Chemical Insecticides and New Zealand's Denial.

By Talia Powell.

Contents Page

Introduction	3
Definitions	4
The Science of Chemical Insecticides	4
A General History of Insecticides	5
New Generation Insecticides; Neonicotinoids	6
Advantages of Chemical Insecticides	8
Disadvantages of Chemical Insecticides	9
International Sphere	
International Laws of Chemical Insecticides	10
The Rotterdam Convention	12
The Stockholm Convention	13
International Best and Worst Chemical Insecticide Practices	14
New Zealand	
New Zealand's Chemical Insecticide History	19
New Zealand's Current Dilemma	21
New Zealand's Current Chemical Insecticide Practices	23
Alternative Options for New Zealand	24
The Possibility of Change in New Zealand	26
The Necessity of Change in New Zealand	27
Conclusion	28

Introduction

A global decline in pollinators is causing concern for food production and security. It has motivated multiple countries to research potential threats to pollinators. One key pollinator is the bee. There are over 20,000 species of bee globally,[1] and 41 species in New Zealand.[2] Bees play an important role in the reproductive cycle of many flowering plants.[3] In order for fruit and seeds to be produced, pollen from the male plant organs has to be transferred to female plant organs.[4] Pollinators conduct this transfer. Achim Steiner, UN Under-Secretary-General and UNEP Executive Director said "of the 100 crop species that provide 90% of the world's food, over 70 are pollinated by bees".[5] This illustrates the integral role of bees in the world, and how serious the issue of bee decline is.

Chemical insecticides play a crucial role in the production of large and healthy crop yields, but can have negative effects on non-target organisms. Research conducted by the European Union's Food Safety Authority has determined that neonicotinoids, a class of insecticides previously thought to have few negative environmental effects, are contributing to bee decline.[6] As the world's population continues to increase, there will be a rise in global demand for food.[7] While insecticides will be required to ensure adequate food production, their use needs to be monitored and reduced to provide security of pollination services.[8]

This essay considers the history of chemical insecticide use, its conflicting benefits and harms, and possible methods for managing and mitigating harms. It will also contemplate the place of chemical insecticides in international law. International best pest management practises will be analysed, alongside the recent developments around neonicotinoids, and compared to New Zealand's current insecticide law and practices. The importance of bee

[1] United Nations Environment Programme *UNEP Emerging Issues; Global Honey Bee Colony Disorders and other Threats to Insect Pollinators* (United Nations Environment Programme, 2010) at 2.
[2] Allan Gillingham "New Zealand's bees species" (24 November 2008) Te Ara The Encyclopedia of New Zealand < https://teara.govt.nz/en/diagram/15740/new-zealands-bee-species >.
[3] United Nationals Environment Program "Humans must change behaviour to save bees, vital for food production - UN report" *United Nations News* (online ed., 10 March 2011).
[4] United Nations Environment Programme, above n 1, at 2.
[5] United Nationals Environment Program, above n 3.
[6] European Food Safety Authority *Q&A: Conclusions on neonicotinoids 2018 (*European Food Safety Authority, 28 February 2018), at 1.
[7] Oberemok et al, "A short history of insecticides" (2015) 55 JPPR 221 at 224.
[8] At 225.

health and insecticide management in New Zealand will be considered, and alternatives to New Zealand's current practise suggested.

Definitions

Insectides are a class of pesticides; products that deter or kill pests. There are many different kinds of pesticides, and New Zealand's Environmental Protection Agency (EPA) includes insecticides, herbicides and fungicides within their definition.[9] There are several different kinds of insecticides including botanical, biological, mechanical and chemical. Botanical insecticides use natural plant toxins, biological insecticides might manipulate natural predatory relationships, mechanical insecticides involve physical methods of pest prevention, and chemical insecticides use active substances. All of them are designed to prevent harm from insects.[10]

The Science of Chemical Insecticides

There are two broad categories of chemical insecticides, contact and systematic. Contact insecticides remain on the site of application and have fatal effects on insects that come into contact with them via absorption through the cuticles of the exoskeletons.[11] Systematic insecticides move through the plants vessels after application, allowing it to effect all areas of the plant.[12] They effect insects though consumption or contact.[13] Chemical insecticides are manufactured as coatings, spray and dusts.

There are several effect mechanisms insecticides use to kill the insects. The chemicals act as nerve signal inhibitors, growth inhibitors or molecule synthesis disrupters. Organochlorides like dichloro diphenyl trichloroethane (DDT) are nerve signal inhibitors. They function by changing potassium and sodium concentrations in nerve cells, preventing the transfer of

---

[9] New Zealand Environmental Protection Agency "Pesticides" Environmental Protection Agency, Te Mana Rauhi Taiao < https://www.epa.govt.nz/industry-areas/hazardous-substances/guidance-for-importers-and-manufacturers/pesticides/>.

[10] New Zealand Environmental Protection Agency, above n 9.

[11] European Commission "Neonicotinoids" (28 March 2018) European Commission – Plants < https://ec.europa.eu/food/plant/pesticides/approval_active_substances/approval_renewal/neonicotinoids_en>; Jeroen P van der Sluijs, et al. "Neonicotinoids, bee disorders and the sustainability of pollinator services" (2013) 5 Curr. Opin. Environ. Sustainability 293 at 293.

[12] At 293.

[13] Jeroen P van der Sluijs, et al., above n 11, at 293.

electrical signals.[14] As a result, the transfer of information between the brain and muscles is impaired, resulting in spontaneous twitching.[15]

Modern chemical classes can effect growth and essential molecule production. Growth inhibitors work by preventing the growth of, or shedding an exoskeleton. For example, benzoylureas' inhibit the synthesis of chitin.[16] This results in desiccation, and prevents the insect from progressing to the next life stage. Cyclic ketoenols effect insect development by inhibiting the synthesis of lipids which are integral to cell structure and function.[17]

A General History of Insecticides

For centuries insecticides have been used to eradicate insect pests and protect plants, particularly crops, from damage.[18] The first records of botanical insecticides are from 1200BCE China.[19] By 300AD the Chinese had started utilising biological insecticides, and in the fourth century white arsenic, a basic chemical insecticide was recommended when transplanting rice by alchemist Ko Hung.[20] During the Renaissance period, insecticidal methods developed a stronger focus on science due to the invention of the microscope in the late 1500s.[21] Consequent knowledge of insects, their habits and life cycles enabled development of more targeted and successful forms of insecticide.[22]

The first synthetic chemical insecticide, organochloride DDT was created in 1939.[23] The synthesis and sale of chemical insecticides has historically been followed by unforeseen damage and urgent research into the causes. Bans and restrictions are then imposed to mitigate the damage. Some of the early chemical insecticides included organochlorides, organophosphates, carbamates, and formamidine compounds.[24] Each of these classes of chemicals was originally used without concern for their effects. All are now restricted or prohibited.

