributed to AFB, natural disasters, Argentine ants, and theft and vandalism are less common.

6.4.1 Colony Death

Colony deaths by region as reported among beekeepers with more than 250 colonies are shown in Fig. 8. Colony death was reported as the cause of 36.94% of colony losses among the 93.85% of beekeepers with more than 250 colonies who experienced any colony losses over winter 2016. The average commercial beekeeper attributed 34.96% of his/her colony losses to colony death, although there is wide variation among individual beekeepers: 10.78% of beekeepers with more than 250 colonies attributed 80% or more of their losses to colony death while 14.97% did not attribute any losses to colony death. The average share of losses attributed to colony death varies little across operation size (Fig. 11), although non-commercial beekeepers report the most extreme distribution. The Middle North Island and Middle South Island experienced the greatest number of colony deaths overall (Fig. 10).

Two important indicators to discern possible causes of colony death have been identified and included in all surveys undertaken by COLOSS. The first indicator is the presence of dead worker bees in the cells with no food present in the colony, which is indicative of starvation. The second is the presence of many dead bees in or in front of the colony, which is indicative of exposure to environmental toxins such as plant toxins or chemicals such as pesticides, fungicides, or surfactants.

On average, 37.14% of losses that were attributed to colony death by beekeepers with more than 250 colonies showed signs of starvation (Fig. 12). Signs of starvation were similar across operation size classes (Fig. 13), on average. Starvation may be a symptom of excessive competition for nectar and pollen sources and is symptomatic of the rapid increase in colony numbers associated with the mānuka honey boom (see Section 6.10). In addition, colony weakening during pollen and nectar death and during bad weather are common, although these problems may be mitigated by supplementary feeding of sugar and protein; we report on these topics in Section 6.3.1.

In addition, 31.37% of losses that were attributed to colony loss by beekeepers with more than 250 colonies showed signs of toxicity (Fig. 14), indicating that toxic exposure is also a concern, although the survey does not distinguish between insecticides/agrochemicals and naturally occurring karaka poisoning (Palmer-Jones and Line 1962). Exposure to toxicity is qualitatively lower among semi-commercial beekeepers than among the largest commercial beekeepers (Fig. 15).

One method to mitigate toxin loads embedded inside the colonies is replacing wax brood combs with new foundation. Beekeepers with more than 250 colonies replaced 16.81% of brood combs, on average, with the highest level of replacement in the Middle South Island and the lowest level of replacement on the Upper North Island (Fig. 16). Non-commercial beekeepers reported replacing just 6.99% of brood combs, on average, significantly lower than other beekeepers (Fig. 17). Overall, 68.14% of the non-commercial beekeepers reported that they did not replace any brood combs with foundation vis-à-vis 30.52% of semi-commercial beekeepers, 21.50% of commercial beekeepers, and 7.69% of large commercial beekeepers.

6.4.2 Queen Problems

A colony functions as a “superorganism” such that any disruption in the replenishment of each cohort from egg to larvae in the brood or from nurse to forager in the worker population can cause a colony to fail. A well-mated but healthy queen drives the reproduction and growth of the colony, but she needs nurse bees to feed her, and nurse bees need foragers to bring pollen and nectar to make royal jelly. She, of course, needs healthy drones for mating in order to produce worker bees. As such, colonies with queen problems such as drone-laying queens, drone-laying workers in absence of a queen, and queens that are sick or not well mated are at risk of colony loss.

More of the total colony losses were attributed to queen problems than to any other cause apart from colony death (Fig. 8 and Fig. 9). Beekeepers with more than 250 colonies that experienced colony loss attributed a greater share of colony losses to queen problems, on average, than smaller beekeepers (Fig. 19). For example, non-commercial beekeepers who lost colonies over winter 2016 attributed 22.14% of the losses to queen problems, on average, versus more than 40% of losses among commercial beekeepers. The distribution of colony losses attributed to queen problems also depended on operation size: for example, 68.42% of beekeepers with 1–50 colonies who experienced colony losses attributed none of their colony losses to queen problems versus 56.29% of beekeepers with at least 250 colonies attributed at least 30% of their colony losses to queen problems. For commercial beekeepers, queen problems were attributed more to colony losses in the Lower South Island than elsewhere (Fig. 18) while comparatively few colony losses were attributed to queen problems in the Middle South Island.

