Ministry for Primary Industries
Manatū Ahu Matua

Report on the 2015 New Zealand Colony Loss and Survival Survey

MPI Technical Paper No: 2016/07

Prepared for the Ministry Primary Industries
By Landcare Research

ISBN No: 978-1-77665-194-8 (online)
ISSN No: ISSN 2253-3923 (online)

March 2016

New Zealand Government

Growing and Protecting New Zealand

Disclaimer

While every effort has been made to ensure the information in this publication is accurate, the Ministry for Primary Industries does not accept any responsibility or liability for error of fact, omission, interpretation or opinion that may be present, nor for the consequences of any decisions based on this information.

Requests for a copy should be directed to:

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

This publication is also available on the Ministry for Primary Industries website at http://www.mpi.govt.nz/news-and-resources/publications/

Report on the 2015 New Zealand Colony Loss and Survival Survey

Report on the 2015 New Zealand Colony Loss and Survival Survey

Pike Brown, Linda Newstrom-Lloyd

Landcare Research

Prepared for:

Ministry of Primary Industries (MPI)
Bee Industry Advisory Council (BIAC)
(a coalition of the National Beekeepers' Association (NBA) and Federated Farmers Bee Industry Group (FF-BIG))

December 2015

Landcare Research, Gerald Street, PO Box 69040, Lincoln 7640, New Zealand,
Ph +64 3 321 9999, Fax +64 3 321 9998, www.landcareresearch.co.nz

Reviewed by:	*Approved for release by:*
Christine Harper Business Development Manager Landcare Research	Adam Daigneault Research Priority Area Leader – Supporting Business & Policy Portfolio Landcare Research
Landcare Research Contract Report:	LC2436

Disclaimer

This report has been prepared by Landcare Research for Ministry of Primary Industries (MPI) and the Bee Industry Advisory Council (BIAC). If used by other parties, no warranty or representation is given as to its accuracy and no liability is accepted for loss or damage arising directly or indirectly from reliance on the information in it.

Contents

Executive Summary

The 2015 New Zealand Colony Loss survey seeks to quantify colony losses over winter 2015. It also seeks to provide baseline data for monitoring bee health over time and investigating emerging challenges for the apiculture industry and those industries that rely on pollination services.

The survey questionnaire was based on a standardised survey that has been conducted in 31 countries, although it was adapted to address issues of particular concern to New Zealand. The survey was administered online and was open to all beekeepers in New Zealand. The 316 largest beekeepers (i.e. those with 400 or more hives in autumn 2015) were particularly encouraged to participate, and 46.2% of them completed the survey. Moreover, 51.7% of those beekeepers with more than 1000 hives completed the survey. All told, 366 beekeepers with 225,660 hives participated in the survey. These figures represent 6.70% of all beekeepers and 39.6% of the total number of hives in New Zealand in autumn 2015.

The survey is anonymous, and beekeepers are the unit of analysis. Results are aggregated separately by apiary registry location and by operation size; reporting by location is restricted to 149 beekeepers with at least 251 hives while reporting by operation size includes the entire sample of 366. The descriptive statistics presented here and on the Landcare Research website are presented as bar charts, pie charts, and/or histograms. See www.landcareresearch.co.nz/science/portfolios /enhancing-policy-effectiveness/bee-health.

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 losses during winter 2015 to be 10.73%, with a 95% confidence interval of [8.66%, 12.80%].

The mean reported hive losses among operators with at least 251 hives in our sample was 8.81%, although 10% of these operators lost 20% or more of their hives and one operator reported losing 100% of his / her hives. Operators in Coromandel / Bay of Plenty / Rotorua / Poverty Bay and in Hawke’s Bay / Wairarapa / Manawatu / Taranaki reported the highest loss rates. The mean reported losses of nucs, splits, and tops over winter 2015 was 19.00%, although one-third of respondents reported losing 20% or more of their nucs / splits / tops.

Beekeepers with fewer than 251 hives reported average hive losses of 24.33% and average losses to nucs / splits / tops of 37.32%.

Colony losses across apiary registry locations and operation sizes were most frequently attributed to queen problems, secondly to colony death, and thirdly to wasps. Losses to natural and human disasters were infrequent. Losses attributed to American foulbrood were rare. 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.

Information on queen problems, pests and diseases, *Varroa* treatments, pollination services, honey, apiary site takeovers, and overcrowding was also included in the survey to facilitate further analyses of factors contributing to colony loss. These data also provide useful baseline information on beekeeping management practices.

1 Introduction

1.1 Concern for Increasing Rates of Colony Loss

Managed bees are the backbone of temperate agricultural economies because of their cost-effective pollination services. In New Zealand, the honey bee (*Apis mellifera*) is the most ubiquitous, abundant, and readily managed of all commercial pollinators available to pastoral, arable, and horticultural production (Newstrom-Lloyd 2013). Concern about global threats to bee health and risks to the continued availability of this most-valued pollinator has become the subject of recent international scientific investigation as well as ongoing commentary in the popular press. It is widely recognised that stressors are now accumulating and impinging on honey bees resulting in global declines and increasing threats to bee health (Goulson et al. 2015).

Although many countries are seeing rapid increases in the number of managed bee colonies (van der Zee et al. 2012), including New Zealand (Newstrom-Lloyd 2015), an increase in hive numbers is not indicative of the sustainability or security of pollination services or honey harvesting. It is also not indicative of bee health in general. To assess the sustainability and security of bee services and bee health, 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; indeed some beekeepers have discontinued pollination services altogether.

Understanding colony loss is critical to agricultural sustainability and food security. In temperate regions, it is typical for a low level of colony loss to 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). When colony losses exceed this figure, Canadian beekeepers report that colonies cannot be replaced quickly enough for good pollination services and honey harvesting, thus compromising beekeepers' livelihoods.

With less severe winters and warmer spring weather than Canada, New Zealand generally sustains lower wintering loss rates. Beekeeper Barry Foster of Tawari Apiaries Ltd. estimates that the historical average wintering loss rate for New Zealand was 3-5%, and that this figure has increased to 10% in recent years due to the parasitic *Varroa* mite and to a general weakening of colony health (Foster pers. comm.).

New Zealand does not systematically record annual wintering losses. However, information from individual beekeepers suggests that some regions have experienced losses well in excess of 10% in recent years. To monitor wintering colony losses at a national level, Ministry of Primary Industries and the Bee Industry Advisory Council (BIAC), a coalition of the National Beekeepers' Association (NBA) and Federated Farmers Bee Industry Group (FF-BIG), commissioned the first New Zealand Colony Loss and Survival (NZ COLOSS) survey in 2015. Specifically, the objectives of the survey are as follows: "The Ministry for Primary Industries and the Bee Industry Advisory Council require objective data to establish a baseline assessment of bee health via a robust, repeatable survey to provide longer-term trend analysis and continued investigation of industry challenges and their causes."

2 Project Milestones and Objectives

Deliverable/Milestone	Performance Standards
Milestone 1. **ADVISORY GROUP, SURVEY DESIGN AND COMMUNICATIONS** 1a. Work with MPI to 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 international standardised survey, and add New Zealand-specific questions. 1c. Work with the advisory group to develop communication about the Bee Health Survey.	• Survey questionnaire is complete and appropriate to New Zealand circumstances. • Survey programmed into an on-line survey tool. • 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 250 commercial beekeepers registered with the MPI risk-management programmes. 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. 2d. Provide a general url survey link in publicity about the survey that will reach all beekeepers through local bee clubs and national beekeeper mailing lists.	• Target 250 commercial beekeepers have had at least 4 personal requests / reminders to complete the survey. • Response rates to be calculated from the list of 250 commercial beekeepers. • Responses from other beekeepers will be managed separately.
Milestone 3: **SURVEY COLLATION AND ANALYSIS** 3. Collate and analyse information received from all survey respondents.	• Build a baseline of data for future surveys and analysis. • Compare colony loss across geography, enterprise size, and management practices.
Milestone 4 5: **SURVEY REPORT** 4. Submit to MPI a report, an online presentation of results, and all de-identified data in association with the survey.	• 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 short report that expands the detail provided online, offers analysis of the data, 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.

3 Methods

3.1 Survey Design

The NZ COLOSS 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 respondents who indicated that they had new queens in autumn 2015 were asked about the source of those queens. Similarly, only respondents 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). To reach beekeepers without Internet access, the survey was also made available via telephone interview and via mail.

The survey questionnaire is based on an annual survey of beekeepers developed by the international COLOSS honey bee research association (http://www.coloss.org/). 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.

The first standardised international COLOSS survey was conducted in 2009, and it has grown each year since implementation. For the northern hemisphere 2014-2015 winter, the COLOSS survey was administered to more than 23,000 beekeepers in 31 countries.

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 may differ from those facing beekeepers in the northern hemisphere, hence the questionnaire was adapted to the local context. For example, the NZ COLOSS survey included questions on competition for apiary sites, American foulbrood (AFB – many New Zealand beekeepers are trained to recognise indicators), and wasps. In addition, the NZ COLOSS survey includes questions pertaining to losses of nucs, splits, and tops to help distinguish these losses from hive losses. These losses are not included in the many surveys conducted in other countries, but in New Zealand, losses in nucs / splits / tops are considered to be important given the large recent losses for some operators.

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, wasps, and disasters.

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 NZ COLOSS survey does not ask beekeepers to attribute losses to these causes. However, the NZ COLOSS 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 deformed wing virus and *Nosema ceranae*.

In addition, colony losses have been attributed to “Colony Collapse Disorder (CCD)” in the United States and to “Colony Depopulation Syndrome (CDS)” in Europe. The main distinctions between the two are:

Colony Collapse Disorder (CCD) (van Engelsdorp et al. 2009)

a) Rapid loss of adult worker bees with excess brood populations relative to adult bees
b) Lack of dead worker bees within and surrounding the hive
c) Delayed invasion of hive pests and of honey robbing by alien bees
d) Absence of *Varroa* and *Nosema* at levels thought to cause economic damage

Colony Depopulation Syndrome (CDS) (Van der Zee et al. 2012)

a) Reduced to no, or only a few remaining, living bees in the hive
b) No, or only a few dead bees in or in front of the hive or at the apiary
c) Food present in the hive

These definitions are not meant to be a complete description of the symptomatology but are instead intended to foster standardise reporting (van der Zee et al. 2012). Consistent with international COLOSS surveys, the NZ COLOSS survey includes many of the above indicators. However, the survey is not intended to diagnose CCD or CDS in New Zealand.

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.

First, AsureQuality provided contact information for every beekeeper in New Zealand who reported 400 or more hives as of 31 March 2015 in the nationally mandated annual disease return (n = 316). These beekeepers were invited to participate in the survey via email, and those for whom email addresses were not on file were initially contacted by telephone.

Non-respondents received both bi-weekly email reminders and personal telephone calls from Landcare Research staff to encourage participation. Ultimately, 146 of these 316 beekeepers completed the survey, yielding a response rate of 46.2%. Among these respondents were 74 who reported at least 1000 hives on the annual disease return, yielding a response rate of 51.7% among these large commercial operators. Five beekeepers responded to the survey offline.

Second, participation of all beekeepers was encouraged by the NBA and FF-BIG. The NZ COLOSS survey was announced through clubs, professional organisations, websites, and social media aimed at beekeepers. The survey was also promoted through interviews on television and radio news, national and local newspapers, and *The Beekeeper* magazine. Some 220 responses were obtained through these means, representing 4.2% of the non-targeted beekeepers registered with AsureQuality.

All told, 366 beekeepers with 225,660 hives participated in the survey. These figures represent 6.70% of all beekeepers and 39.59% of the total number of hives in New Zealand in autumn 2015. See Table 1 for a breakdown of apiary location and operation size.

To account for the different times at which beekeepers open their hives in spring, the survey was "live" from August through the end of October. Participation was encouraged by prize draws for four $50 Prezzy cards provided by the NBA. Consistent with international practice, all responses are anonymous. Data access is limited to the survey director (Pike Brown), and data are stored exclusively on password-protected computers.

Table 1 Sample description

	Northland Auckland Hauraki Plains	Waikato King Country Taupo	Coromandel Bay of Plenty Rotorua Poverty Bay	Hawke's Bay Wairarapa Manawatu Taranaki	Marlborough Nelson West Coast	Canterbury Kaikoura	Otago / Southland	Total
1-50 hives	34	23	26	57	7	35	16	196
51-250 hives	1	2	7	8	1	1	1	21
251-500 hives	8	2	5	3	4	4	1	24
501-1000 hives	14	10	13	10	3	8	7	56
1001+ hives	17	14	17	17	5	4	7	69
Total	74	51	68	95	20	52	32	**366**

Note: Some operators have hives in multiple apiary registry locations. As such, the total shown in the last column reflects the total number of beekeepers in each size class and is not a row total.

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 the New Zealand context. The survey was pilot tested with the NZ COLOSS Advisory Board for this project. It was available online between August and October 2015.

---

1) Click YES to begin the survey.*

( ) YES, take me to the survey
( ) NO, I don't want to do the survey

2) How many apiaries did you have during your first spring round this year (spring 2015)?*

If you have apiaries in multiple registry locations and you choose to complete a new survey for each of them, this figure should indicate the number of apiaries in one registry location only.

____

3) In which registry location was your apiary located during your first spring round (spring 2015)?*

( ) Northland / Auckland / Hauraki Plains
( ) Waikato / King Country / Taupo
( ) Coromandel / Bay of Plenty / Rotorua / Poverty Bay
( ) Hawke's Bay / Wairarapa / Manawatu / Taranaki
( ) Marlborough / Nelson / West Coast
( ) Canterbury / Kaikoura
( ) Otago / Southland

4) In which registry location(s) were your apiaries located during your first spring round (spring 2015)?*

Tick all that apply.

[ ] Northland / Auckland / Hauraki Plains
[ ] Waikato / King Country / Taupo
[ ] Coromandel / Bay of Plenty / Rotorua / Poverty Bay
[ ] Hawke's Bay / Wairarapa / Manawatu / Taranaki
[ ] Marlborough / Nelson / West Coast
[ ] Canterbury / Kaikoura
[ ] Otago / Southland

5) Are all of your apiaries within 15 km of one another?*

( ) Yes
( ) No
( ) Unsure

6) How many production colonies (viable bee hives) did you have on 31 March 2015, as per your Annual Disease Return?*

If an exact number is not known, please estimate.

____

7) How many production colonies (viable bee hives) did you have during your first spring round this year (spring 2015)?*

If an exact number is not known, please estimate.

____

8) How many nucs, splits, and tops did you have on 31 March 2015, as per your Annual Disease Return?*

If an exact number is not known, please estimate.

____

9) How many nucs, splits, and tops did you have during your first spring round this year (spring 2015)?*

If an exact number is not known, please estimate.

____

10) Of the [question("value"), id="235"] production colonies (viable bee hives) that were lost during winter 2015, how many were lost as a result of...?*

Enter 0 if none were lost to a given cause.

________Queen problems (including drone-laying queens, no queen, etc.)
________Colony death (including starvation and hives that were reduced to a few hundred bees)
________American foulbrood (AFB)
________Natural disasters (gale-force winds, flooding, etc.)
________Theft or vandalism
________Wasps
________Other

11) Of the [question("value"), id="296"] nucs, splits, and tops that were lost during winter 2015, how many were lost as a result of...?*

Enter 0 if none were lost to a given cause.

________Queen problems (including drone-laying queens, no queen, etc.)
________Colony death (including starvation and hives that were reduced to a few hundred bees)
________American foulbrood (AFB)
________Natural disasters (gale-force winds, flooding, etc.)
________Theft or vandalism
________Wasps
________Other

12) Please describe the other cause of losses to your production colonies and/or nucs, splits, and tops.

____

____

____

____

13) Of the [question("option value"), id="237", option="10942"] production colonies that died during the 2014-2015 season, 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

14) Of the [question("option value"), id="300", option="11403"] nucs, splits, and tops that died during the 2014-2015 season, 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

15) Of the [question("option value"), id="237", option="10942"] production colonies that died during winter 2015, 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

16) Of the [question("option value"), id="300", option="11403"] nucs, splits, and tops that died during winter 2015, 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

17) In which apiary registry location were deaths of production colonies and/or nucs, splits, and tops most severe?

18) How many of the [question("value"), id="12"] production colonies that survived winter 2015 are weak but queenright?*

If an exact number is not known, please estimate.

____

19) How many of the [question("value"), id="295"] nucs, splits, and tops that survived winter 2015 were weak but queenright when you opened the hives?*

If an exact number is not known, please estimate.

____

20) In terms of queen problems (such as drone-laying queens, no queen, etc.) how does the 2014-2015 year compare to previous years? The 2014-2015 year was...*

( ) Much worse than normal
( ) Somewhat worse than normal
( ) About normal
( ) Somewhat better than normal
( ) Much better than normal
( ) Unsure

21) Of the [question("value"), id="13"] production colonies that you had on 31 March 2015, did any have new queens (own queens or commercial source)?*

If an exact number is not known, please estimate.

( ) Yes
( ) No
( ) Unsure

22) Of the [question("value"), id="13"] production colonies that you had on 31 March 2015, how many had new queens?*

If an exact number is not known, please estimate.

____

23) How many of these new queens were from queen breeder stock?

If an exact number is not known, please estimate.

____

24) How did production colonies with young queens survive winter 2015 relative to production colonies with old queens? Young queens did...*

( ) Much worse than old queens
( ) Somewhat worse than old queens
( ) About the sameas old queens
( ) Somewhat better than old queens
( ) Much better than old queens
( ) Unsure
( ) N/A

25) Approximately what share of your production colonies had a large amount of faeces inside the hive when you first opened them in spring 2015?

( ) 0%
( ) 10%
( ) 20%
( ) 30%
( ) 40%
( ) 50%
( ) 60%
( ) 70%
( ) 80%
( ) 90%
( ) 100%
( ) Unsure

26) Approximately what share of your nucs, splits, and tops had a large amount of faeces inside the hive when you first opened them in spring 2015?

( ) 0%
( ) 10%
( ) 20%
( ) 30%
( ) 40%
( ) 50%
( ) 60%
( ) 70%
( ) 80%
( ) 90%
( ) 100%
( ) Unsure

27) Did you treat Varroa during the 2014-2015 season.*

( ) Yes
( ) No

28) Please indicate which how you treated Varroa during the 2014-2015 season.*

Tick all that apply.

[ ] Formic acid - short term (3 days or less)
[ ] Formic acid - long term (4 days or more)
[ ] Oxalic acid - sublimation (evaporation)
[ ] Thymol (e.g. Apiguard, ApilifeVar)
[ ] Tau-fluvalinate (e.g. Apistan)
[ ] Flumethrin (e.g. Bayvarol)
[ ] Amitraz (in strips, e.g. Apivar)
[ ] Drone brood removal

[ ] Hyperthermia (heat treatment of brood/bees)
[ ] Complete brood removal (including queen trapping)
[ ] Other method (1): ____
[ ] Other method (2): ____
[ ] Other method (3): ____

Please indicate when you started treatment for Varroa during the 2014-2015 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	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Dec 2014	Jan 2015
	Feb 2015	Mar 2015	Apr 2015	May 2015	Jun 2015	Jul 2015
	Aug 2015	Sep 2015				

29) How many production colonies and nucs, splits, and tops did you have at the start of your last spring round (spring 2014)?

This question will help us to track trends over time.

Production colonies: ____
Nucs, splits, and tops: ____

30) During the 2014-2015 season, were your production colonies used for pollination, honey production, or both?

( ) Pollination only
( ) Honey production only
( ) Both pollination and honey production

31) Did the majority of your bee colonies have a significant flow on one or more of the following plants during the 2014-2015 season?

Tick all that apply.

[ ] Mānuka
[ ] Kānuka
[ ] Mixed mānuka and kānuka
[ ] Clover / pasture
[ ] Rewa rewa
[ ] Kamahi
[ ] Tawari
[ ] Citrus
[ ] Thyme
[ ] Borage
[ ] Rata
[ ] Beech honeydew
[ ] Willow honeydew
[ ] Ling heather

[ ] Native bush blend
[ ] Other: ____

32) Did you migrate any of your colonies at least once during the 2014-2015 season?

( ) Yes
( ) No
( ) Unsure

33) Approximately what proportion of hives were migrated during the 2014-2015 season?

( ) 0%
( ) 10%
( ) 20%
( ) 30%
( ) 40%
( ) 50%
( ) 60%
( ) 70%
( ) 80%
( ) 90%
( ) 100%
( ) Unsure

34) Approximately what proportion of brood combs did you replace with comb foundation (per colony) during the 2014-2015 season?

( ) 0%
( ) 1%-10%
( ) 11%-20%
( ) 21%-30%
( ) 31%-40%
( ) 41%-50%
( ) More than 50%
( ) Unsure

35) Did you give any of your colonies a supplemental sugar feed to prepare for winter 2015?

Supplemental sugar feed includes sugar solution and inverted sugar.

( ) Yes
( ) No
( ) Unsure

36) What type of sugar did you use as supplementary feed during the 2014-2015 season?

Tick all that apply.

[ ] Sugar solution
[ ] Invert sugar
[ ] Raw sugar
[ ] Honey
[ ] Other: ____

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

____

38) How many kgs of raw sugar (in addition to any sugar solution) did you give to each production colony, on average?

____

39) How many kgs of honey (in addition to any sugar solution) did you give to each production colony, on average?

____

40) Did you give any of your colonies protein supplements during the 2014-2015 season?

( ) Yes
( ) No
( ) Unsure

41) What type of protein supplement did you use during the 2014-2015 season?

Tick all that apply.

[ ] FeedBee
[ ] Megabee
[ ] Pollen
[ ] Other: ____

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

____

43) Did you notice bees with crippled or deformed wings in your production colonies during the 2014-2015 season?

( ) Yes
( ) No
( ) Unsure

44) During the 2014-2015 season, did you lose any apiary sites because they were taken over by other beekeepers, because they were overcrowded, or because pollen and nectar sources were lost?

Tick all that apply.

[ ] Overtaken by another beekeeper
[ ] Overcrowded (too many hives close to your apiary)
[ ] Pollen and nectar sources were removed without replacement
[ ] None of the above

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

____

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

____

____

____

____

47) (optional) What are the key opportunities facing New Zealand beekeepers?

____

____

____

____

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

____

____

5 Figures

One objective of the NZ COLOSS survey is to establish a baseline assessment for long-term trend analysis. As such, we report descriptive statistics for the majority of questions included in the survey. These figures – which are also available on the Landcare Research website – are presented as bar charts, pie charts, and histograms by apiary registry location (for operators with 251 or more hives) and by operation size (for all beekeepers). Highlighted results follow in the next section of the report.

The figures follow the same general order as the survey questionnaire.

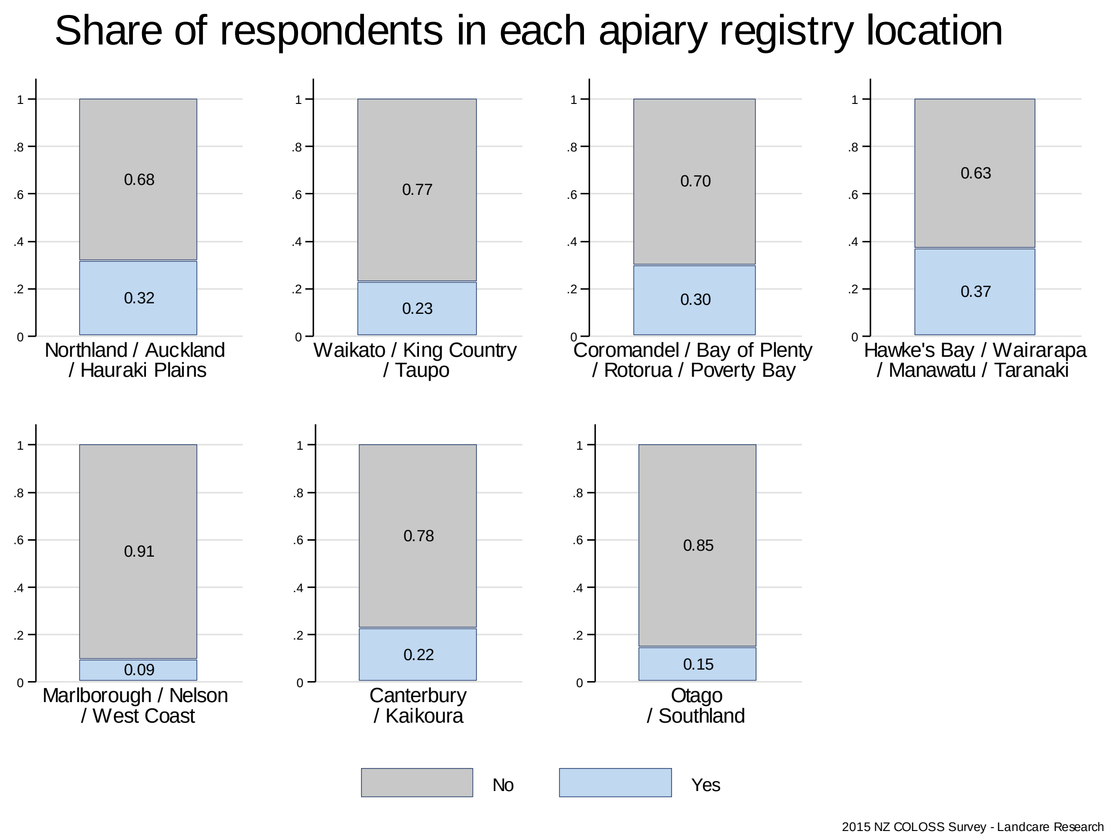

Figure 1. 1 Location of Apiaries: Regional share of respondents who keep bees in each New Zealand Apiary Registration Region. Includes all respondents in all operation size classes.

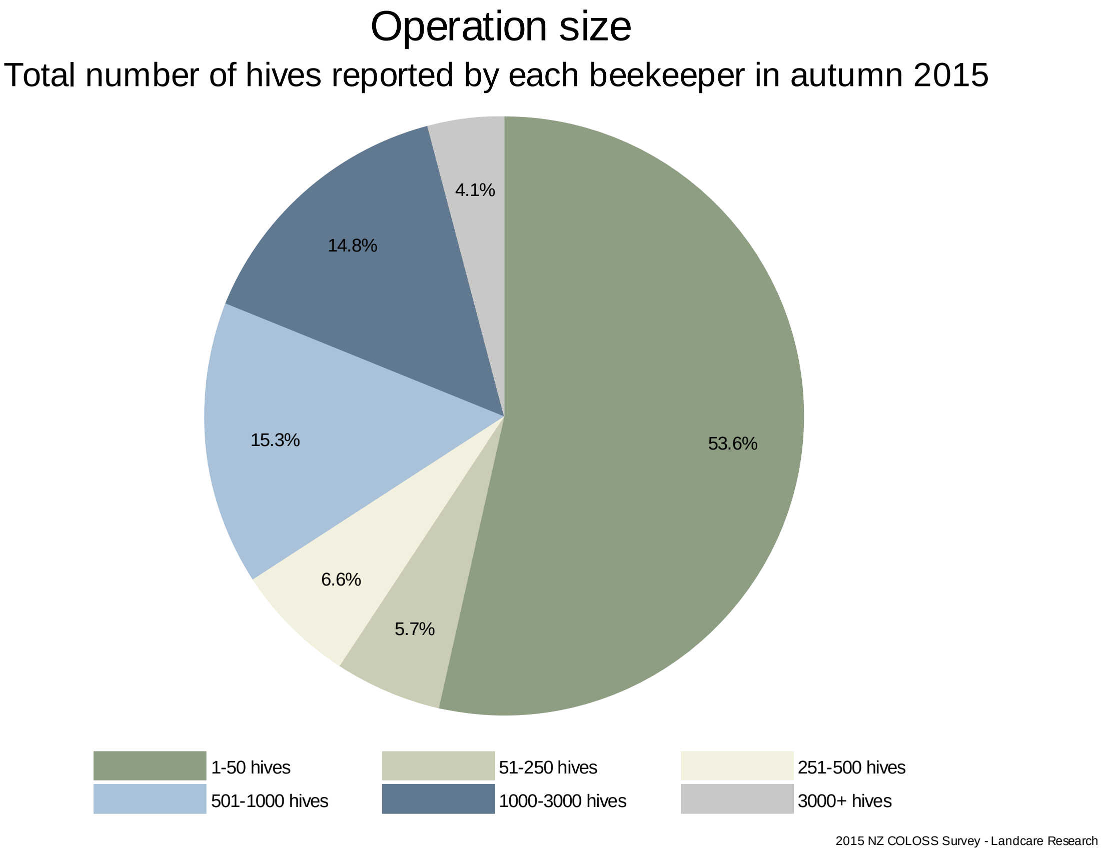

Figure 1. 2 Operation Size: Total number of hives reported by each respondent. Grouped into six operation size classes.

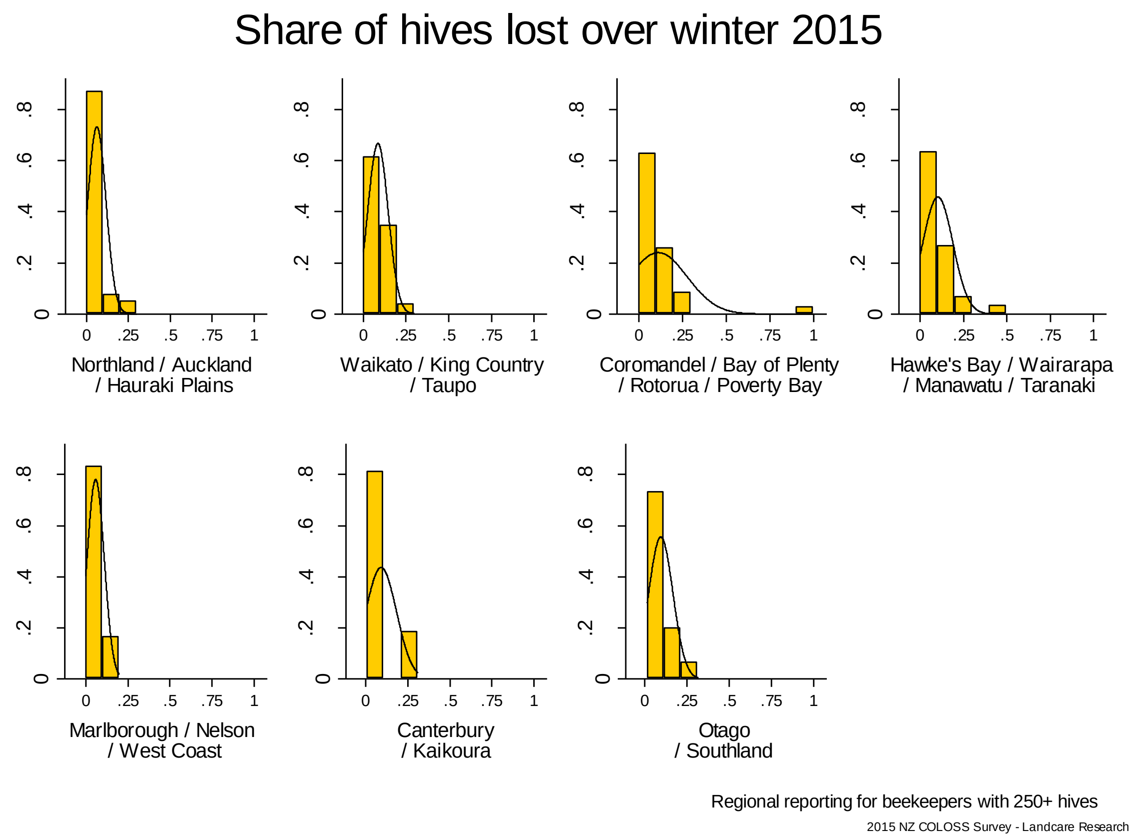

Figure 2. 1 Total Hive Losses: Winter 2015 hive losses as a share of total hives on 31 March 2015 based on reports from respondents with > 250 hives, by region.

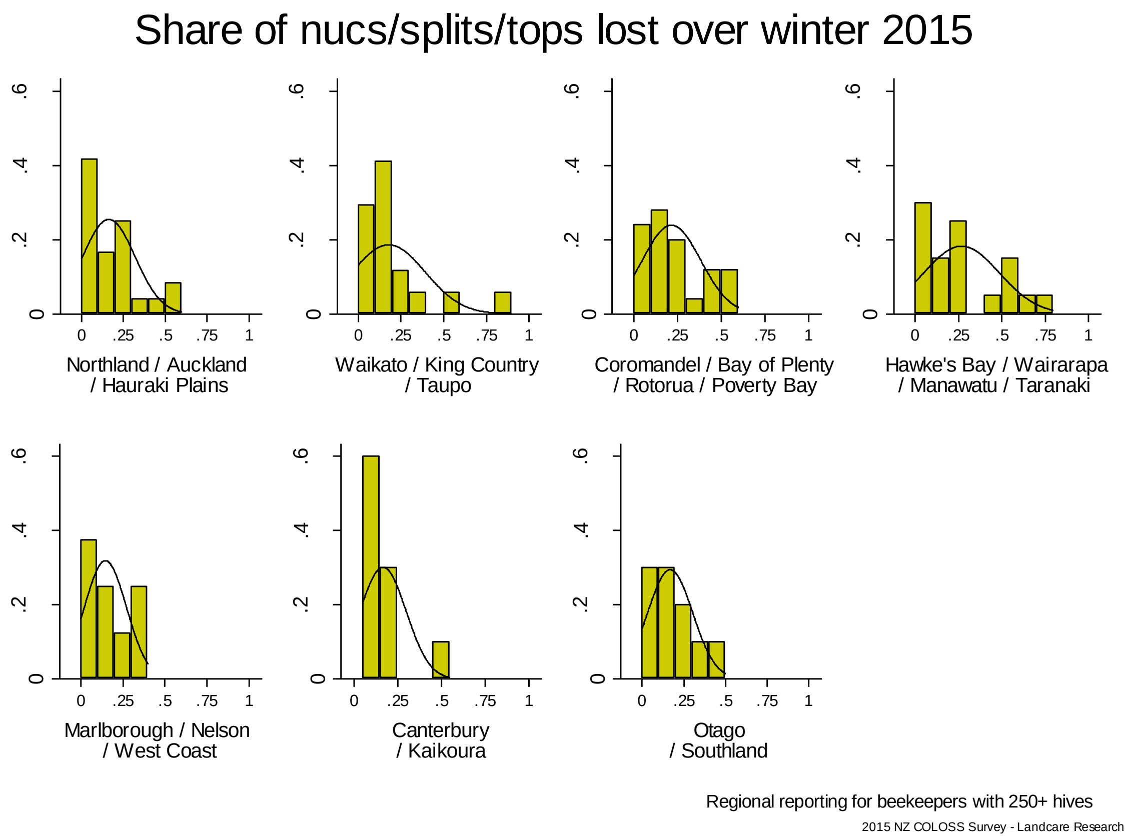

Figure 2. 2 Total Nuc/Split/Top Losses: Winter 2015 nuc/split/top losses as a share of total nucs/splits/tops on 31 March 2015 based on reports from respondents with > 250 hives, by region.

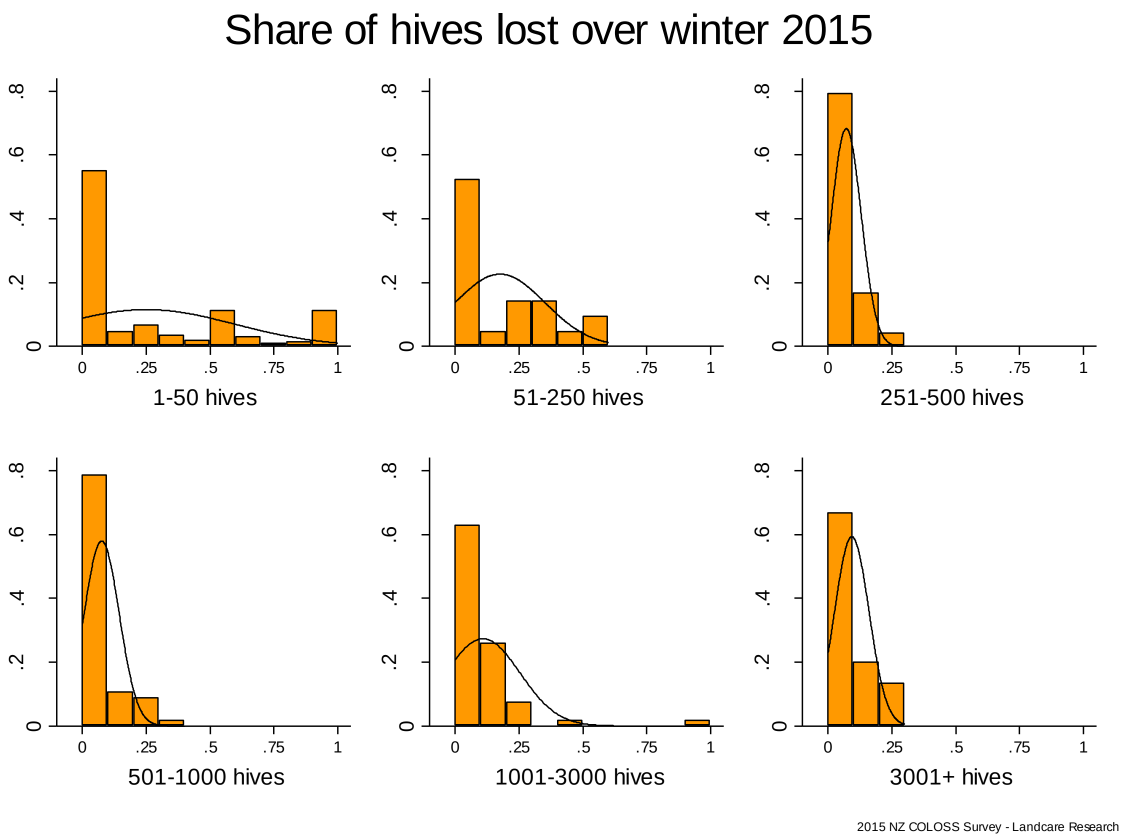

Figure 2. 3 Total Hive Losses: Winter 2015 hive losses as a share of total hives on 31 March 2015 for all respondents, by operation size.

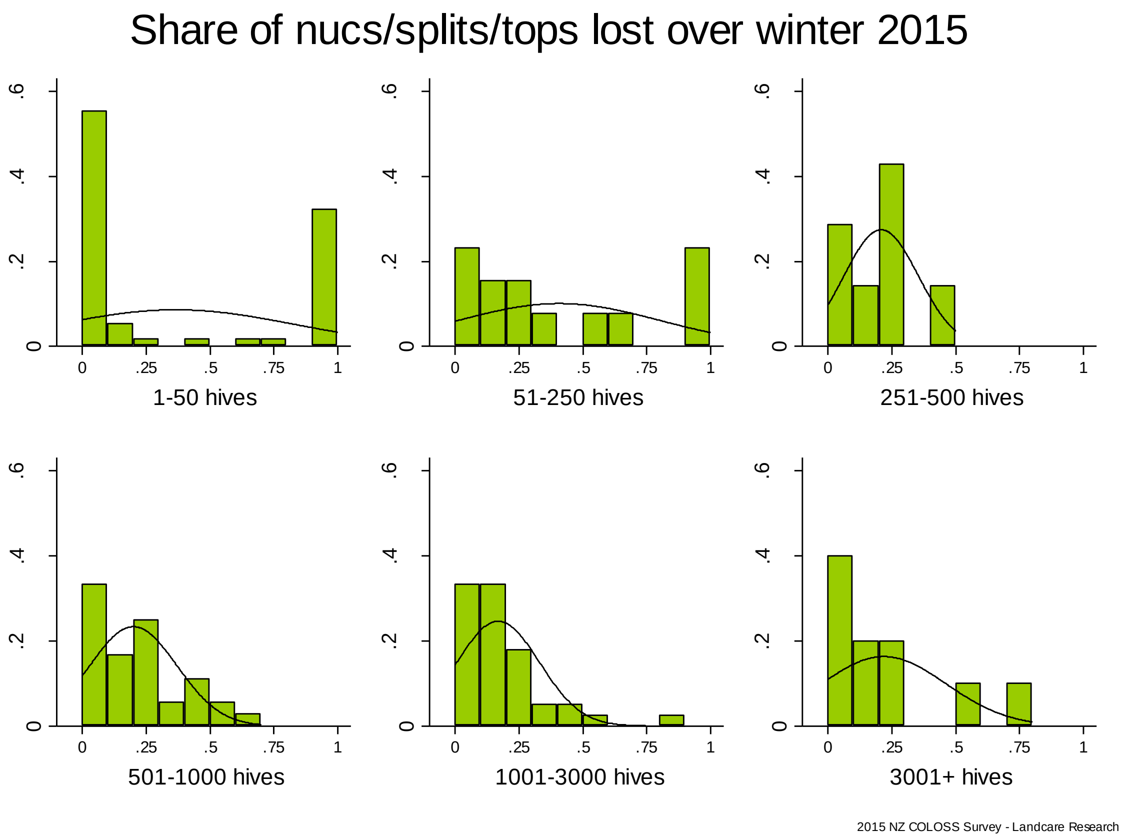

Figure 2. 4 Total Nuc/Split/Top Losses: Winter 2015 nuc/split/top losses as a share of total nucs/splits/tops on 31 March 2015 for all respondents, by operation size.