---

[14] Peter D Stiling *An Introduction to Insect Pests and their Control* (MacMillan Publishers, London, 1985), at 42.
[15] At 42.
[16] Oberemok et al, above n 7, at 233.
[17] At 233.
[18] Paul H. Williams and others *Bumble Bees of North America: An Identification Guide* (1st ed., Princeton University Press, Princeton, 2014) at 70.
[19] Peter Stiling, above n 14, at 9.
[20] At 9.
[21] Peter Stiling, above n 14, At 12.
[22] Peter Stiling, above n 14, at 12.
[23] Oberemok et al, above n 7, at 221 & 222.
[24] Peter Stiling, above n 14, at 43 & 44; Oberemok et al, above n 7, at 221 & 222.

Despite this pattern, demand for chemical insecticides has continued to be met. As science and technology improved, new chemicals came onto the market.

New Generation Insecticides; Neonicotinoids

Between the 1970s and 1990s the world transitioned from persistent chemicals, such as organochlorides and organophosphates, towards more environmentally friendly options. The first neonicotinoid to appear on the international market was imidacloprid in 1993.[25] Since then, neonicotinoids have become incredibly popular and wide spread in their use.[26] They are systematic chemicals found in some insecticides and move around the plant via phloemic and xylemic transport.[27]

Neonicotinoids negatively interact with the binding sites on receptors in the insect nervous system, causing hyper-excitation of sensory cells causing paralysis and death.[28] The receptor binding sites in insects are different to those in vertebrae, which results in a targeted effect on insects.[29] This is a huge benefit as it reduces the risk of non-target higher order organisms being effected by the chemicals.

Although it was initially believed neonicotinoids had minimal negative environmental impact, recent research has proved contrary to this. Neonicotinoids have significant leaching potential and contaminate soils and ground waters, especially when applied as a seed coating.[30] This means that the insecticides persist and travel to unintended locations via soil and water transfer, and that untreated plants sown in the same soil, are exposed to the chemicals.[31] This in turn exposes unintended insect targets.

Furthermore, neonicotinoids have been found to cause severe symptoms in bees. In isolation, the symptoms do not always demonstrate a strong causal link with neonicotinoids,[32] but scientists agree that neonicotinoids have neurological effects bees.[33] It has been concluded

[25] At 222.
[26] Jeroen P van der Sluijs, above n 11, at 294.
[27] At 293.
[28] At 293.
[29] At 293.
[30] Jeroen P van der Sluijs, above n 11, at 294.
[31] At 294.
[32] At 295.
[33] At 297.

that exposure to neonicotinoids can cause loss of navigation skills and homing instincts,[34] poor social skills and reductions in queen production,[35] increased sensitivity to disease,[36] and abnormal foraging behaviour.[37] All of which can lead to death of individuals and colonies. Bees can be exposed to neonicotinoids through a variety of avenues such as ingestion of contaminated nectar and pollen, exposure through contaminated ground water collected by plants,[38] and through inhaling aerial sprays or chemical particles in the wind.[39]

The research conducted around the effects of neonicotinoids is causing international debate over their use. There are sources that argue there is not enough evidence to link neonicotinoids with the collapse of bee colonies and population decline.[40] However, the research supporting those claims has been criticised for conflicts of interest as the studies were funded by insecticide manufacturing companies.[41]

Advantages of Insecticides

There are many advantages to using insecticides, both in general and specific senses, the main one being the control and security they provide. This can be for individual crop producers who get a larger, healthier yield that has a higher value and economic worth. It can be on a national level, where insecticides enable countries to produce enough food for its habitants, and in some cases, surplus amounts for export. In some African countries, insecticides help reduce the spread of diseases like malaria.[42]

Variety in insecticides means producers can select a chemical that suits their needs. This might be in terms of the pest they are trying to eradicate, the duration of the effect, the application method, or the active ingredient. Chemical insecticides come as coatings, spray

[34] At 297.
[35] N. Tsvetkov et al. "Chronic exposure to neonicotinoids reduces honey bee health near corn crops" (2017) 356 Science 1395, at 356.
[36] Jeroen P van der Sluijs, above n 11, at 297.
[37] B.A. Woodcock and others "Country-specific effects of neonicotinoid pestcides on honey bees and wild bees" (2017) 356 Science 1393 at 139; Jeroen P van der Sluijs, above n 14, at 293.
[38] Jeroen P van der Sluijs, above n 11, at 295.
[39] At 295.
[40] Michael Eisenstein "Pesticides: Seeking answers amid a toxic debate" Nature News (online ed., 20 May 2015) at 53.
[41] At 53.
[42] United States Environmental Protection Agency "DDT – A brief History and Status" EPA United States Environmental Protection Agency < https://www.epa.gov/ingredients-used-pesticide-products/ddt-brief-history-and-status >.

and dust.[43] This diversity is an advantage as application can be targeted and efficient. Seeds can be coated and protected prior to planting, established plants can be sprayed and dust can be spread through soils.

Furthermore, chemical insecticides are relatively cheap to produce and purchase, which is economically beneficial for crop producers.[44] As such, they are often a default insecticidal method for farmers. In a broader context, being produced and purchased cheaply means crop production costs are kept down, while the quality remains high making a valued affordable product. In some third world countries, cheap accessible pesticides means insect vector diseases like malaria can be fought over large areas.[45]

Disadvantages of Insecticides

Disadvantages of using insecticides have emerged during the years of use. Different insecticide products have different active ingredients, and the degree of harm caused by the product varies depending on the active ingredient.

The first and most serious kind of disadvantage has been the unforeseen harmful effects on nontarget organisms.[46] Many chemicals are non-specific and administering them has lethal effects on non-target species.[47] Non-target insects that consume or come into contact with insecticide meet the same fate as the target insects, despite not causing damage.[48]

Insecticides do not normally contain a high enough concentration of the active ingredient for it to have fatal effects on higher order organisms like fish, birds, reptiles and mammals. However, sublethal effects can occur through consumption of contaminated insects which

---

[43] Peter D Stiling, above n 14, at 40.