6.4.3 Wasps

Widespread infestations of the giant willow aphid have contributed to increasing populations of wasps that feed on the honeydew produced by these aphids. Wasps kill honey bee colonies in winter by robbing their honey stores and/or by seeking protein to feed their own young. As shown in Figure 21, beekeepers attributed 12.51% of colony losses to wasps, on average, somewhat higher for non-commercial beekeepers (13.08%) than for semi-commercial beekeepers (11.90%) and commercial beekeepers (10.36%). Wasps contribute a much greater average share of colony losses in the North Island (11.85% among beekeepers with more than 250 colonies) than in the South Island (2.80%), with the highest average share in the Middle North Island (Fig. 20). Indeed, the Middle North Island also had the greatest number of colony losses attributed to wasps.

6.4.4 American Foulbrood Disease

Among the 275,356 colonies reported on by all beekeepers, 735 cases of AFB were reported. Among beekeepers with 250 or more colonies who reported losing any colonies in winter 2016, 3.01% of losses were attributed to AFB (Fig. 22). However, one large commercial beekeeper lost 200 colonies to AFB in the Middle North Island. New Zealand has a strong program for preventing the spread of AFB that includes beekeeper training, annual inspections, and a quarantine requirement to burn colonies with any signs of AFB infestation. As such, overall losses to AFB are low by international standards. That being said, AFB affected 0.059% of the colonies included in the 2015 NZ Colony Loss Survey compared to 0.208% of the colonies included in the 2016 NZ Colony Loss Survey, a trend that should be monitored over time.

6.4.5 Natural disasters, Argentine Ants, and Theft or Vandalism

Some colony losses are neither related to colony death, queen problems, or disease, but – like wasps – stem from factors over which beekeepers exert little control. For example, natural disasters such as gale force winds, flooding, and fire (Fig. 24 and Fig. 25), incursions of Argentine ants (Fig. 26 and Fig. 27) and theft and vandalism (Fig. 28 and Fig. 29) may contribute significantly to colony loss. Survey results indicate that losses due to these factors are low vis-à-vis colony death, queen problems, and wasps. Still, beekeepers with more than 250 colonies who reported having any losses attributed 2.82% of their losses to natural disasters, 2.37% of their losses to Argentine ants, and 1.41% of their losses to theft or vandalism. Natural disasters were most prevalent in the Upper North Island. Although the range of Argentine ants has thus far thought to be restricted to the Upper South Island through to Christchurch, a small number of losses are reported in the Lower South Island; establishment in the Lower South Island is possible with hive migration and should be monitored, but misidentification of ant species is another possible explanation. Theft and vandalism are rare overall but less uncommon in mānuka-producing areas than elsewhere. Overall, natural disasters, Argentine ants, and theft or vandalism affected large and small beekeepers at similar rates.

6.5 State of surviving colonies

Production colonies may survive winter but enter spring in a weakened state. Beekeepers with more than 250 colonies reported that 16.40% of their colonies were weak but queenright in spring 2016 (Fig. 34), with higher shares reported in the Lower North Island, Middle South Island, and Lower South Island. Weak colonies were a pronounced challenge for non-commercial beekeepers, who reported that 32.36% of their surviving colonies were weak but queenright, on average (Fig. 35).

6.6 Queen performance

Despite significant colony losses due to queen problems (Fig. 18 and Fig. 19), beekeepers reported that queens performed better during the 2015/2016 season than in previous seasons, on average. More beekeepers with more than 250 colonies reported that queen performance had improved than had reported that it had declined in 2015/2016 in the Upper North Island, Middle North Island, Lower North Island, Middle South Island, and Lower South Island (Fig. 36), sometimes by a factor of 2. Queen performance in 2015/2016 was particularly improved for commercial beekeepers (Fig. 37).

6.7 Varroa

The *Varroa* mite is an ectoparasite that feeds off the bodily fluids of adult, pupal, and larval honey bees. *Varroa* can transmit deformed wing virus (which is also transmitted sexually; see Amiri et al. 2016) and many other viruses. Wasps invade and kill weak colonies, particularly in autumn. The *Varroa* mite arrived in the North Island in 2000 and spread to the South Island in 2006, resulting in more frequent colony losses and increased labour and control costs.