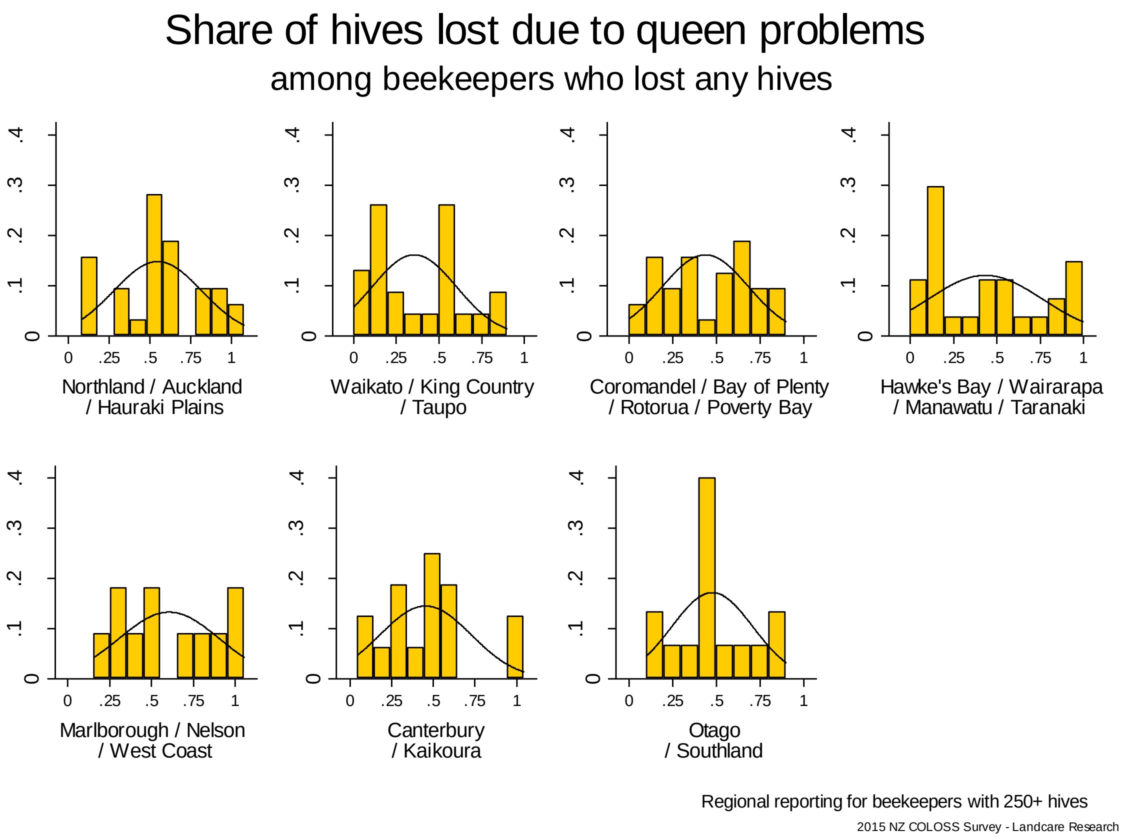

Figure 3. 1 Losses Attributable to Queen Problems: Winter 2015 hive losses that resulted from queen problems (including drone-laying queens and no queen) based on reports from respondents with > 250 hives who lost any hives, by region.

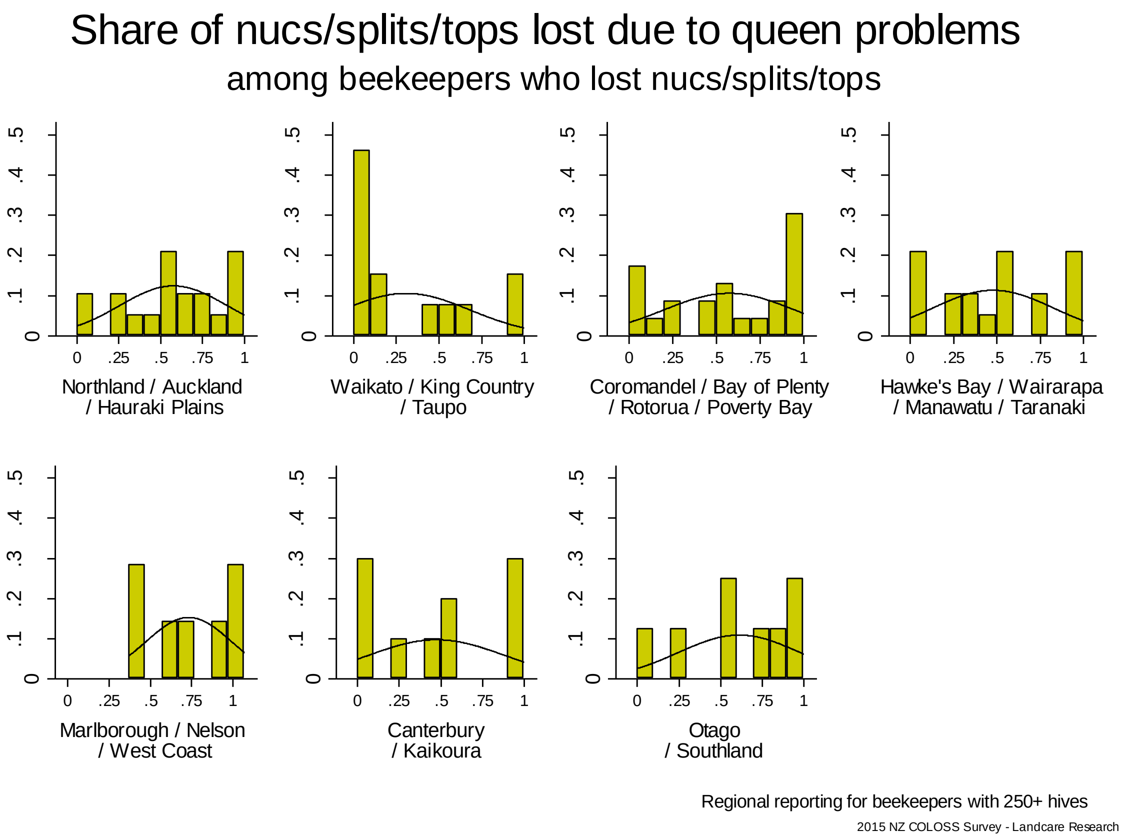

Figure 3. 2 Losses Attributable to Queen Problems: Winter 2015 nuc/split/top losses that resulted from queen problems (including drone-laying queens and no queen) based on reports from respondents with > 250 hives who lost any nucs/splits/tops, by region.

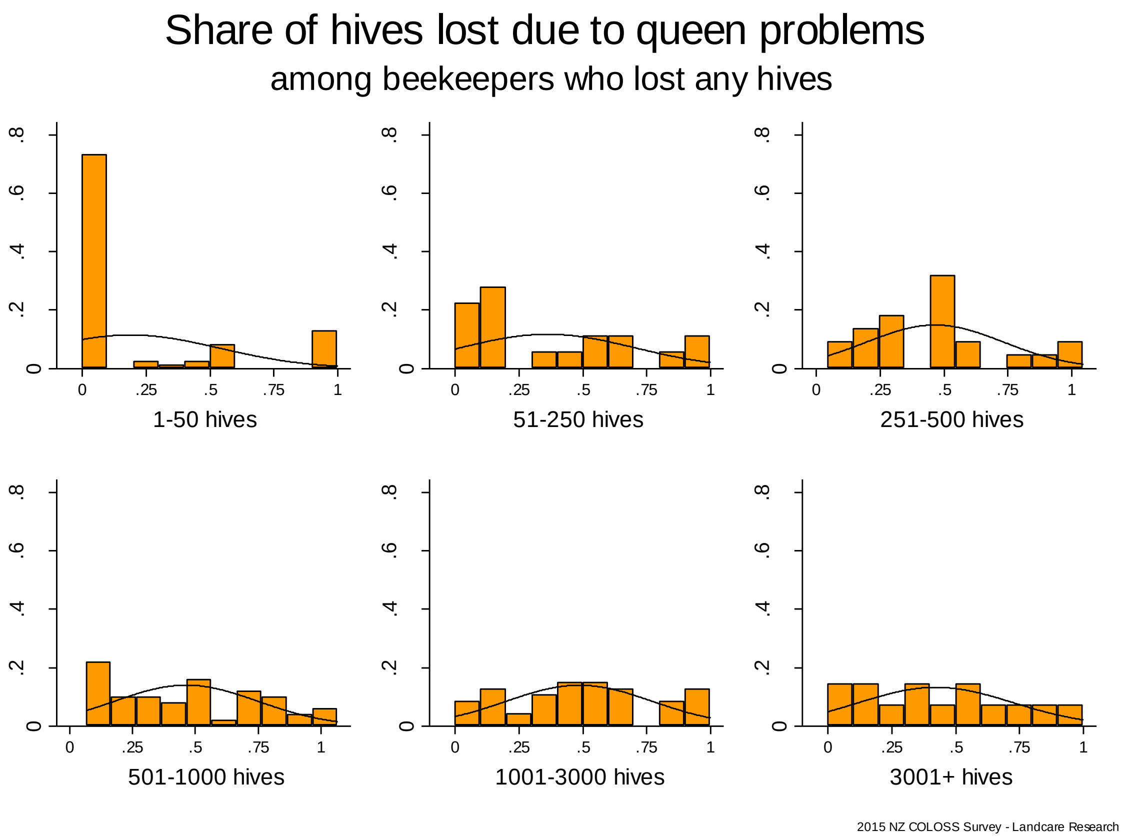

Figure 3. 3 Losses Attributable to Queen Problems: Winter 2015 hive losses that resulted from queen problems (including drone-laying and no queen) based on reports from all respondents who lost any hives, by operation size.

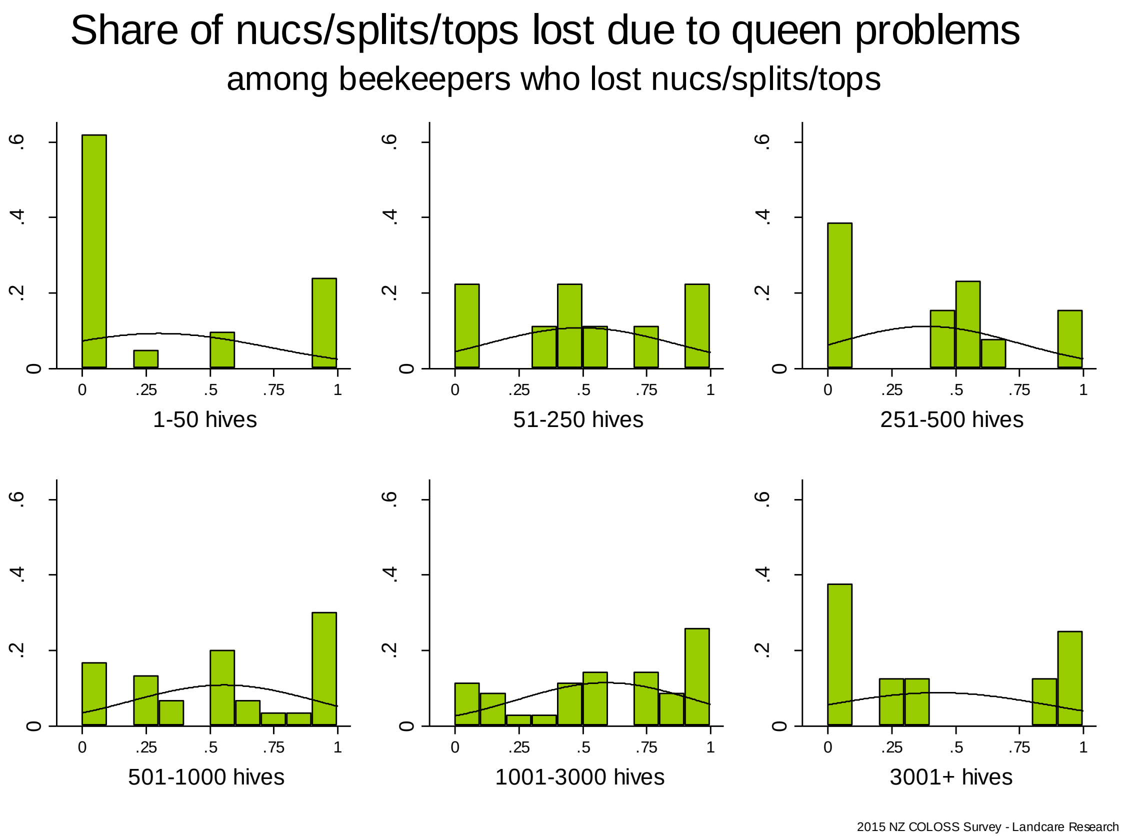

Figure 3. 4 Losses Attributable to Queen Problems: Winter 2015 nuc/split/top losses that resulted from queen problems (including drone-laying and no queen) based on reports from all respondents who lost any nucs/splits/tops, by operation size.

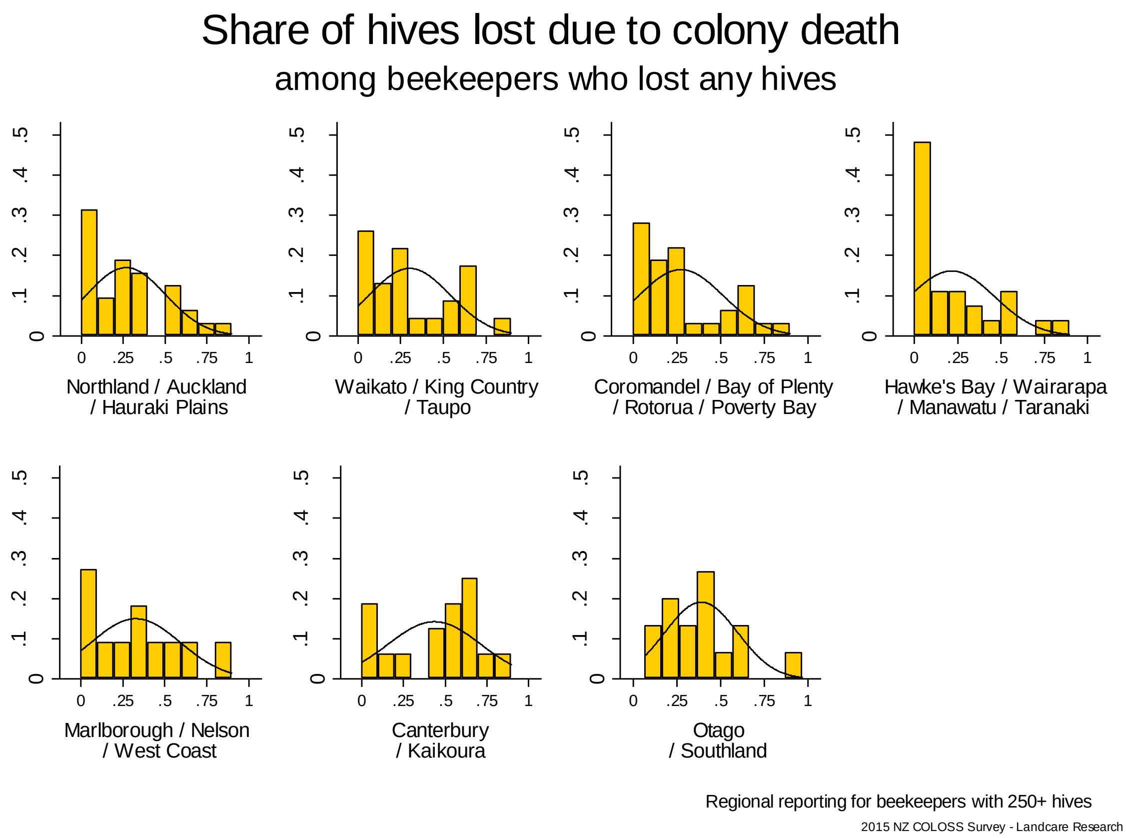

Figure 4. 1 Losses Attributable to Colony Death: Winter 2015 hive losses that resulted from colony death based on reports from respondents with > 250 hives who lost any hives, by region.

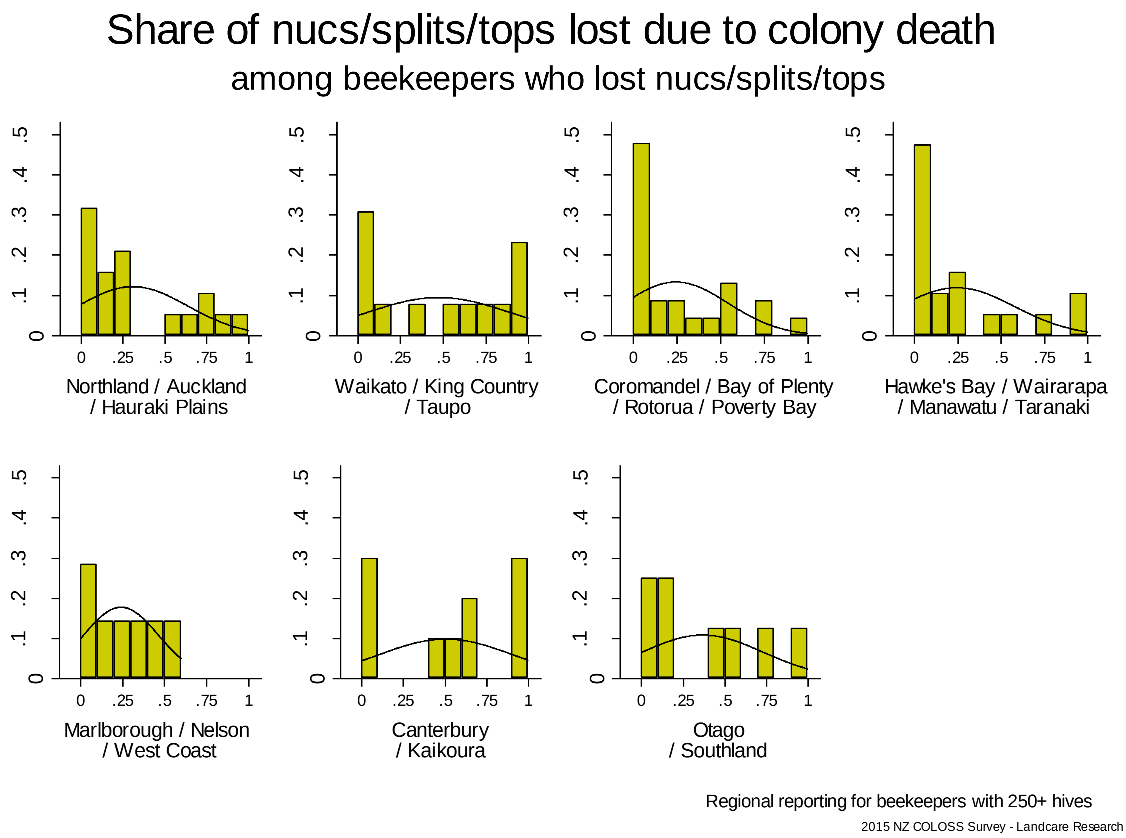

Figure 4. 2 Losses Attributable to Colony Death: Winter 2015 nuc/split/top losses that resulted from colony death based on reports from respondents with > 250 hives who lost any nucs/splits/tops, by region.

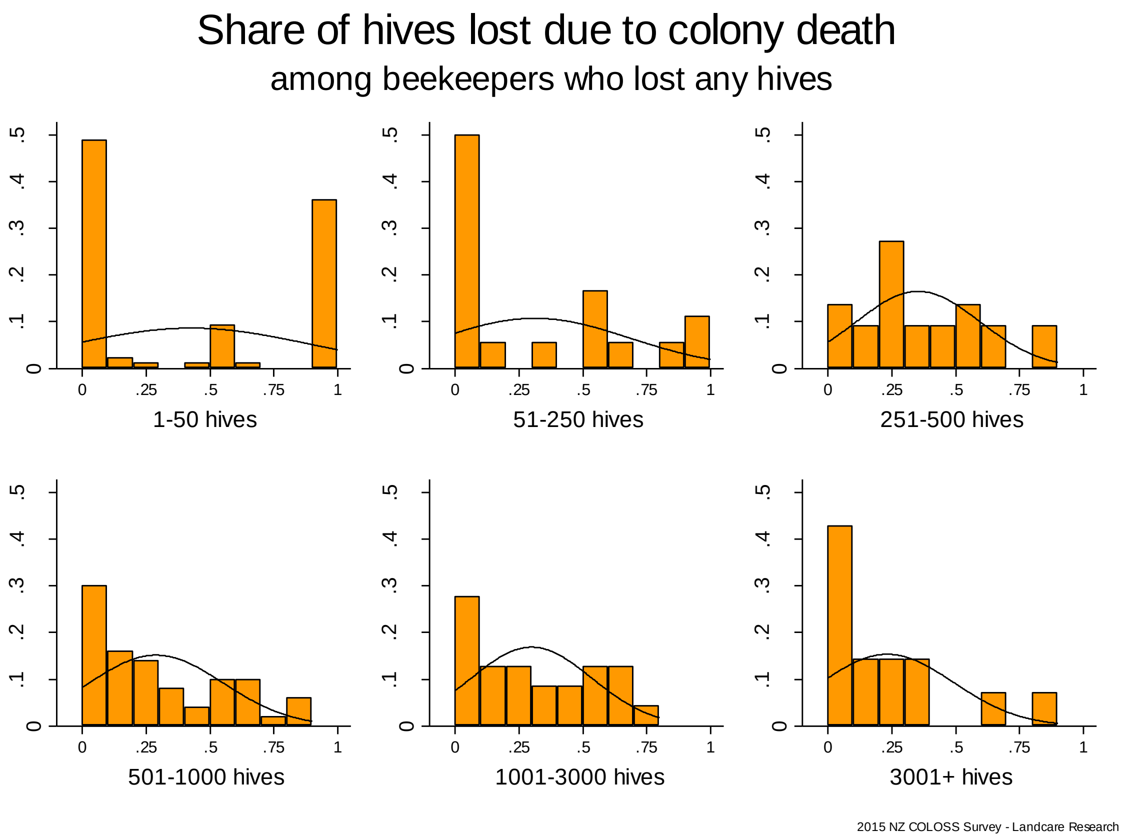

Figure 4. 3 Losses Attributable to Colony Death: Winter 2015 hive losses that resulted from colony death based on reports from all respondents who lost any hives, by operation size.

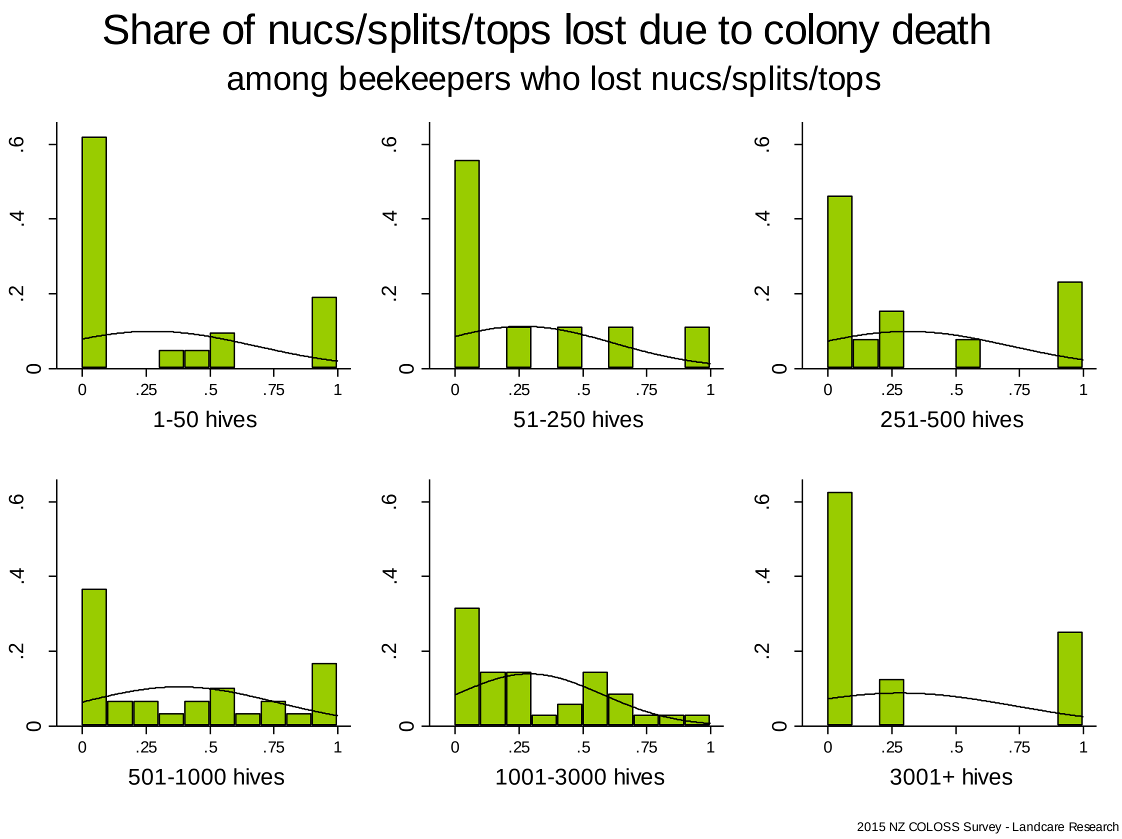

Figure 4. 4 Losses Attributable to Colony Death: Winter 2015 nuc/split/top losses that resulted from colony death based on reports from all respondents who any lost any nucs/splits/tops, by operation size.

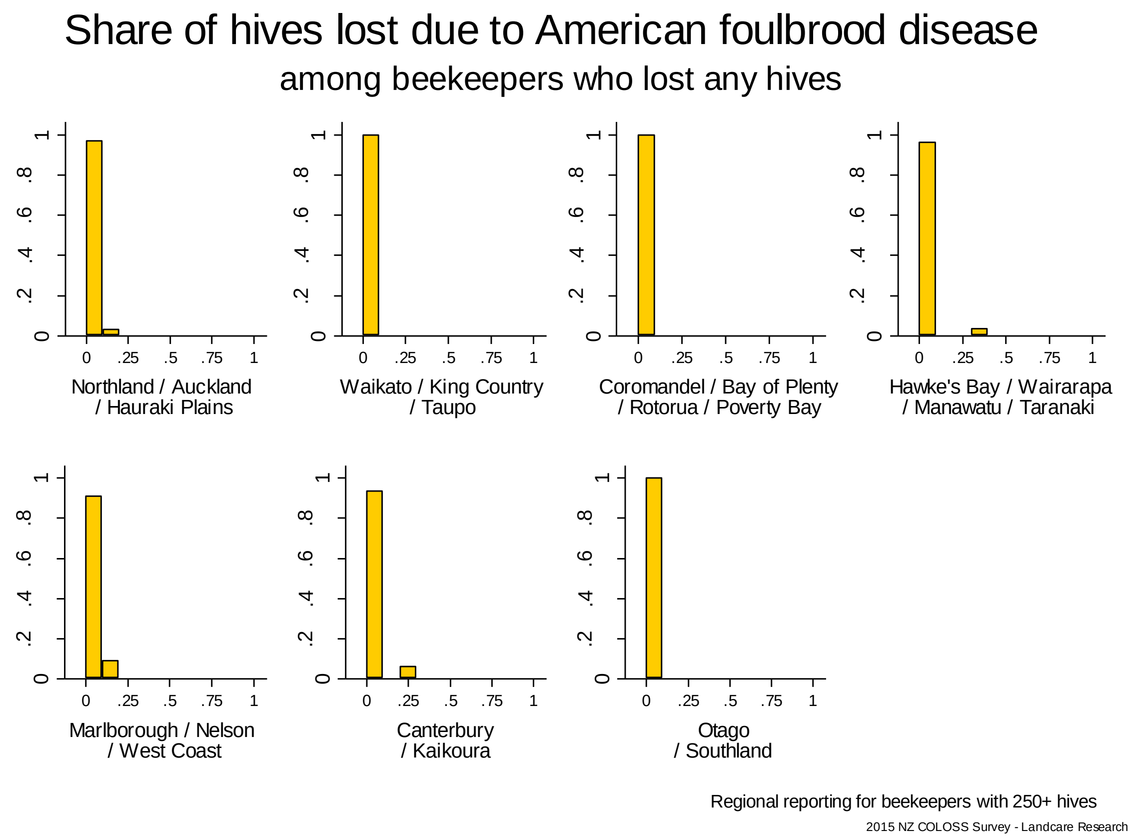

Figure 5. 1 Losses Attributable to American Foulbrood: Winter 2015 hive losses that resulted from AFB based on reports from respondents with > 250 hives who lost any hives, by region.

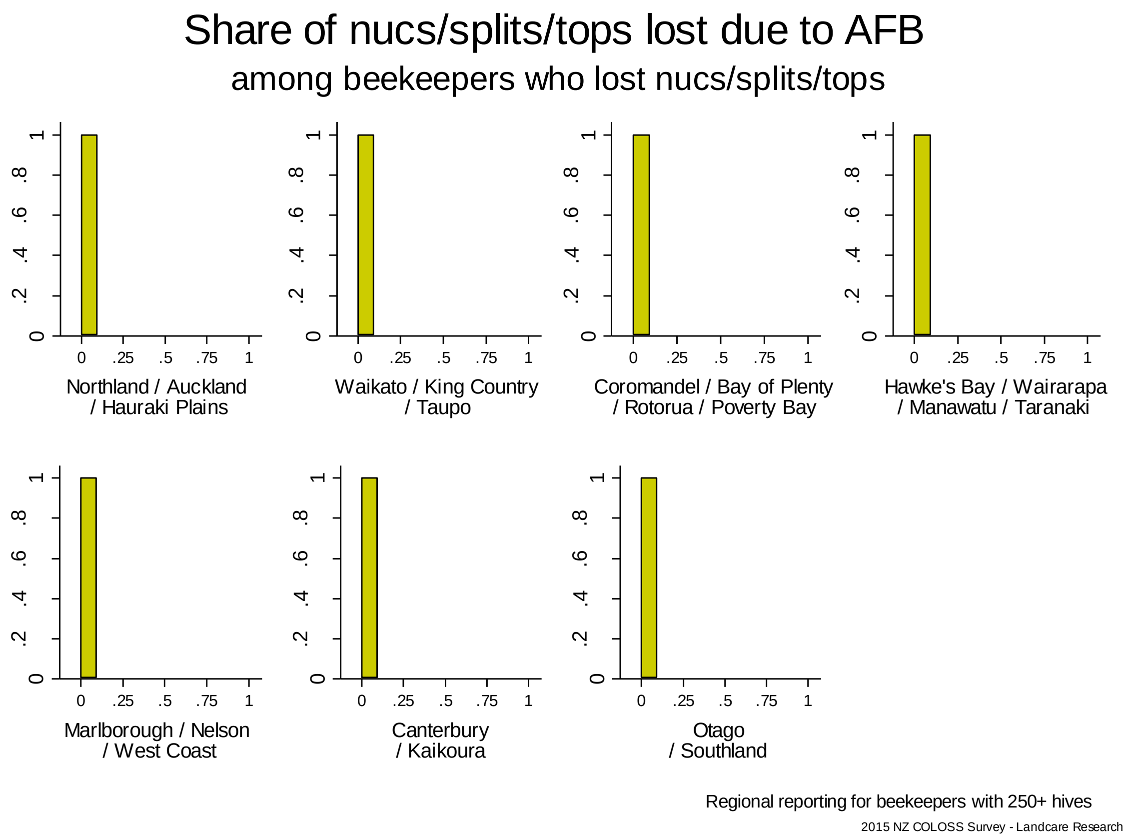

Figure 5. 2 Losses Attributable to American Foulbrood: Winter 2015 nuc/split/top losses that resulted from AFB based on reports from respondents with > 250 hives who lost any nucs/splits/tops, by region.

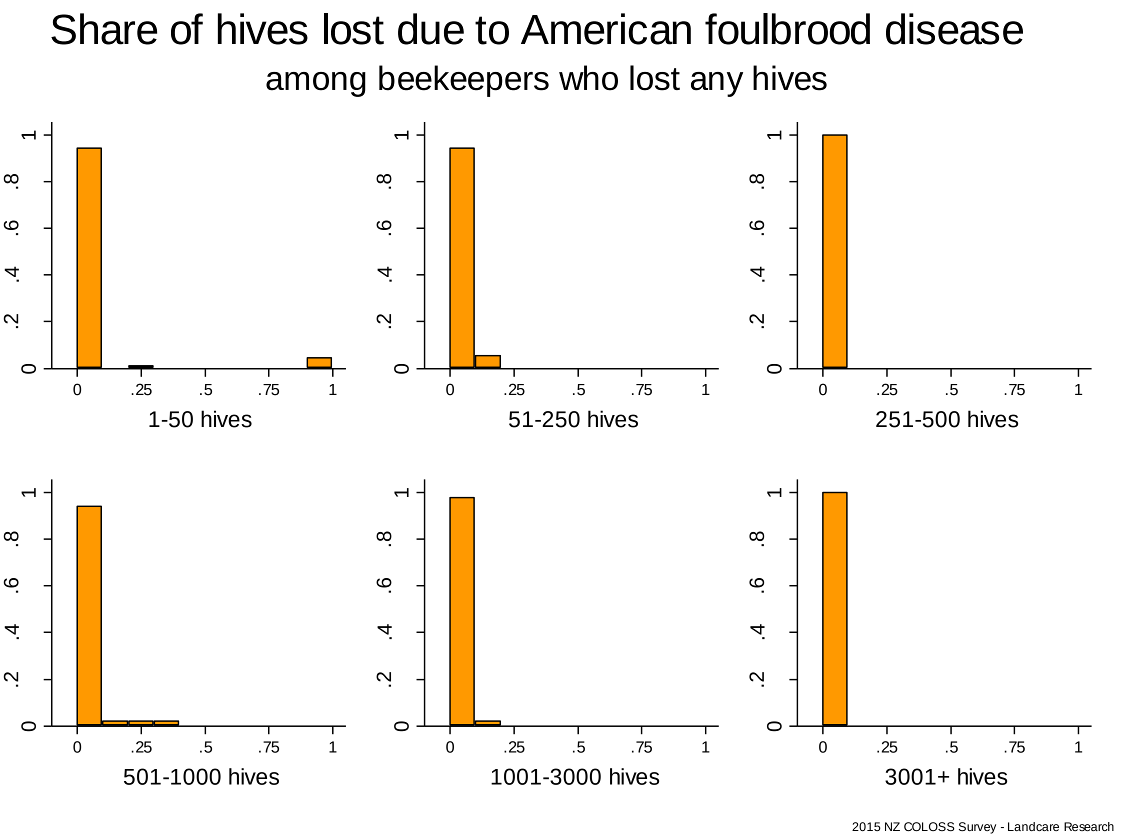

Figure 5. 3 Losses Attributable to American Foulbrood: Winter 2015 hive losses that resulted from AFB based on reports from all respondents who lost any hives, by operation size.

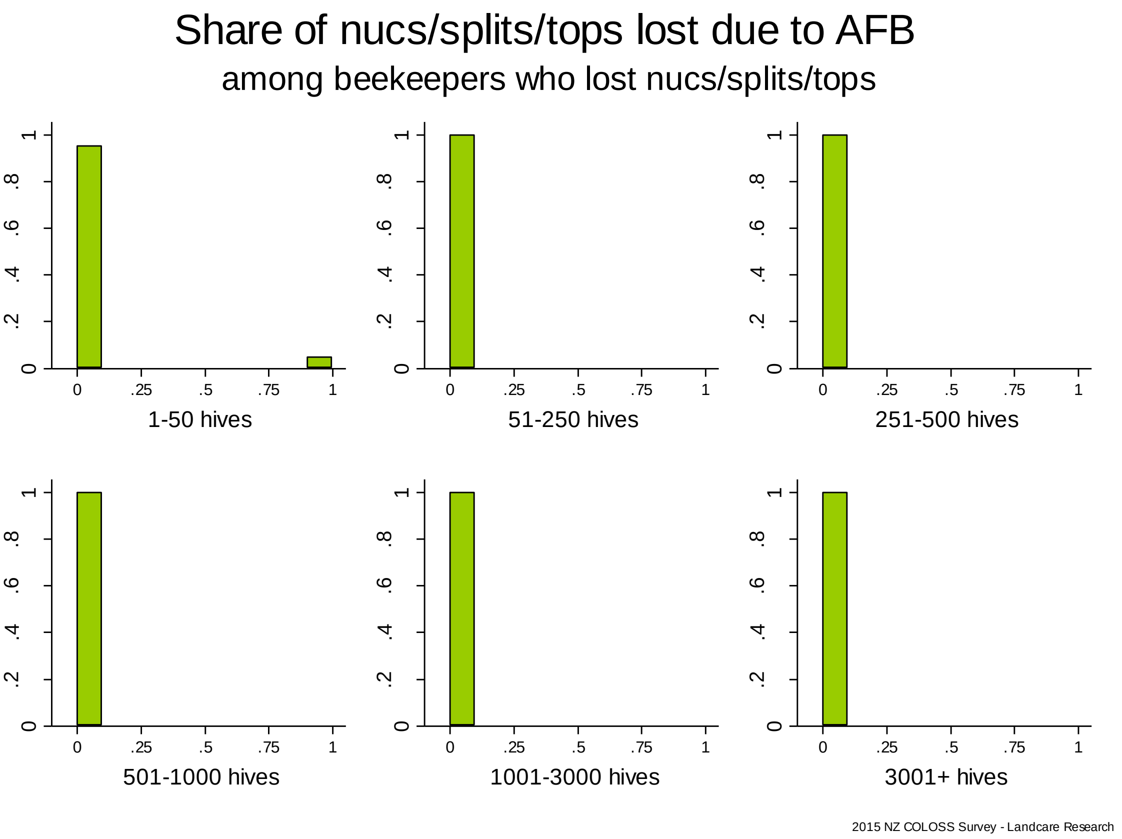

Figure 5. 4 Losses Attributable to American Foulbrood: Winter 2015 nuc/split/top losses that resulted from AFB based on reports from all respondents who lost any nuc/splits/tops, by operation size.

