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What influences varroa management planning amongst New Zealand beekeepers, and what approaches could strengthen it to improve varroa level control?

Kellogg Rural Leadership Programme 55

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I wish to thank the Kellogg Programme Investing Partners for their continued support.

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Contents

Figures:

Executive summary

Varroa destructor remains the most significant biological threat to honeybee health in New Zealand and continues to be the leading driver of colony loss. Despite well-established management tools and guidance, national data shows that losses remain persistent, with no sustained improvement over time. This points to a core issue within the sector not as a lack of knowledge, but inconsistency in how varroa is managed in practice.

This research set out to understand what influences consistency in varroa management planning among New Zealand beekeepers, and to identify practical ways to strengthen alignment and improve control outcomes. A mixed-methods approach was used, combining a nationwide survey with semi-structured interviews across a range of industry participants, including beekeepers, suppliers, scientists, and government.

Findings from both the literature and primary research show that the fundamentals of effective varroa management are well understood. Monitoring, treatment timing, chemical rotation, and awareness of reinvasion risk are all widely recognised. However, how consistently these are applied varies significantly. The key influences on this consistency can be grouped as follows:

- **Operational pressures** such as time, labour, and financial constraints, which affect the ability to monitor regularly and apply treatments at the right time
- **Behavioural factors**, including confidence, experience, and stewardship beliefs, which contribute to a gap between knowing what to do and consistently doing it
- **System-level influences**, particularly reinvasion and neighbouring beekeeper practices, which mean outcomes are interconnected rather than isolated
- **Lack of coordination across the sector**, with limited alignment in treatment timing, monitoring approaches, and resistance management

Taken together, the findings show that varroa management is not simply a technical challenge, but one shaped by behavioural, operational, and wider system dynamics. Improving long-term outcomes will depend less on developing new tools, and more on strengthening consistency in how existing management practices are applied across the sector. The findings also suggest that ongoing inconsistency creates wider risks for long-term treatment effectiveness, reinvasion pressure, and overall industry resilience.

The recommendations focus on practical, low-cost steps that reflect how the industry operates. The key actions include:

- Improving regional communication and visibility of mite pressure and treatment timing
- Encouraging regular engagement between neighbouring operators
- Promoting voluntary sharing of management approaches to lift overall consistency
- Supporting simple, practical tools to improve day-to-day decision-making
- Taking a staged approach toward stronger industry alignment over time

Looking ahead, there is an opportunity to build on these initial steps over time. This could support stronger regional coordination, improved information sharing, and greater alignment across the sector. Importantly, meaningful progress does not necessarily require large-scale investment or immediate regulatory intervention. Instead, it can begin through practical actions that improve communication, build trust, and support more consistent management behaviour. Achieving this will require involvement across the wider industry, including commercial and non-commercial beekeepers, regional operators, industry organisations, suppliers, advisors, researchers, and training providers working together toward more consistent and coordinated varroa management practices.

Overall, this research finds that consistency in varroa management is shaped by the interaction between individual decision-making and wider system influences. Addressing this variability will be key to improving varroa control and supporting a more resilient and aligned apiculture sector in New Zealand.

Acknowledgements

I knew about the Kellogg Rural Leadership Programme for a while, but I never really thought to apply until I did. Once I investigated it properly and did a bit of research on the programme, it just clicked. Reading through past reports and seeing the sort of people involved, I thought this is right up my alley and exactly what I needed at this point in my career.

The application process was straightforward and smooth and being accepted on my first attempt was an exciting moment. From there, I was keen to get stuck in and take the opportunity to develop myself, particularly in leadership and personal growth.

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The calibre of the programme itself really stood out. It is the best development experience I've been a part of. The exposure and networking you get through Kellogg is something I hadn't experienced before, and it went well beyond what I expected going into it. The range of people involved across the rural sector, different roles, and different stages of their careers really opened my eyes. One of the biggest takeaways for me is how much you can learn from people at all levels and from completely different perspectives.

To cohort 55, thank you. It's been a great experience to be part of the programme alongside you all. Seeing everyone develop, share ideas, and bring different perspectives has been something special. I've taken a lot from the conversations and the way people approach things, and I wish nothing but the best for all of you moving forward.

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1.0 Introduction

Honeybees play a critical role in New Zealand's agricultural and ecological systems through the pollination services they provide to pastoral, horticultural, and arable industries. The sustainability of these services is increasingly threatened by the parasitic mite *Varroa destructor*, first detected in New Zealand in 2000 and now established nationwide. Varroa is widely recognised as the most significant biological threat to managed honeybee populations, weakening colonies through parasitism and virus transmission and ultimately causing colony collapse if not effectively controlled.

Recent national monitoring reinforces the ongoing impact of this threat. Data from the 2025 New Zealand Colony Loss Survey estimated winter losses at 12.8% (Ministry for Primary Industries [MPI], 2025), with varroa remaining the leading reported cause of colony loss. While overall loss percentages fluctuate between seasons, the continued dominance of varroa as the primary driver of mortality highlights its persistent influence on beekeeper outcomes and sector stability.

The financial implications of these losses are substantial. Using data from the 2021 national colony loss survey, winter colony losses were estimated to cost commercial beekeepers approximately $24,181,835, equating to $38.04 per managed colony in 2021 dollars (Stahlmann-Brown et al., 2023, p.186). When adjusted for inflation using the New Zealand Consumer Price Index, this per-colony cost is equivalent to approximately $46 per managed colony in 2026 dollars (Statistics New Zealand, 2026). This adjustment illustrates that the economic burden of colony loss remains significant in present-day terms and reinforces the importance of sustained and effective varroa management.

In New Zealand, varroa control largely relies on beekeeper-led decision-making, including monitoring practices, treatment timing, and miticide selection. However, variability in management approaches, treatment consistency, and monitoring thresholds may contribute to uneven control outcomes and an increased risk of reinfestation and the development of resistance. Because varroa spreads through bee drift, robbing, and hive movement, inadequate control by individual operators can have consequences beyond a single apiary, influencing disease pressure across neighbouring operations and the wider apiculture system. This creates a collective action challenge, where individual management decisions contribute to system-wide disease pressure and influence outcomes beyond the boundaries of a single operation.

Given the importance of bee pollination for agricultural production and the central role of varroa in colony losses, there is a clear need to better understand the factors influencing consistency in varroa management practices and how greater alignment across the sector might be achieved. Improving consistency in monitoring, treatment thresholds, and management planning may contribute to more effective varroa control, reduced colony losses, and increased resilience across New Zealand's apiculture sector (Goodwin & Haine, 2007; Vallance et al., 2024). This research therefore explores the behavioural, operational, and structural factors shaping varroa management planning among New Zealand beekeepers and identifies approaches that could support more consistent and effective control outcomes.

1.1 Research question

Building on this, the focus of this project is to understand what influences consistency in varroa management across New Zealand's beekeeping sector, and how greater alignment could be supported to improve colony survival and reduce variability in losses year to year.

The study looks at how varroa management decisions are made in practice, including monitoring frequency, treatment timing, threshold use, and product selection. It also explores the factors that shape these decisions, such as knowledge levels, operational constraints, and access to information and advice.

The scope includes engagement with commercial, semi-commercial, and non-commercial beekeepers, also industry representatives, suppliers, and government-type roles, alongside analysis of existing literature and industry data. It also considers the role of education, training, and advisory systems, and how these influence management behaviour across different parts of the sector.

Rather than testing specific treatments or biological responses, this research focuses on the behavioural, operational, and system-level factors that influence how consistently varroa is managed. The aim is to identify practical approaches that could strengthen alignment and support more effective, coordinated control across the industry.

Research Question:
What influences consistency in varroa management planning among New Zealand beekeepers, and what approaches could strengthen it to improve varroa control outcomes?

2.0 Literature Review

While the biological mechanisms of *Varroa destructor* are well understood, the persistence of colony losses suggests that effective control is influenced by more than technical knowledge alone. Existing literature demonstrates that monitoring frequency, treatment timing, chemical rotation, reinvasion pressure, stewardship beliefs, and wider behavioural factors all influence management outcomes. This chapter examines the biological, behavioural, and structural factors shaping varroa management consistency and identifies key gaps that inform this research.

2.1 Colony Loss Trends and Varroa Contribution in New Zealand

National colony loss surveys consistently indicate that honeybee mortality remains a persistent and sector-wide issue in New Zealand. Longitudinal data since 2017 show that winter colony losses have fluctuated but remained consistently elevated, generally ranging between approximately 10% and 13%, with a notable peak during 2021–2022 followed by a partial decline and subsequent increase in the most recent year (Figure 1). This pattern demonstrates the absence of any sustained downward trend and suggests that current management approaches have not achieved consistent control at a national scale. The most recent data from the 2025 New Zealand Colony Loss Survey reported winter losses of 12.8%, equating to approximately 63,435 colonies lost, reinforcing the persistence of the issue (MPI, 2025)

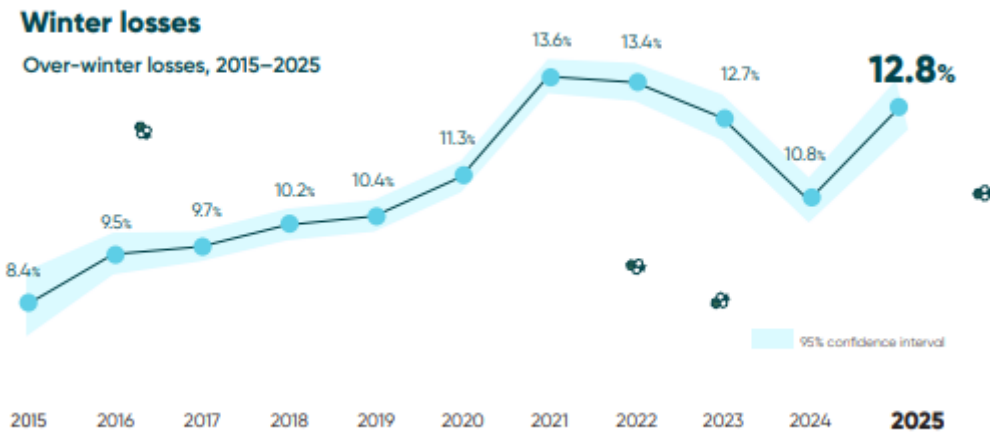

Figure 1. Winter colony losses in New Zealand (2015–2025) (MPI, 2025)

Although colony mortality arises from multiple interacting causes including queen failure, nutritional stress, climatic variability, pesticide exposure, and disease, *Varroa destructor* remains the dominant and most consistently reported contributing factor in New Zealand colony losses. Long-term trends in reported causes indicate that varroa-related losses have increased over time and continue to account for the largest proportion of mortality. In 2025, varroa was associated with approximately 7.0% of all colonies entering winter, substantially exceeding all other reported causes such as queen problems (2.8%), starvation (0.5%), and wasps (0.4%) (Figure 2, MPI, 2025). Recent research further indicates that emerging miticide resistance may be compounding this pressure (McGruddy et al., 2024).

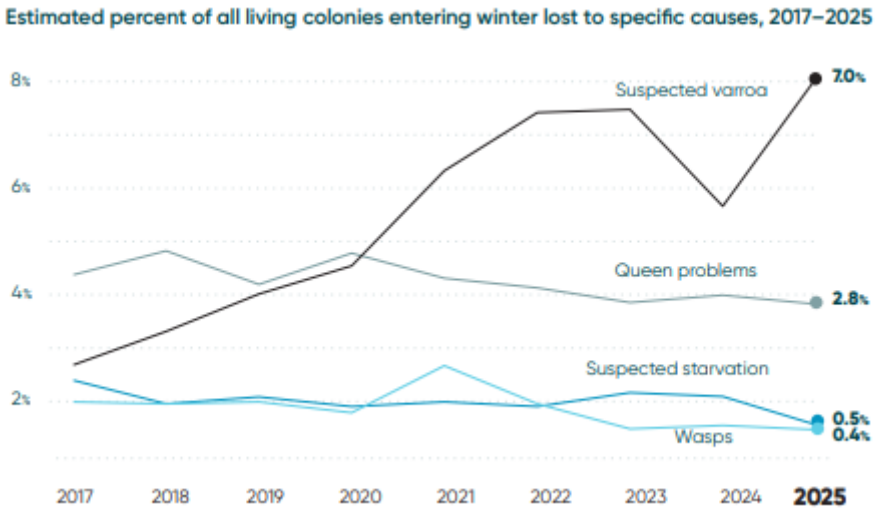

Figure 2. Estimated percentage of colonies lost to specific causes (2017–2025) (MPI, 2025)

The sustained dominance of *Varroa destructor* within national colony loss reporting is particularly significant because it distinguishes environmentally driven mortality from management-sensitive mortality. While environmental stressors may fluctuate seasonally and regionally, varroa infestation levels are strongly influenced by beekeeper management decisions, including monitoring frequency, treatment timing,

threshold interpretation, and chemical rotation practices (Goodwin & Van Eaton, 2001). Contemporary evidence further demonstrates that deviation from recommended treatment windows is associated with increased colony mortality, reinforcing the central role of management consistency in determining outcomes (O'Shea-Wheller et al., 2025).

Importantly, the technical requirements for effective varroa control are well established within both scientific and industry literature (Goodwin & Van Eaton, 2001). Monitoring tools are readily available, treatment windows are widely communicated, and chemical efficacy profiles are clearly documented. The continued prominence of varroa in national mortality data therefore suggests that variability in outcomes cannot be attributed solely to a lack of knowledge. Rather, it indicates inconsistencies in implementation. Effective control requires forward planning, labour allocation, financial commitment, and coordination across seasonal management cycles. Where these inputs are constrained, whether by cost pressures, workforce limitations, time scarcity, or competing operational priorities, adherence to optimal treatment regimens may be compromised.

International research reinforces this interpretation. Across temperate beekeeping systems in Europe and North America, *Varroa destructor* has been widely recognised as the primary underlying cause of colony collapse (Rosenkranz et al,.2010). However, survival outcomes vary substantially depending on the timing, consistency, and coordination of treatment practices (O'Shea-Wheller et al., 2025). These findings suggest that awareness of varroa risk does not always translate into consistent implementation of recommended management practices.

The New Zealand context introduces additional structural complexity into varroa management. The apiculture sector operates within a comparatively high-density apiary landscape, characterised by substantial hive movement associated with pollination contracts and geographically dispersed honey flows (MPI, 2025). Following a period of rapid industry expansion driven in part by strong mānuka honey returns subsequent market contraction has placed sustained pressure on operational margins (Ministry for Primary Industries [MPI] 2023). Under such economic conditions, preventative management activities may be deprioritised relative to immediate production demands. These economic pressures are particularly relevant because reduced profitability may constrain labour availability, delay preventative treatment investment, and reinforce short-term decision-making behaviour.

Reinvasion dynamics further complicate the relationship between individual management and colony survival. Varroa mites can spread between colonies through drifting, robbing, and swarming behaviour, particularly where neighbouring colonies maintain elevated infestation levels. Recent New Zealand research identified that reinvasion pressure was intensified by crowded apiary environments, differing treatment timing between neighbouring beekeepers, unmanaged colonies, and inconsistent management practices across surrounding operations (Vallance et al., 2024). Colonies collapsing from high mite burdens may then act as sources of reinfestation for surrounding apiaries, undermining otherwise well-managed treatment programmes. The same research also highlighted substantial variation in monitoring intensity, treatment timing, and treatment selection across the industry, reinforcing that varroa outcomes are shaped not only by technical recommendations themselves, but also by operational realities and the wider coordination occurring across apiaries and regions.

Together, longitudinal national survey data, biological research, and recent New Zealand industry evidence position varroa as both a biological constraint and a management-dependent risk. The continued prominence of varroa within New Zealand loss reporting indicates that variability in monitoring, treatment timing, reinvasion management, and coordination remains a critical limiting factor in improving colony survival outcomes.

2.2 Evidence-Based Varroa Management Practices

Monitoring is widely recognised as a foundational component of effective *Varroa destructor* management. Scientific and industry literature consistently identifies structured monitoring as essential for estimating infestation levels, optimising treatment timing, and assessing treatment effectiveness (Goodwin & Van Eaton, 2001; Honeybee Health Coalition, 2022). Common monitoring approaches include alcohol washes, sugar shake methods, carbon dioxide testing, and natural mite fall assessments, all of which are designed to estimate internal mite pressure within colonies and support evidence-based treatment decisions.