Over half of beekeepers with more than 250 colonies reported monitoring for *Varroa* (Fig. 40). Sticky boards and sugar shake/roll are commonly used for monitoring, as is visual inspection (which accounts for the vast majority of monitoring included under the “other” category). The largest beekeeping operations reported using alcohol wash more frequently than smaller beekeepers (Fig. 41), but methods do not otherwise vary appreciably over operation sizes. Beekeepers across all regions and across all operation sizes reported using flumethrin and amitraz to treat *Varroa* much more commonly than any other method (Fig. 42 and Fig. 43).

6.8 Pollination and Honey Harvesting

High-value honey from mānuka presents an opportunity to many beekeepers to pursue honey and to abandon pollination services that were formerly provided for pastoral, arable, and horticultural plantations. To wit, beekeepers across all size groups reported that 73.64% of production colonies were used exclusively for honey production (Fig. 45), on average. Honey production dominates across all regions for beekeepers with more than 250 hives (Fig. 44), although pollination services are provided by at least one-quarter of beekeepers in the Upper North Island and Middle North Island.

Nectar flows across regions are reported in Figure 46. Among beekeepers with more than 250 colonies in the Upper North Island, mānuka, kānuka, and native bush blend were most common, together with clover/pasture. Rewarewa became more significant in the Middle North Island and Lower North Island. Beech honeydew was a common source of flow in the Upper South Island and Middle South Island, while clover/pasture and willow honey (spring) were the most significant sources of flow in the Lower South Island. Large commercial beekeepers focused more on mānuka than smaller beekeepers while semi-commercial and commercial beekeepers' bees had a comparatively high flow on clover pasture (Fig. 47). Only non-commercial and semi-commercial beekeepers' bees had a significant flow on urban floral and garden sources. Larger beekeepers report migrating hives to take advantage of different nectar flows in much higher numbers than smaller beekeepers (Fig. 49).

6.9 Supplementary feeding

If pollen and nectar sources within foraging range are insufficient, bees consume their stores. If the weather is too severe for bees to forage and if they do not have sufficient stores of pollen and nectar in the colony, then bees will starve. Bees also use nectar for carbohydrates for wax production. Hence, many beekeepers actively plant forage resources for their bees to improve nutrition and overwintering success (DeGrandi-Hoffman 2016). In addition, beekeepers may provide supplemental nutrition. Nectar supplies fuel for adult bees and can be supplemented by supplying sugar, a source of carbohydrates. Pollen, which is needed for the brood, provides protein, lipids, vitamins, and minerals (Black 2006). A variety of protein supplements are commercially available.

Over 90% of beekeepers with more than 250 colonies used supplemental sugar during the 2015/2016 season (Fig. 50). Sugar feeding among these large beekeepers is common across the entire country. In contrast to commercial beekeepers, only 40% of non-commercial beekeepers provided supplementary feed in the form of sugar (Fig. 51). Sugar solution is most commonly used across all regions and size classes, although invert sugar is also widely used in the North Island and raw sugar is also widely used in the South Island.

Just over half of beekeepers with 250 or more colonies provide supplemental protein to their bees (Fig. 52). FeedBee and MegaBee are most commonly used, with strong regional preferences apparent (e.g. three times as many beekeepers use FeedBee as MegaBee in the upper South Island, while three times as many beekeepers use MegaBee as FeedBee elsewhere in the South Island), likely a result of proximity to the major suppliers. Supplemental protein feeding is especially common among the beekeepers with the most colonies, who substitute or augment commercial products with homemade products (Fig. 53). Fewer than 10% of non-commercial beekeepers provided supplemental protein in 2015/2016.

6.10 Apiary Losses

Beekeepers typically keep bees based on agreements with landowners. Any rearrangements in permissions by landowners, encroachment into the foraging range of an apiary, or removal of major pollen or nectar sources can significantly impact beekeeping operations financially and/or via bee health, as can the arrival of pests or diseases via relocation of new hives to the area.

Apiary sites being overtaken by other beekeepers coincides with the rapid expansion of the mānuka honey industry. Up to 50.00% of beekeepers with more than 250 colonies in the Upper South Island reported losing one or more apiary sites to other beekeepers during the 2015/2016 season (Fig. 54), as did 29.65% of these beekeepers nationwide. In areas where mānuka is prevalent (i.e. Upper North Island through Upper South Island), 36.43% of these beekeepers reported apiaries being overtaken by other beekeepers in 2015/2016 as compared with 53.90% in 2014/2015. This problem is pronounced among large commercial beekeepers, who report that 6.06% of all apiaries were lost to being overtaken during the 2015/2016 season (Fig. 55); in contrast, only 0.58% of non-commercial beekeepers reported having sites overtaken by other beekeepers, accounting for just 0.31% of their apiaries.