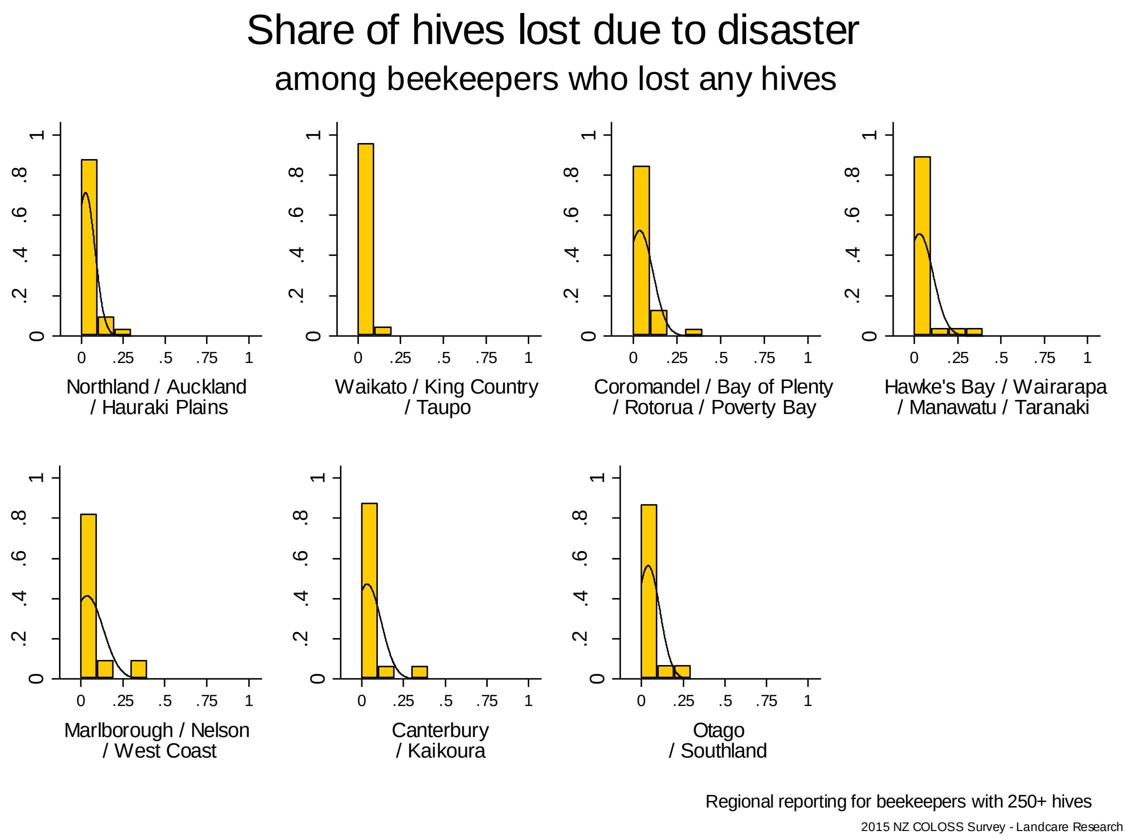

Figure 6. 1 Losses Attributable to Natural Disasters: Winter 2015 hive losses that resulted from natural disasters based on reports from respondents with > 250 hives who lost any hives, by region. Natural disasters include gale force winds, flooding, etc.

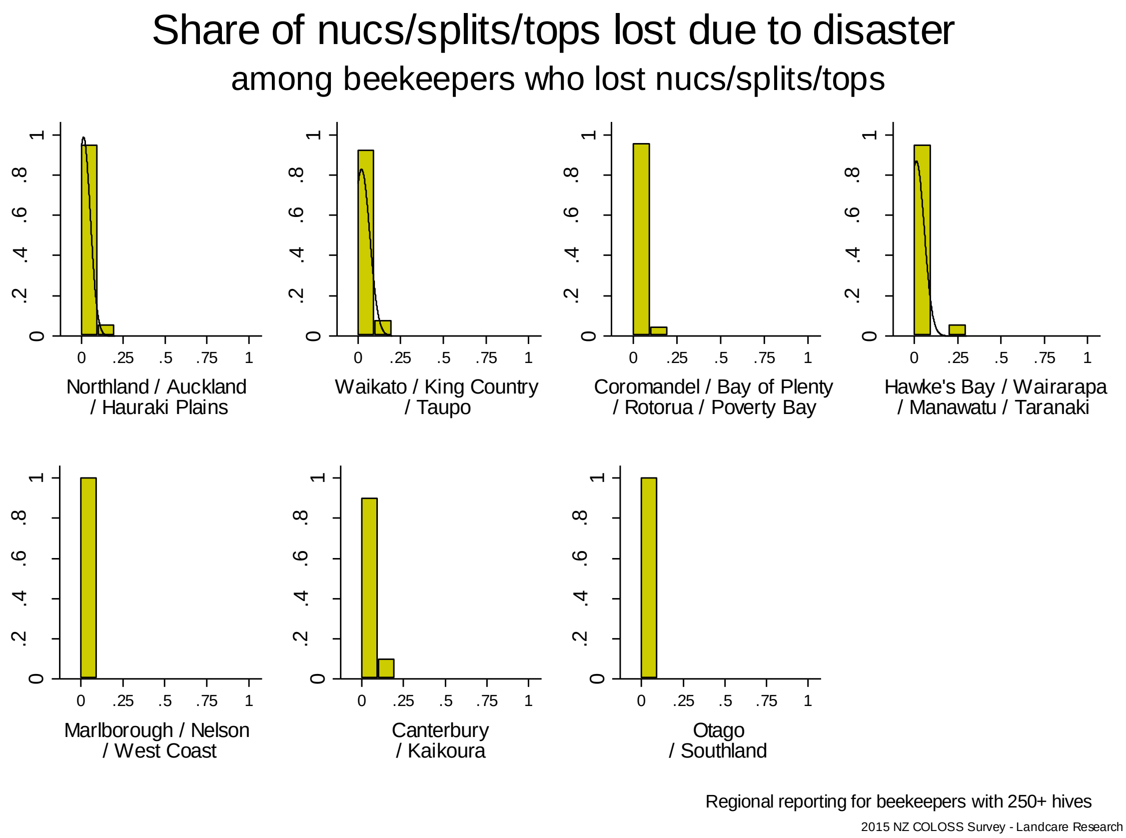

Figure 6. 2 Losses Attributable to Natural Disasters: Winter 2015 nuc/split/top losses that resulted from natural disasters based on reports from respondents with > 250 hives who lost any nuc/splits/tops, by region. Natural disasters include gale force winds, flooding, etc.

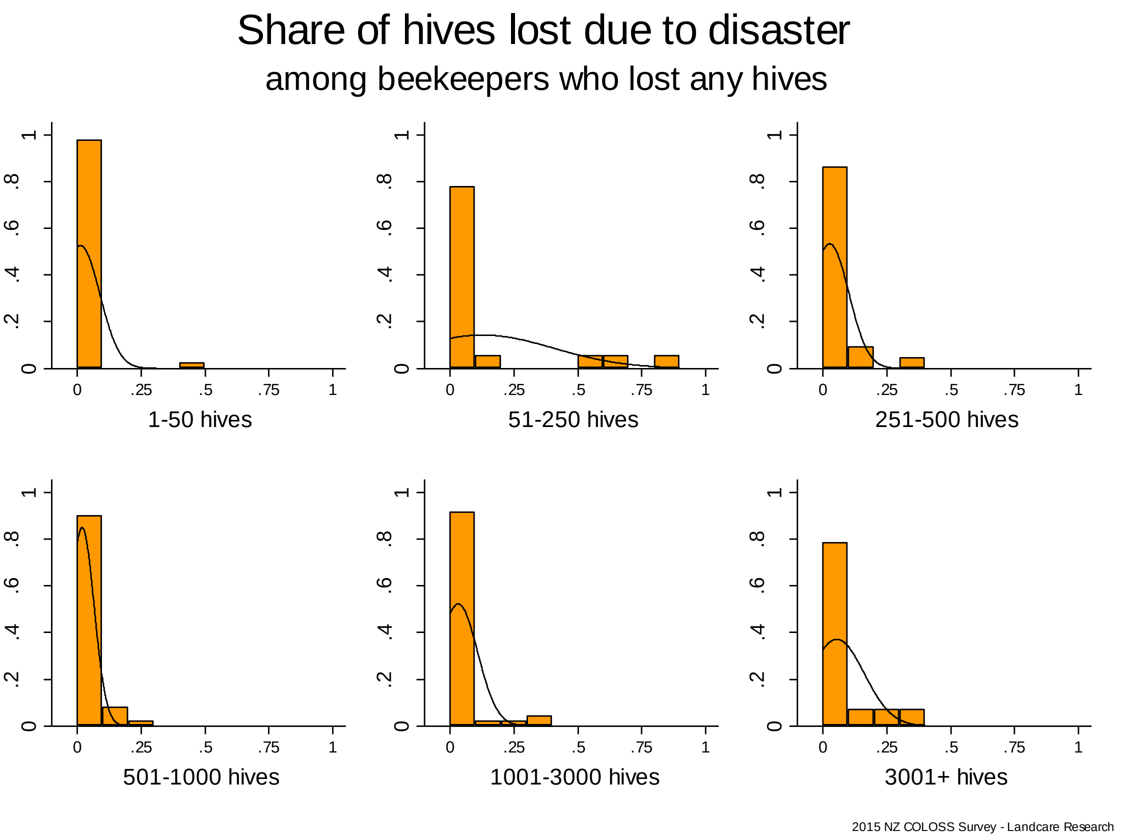

Figure 6. 3 Losses Attributable to Natural Disasters: Winter 2015 hive losses that resulted from natural disasters based on reports from all respondents who lost any hives, by operation size. Natural disasters include gale force winds, flooding, etc.

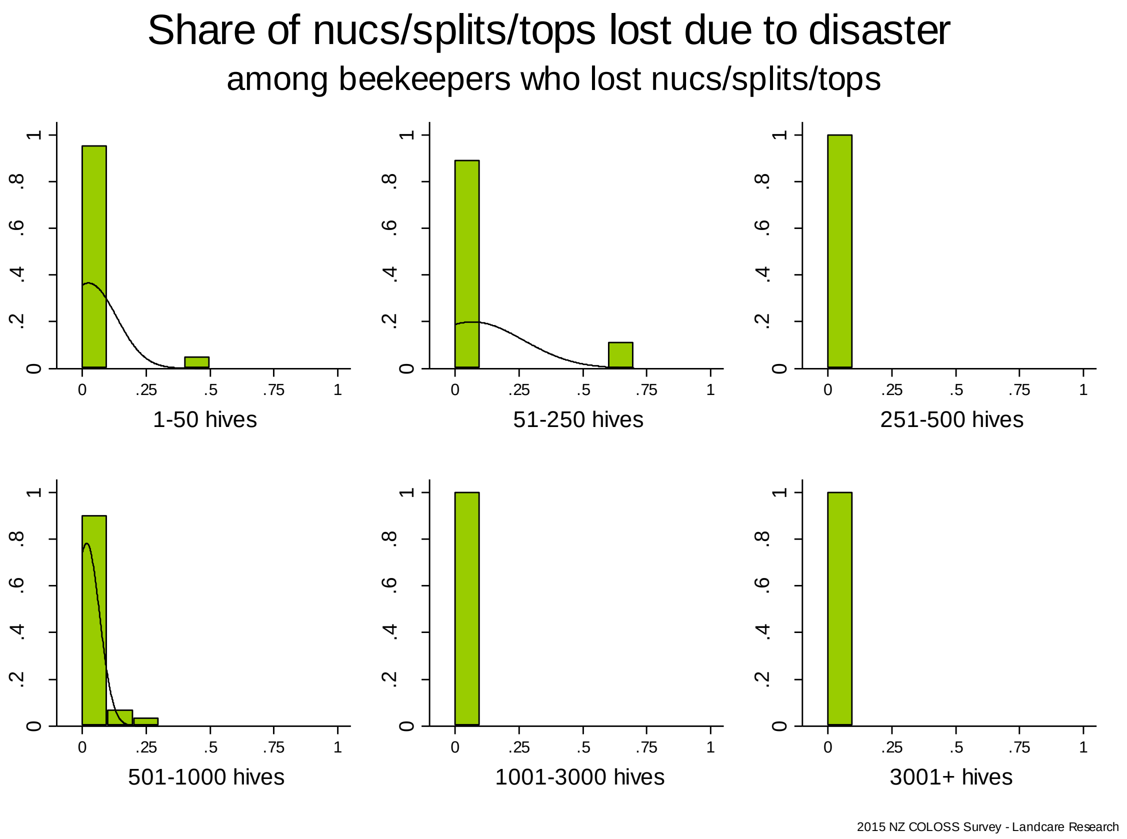

Figure 6. 4 Losses Attributable to Natural Disasters: Winter 2015 nuc/split/top losses that resulted from natural disasters based on reports from all respondents who lost any nucs/splits/tops, by operation size. Natural disasters include gale force winds, flooding, etc.

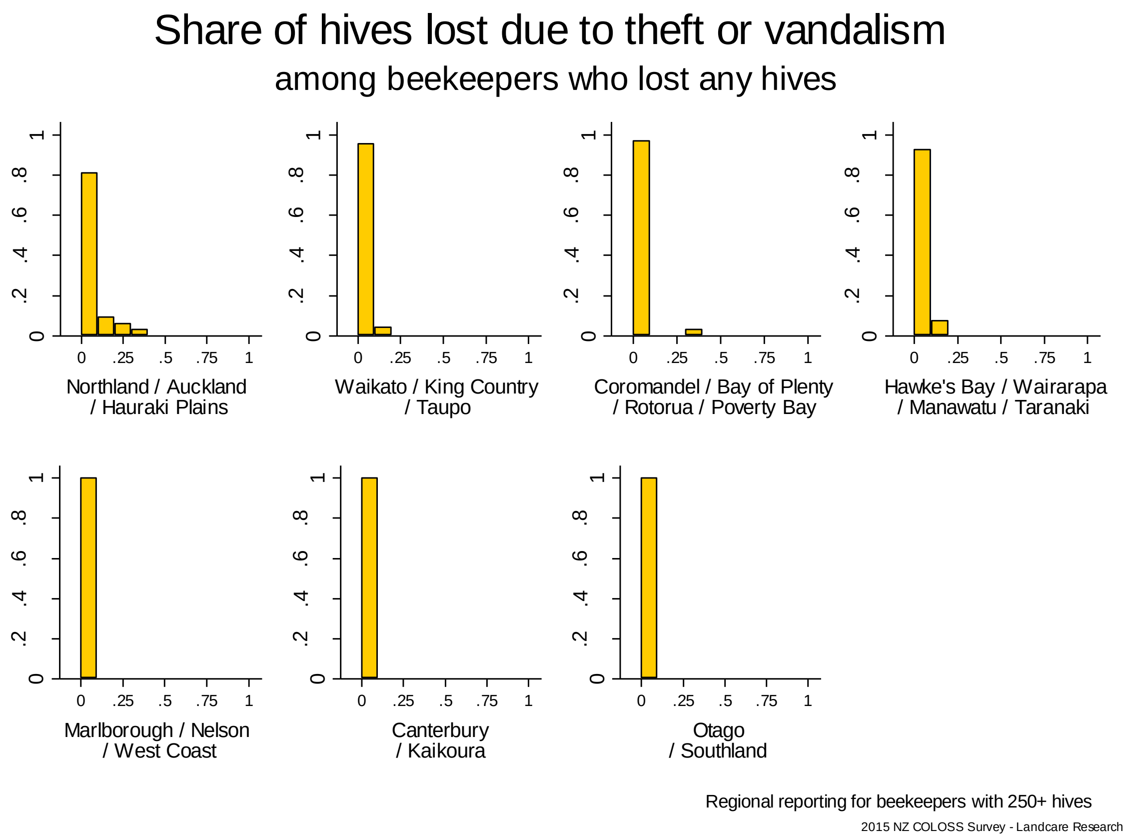

Figure 7. 1 Losses Attributable to Theft or Vandalism: Winter 2015 hive losses that resulted from theft or vandalism based on reports from respondents with > 250 hives who lost any hives, by region.

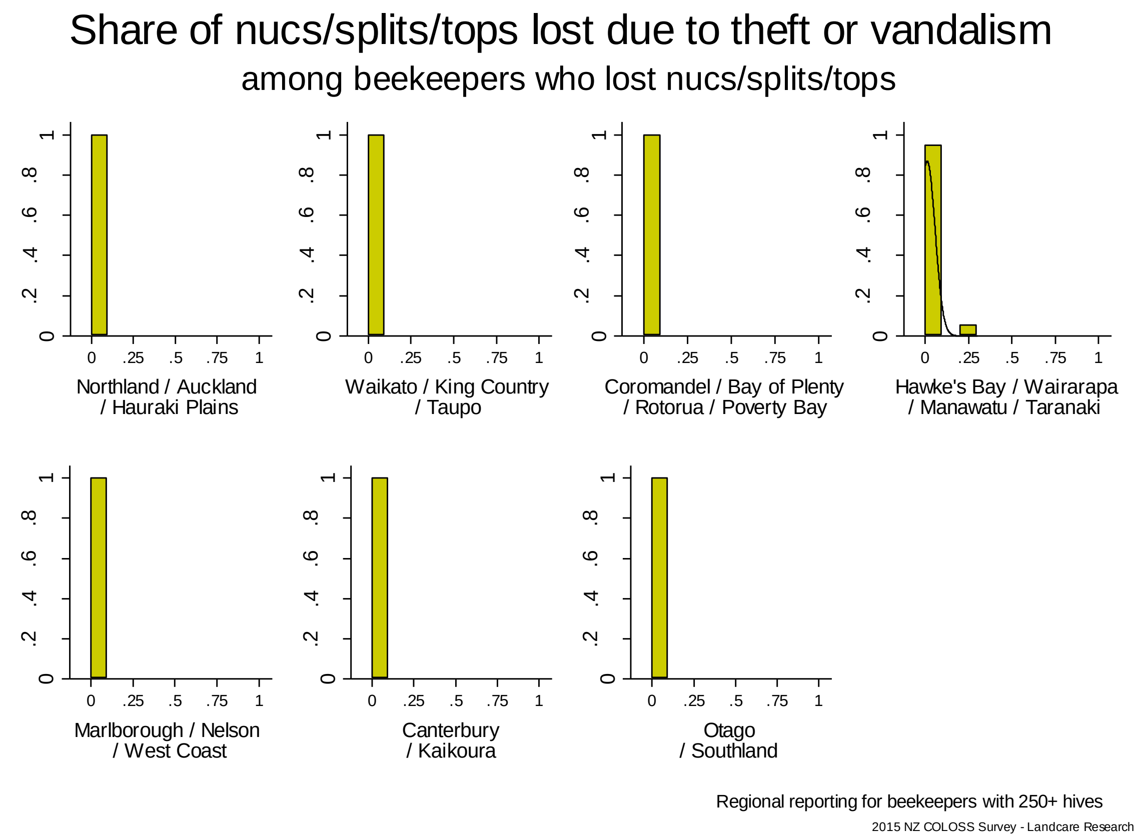

Figure 7. 2 Losses Attributable to Theft or Vandalism: Winter 2015 nuc/split/top losses that resulted from theft or vandalism based on reports from respondents with > 250 hives who lost any nucs/splits/tops, by region.

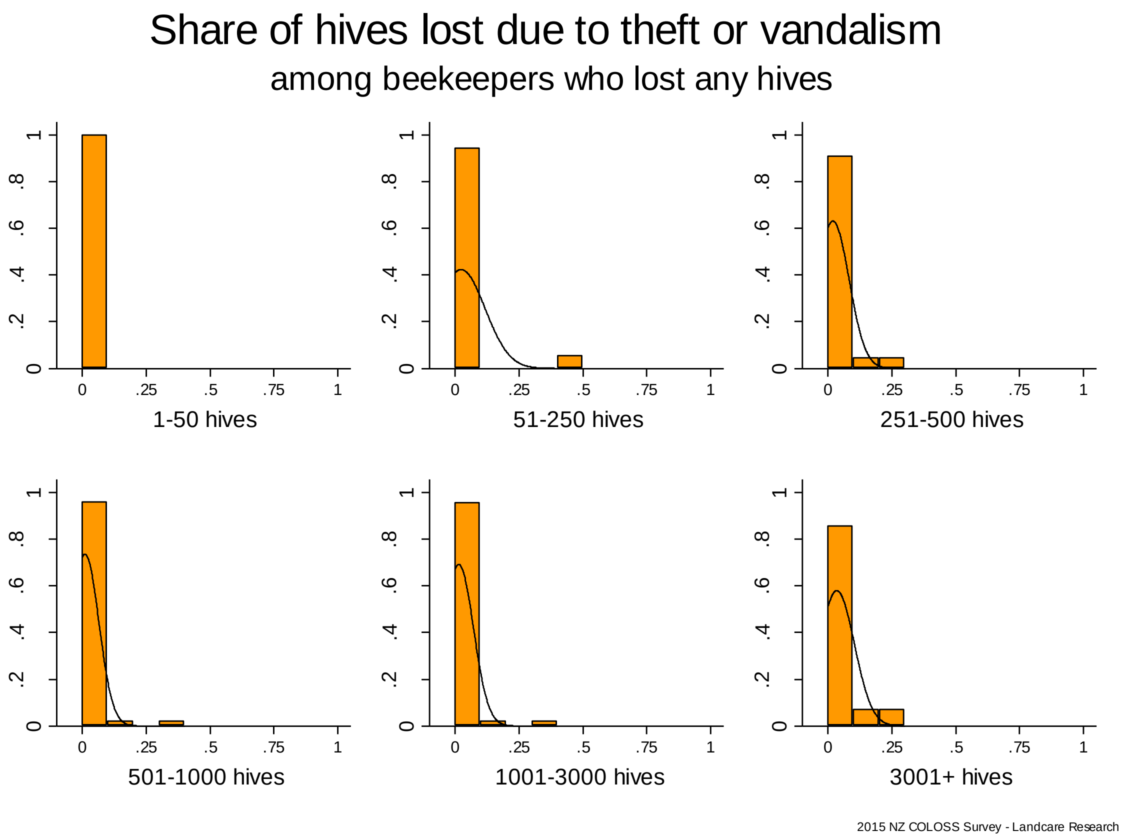

Figure 7. 3 Losses Attributable to Theft or Vandalism: Winter 2015 hive losses that resulted from theft or vandalism based on reports from all respondents who lost any hives, by operation size.

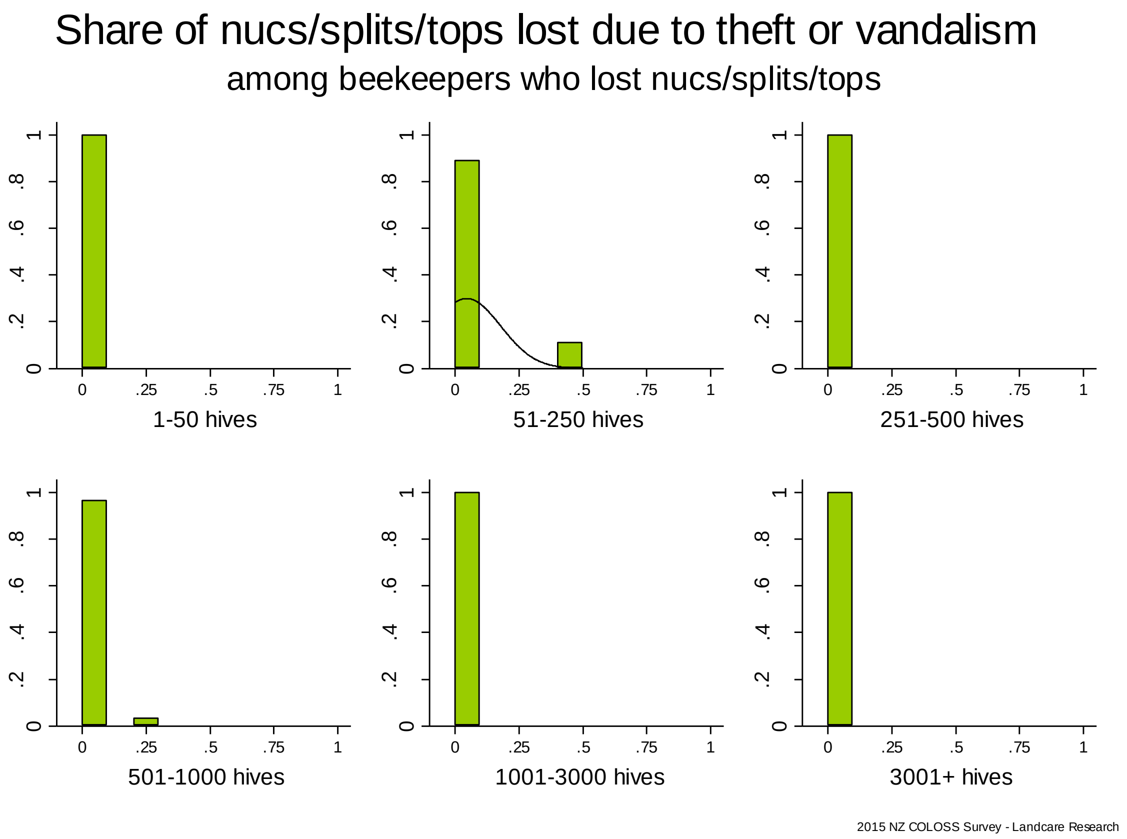

Figure 7. 4 Losses Attributable to Theft or Vandalism: Winter 2015 nuc/split/top losses that resulted from theft or vandalism based on reports from all respondents who lost any nucs/splits/tops, by operation size.

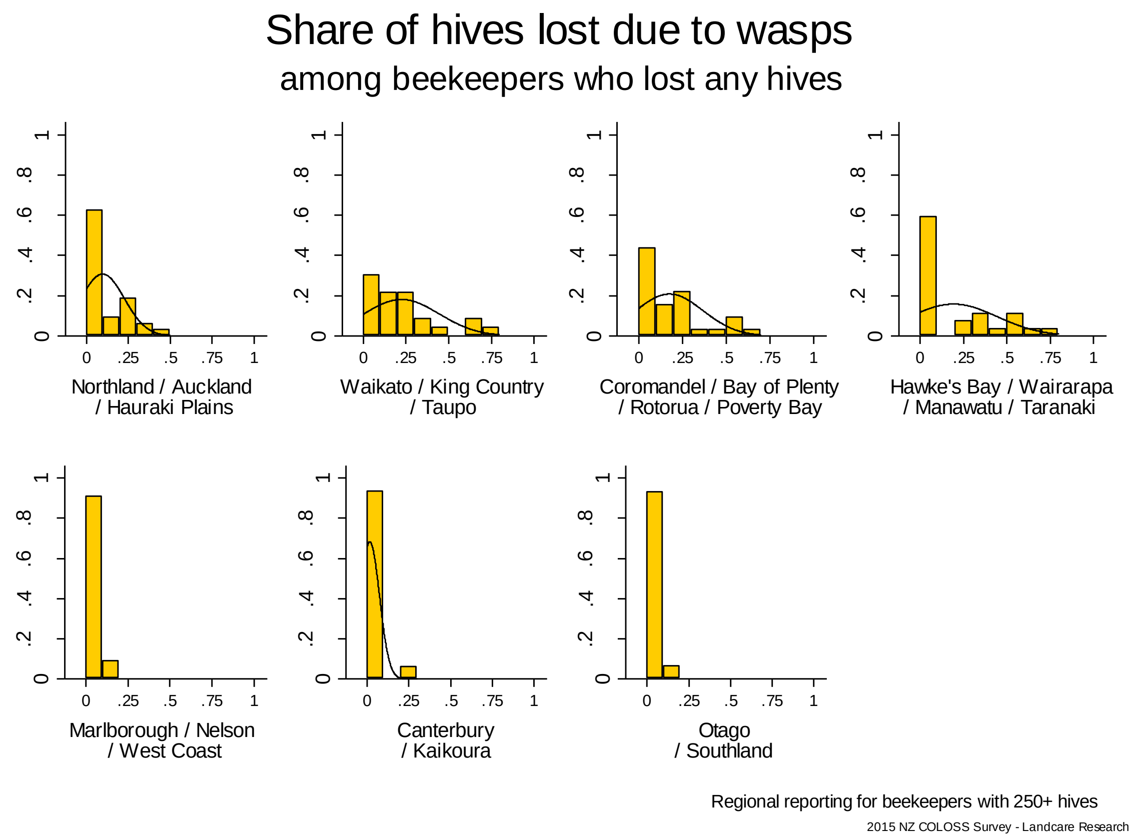

Figure 8. 1 Losses Attributable to Wasps: Winter 2015 hive losses that resulted from wasp problems based on reports from respondents with > 250 hives who lost any hives, by region.

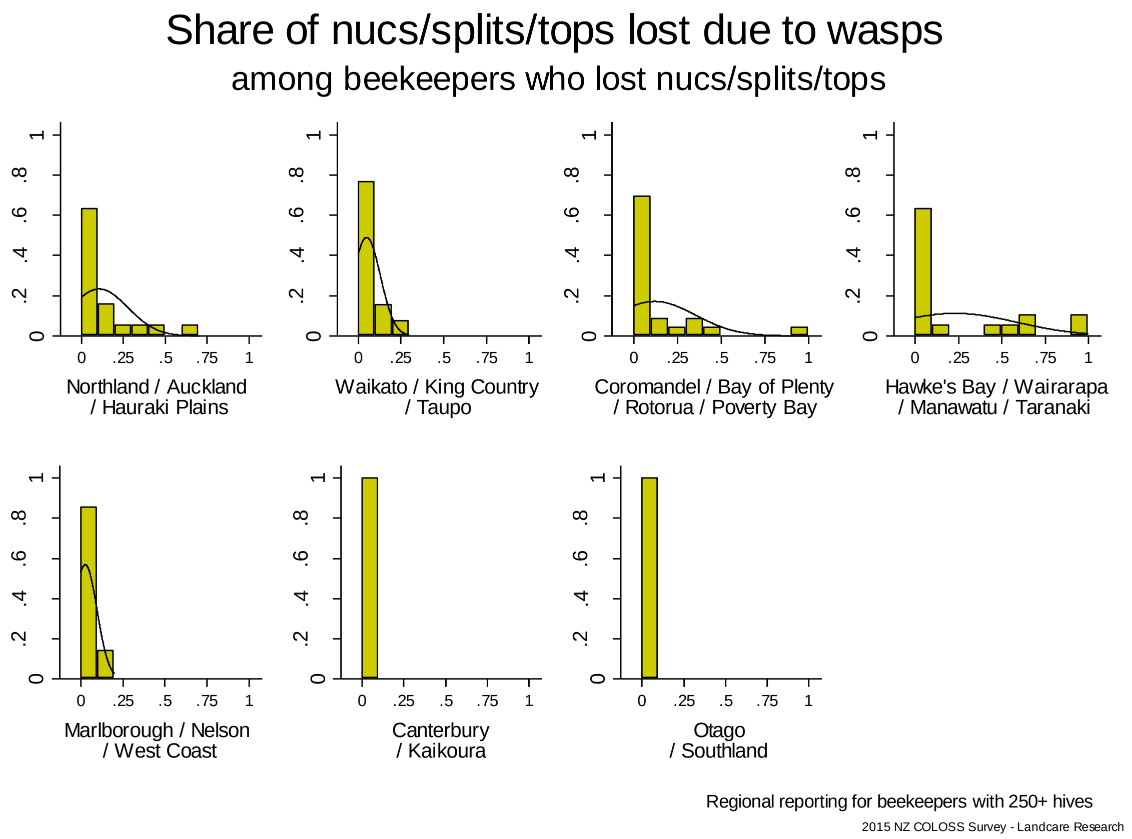

Figure 8. 2 Losses Attributable to Wasps: Winter 2015 nuc/split/top losses that resulted from wasp problems based on reports from respondents with > 250 hives who lost any nucs/splits/tops, by region.

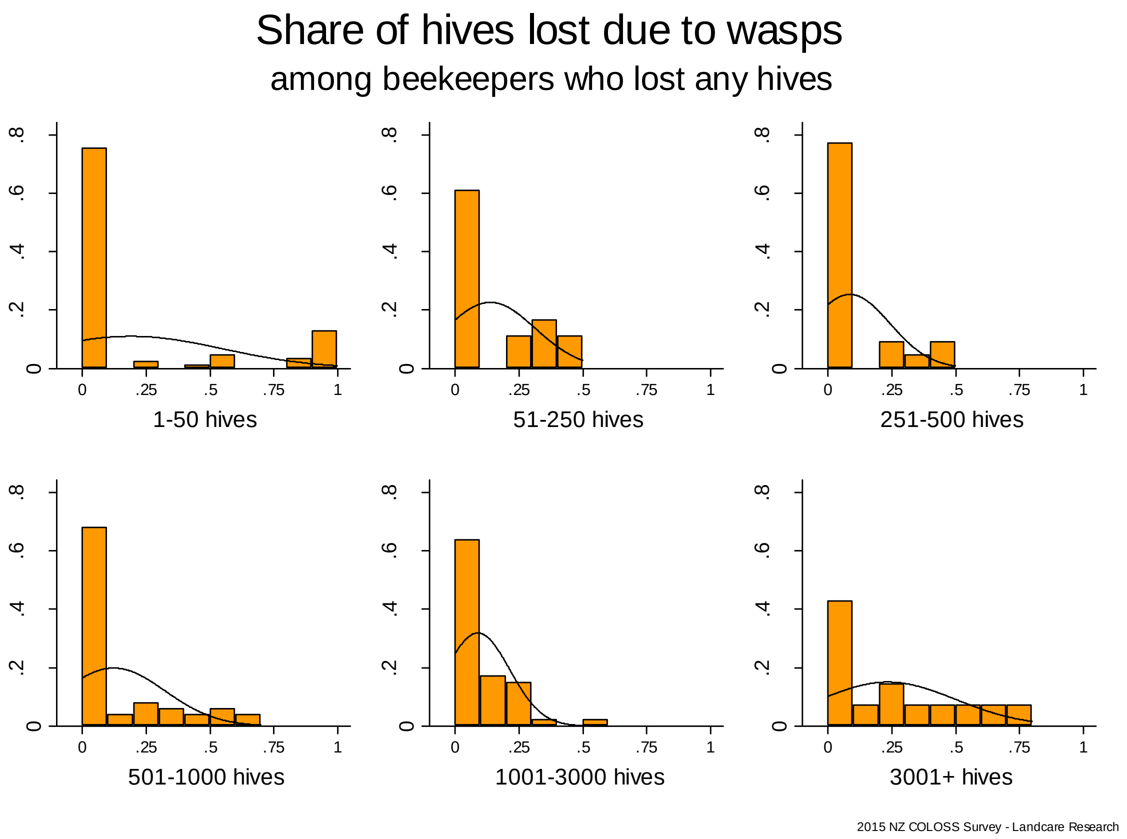

Figure 8. 3 Losses Attributable to Wasps: Winter 2015 hive losses that resulted from wasp problems based on reports from all respondents who lost any hives, by operation size.

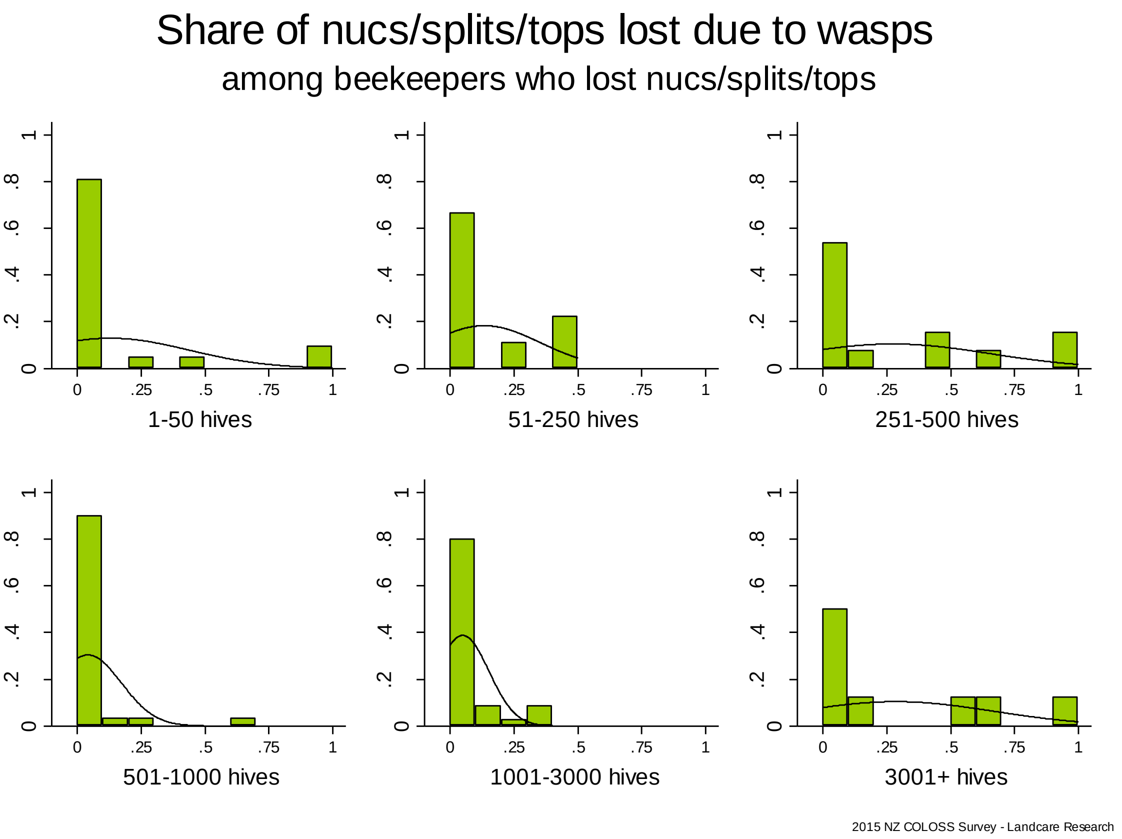

Figure 8. 4 Losses Attributable to Wasps: Winter 2015 nuc/split/top losses that resulted from wasp problems based on reports from all respondents who any lost any nucs/splits/tops, by operation size.

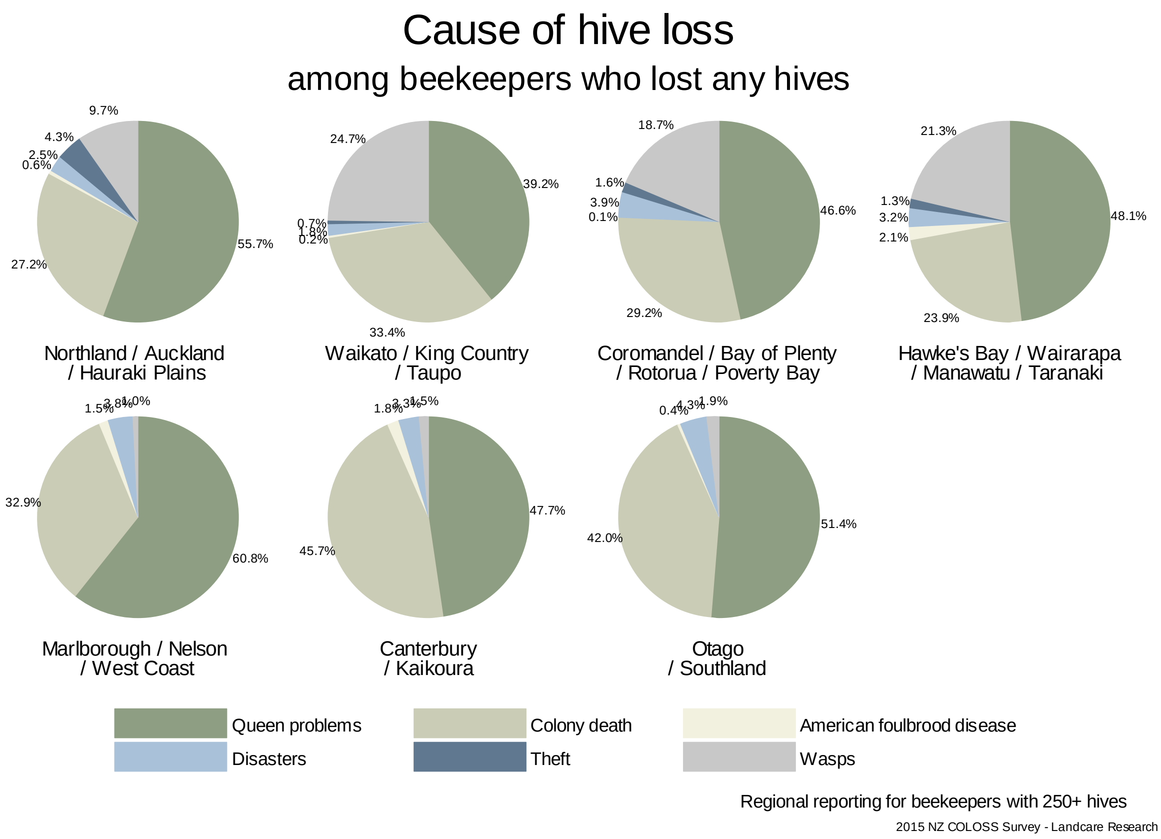

Figure 9. 1 Summary of Reasons Underlying Hive Losses: Regional Average Share of Hive losses attributed to each cause based on reports from respondents with > 250 hives who reported losses, by region.