Monitoring is particularly important because untreated varroa populations can increase rapidly across successive brood cycles, reducing colony health and increasing colony mortality risk if intervention is delayed (Rosenkranz et al., 2010). Within Integrated Pest Management (IPM) frameworks, monitoring functions not merely as a diagnostic exercise, but as a decision-support mechanism guiding threshold-based intervention. IPM approaches emphasise the integration of multiple management strategies, including monitoring, cultural controls, mechanical approaches, and chemical treatments, with the aim of reducing environmental impacts and minimising overreliance on chemical control (Jack & Ellis, 2021).

The distinction between threshold-based management and routine calendar treatment is particularly important in varroa management due to the mite's capacity for rapid population growth and reinvasion pressure (Goodwin & Van Eaton, 2001). Recent New Zealand monitoring guidance has similarly highlighted that "treatment by the calendar" may set beekeepers up for failure where reinvasion pressure, seasonal variability, and changing infestation dynamics are not continually assessed (Hall & Pragert, 2023). Monitoring conducted over time, rather than as isolated one-off measurements, allows beekeepers to better understand infestation trends and identify when additional intervention may be required.

Monitoring also provides important feedback on treatment effectiveness. Post-treatment assessment enables beekeepers to identify residual mite loads, ineffective application, or potential resistance issues before colonies reach damaging infestation levels (Honeybee Health Coalition, 2022). This is particularly important given increasing international concern regarding chemical overreliance and the development of miticide resistance within varroa populations (Jack & Ellis, 2021). Repeated chemical use without verification of efficacy may accelerate resistance development and weaken long-term control strategies.

However, widespread endorsement of monitoring within scientific and industry literature does not necessarily translate into consistent field implementation. Monitoring requires time, labour, equipment, and confidence in interpretation. New Zealand research has highlighted that monitoring methods considered highly accurate may also be difficult to deploy consistently at commercial scale, increasing the likelihood that monitoring is delayed, conducted inconsistently, or omitted altogether (Hall & Pragert, 2023). For commercial operators managing large hive numbers, conducting regular alcohol washes or sugar shake assessments across representative apiaries requires substantial logistical planning and workforce capability. Smaller-scale or non-commercial beekeepers may face different barriers, including uncertainty around threshold interpretation or reduced confidence in acting on monitoring results.

Recent New Zealand research reinforces these implementation challenges. Focus group research conducted through Project Varroa identified substantial variation in monitoring intensity and monitoring approaches across the sector, ranging from systematic whole-apiary assessment through to minimal or absent monitoring practices (Vallance et al., 2024). Some participants relied heavily on structured monitoring programmes, while others reported relying primarily on visual estimation or routine treatment without measurement. The research also highlighted that operational pressures, labour constraints, treatment costs, and reinvasion concerns influenced monitoring behaviour and treatment decision-making across both commercial and hobbyist operations (Vallance et al., 2024).

At a systems level, variability in monitoring behaviour has broader implications beyond individual colony survival. Delayed detection, inconsistent monitoring, and poorly timed intervention may contribute to elevated infestation pressure and increased reinvasion risk across surrounding apiaries, particularly within high-density beekeeping environments (Vallance et al., 2024). Monitoring discipline therefore contributes not only to individual colony health outcomes, but also to wider landscape-level varroa management effectiveness across the apiculture sector.

2.3 Treatment Timing and Colony Survival

Treatment timing has emerged as a critical determinant of colony survival within *Varroa destructor* management. Colony outcomes are influenced not only by the treatment product selected, but also by whether treatments are applied within biologically appropriate windows aligned with seasonal mite population dynamics. The biological basis for this relationship is well established. Varroa populations increase rapidly during brood-rearing periods, as mites reproduce within capped brood cells and expand alongside growing worker populations (Goodwin & Van Eaton, 2001). Treatments applied too early may allow mite populations to rebound before winter, while treatments applied too late may result in colonies entering winter with damaging infestation levels.

Maintaining effective seasonal control therefore requires more than routine chemical application alone. Successful treatment timing depends on continual assessment of infestation pressure, brood activity, seasonal conditions, and reinvasion risk. New Zealand guidance has cautioned against rigid calendar-based treatment schedules that fail to account for changing infestation dynamics and seasonal variability (Goodwin & Van Eaton, 2001). More recent New Zealand monitoring guidance similarly suggests that "treatment by the calendar" may set beekeepers up for failure where reinvasion pressure and changing environmental conditions are not continually assessed (Hall & Pragert, 2023). Adaptive and monitoring-informed timing is therefore regarded as more sustainable and more closely aligned with Integrated Pest Management (IPM) principles.

Integrated Pest Management approaches emphasise that treatment decisions should be guided by measured mite levels, seasonal colony condition, and risk assessment rather than routine or repeated application alone (Jack & Ellis, 2021). This is particularly important given growing international concern regarding miticide resistance and long-term dependence on chemical control strategies. Repeated or poorly timed chemical applications may increase selection pressure for resistant mite populations and reduce long-term treatment effectiveness (Honeybee Health Coalition, 2022).

However, translating biological knowledge into consistent seasonal planning is not straightforward. Effective treatment timing requires alignment with brood cycles, regional climatic variation, honey flows, pollination contracts, and operational logistics. For commercial operations managing large hive numbers across multiple apiaries, biologically ideal treatment periods may conflict with labour availability, weather events, transport scheduling, and seasonal workload pressures. During periods of reduced honey returns or financial pressure, preventative treatments may also be delayed managing short-term operational costs despite the longer-term risks associated with rising mite populations.

Recent New Zealand research further reinforces these challenges. Focus group research conducted through Project Varroa identified substantial variation in treatment timing practices across the industry, with participants reporting that reinvasion pressure, changing environmental conditions, and differing treatment schedules between neighbouring operations were making traditional calendar-based approaches increasingly unreliable (Vallance et al., 2024). The same research highlighted that operational pressures, treatment expense, labour shortages, and wider management constraints were influencing treatment decisions across both commercial and hobbyist sectors.

The significance of treatment timing and wider varroa management practices is also reflected in recent New Zealand colony loss reporting. Ministry for Primary Industries survey data continues to identify varroa as the leading reported contributor to overwinter colony losses, reinforcing the ongoing challenge of maintaining effective seasonal control across the sector (Ministry of Primary Industries (Figure 3, MPI, 2024).

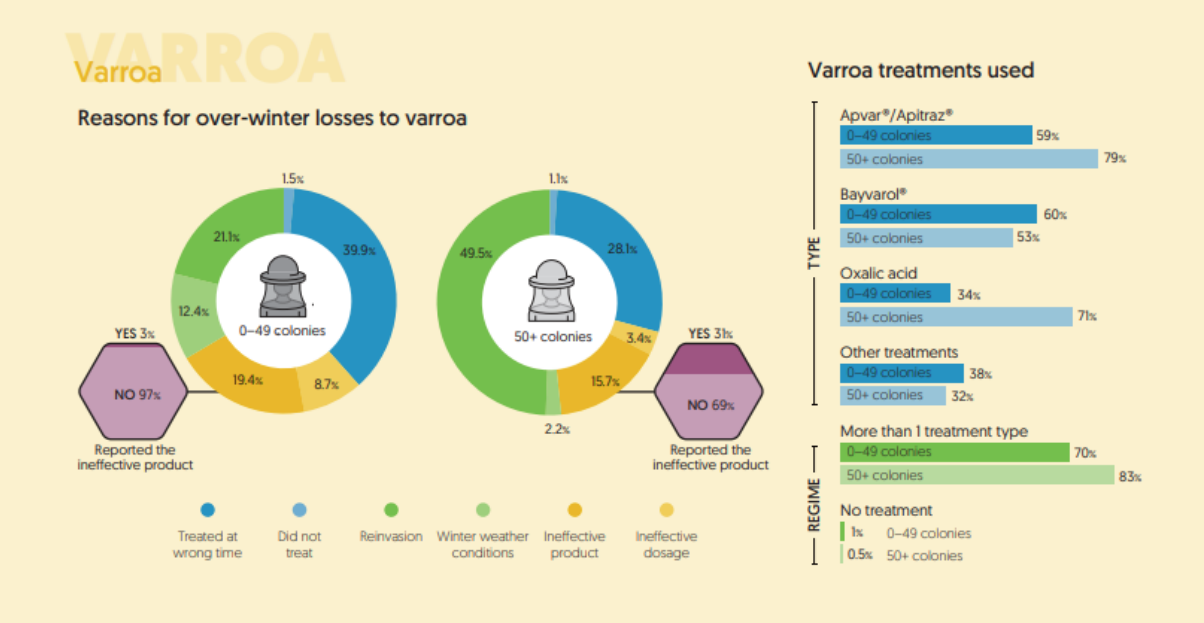

Figure 3. Primary reported contributors to overwinter colony losses in New Zealand apiaries (MPI, 2024).

At a systems level, inconsistent timing between neighbouring operations may further increase reinvasion pressure, particularly within high-density beekeeping regions where untreated or poorly timed colonies contribute to elevated mite loads across surrounding apiaries. Treatment timing therefore influences not only individual colony survival, but also wider landscape-level varroa pressure and the long-term sustainability of available control tools.

2.4 Chemical Rotation and Resistance Development

Resistance development poses a significant long-term threat to the sustainability of *Varroa destructor* management strategies. Resistance occurs when some mites survive chemical treatment due to genetic differences that allow them to tolerate a product that would normally be effective. If the same chemical or chemical class is used repeatedly, surviving mites can reproduce and pass those resistance traits to the next generation, gradually reducing treatment effectiveness over time (Agriculture Victoria, 2026).

This process is particularly important in varroa management because chemical treatments remain a central control tool for many beekeepers. Over successive treatment cycles, repeated reliance on the same active ingredient or mode of action can increase the proportion of resistant mites within a population. As resistance builds, treatments may appear to work less effectively, leaving higher residual mite loads after application and increasing the risk of colony decline.

Importantly, resistance development may not appear as sudden treatment failure. Declining efficacy can occur gradually and may go unnoticed where monitoring is inconsistent. Without post-treatment checks, beekeepers may not identify residual mite levels, poor treatment performance, or early signs of resistance. In response, there is a risk that underperforming treatments are applied more frequently or relied on for longer, which can further increase resistance pressure (Honeybee Health Coalition, 2022).

Resistance management therefore creates a tension between short-term operational convenience and long-term control. Repeated use of a familiar product may be practical, predictable, and easier to manage across large hive numbers, but this approach can conflict with the need to protect treatment effectiveness over time. Effective resistance management requires forward planning, accurate treatment records, post-treatment monitoring, and a willingness to rotate products strategically rather than waiting for visible treatment failure. (Figure 4, *Goodwin & Van Eaton, 2001).*

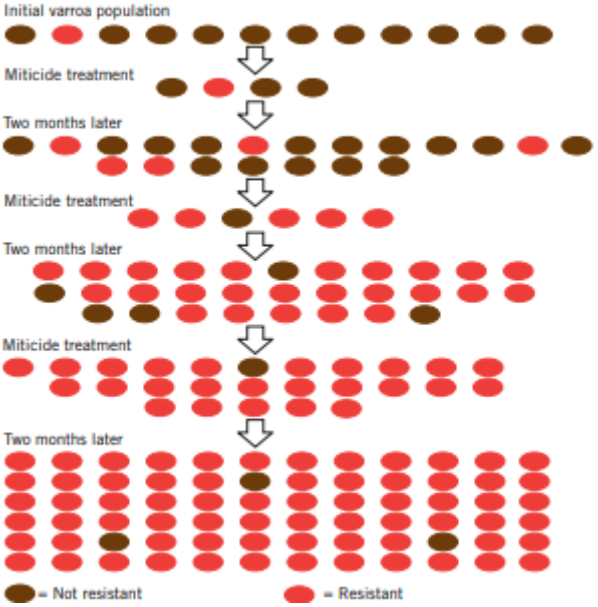

Figure 4. Development of chemical resistance in varroa populations following repeated miticide use (Goodwin & Van Eaton, 2001).

Resistance management has become a critical component of long-term varroa control. To reduce resistance risk, both New Zealand and international guidance emphasise chemical rotation across seasons and treatment cycles (Figure 4, Goodwin & Van Eaton, 2001; National Bee Unit, 2020). Rotational strategies aim to minimise repeated exposure to a single mode of action by alternating treatments with different chemical pathways. However, changing product names alone is insufficient where products belong to the same chemical class. The National Bee Unit (2020) cautions that rotation strategies must consider chemical groups and the potential for cross-resistance, particularly where treatments share similar modes of action.

Despite the availability of this guidance, consistent implementation remains challenging. Effective rotation requires beekeepers to maintain accurate treatment records, recognise chemical classes, interpret monitoring results, and retain access to suitable alternative products. Were economic constraints, product availability, labour pressure, or operational uncertainty influence decision-making, short-term practicality may take priority over strategic chemical diversity. In this context, resistance management is not solely a technical issue, but also a behavioural and operational challenge shaped by adoption decisions, operational pressures, and treatment practices (Traynor et al., 2020).

Resistance also carries collective implications across the wider apicultural system. Once resistant mite populations become established within a region, treatment efficacy may decline across multiple operations. Individual decisions regarding treatment choice, monitoring, and chemical rotation therefore contribute to broader sector-level sustainability. Resistance should consequently be understood not only as a biological process, but also as a cumulative outcome of management behaviour across the apicultural landscape. Examining how beekeepers interpret rotation guidance, perceive resistance risk, and prioritise long-term mitigation within operational constraints is therefore central to understanding the durability of varroa control strategies in New Zealand.

2.5 Reinvasion and Neighbouring Beekeeper Effects

Reinvasion, or mite drift, remains one of the most persistent and operationally challenging aspects of *Varroa destructor* management. Even where treatment protocols are correctly timed and technically effective, colonies may experience renewed infestation pressure through the movement of mites from neighbouring hives (MPI, 2024). This dynamic complicates control efforts and can undermine otherwise well-managed treatment programmes.

Reinvasion occurs primarily through natural honeybee behaviour. Worker bees may drift between neighbouring colonies, particularly in densely stocked apiaries, facilitating horizontal mite transmission. Robbing behaviour, where bees from stronger colonies exploit weakened or collapsing hives, can also result

in substantial mite transfer during periods of elevated infestation pressure. New Zealand guidance and practitioner observations similarly identify drifting and robbing as significant pathways for mite dispersal between colonies and surrounding apiaries (Goodwin & Van Eaton, 2001; Oliver, 2016).

Research demonstrates that apiary density and colony proximity influence infestation dynamics. Closely grouped colonies are more vulnerable to drifting and reinfestation, particularly during late-season periods when mite levels are elevated and colonies begin weakening ahead of winter (Peck & Seeley, 2019). Reinvasion has also been observed beyond individual apiaries, indicating that mite movement can operate across wider landscapes rather than remaining confined to single operations.

Within the New Zealand context, where commercial and non-commercial operations often exist in close geographic proximity, reinvasion risk is likely heightened in some regions. Drifting, robbing, and unmanaged colonies are recognised contributors to reinfestation pressure, particularly where monitoring practices and treatment timing vary between neighbouring operations (Goodwin & Van Eaton, 2001; MPI, 2024; Vallance et al., 2024).

Reinvasion introduces a strong collective dimension to varroa management. Because mite transmission occurs across apiary boundaries, variability in monitoring, treatment timing, or treatment effectiveness within one operation may increase infestation pressure for surrounding beekeepers. This creates a situation where strong individual management effort does not always guarantee stable control outcomes if neighbouring colonies remain poorly managed or untreated.

Seasonal timing further intensifies this challenge. Autumn represents a critical period when mite populations peak and colonies prepare for winter. Reinvasion during this period may rapidly increase infestation levels and compromise overwinter survival (Goodwin & Van Eaton, 2001; MPI, 2024). Practitioner observations similarly describe colonies experiencing rapid reinfestation following the collapse of nearby unmanaged hives (Oliver, 2016). These dynamics highlight the interconnected nature of infestation pressure across the wider apicultural landscape.

Effective mitigation may therefore depend not only on individual management quality, but also on communication and coordination between neighbouring operations. Shared treatment windows, transparency around infestation pressure, and greater regional alignment of monitoring practices may help reduce reinvasion-driven variability. Without greater coordination, reinvasion is likely to remain a persistent source of instability within varroa control systems.

Reinvasion may also increase viral transmission pressure within and between colonies. Research has demonstrated a close relationship between *Varroa destructor* infestation and the amplification and spread of Deformed Wing Virus (DWV), reinforcing the broader biological consequences of uncontrolled mite movement across apiaries (Piou et al., 2022).