Losing apiaries and seeing apiaries compromised due to overcrowding also coincides with growth in the mānuka honey industry, a challenge that is exacerbated by new beekeepers not fully understanding stocking rates in a given region (Newstrom-Lloyd 2016). Overcrowding is more common in the North Island than in the South Island: 23.48% of beekeepers with more than 250 colonies in the North Island reported having lost apiary sites to overcrowding during the 2015/2016 season while only 10.53% of those in the South Island did so (Fig. 56).

Losing an entire apiary site due to overcrowding is not common, with average losses of 0.76% of apiaries (Fig. 57). That being said, an apiary being compromised by overcrowding is a common problem, particularly in the North Island, where 57.14% of beekeepers with more than 250 colonies reported that overcrowding had compromised their apiaries (Fig. 58). In contrast, 19.30% of such beekeepers in the South Island reported that overcrowding had compromised their apiaries. Commercial and large commercial beekeepers noted that 7.44% and 14.74% of their apiaries had been compromised due to overcrowding, respectively, compared with 2.37% of non-commercial apiaries (Fig. 59).

Apiary sites lost to the sudden removal of pollen and nectar sources is less commonly reported, but may nevertheless be problematic in some areas. For example, 7.83% of beekeepers with more than 250 colonies in the North Island reported losing apiary sites due to pollen and nectar sources being removed (Fig. 60). In addition, 13.39% of North Island beekeepers with more than 250 hives reported that apiary sites had been compromised due to lost pollen and nectar sources (Fig. 62); again, apiaries in the Middle North Island were most compromised due to pollen and nectar sources being removed.

Giant willow aphids were first reported in Auckland in late December 2013 and have since spread throughout the country. These pests tap the sugar flow in willow stems, causing willow honeydew to flow, thereby attracting wasps to areas that provide important sources of flow for honey bees. In addition, giant willow aphids transform some of the willow sucrose to glucose and fructose. In this process, enzymes attach glucose to sucrose to make it less osmotically active melezitose, which is then present in the honeydew. Bees take this honeydew back to the hive where the melezitose crystallizes in the comb during the honey-conditioning phase. The crystals are not suitable as food for the bees and they also clog filters during honey extraction. Thus, giant willow aphid may also cause apiaries to be lost and/or compromised. Indeed, as Figure 64 indicates, beekeepers with more than 250 colonies in the Middle North Island lost 1.97% of their apiary sites as a result of giant willow aphid infestation. A further 6.09% of their apiaries were compromised due to giant willow aphid (Fig. 66). No South Island beekeepers with more than 250 reported losing apiaries to giant willow aphid, although one South Island respondent did note this his/her apiaries had been compromised by giant willow aphid.

7 Future Improvements to the NZ Colony Loss Survey

We have six specific suggestions for improving the future iterations of the NZ Colony Loss Survey.

First, we suggest exploring ways to allow beekeepers whose wintering apiary locations span multiple regions to enter region-specific loss details. We are cognizant that this would raise the response burden for some beekeepers, but we also think that the gains would be considerable.

Second, we recommend including bees robbing hives as an additional cause of winter colony loss because of the extent of overcrowding.

Third, we suggest asking beekeepers to attribute winter colony losses to the *Varroa mite*. The survey already asks about deformed wing virus, methods for treating *Varroa*, and the timing of treatment, and results suggest that New Zealand beekeepers are well versed in identifying and treating this pest. We also suggest expanding the questionnaire to cover Parasitic Mite Syndrome and resistance to *Varroa* treatment.

Fourth, we recommend asking questions about the treatment of *Nosema*, which was first detected in New Zealand in 2010. Indeed, we believe that the NZ Colony Loss Survey may be used to help identify the need for training beekeepers in identifying and treating this disease.

Fifth, we recognise that the term “colony death” is somewhat opaque to beekeepers. While we are committed to keeping the core set of questions from international COLOSS surveys, we suggest considering asking about forms of colony death (e.g., starvation and exposure to toxins) independently and then summing them to calculate colony deaths.

Finally, additional work on the survey may facilitate better capturing spring, summer, and autumn losses.

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