[44] Peter Hugh *The Global Politics of Pesticides: Forging Consensus from Conflicting Interests* (Earthscan Publications ltd, London, 1998) at 136.

[45] Secretariat for the Stockholm Convention "Acceptable Purposes: DDT" United Nations – Stockholm Convention <http://chm.pops.int/Implementation/Exemptions/AcceptablePurposes/AcceptablePurposesDDT/tabid/456/Default.aspx >.

[46] Gilbert Waldbauer *Insights from Insects: What Bad Bugs Can Teach Us* (Prometheus Books, New York, 2005) at 210.

[47] P. Müiller "Effects of Pesticide on Fauna and Flora" in *Pesticides: Food and Environmental Implications* (International Atomic Energy Agency, Vienna, 1988) at 11.

[48] European Food Safety Authority, above n 6, at 1; Clarence Cottam and Elmer Higgins "DDT and its Effect on Fish and Wildlife" in Thomas R. Dunlap (ed) *DDT, Silent Spring, and the Rise of Environmentalism* (University of Washington Press, Seattle, 2008) at 59.

results in build-ups of chemicals in the predator's tissues.[49] This causes sickness, behavioural changes, infertility and mortality.[50] These unintended effects were seen with the widespread application of DDT and dichloro diphenyl dichloroethan (DDD) in the 1940s and 1950s.[51] The United States of America administered DDT and DDD in attempts to eradicate several kinds of insect pests. Unexpectedly, there was a dramatic decline in fish, reptiles and birds in the areas of application.[52] Some animals died from direct consumption or contact with the chemicals. Some populations, like the American bald eagle, plummeted because of side effects of chemicals contamination. DDT compromised the strength of American bald eagle egg shells and prevented successful reproduction.[53] Many countries have since banned or restricted the use of chemicals known to have these effects.

Another disadvantage to using chemical insecticides is their persistent and long lasting nature.[54] Some synthetic chemicals persist for decades in the environment, remaining in the plant or soil and causing intergenerational pollution.[55]

A final disadvantage is that insects develop resistance to active substances which render the insecticide useless on certain species.[56] This phenonium occurs because crop monocultures provide excellent habitats for insects. The abundance of food results in large populations and fast rates of reproduction. Any genes that provide resistance are quickly selected for and passed to the next generation resulting in populations with immunity to certain toxins.[57]

International Sphere

A International Laws of Chemical Insecticides

International collaboration over the control of insecticides is part of a larger initiative for the control of toxins, pesticides and chemicals in general. The international community was slow to take a stance in relation to the use of pesticides. The majority of regulation or action against chemical use is done at national and governmental levels, because pesticide pollution

[49] Gilbert Waldbauer, above n 53, at 213.
[50] P. Müiller, above n 46, at 11.
[51] Peter Stiling, above n 14, at 56.
[52] Gilbert Waldbauer, above n 46, at 213.
[53] "Eagle population soars" (1994) 263 AAAS 922 at 922; Peter Stiling, above n 14, at 56.
[54] European Food Safety Authority, above n 6, at 2.
[55] Peter Stiling, above n 14, at 42.
[56] Rene Feyereisen "Insect P450 inhibitors and insecticides: challenges and opportunities" (2015) 71 PMS 793 at 793.
[57] At 793.

is fundamentally a localised problem.[58] The countries using the chemicals have to manage the pollution and environmental risks nationally, because such risks rarely transfers to other countries.[59] As author Peter Hugh wrote, "the ecologies of the US or the EU countries are never greatly affected by the misuse of pesticides in African or South American countries".[60] As a result, there was originally little pressure for the international community to draw conclusions on the use of chemical pesticides.

However, as connections were made between pesticides and harms to human health, animals and the environment, moral and ethical questions surfaced. Campaigns from the public and non-governmental organisations demanded international attention. Rachel Carson's 1962 *Silent Spring* fuelled international debate and marked a pivotal point in the environmental movement.[61] The first international attempt at recognising the harm of these chemicals came with the development of the International Register of Potentially Toxic Chemicals. The United Nations Conference on the Human Environment, Stockholm, 1972, recommended the development of a register or data base for toxic chemicals, and by 1976 the register was established.[62]

International accidents and poisoning cases involving pesticide chemicals demanded further attention. Incidents such as the 1984 Bhopal Disaster reminded the world about the dangers of exposure to toxic chemicals.[63] The UN responded to such disasters by adopting Conventions during the late 1990s and early 2000s. These will be discussed shortly.

The most recent insecticidal chemical controversy to feature on the international stage is the use of neonicotinoids. The EU has recently made the impressive step of banning the outdoor use of three common neonicotinoids; clothianidin, imidacloprid and thiamethoxam.[64] This move has drawn a lot of international attention and has refuelled the conversation on the use of these chemicals.

---

58 Peter Hugh, above n 44, at 82.
59 At 82.
60 Peter Hugh, above n 44, at 82.
61 At 76.
62 J. W. Huismans "The International Register of Potentially Toxic Chemicals (IRPTC)" (1980) 4 EES 393 at 393.
63 Oberemok et al., above n 7, at 222.
64 New Zealand Environmental Protection Authority "Bees and Other Pollinators" New Zealand Environmental Protection Authority, Te Mana Rauhi Taiao < https://www.epa.govt.nz/everyday-environment/animals-and-insects/bees/ >.

B The Rotterdam Convention

The Rotterdam Convention, was adopted by the UN in 1998 and entered into force in 2004.[65] This convention created the first kind of legal responsibility in relation to the use and sale of hazardous pesticides and industrial chemicals, by implementing the Prior Informed Consent (PIC) Procedure.[66] The PIC procedure is a mechanism that allows countries importing chemicals to make an informed decision on whether or not they wish to receive chemicals listed under Annex III of the Convention. Annex III is a list of chemicals that have been banned by two or more parties because of human or environmental health concerns.[67] The Chemical Review Committee was established under the Rotterdam Convention to review chemicals and pesticide products, in order to classify them appropriately.[68]

The Convention also has an Information Exchange scheme which requires that countries notify the Secretariat of the Convention when banning or severely restricting a chemical domestically.[69] The Convention requires information on toxic chemicals to be shared between countries in an attempt to promote shared responsibility in protecting human health and the environment from potential harm.[70] All exporters exporting chemicals listed under Annex III, are required to meet labelling requirements and to supply a safety data sheet for the imported products.[71] This Convention clearly demonstrates the importance of the control of these chemicals to the international community.