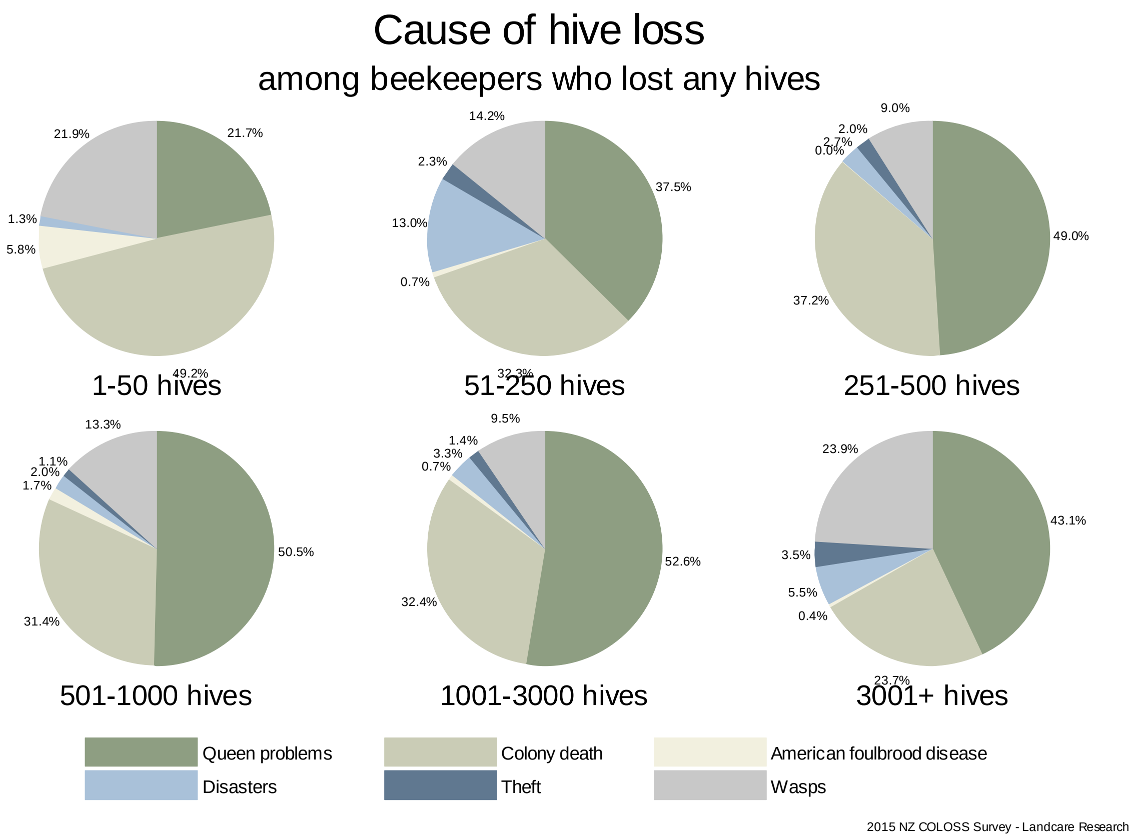

Figure 9. 2 Summary of Reasons Underlying Nuc/Split/Top Losses: Regional Average Share of nuc/splits/tops losses attributed to each cause based on reports from respondents with > 250 hives who reported losses, by region.

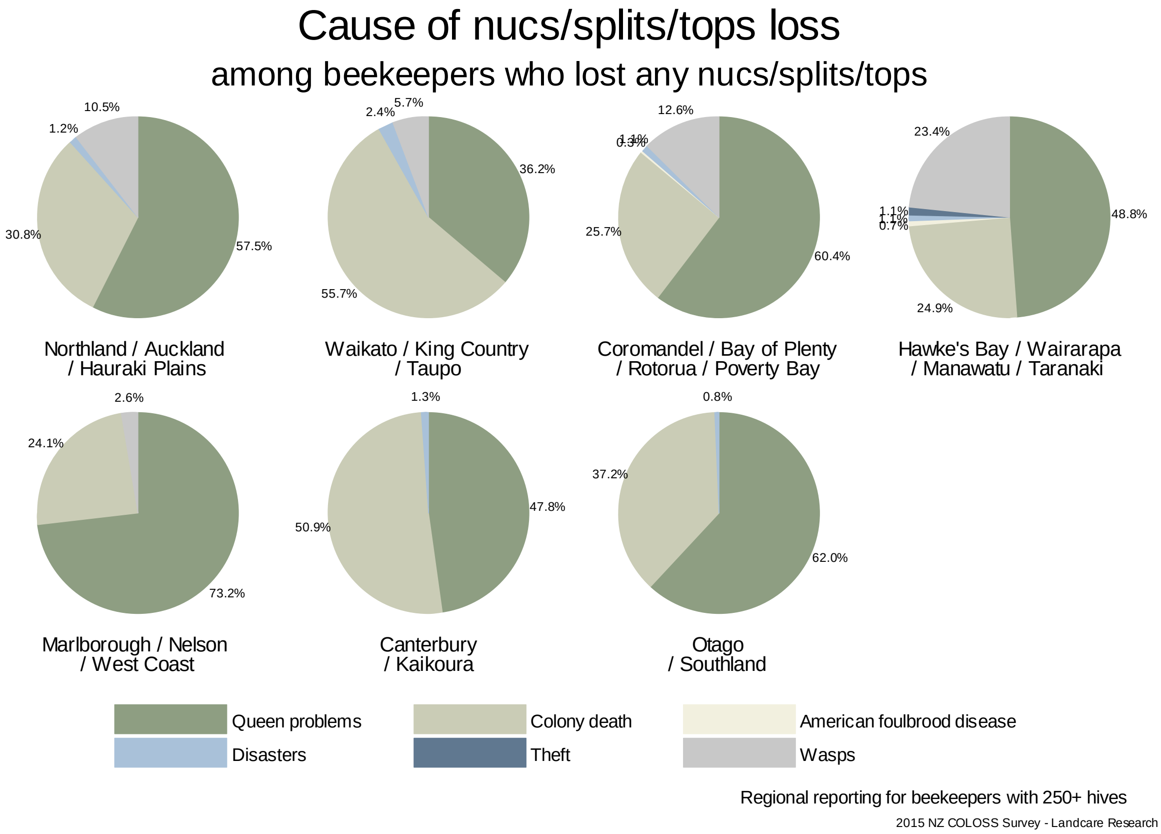

Figure 9. 3 Summary of Reasons Underlying Hive Losses: Operation Size Average Share of Hive losses attributed to each cause based on reports from respondents all respondents who reported losses, by operation size.

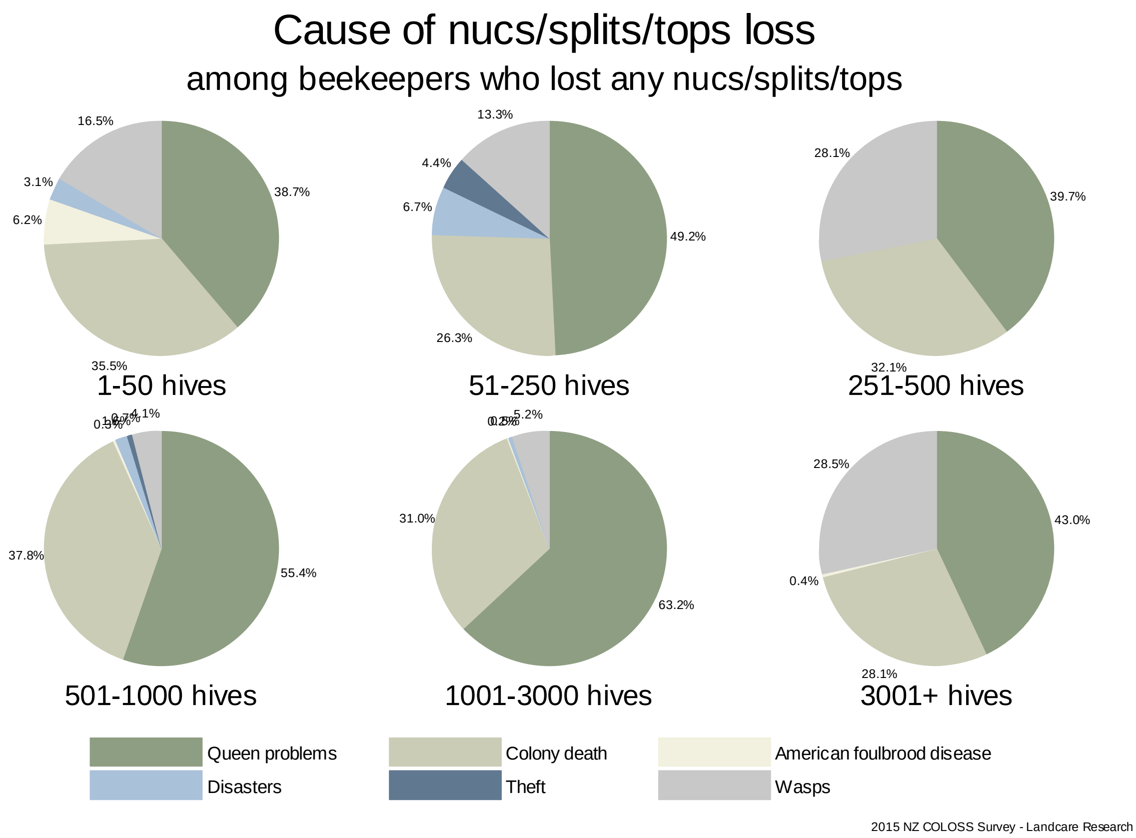

Figure 9. 4 Summary of Reasons Underlying Nuc/Split/Top Losses: Operation size share of nucs/splits/tops losses attributed to each cause based on reports from all respondents who reported losses, by operation size.

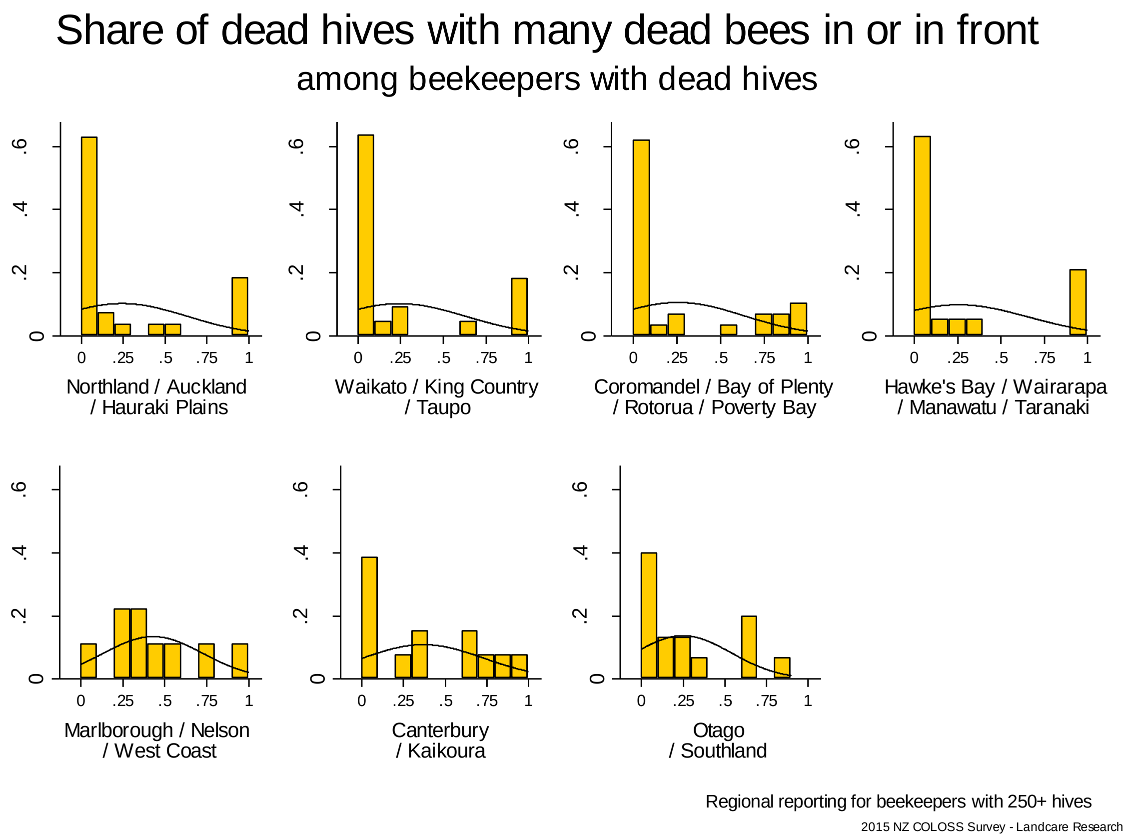

Figure 10. 1 Indicators of Hive Death: Dead hives that had many dead bees in or in front of the hive after winter 2015 based on reports from respondents with > 250 hives, by region.

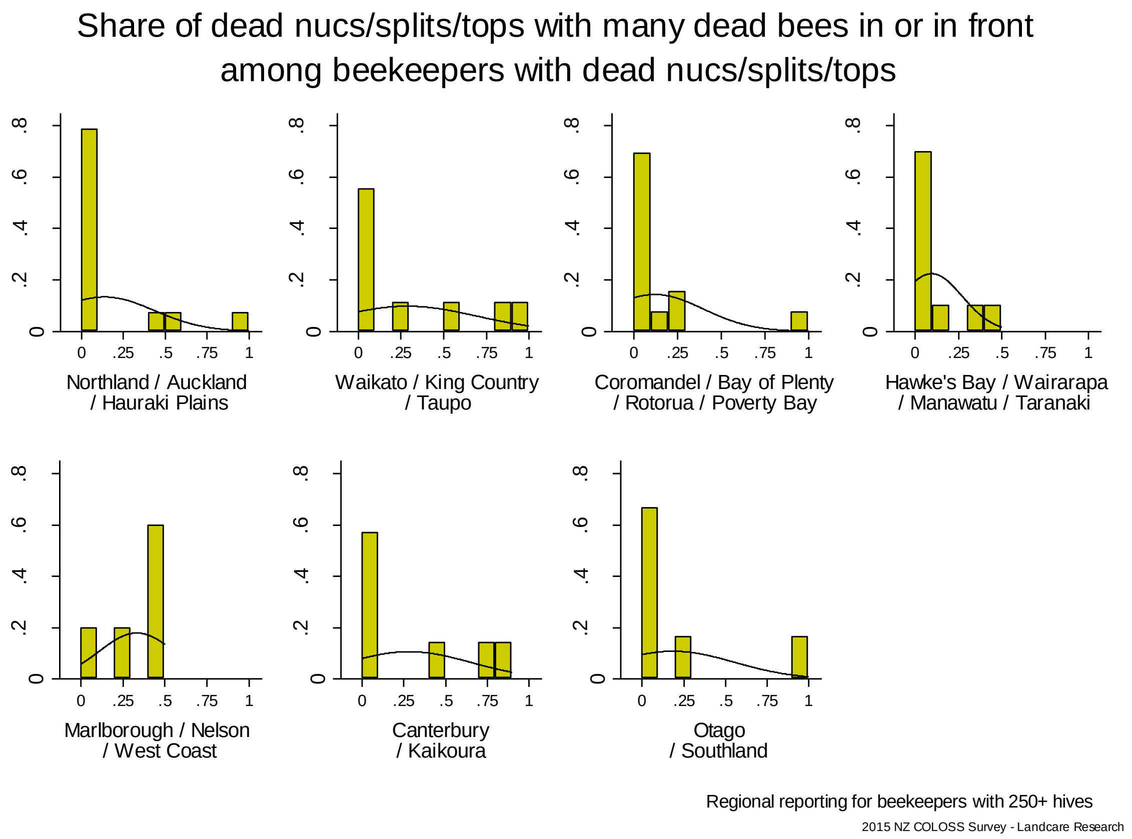

Figure 10. 2 Indicators of Nuc/Split/Top Death: Dead nucs/splits/tops that had many dead bees in or in front of the nucs/splits/tops after winter 2015 based on reports from respondents with > 250 hives, by region.

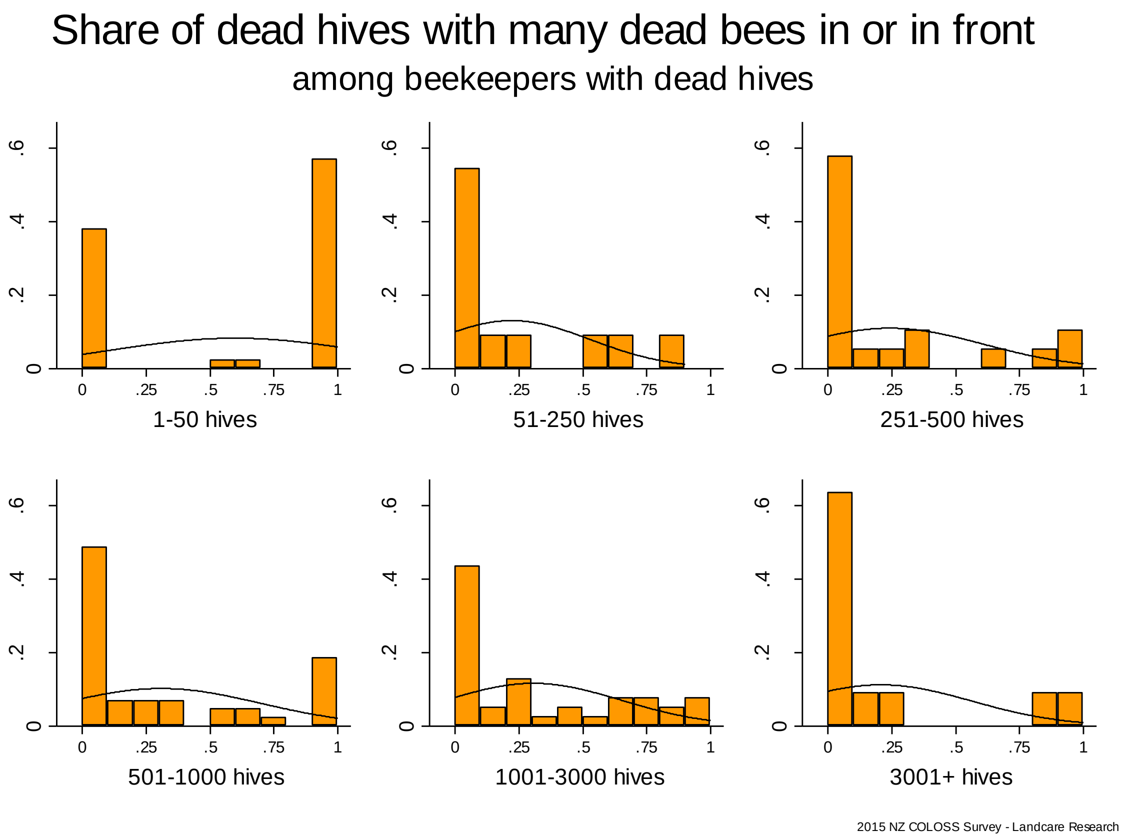

Figure 10. 3 Indicators of Hive Death: Dead hives that had many dead bees in or in front of the hive after winter 2015 based on reports from all respondents, by operation size.

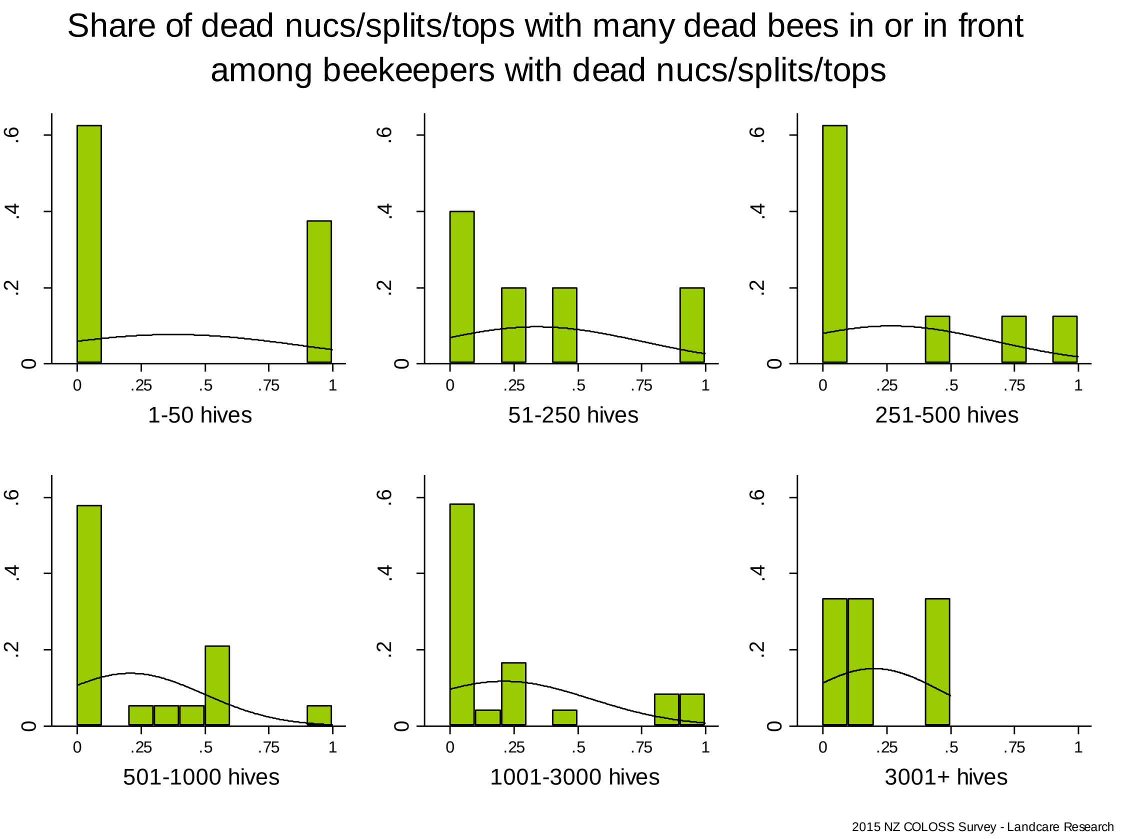

Figure 10. 4 Indicators of Nuc/Split/Top Death: Dead nucs/splits/tops that had many dead bees in or in front of the nucs/splits/tops after winter 2015 based on reports from all respondents, by operation size.

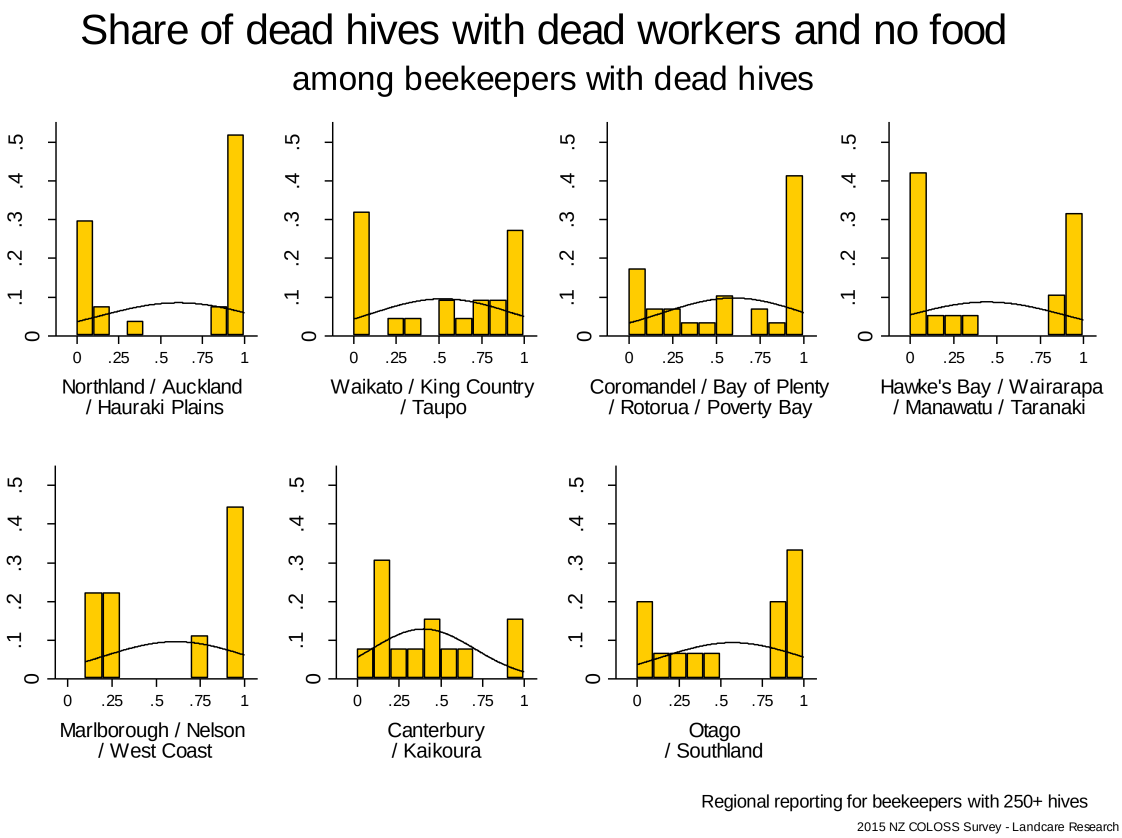

Figure 11. 1 Indicators of Hive Death: Dead workers in cells and no food present after winter 2015 based on reports from respondents with > 250 hives, by region.

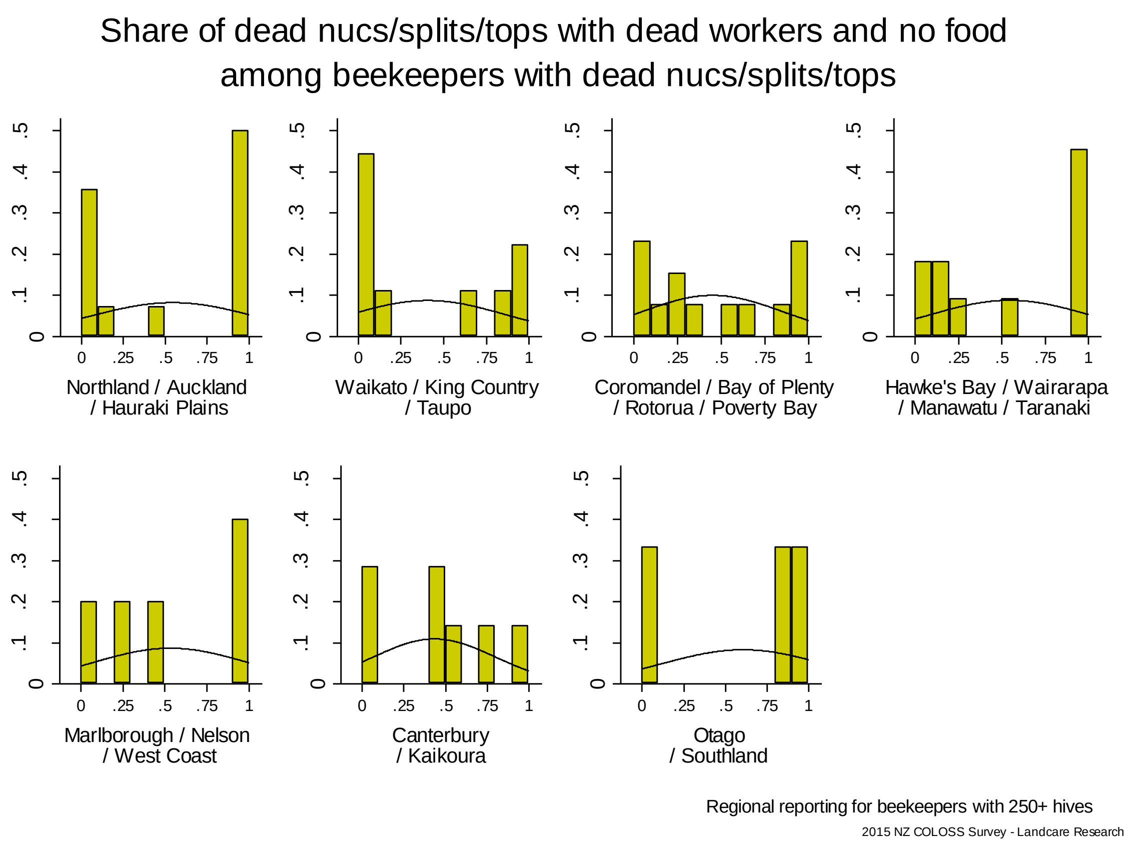

Figure 11. 2 Indicators of Nuc/Split/Top Death: Dead workers in cells and no food present after winter 2015 based on reports from respondents with > 250 hives, by region.

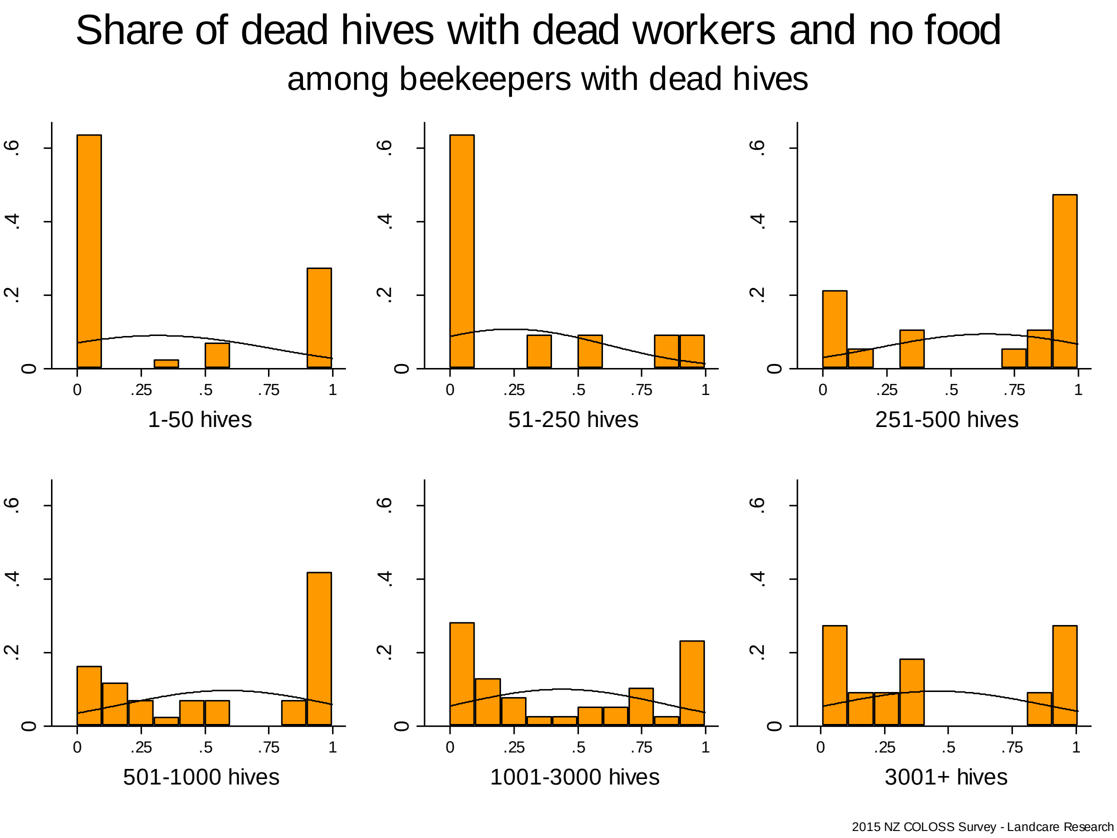

Figure 11. 3 Indicators of Hive Death: Dead workers in cells and no food present after winter 2015 based on reports from all respondents, by operation size.

Figure 11. 4 Indicators of Nuc/Split/Top Death: Dead workers in cells and no food present after winter 2015 based on reports from all respondents, by operation size.

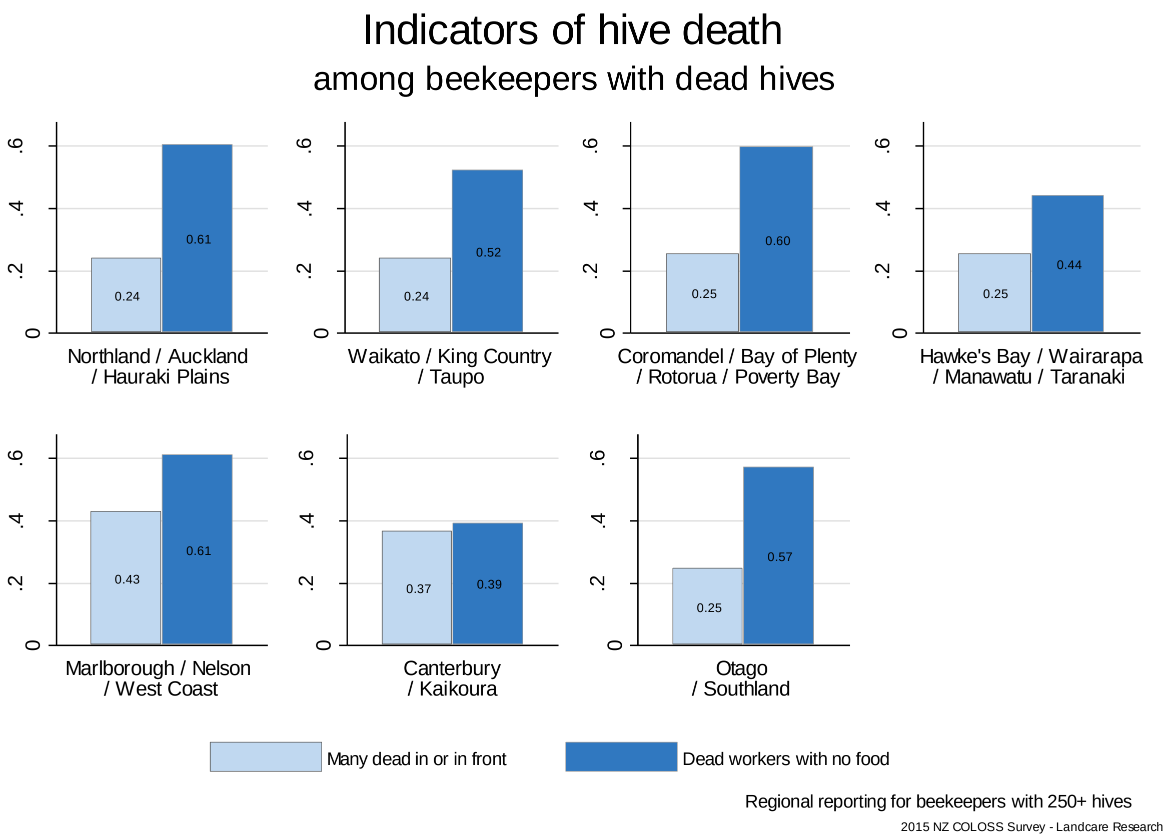

Figure 12. 1 Comparison of Indicators of Hive Death: Indicators of hive deaths based on reports from respondents with > 250 hives who reported hive deaths, by region.

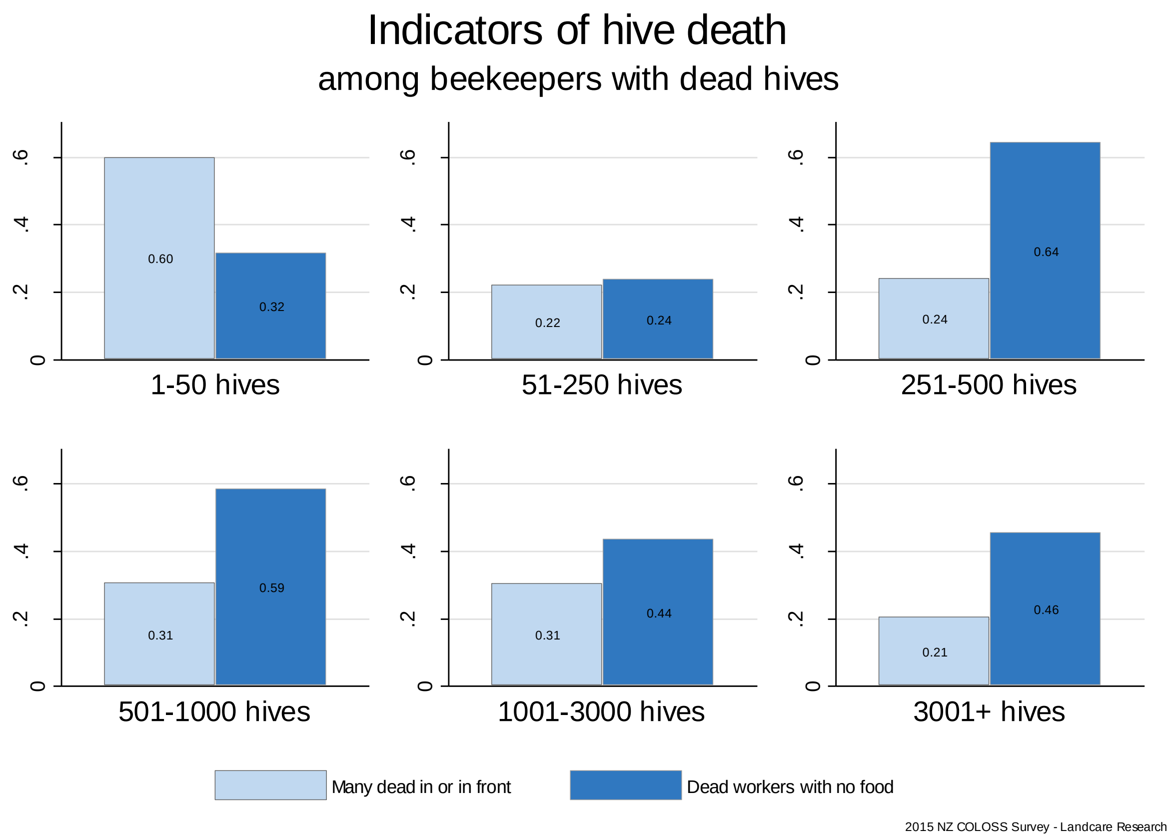

Figure 12. 2 Comparison of Indicators of Nuc/Split/Top Death: Indicators of nuc/split/top deaths based on reports from respondents with > 250 hives who reported nucs/splits/tops deaths, by region.