Reinvasion should therefore be understood not only as a biological transmission mechanism, but also as a behavioural and organisational coordination challenge. Its persistence reinforces the need to examine management consistency beyond individual colonies and toward the wider apicultural landscape. Understanding beekeeper perceptions of neighbouring risk, willingness to coordinate, and attitudes toward collective standards is therefore central to evaluating the feasibility of strengthened sector-wide varroa control. Recent New Zealand research further supports this perspective, indicating that reinvasion pressure is strongly influenced by variability in beekeeper behaviour, including inconsistent treatment timing, absent treatment, and the presence of unmanaged or poorly managed colonies within shared landscapes (Vallance et al., 2024).

2.6 Stewardship, Responsibility and Management Behaviour

Management decisions in apiculture are influenced not only by technical knowledge and access to treatment tools, but also by how beekeepers understand responsibility for colony health, chemical use, and long-term sustainability. Awareness of varroa risk does not always translate into consistent behaviour, with monitoring frequency, treatment timing, and chemical rotation often varying considerably between

operations. Similar patterns have also been identified in Australian research, where beekeeper attitudes towards chemical use, treatment responsibility, and management approaches were shown to influence responses to varroa control and preparedness (Sattler et al., 2026).

New Zealand guidance developed following the arrival of *Varroa destructor* highlighted that effective long-term control would require significant changes in beekeeper practice, including regular monitoring, strategic treatment timing, resistance awareness, and greater planning discipline (Goodwin & Van Eaton, 2001). These changes represented more than technical adjustments alone, requiring many beekeepers to shift away from historically lower-intervention approaches toward more structured and proactive forms of hive management.

Recent New Zealand reporting continues to demonstrate substantial variation in varroa outcomes across the sector. The Ministry for Primary Industries [MPI] (2024) Colony Loss Survey identified incorrect treatment timing, reinvasion, poor treatment performance, and inconsistent practices as major contributors to colony losses. These findings suggest that differences in outcomes are influenced not only by access to information, but also by how consistently recommended practices are implemented in practice.

Research has also highlighted that beekeeping is shaped by broader ideas of stewardship, care, and environmental responsibility, with beekeepers often viewing their role as extending beyond production outcomes alone (Maderson & Elsner-Adams, 2024). Stewardship within beekeeping involves balancing colony health, environmental considerations, chemical use, and long-term sustainability across interconnected landscapes and communities. Research by Thoms et al. (2019) further demonstrated that stewardship beliefs within beekeeping are not always interpreted consistently. Their research identified differing views around what constitutes "good" beekeeping practice, with some beekeepers associating stewardship with minimal intervention and reduced chemical use, while others viewed stewardship as requiring active hive management to maintain colony health and survival. These differing beliefs influenced willingness to treat for varroa and highlighted how management behaviour may be shaped not only by technical knowledge, but also by underlying values and perceptions of responsibility.

Similar themes were identified by Sattler et al. (2026), who found that beekeeper attitudes towards treatment approaches, chemical intervention, and management responsibility influenced preparedness and responses to varroa management in Australia. Together, these findings reinforce that varroa management operates not only as a technical challenge, but also as a behavioural and values-based issue shaped by how beekeepers understand their role in protecting colony health and managing wider impacts across surrounding apiaries and environments.

This introduces an important stewardship dimension within varroa management. Decisions around monitoring frequency, treatment timing, chemical rotation, and reporting treatment failure influence not only individual colony outcomes, but also infestation pressure across neighbouring operations. Delayed treatment, inconsistent monitoring, or unmanaged colonies within one operation may undermine surrounding control programmes through reinvasion and increasing mite pressure. In this context, stewardship involves recognising that individual management decisions may influence the effectiveness and long-term sustainability of varroa control beyond a single operation.

Operational realities further complicate these decisions. Commercial beekeepers managing large hive numbers often operate under labour constraints, pollination commitments, weather pressures, and logistical demands that can influence monitoring discipline and treatment timing. Smaller-scale or non-commercial beekeepers may face different challenges, including lower confidence in monitoring interpretation, reduced access to advisory support, or differing views around chemical intervention. Similar behavioural variation was identified by Sattler et al. (2026), where differing attitudes towards treatment approaches and management responsibility influenced beekeeper responses to varroa control measures. While these pressures differ between operations, they contribute to substantial variation in how recommendations are interpreted and applied.

Research has demonstrated that reinvasion and movement of mites between neighbouring colonies and apiaries can rapidly increase infestation pressure, even where treatment has previously been applied effectively (Greatti et al., 1992). New Zealand guidance similarly recognises that drifting, robbing, and unmanaged colonies may compromise otherwise effective control programmes through reinfestation pressure and inconsistent treatment timing (Goodwin & Van Eaton, 2001). These dynamics reinforce that

varroa outcomes are shaped not only by individual treatment decisions, but also by management practices occurring across surrounding apiaries and regions.

Viewed this way, varroa management extends beyond technical treatment decisions alone and reflects broader questions of stewardship, collective responsibility, and long-term sustainability across the apicultural system (Maderson & Elsner-Adams, 2024). Understanding these behavioural and operational influences is therefore critical to explaining why outcomes continue to vary across New Zealand's apiculture sector.

This perspective supports examining varroa management not only as a biological challenge, but also as a behavioural and system-level coordination issue shaped by the interaction between beekeeper decision-making and the wider apicultural environment.

2.7 Behavioural Drivers of Management Consistency

Findings from the New Zealand Colony Loss Survey provide important insight into the behavioural and system-level factors shaping *Varroa destructor* management outcomes. While overall colony losses declined in 2024, the underlying drivers of loss highlight persistent inconsistency in management practices and reinforce the role of both individual decision-making and wider industry dynamics (MPI, 2024).

At an individual level, beekeeper behaviour plays a significant role in shaping varroa management outcomes. Research and industry guidance suggest that variability in monitoring practices, threshold interpretation, and treatment timing can influence the effectiveness of varroa control strategies (Goodwin & Van Eaton, 2001). Differences in decision-making and management planning may therefore contribute to inconsistent outcomes across beekeeping operations.

In addition to variability in decision-making, behavioural patterns relating to system engagement are also evident. The survey reports that when treatment products were perceived to be ineffective, most beekeepers did not report this to authorities or manufacturers (MPI, 2024). This lack of reporting weakens feedback loops within the system, reducing the ability to identify emerging resistance or product performance issues. Guidance from Agriculture Victoria similarly notes that repeated use of underperforming treatments may accelerate resistance development where ineffective products continue to be relied upon (Agriculture Victoria, 2026).

Beyond individual behaviour, the survey provides clear evidence that varroa management is influenced by collective dynamics across the wider beekeeping system. Commercial beekeepers most frequently identified reinvasion as the primary driver of colony loss (Figure 5, MPI, 2024). This highlights the extent to which individual outcomes are affected by neighbouring practices and indicates that even effective individual management may be undermined by lack of alignment across surrounding apiaries. New Zealand guidance similarly identifies drifting, robbing, and unmanaged colonies as important contributors to reinfestation pressure and inconsistent varroa control outcomes (Goodwin & Van Eaton, 2001; MPI, 2024).

The survey also highlights structural features of the industry that may limit coordination. A notable proportion of beekeepers operate in relative isolation, with 27% of non-commercial and 11% of commercial beekeepers described as essentially solitary (MPI, 2024). This fragmentation reduces opportunities for shared learning, communication, and coordinated action. At the same time, while biosecurity is framed as a shared responsibility system, beekeepers expressed lower confidence in the system's ability to eradicate pests and diseases (MPI, 2024), indicating a disconnect between collective responsibility and perceived system effectiveness.

Taken together, these findings reinforce that varroa management is both a behavioural and system-level challenge. Individual inconsistencies in monitoring, timing, and engagement contribute to variability in outcomes, while lack of coordination amplifies these effects through processes such as reinvasion. This positions varroa management as a collective-action problem, where effective control depends not only on individual practice, but also on alignment across the wider beekeeping system (Peshin et al., 2009).

Figure 5. Comparison of industry practices between commercial and non-commercial beekeepers (MPI, 2024).

Broader agricultural adoption research similarly demonstrates that awareness of recommended practice does not automatically translate into implementation. Uptake is often influenced by operational pressures, perceived practicality, workload intensity, financial constraints, and confidence that recommended practices will produce reliable outcomes. Structured pest management systems require monitoring, threshold interpretation, treatment timing, rotation strategies, and post-treatment evaluation to function effectively (Goodwin & Van Eaton, 2001; Honeybee Health Coalition, 2022). These interdependent requirements increase management complexity and may contribute to partial, inconsistent, or reactive implementation where time, labour, or confidence are limited.

Social norms and advisory networks add further layers of influence. Beekeepers, like other primary producers, frequently calibrate management decisions against peer behaviour, trusted networks, and industry expectations. Recommendations perceived as practical, achievable, and aligned with operational realities are generally more likely to be adopted consistently. Conversely, where guidance is viewed as impractical, labour-intensive, or disconnected from operational realities, implementation variability may persist (Oliver, 2016).

These behavioural dynamics are also reflected within the New Zealand context, where variability in implementation has been linked not only to knowledge gaps, but also to operational trade-offs, differing beliefs about treatment necessity, and variation in management discipline across beekeepers (Vallance et al., 2024).

From a systems perspective, uneven adoption carries collective implications. In pest and disease systems where transmission operates across shared landscapes, inconsistent implementation of control measures can reduce overall effectiveness and elevate risk for surrounding operators. Varroa management exhibits similar characteristics, particularly in regions of high apiary density where reinvasion pressure may magnify the consequences of delayed treatment, poor monitoring, or inconsistent management practices. Behavioural variability therefore extends beyond individual colony outcomes and becomes a contributor to wider sector-level infestation pressure.

2.8 Research Gap and Framework

Despite substantial research on the biological dynamics of *Varroa destructor*, including treatment efficacy, resistance development, and reinvasion mechanisms, there has been comparatively less focus on the behavioural and structural factors influencing how consistently varroa is managed across the sector. Existing research clearly demonstrates that monitoring frequency, treatment timing, chemical rotation, and reinvasion pressure are key drivers of colony survival outcomes (Goodwin & Van Eaton, 2001; O'Shea-Wheller et al., 2025; MPI, 2024). However, much of this research remains focused on what works biologically, rather than how management decisions are interpreted and applied in practice.

Research across wider agricultural systems demonstrates that adoption of recommended management practices is influenced by operational complexity, perceived practicality, economic pressure, social norms, and advisory relationships, rather than access to information alone (Ugochukwu & Phillips, 2018). Within beekeeping, stewardship beliefs and perceptions of responsibility have also been shown to influence management behaviour and willingness to intervene for varroa control (Thoms et al., 2019). Similar patterns were identified by Sattler et al. (2025), who found that beekeeper attitudes towards treatment approaches, chemical intervention, and management responsibility influenced preparedness and responses to varroa management in Australia. While these behavioural and structural influences are recognised internationally, they have received comparatively less attention within New Zealand apiculture, particularly in relation to planning discipline, treatment timing, and coordination across neighbouring operations.

National reporting continues to identify varroa as the leading contributor to colony loss in New Zealand (MPI, 2025), yet much of the available data focuses on loss rates rather than the behavioural and operational factors shaping management decisions behind those outcomes. There is limited empirical evidence examining how beekeepers interpret monitoring thresholds, decide when to treat, assess resistance risk, or respond to reinvasion pressure from neighbouring apiaries. Similarly, there is limited understanding of how economic pressure, peer influence, advisory support, and perceptions of shared responsibility influence management consistency across the sector.

These gaps are significant because varroa management operates within an interconnected system rather than at the level of isolated apiaries alone. Reinvasion research demonstrates that delayed treatment or poor monitoring within one operation may increase infestation pressure across surrounding apiaries (Frey & Rosenkranz, 2014). Resistance research similarly shows that repeated management decisions influence long-term treatment effectiveness at a broader scale (Rosenkranz et al., 2010). In this context, consistency of management becomes just as important as the treatments themselves. Without understanding the factors driving variation in practice, even well-supported technical recommendations are unlikely to be implemented consistently.

To address this gap, the study is framed using a socio-technical systems perspective. Varroa management is understood as the result of interaction between biological processes and human decision-making, shaped by economic conditions, operational constraints, advisory systems, stewardship beliefs, and wider industry structures. Monitoring, treatment timing, and chemical rotation are therefore treated not only as technical tasks, but also as behavioural processes shaped by wider system influences.

Within this framework, management consistency is influenced by a range of interconnected factors, including:

- knowledge and interpretation of monitoring data
- economic and labour constraints
- perceived complexity of management practices
- stewardship beliefs and professional identity
- social norms and peer influence
- advisory and extension support
- perceptions of collective responsibility and coordination

Examining varroa management in this way shifts the focus from what works biologically to what enables consistent implementation in practice. It moves the discussion beyond individual treatment decisions toward understanding how management behaviour aligns, or fails to align, across the wider sector.

The themes identified throughout the literature directly informed the design of this study. The survey and interview instruments were structured to explore knowledge–action gaps, economic and time pressures, treatment timing decision-making (O'Shea-Wheller et al., 2025), resistance awareness, stewardship beliefs (Thoms et al., 2019), and wider industry challenges associated with varroa management consistency (Vallance et al., 2024). This approach allows the research to link behavioural drivers with sector-wide outcomes and identify practical mechanisms that may strengthen consistency in varroa management.

Taken together, national survey data (MPI, 2025), international biological research (Rosenkranz et al., 2010), and recent New Zealand behavioural research (Vallance et al., 2024) position varroa as both a biological constraint and a management-dependent challenge. Understanding what influences consistency in management is therefore critical to reducing the ongoing impact of varroa across New Zealand's apiculture sector.

This provides the foundation for examining how behavioural, operational, and system-level factors influence varroa management decisions, and for identifying practical approaches that may strengthen consistency in varroa management planning across New Zealand.

3.0 Methodology

This research investigated what influences consistency in varroa management across New Zealand and explored practical approaches that may strengthen alignment over time. A mixed-methods approach was used, combining a nationwide survey with semi-structured interviews. This approach suited the research question, allowing both identification of broader patterns and a clearer understanding of the factors driving them.

Varroa management is not simply a technical process of applying treatments. It involves judgement, prioritisation, interpretation of monitoring data, labour allocation, financial decision-making, and interaction with neighbouring operators. While biological research outlines what effective control looks like, the variation seen in colony survival outcomes shows that implementation is not consistent. Understanding this required both measurement of reported practices and insight into the reasoning and constraints behind them.

The survey provided sector-wide insight into monitoring frequency, treatment timing, rotation practices, and perceptions of reinvasion risk. It also allowed comparison across operation sizes and highlighted trends in stewardship and coordination. However, survey data alone could not explain why particular behaviours occur. Semi-structured interviews therefore added depth, allowing closer examination of how decisions are made under real seasonal, operational, and commercial pressures.

This research was framed within a socio-technical systems perspective, where varroa management is understood as the result of interaction between biological dynamics and human decision-making within economic and industry structures. Monitoring, timing, and rotation are treated as behavioural processes rather than purely technical tasks. This reflects the literature, which identifies behavioural consistency as a critical but underexplored dimension of varroa control in New Zealand, and aligns with the study's focus on explaining variability in practice.

The research was pragmatic in orientation, with a focus on generating findings that are relevant to beekeepers, industry stakeholders, and sector decision-makers. Methodological choices prioritised practicality, clarity, and depth of interpretation, ensuring the findings remain grounded in real-world beekeeping contexts and capable of informing practical recommendations.

3.1 Participants and approach

The study focused primarily on New Zealand beekeepers managing colonies affected by varroa, including commercial, semi-commercial, and non-commercial operators. Including all three groups was important, as management capacity, hive numbers, labour availability, and economic exposure vary across the sector. These differences influence monitoring discipline, treatment timing, and willingness to follow structured rotation strategies.

While the primary focus was on beekeepers, the study also recognised the role of wider industry participants, including suppliers, scientists, and government or regulatory stakeholders. These groups influence the advisory and operational environment within which varroa management decisions are made and provide useful context for understanding what shapes management consistency in practice.

Survey participants were recruited through a mix of industry channels, including association mailing lists, beekeeper networks, online platforms, and direct outreach through existing industry connections. This included newsletters, social media groups, and word of mouth. This approach reflects the reality of the sector and allowed the survey to reach a broad range of participants. Efforts were made to encourage participation across a range of operation sizes, from large-scale commercial operators through to smaller non-commercial beekeepers, as well as wider industry participants where relevant. This helped ensure the dataset captured variation across different parts of the sector, rather than reflecting a single group.