C The Stockholm Convention

The UN Stockholm Convention on Persistent Organic Pollutants was adopted in 2001 and entered into force in 2004.[72] It aims to protect humans and the environment from persistent

---

65 Secretariat for the Rotterdam Convention "Text of the Convention" The United Nations – Rotterdam Convention < http://www.pic.int/TheConvention/Overview/TextoftheConvention/tabid/1048/language/en-US/Default.aspx >.

66 Secretariat for the Rotterdam Convention "Overview" The United Nations – Rotterdam Convention < http://www.pic.int/TheConvention/Overview/tabid/1044/language/en-US/Default.aspx >.

67 Secretariat for the Rotterdam Convention "Annex III Chemicals" United Nations – Rotterdam Convention < http://www.pic.int/TheConvention/Chemicals/AnnexIIIChemicals/tabid/1132/language/en-US/Default.aspx >.

68 Secretariat for the Rotterdam Convention "Chemical Review Committee - Overview" United Nations – Rotterdam Convention <http://www.pic.int/TheConvention/ChemicalReviewCommittee/OverviewandMandate/tabid/1059/language/en-US/Default.aspx >.

69 Secretariat for the Rotterdam Convention "How it works" United Nations – Rotterdam Convention < http://www.pic.int/TheConvention/Overview/Howitworks/tabid/1046/language/en-US/Default.aspx >.

70 Secretariat for the Rotterdam Convention "Overview", above n 66.

71 Secretariat for the Rotterdam Convention "Labelling and Trade" United Nations – Rotterdam Convention < http://www.pic.int/Implementation/Customs/LabelingTrade/tabid/1612/language/en-US/Default.aspx >.

72 Secretariat for the Stockholm Convention "Overview" The United Nations – Stockholm Convention < http://chm.pops.int/TheConvention/Overview/tabid/3351/Default.aspx >.

organic pollutants (POPs) by requiring parties to the convention to prevent or reduce the release of POPs into the environment.[73] Persistent organic pollutants can be found in pesticides like insecticides, and can remain in the environment for extended periods of time, sometimes decades. They pose health and environmental threats as they cause cancer, damage nervous systems, cause reproductive disorders and disrupt immune systems.[74] The long life of these pollutants means they have the ability to affect generations of organisms, and their ability to accumulate in fatty tissue means they are easily transported.[75] As a result, POPs travel globally in humans and animals, and have even been found in Antarctica where pesticide has never been administered.[76] As a result, the risks that came with using pesticides and insecticides stopped being localised, and were transboundary. The effort to minimise their presence in the environment became a global one which resulted in the adoption of the Convention.[77]

Originally, the Convention recognised 12 POPs as causing adverse effects on humans and ecosystems but between 2009 and 2017, 16 additional chemicals have been added to this list.[78] The increase in chemicals proves that science is ever evolving and the true effects of chemicals are not always clear until they materialise.

A theme through the international conventions and conversations has been IPM. Providing alternatives for the chemicals people rely on for the production of crops and consequently, economic and food security is important.[79] Integrated Pest Management is a concept that has been around for decades, and is considered a valid alternative by the international community. It involves the use of biological and mechanical insecticide mechanisms such as

---

[73] Secretariat for the Stockholm Convention "Overview".
[74] Secretariat for the Stockholm Convention "What are POPs" The United Nations – Stockholm Convention < http://chm.pops.int/TheConvention/ThePOPs/tabid/673/Default.aspx >.
[75] Secretariat for the Stockholm Convention "What are POPs".
[76] Marci Vecchiato, Elena Argiriadis, Stefano Zambo, Carlo Barbante, Giuseppa Toscano, Andrea Gambaro and Rossano Piazza "Persistant Organic Pollutants (POPs) in Antarctica: Occurrence in continental and coastal surface snow" (2014) 119 MicroChem. J. 75 at 75.
[77] Secretariat for the Stockholm Convention "Overview", above n 72.
[78] Secretariat for the Stockholm Convention "The 12 initial POPs under the Stockholm Convention" United Nations - Stockholm Convention < http://chm.pops.int/TheConvention/ThePOPs/The12InitialPOPs/tabid/296/Default.aspx >; Secretariat for the Stockholm Convention "The New POPs under the Stockholm Convention" United Nations - Stockholm Convention < http://chm.pops.int/TheConvention/ThePOPs/TheNewPOPs/tabid/2511/Default.aspx >.
[79] P. Kraus "Global pest management in the Future" in *Pesticides: Food and Environmental Implications* (International Atomic Energy Agency, Vienna, 1988) at 7.

selecting for resistance to pests in plants, promoting population growth in natural enemies of the target insects, diversifying monocultures and rotating crops.[80]

C International Best and Worst Chemical Insecticide Practices

Member countries of the EU demonstrate some of the best practises in insecticide regulation and management. The EU is unique in its political collaboration format, and this has allowed it to be ambitious and stringent in its pursuit of environmentally friendly standards and practises.[81] Scientists have documented the decline in pollinators, particularly bees, in Europe and the declining trend is alarming.[82] The urgency with which Europe is now regulating insecticides reflects the seriousness of chemical insecticide overuse and overreliance.