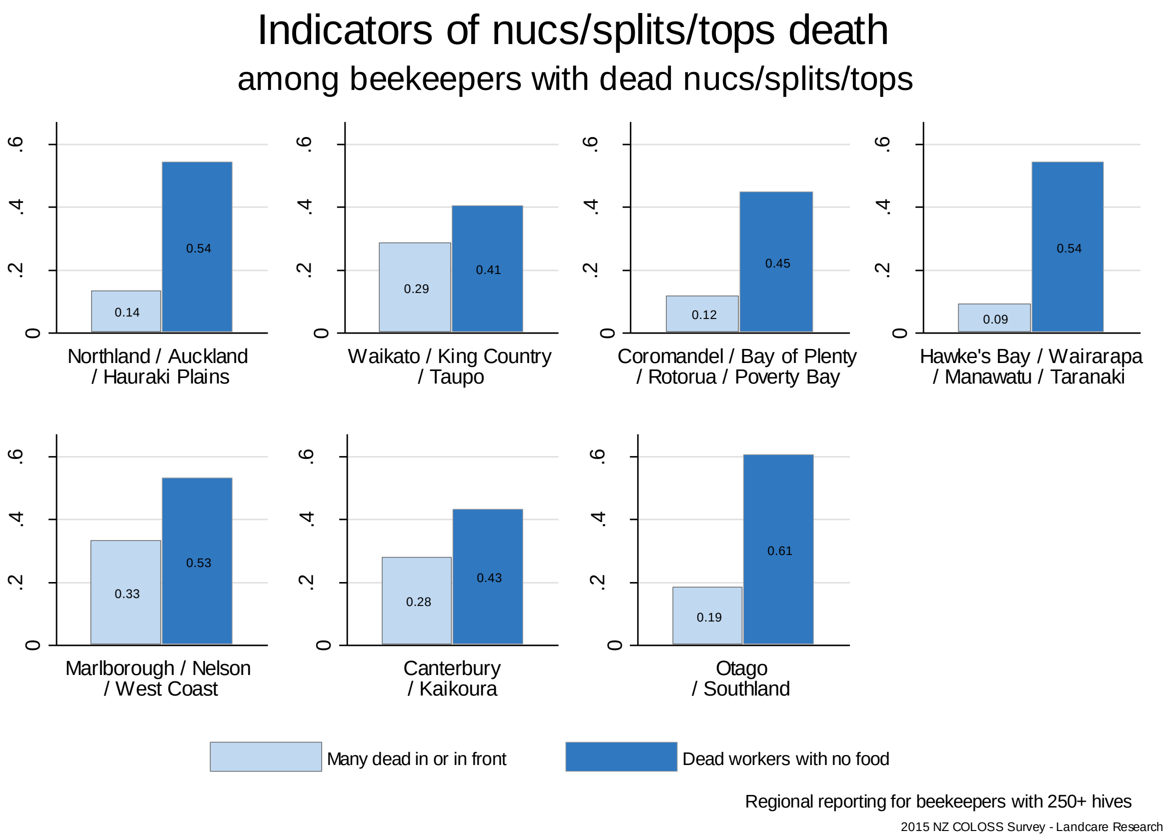

Figure 12. 3 Comparison of Indicators of Hive Death: Indicators of hive deaths based on reports from all respondents who reported hive deaths, by operation size.

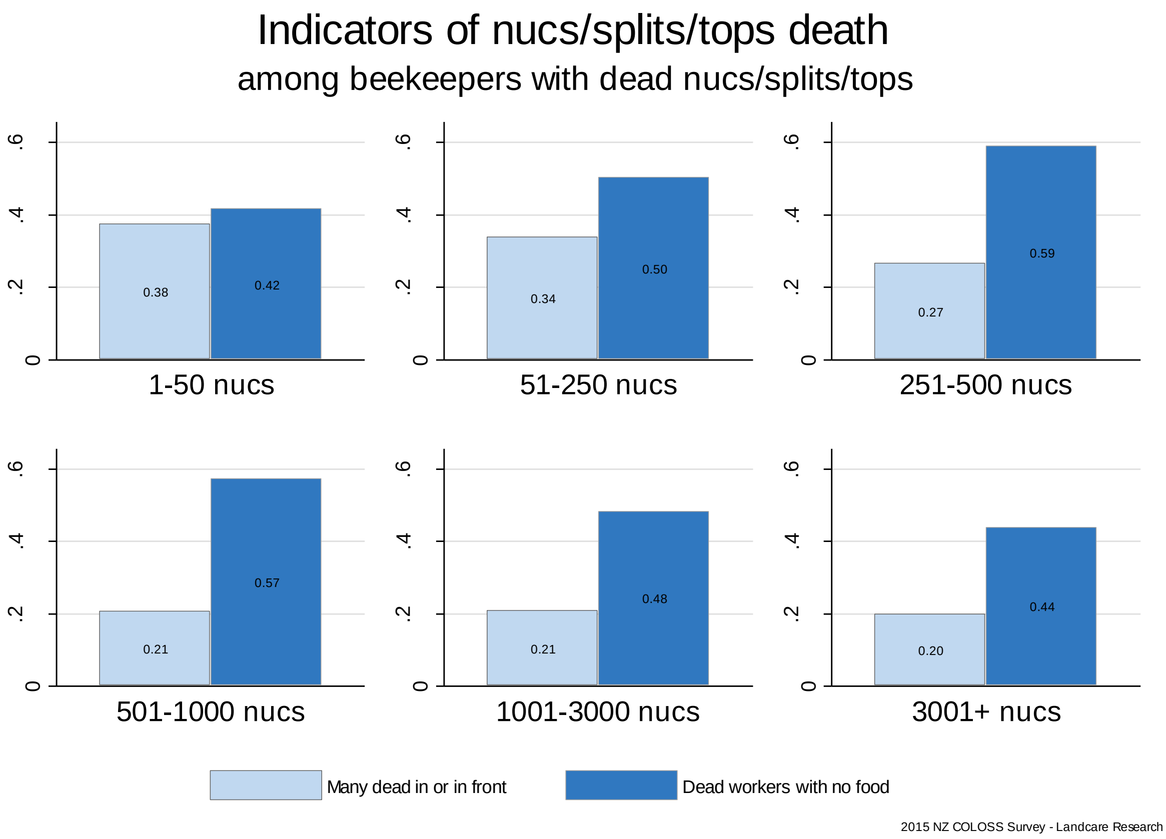

Figure 12. 4 Comparison of Indicators of Nuc/Split/Top Death: Indicators of nuc/split/top deaths based on reports from all respondents who reported nucs/splits/tops deaths, by operation size.

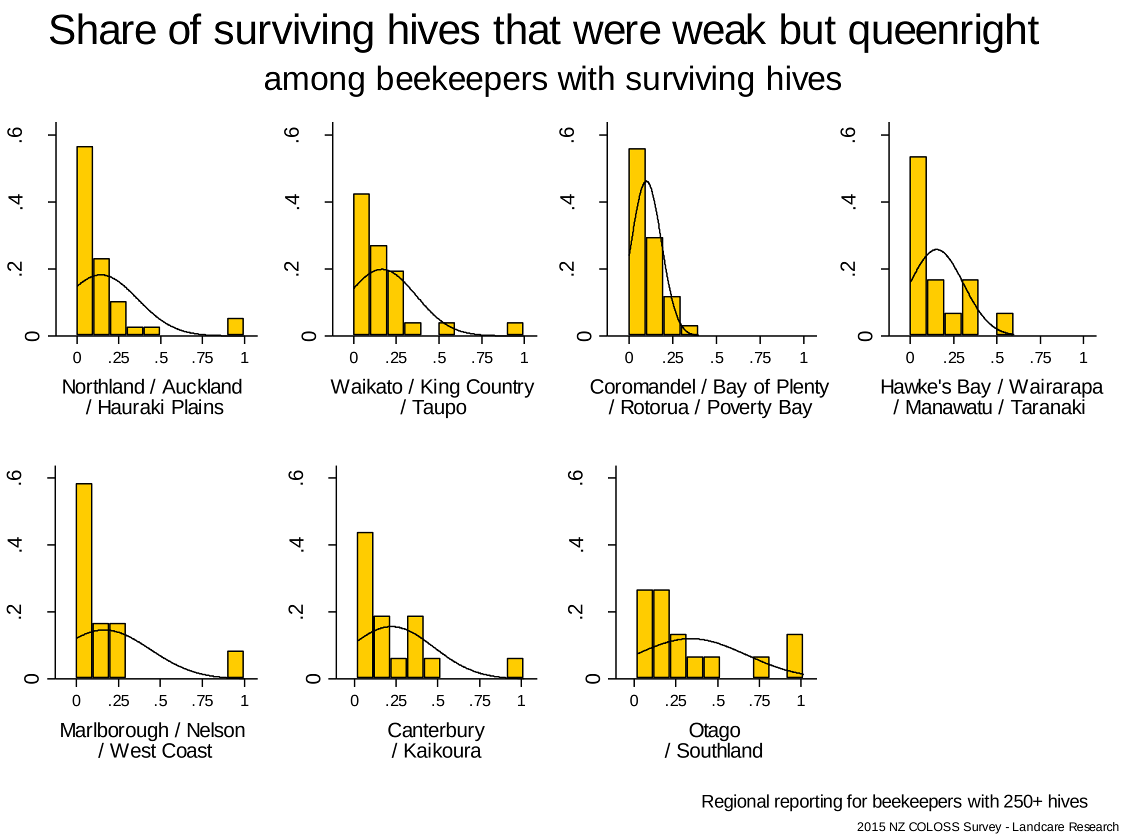

Figure 13. 1 Weak But Queenright Hives: Hives that survived winter 2015 and that were weak but queenright based on reports from respondents with > 250 hives, by region.

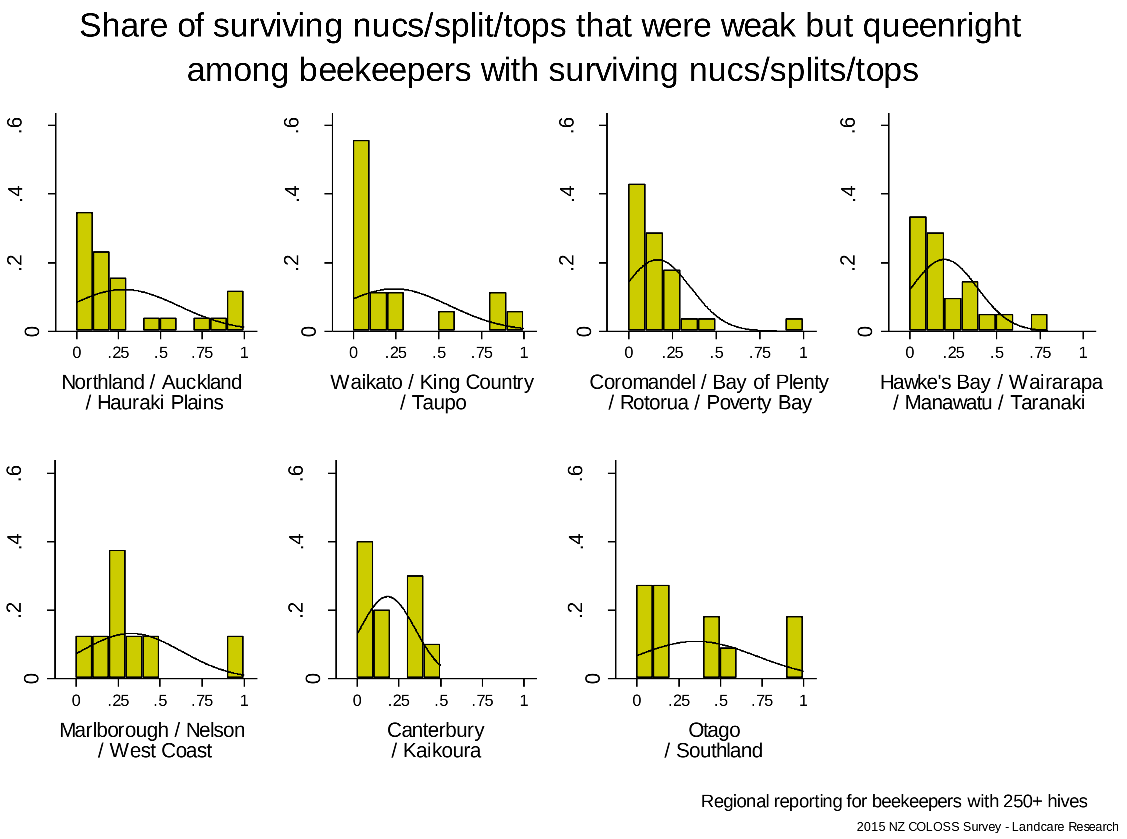

Figure 13. 2 Weak But Queenright Nucs/Splits/Tops: Nucs/splits/tops that that survived winter 2015 and that were weak but queenright based on reports from respondents with > 250 hives, by region.

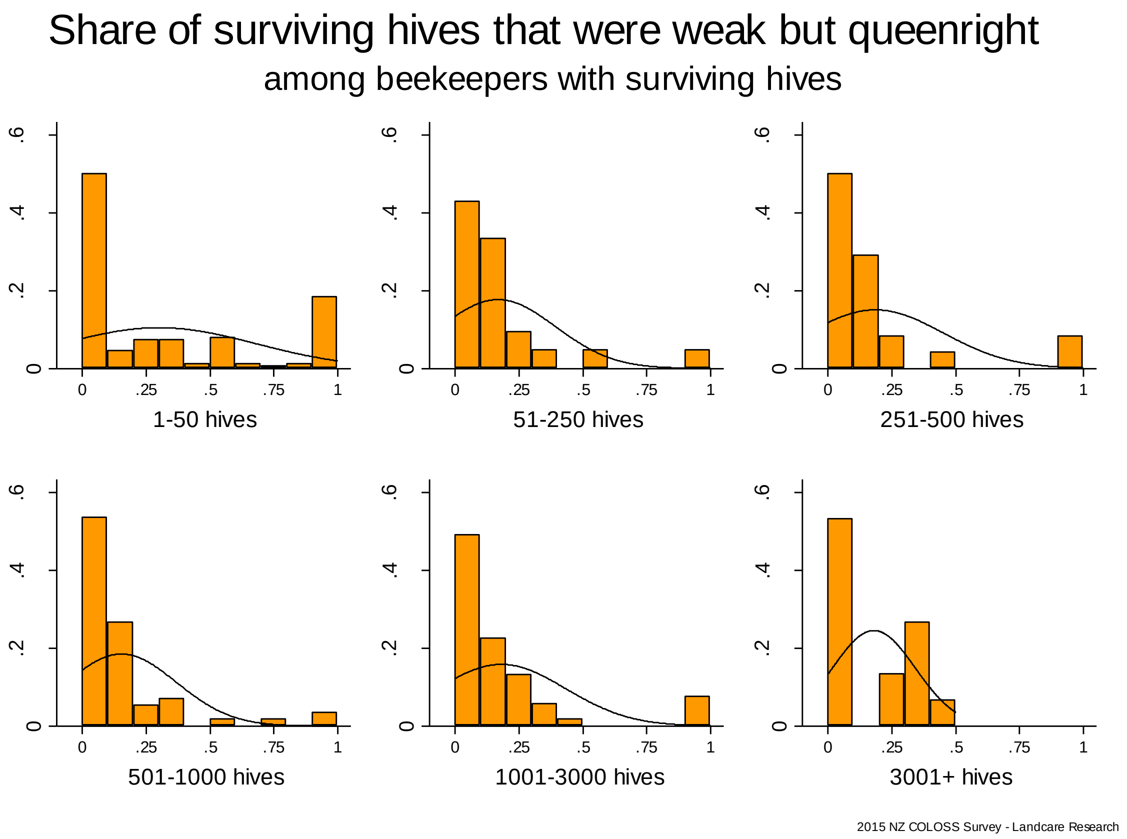

Figure 13. 3 Weak But Queenright Hives: Hives that survived winter 2015 and that were weak but queenright based on reports from all respondents, by operation size.

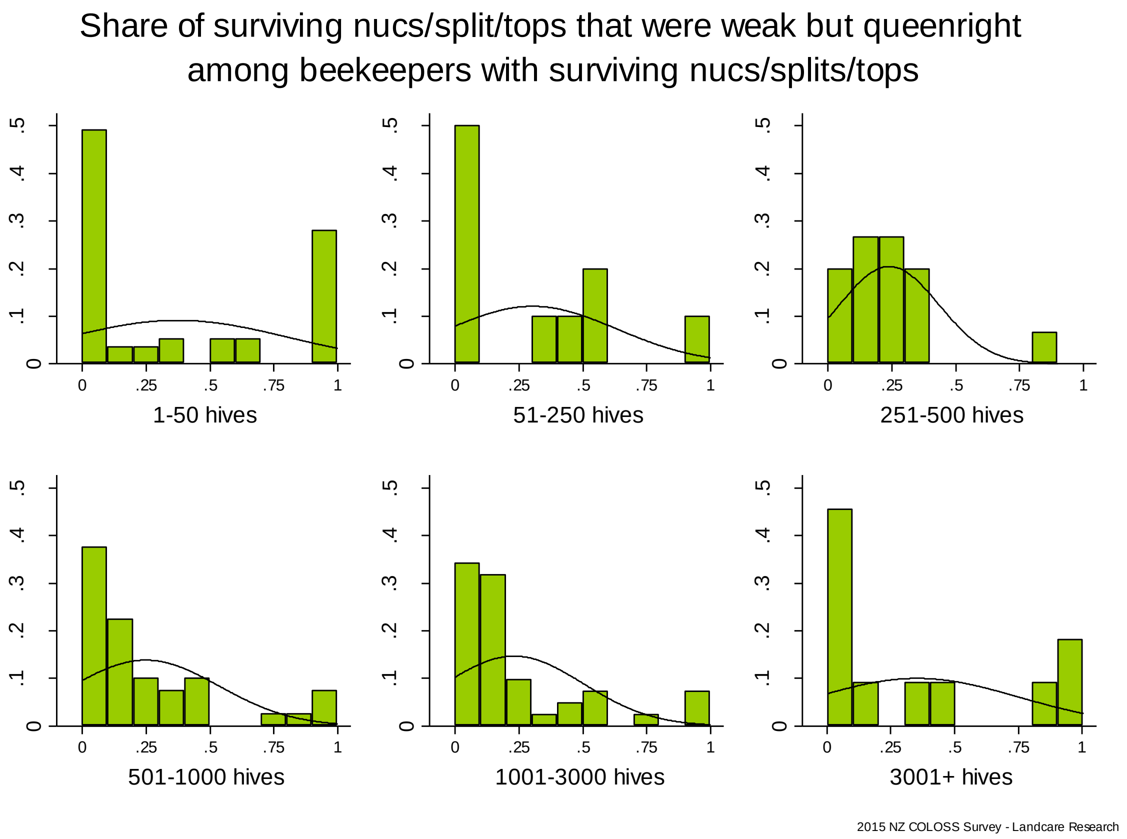

Figure 13. 4 Weak But Queenright Nucs/Splits/Tops: Nucs/splits/tops that survived winter 2015 and that were weak but queenright based on reports from all respondents, by operation size.

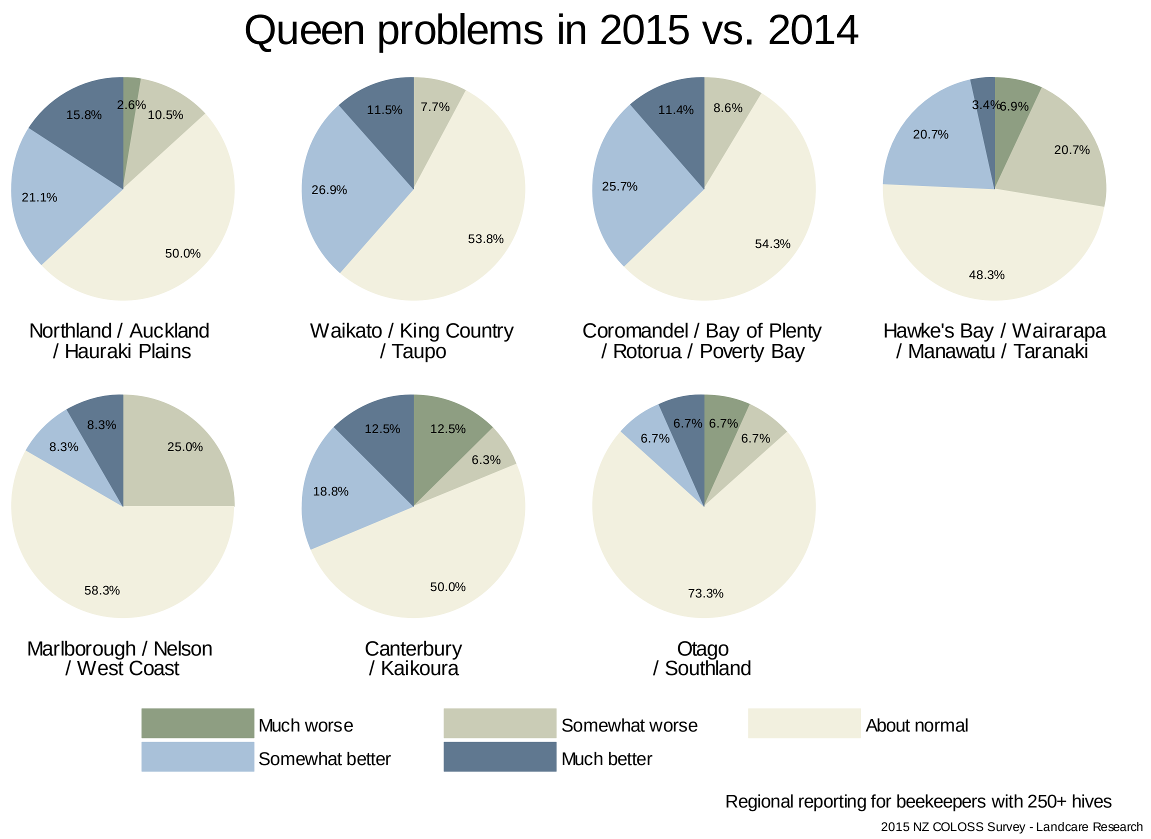

Figure 14. 1 Queen Problems in 2015 Vis-à-Vis 2014: Queen problems in 2015 compared to those in 2014 for respondents with > 250 hives, by region.

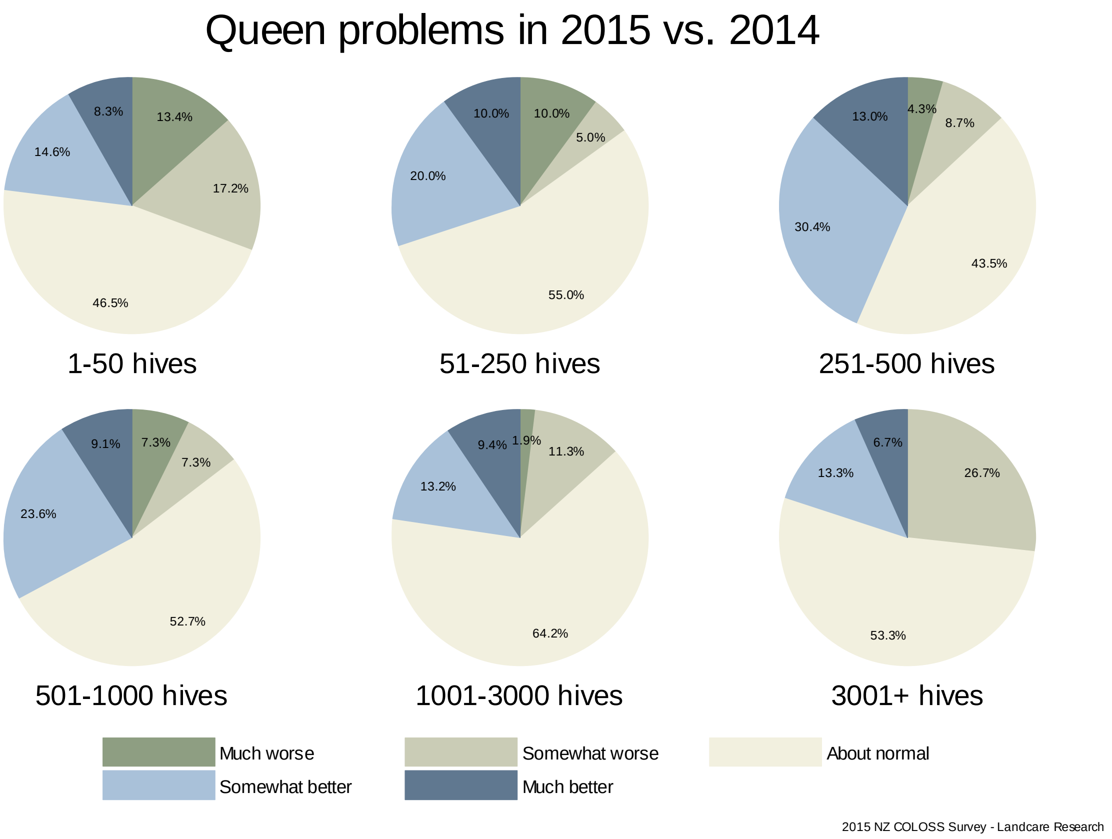

Figure 14. 2 Queen Problems in 2015 Vis-à-Vis 2014:Queen problems in 2015 compared to queen problems in 2014 for all respondents, by operation size.

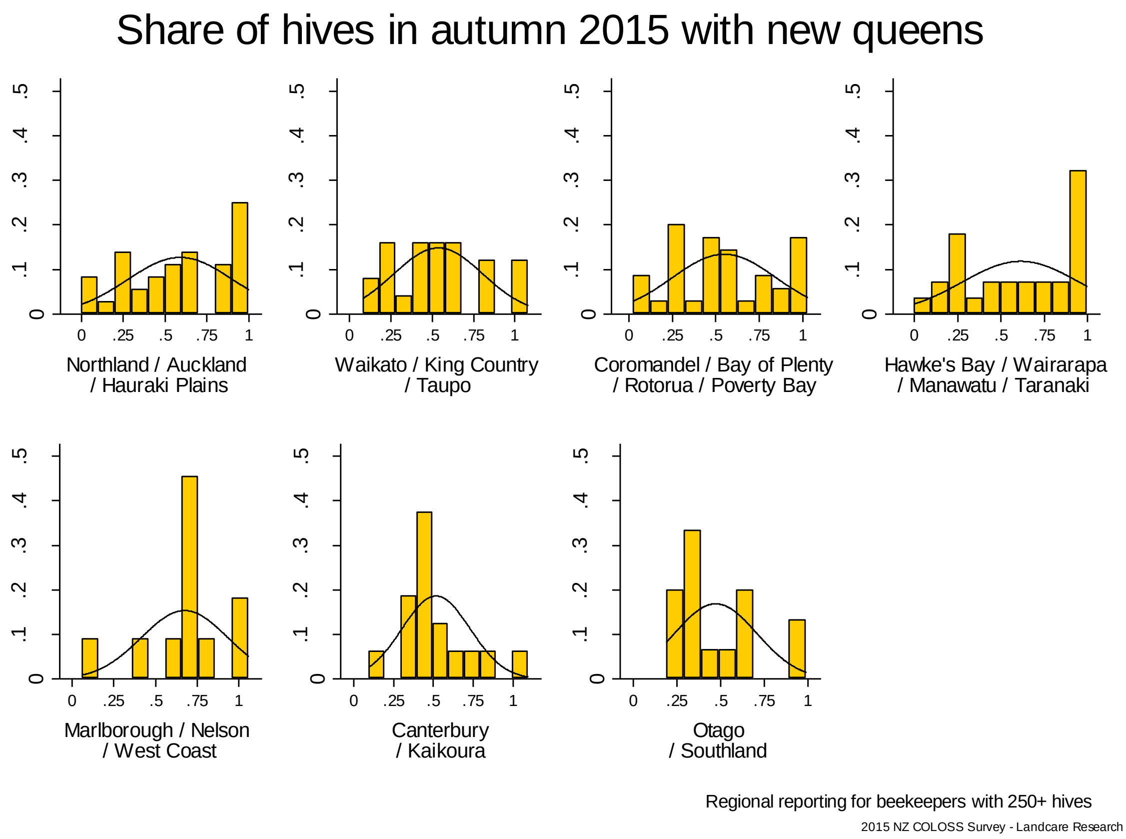

Figure 15. 1 New Queens in Hives: Hives that had new queens in autumn 2015 based on reports from respondents with > 250 hives, by region.

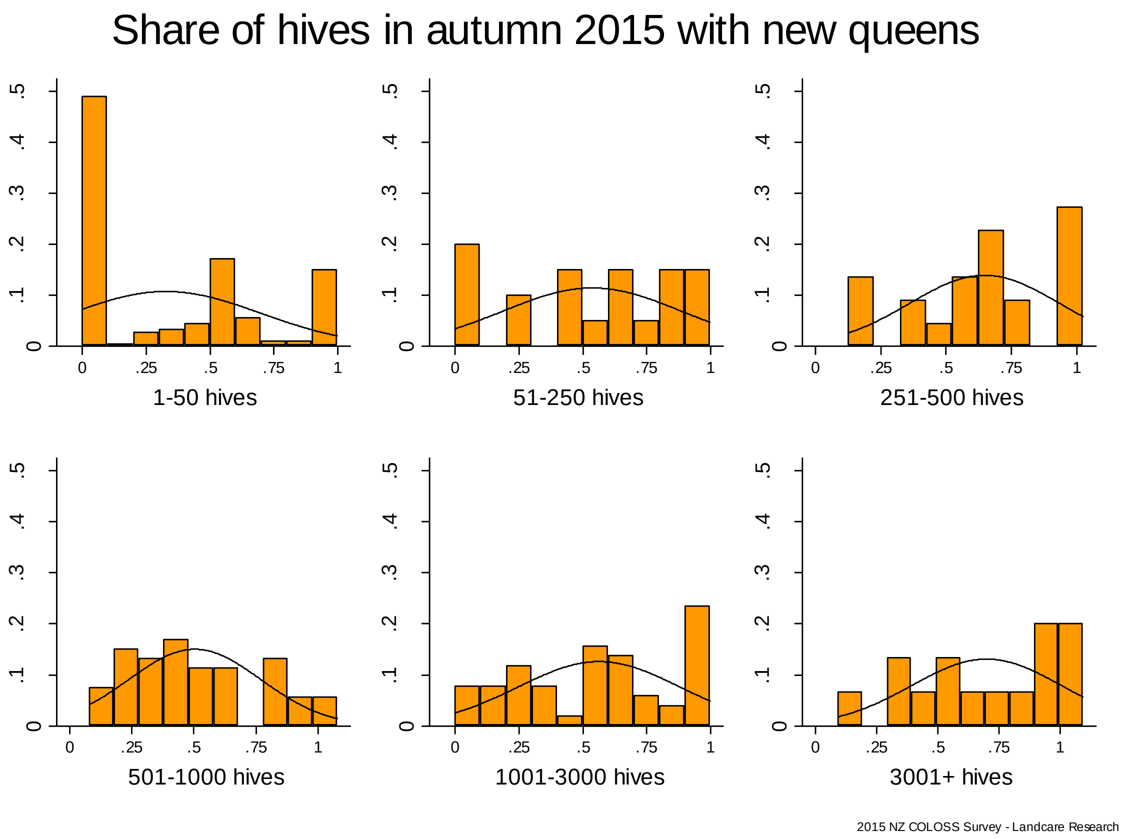

Figure 15. 2 New Queens in Hives: Hives that had new queens in autumn 2015 based on reports from all respondents, by operation size.

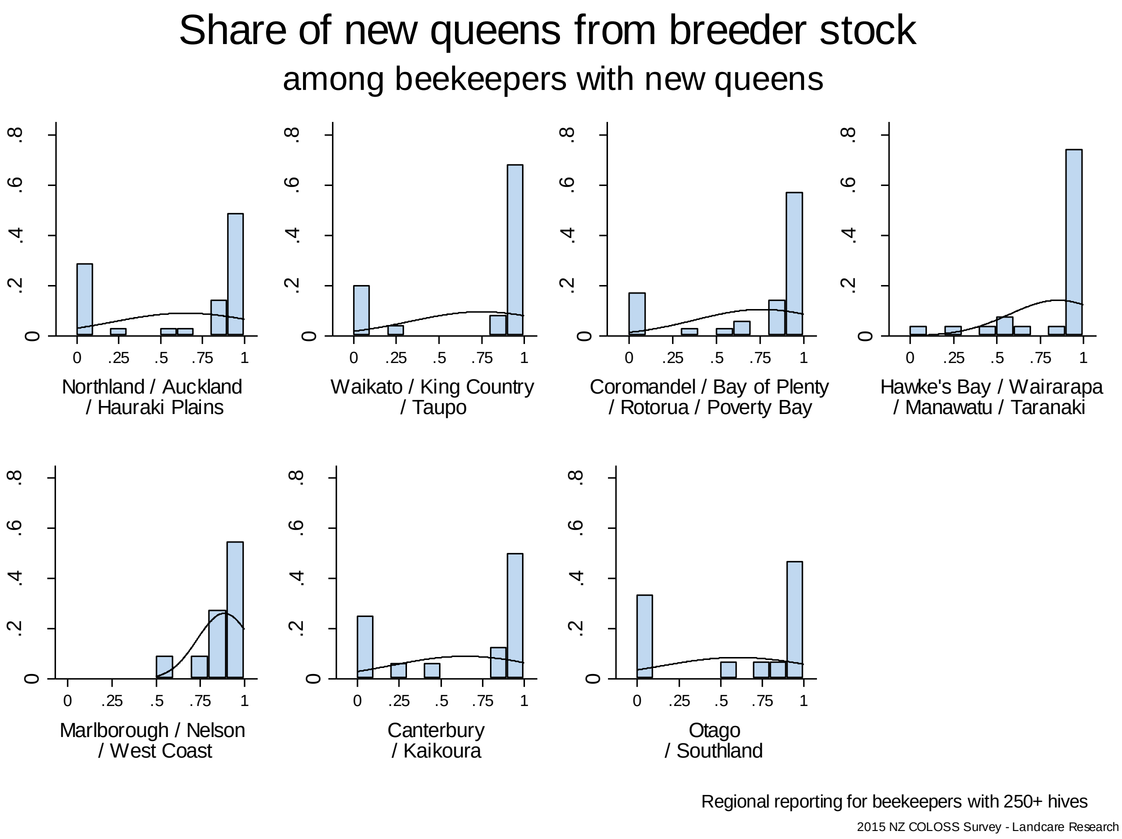

Figure 16. 1 Queens from Breeder Stock: New queens in autumn 2015 that were from queen breeder stock based on reports from respondents with > 250 hives, by region.

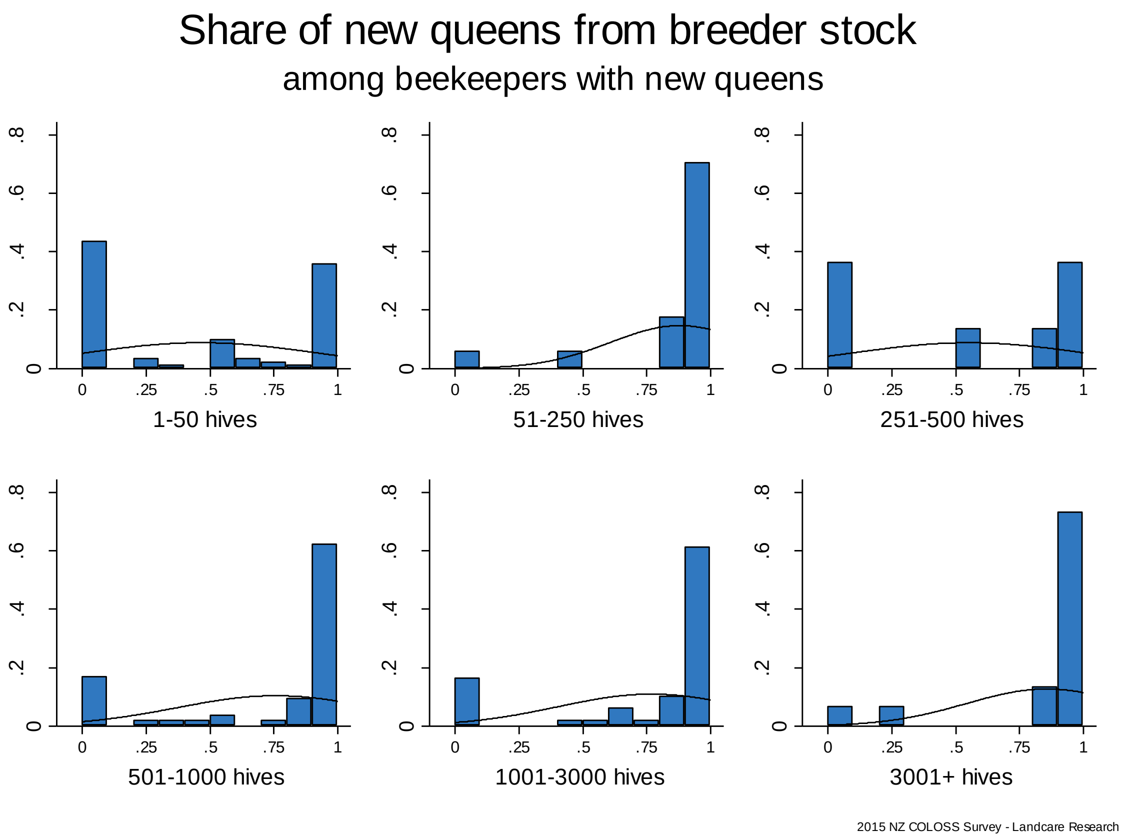

Figure 16. 2 Queens from Breeder Stock: New queens in autumn 2015 that were from queen breeder stock based on reports from all respondents, by operation size.

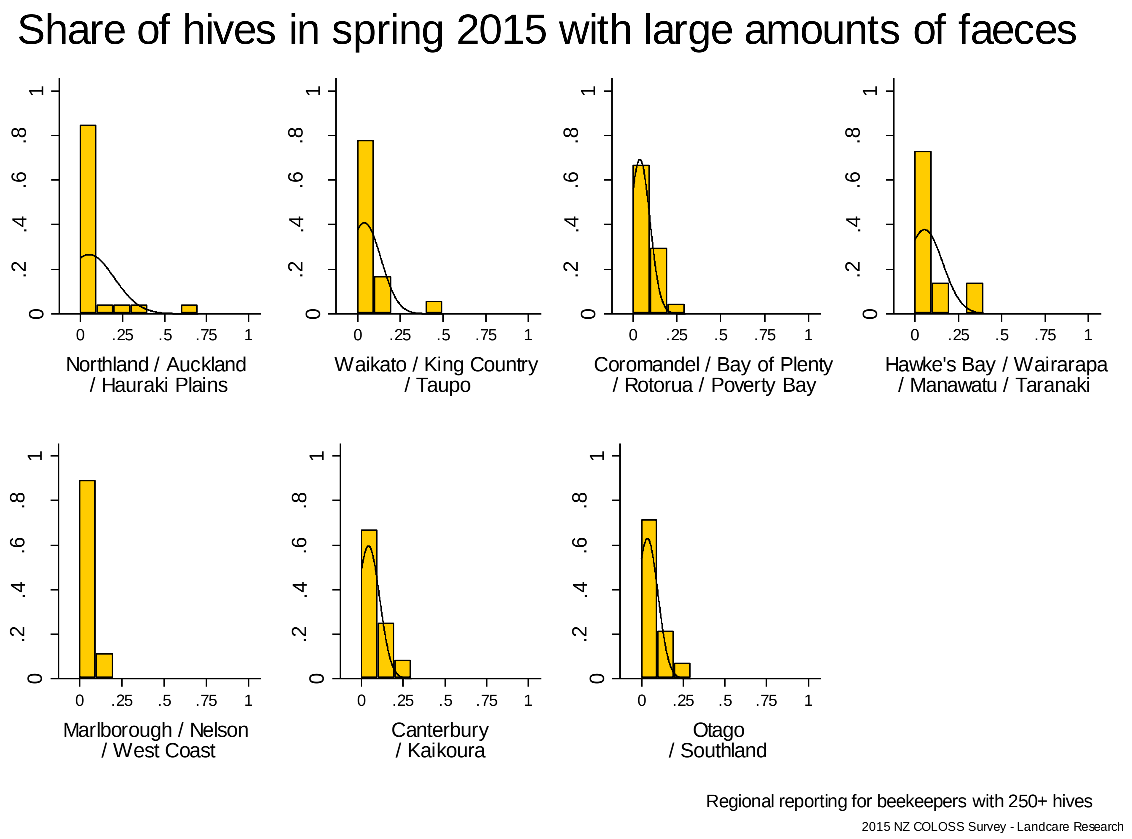

Figure 17. 1 Faeces: Hives that had a large amount of faeces inside when they were first opened in spring 2015 based on reports from respondents with > 250 hives, by region.