Interview participants were drawn from a mix of survey respondents who indicated willingness to take part in follow-up interviews, alongside additional industry contacts approached directly to ensure a broader range of perspectives. In total, 12 semi-structured interviews were completed across a range of industry roles, including commercial, semi-commercial, and non-commercial beekeepers, as well as suppliers, scientists, and government stakeholders. This helped capture not only beekeeper decision-making, but also the wider structural, advisory, and behavioural factors influencing management consistency across the sector.

3.2 Survey Design

The survey was developed directly from the key themes identified in the literature review. Each section was designed to reflect the main behavioural and structural drivers influencing varroa management, ensuring the survey stayed aligned with the overall research framework.

The survey covered the following areas:

- Monitoring practices and frequency
- Confidence in monitoring and threshold interpretation
- Treatment timing decision-making
- Chemical rotation and resistance awareness
- Perceptions of reinvasion and neighbouring beekeeper influence
- Economic and labour pressures
- Stewardship beliefs and attitudes toward chemical use
- Perceptions of collective responsibility and coordination

A mix of question types was used to capture both patterns and context. Multiple-choice questions were used to identify common behaviours, such as monitoring frequency or reliance on calendar-based treatment. Rating-style questions were used to explore levels of agreement around responsibility, coordination, perceived barriers, and confidence in planning. Short open-ended questions allowed respondents to expand on their decision-making and any constraints they were working within.

The survey was designed to take approximately five to seven minutes to complete. This reflected the time pressures within the industry and aimed to make it practical for respondents to engage, while still capturing enough detail to support meaningful analysis.

A few questions were added during the data collection period to further investigate themes emerging from early responses and ongoing industry discussion. Consequently, although the survey received a total of **173** participants, sample sizes vary slightly between some survey items and figures presented in the findings.

Some survey questions allowed participants to select multiple responses. As a result, totals and percentages in some figures may exceed total participants.

While the survey relied on self-reported behaviour, this was appropriate given the focus of the study. The aim was to understand how management decisions are made and applied in practice, rather than to directly measure biological outcomes. Self-reported data provided useful insight into how decisions are approached under real-world conditions.

3.3 Interview Method

12 semi-structured interviews were conducted to provide contextual depth across a range of perspectives, including beekeepers, industry participants, and other stakeholders. The interviews allowed for a deeper look into decision-making processes that the structured survey responses couldn't fully capture. For example, while a survey might show that a beekeeper treats at fixed times each year, the interviews helped unpack whether that was a deliberate strategy, driven by time constraints, influenced by advisors, or simply habit.

Interviews explored:

- How monitoring routines are integrated into seasonal workflow
- How treatment timing decisions are prioritised
- Experiences with treatment decline or suspected resistance
- Interpretation of advisory and industry messaging
- Perceptions of neighbouring beekeeper management
- Economic pressures influencing planning discipline
- Attitudes toward voluntary alignment versus more formal coordination

Interviews were conducted via video call and recorded with participant consent. Transcripts were anonymised prior to analysis. Interview questions were approved by the Lincoln human ethics committee with all interviewees providing written consent prior to the interviews.

The interviews added depth to the survey findings and helped strengthen the interpretation. Where variability showed up in the survey, interviews gave insight into the reasons behind it. Where responses appeared consistent, they helped determine whether this reflected structured planning or simply reactive routine.

3.4 Data Analysis

Survey data were analysed using descriptive statistical methods. Frequency distributions were used to identify common monitoring practices, treatment timing approaches, and rotation behaviours. Cross-tabulation was then used to explore differences between commercial and non-commercial operators and to look at how attitudes aligned with reported behaviour.

Survey data were used to identify trends in stewardship across the sector, perceptions of coordination, and key barriers influencing management decisions. While more advanced statistical modelling was outside the scope of this study, the analysis was sufficient to highlight areas of strong alignment, as well as areas where variability across the sector remained.

Interview transcripts were analysed using thematic analysis. Coding was conducted manually and initially guided by key themes drawn from the literature, including knowledge action gaps, economic constraints, management complexity, stewardship, and perceptions of collective responsibility. Additional themes were then identified directly from participant insights as they emerged.

Comparing the mixed methods research and analysis. Where findings aligned, this strengthened confidence in the results. Where they differed, it prompted closer examination of the underlying factors influencing decision-making.

3.5 Study approach

This study drew on both survey and interview data, allowing findings to be cross-checked across different sources. Using both approaches helped build a more complete picture of varroa management practices and reduced reliance on any single dataset. The survey design was also aligned with the conceptual framework, ensuring the data collected directly addressed the research question.

Given my background within the beekeeping sector, I was aware of the potential for prior experience to influence how results were interpreted. While this familiarity provided useful context, it also required a conscious effort to avoid making assumptions. Analysis was approached consistently, with care taken not to favour outcomes that aligned with prior experience. Interview questions were kept open-ended to allow participants to speak freely and minimise any unintended influence.

Participation in the study was voluntary, with all participants informed of the purpose of the research and how findings would be used. Survey responses remained anonymous, and interview transcripts were de-identified prior to analysis.

Given the commercial sensitivity around management practices, findings are presented in aggregated form to protect confidentiality and avoid any potential reputational risk. All data were securely stored and used solely for the purposes of this research.

Ethical approval for this study was granted by the Lincoln University Human Ethics Committee (HEC2026-10).

Use of AI:

AI was used to help edit and improve the clarity, structure, and readability of this report. All research design, the data collection, analysis, the findings results, conclusions, and recommendations were completed by the author. The content, findings, and views presented in this report are the author's own work.

4.0 Findings

This chapter presents the findings from the survey and semi-structured interviews and explores the factors influencing consistency in varroa management planning across New Zealand. Findings are organised into key themes that emerged across both data sets and are aligned with the major themes identified throughout the literature review. The chapter focuses on the behavioural, operational, and sector-wide factors influencing management consistency, alongside potential approaches that may strengthen long-term varroa control.

4.1 Industry Alignment and Coordination

Industry coordination emerged as one of the strongest themes across both survey and interview findings. Survey responses highlighted growing support for greater alignment across the sector, while interview findings provided further insight into why coordination remains difficult in practice.

Figure 6. Results show preferred approaches to improving varroa management consistency nationally, Source: Author's own survey data.

Industry-led standards (Figure 6) received the highest level of support among respondents **n = 56**), compared with fully voluntary education-led approaches **n = 26** and formal regulation **n = 18**, while 25 respondents remained unsure. This suggests a stronger preference for coordinated industry-led approaches over both purely voluntary systems and formal regulatory intervention. This finding is important because it indicates that many participants recognise the limitations of relying solely on individual decision-making, while also showing hesitation toward formal regulation. Support for industry-led standards may reflect a preference for approaches that improve coordination, consistency, and accountability across the sector while still retaining practical flexibility and industry ownership. This has implications for how future varroa management initiatives may be designed and implemented within New Zealand's apiculture industry.

Survey findings also indicated strong support for greater collaboration across the industry. When asked whether sharing aspects of varroa management plans across the sector would improve consistency, most respondents were supportive, with **n = 40** somewhat agreeing and **n = 47** strongly agreeing. In comparison, only a small number disagreed (**n = 8** strongly disagreed and **n = 6** somewhat disagreed), while **n = 21** respondents remained neutral. This suggests many beekeepers are open to greater information sharing and more coordinated planning approaches.

Responses also highlighted some scepticism around whether voluntary approaches alone would be sufficient to protect long-term industry outcomes. The largest proportion of respondents indicated that voluntary approaches were probably not sufficient (**n = 46**), while a further **n = 13** believed they were not sufficient. In comparison, fewer respondents believed voluntary approaches were probably (**n = 15**) or (**n = 9**) sufficient, while **n = 36** remained neutral. This further reinforces broader support for more structured coordination mechanisms.

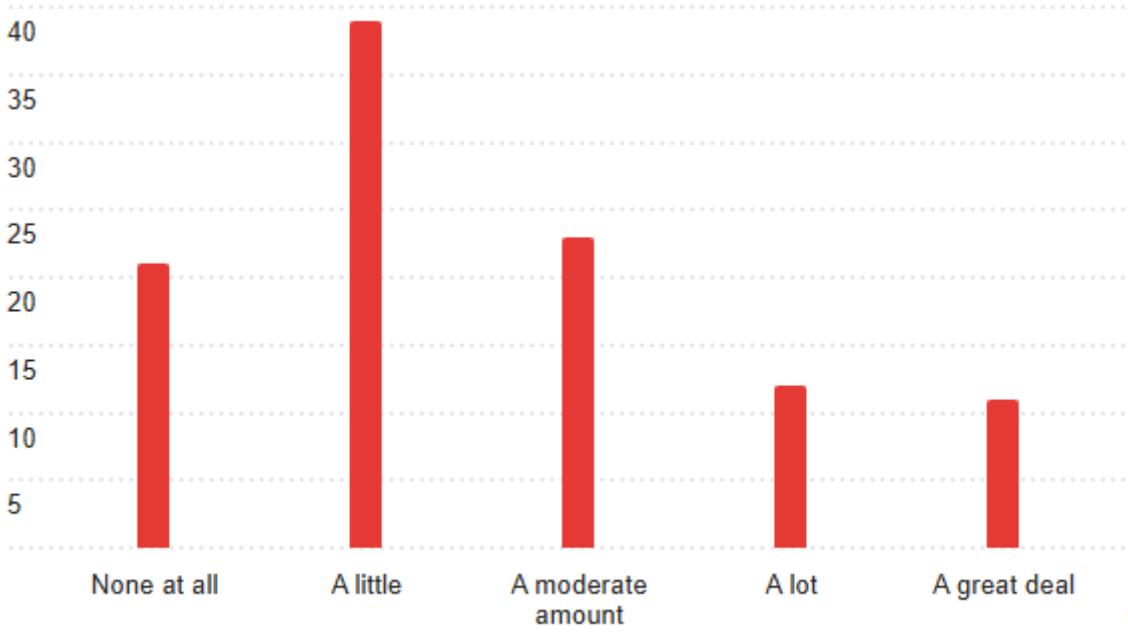

Figure 7. Results highlight respondent perspectives on the perceived influence of neighbouring beekeeping practices on individual varroa management outcomes. Source: Author's own survey data.

Surveys showed mixed perceptions regarding the influence of neighbouring beekeeping practices on varroa management outcomes. The largest proportion of respondents indicated that neighbouring practices influenced their operations a little (**n = 41**), followed by a moderate amount (**n = 25**). However, a notable proportion reported that neighbouring practices influenced their ability to manage varroa a lot (**n = 14**) or a great deal (**n = 13**), while **23** respondents reported no influence at all. Although perceptions varied, these findings are important because they suggest many respondents recognise that varroa management outcomes are not determined solely by individual beekeeper practices. Instead, they reflect the interconnected nature of varroa spread, where neighbouring treatment timing, monitoring discipline, and overall management approaches may influence reinvasion pressure and colony outcomes across surrounding operations. This highlights the potential importance of greater coordination and alignment within the sector to improve long-term varroa control. (Figure 7)

Survey Findings Summary

Support for stronger industry coordination emerged as one of the strongest and most consistent themes across survey findings. Responses indicated that many participants believed varroa management consistency varies significantly across New Zealand, reinforcing perceptions that management approaches differ considerably between operators, regions, and business models. Survey findings suggest many respondents recognise that individual varroa outcomes are increasingly influenced by neighbouring beekeeper behaviour and wider industry fragmentation. While support for formal regulation remained limited, there was clear support for stronger coordination and more structured industry-led approaches.

Support for sharing aspects of varroa management plans further reinforced a willingness among many respondents to improve collaboration, while responses regarding neighbouring beekeeper influence highlighted broader concerns around reinvasion and the interconnected nature of varroa management outcomes.

Interview Findings Summary

Interviews reinforced survey trends while providing greater insight into why alignment challenges persist in practice. Participants consistently described the industry as fragmented, with many suggesting that beekeepers often operate independently rather than within any structured framework.

Several participants noted that informal coordination already occurs in some regions, particularly between neighbouring operators with established relationships. However, these arrangements were often inconsistent and largely dependent on individual relationships rather than formal systems or wider industry alignment.

Reinvasion emerged as one of the most recurring issues discussed throughout interviews. Participants repeatedly described situations where neighbouring beekeeper behaviour directly influenced their own outcomes, particularly where hives were poorly managed, treatment timing differed significantly, or neighbouring operations had abandoned colonies. This reinforced concerns that effective varroa management is often undermined by factors outside an individual beekeeper's control.

Several participants explained that relatively simple communication between neighbouring operators could improve outcomes, particularly around treatment timing, hive movements, and reducing reinvasion risk. However, participants acknowledged that this level of communication remains inconsistent across the sector.

Several interviewees linked current fragmentation to the mānuka expansion period, where rapid hive growth, heightened competition, and commercial secrecy contributed to increasingly siloed behaviour across the industry.

While many participants acknowledged that stronger coordination may be necessary, there was less support for formal regulation. Instead, participants frequently discussed industry-led standards, minimum expectations, and regional coordination models as more realistic pathways for improving consistency.

Several participants also noted that lower hive numbers, reduced stocking pressure, and increasing awareness of varroa risks may create a stronger opportunity for improved collaboration moving forward.

Interviewee Perspectives

> *"Everybody does their own thing."*
>
> *"There's no coordination… it's every beekeeper on his own."*
>
> *"If some don't do the right thing, everyone pays."*
>
> *"Reinvasion is undeniable."*
>
> *"If I'm treating six weeks after you… you could get reinvasion from me."*
>
> *"The industry is in need of strong leadership."*

These findings demonstrate that while varroa is often managed as an individual beekeeper responsibility, outcomes are heavily influenced by surrounding beekeeper behaviour and wider industry practices. This creates a mismatch between individual decision-making and the biological reality of varroa spread, reinforcing the issue as a broader system-level coordination challenge. Industry-led coordination appears to be viewed as a more practical and acceptable pathway than either fully voluntary approaches or formal regulation.

4.2 Treatment Behaviour, Rotation and Management Approaches

Treatment behaviour emerged as a significant source of inconsistency across both survey and interview findings. Survey responses highlighted variation in how treatment decisions are made, while interview findings provided greater insight into the operational challenges influencing treatment timing, application, and long-term management approaches.

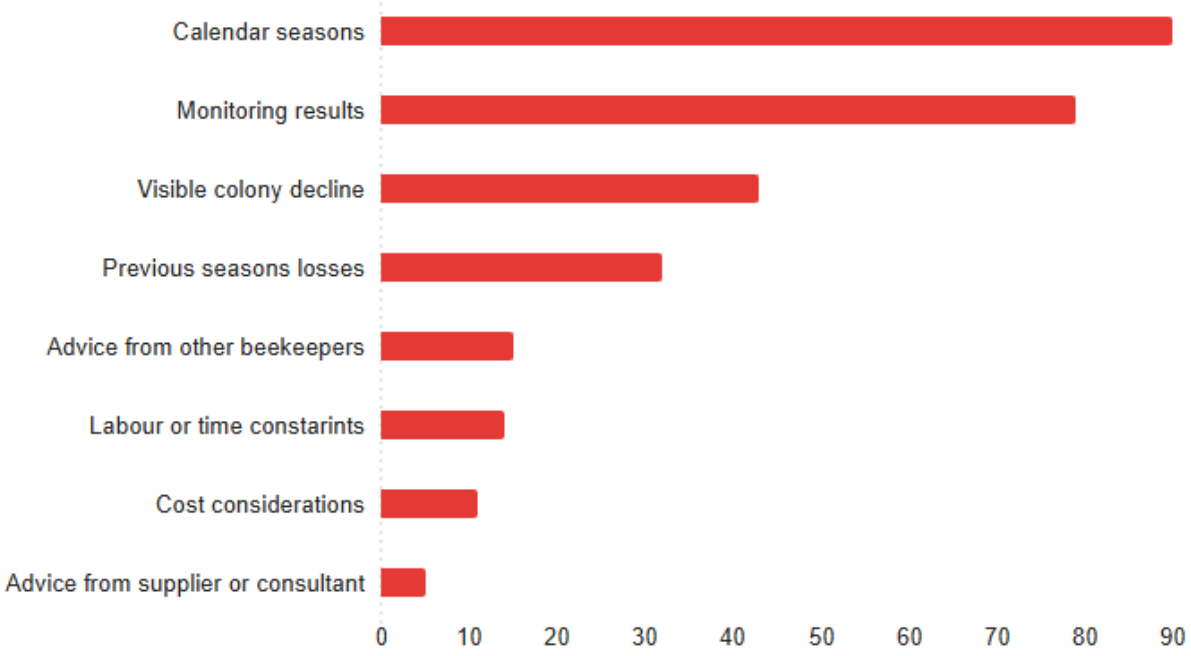

Figure 8. Results highlight respondent perspectives on the key factors influencing treatment decisions for varroa management, (Multiple choice graph). Source: Author's own survey data.