Pesticide reduction strategies are derived from Directive 2009/128/EC (the Directive).[83] The purpose of the Directive is to reduce the impacts and risk of pesticide use on humans and the environment.[84] It aims to give members of the EU strategies for sustainable pesticide use and IPM.[85] Each member state was required to construct and implement National Action Plans (NAPs) which detail steps and targets for achieving the Directive.[86] The Directive identifies certain measures that must be included in the NAPs.[87] These include setting initial and follow up training requirements for all pesticide professional users, distributors and advisors, run by designated competent authorities.[88] Requirements for the sale of pesticides include providing information regarding the risks to human health and the environment, and to restrict sales to certified professionals where possible.[89] Member states are also required to partake in information sharing and awareness-raising by informing general public through educational programmes that supply balanced information,[90] and by gathering information on poisoning

[80] European Commission *Member State National Action plans and on progress in the implementation of Directive 2009/128/EC on the sustainable use of pesticides* (European Commission COM(2017) 587 Final, October 2017) at 13.
[81] Daniel Kelemen and David Vogel "Trading Places: The Role of the United States and the European Union in International Environmental Politics" (2010) 43 CPS 427 at 442.
[82] Sharon Levy "The pollinator crisis: what's best for bees" Nature News (online ed., 9 November, 2011) at 164; Jennifer C. Geib et al., "Bumble bee nest abundance, foraging distance, and host plant reproduction: implications for management and conservation" (2015) 25 Ecological Applications 768 at 768.
[83] European Commission, above n 80, at 1.
[84] At 1.
[85] At 1.
[86] Directive 2009/128/EC, art 4; European Commission "Main Actions" (29 March 2018) European Commission – Plants <https://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides/main-actions_en >.
[87] European Commission, above n 80, at 3.
[88] Directive, above n 86, art 5.
[89] Articles 6(1) & 6(2).
[90] Art 7(1).

cases.[91] Other measures include the prohibition of aerial spraying,[92] and inspecting pesticide machinery at regular intervals.[93]

Although these guiding methods are specific and have been provided to the member states, the levels of implementation and measurability vary between countries.[94] The 2017 report from the Commission to the European Parliament and the Council (the report) on Member State NAPs and progress in implementing the Directive states that "member states had different starting points for the development of the NAPs".[95] Some had existing plans that just required alterations, others created their first plan under the Directive.[96]
The measurability of the goals set in the plans was a key theme in the report. The Commission reported that while goals had been set, the majority of them did not have processes in place for measuring progress.[97] This was identified as a major flaw in the NAPs, as without measurability, no progress is measured and no data, on which future decisions could be based, is collected. The report gave examples of good measurable pesticide risk reduction targets from Germany, Finland, Denmark and the Netherlands.[98] These targets were specific as the countries had developed "indicators based on pesticide hazard classification, with higher risk pesticides having a higher weighting".[99] This means it is possible for these countries to measure risk reduction by measuring the reduction in use of high risk chemicals.

The Commission also reported a high level of compliance in terms of both providing training to pesticide operators and restricting pesticide sales to non-professionals.[100] It did note however that the processes for reporting poisoning cases were lacking in some member states. It promoted the use of dedicated systems for collating information on both chronic and acute poisoning cases, while noting it is difficult in some case to link symptoms to pesticide exposure.[101]

[91] Art 7(2).
[92] Art 9(1).
[93] Art 8(1).
[94] European Commission, above n 80, at 4.
[95] European Commission, above n 80, at 4.
[96] At 4.
[97] At 4.
[98] At 5.
[99] At 5.
[100] At 6.
[101] At 7.

Furthermore, it reported that every member state had banned aerial spraying, with minimal exceptions that are under strict conditions.[102] In 2015 95 per cent of the aerial spraying had been done under exception by two member states, Spain and Hungary, and the spraying covered 0.7 percent and 0.9 per cent respectively of the surface area of the two countries.[103] Under the Directive, states were required to complete inspections of equipment and machinery used in relation to pesticide. It was reported that all states had done this, but to different standards which resulted in a clarified standard published in 2015.[104]

The Commission also reported that attempts to raise awareness were promising with the use of national websites to provide balanced and accurate information, but that this reach should be expanded.[105] Information and awareness campaigns in Denmark, Poland and Sweden, along with "pesticide-risk" themed competitions in Polish and Italian schools were highlighted by the Commission as good examples of targeted information sharing.[106]

The significance of IPM in regulating pesticides is a key reason the EU are considered to exercise best practise. Integrated Pest Management involves an "integrated approach to the prevention and/or suppression of organisms harmful to plants" by utilising "all available information, tools and plant protection methods".[107] This means that the EU does not just demand or promote the removal of chemicals, but supports an alternative for them, and encourages member states to set phase-out goals. Annex III of the Directive sets out eight principles by which IPM should function.[108] These include firstly, using supported alternatives to chemicals, such as crop rotation, seed selection, selection for resistance in cultivars, utilisation of natural predators and decreasing monocultures.[109] Secondly, monitoring harmful organisms, observing them and providing warnings, early diagnosis of issues and forecasts where feasible.[110] Thirdly, using the results of the monitoring and region/area-specific context to determine if and which protective measures to apply.[111]

---

[102] At 8.
[103] At 8.
[104] European Commission, above n 80, at 7 & 8.
[105] At 9.
[106] At 9.
[107] At 13.
[108] Directive, above n 986, Annex III(1) – (8).
[109] European Commission, above n 80, at 13; Directive, above n 86, Annex III (1).
[110] Directive, above n 86, Annex III (2).
[111] Annex III (3).

Fourthly, preferring the use of physical and non-chemical methods over chemical ones.[112] Fifthly, when using pesticides, ensuring they are as specific as possible for the target, with the least amount of side effects.[113] Sixthly, only using necessary levels of any pesticide action while not increasing risks of resistance in the target organisms.[114] Seventhly, considering resistance risk for every application, especially where resistances are known and employing strategies to conquer this.[115] Finally, consistently checking the success of the protective measures.[116] All eight of these principles play a crucial role in reminding those involved of the standards they are trying to reach. They act as an important foundation from which management processes and effective regulation can grow.

Alongside the NAPs and IPM goals and programs, the EU has also taken more direct action by banning and restricting certain chemicals. Many highly toxic and persistent chemicals and active substances have already been banned or severely restricted by the EU. After the implementation of the 2006 Thematic Strategy on the sustainable use of pesticides the number of approved substances decreased by approximately 50per cent.[117] As at March 2016 the EU had over 800 active substances listed as not approved.[118]

Regulation (EU) No 485 was issued in 2013, granting a moratorium and severely restricted the use of three neonicotinoids in an attempt to protect bees.[119] In February 2018 the European Food Safety Authority published a review of chemicals in question, confirming the risks to bees.[120] As a result of these conclusions there has been a ban on the outdoor use of the three neonicotinoids; clothianidin, imidacloprid and thiamethoxam.[121]

---

[112] Annex III (4).
[113] Annex III (5).
[114] Directive, above n 86, Annex III (6).
[115] Annex III (7).
[116] Annex III (8).
[117] European Commission, above n 80, at 1.
[118] European Commission "Search Active Substances" Plants (7 March 2016) EU Pesticides Database < http://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=activesubstance.selection&language=EN >.
[119] Regulation 485/2013 amending Implementing Regulation (EU) No 540/2011, as regards the conditions of approval of the active substances clothianidin, thiamethoxam and imidacloprid, and prohibiting the use and sale of seeds treated with plant protection products containing those active substances [2013] OJ L13912.
[120] European Commission "Current Status of Neonicotinoids in the EU" European Commission - Plants < https://ec.europa.eu/food/plant/pesticides/approval_active_substances/approval_renewal/neonicotinoids_en >; European Food Safety Authority "Neonicotinoids: risks to bees confirmed" (28 February 2018) European Food Safety Authority < https://www.efsa.europa.eu/en/press/news/180228 >.
[121] New Zealand Environmental Protection Authority "Bees and Other pollinators", above n 64.