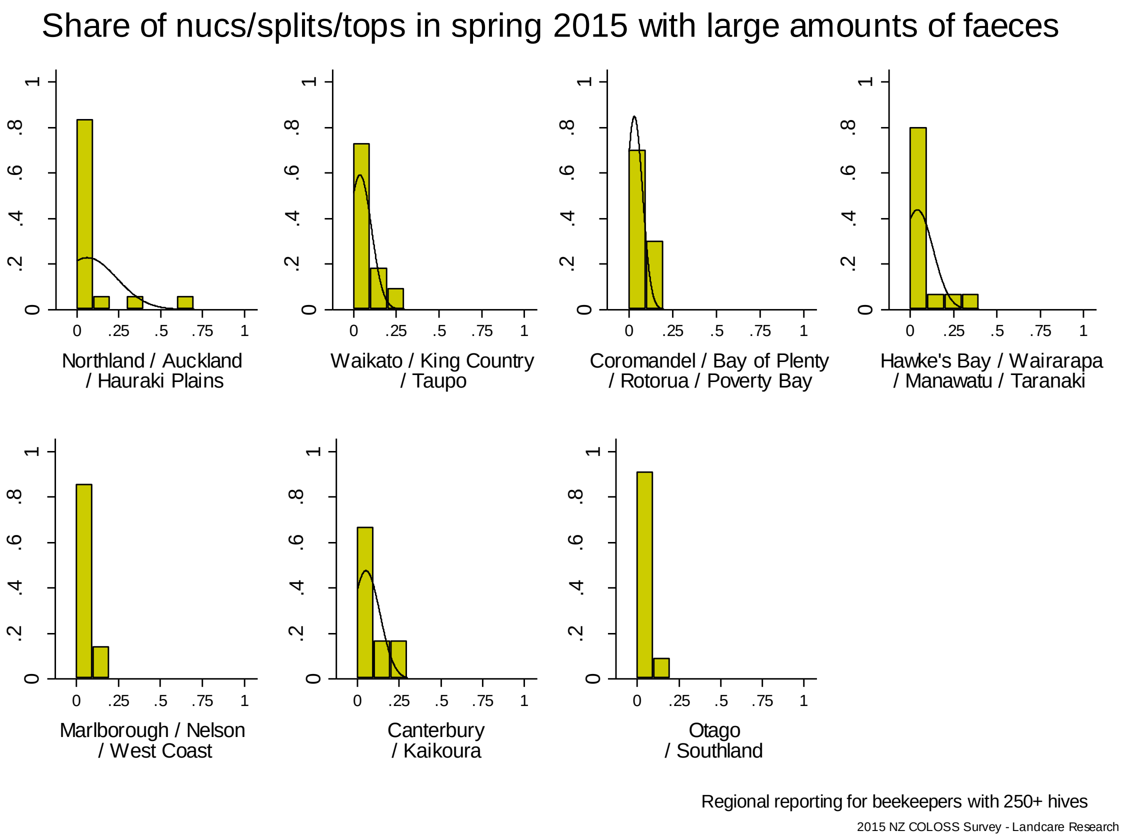

Figure 17. 2 Faeces: Nucs/splits/tops that had a large amount of faeces inside when they were first opened in spring 2015 based on reports from respondents with > 250 hives, by region.

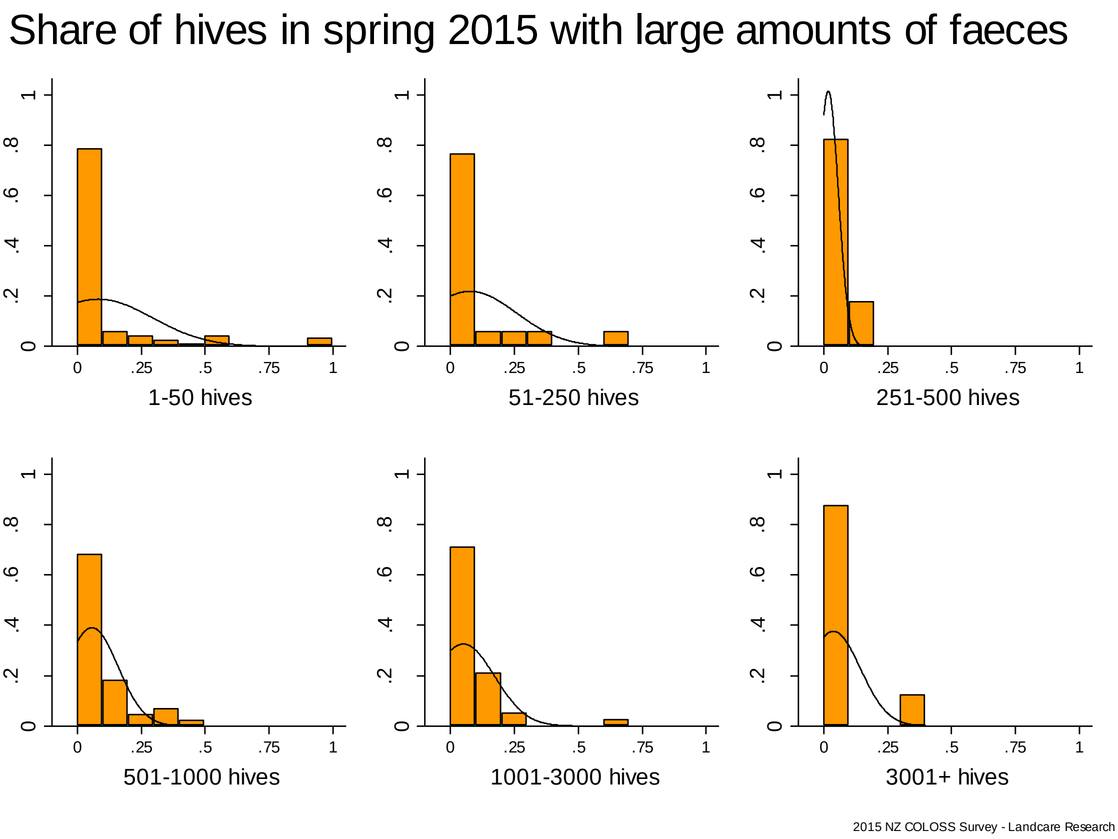

Figure 17. 3 Faeces: Hives that had a large amount of faeces inside hive when they were first opened in spring 2015 based on reports from all respondents, by operation size.

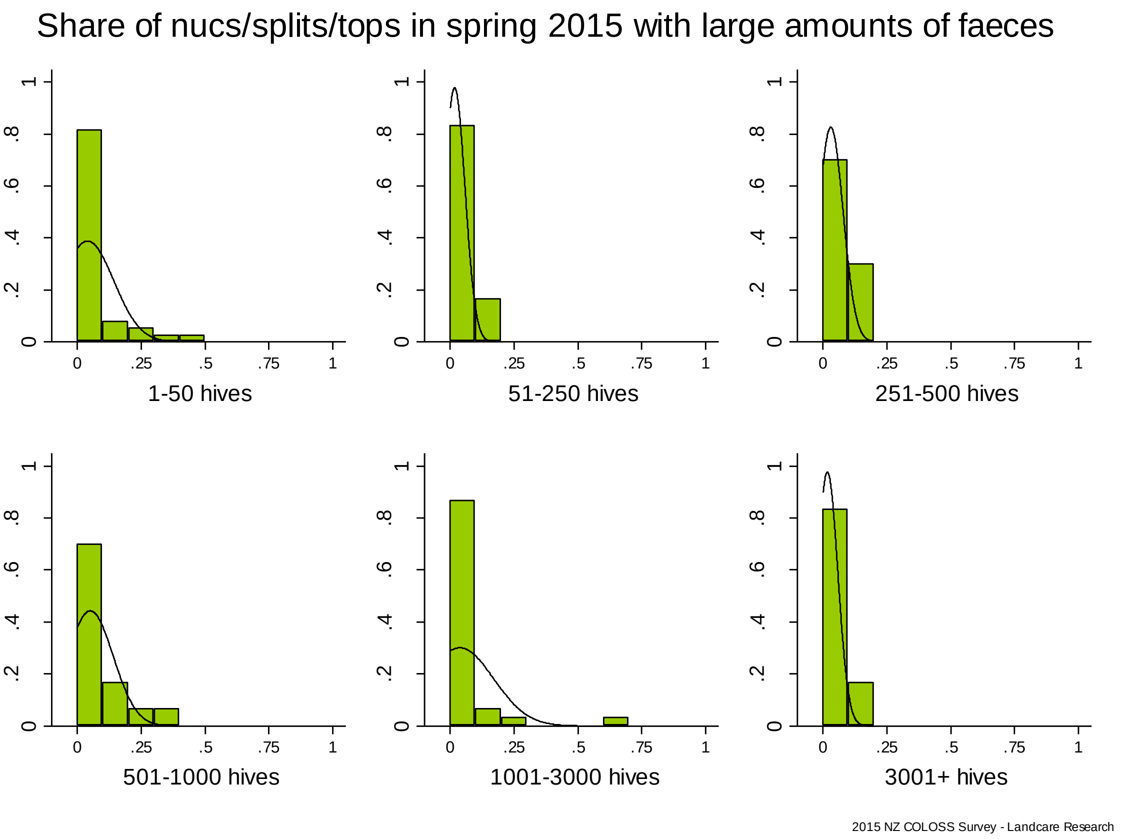

Figure 17. 4 Faeces: Nucs/splits/tops had a large amount of faeces inside when they were first opened in spring 2015 based on reports from all respondents, by operation size.

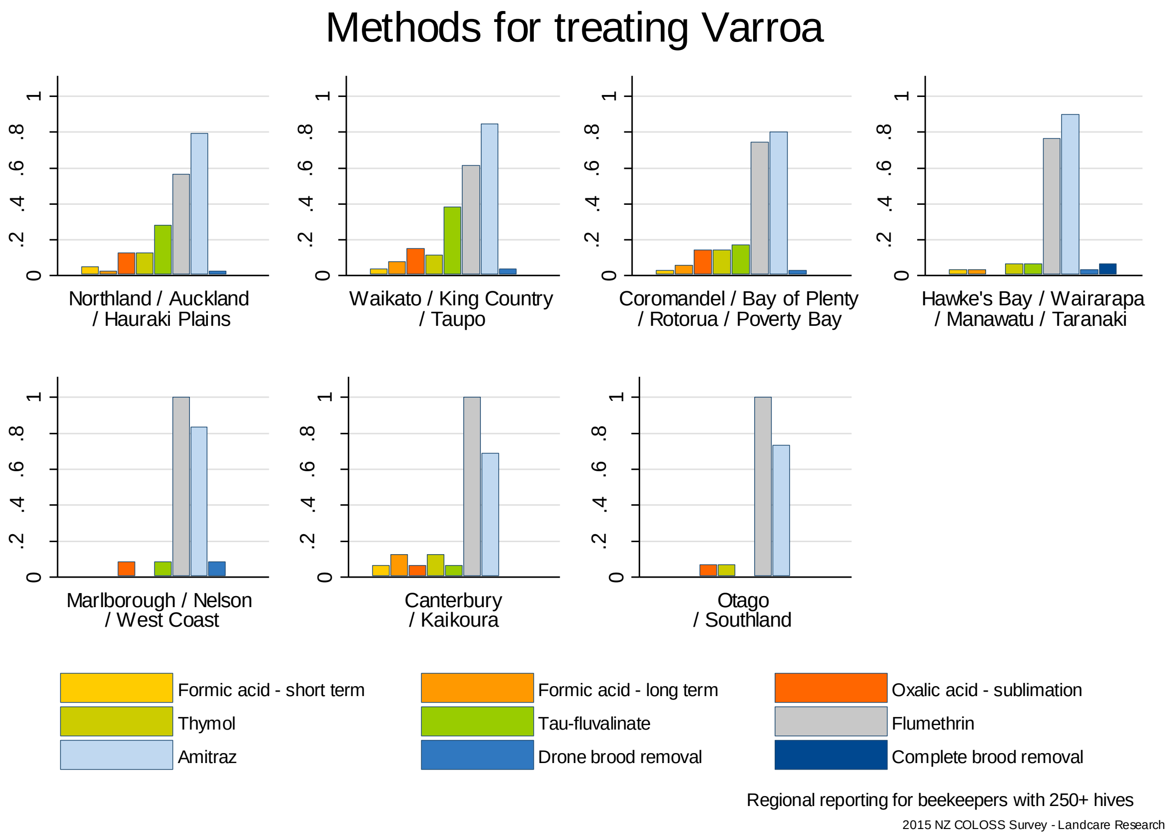

Figure 18. 1 *Varroa* Treatments: Summary of Varroa treatment methods based on reports from respondents with > 250 hives, by region.

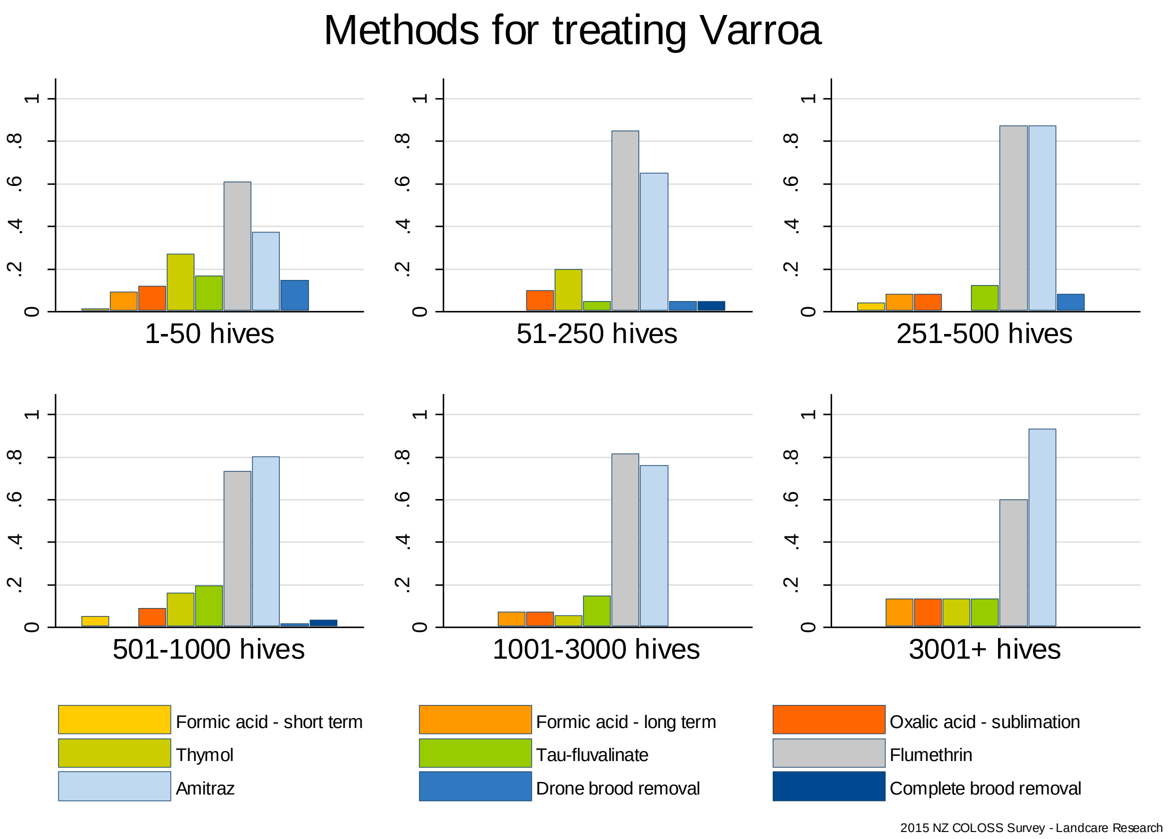

Figure 18. 2 *Varroa* Treatments: Summary of *Varroa* treatment methods based on reports from all respondents, by operation size.

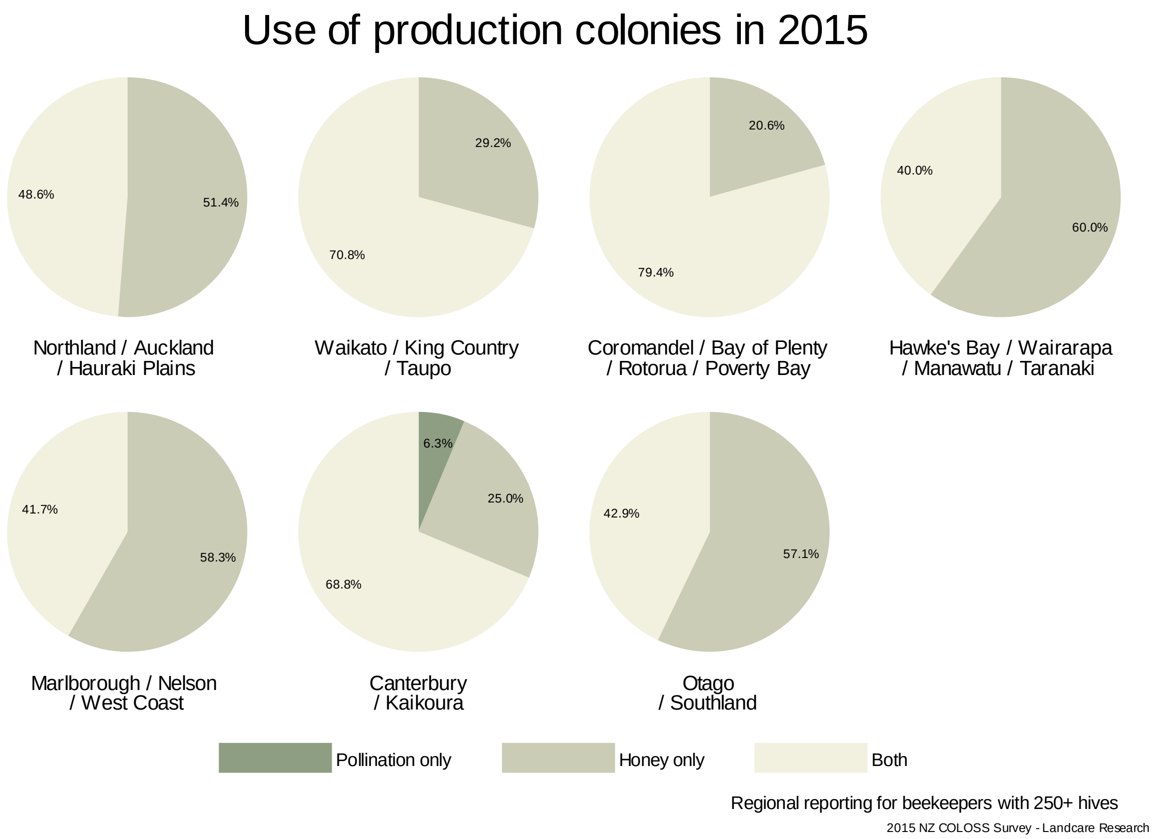

Figure 19. 1 Pollination Services and Honey Harvesting: Use of production colonies in the 2014-2015 season for pollination only, pollination plus honey harvesting, and honey harvesting only based on reports from respondents with > 250 hives, by region.

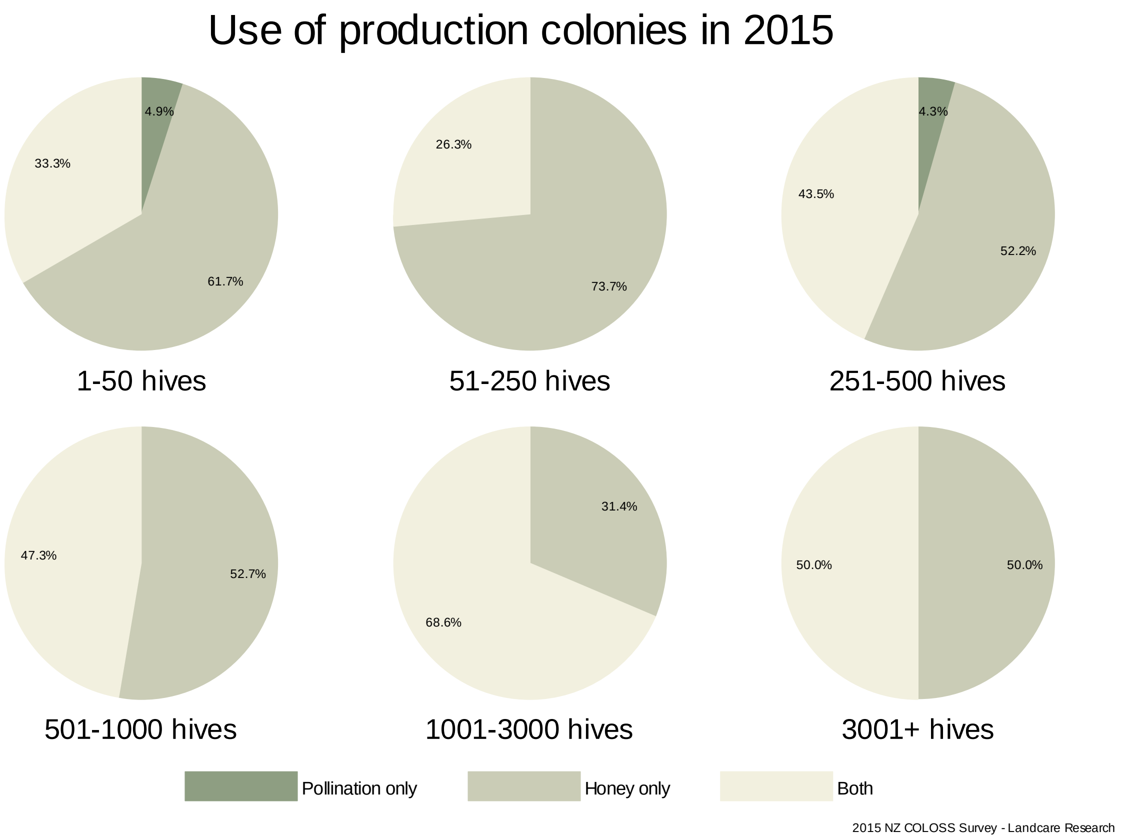

Figure 19. 2 Pollination Services and Honey Harvesting: Use of production colonies in the 2014-2015 season for pollination only, pollination plus honey harvesting, and honey harvesting only based on reports from all respondents.

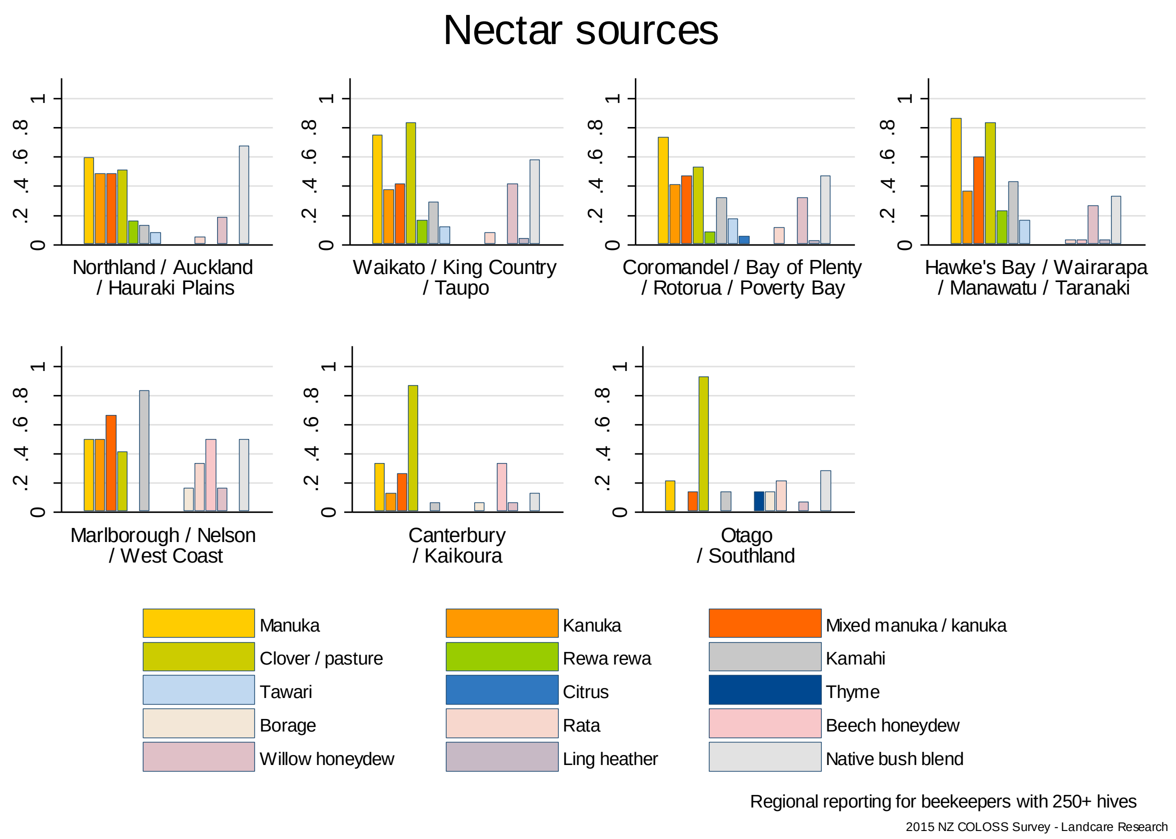

Figure 20. 1 Nectar Flow Sources: Significant sources of nectar flow during the 2014-2015 season based on reports from respondents with > 250 hives, by region.

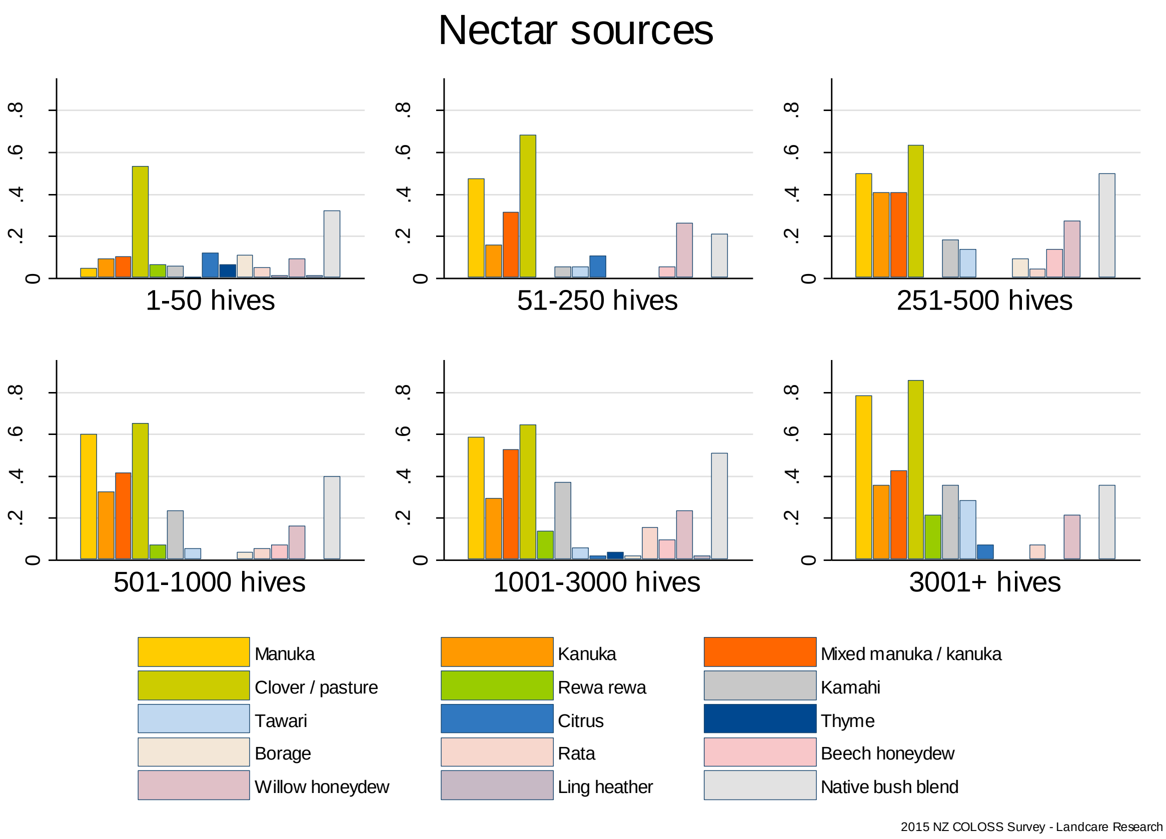

Figure 20. 2 Nectar Flow Sources: Significant sources of nectar flow during the 2014-2015 season based reports from on all respondents, by operation size.

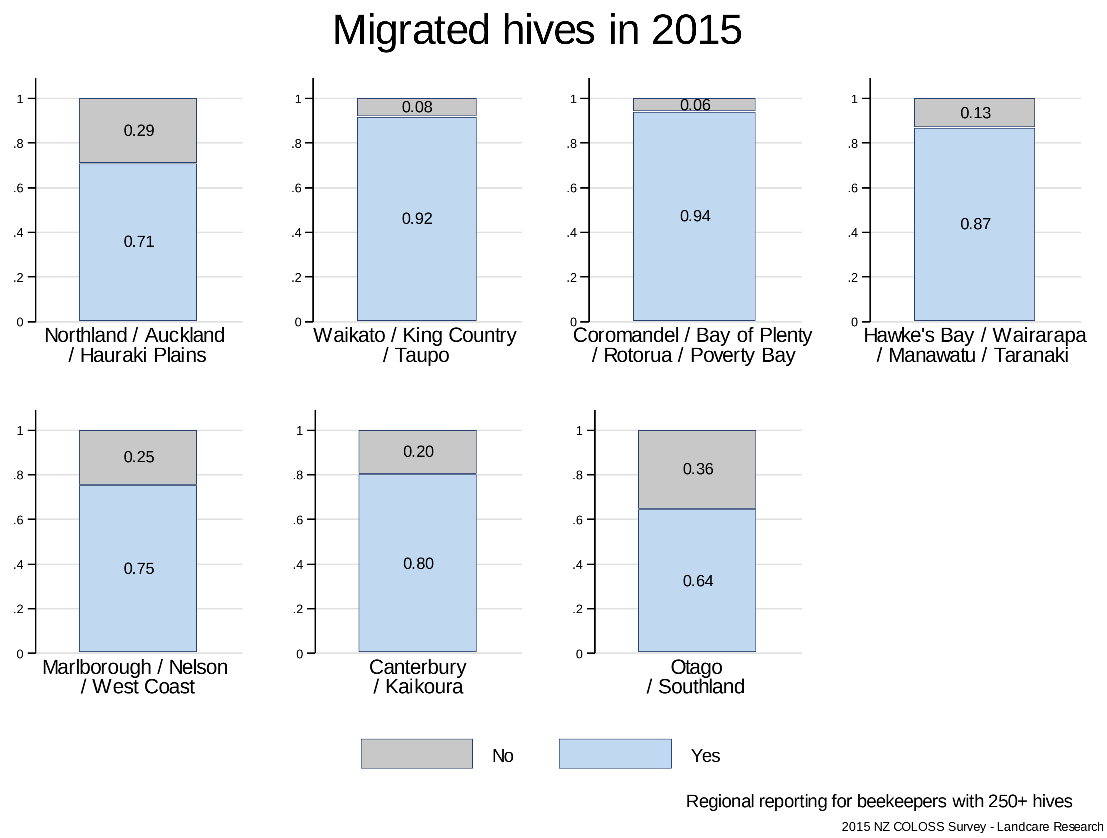

Figure 21. 1 Migratory Hives: Share of respondents that migrated hives at least once during the 2014-2015 season based on reports from respondents with > 250 hives, by region.

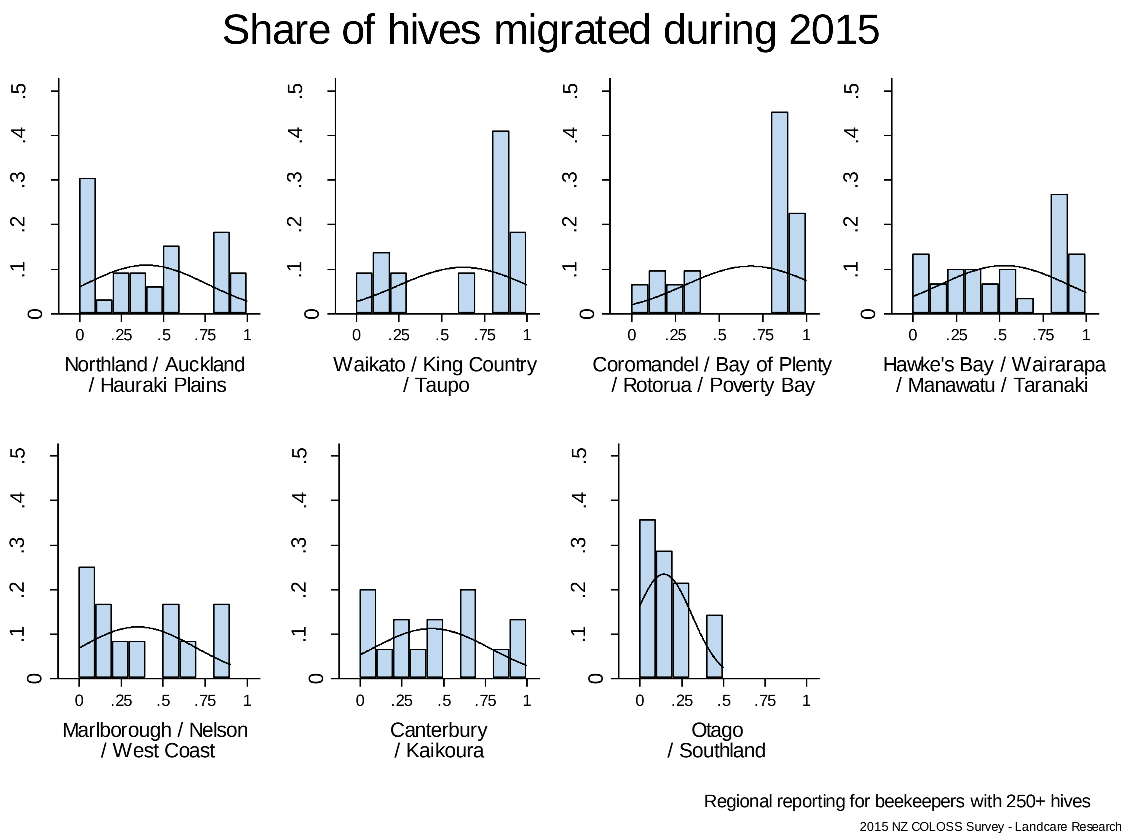

Figure 21. 2 Proportion Migratory Hives: Share of hives that were migrated at least once during the 2014-2015 season based on reports from respondents with > 250 hives that migrated hives, by region.

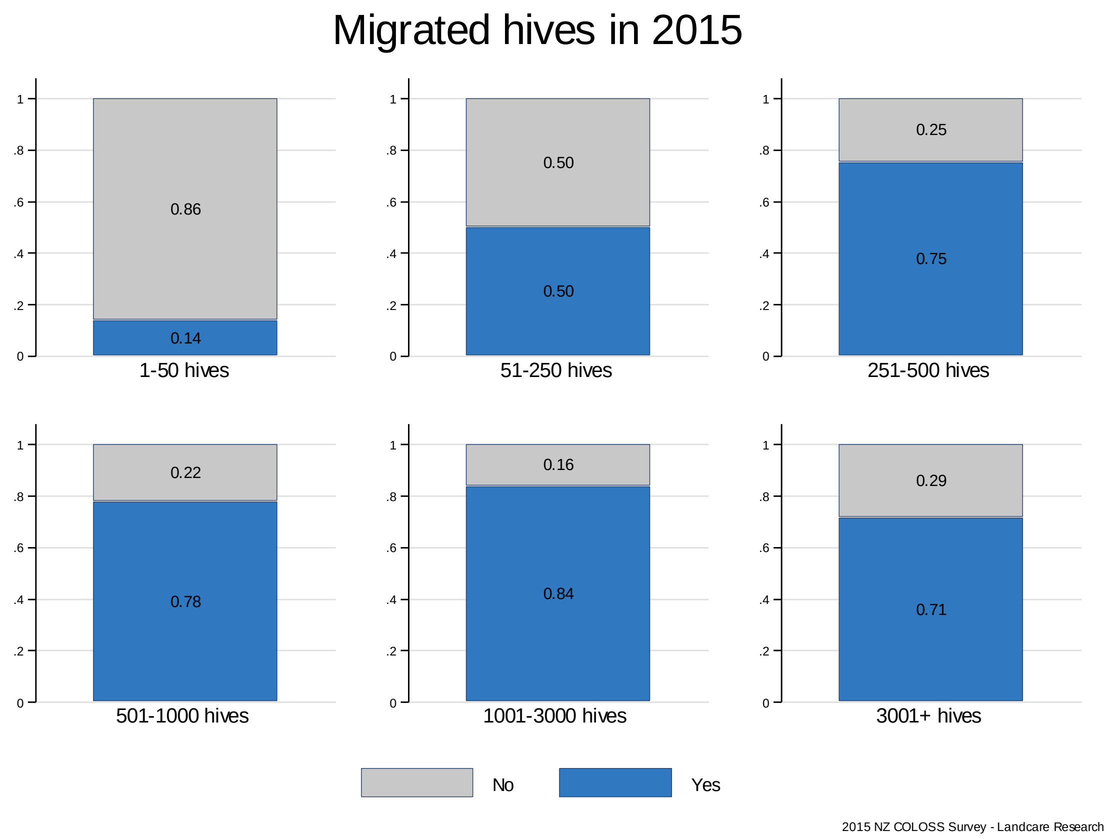

Figure 22. 1 Migratory Hives: Share of respondents who migrated hives at least once during the 2014-2015 season based on reports from all respondents, by operation size.

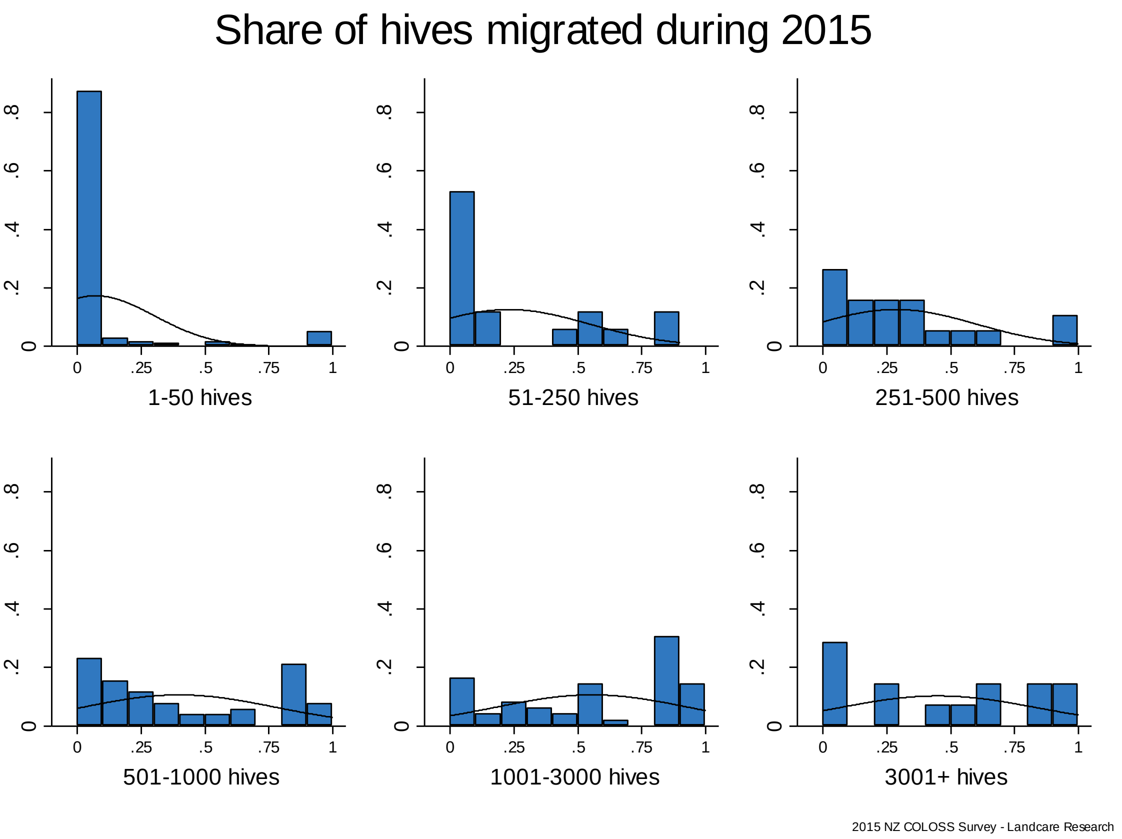

Figure 22. 2 Proportion Migratory Hives: Share of hives that were migrated at least once during the 2014-2015 season based on reports from all respondents that migrated hives, by operation size.