Surveys conducted results showed that treatment decisions were primarily influenced by seasonal timing (**n = 90**) and monitoring results (**n = 79**), indicating that many beekeepers rely on a combination of calendar-based planning and active monitoring when making treatment decisions. Visible colony decline (**n = 43**) and previous season losses (**n = 31**) were also identified as important influences, suggesting that reactive decision-making remains present across parts of the industry. External advice, cost considerations, and labour constraints were reported less frequently, indicating that treatment decisions are largely shaped by operational experience and seasonal management practices. These findings are important because they highlight significant variability in how treatment decisions are made across the sector. While the strong influence of monitoring results suggests many beekeepers are using more adaptive and evidence-based approaches, the continued reliance on visible colony decline and previous losses indicates that some management responses may still occur only after varroa pressure has already increased, In some cases when the level is too high its already too late. This has important implications for treatment effectiveness, colony survival, and long-term consistency in varroa control outcomes across New Zealand's apiculture industry. (Figure 8)

Responses also indicated relatively strong awareness of treatment rotation practices, with most respondents reporting that they rotate varroa treatments every season (**n = 86**) to reduce the risk of resistance. In comparison, smaller proportions reported rotating every two seasons (**n = 11**), rarely rotating treatments (**n = 10**), or sticking to the same treatment plan (**n = 19**). While this suggests a high level of awareness around resistance management, interview participants frequently highlighted that treatment inconsistency often stemmed less from treatment availability and more from issues related to timing, application practices, and broader management discipline.

Reliance on monitoring thresholds was more mixed. While **n = 29** respondents reported always relying on monitoring results or thresholds and **n = 23** reported doing so often, a significant proportion indicated they only sometimes (**n = 20**), rarely (**n = 14**), or never (**n = 16**) relied on thresholds when deciding whether to treat. This suggests that while structured monitoring practices are well established for some operators, treatment decision-making remains inconsistent across parts of the industry.

Survey Findings Summary

Treatment behaviour emerged as a significant source of inconsistency across survey findings. While many respondents reported structured decision-making practices such as treatment rotation and monitoring-based decision making, the results also highlighted ongoing variability in how treatments are timed and applied in practice. The continued reliance on visible colony decline and previous losses as treatment triggers suggests reactive decision-making remains present across parts of the industry, reinforcing broader concerns around treatment consistency.

Interview Findings Summary

Interview findings provided deeper insight into why treatment inconsistency continues across the sector. While most participants acknowledged that effective varroa management requires ongoing treatment throughout the season, there was considerable variation in how treatments were selected, timed, rotated, and applied in practice.

Participants consistently highlighted that traditional spring and autumn treatment programmes are becoming less effective as mite pressure increases. Traditional spring and autumn treatment programmes were frequently described as no longer being sufficient, with many operators now introducing additional summer treatments to reduce mite loads and associated virus pressure before autumn. Some participants described treatment programmes as becoming increasingly year-round as operators attempted to stay ahead of rising mite pressure.

Timing consistently emerged as one of the most critical factors influencing treatment success. Participants repeatedly explained that even effective treatments can fail when applied too late, particularly when mite populations have already reached damaging thresholds. One participant described this as operators often "expecting too much" from treatments by applying them after mite levels had already escalated.

Interview findings also highlighted that commercial beekeepers often understood recommended management practices, but execution remained inconsistent. Rather than a lack of knowledge, participants frequently identified operational challenges such as timing pressures, workload constraints, reinvasion risk, and financial pressures as barriers to effective treatment implementation.

Treatment application was also identified as a recurring issue. Participants described examples of underdosing, incorrect strip placement, and inconsistent product use, all of which reduced treatment effectiveness. Several participants noted that treatment failure was often incorrectly attributed to resistance when poor timing, incorrect application, or weak management discipline were more likely contributing factors, which can lead to resistance issues in the future.

Economic pressure also emerged as an influencing factor. Participants discussed how rising treatment costs may encourage some operators to reduce treatment inputs, rely on cheaper alternatives, or shift toward

organic treatments without fully understanding the increased monitoring and labour requirements that those approaches often demand.

Treatment rotation was widely recognised as important for long-term management, although implementation varied considerably across operations. Some businesses described structured rotation programmes, trialling alternative treatments, and adjusting programmes annually. Others continued relying on familiar routines that were easier to implement but often less responsive to changing conditions.

Larger commercial operators generally described more structured and adaptive treatment systems supported by regular monitoring, product trials, and ongoing adjustments throughout the season. In contrast, simpler treatment approaches were often viewed as easier to manage operationally, but potentially less responsive to rising varroa pressure.

Interviewee Perspectives

> "Timing… that would be the one thing."
>
> "Spring and autumn alone aren't enough anymore."
>
> "We now treat nearly year-round."
>
> "You were just expecting too much from your treatment."
>
> "People were half dosing."
>
> "Two strips instead of four."
>
> "They put treatments in the wrong place."

These findings suggest that treatment inconsistency is driven less by a lack of available treatment options and more by variation in how treatments are timed, applied, monitored, and adapted to changing conditions. As varroa pressure increases, treatment success is becoming increasingly dependent on operational discipline, timing accuracy, monitoring capability, and the ability to adapt management approaches across the season.

4.3 Economic and Operational Constraints

Economic and operational pressures emerged as a recurring theme across both survey and interview findings. While participants identified a range of factors that contribute to inconsistent varroa management, financial pressures, seasonal workload demands, labour constraints, and broader operational complexity were repeatedly identified as significant barriers to consistent implementation.

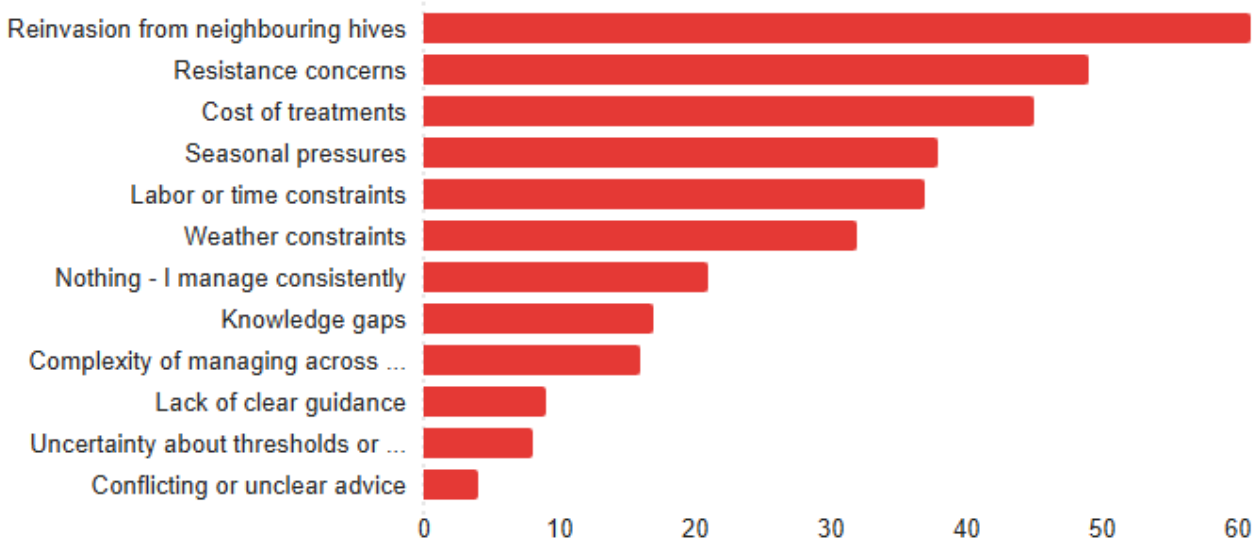

Figure 9. Results highlight broader challenges respondents identified when managing varroa consistently. (Multiple choice graph) Source: Author's own survey data.

The Survey findings highlighted that barriers to consistent varroa management extend beyond economic and operational factors alone. Reinvasion from neighbouring hives emerged as the most identified challenge (**n = 61**), followed by resistance concerns (**n = 49**). Several responses also reflected significant operational pressures, including the cost of treatments (**n = 45**), seasonal pressures (**n = 38**), labour or time constraints (**n = 37**), and weather-related challenges (**n = 31**). These findings are important because they demonstrate that inconsistency in varroa management is influenced by a combination of interconnected system-level pressures and practical on-the-ground constraints. The strong concern around reinvasion and resistance suggests that many beekeepers recognise varroa management outcomes are affected not only by their own practices, but also by the management decisions of surrounding operations. At the same time, operational challenges such as cost, labour availability, seasonal workload, and weather conditions may reduce the ability of beekeepers to consistently apply best-practice management approaches. Together, these findings reinforce the complexity of achieving consistent varroa control across New Zealand's apiculture sector. (Figure 9)

Survey responses provided further insight into why management consistency can decline over time. Time pressure emerged as the most identified reason for reduced consistency (**n = 46**), followed by financial constraints (**n = 28**), reduced perceived risk during certain periods (**n = 25**), and the influence of neighbouring apiaries (**n = 23**). Participants also identified a lack of clear decision thresholds (**n = 15**) and broader operational complexity (**n = 14**) as contributing factors. These findings reinforce that inconsistent varroa management is often influenced by competing operational demands, financial pressures, and changing perceptions of risk, rather than a simple lack of knowledge around recommended management practices.

Survey Findings Summary

Survey findings highlight that economic and operational pressures regularly disrupt the consistent implementation of recommended varroa management practices. While broader system pressures such as reinvasion and resistance remain influential, respondents frequently identified practical barriers including treatment costs, labour demands, seasonal pressures, weather limitations, and competing operational priorities. Time pressure and financial constraints emerged as particularly significant challenges, reinforcing that management inconsistency is often shaped by practical feasibility and operational pressure, rather than simply a lack of awareness around recommended management practices.

Interview Findings Summary

Interview results reinforced survey trends, with participants consistently describing financial pressure, labour demands, seasonal workloads, and broader operational complexity as major barriers to maintaining consistent varroa management practices.

Treatment costs emerged as a recurring concern across multiple interviews. Several participants explained that while treatment costs may appear manageable for smaller operators, they become increasingly significant when applied across large commercial operations managing thousands of hives. Participants also noted that declining honey returns and broader financial pressure across the industry have reduced the ability of some businesses to absorb rising treatment costs. In some cases, participants suggested these pressures may contribute to delayed treatment decisions, reduced treatment inputs, or increased reliance on lower-cost alternatives.

Several participants also discussed the practical difficulty of balancing varroa management alongside other competing operational priorities. Harvesting, hive movements, staffing requirements, queen work, feeding programmes, and general seasonal workloads were frequently identified as competing demands that can reduce the ability to execute treatment programmes consistently.

Labour shortages were repeatedly identified as a significant operational barrier. Participants described the challenge of finding and retaining skilled staff capable of carrying out treatments correctly, particularly during high-pressure periods where multiple operational tasks need to be completed simultaneously.

Weather-related disruptions were also frequently raised. Participants explained that poor weather can delay hive access, disrupt treatment timing, and reduce flexibility during already narrow management windows. In some cases, missing these windows created flow-on effects that impacted broader seasonal planning.

Geographic scale and logistical complexity were particularly challenging for larger commercial operators. Managing treatment programmes across multiple apiaries, coordinating staff across large regions, transporting hives, and ensuring treatments were applied consistently across dispersed operations were all described as ongoing challenges.

Several participants also discussed how reduced perceived risk can influence operational decision-making. During periods where colonies appear healthy or mite levels seem manageable, some operators may delay treatment decisions or prioritise other operational tasks, often creating greater pressure later in the season.

Across multiple interviews, participants repeatedly reinforced that many beekeepers understand what effective varroa management requires. However, maintaining consistency was often described as a practical challenge shaped by financial pressure, staffing limitations, competing operational priorities, and the day-to-day realities of running a beekeeping business, rather than a simple lack of technical knowledge.

Interviewee Perspectives

> *"It's super expensive."*
>
> *"It all adds up pretty quickly when you're running large numbers."*
>
> *"People are just trying to survive."*
>
> *"Weather can throw your whole plan out."*
>
> *"You can have the best plan in the world, but you still need the people to actually do it."*
>
> *"When you're spread across multiple regions, it gets very hard."*

The findings suggest that inconsistent varroa management is often driven by practical feasibility rather than a lack of awareness around recommended practices. Financial pressure, labour shortages, weather disruptions, and competing operational demands can make consistent implementation difficult, particularly for larger operations managing significant hive numbers across multiple locations. This reinforces that improving consistency requires solutions that are not only technically effective, but also operationally realistic.

4.4 Information, Training, and Advisory Systems

Information, training, and advisory systems emerged as a recurring theme across both survey and interview findings. While many participants expressed confidence in managing varroa, survey and interview responses highlighted ongoing concerns around informal learning pathways, inconsistent advice, and limited access to practical training across parts of the industry.

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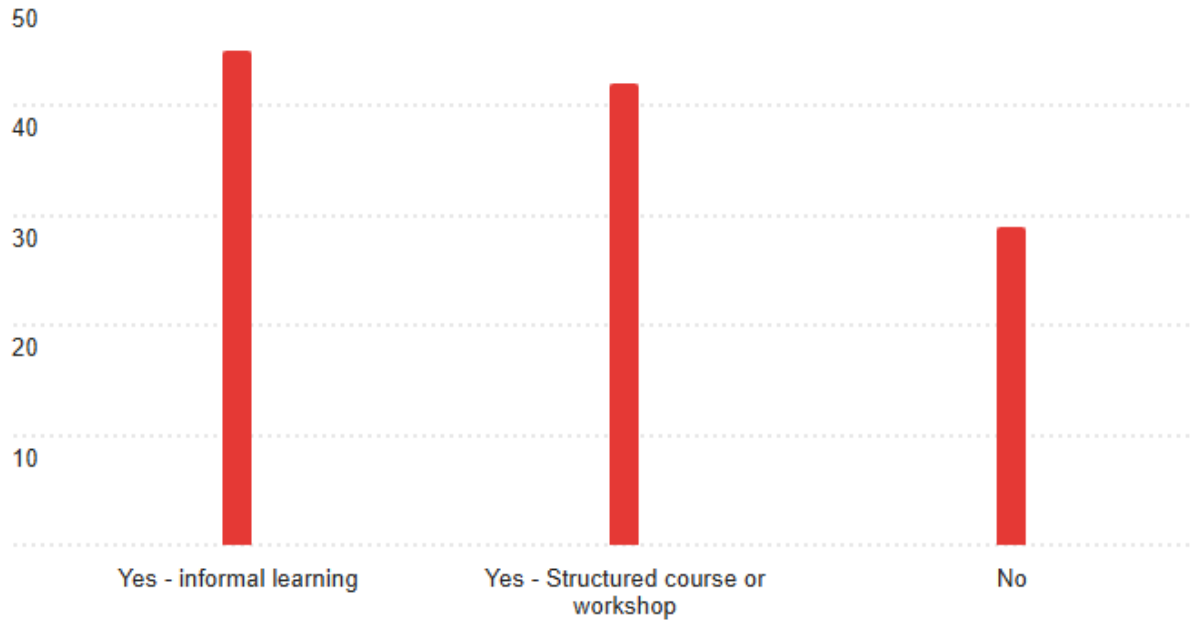

Figure 10. Results highlight respondent experiences with training in varroa management. Source: Author's own survey data.

Survey findings showed varied pathways through which participants had developed varroa management knowledge. Informal learning was reported as the leading of training (**n = 47**), followed closely by structured courses or workshops (**n = 44**). However, a notable proportion of respondents indicated they had received no formal training (**n = 31**). These findings are important because they suggest that access to varroa management knowledge and training remains inconsistent across the industry. The strong reliance on informal learning may indicate that many beekeepers are developing management practices through personal experience, peer networks, and industry discussions rather than through standardised training pathways. While these informal systems can provide valuable practical knowledge, variability in information sources may also contribute to differences in monitoring practices, treatment timing, and overall management consistency. The proportion of respondents reporting no formal training further highlights the potential challenges in achieving aligned varroa management approaches across New Zealand's apiculture sector. (Figure 10)

Survey responses also highlighted strong support for improved training opportunities across the sector.