Implementing the various bans and restrictions has not been without issues for some. In the United Kingdom, farmers have complained about restricted freedom in pesticide choice, reporting increases in insects and decreases in crop yield.[122] However, such changes were never going to be popular with farmers, or the pesticide industry, as using alternatives to chemical insecticides requires time and energy-intensive practises. Also, in some cases there is a reduction of profit.[123] There are provisions that allow exemptions to be granted, and this has been done previously. However, as the Commission has stated in the report, this approach is a short term fix, with a longer term cost.[124]

Some of the worst international practises with pesticide law and regulation are in third world African countries. These countries face an entirely different set of circumstances to those in New Zealand, and the use of highly toxic insecticides saves more lives than it risks. For example, DDT is used in African countries like Zambia and Ethiopia to kill insects that are vectors for lethal human diseases like malaria. The World Health Organisation supported the use of DDT to fight the spread of malaria, and certain countries have exemptions from the Stockholm Convention which allow them to use DDT for this very specific purpose.[125]

New Zealand

A New Zealand's Insecticide History

In the past, New Zealand has proven itself to be an innovative and ambitious country when it comes to environmental law, enacting novel legislation such as the Resource Management Act 1991 (RMA). The RMA is legislative instrument which was the first of its kind, with its purpose of sustainable management, and its function of regulating several major environmental concepts and industries. When concerns around insecticide and pesticide use first rose, NZ was quick to act, banning the toxic DDT chemical in 1970, two years before the US and 13 years before the EU's total ban.[126]

---

[122] Ben Webster "Farmers plot their return to bee-killer pesticides" The Times UK (online ed., UK, 5 May 2015) at 1.
[123] Peter Hugh, above n 44, at 136.
[124] European Commission, above n 80, at 14.
[125] Kenneth Kimutai "Is DDT still being used?" (25 April 2017) World Atlas < https://www.worldatlas.com/articles/is-ddt-still-being-used.html >; Secretariat for the Stockholm Convention "Acceptable Purposes: DDT", above n 45.
[126] Alsion Popay "Insect pests of crops, pasture and forestry, DDT spraying" (25 November 2008) Te Ara The Encyclopedia of New Zealand < https://teara.govt.nz/en/photograph/17969/ddt-spraying >.

In 1996 New Zealand enacted the Hazardous Substances and New Organisms Act (HSNO) which is purposed with "protecting the environment, and … people and communities, by preventing or managing the adverse effects of hazardous substances and new organisms".[127] Many active ingredients in chemical insecticides are considered hazardous substances. The HSNO requires approval from New Zealand's Environmental Protection Agency (EPA) before such substances can be imported or manufactured in NZ.[128] The EPA was re-established by s7 of the Environmental Protection Act 2011, [129] and has the authority to introduce hazard classification systems and prescribe controls and requirements for the packing, keeping, use, labelling and advertising (among other things) of hazardous substances.[130] These controls prescribe when, where, how, and for what purpose hazardous substances, like insecticides, can be administered.

New Zealand ratified both the Rotterdam,[131] and Stockholm Conventions in 2004.[132] These Conventions were ratified via the enactment of the Imports and Exports (Restrictions) Prohibition Order (No 2) 2004. This order addresses the import and export of Stockholm and Rotterdam chemicals, and requires consent and permits from the EPA, if and when there needs to be transboundary movement of the chemicals.[133]

B New Zealand's Current Dilemma

The international community has linked a significant decline in pollinators like bees with the use of neonicotinoid insecticides. Some have taken steps to prevent the harms. New Zealand has been slow to respond to the emerging research and the question as to whether this is the best choice arises.

New Zealand does not currently have a large amount of national research on the effects of insecticides on bees. This means there is no definitive way of determining whether or not there is a decrease in bee populations, and if there is, whether this is due to insecticide poisoning. The majority of research available on the effect of neonicotinoids on bees is

[127] Section 4.
[128] New Zealand Environmental Protection Authority "Pesticides", above n 9.
[129] Section 7.
[130] Hazardous Substances and New Organisms Act 1996, ss 74 – 77B.
[131] Secretariat for the Rotterdam Convention "Country Profiles" United Nations – Rotterdam Convention < http://www.pic.int/Countries/CountryProfiles/tabid/1087/language/en-US/Default.aspx >.
[132] Secretariat for the Stockholm Convention "Country Profiles" United Nations - Stockholm Convention < http://chm.pops.int/Countries/CountryProfiles/tabid/4501/Default.aspx>.
[133] Imports and Exports (Restrictions) Prohibition Order (No 2) 2004, ss 7 – 11.

international. The New Zealand research available is minimal, and based primarily on honey bees, a commercially farmed species of bees. There is little research on the 40 other species of bee in New Zealand.