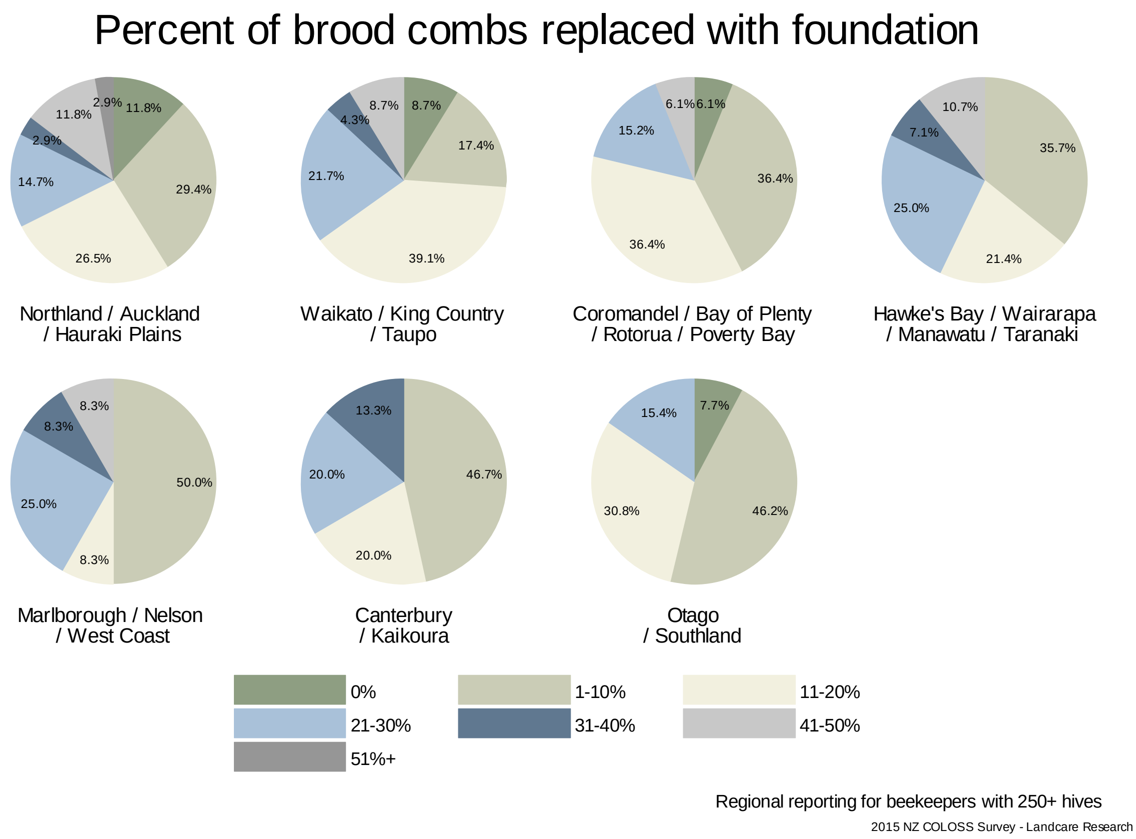

Figure 23. 1 Brood Comb Replacement: Proportion of brood combs replaced by comb foundation (per colony)during the 2014-2015 season based on reports from respondents with > 250 hives, by region.

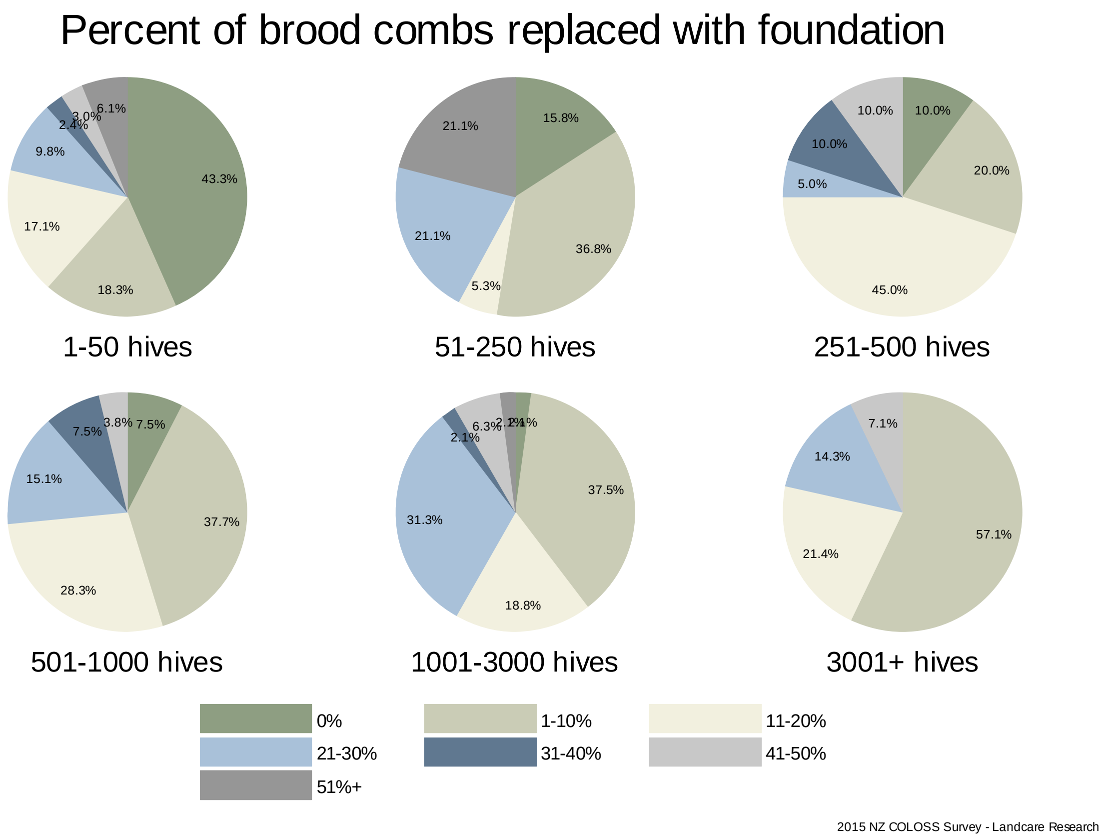

Figure 23. 2 Brood Comb Replacement: Proportion of brood combs replaced by comb foundation (per colony) during the 2014-2015 season based on reports from all respondents, by operation size.

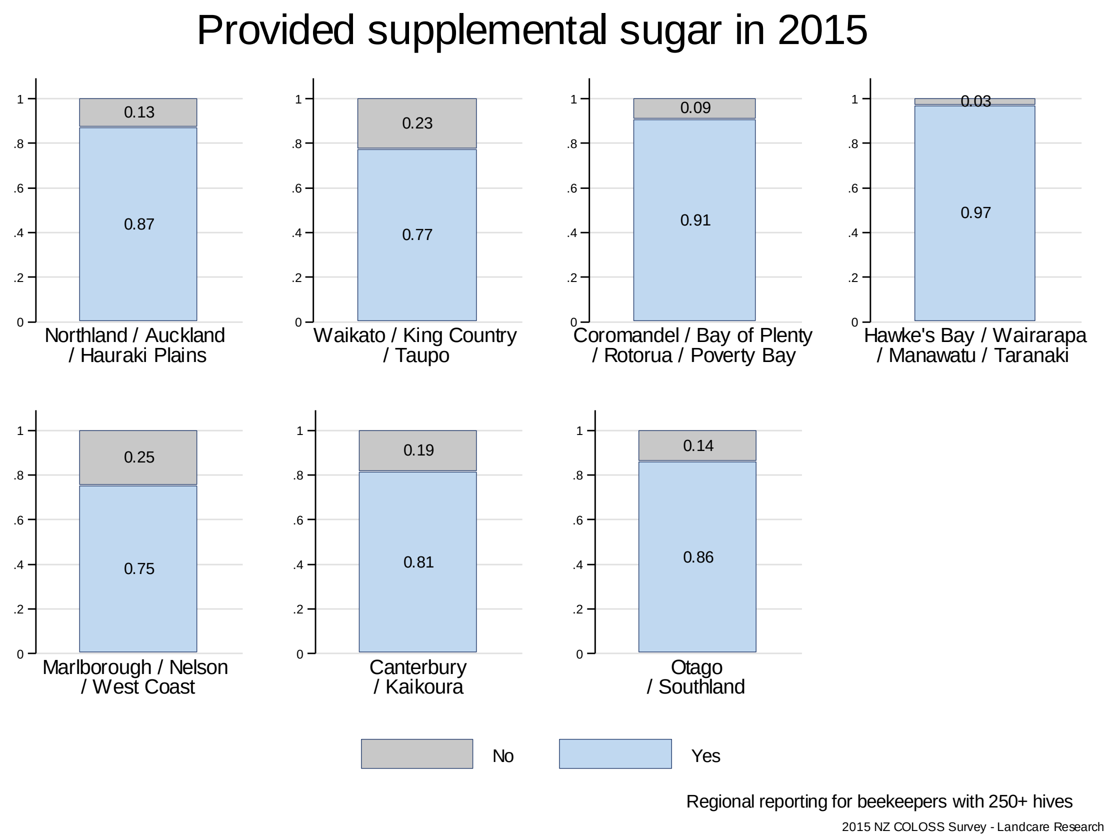

Figure 24. 1 Carbohydrate Feeding: Share of colonies that were provided with supplemental sugar feed to prepare for winter 2015 based on reports from respondents with > 250 hives, by region.

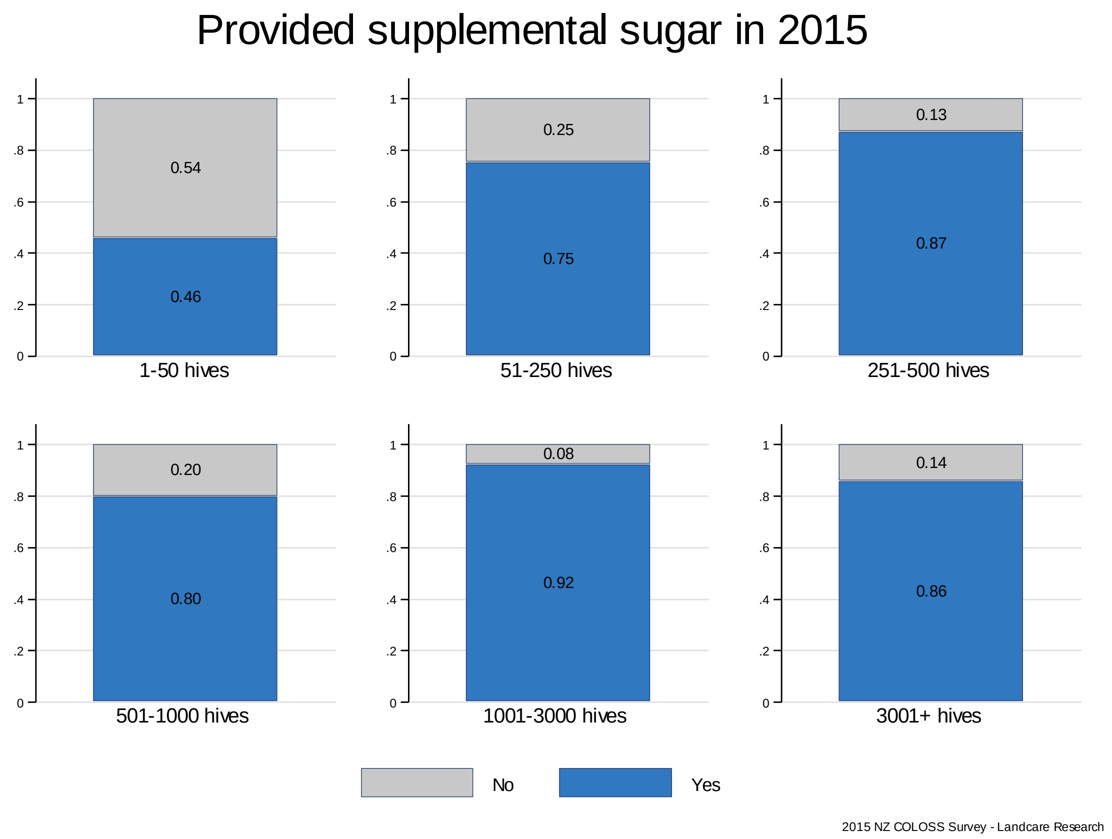

Figure 24. 2 Carbohydrate Feeding: Share of production colonies that were provided with supplemental sugar feed to prepare for winter 2015 based on reports from all respondents, by operation size.

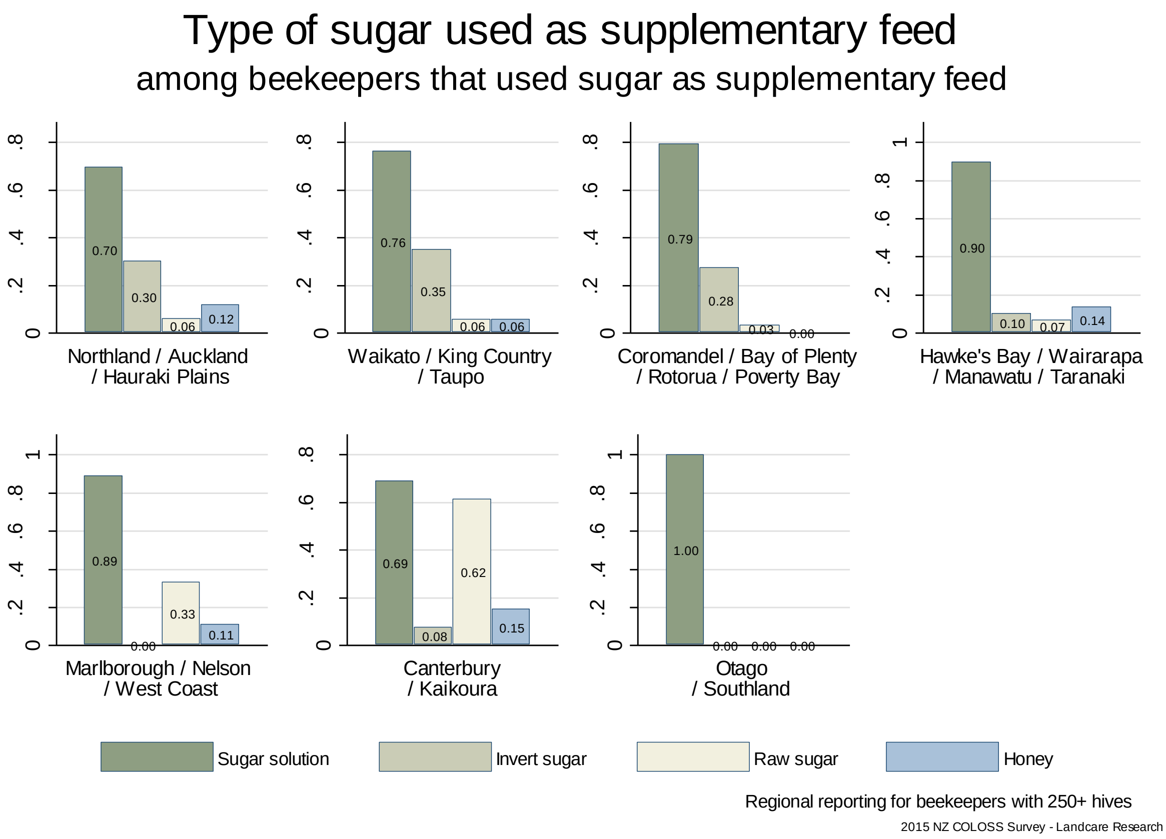

Figure 25. 1 Types of Carbohydrate Feed: Types of supplemental sugar feed provided to production colonies during the 2014-2015 season based on reports from respondents with > 250 hives, by region.

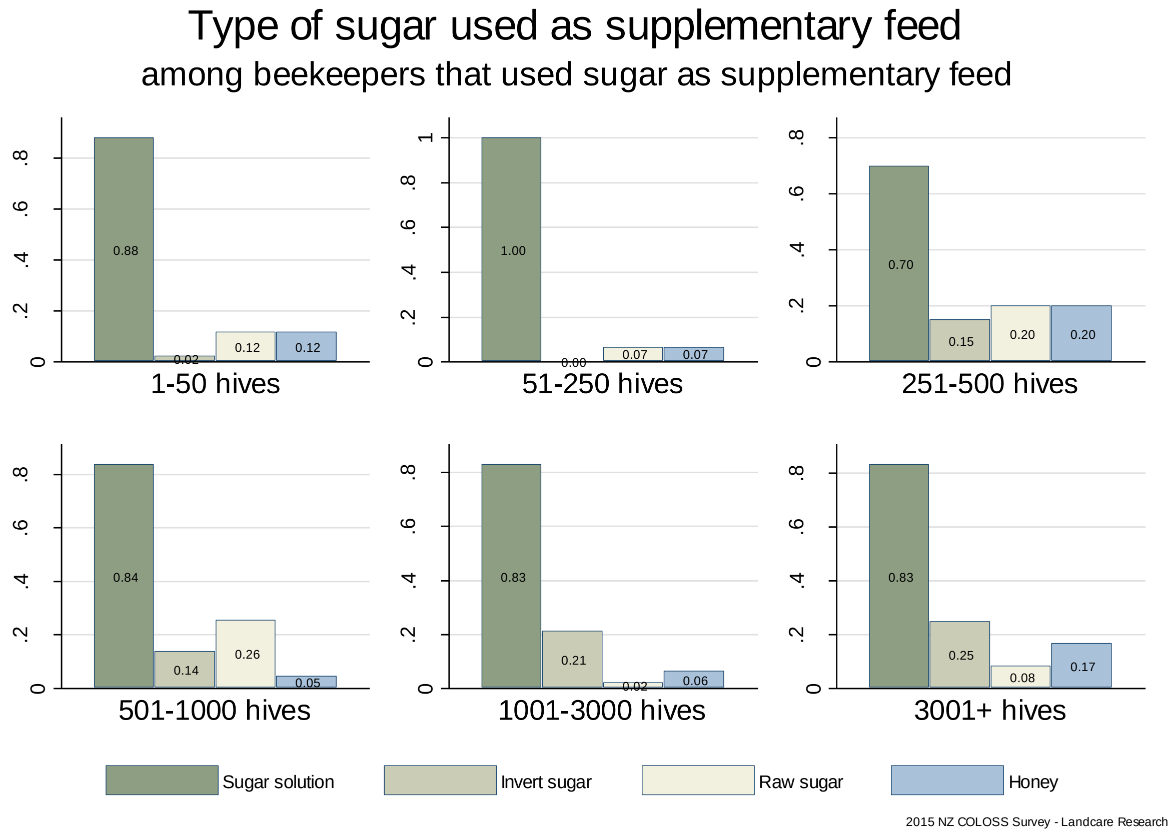

Figure 25. 2 Types of Carbohydrate Feed: Types of supplemental sugar feed provided to production colonies during the 2014-2015 season based on reports from all respondents, by operation size.

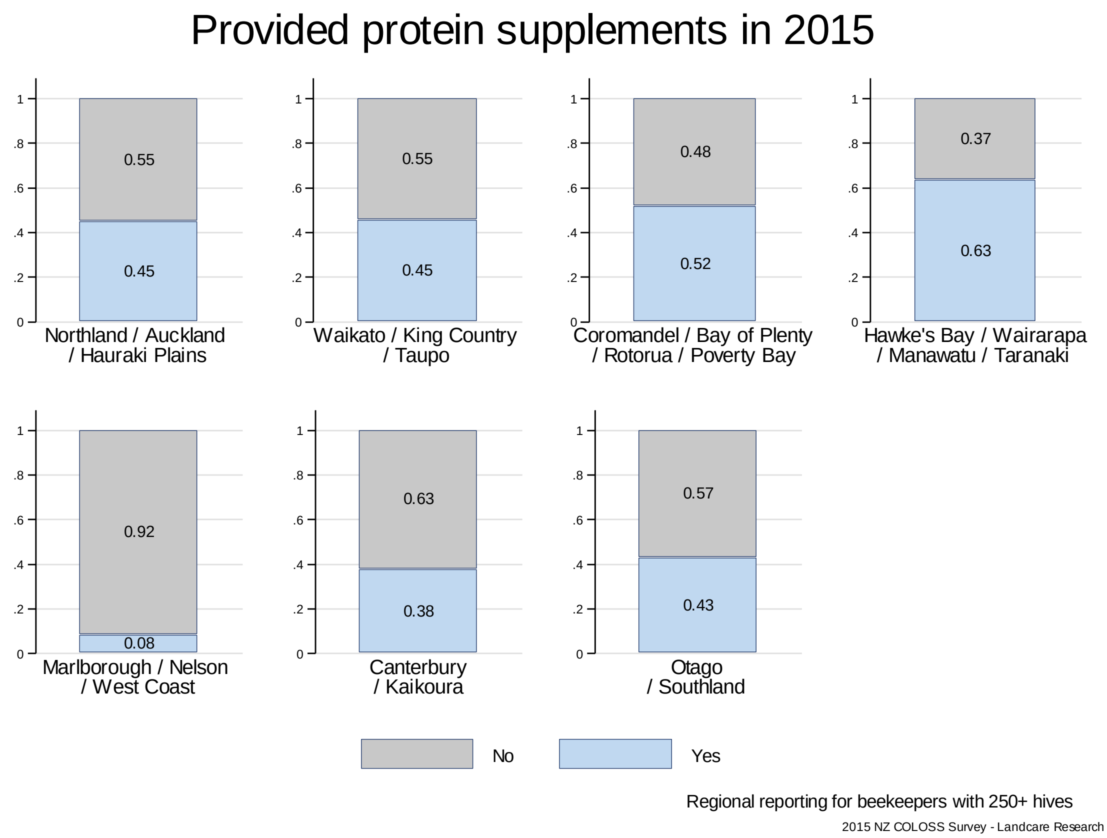

Figure 26. 1 Protein Feeding: Share of production colonies that were provided with supplemental protein feed during the 2014-2015 season based on reports from respondents with > 250 hives, by region.

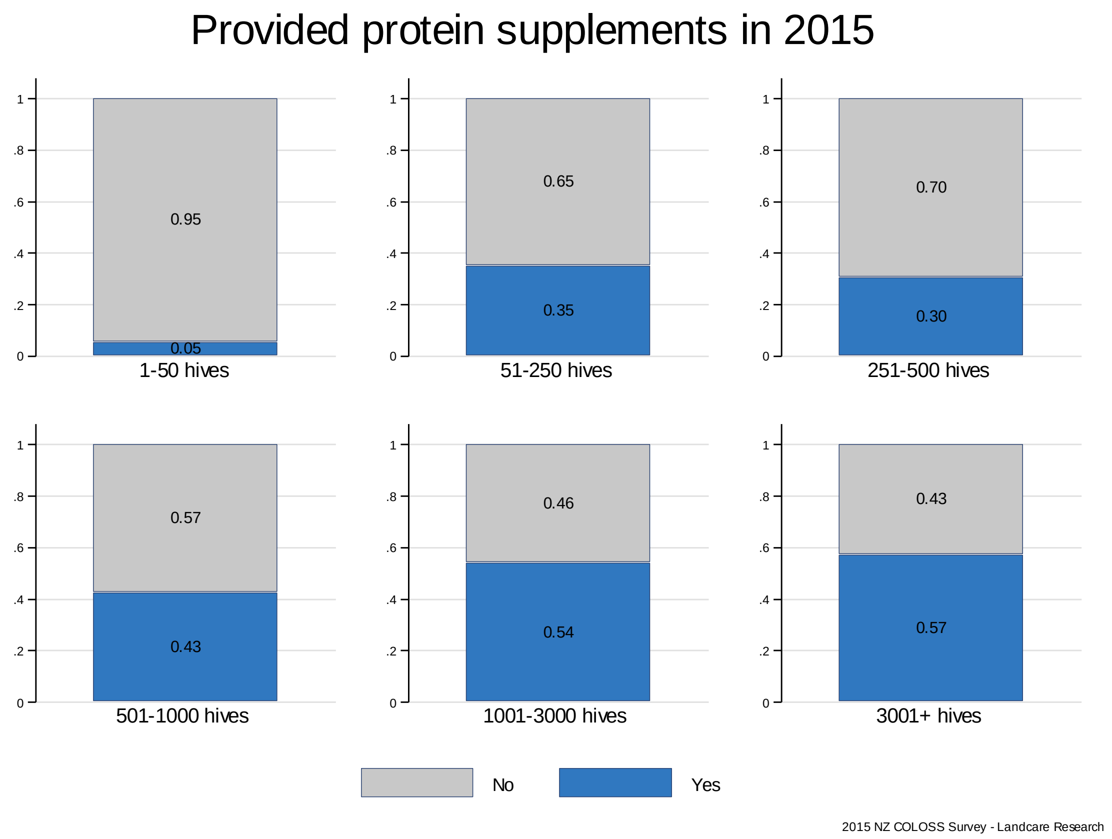

Figure 26. 2 Protein Feeding: Share of production colonies that were provided with supplemental protein feed during the 2014-2015 season based on reports from all respondents, by operation size.

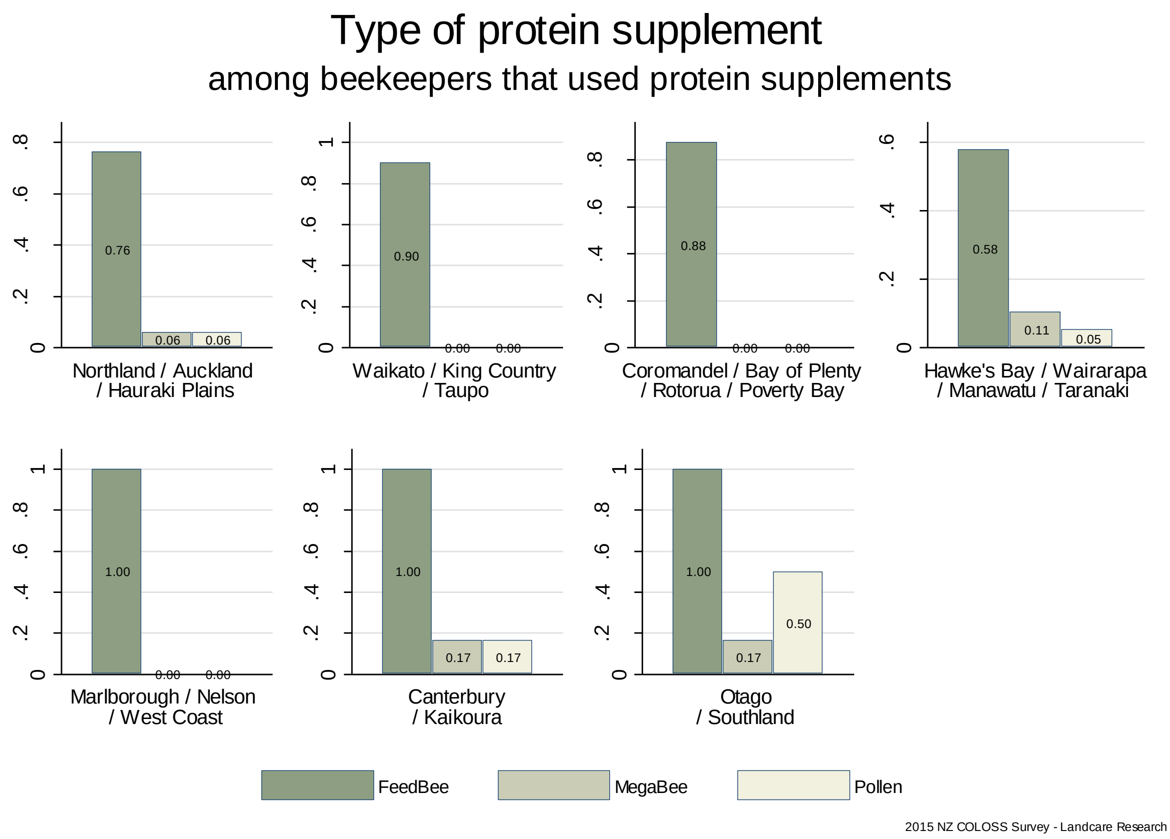

Figure 27. 1 Types of Protein Feed: Types of supplemental protein feed provided to production colonies during the 2014-2015 season based on reports from respondents with > 250 hives, by region.

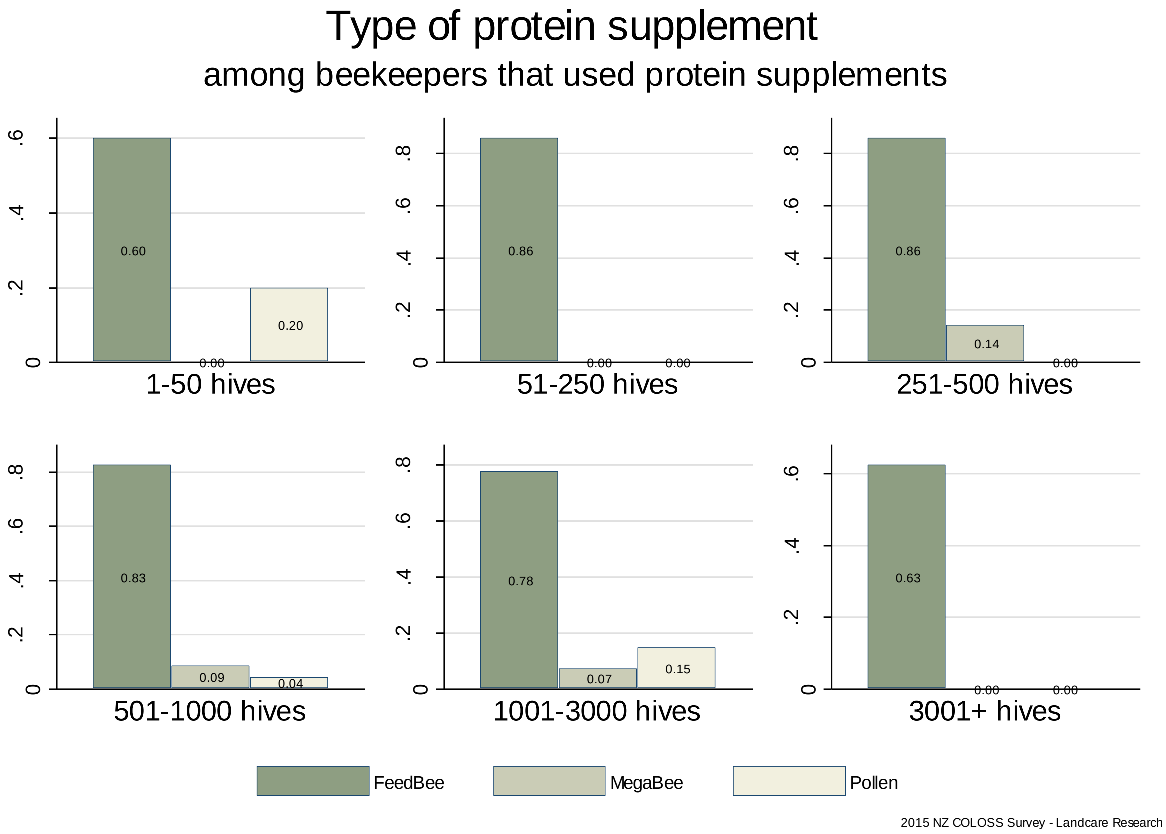

Figure 27. 2 Types of Protein Feed: Types of supplemental protein feed provided to production colonies during the 2014-2015 season based on reports from all respondents, by operation size.

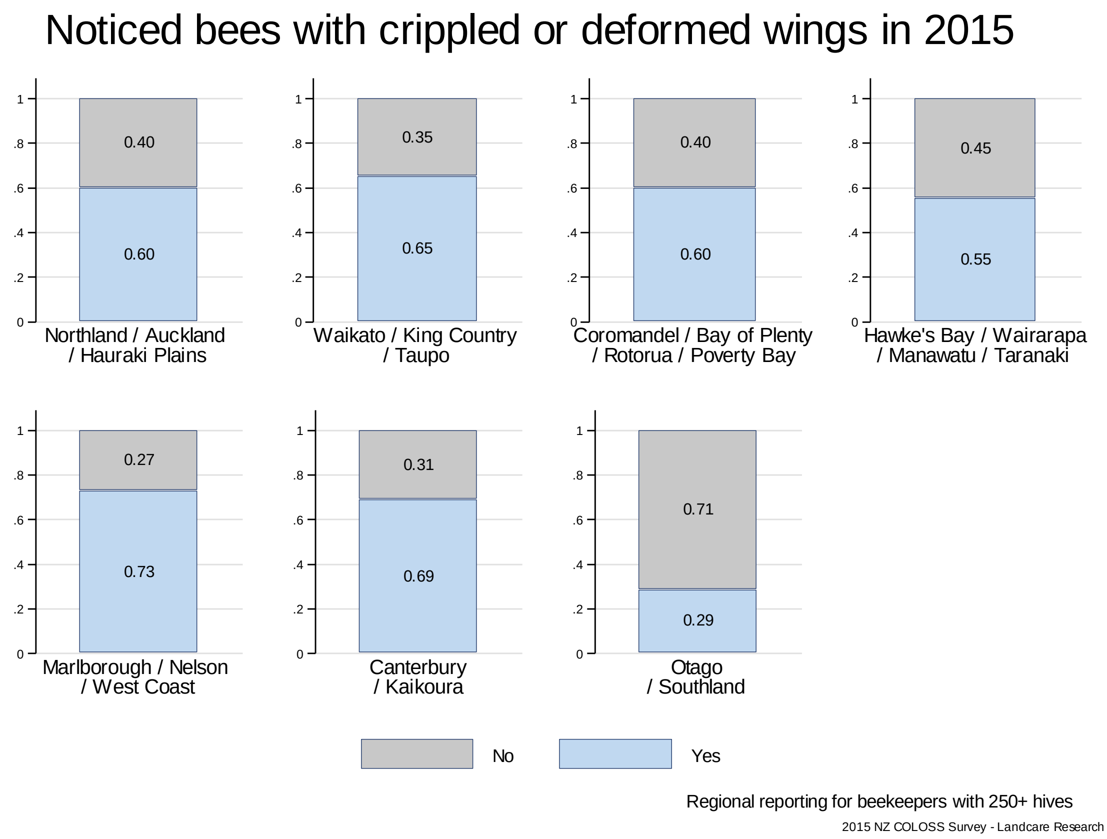

Figure 28. 1 Crippled or Deformed Wings: Share of respondents who observed crippled or deformed wings during the 2014-2015 season based on reports from respondents with > 250 hives, by region.

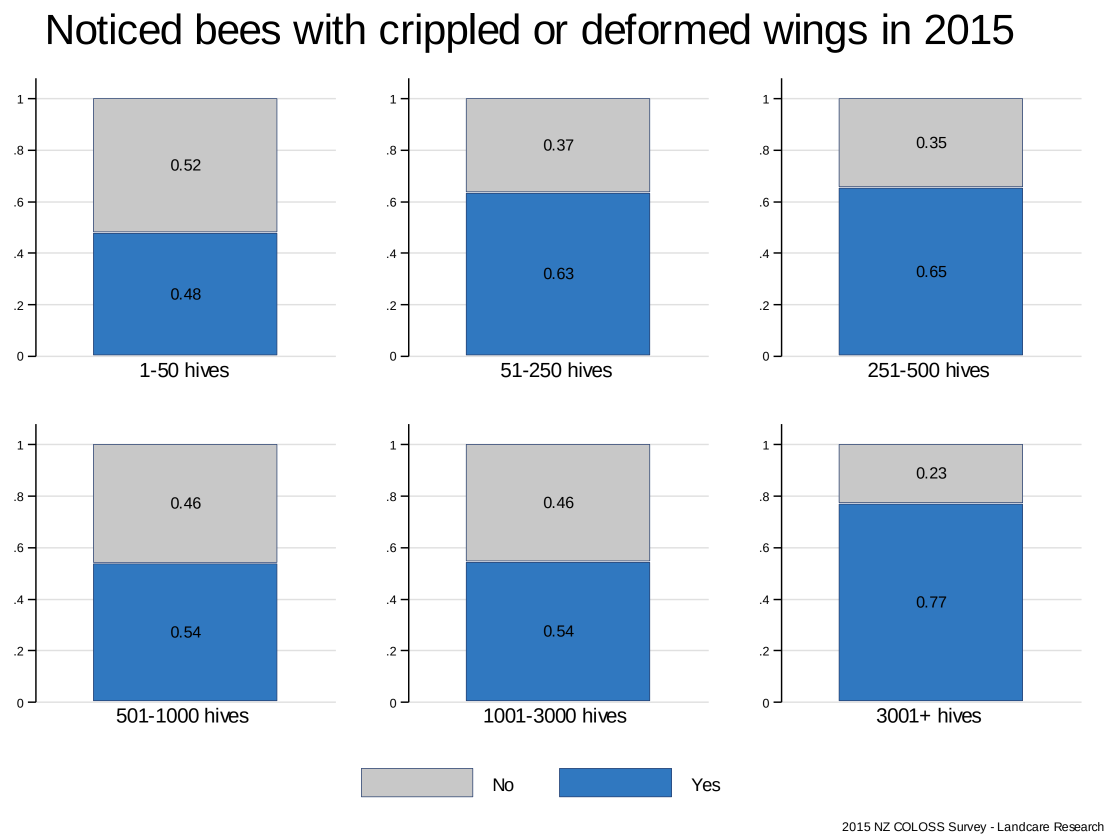

Figure 28. 2 Crippled or Deformed Wings: Share of respondents who observed crippled or deformed wings during the 2014-2015 season based on reports from all respondents, by operation size.