Comments: "I think informal training is necessary to improve beekeepers' knowledge on varroa"

Most respondents viewed training as an important factor in improving management consistency, with **n = 40** identifying training as extremely important and **n = 45** identifying it as very important. A further **n = 25** viewed training as moderately important, while only a small number considered training slightly important (**n = 8**) or not important at all (**n = 4**). These findings suggest there is broad recognition that improved training could strengthen long-term varroa management outcomes.

Despite this, respondents generally reported high levels of confidence in their own decision-making.

Most respondents indicated they were either very confident (**n = 66**) or moderately confident (**n = 53**) in making varroa management decisions, such as when to treat and what products to use. Smaller proportions reported being only slightly confident (**n = 13**) or not confident (**n = 1**). This highlights an important tension within the findings, where confidence in individual decision-making remains relatively high despite broader concerns around management inconsistency across the sector.

Survey Findings Summary

Survey results suggest that while many beekeepers feel confident managing varroa, training pathways remain highly variable and are often built through informal learning. Strong support for improved training opportunities indicates broader recognition that access to consistent, practical education remains an important component of improving management consistency. At the same time, high levels of self-reported confidence suggest that improving outcomes may depend less on individual confidence and more on strengthening the consistency, accessibility, and quality of information available across the wider industry.

Interview Findings Summary

Interview findings reinforced survey trends while providing greater insight into how information is accessed and applied across the industry.

A lot of participants described learning varroa management through informal pathways, including trial and error, conversations with other beekeepers, supplier advice, online forums, and social media groups. While these pathways were often seen as practical and accessible, participants also acknowledged that the quality of information can vary significantly depending on where advice is sourced.

Supplier advice was frequently identified as highly influential, particularly for smaller operators and newer entrants who often rely heavily on suppliers for guidance around treatment products, application methods, and timing decisions. While many participants valued these relationships, others raised concerns that advice can vary depending on who people speak to.

Conflicting advice was raised repeatedly throughout interviews. Participants described receiving different recommendations from suppliers, experienced beekeepers, scientists, consultants, and online platforms, creating confusion around treatment timing, monitoring approaches, resistance management, and longer-term planning.

Online platforms, particularly Facebook groups, were discussed as both useful and problematic. Participants acknowledged these platforms can provide quick access to advice and peer support, but they also raised concerns around misinformation, conflicting opinions, and inexperienced operators providing advice beyond their level of expertise.

A recurring issue raised throughout interviews was the gap between technical information and practical implementation. While scientific research and technical guidance were viewed as important, participants often felt recommendations did not always translate easily into real-world beekeeping environments where labour constraints, seasonal workloads, weather pressures, and financial limitations also influence decision-making.

Knowledge gaps among hobbyist beekeepers and newer entrants were also raised consistently. Participants expressed concern that some people enter beekeeping without fully understanding varroa biology, monitoring thresholds, treatment application, or long-term resistance management.

Trusted relationships were repeatedly identified as highly important. Many participants placed significant value on advice from experienced operators, respected industry peers, scientists, and suppliers who understood both the technical and operational realities of managing varroa.

Participants also highlighted that while training opportunities do exist, access remains inconsistent and often depends on location, individual motivation, and existing industry connections. A common view across interviews was that the industry lacks consistent baseline expectations around varroa competency.

Across the interviews, a recurring frustration was that information is widely available, but access to practical, consistent, and trusted guidance remains far less reliable.

Interviewee Perspectives

"A lot of people are learning off Facebook."

"Everyone's got an opinion."

"Some of the advice contradicts itself."

"There's plenty of information out there."

"That doesn't mean people know what to do with it."

"New people coming in don't always understand varroa properly."

"Good advice needs to be practical."

These findings suggest that information challenges within the industry are less about a lack of available knowledge and more about inconsistency in how information is accessed, interpreted, and applied. While information is widely available, improving management consistency may require clearer training pathways, stronger baseline competency expectations, and more practical advisory systems that better translate technical knowledge into real-world beekeeping decisions.

4.5 Knowledge–Action Gap and Behavioural Drivers

Behavioural factors emerged as a recurring theme across both survey and interview results. While many participants demonstrated awareness of recommended varroa management practices, both survey and interview responses highlighted ongoing gaps between knowledge and consistent implementation. Reactive decision-making, delayed action, and differing attitudes towards long-term stewardship were frequently identified as contributing factors.

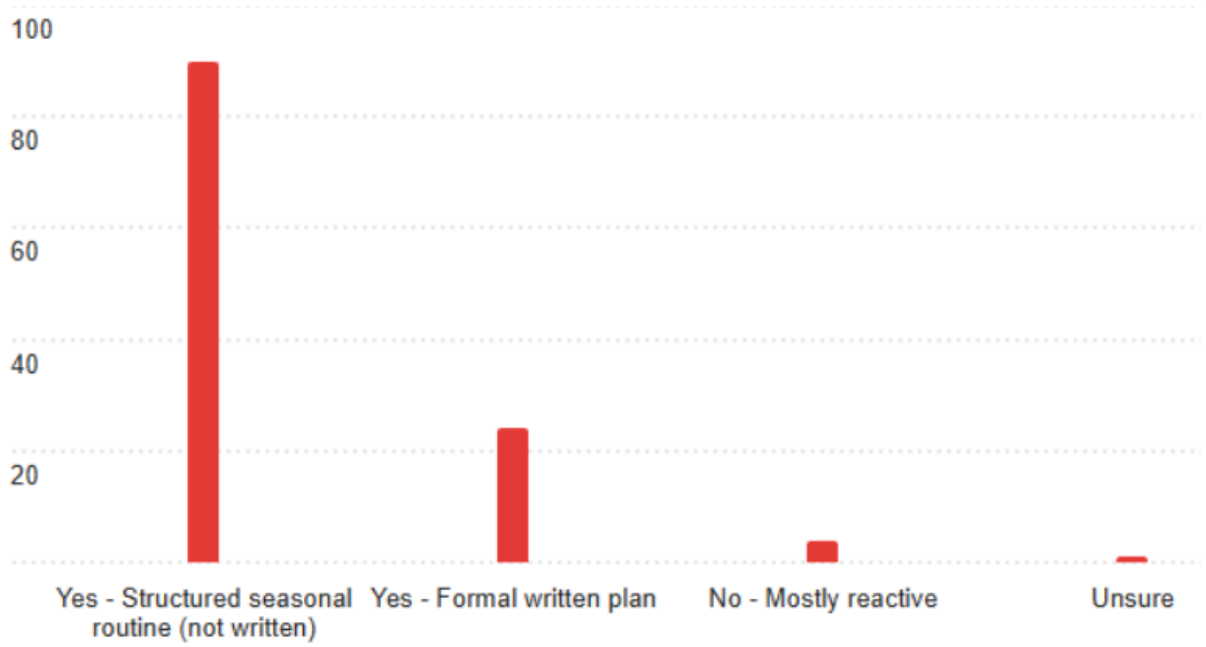

Figure 11. Results highlight respondent approaches to planning varroa management each season. Source: Author's own survey data.

Most of respondents reported following some form of planned approach to varroa management. The largest proportion indicated they follow a structured seasonal routine that is not formally documented (**n = 94**), while **n = 28** reported using a formal written plan. In comparison, only a small number described their approach as mostly reactive (**n = 8**), while **n = 1** respondent remained unsure. These findings are important because they suggest that although many beekeepers consider their varroa management to be proactive, planning approaches are often based on informal routines rather than clearly documented systems. While informal seasonal routines may reflect practical experience and established management habits, the absence of formal planning may also increase the risk of inconsistency in monitoring, treatment timing, record-keeping, and long-term decision-making. This highlights the potential value of more structured planning approaches in supporting greater consistency and coordination across New Zealand's apiculture sector. (Figure 11)

This pattern was reinforced when respondents were asked whether they formally document or plan their varroa management each season. Most respondents indicated they rely on informal planning (**n = 65**), while **n = 31** reported maintaining written plans. However, **n = 23** respondents indicated they do not document or plan their varroa management at all, while **n = 2** remained unsure. This reinforces that while planning is common, formal systems that support consistency are less widely adopted.

Awareness of long-term treatment stewardship was also strong across survey responses. Most respondents either strongly agreed (**n = 77**) or agreed (**n = 35**) that responsible use of varroa treatments is important for maintaining long-term treatment effectiveness across the industry. Only a small number remained neutral (**n = 7**) or disagreed (**n = 1**). This suggests that awareness of resistance management and long-term treatment sustainability is generally well understood across the sector.

Survey Findings Summary

Survey findings suggest that awareness of recommended varroa management practices is generally strong across the industry. Most respondents reported having planned approaches to management and demonstrated strong awareness of long-term treatment stewardship. However, the heavy reliance on informal planning systems highlights a clear gap between knowing what should be done and consistently applying structured management practices over time.

Interview Findings Summary

Interview results reinforced survey trends while providing deeper insight into why knowledge does not always translate into consistent action.

A recurring theme across interviews was that many beekeepers understand the basic principles of effective varroa management, but this knowledge is not always applied consistently in practice. Participants repeatedly described a gap between knowing what should be done and consistently following through with monitoring, treatment timing, and longer-term planning.

Reactive decision-making remained one of the strongest behavioural themes. Many participants described situations where action was often triggered by visible colony decline, elevated mite loads, or significant losses rather than proactive monitoring and early intervention. In many cases, behaviour change was driven by consequence rather than prevention.

Complacency was also raised repeatedly. Participants described situations where strong honey production, healthy-looking colonies, or previous seasons without major losses created a false sense of confidence that current management practices were working. This often-reduced urgency around monitoring and early intervention.

Routine and habit also strongly influenced decision-making. Some beekeepers were described as relying on familiar treatment programmes because they were simple, predictable, and had worked historically. While

this provided operational structure, participants noted it could reduce adaptability when mite pressure changed or treatment performance declined.

Convenience regularly influenced management behaviour. Participants explained that beekeepers are often more likely to adopt management practices that are simpler, cheaper, and require less labour. Where recommended practices were viewed as overly complex, labour intensive, or costly, participants noted adoption often declined.

Short-term thinking also emerged as a recurring issue. Immediate production demands, harvesting pressures, labour shortages, and financial pressures were frequently prioritised over longer-term monitoring discipline and resistance management.

Execution discipline was another major issue raised throughout interviews. Participants described examples of underdosing, incorrect strip placement, inconsistent treatment application, and poor follow-through. In these situations, the issue was often not knowledge, but inconsistency in how known practices were implemented.

Overconfidence was also discussed. Participants described situations where some beekeepers believed they were effectively managing varroa despite limited monitoring, outdated treatment routines, or inconsistent planning.

Capability differences were raised repeatedly across interviews. Participants noted that some operators consistently demonstrated strong planning discipline, regular monitoring, and adaptive decision-making, while others remained highly reactive and struggled to maintain consistency.

Attitudes toward long-term stewardship also varied. While many operators were highly conscious of protecting treatment effectiveness, others were described as prioritising short-term convenience, lower costs, or immediate operational pressures over longer-term sustainability.

Across the interviews, participants repeatedly reinforced that inconsistent varroa management is often shaped less by a lack of knowledge and more by behavioural habits, decision-making patterns, perceived risk, and varying levels of management discipline.

Interviewee Perspectives

> *"That's a very reactive thing… we need proactive rather than reactive."*
>
> *"It's usually when things go wrong."*
>
> *"They continue until they get scared."*
>
> *"If it requires less labour… they'll adopt it."*
>
> *"They just do calendar applications because it works."*
>
> *"They say they don't have time."*

These findings suggest that improving varroa management consistency is not simply a technical challenge, but a behavioural one. While awareness of recommended practices is generally strong, implementation is often shaped by habit, convenience, perceived risk, cost pressures, operational realities, and varying levels of discipline. This reinforces that improving consistency will require approaches that not only increase knowledge but also encourage proactive behaviour and make effective management practices easier to apply consistently.

4.6 Variability in Varroa Management Practices

Variability in management practices emerged as a defining theme across both survey and interview findings. While many participants demonstrated awareness of recommended varroa management principles, significant variation remained in how beekeepers monitored varroa, selected management approaches, and applied seasonal decision-making processes.

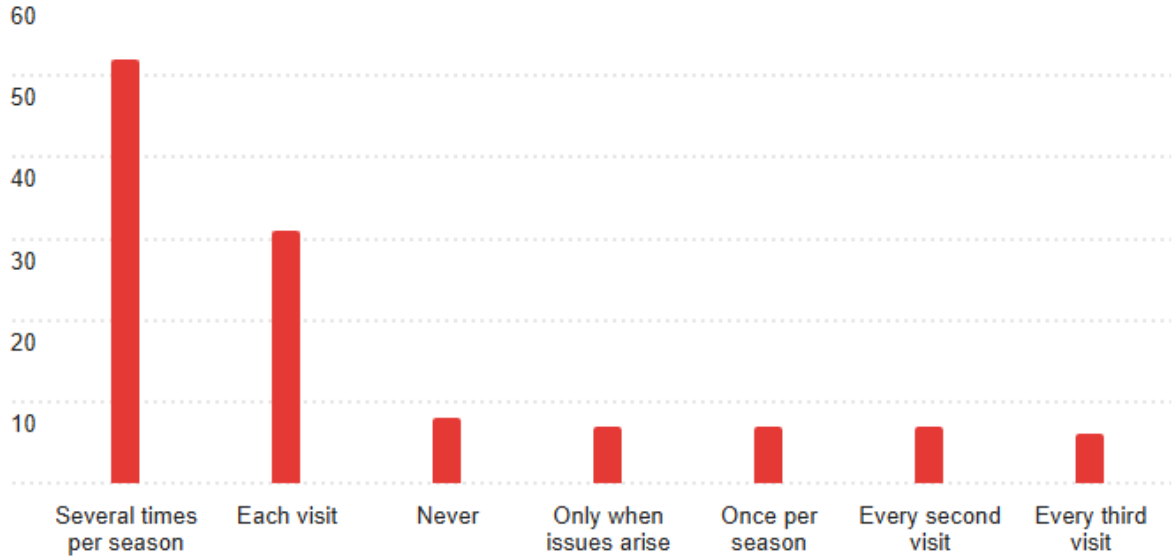

Figure 12. Results highlight how frequently respondents monitor varroa levels. Source: Author's own survey data.

Surveys highlighted significant variation in how frequently respondents monitor varroa levels. The largest proportion of respondents indicated they monitor several times per season (**n = 54**), followed by those who monitor during each hive visit (**n = 33**). However, smaller groups reported monitoring only when issues arise (**n = 9**), once per season (**n = 9**), every second visit (**n = 9**), or every third visit (**n = 8**), while **n = 10** respondents indicated they never monitor. These findings are important because they demonstrate substantial differences in how beekeepers assess and respond to varroa risk across the industry. Frequent monitoring is generally associated with more proactive and adaptive management, allowing treatment decisions to be based on changing infestation levels rather than visible colony decline alone. In contrast, less frequent or reactive monitoring approaches may increase the risk of delayed treatment responses, higher mite loads, and poorer colony outcomes. The variation identified in these findings therefore reinforces wider concerns around inconsistency in varroa management practices and highlights the importance of monitoring as a key component of effective long-term control. (Figure 12)

Variation was also evident in how respondents monitored varroa levels. Drone uncapping (**n = 47**) and alcohol washes (**n = 46**) were the most used methods, followed by sticky boards (**n = 21**), soap washes (**n = 17**), and sugar shakes (**n = 17**). However, **n = 15** respondents indicated that no monitoring method applied to their operation. These findings further highlight the absence of a consistent monitoring approach across the sector.

This broader variability was reinforced across wider survey responses, where many participants indicated that varroa management consistency varies significantly across New Zealand. Collectively, these findings suggest that while recommended management tools are widely available, how they are applied remains highly inconsistent across different operators.

Survey Findings Summary

Survey highlighted that variability remains a defining feature of varroa management across New Zealand. Differences in monitoring frequency, monitoring methods, and broader management approaches suggest that there is no consistent operating model being applied across the industry. This variation contributes to inconsistent outcomes and reinforces broader concerns around long-term varroa control.

Interview Findings Summary

Interview results reinforced survey trends and highlighted the extent of variation that exists across varroa management practices throughout the industry.

A recurring theme across interviews was the significant variation between operators in how varroa is monitored, treated, and managed throughout the season. Participants repeatedly described an industry where management approaches often differ depending on hive numbers, business scale, experience levels, regional conditions, and individual management philosophies.

Differences between commercial, semi-commercial, and non-commercial operators were raised frequently. Larger commercial operators often described more structured systems involving regular monitoring, planned treatment rotations, annual reviews, and greater use of data to inform decision-making. In contrast, smaller operators were often described as relying on simpler systems, informal routines, or more reactive approaches.