The EPA has acknowledged the EU's research and reasons for imposing the most recent bans, but claims the same results have not been seen in New Zealand. The EPA based this finding on a report conducted on behalf of the Ministry for Primary Industries by Landcare Research (LCR). Landcare Research conducted a survey on bee colony losses in 2016 in an attempt to quantify these losses and determine causes.[134]

Invitations to partake in the survey were issued to all New Zealand beekeepers, and there was a 37.88 per cent response rate.[135] The survey asks beekeepers about colony losses, health, production and problems, and LCR collated the information supplied to form conclusions about colony loss in New Zealand. The survey asked a range of questions focused on topics such as queen problems, pests, diseases, mite treatments, starvation, nutrition and pollination.[136] It did not specifically ask beekeepers to attribute colony problems with pesticides, plant toxins, varroa mite or other pathogens.[137] This is because these areas are considered difficult to diagnose.[138] Thus, in line with international surveys, beekeepers were asked to report on symptoms which helped LCR distinguish different causes of colony problems.[139] The survey concluded that the most common reason for common loss was colony death.[140] Two important symptoms related to colony death were identified. The first was "presence of dead worker bees in the cells with no food present in the colony" which indicated starvation, and the second was the "presence of many dead bees in or in front of the colony" which indicated toxin exposure.[141] Landcare Research concluded that 31.37 per cent of losses attributed to colony death by the surveyed beekeepers were due to toxin exposure.[142] The second largest cause of colony loss was queen problems. These problems involved

[134] P. Brown, Landcare Research *New Zealand Colony Loss Survey Report – 2016* (Ministry of Primary Industries, MPI Technical Paper No:2017/16, February 2017) at 1.
[135] At 1.
[136] P. Brown, above n 134, at 1.
[137] At 6.
[138] At 6.
[139] At 6.
[140] At 60.
[141] At 60.
[142] At 61.

drone-laying queens, lack of queens, sick and poorly mated queens.[143] Interestingly, international research has linked exposure to neonicotinoids with poor queen health.[144]

In critiquing the report, it is important to remember that only 37.88 per cent of New Zealand's beekeepers responded. Furthermore, the data used is based on answers provided by individual beekeepers, who's responses are based on personal knowledge and interpretations of their colonies. This means there is limited standardisation in the interpretation of questions and provision of answers.

In addition to this, the survey does not specifically address the effects of insecticides like neonicotinoids on bees. There were no specific questions about the use, location or likelihood of neonicotinoids contamination in the survey, thus it seems inappropriate for the EPA to determine New Zealand's susceptibility to neonicotinoids on this research.

There has not been enough research to accurately determine trends in bee populations, or the effect of insecticides on population numbers in New Zealand. However, the bee and chemicals used in the international research are the same as those in New Zealand. Thus it follows the effects of combining the two would be the same, giving reason to believe the European research would apply in New Zealand. Should this be the case, New Zealand would need to seriously consider whether current measures are enough to protect bees. The current measures will now be considered.

[143] At 61.
[144] N. Tsvetkov et al., above n 35, at 357.

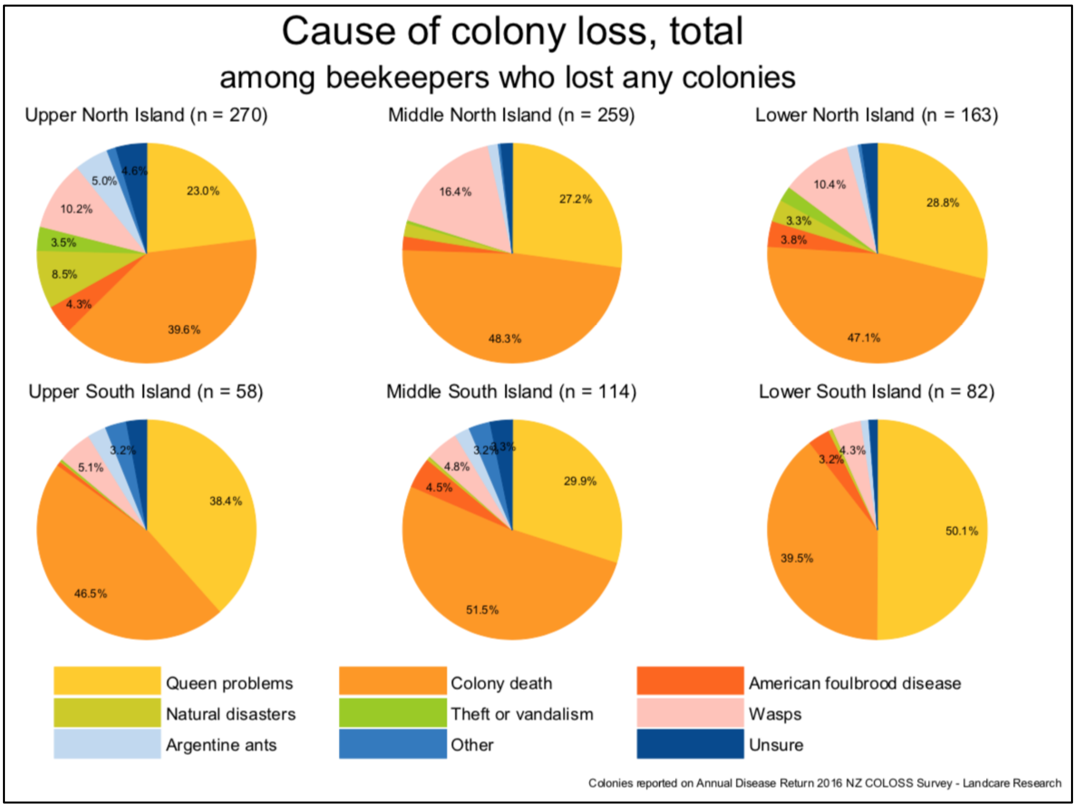

Figure 1; The cause of colony loss, total, among beekeepers who lost any colonies. Retrieved from the 'Ministry for Primary Industries' "New Zealand Colony Loss Survey Report – 2016".

C New Zealand's Current Insecticide Practices

New Zealand has shown an interest in and commitment to safe pesticide and insecticide use by ratifying both the Rotterdam and Stockholm Conventions, and legislating for changes. However, these measures are no longer at the same level as best international practises, and will not be adequate if its confirmed neonicotinoids are causing bee declines.

New Zealand has a collection of pest management action plans but nothing specific about pesticide or insecticide management as they come under the broader umbrella of general pest management. [145] New Zealand does not have an official plan for pesticide reduction, or for the introduction or promotion of IPM. Integrated pest management is promoted by separate research organisations such as Plant and Food Research,[146] the Foundation for Arable Research,[147] as well as by commercial companies such as BioForce Ltd.[148]

[145] Ministry of Agriculture and Forestry *MAF Biosecurity New Zealand Pest Management National Plan of*

au

Ahumara Kai < https://www.plantandfood.co.nz/page/our-research/bioprotection/products-systems/ipdm/ >.