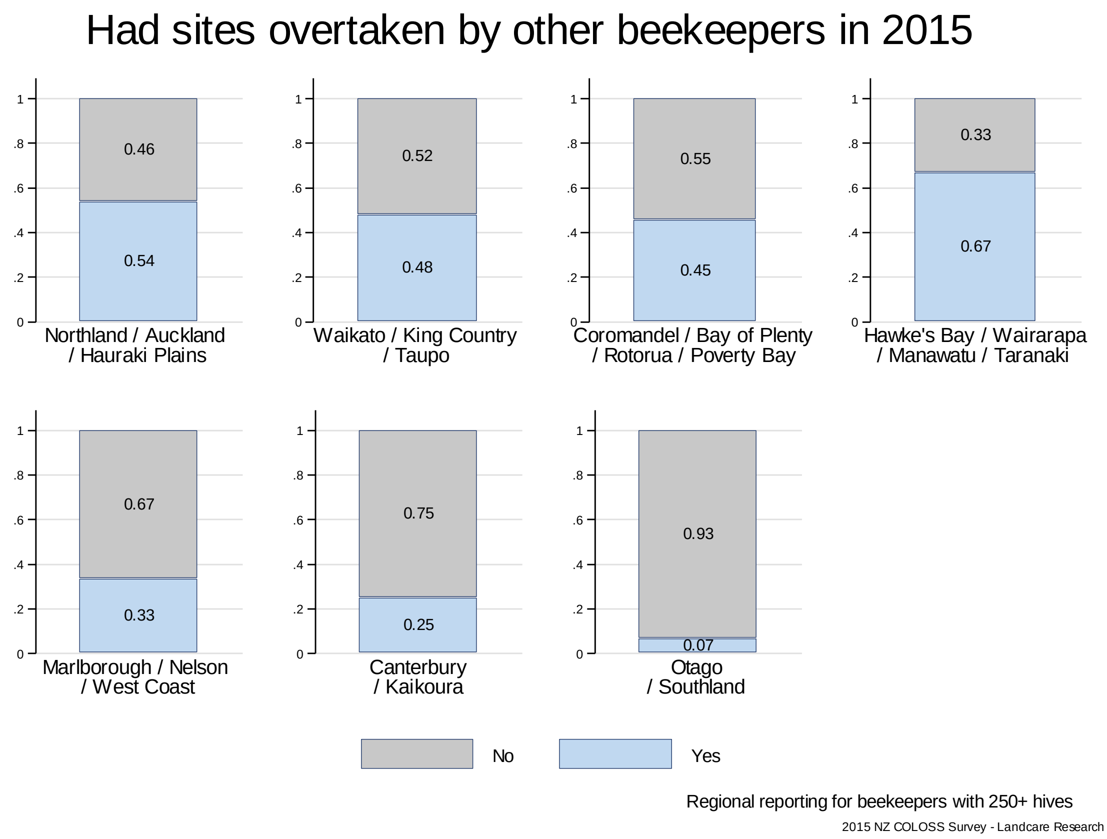

Figure 29. 1 Apiary Takeovers: Share of respondents who lost apiary sites because they were taken over by other beekeepers during the 2014-2015 season based on reports from respondents with > 250 hives, by region.

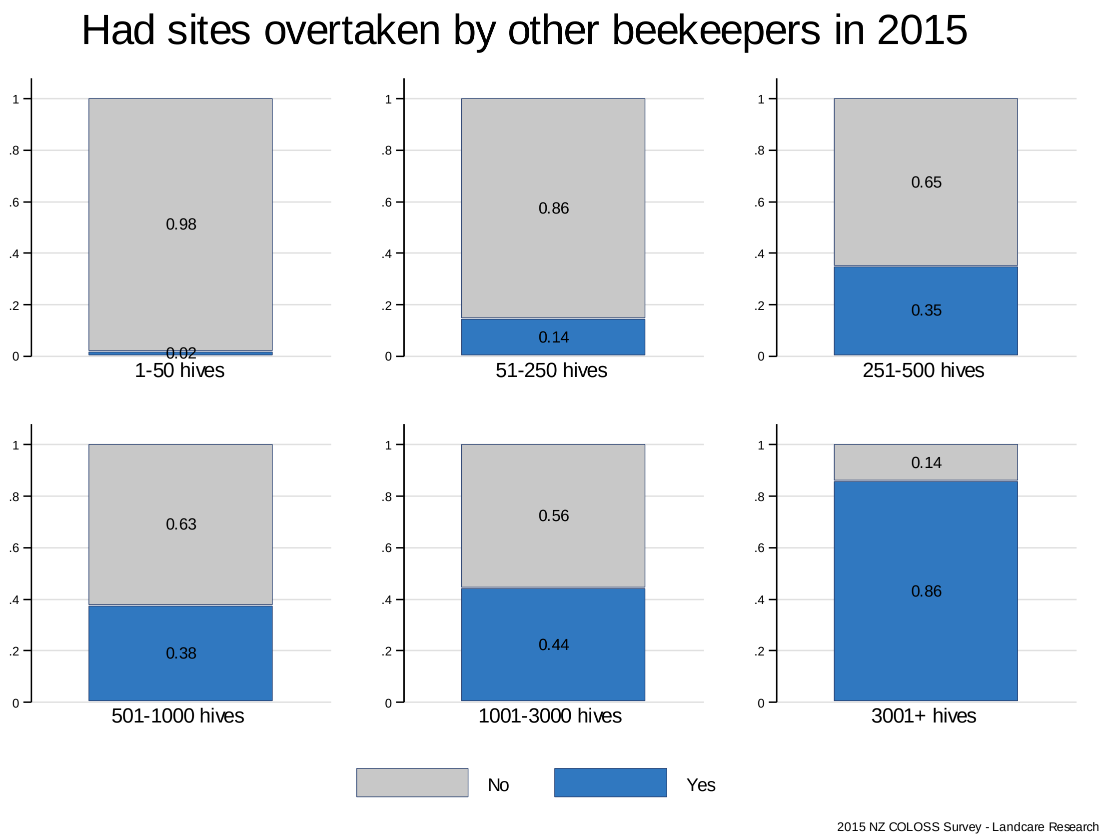

Figure 29. 2 Apiary Takeovers: Share of respondents who lost apiary sites because they were taken over by other beekeepers during the 2014-2015 season based on reports from all respondents, by operation size.

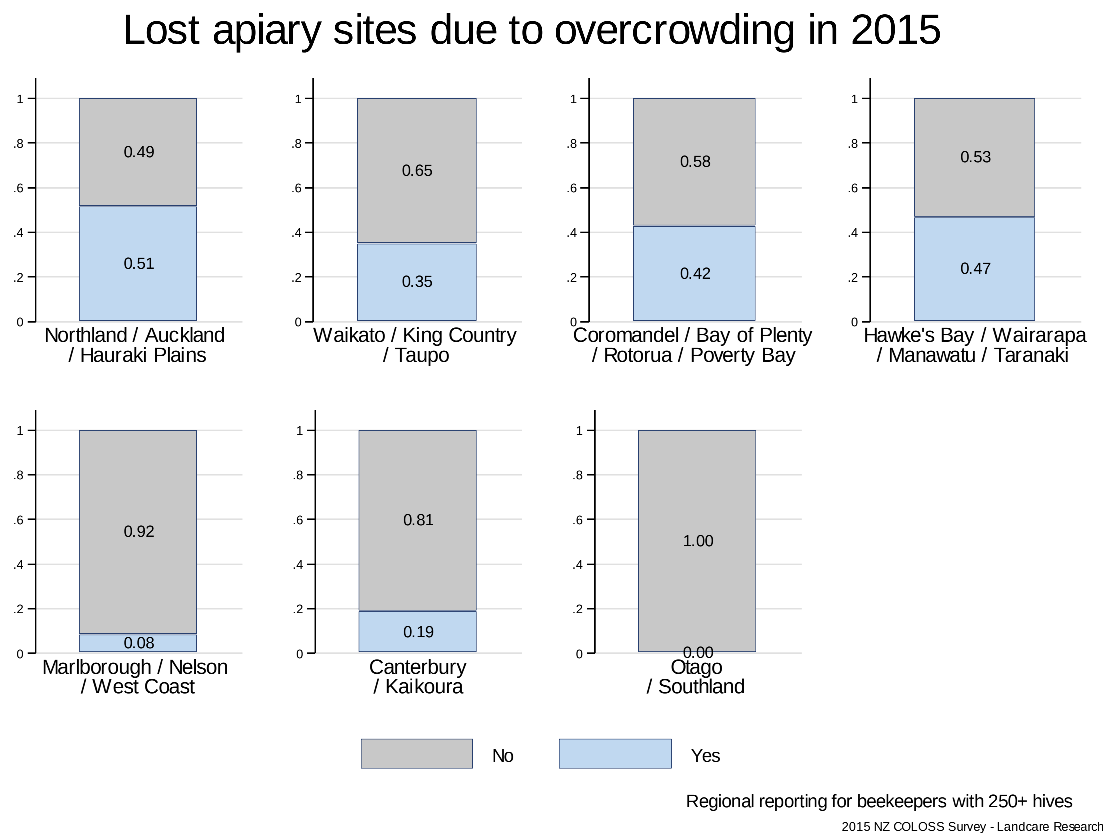

Figure 30. 1 Overcrowded Apiaries: Share of respondents who lost apiary sites because they were overcrowded (i.e., too many hives close to the apiary) during the 2014-2015 season based on reports from respondents with > 250 hives, by region.

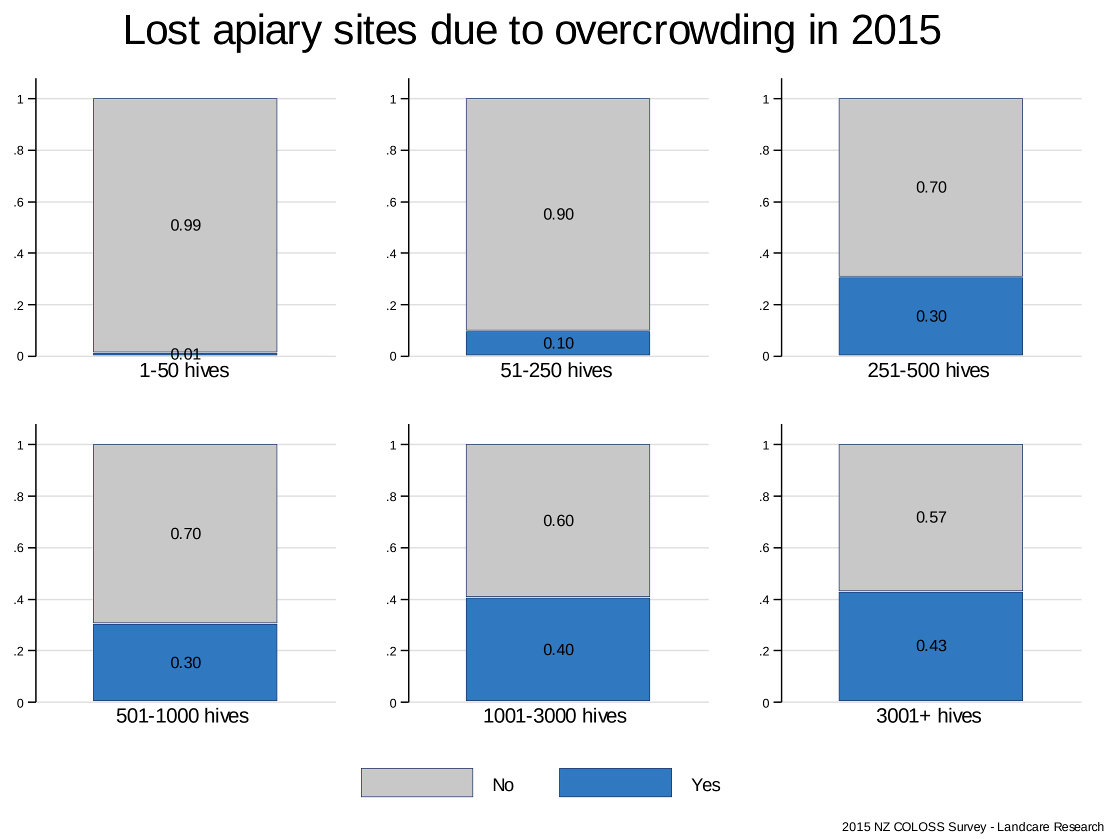

Figure 30. 2 Overcrowded Apiaries: Share of respondents who lost apiary sites because they were overcrowded (i.e., too many hives close to apiary) during the 2014-2015 season based on reports from all respondents, by operation size.

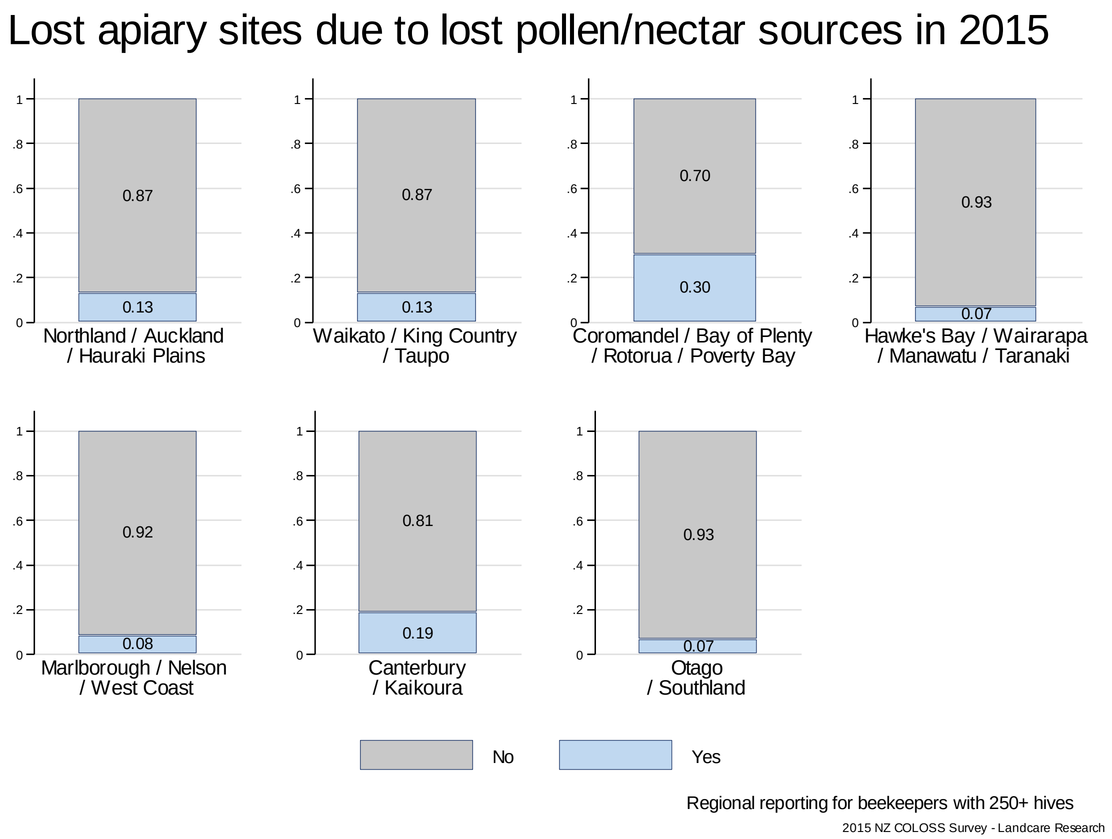

Figure 31. 1 Forage Removed from Apiaries: Share of respondents who lost apiary sites because pollen and nectar sources were removed without replacement during the 2014-2015 season based on reports from respondents with > 250 hives, by region.

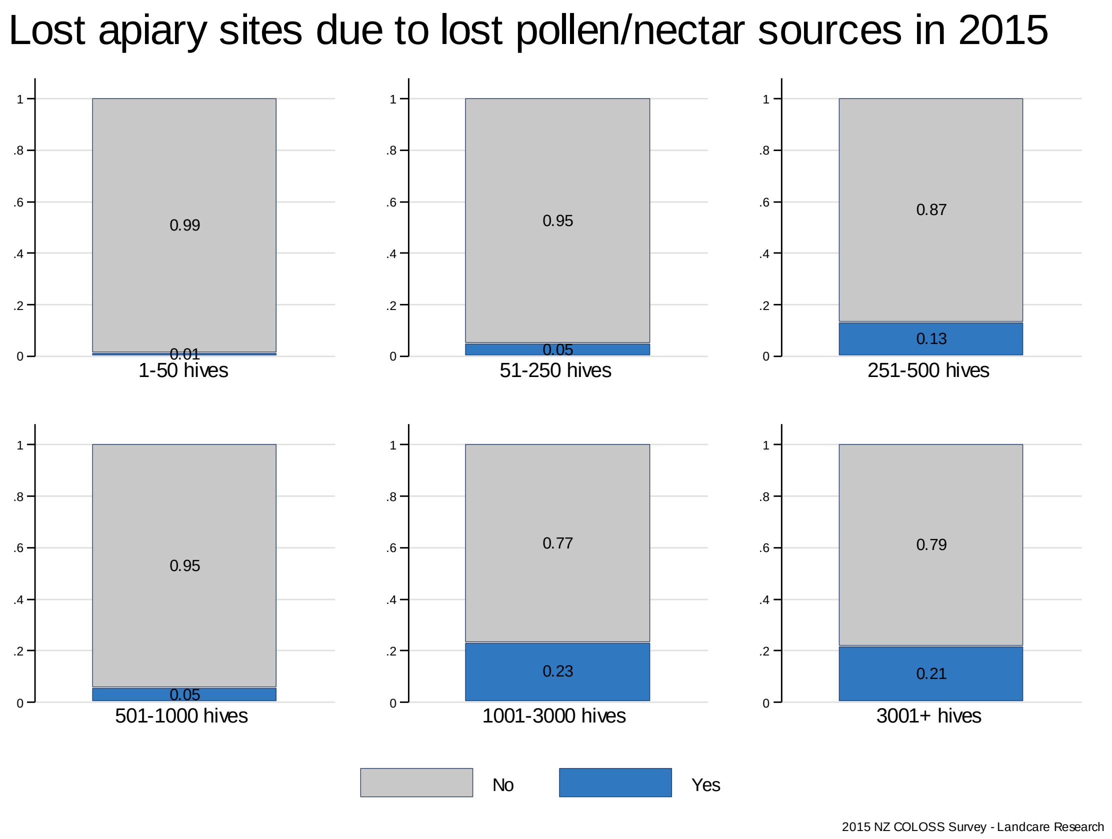

Figure 31. 2 Forage Removed from Apiaries: Share of respondents who lost apiary sites because pollen and nectar sources were removed without replacement during the 2014-2015 season based on reports from respondents with > 250 hives, by region.

6 Highlighted Results

Figures are presented in the order in which they appeared

6.1 Region and Operation Size

Beekeepers responded to the survey; hence, beekeepers are the reporting unit throughout these results. Most information from the NZ COLOSS survey is reported separately according to apiary registry location (i.e. “region”) and total number of hives comprising each beekeeping operation (i.e. “operation size”) as of 31 March 2015. Because larger beekeeping operations represent a disproportionate number of hives, all figures reported by region restrict the sample to semi-commercial and commercial operators with at least 250 hives (the sole exception is Fig. 1.1). Figures reported by operation size include all respondents.

Results of the NZ COLOSS are variously reported as bar charts, pie charts, and histograms. The latter are useful for showing the distribution of survey responses. A normal distribution curve is overlaid on many histograms to indicate the mean and variance of losses in each region.

Fig. 1.1 shows the region(s) in which the 366 beekeepers who responded to the NZ COLOSS survey register their hives. Because some beekeeping operations span multiple apiary registry locations, individual respondents may be included in more than one region. In contrast to all other figures reported by region, Fig 1.1 is not restricted to beekeeping operations with 251+ hives.

Fig. 1.2 shows the operation size reported by each respondent as of 31 March 2015 using AsureQuality’s size classifications. “Non-commercial beekeepers” are reported in two groups, namely those with between 1 and 50 hives (comprising 53.6% of the sample) and those with between 51 and 250 hives (comprising 5.7% of the sample). Semi-commercial operators (with 251-500 hives) comprised 6.6% of the sample. Commercial (501-1000 hives) and large commercial (1001-3000 hives) operators comprised 15.3% and 14.8% of the sample, respectively. Finally, the largest commercial operators (with 3001+ hives) comprised 4.1% of the sample. Throughout this report, operators with 251+ hives are collectively referred to as “commercial operators”.

6.2 Share of Colonies Lost over Winter 2015

Each respondent’s hive losses for winter 2015 is defined as the number of hives that he/she had on 31 March 2015 less the number that were alive when he/she opened the hives in spring (typically between August and October, earlier in the north of New Zealand and later in the south). Losses to nucs, splits, and tops are calculated analogously.

Figs. 2.1 and 2.2 respectively show the distribution of hive losses and nuc/split/top losses over winter 2015 for each apiary registry location. As noted above, reporting by region is restricted to commercial operators with at least 251 hives. Figs. 2.3 and 2.4 show the distribution of hive losses and nuc/split/top losses over winter 2015 by operation size class, including non-commercial operators.

Most commercial operators experienced low shares of hive loss during winter 2015 (Fig 2.1). The mean reported hive losses among this group was 8.81%, although 10% of these operators lost 20% or more of their hives and one operator reported losing 100% of his / her hives. Operators in Coromandel / Bay of Plenty / Rotorua / Poverty Bay and in Hawke's Bay / Wairarapa / Manawatu / Taranaki reported the highest loss rates.

Commercial and semi-commercial operators report qualitatively higher shares of losses for nucs, splits, and tops than for hives across all regions (Fig 2.2). The mean reported losses of nucs, splits, and tops over winter 2015 was 19.00%, although one-third of respondents reported losing 20% or more of their nucs / splits / tops. Reported losses were generally lowest in the South Island.

Non-commercial beekeepers reported higher shares of hives lost (24.3% overall) over winter 2015 than commercial operators (8.8% overall) (Fig 2.3). Qualitatively, semi-commercial operators reported the lowest share of hives lost. A similar pattern exists for nucs / splits / tops; specifically, non-commercial operators who had nucs / splits / tops in autumn 2015 lost 37.32% of them, on average, while commercial operators lost 19.00% of them, on average.

6.3 National-Level Estimates of Hive Losses During Winter 2015

To estimate hive losses for winter 2015 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. The 95% confidence interval (which may be interpreted as the true value falling within this range 95% percent 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). We do not report corresponding losses for nucs / splits / tops because national figures are not available.

Our national-level estimate of hive losses during winter 2015 based on the NZ COLOSS survey is 10.73%, with a 95% confidence interval of [8.66%, 12.80%].

For robustness, we estimated national-level hive losses for winter 2015 in two alternative ways. First, we divide the average number of hives lost per beekeeper within each operation size class by the share of beekeepers within each size class in AsureQuality's apiary registry represented in the survey. Using this method, our national-level estimate of hive losses during winter 2015 based on the NZ COLOSS survey is 10.68%, with a 95% confidence interval of [8.61%, 12.75%].

As a second alternative, we divide the total number of hives lost during winter 2015 by the total number of hives on 31 March 2015 as reported in the NZ COLOSS survey. Using this method, our national-level estimate of hive losses during winter 2015 based on the NZ COLOSS survey is 8.37%, with a 95% confidence interval of [6.30%, 10.44%], although we recognise that our survey sample has a disproportionate number of commercial operators who reported lower shares of hives lost, on average, than non-commercial operators.

6.4 Colony Losses

The largest proportion of colony losses across all regions and all operation size classes for hives and nucs / splits / tops were firstly attributed to queen problems, secondly to colony death events, and thirdly to wasps (Figs. 9.1, 9.2, 9.3, and 9.4). Losses to natural and human disasters are infrequent. Losses attributed to American Foul Brood are rare.

6.4.1 Disasters

Some hive losses are neither related to bee health problems nor to colony death, but rather stem from disasters that are outside of beekeeper control. Both natural disasters (including gale force winds, flooding, fire, etc.) and human disasters (e.g. theft and vandalism) can dramatically damage part or all of an apiary. Our survey results show that the overall share of losses due to natural disasters and human disasters is low vis-à-vis other causes. Overall, just 2.9% of all hive losses were attributable to natural disasters and 1.0% of all hive losses were attributable to human disasters (Figs. 9.1 and 9.2). Losses of nucs / splits / tops attributable to natural and human disasters are even lower (Figs. 9.3 and 9.4). Losses to disasters are highest among beekeepers with between 51 and 250 hives (Figs. 9.2 and 9.4).

Most beekeepers experienced low levels of theft and vandalism. Indeed, no beekeepers reported theft or vandalism in the South Island, although eight North Island commercial beekeepers reported losing 10% or more of their hives to theft and vandalism (including three who lost more than 25% of their fives to theft and vandalism) (Fig. 7.1). Only one commercial beekeeper reported theft or vandalism of nucs / splits / tops (Fig. 7.2). The largest commercial operators (with 3001+ hives) experienced higher rates of theft and vandalism of hives than other beekeepers (Fig. 7.3).

Survey respondents infrequently attributed colony losses to natural disasters, although five commercial operators reported that natural disasters caused between one-quarter and one-third of their hive losses (Fig. 6.1 and Fig. 6.3). In one case, this amounted to 300 hives lost.

6.4.2 Colony Death

Many survey respondents who experienced hive losses during winter 2015 attributed the cause to colony death. Overall, beekeepers reported that 34.4% of hive losses and 31.0% of nuc / split / top losses were attributed to colony death (Figs. 4.3 and 4.4). Commercial operators attributed qualitatively lower shares of hive losses to dying colonies than non-commercial operators, although some beekeepers with fewer than 50 hives report losing all of their hives to colony death (Fig. 4.3). Ten commercial operators attributed 100% of the nuc / split / top losses to colony death (Fig. 4.4). Among commercial operators, 25.5% of the hive losses in the North Island were attributed to colony death while 38.9% of the hive losses in the South Island were attributed to colony death (Fig. 4.1).

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

For hives and for nucs / splits / tops across all regions and all operation sizes, dead worker bees in the cells and no food present was more frequently observed than dead bees in front of the hive (Figs 12.1 to 12.4). The single exception is for beekeepers with 1-50 hives (Fig. 12.3).

Some 45.5% of hives that were reported as being dead showed signs of starvation. Colony weakening during pollen and nectar dearth and during bad weather is common, although these problems may be mitigated by supplementary feeding of sugar and protein.

Overall, 36.1% of hives that were reported as being dead had dead bees in or in front of the hive, indicating that toxic exposure is problematic. One method employed by beekeepers overseas to mitigate the load of toxins embedded inside the hives is to replace wax brood combs with new foundation. This approach may be increasingly important as *Varroa* miticide treatments inside hives are used long term.

Levels of brood comb replacement varied by region and by operation size. Fig 23.1 indicates that while 42.8% of respondents in Hawke's Bay / Wairarapa / Manuwatu / Taranaki and 41.6% of respondents in Marlborough / Nelson / West Coast replaced at least 20% of brood combs with foundation, only 15.4% of respondents in Otago / Southland did so. Larger commercial operators report replacing a greater share of brood combs, on average, than non-commercial and semi-commercial operators (Fig 23.2). Overall, 25% of the respondents reported that they did not replace any brood combs with foundation.

6.4.3 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.

Queen problems were the most commonly reported reason for colony loss (Figs 9.1, 9.2., 9.3., and 9.4). Commercial operators attribute a greater share of hive losses to queen problems, on average, than non-commercial operators (Fig. 3.3). The distribution of hive losses attributable to queen problems also depends on operation size; for example, 73.3% of operators with 1-50 hives reported that none of their hive losses were attributable to queen problems while 50% of the largest commercial operators attributed at least 35% of their hive losses to queen problems. For commercial operators, queen problems are qualitatively attributed to more hive deaths in Northland / Auckland / Hauraki Plains and in Marlborough / Nelson / West Coast than elsewhere (Fig. 3.1). Queen problems are qualitatively attributed to more deaths of nucs / splits / tops in Marlborough / Nelson / West Coast (Fig. 3.2).

It is common practice to replace old queens with new queens to ensure hive productivity, and large operations often have their own queen-raising systems. As such, it is not surprising that the largest commercial operators reported that 69.9% of the queens in autumn 2015 were new (Fig. 15.2). In contrast, non-commercial operators reported that 34.8% of their hives had new queens. Overall, the median respondent reported that 48% of queens in autumn 2015 were new. Among commercial operators, new queens were especially common in Marlborough / Nelson / West Coast, although 28.6% of commercial respondents in Hawke's Bay / Wairarapa / Manawatu / Taranaki reported that at least 90% of their queens were new (Fig. 15.1).

6.4.4 Pests

Two pests significantly contribute to colony loss, namely, the *Varroa* mite (*Varroa destructor*) and wasps. 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 and many other viruses. Wasps invade and kill weak colonies, particularly in autumn.

One of the drivers most frequently discussed as a highly significant factor influencing the increases in colony losses is longterm infestations of *Varroa* (van der Zee et al. 2012; CAPA 2014; Goulson 2015). 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. Commercial operators across all regions rely mostly on two synthetic chemical treatments for controlling *Varroa*, flumethrin and amitraz (Fig. 18.1). Organic treatments, particularly thymol, are used more often by non-commercial than commercial beekeepers (Fig.18.2).

Widespread infestations of the giant willow aphid have contributed to increasing populations of wasps that feed on the honeydew produced by these aphids. Survey respondents attributed 14.4% of the hive losses and 10.9% of the nuc / split / top losses to wasps overall, although these losses are heavily concentrated in the North Island. Fig. 8.1 shows that 5% to 23% of hives lost to commercial operators in each of the four regions in the North Island are attributable to wasps. In contrast, 2.6% of commercial hive losses in Marlborough / Nelson / West Coast were attributed to wasps; no hive losses in Canterbury / Kaikoura and Otago / Southland were attributed to wasps.

6.5 Diseases

The NZ COLOSS survey includes questions relevant to three diseases that potentially affect New Zealand bees, namely AFB, deformed wing virus, and *Nosema ceranae*. In the NZ COLOSS survey, the share of hive losses attributable to AFB is very small, with only 134 claimed cases in the 225,660 hives reported on by all respondents (Figs. 5.1, 5.2., 5.3, and 5.4).

Deformed wing virus is spread by the *Varroa* mite. The symptoms are readily observed by looking for crippled or deformed wings. The share of commercial beekeepers who observed symptoms of deformed wing virus ranged from 28.6% in Otago / Southland to 72.7% in Marlborough / Nelson / West Coast (Fig. 28.1). Otago/Southland is the last region of New Zealand to be infested by the *Varroa* mite and the colder climate would limit the population build-up of the mite during winter. The highest share of beekeepers that reported symptoms of deformed wings virus belonged to the largest commercial operations, at 76.9% (Fig 28.2).

A large amount of faeces in the hive is thought to be indicative of an infestation of *Nosema ceranae.* This disease has become a problem overseas, but symptoms are only beginning to be noticed in New Zealand. Commercial operators reported low levels of faeces across all regions (Fig 17.1). Indeed, only 9.4% of commercial operators reported hives with large amounts of faeces, and only 1.7% of commercial operators reported that more than 20% of their hives were affected. The average share of hives in which beekeepers noticed faeces was 6.6% across all operation sizes (Fig. 17.3). Among the largest commercial operators, 10 % of the respondents noticed large amounts of faeces in 30 % of their hives.

6.6 Sugar and Protein Supplements

Experienced beekeepers closely monitor the weather and floral resources within foraging range of their apiaries. Many beekeepers are actively planting forage resources for their bees to improve nutrition and overwintering success (DeGrandi-Hoffman 2015).

If pollen and nectar sources within foraging range are too low, then bees will use up their stores in the hive. If the weather is too severe for bees to forage and if they do not have sufficient stores of pollen and nectar in the hive, then bees can begin to starve.

To prevent starvation, beekeepers may provide supplemental feed. Nectar supplies fuel for adult bees and can be supplemented by supplying sugar as it is primarily a carbohydrate source. Pollen, which is needed for the brood, provides protein, lipids, vitamins, and minerals (Black 2006). Various protein supplements are available.

Some 85.9% of commercial beekeepers reported that they used supplemental sugar during the 2014-2015 season (Fig. 24.1). Sugar feeding among commercial beekeepers is pronounced in Hawke's Bay / Wairarapa / Manawatu / Taranaki, where 96.7% of respondents reported giving supplemental sugar to their bees. Only 48.5% of non-commercial beekeepers reported giving their bees supplemental sugar (Fig. 24.2). The type of sugar most often used was sugar solution (Figs. 25.1 and 25.2) while invert sugar, raw sugar, and honey were less commonly used.

Only 8.3% of commercial beekeepers provided protein supplements to their bees in Marlborough / Nelson / West Coast (Fig. 26.1). At the other extreme, 63.3% of commercial beekeepers in Hawke's Bay / Wairarapa / Manawatu / Taranaki provided protein supplements. Among beekeepers with 1-50 hives, 2.4% reported using protein supplements (Fig. 26.1). FeedBee was the most commonly used supplement (Figs. 27.1 and 27.2).

The main seasons of pollen and nectar deficits are spring and autumn. During the main honey flow in summer, pollen and nectar are plentiful. Regional differences in the suite of plant species available for honey harvesting are shown in Fig. 20.1. Fewer plant species are available for the honey flow in the southernmost parts of New Zealand. Mānuka / kānuka honey harvesting is prevalent throughout the North Island to the top of the South Island (Fig.20.1).Commercial operators are especially likely to harvest mānuka and kānuka honey (Fig. 20.2).

6.7 Pollination and Honey Harvesting

The higher value honey from mānuka sources – particularly medical-grade mānuka honey – presents an option to many beekeepers to pursue honey and abandon pollination services that were formerly provided for pastoral, arable, and horticultural plantations. Most beekeepers who do elect to provide pollination services also harvest honey, which often subsidises pollination services in New Zealand. The only region in which some beekeepers use hives only for pollination is Canterbury / Kaikoura (Fig. 19.1), where the seed-production industry is concentrated and where the demand for pollinators and the type of crops for seed production are distinctive. Otherwise, beekeepers in most regions engage in both pollination services and honey harvesting.

6.8 Apiary Losses

Beekeepers typically keep bees based on agreements with landowners. Depending on the size of the operation, beekeepers may travel great distances to service their hives and to deliver them for pollination services. 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 a beekeeping operation, either financially or via bee health. Although discussed by beekeepers, apiary competition has not previously been surveyed.

Apiary sites being overtaken by other beekeepers is a new problem in New Zealand and coincides with the rapid expansion of the mānuka honey industry. 53.9% of commercial beekeepers in the North Island (where mānuka is prevalent) report having lost apiary sites to other beekeepers during the 2014-2015 season as compared to 21.4% of beekeepers in the South Island (Fig. 29.1). This problem is pronounced among the largest commercial operators, 85.7% of whom reported losing some apiary sites in this way (Fig. 29.2).

Losing apiary sites to overcrowding also coincides with the growth of the mānuka honey industry. This problem is exacerbated because many new beekeepers may not fully understand stocking rates in a given region (Newstrom-Lloyd 2015). Similar to sites being overtaken by other beekeepers, overcrowding is more common in the North Island than in the South Island: 46.1% of commercial beekeepers in the North Island reported having lost apiary sites to overcrowding during the 2014-2015 season while only 9.5% of commercial beekeepers in the South Island did so (Fig. 30.1). Overcrowding is most prevalent in

Northland / Auckland / Hauraki Plains, where 51.3% of commercial beekeepers reported the problem. Fewer than 2% of non-commercial operators reported that overcrowding was a problem during the 2014-2015 season.

Apiary sites lost to the sudden removal of pollen and nectar sources is less commonly reported, but is nevertheless problematic in some areas. 30.3% of commercial respondents in Coromandel / Bay of Plenty / Rotorua / Poverty Bay reported losing apiary sites to decreased pollen and nectar sources during the 2014-2015 season, as did 18.8% of commercial respondents in Canterbury / Kaikoura (Fig. 31.1). Reductions in pollen and nectar sources are tied to the removal of willow and gorse as well as land-use changes. Large commercial operators with 1001 or more hives report this problem most frequently (Fig. 31.2).

7 Future Improvements to the NZ COLOSS Survey

We have five specific suggestions for improving the future iterations of the NZ COLOSS survey.

First, we suggest including optional questions on the acquisition and disposal of hives as is practiced in surveys in some countries (e.g. USA), allowing us to capture hive gains through the winter period as hives are often sold from South Island beekeepers to North Island beekeepers. Quantifying splitting, buying, merging and selling activities, after 31 March and before the hives are opened in spring will improve the precision of our estimates of colony losses.

Second, 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 resistance to *Varroa* treatment.

Third, we recommend asking questions pertaining to the treatment of *Nosema ceranae*, which was first detected in New Zealand in 2010. Indeed, we believe that the NZ COLOSS survey may be used to help identify the need for training beekeepers in identifying and treating this disease.

Fourth, we would recommend exploring the feasibility of reporting results at a level that is less aggregated than the apiary registry location. While reporting results at a lower level of aggregation would add considerable complexity – particularly for beekeepers whose operations span multiple districts – it would also enable better capturing of pollination services and mānuka honey production and geographically pinpointing industry stressors such as pests and apiary competition.

Finally, we recommend sharing the questionnaire with beekeepers in advance to help them prepare for the survey as practiced by Bee Informed in USA (https://beeinformed.org/). A further possibility that may be worth consideration is developing a simple tool on which beekeepers may record observations throughout the year and that feeds directly into the survey.

8 Acknowledgements

We gratefully acknowledge the 366 beekeepers shared their time and expertise in responding to the survey.

We also thank Daniel Paul (CEO of the National Beekeepers' Association), Barry Foster (Executive Council of the National Beekeepers' Association), Ricki Leahy (President of National Beekeepers' Association), and John Hartnell (Chair of the Federated Farmers Bee Industry Group) for organising and enabling the survey.

The NZ COLOSS Advisory Board is comprised of Barry Foster (Executive Council of the National Beekeepers' Association), John Hartnell (Chair of Federated Farmers Bee Industry Group), Dr. John McLean (Technical Committee of National Beekeepers' Association), Neil Mossop (Managing Director, Mossop's Honey), and Nick Willis (Contract Manager, Ministry for Primary Industries). The advisory board was instrumental in questionnaire development and providing thoughtful help for interpreting results.

Christine Harper and Tamsin Rees from Landcare Research greatly increased response rates by telephoning beekeepers and encouraging their participation. During these conversations, they collected rich qualitative data that will be used in further analysis.

This project was funded by Ministry of Primary Industries Contract #17392.

9 References

Black J 2006. Honeybee Nutrition: Review of research and practices. Rural Industries Research and Development Corporation. RIRDC Publication No 06/052. RIRDC Project No JLB-2A.

CAPA National Survey Committee and Provincial Apiarists 2014. CAPA Statement on Honey Bee Wintering Losses in Canada. http://www.capabees.com/content/uploads/2013/07/2014-CAPA-Statement-on-Honey-Bee-Wintering-Losses-in-Canada.pdf

DeGrandi-Hoffman G, Chen Y, Rivera R, Carroll M, Chambers M, Hidalgo G, de Jong E 2015. Honey bee colonies provided with natural forage have lower pathogen loads and higher overwinter survival than those fed protein supplements. Apidologie. DOI: 10.1007/s13592-015-0386-6.

Goulson D, Nicholls E, Botias C, Rotheray EL 2015. Bee declines driven by combined stress from parasites, pesticides and lack of flowers. Science 347: 1255957. http://DOI:10.1126/science.1255957

McCullagh P, Nelder JA 1989. Generalized linear models (Vol. 37). CRC press.

Neumann P, Carreck NL 2010 Honey Bee colony losses. Journal of Apicultural Research. 49: 1.1-6. http://dx.doi.org/10.3896/IBRA.1.49.1.01

Newstrom-Lloyd LE 2013. Pollination in New Zealand. In: Dymond JR, ed. Ecosystem services in New Zealand: Conditions and trends. Manaaki Whenua Press, Lincoln, New Zealand.

Newstrom-Lloyd LE 2105. Managing mānuka for carrying capacity and competition. Trees for Bees Corner. The New Zealand Beekeeper. 23(11): 18-19.

Sumner DA, Boriss H 2006. Bee-economics and the leap in pollination fees. Agricultural and Resource Economics Update. 9(3).

Van der Zee R, Gray A, Holzmann C, Pisam L, Brodschneider R, Chlebo R, Coffey MF, Kence A, Kristiansen P, Mutinelli F, Nguyen BK, Adjlane N, Peterson M, Soroker V, Topolska G, Vejsnaes F, Wilkins S 2012. Standard survey methods for estimating colony losses and explanatory risk factors in *Apis mellifera*. In: Dietemann V, Ellis JD, Neumann P, eds. The COLOSS BEEBOOK, Volume I: Standard methods for *Apis mellifera* research. Journal of Apicultural Research 52(4). http://dx.doi.org/10.3896/IBRA.1.52.4.18.

van Engelsdorp D, Evans JD, Saegerman C, Mullin C, Haubruge E, Nguyen BK, Frazier M, Frazier J, Cox-Foster D, Chen Y, Underwood R, Tarpy D, Pettis JS 2009. Colony Collapse Disorder: A descriptive study. PloS ONE 4(8): e6481. http://dx.doi.org/10.1371/journal.pone.0006481.