Monitoring practices varied considerably. Some operators were described as regularly monitoring mite levels and adjusting treatment decisions based on results, while others monitored infrequently or relied heavily on visual colony performance as an indicator of varroa pressure.

Treatment approaches also varied significantly. Participants described differences in treatment timing, product selection, rotation strategies, and treatment frequency. Some operators were actively adapting their programmes as conditions changed, while others continued relying on long-established routines regardless of changing varroa pressure.

Capability differences were also repeatedly raised throughout interviews. Participants described a wide gap between highly disciplined operators who consistently apply strong management systems and others who struggle with planning, monitoring, treatment execution, or broader operational decision-making.

Regional variation also emerged throughout interviews. Participants explained that environmental conditions, flowering patterns, climate differences, and regional operational pressures can all influence how varroa is managed across different parts of New Zealand.

Financial capability also contributed to variation. Some operators were better positioned to invest in monitoring tools, labour, and treatment programmes, while others were operating under tighter financial constraints.

A recurring frustration across interviews was the absence of consistent baseline expectations across the wider industry. Participants frequently described an environment where there is no single approach to managing varroa, resulting in significant variation in management quality.

Across the interviews, participants repeatedly reinforced that variability itself has become a major challenge, as strong operators can still be impacted by weaker management practices occurring around them.

Interviewee Perspectives

> "Everybody manages differently."
>
> "Some operators are incredibly good."
>
> "Others are miles behind."
>
> "There's no real standard."
>
> "Some monitor all the time. Others don't monitor at all."

These findings suggest that variability is not simply a by-product of different operating models, but a major contributor to inconsistent varroa outcomes across the industry. Significant differences in monitoring practices, treatment approaches, capability, scale, and financial capacity reinforce the absence of a consistent baseline for effective varroa management across New Zealand.

4.7 Varroa as a System-Level Coordination Issue

Survey findings highlighted that varroa management cannot be understood as an individual beekeeper issue alone. While individual management decisions remain important, responses indicated that varroa operates across apiaries, regions, and beekeeper boundaries. This means the effectiveness of one beekeeper's management can be directly influenced by the actions, timing, and capability of others around them.

Survey results showed strong support for greater collaboration across the industry. When asked whether sharing aspects of varroa management plans across the sector would improve consistency, most respondents were supportive, with **n = 48** strongly agreeing and **n = 40** somewhat agreeing. In comparison, **n = 22** respondents remained neutral, while only small numbers somewhat disagreed (**n = 6**) or strongly disagreed (**n = 8**). These findings suggest many beekeepers recognise value in greater information sharing and more coordinated planning.

Responses also highlighted growing scepticism around whether voluntary approaches alone are enough to protect wider industry outcomes. The largest proportion of respondents indicated that voluntary approaches were probably not sufficient (**n = 47**), while **n = 13** believed they were not sufficient. In comparison, **n = 16** believed voluntary approaches were probably sufficient, **n = 9** believed they were sufficient, and **n = 37** remained neutral. This suggests that while uncertainty remains, confidence in fully voluntary coordination appears limited.

This was reinforced when respondents were asked which approach would most improve varroa management consistency nationally. Industry-led shared standards received the highest level of support (**n = 58**), compared with fully voluntary, education-led approaches (**n = 28**) and formal regulation (**n = 21**), while **n = 29** respondents remained unsure. These findings suggest respondents are generally seeking greater structure, while remaining cautious about formal regulatory intervention.

Neighbouring beekeeper behaviour also remained a clear concern. While **n = 22** respondents indicated neighbouring practices had no influence on their operations, many reported that neighbouring practices influenced their ability to manage varroa a little (**n = 41**), a moderate amount (**n = 24**), a lot (**n = 13**), or a great deal (**n = 12**). This reinforces the interconnected nature of varroa management and highlights how individual decisions can create wider consequences across the sector.

Support for greater structure was further reinforced when respondents were asked whether industry-led standards could strengthen long-term varroa control. The largest proportion indicated this would probably strengthen long-term control (**n = 60**), while **n = 15** indicated it would strengthen outcomes. In comparison, **n = 15** believed it would probably not strengthen outcomes, **n = 8** believed it would not, and **n = 30** remained neutral.

Survey Finding Summary

The results suggest that many respondents increasingly view varroa as a collective management issue rather than purely an individual responsibility. While there was limited appetite for formal regulation, there was clear support for stronger coordination, greater information sharing, and more structured industry-led approaches. These findings directly align with the research question by suggesting that improving consistency will likely require practical coordination mechanisms that support individual beekeeper action while recognising the wider system varroa operates within.

Interview Findings Summary

Interview findings reinforced survey trends and consistently positioned varroa as a broader system-level issue rather than purely an individual beekeeper responsibility.

Reinvasion emerged as one of the strongest and most consistent issues raised throughout interviews. Participants repeatedly described situations where neighbouring beekeeper behaviour directly influenced their own outcomes, particularly where neighbouring operations delayed treatments, poorly managed mite levels, or failed to monitor effectively. Many described reinvasion as one of the most frustrating aspects of varroa management, as strong management within one operation could still be undermined by poor management elsewhere.

This was closely linked to broader biological realities such as drifting and robbing behaviour, which participants frequently identified as making individual management increasingly difficult in highly populated beekeeping areas. Participants explained that neighbouring colonies can quickly become sources of reinfestation when mite levels are poorly managed. A small number of participants also raised concerns around unmanaged or abandoned colonies contributing to wider reinvasion pressure.

These biological pressures were often intensified by broader structural issues within the industry. Participants frequently described the sector as highly fragmented, with many operators working independently and limited alignment around treatment timing, communication, or wider management expectations. While informal regional coordination does occur in some areas, particularly where neighbouring operators have strong relationships, participants consistently noted that these arrangements remain inconsistent and are often reliant on individual goodwill rather than any broader system.

A recurring frustration throughout interviews was that highly disciplined operators often felt they were carrying the consequences of weaker management practices occurring elsewhere. Many participants described situations where strong internal systems were undermined by neighbouring practices that sat completely outside their control.

This frustration often led discussions toward broader leadership and coordination gaps. Participants repeatedly raised concerns that the industry has struggled to develop a stronger collective response to varroa despite increasing biological pressure. Many felt the current system places too much responsibility on individual operators without adequately addressing the wider conditions influencing outcomes.

Minimum standards were frequently discussed as a potential pathway forward. Many participants supported stronger baseline expectations around monitoring, treatment planning, and management practices. However, support for formal regulation remained more mixed, with many favouring practical industry-led approaches that could improve alignment without creating unnecessary regulatory burden.

Across the interviews, participants repeatedly reinforced that while individual beekeeper capability remains important, long-term varroa control is increasingly shaped by wider coordination failures occurring across the broader system.

Interviewee Perspectives

> *"If some don't do the right thing, everyone pays."*
>
> *"Reinvasion is undeniable."*
>
> *"It's every beekeeper on their own."*
>
> *"If I'm treating six weeks after you, you could get reinvasion from me."*
>
> *"The industry is in need of strong leadership."*

These findings suggest that varroa management has evolved beyond an individual beekeeper challenge and increasingly operates as a broader collective action issue. While individual capability remains critical, biological realities such as reinvasion, combined with fragmented management practices and limited coordination, continue to undermine long-term control efforts. Improving consistency is therefore likely to require stronger industry leadership, clearer baseline expectations, and more coordinated approaches that better reflect the wider system varroa operates within.

5.0 Discussion

The results and findings show that inconsistency in varroa management is not driven by a lack of knowledge alone, but by a combination of behavioural, operational, and system-level factors that influence how consistently management practices are applied in practice. This chapter discusses the broader implications of the findings and examines what they reveal about the underlying drivers of inconsistency in varroa management across New Zealand. While previous chapters identified biological, operational, behavioural, and structural influences on varroa outcomes, the findings suggest that management inconsistency is driven less by a lack of technical knowledge and more by variability in implementation, competing operational pressures, fragmented information systems, and weak coordination across the wider apiculture sector. The discussion explores how these factors interact and considers what they mean for improving long-term varroa control outcomes in New Zealand.

5.1 Varroa management inconsistency is about application, not knowledge

One of the clearest things found from this research was that inconsistent varroa outcomes appear to be driven less by a lack of awareness regarding recommended management practices and more by inconsistency in execution. Survey findings showed that many participants reported moderate to high confidence in their ability to make varroa management decisions, while interview participants frequently demonstrated strong awareness of recommended monitoring practices, treatment timing principles, and resistance management strategies.

Despite this awareness, implementation remained highly variable. Survey findings showed that many beekeepers relied on informal planning systems rather than structured written plans, while interview participants repeatedly described reactive decision-making, delayed treatment responses, inconsistent monitoring routines, and poor treatment execution. Participants frequently discussed situations where action was triggered only after visible colony decline, elevated mite levels, or significant losses had already occurred.

These results strongly align with previous literature suggesting that the technical foundations of effective varroa management are already well established. Monitoring tools, treatment guidance, and resistance management principles have been widely documented within both scientific and industry literature for many years (Goodwin & Van Eaton, 2001; Honeybee Health Coalition, 2022). Integrated Pest Management (IPM) literature similarly emphasises that successful varroa control depends on continual monitoring, adaptive decision-making, and disciplined implementation rather than treatment alone (Jack & Ellis, 2021). However, recent New Zealand research has continued to identify substantial variation in monitoring intensity, treatment timing, and management consistency across the sector (Vallance et al., 2024).

The findings from this study reinforce that awareness of recommended practice does not necessarily translate into consistent implementation in the field. Instead, management consistency appeared to be heavily influenced by operational pressure, routine behaviour, planning discipline, and competing priorities. Participants frequently described situations where management became reactive rather than preventative as seasonal pressures intensified.

Importantly, these findings help explain why varroa continues to remain the leading contributor to colony loss in New Zealand despite the availability of well-established management guidance (MPI, 2025). The issue appears less related to absence of information and more related to maintaining consistent execution across entire seasons and varying operational conditions.

This finding is particularly significant because it challenges the assumption that improving technical information alone will resolve varroa-related losses. Information remains important, but this research suggests that improving execution discipline, planning systems, monitoring consistency, and proactive management behaviour may be equally important for improving long-term varroa outcomes across the New Zealand apiculture sector.

5.2 Economic and operational pressures drive short-term decisions

The findings from this research showed that economic and operational pressures play a major role in shaping consistency in varroa management. Survey respondents frequently identified treatment costs, labour shortages, time pressure, weather disruptions, and wider operational complexity as significant barriers to maintaining consistent management practices across the season.

Interview participants reinforced these findings, often describing the practical realities of managing varroa alongside harvesting, hive movements, feeding programmes, pollination commitments, staffing pressures, and broader seasonal workloads. For larger commercial operations managing thousands of hives across multiple locations, these challenges were often intensified by logistics, workforce limitations, and the difficulty of maintaining consistent oversight across all apiaries. Participants regularly discussed situations where biologically ideal treatment timing conflicted with weather windows, transport scheduling, staff availability, and competing operational priorities.

These findings align closely with recent New Zealand research conducted through Project Varroa, which identified labour shortages, operational complexity, treatment expense, and reinvasion pressure as major influences on beekeeper decision-making and management consistency (Vallance et al., 2024). Similar challenges were also identified by Goodwin and Van Eaton (2001), who noted that effective varroa control depends on continual monitoring, forward planning, and disciplined seasonal management rather than isolated treatment events alone.

The findings also support broader Integrated Pest Management (IPM) literature, which emphasises that effective pest management relies on ongoing monitoring, adaptive decision-making, and timely intervention across changing seasonal conditions (Jack & Ellis, 2021). However, maintaining this level of consistency appeared difficult under real commercial conditions, particularly during periods of high workload and operational pressure.

These findings also reflect broader structural changes that have occurred within the New Zealand apiculture sector over recent years. Following rapid expansion during the mānuka boom, declining honey returns and tighter operating margins have increased financial pressure across many businesses (MPI, 2023). Under these conditions, preventative management activities can become harder to prioritise when immediate operational demands and financial survival become the primary focus.

Participants commonly described situations where monitoring frequency, post-treatment assessment, or treatment timing were compromised due to staffing shortages, workload pressure, or financial limitations. This reinforces concerns raised by the Honeybee Health Coalition (2022), which highlighted that delayed intervention and inconsistent monitoring can reduce treatment effectiveness and increase longer-term varroa risk.

Importantly, the findings suggest that operational pressure influences not only whether management occurs, but also the consistency and quality of implementation. Monitoring routines, treatment timing, record keeping, and rotation planning all appeared vulnerable to compromise during difficult seasons. This reinforces the view that effective varroa management is not solely a technical issue, but also an operational and behavioural challenge shaped by wider economic conditions and management capacity.

Taken together, these findings suggest that approaches aimed at improving consistency must remain operationally realistic. Management systems that are perceived as overly complicated, labour-intensive, or disconnected from day-to-day commercial realities are unlikely to achieve consistent uptake across the wider beekeeping sector.

5.3 Reinvasion could make varroa management a collective issue

One of the strongest findings from this research was the extent to which individual management outcomes are influenced by neighbouring beekeeper behaviour. Survey findings showed that many participants believed neighbouring management decisions directly affected their own ability to manage varroa effectively. Interview participants repeatedly described reinvasion as one of the most frustrating and persistent challenges they face.

Even highly disciplined operators described situations where neighbouring hives, unmanaged colonies, delayed treatments, or inconsistent monitoring created renewed infestation pressure despite strong management within their own operations. These findings align closely with existing biological research demonstrating that mite drift, robbing behaviour, and collapsing colonies contribute to reinfestation across apiary boundaries (Greatti et al., 1992; Frey & Rosenkranz, 2014). Similar concerns were also identified through recent New Zealand Project Varroa research, which highlighted reinvasion and inconsistent neighbouring practices as ongoing challenges across the sector (Vallance et al., 2024).

Importantly, the findings suggest that reinvasion is not simply a biological issue, but also a coordination issue. Participants frequently described frustration that strong individual management effort did not always guarantee stable outcomes where surrounding practices remained inconsistent. This also supports recent New Zealand guidance cautioning against rigid calendar-based treatment approaches where reinvasion pressure and infestation dynamics are continually changing (Hall & Pragert, 2023).

The significance of this finding is that it shifts varroa management beyond purely individual responsibility and positions it more clearly as a collective issue. Individual discipline remains critical, but outcomes are increasingly influenced by the wider behaviour of surrounding operators. This helps explain why many participants supported stronger industry coordination and communication despite relatively low support for formal regulation.

5.4 Information systems remain fragmented and inconsistent

The findings also highlighted significant inconsistency in how varroa management knowledge is accessed, interpreted, and applied across the sector. While most participants reported feeling reasonably confident in their decision-making, both survey and interview findings highlighted heavy reliance on informal learning pathways, including social media groups, peer advice, supplier relationships, and trial-and-error learning.

Participants frequently discussed receiving conflicting advice from different sources, particularly around treatment timing, resistance management, monitoring thresholds, and long-term planning. These findings align with broader extension and adoption literature, which suggests that trust in advisory systems and consistency of messaging strongly influence behavioural uptake and management consistency (Klerkx & Jansen, 2010; Koutsouris et al., 2023).

The findings also support recent New Zealand research conducted through Project Varroa, which identified substantial variation in monitoring approaches, treatment timing, and wider management behaviour across

the industry (Vallance et al., 2024). Similar concerns are reflected within industry guidance from the Honeybee Health Coalition (2022), which emphasises the importance of consistent monitoring, post-treatment assessment, and structured resistance management.

Importantly, the issue does not appear to be a lack of available information. Rather, it is the inconsistency of messaging and limited access to practical, trusted guidance that appears to contribute to variability in management behaviour. Participants often appeared more influenced by practical advice from trusted operators than formal technical guidance alone, particularly where recommendations were perceived as difficult to apply under real operational conditions.

Taken together, these findings suggest that future efforts to improve consistency may need to focus less on increasing the volume of information available and more on improving alignment, practicality, and trust within advisory messaging across the wider New Zealand apiculture sector.

5.5 Greater coordination appears necessary, but regulation remains unpopular

The final major discussion theme relates to industry coordination. Survey findings demonstrated clear support for stronger industry-led coordination mechanisms, while support for formal regulation remained comparatively low.

Interview participants frequently described the sector as fragmented and lacking consistent leadership around varroa management expectations. At the same time, many participants acknowledged that purely voluntary approaches may be insufficient to address growing reinvasion pressure, treatment inconsistency, and long-term resistance risk. This reflects wider concerns identified throughout the literature review, particularly around reinvasion, inconsistent implementation, and the collective nature of varroa management across interconnected apiary systems (Frey & Rosenkranz, 2014; Vallance et al., 2024).

The findings suggest that the industry increasingly recognises stronger coordination is required, but there remains limited appetite for highly regulatory solutions. Participants generally appeared more supportive of practical industry-led approaches focused on communication, regional alignment, information sharing, and clearer expectations rather than strict compliance-based systems. This aligns with broader behavioural and stewardship literature suggesting that management uptake is more likely where approaches are viewed as practical, achievable, and relevant to operational realities (Thoms et al., 2019).

The results also reinforce concerns raised by Goodwin and Van Eaton (2001) and the Honeybee Health Coalition (2022), which both emphasise that long-term varroa control depends on consistent monitoring, timely treatment, resistance management, and coordinated implementation over time. However, this research suggests that maintaining consistency becomes increasingly difficult where wider industry practices remain fragmented.

Importantly, the results indicate that varroa management in New Zealand is no longer viewed purely as a technical issue. It is increasingly shaped by behavioural consistency, operational pressure, reinvasion dynamics, and the ability of the wider sector to coordinate around a shared long-term response.

Taken together, these findings suggest that improving varroa control outcomes in New Zealand will require moving beyond a narrow focus on treatment tools alone. While effective biological management remains critical, long-term success is likely to depend on improving behavioural consistency, reducing operational barriers, strengthening trusted information systems, and addressing the collective challenges created by reinvasion and fragmented industry coordination.

Overall, the results suggest that improving consistency in varroa management is less about introducing new tools, and more about improving how existing practices are applied, supported, and aligned across the wider system.

6.0 Conclusion

The research was set out to understand what influences consistency in varroa management planning among New Zealand beekeepers, and what approaches could strengthen it to improve varroa level control. The findings show that consistency is not determined by knowledge alone, but by the interaction of behavioural, operational, and system-level factors that shape how management is applied in practice.

At an individual level, consistency is influenced by the realities of beekeeping operations. Time pressure, labour availability, financial constraints, and competing priorities all affect whether monitoring is carried out regularly, treatments are applied at the right time, and rotation strategies are followed. While the technical knowledge and tools required for effective varroa control are well established, applying them consistently requires planning, resourcing, and discipline. Where these are constrained, management tends to lean more toward reactive responses rather than structured, proactive planning.

Behavioural factors further shape this variability. The research highlights a clear gap between knowing what should be done and consistently doing it. Differences in confidence, experience, and interpretation of monitoring results influence decision-making, as do underlying stewardship beliefs and attitudes toward intervention. Some beekeepers take a highly structured and preventative approach, while others rely on simpler or more reactive systems. These differences are not just about knowledge, but about how individuals prioritise risk, effort, and practicality within their own operation.

At a wider level, consistency is strongly influenced by system dynamics beyond the individual beekeeper. Reinvasion from neighbouring apiaries means that management outcomes are interconnected, and that inconsistent practices in one operation can undermine others. This creates a situation where individual effort does not always translate into consistent outcomes, reinforcing the challenge of maintaining disciplined management over time. Alongside this, the industry currently operates with limited coordination, with no consistent framework guiding monitoring, treatment timing, or resistance management at a regional or national level. This lack of alignment contributes to ongoing variability across the sector.

Taken together, the results show that varroa management isnt simply a technical task, but a system-level challenge shaped by how people make decisions within real-world constraints. Consistency is influenced by operational pressures, behavioural drivers, and the actions of others within the system. As a result, improving varroa control is less about developing new tools and more about strengthening how existing practices are applied in a consistent and coordinated way.

Strengthening consistency will require approaches that move beyond individual decision-making and support greater alignment across the sector. This includes clearer and more practical guidance, improved confidence in monitoring and decision-making, and increased coordination between beekeepers to reduce the impact of reinvasion and timing mismatches. Any approach needs to reflect how beekeepers operate, rather than assuming ideal conditions, and must be practical, achievable, and relevant across different operation types.

Overall, the research concludes and finds that consistency in varroa management is shaped by the interaction between individual behaviour and wider system influences, and that improving outcomes will depend on strengthening alignment across both. This provides a clear basis for the recommendations that follow, which focus on practical ways to support more consistent and coordinated varroa management across New Zealand's apiculture sector.

7.0 Recommendations

These recommendations focus on practical first steps that can realistically be taken within the New Zealand apiculture sector. The findings from this research suggest that improving consistency in varroa management is less about developing new tools, and more about improving the day-to-day application of existing practices. Given the realities of time, labour, and cost pressures, the most realistic way forward is to start small and build toward better alignment over time. A clear starting point is improving communication at a regional level. One of the biggest issues coming through is how disconnected management can be between neighbouring operations, even though outcomes are closely linked. Simple things like regional Facebook groups or messaging groups could make a difference here. Sharing information such as mite levels, treatment timing, or what people are seeing through the season helps build a clearer local picture. It does not need to be perfect, but even a bit more visibility can help reduce the mismatch that currently exists.

- Establish informal regional varroa communication groups.
- Encourage participation from commercial operators, contractors, and local beekeepers.
- Share seasonal observations, mite pressure trends, and treatment timing information.
- Use simple existing platforms such as Facebook groups or messaging apps.

(This can be led by anyone who has a passion to make a difference in their region)

There is also value in creating more regular opportunities for commercial operators in the same areas to talk to each other. This could be as simple as a monthly or quarterly catch-up. A lot of the variability identified in this research comes back to people making decisions in isolation, even though those decisions affect others. Getting people talking more regularly creates a better chance of aligning timing and approach, especially through the key pressure periods.

- Hold monthly or quarterly regional catchups during key seasonal periods.
- Involve neighbouring commercial operators and larger-scale beekeepers.
- Discuss treatment timing, reinvasion pressure, and seasonal challenges.
- Encourage greater alignment in regional management timing where practical.

Another step is encouraging greater openness around varroa management approaches. Currently, a wide range of monitoring, treatment timing, and rotation strategies are being used across the sector, but many of these practices remain largely invisible outside individual operations. Sharing general approaches and experiences could help strengthen alignment over time without forcing all beekeepers into the same system. It would also help build a clearer understanding of what effective management looks like in practice.

- Encourage greater sharing of general varroa management approaches across the industry.
- Promote discussion around monitoring methods, treatment timing, and rotation practices.
- Support peer-to-peer learning opportunities between beekeepers and operators.
- Improve visibility of practical management approaches that are working effectively.

The research also shows that knowing what to do does not always mean it happens consistently. Time pressure, confidence, and day-to-day workload all play a part. Because of that, there is value in keeping things simple when it comes to guidance. Practical tools like seasonal checklists or basic planning prompts could help people stay on track. The key is that they need to fit into how beekeeping works, not add another layer of complexity.

- Develop simple seasonal planning checklists.
- Create practical treatment-planning prompts for key seasonal periods.
- Focus on tools that fit existing workflows rather than adding complexity.
- Encourage routine-based planning approaches that are easy to maintain.

There is also an opportunity to make better use of the communication channels that already exist. Suppliers, newsletters, advisory networks, and industry groups all play a role in shaping how people think about varroa management. Where messaging is consistent, it helps reinforce good practice. Where it is mixed, it can add

to the variability. Getting more alignment in what is being communicated would help support more consistent decision-making across the board.

- Improve consistency of messaging across suppliers, advisory services, and industry organisations.
- Reinforce key guidance around monitoring, treatment timing, and resistance management.
- Encourage collaboration between industry groups and advisory networks.
- Support clearer communication around seasonal varroa risks and management expectations.

Rather than jumping straight to regulation, a staged approach makes more sense. The first step is building better coordination and a shared understanding of what consistent management looks like. If that starts to improve, there may be a natural move toward more formal alignment over time. Trying to force that too early is unlikely to land well, especially given how varied operations are across the sector

- Prioritise voluntary coordination and communication before regulatory approaches.
- Focus initially on improving industry alignment and shared understanding.
- Explore industry-led standards before considering formal regulation.
- Allow flexibility for differences in operation size, scale, and management style.

A key point running through all of this is that varroa management is not just an individual responsibility. Reinvasion and neighbouring effects mean that what one beekeeper does has an impact on others. Improving outcomes will require beekeepers, industry organisations, suppliers, advisors, and the wider sector to contribute toward a more coordinated approach. Without greater participation and shared responsibility across the industry, it is difficult to achieve real consistency, no matter how good individual practices are,

The following are the necessary people involved.

- Commercial beekeepers
- Semi-commercial and hobbyist beekeepers
- Beekeeping contractors and regional operators
- Industry organisations
- Treatment suppliers and manufacturers
- Advisors, consultants, and training providers
- Research organisations and extension services
- Regional beekeeper networks and communication groups

Looking ahead, if these early steps start to gain traction, there is potential to build on them. Over time, this could include more coordinated treatment timing at a regional level, better sharing of information around mite pressure, or simple ways of identifying higher-risk areas. If the industry gets to that point, there may also be more opportunity to justify targeted investment to support it. The key point is that improving consistency does not require large-scale change from the outset. It can start with practical steps that improve communication, build trust, and help people make more consistent decisions. From there, it gives the industry something to build on.

8.0 Limitations

There are a few limitations to keep in mind when interpreting these findings. This research is based on what people said they do, rather than directly observing what happens in practice. That's fine for understanding decision-making, but it does mean responses may not always reflect day-to-day behaviour exactly. The survey was also voluntary and shared through industry networks, so it's likely that those who responded are more engaged in varroa management. Because of that, the results may not fully capture those who are less consistent, who are often part of the wider issue.

The study included a mix of participants across the industry, including commercial, semi-commercial, and non-commercial beekeepers, as well as others working in the sector such as suppliers, scientists, and government. This gave a broader view of the system, but not all responses reflect direct, hands-on management decisions. The sample size is also relatively small compared to the size and spread of the New Zealand industry, so while the findings show clear patterns, they won't represent every situation. It's also worth noting that this research captures a point in time. Varroa management shifts through the season and from year to year depending on conditions, so what people are doing now may change. Overall, the study

focuses on what influences management decisions rather than measuring direct outcomes. Even with that, it still provides a solid and practical understanding of what is driving consistency in varroa management, and a good base for the recommendations that follow.

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10.0 Appendix

Appendix A: Interview Guide A – Commercial / Practical Beekeepers

Section 1 – Background

1. Can you tell me about your operation and your role within it?
    - Hive numbers
    - Regions
    - Type of operation

Section 2 – Industry Context

2. How has Varroa management changed over time in your experience?
    - What's improved?
    - What hasn't?

Section 3 – Current Practices

3. How do you plan Varroa management across a season?
    - Monitoring routines
    - Treatment timing
    - Written vs reactive planning
4. What does good Varroa management look like in theory, and how close is that to reality?
    - Where does it break down?
5. How do you decide when to treat?
    - Monitoring thresholds
    - Calendar vs reactive
    - Production pressures

Section 4 – Constraints and Pressures

6. What makes it difficult to manage Varroa consistently?
    - Labour
    - Cost
    - Time
    - Logistics
7. Have you had situations where you knew the right thing to do, but couldn't do it?
    - Why not?
    - What was the outcome?
8. How are current economic pressures affecting Varroa decisions?
    - Cost cutting
    - Delayed treatment
    - Reduced monitoring

Section 5 – Reinvasion and Coordination

9. How much do neighbouring beekeepers affect Varroa pressure in your hives?
    - Drifting
    - Collapsing colonies
10. Would better coordination between beekeepers make a difference? Why or why not?

Section 6 – Knowledge and Behaviour

11. What influences how you manage Varroa in practice?

- Experience
- Advice
- What others are doing

12. Where does your information on treatment decisions come from?

- Training
- Peers
- Suppliers

13. What causes you (or others) to change how Varroa is managed?
14. What role does training, or advice realistically play?

Section 7 – System Gaps

15. If treatment fails, what will stop someone from reporting or talking about it?
16. Where do you think the current system falls short?

Section 8 – Improvement

17. What would most improve Varroa control across the industry?
18. Do you think more structure or coordination would help? Why or why not?

Final

19. If you could change one thing about Varroa management, what would it be?

Appendix B: Interview Guide B – Government / Scientists / Suppliers

Section 1 – Background

1. Can you describe your role and involvement in the beekeeping industry?

Section 2 – System Perspective

2. How has Varroa management evolved in New Zealand from your perspective?
3. How well do you think Varroa management is working at an industry level?
    - Where is it working well vs not?

Section 3 – Behaviour and Knowledge

4. What influences how beekeepers manage Varroa in practice?
5. Where do you think beekeepers are getting their information from?
    - Accuracy / reliability
6. What drives behaviour change in beekeepers?

Section 4 – System Performance

7. How effective are current training and advisory systems?
8. Where do you see the biggest gaps between recommended practice and what happens on the ground?
9. Is there evidence that training changes behaviour?
    - Observable differences

Section 5 – System Weakness

10. If treatment failure is not being reported, what does that indicate about the system?
11. Where do people fall through the gaps? Who is most at risk?

Section 6 – Coordination and Structure

12. To what extent is Varroa a coordination issue rather than an individual issue?
13. Would greater coordination improve outcomes? Why or why not?

Section 7 – Policy and Standards

14. What are your views on minimum standards or expectations for Varroa management?
15. What would it take to implement something like that in New Zealand?
16. What barriers would exist?

- Cost
- Enforcement
- Industry acceptance

Section 8 – System Relationships

17. How would you describe your relationship within the beekeeping industry?

Section 9 – Reality Gap

18. What is the gap between research/recommendations and what is achievable on the ground?

Final

19. If you could change one thing about how Varroa is managed, what would it be?

Appendix C: Survey Questionnaire

Participant Information and Consent

You are invited to participate in a research project titled Consistency in Varroa Management Planning in New Zealand. The purpose of this study is to understand how varroa management is approached across the New Zealand apiculture sector and what influences consistency in monitoring, treatment, and planning.

Participation is voluntary, anonymous, and takes approximately 5 minutes. You may skip any questions. Data will be reported in aggregated form only.

Do you consent to participate in this anonymous survey?

☐ Yes – I have read the information and agree to participate

☐ No – I do not wish to participate

Section 1: Background

1. Which best describes your role?

☐ Commercial beekeeper

☐ Semi-commercial beekeeper

☐ Non-commercial beekeeper

☐ Industry service provider

☐ Other (please specify): _____

2. How many hives do you currently manage?

☐ 1–20

☐ 21–200

☐ 201–1000

☐ 1000+

3. Which region do you operate in?

☐ Northland

☐ Auckland

☐ Waikato

☐ Bay of Plenty

☐ Gisborne

☐ Hawke's Bay

☐ Taranaki

☐ Manawatū

☐ Whanganui

☐ Wellington

☐ Tasman

☐ Nelson

☐ Marlborough

☐ West Coast

☐ Canterbury

☐ Otago

☐ Southland

☐ Across multiple regions (please specify): _____

4. How many years have you been beekeeping?

☐ 0–5

☐ 6–10

☐ 11–20

☐ 20+

Section 2: Current Varroa Planning Practices

5. Do you follow a planned approach to varroa management each season?

☐ Yes – formal written plan

☐ Yes – structured seasonal routine (not written)

☐ No – mostly reactive

☐ Unsure

6. How often do you monitor varroa levels?

☐ Each visit

☐ Every second visit

☐ Every third visit

☐ Several times per season

☐ Once per season

☐ Only when issues arise

☐ Never

7. How do you monitor your varroa levels? (Select all that apply)

☐ Alcohol washes

☐ Sugar shakes

☐ Soap wash

☐ Sticky boards

☐ Drone uncapping

☐ None

☐ Other: _____

8. What influences your decision on when to treat? (Select all that apply)

☐ Monitoring results

☐ Calendar seasons

☐ Visible colony decline

☐ Advice from other beekeepers

☐ Advice from supplier or consultant

☐ Previous season losses

☐ Cost considerations

☐ Labour or time constraints

☐ Other: _____

9. How confident are you in making varroa management decisions?

☐ Not confident

☐ Slightly confident

☐ Moderately confident

☐ Very confident

10. When deciding whether to treat, how often do you rely on monitoring results or thresholds?

☐ Always

☐ Often

☐ Sometimes

☐ Rarely

☐ Never

11. Do you rotate varroa treatments between seasons?

☐ Yes, every season

☐ Every 2 seasons

☐ Rarely rotate

☐ No, same plan each year

Final Question

30. In your view, what would most realistically improve varroa control nationally?

_____