[147] Foundation for Arable Research "Integrated Pest Management "Foundation for Arable Research < https://www.far.org.nz/research/weeds_and_pests/integrated_pest_management >.

The New Zealand EPA permits the controlled use of neonicotinoids which have now been severely restricted in Europe.[149] The restrictions on the use of neonicotinoids include; no spraying near bee hives, on crops where bees are foraging or likely to forage, in areas where flowering crops are present, and on flowering or budding plants.[150] New Zealand allows restricted aerial spraying of chemicals despite the risks this carries for pollinators, which have been published by both the UN and the EU.[151] The EPA has power under s38D of HSNO to place controls on the use of some chemicals, such as requiring certain levels of training for professional administrators, and requiring any level of auditing, monitoring, reporting and record-keeping considered necessary.[152] The EPA also prevents the importation to, or manufacturing in New Zealand, of any chemical without approval.[153]

D Alternatives Options for New Zealand

At this point of time, New Zealand should take precautionary steps. Dangers of neonicotinoids have been highlighted and can be accepted and acted upon or dismissed. However, before dismissing them, it is paramount New Zealand authorise its own scientific research into neonicotinoid effects on bees. After this research has returned conclusive results, New Zealand may be able to make a decision regarding future chemical insecticide use for neonicotinoids.

In addition to commissioning additional research, measures for consideration include prioritising national pesticide risk reduction, legislating against neonicotinoids, establishing clear pest management principles, creating a targeted regulatory body and initiating education programs in the communities.

One method for prioritising national pesticide risk reduction is by creating a national plan of action (NPA). New Zealand Ministries have created NPAs previously for pest management and biodiversity. A NPA would provide New Zealand with goals, which are essential for the success of any large project. These NPAs would involve specific time frames and measurable

---

[148] BioForce Ltd "Integrated Pest Management" BioForce Ltd < https://www.bioforce.co.nz/Sustainable+Practices++IPM/IPM.html >.

[149] New Zealand Environmental Protection Authority "Bees and Other pollinators", above n 64.

[150] New Zealand Environmental Protection Authority "Bees and Other pollinators", above n 64.

[151] United Nations Environment Programme, above n 1, at 7.

[152] Sections 38D(1)(b) and 38D(1)(i).

[153] New Zealand Environmental Protection Authority "Pesticides", above n 9.

targets which would allow progress to be monitored. The NPA would create smaller initiatives as steps to achieving the end goal. These initiatives could target specific areas such as pesticide use training, machinery compliance checks, creating networks for IPM users, general education in pesticide harms, and promotion and support for IPM methods.

Another way of prioritising national pesticide risk reduction is to acknowledge issues in legislation or directives. This could take the form of a clear set of principles being included in the HSNO. Incorporating the risks in a legal context would demonstrate their importance.

If a legislative change made IPM and reductions in neonicotinoids compulsory, or the EPA banned the use high toxicity neonicotinoids, the enforcement mechanisms for these regulations would act as motivation for compliance. These bans do not have to take immediate effect but could be phased in through a structured program. In addition, all aerial spraying could be banned to minimise harm through chemical drift.

Creating a regulatory body would be useful for measuring the progress of and enforcing the requirements of the NPA. Isolating this issue from other pest management concerns would allow for a more focused and specific approach, leading to faster and higher levels of compliance and progress. However, even if the logistics of establishing this body proved too much (in terms of cost and resources) New Zealand's EPA's current authority could be extended to fill such additional requirements.

A final precautionary measure to be implemented are education programs. These could span all ages and levels of expertise by targeting schools and general communities, as well as professional industries. Education is often the biggest barrier to change. Understanding why change is important is crucial in recruiting people to help achieve the goals.

E The Possibility of Change in New Zealand

Although there would be benefits to altering New Zealand's insecticide practises and regulation, hurdles also need to be addressed.

In order for industries and farmers to support new IPM initiatives, there has to be a good reason for change. Although there is good scientific reason for change, farmers and industry are often motivated by more tangible benefits. Education on the risks of insecticides and the provision of cost benefit analysis', to prove reducing pesticide use and implementing IPM has long term returns, could help convince those on the front line to support change. However, there is always the possibility that the cheaper and easier option of neonicotinoid insecticides will be more attractive.

Also, if New Zealand established insecticide reduction goals, valid alternatives to the chemicals need to be available. Author Kraus stated "Some countries are striving to reduce chemical crop protection… this can only be achieved if all the other aspects of the integrated pest management are effective enough to fill the gap".[154] Therefore in order for any change to be successful, there needs to be adequate information, processes, goals, measures, equipment and instruction available. A secondary hurdle here is funding. Large-scale projects with long-term goals require funding.[155] It is important to recognise that funding is less likely to be allocated to a concept or program like IPM, when the harms IPM is trying to prevent are not yet visible or urgent. Despite this, it has to be remembered that even though the harms may be currently invisible, they still exist.

Finally, it is important to note that some research has suggested, even if neonicotinoids were banned, bees are likely to suffer continued exposure to neonicotinoids because of their previous widespread use.[156]

F The Necessity of Change in New Zealand

New Zealand places significant reliance on chemical insecticides because of the economy's dependency on agriculture. This dependency could be why New Zealand is hesitant to accept international research on neonicotinoid harms.

Dependency on agriculture has two sides to it. The first is the need for insecticides to ensure the health, size and viability of crop yields. This provides economic security for the producer and security in exports on a national scale. The second side is that many of our agricultural industries need bees for their pollination services. New Zealand kiwifruit exports make up 21 percent of the world's kiwifruit production, and 32 percent of the world's kiwifruit trade.[157]

---

[154] P. Kraus, above n 79, at 7.
[155] Peter Hugh, above n 44, at 138.
[156] B.A. Woodcock et all., above n 37, at 357.
[157] Ministry for the Primary Industries "Exporting – New Zealand produces a little and exports a lot" Ministry for Primary Industries Manatu Ahu Matua < https://www.mpi.govt.nz/exporting/overview/growing-exports/ >.

Bees are the natural pollinators for kiwifruit vines, however growers are experiencing declines in bee populations and are using alternative pollination methods.[158] These methods involve spraying solution containing pollen on crops and using an air blower to distribute pollen. Both methods are more expensive, as pollen has to be purchased, and time consuming, as an operator has to physically administer the pollen.[159] This problem could easily transfer to New Zealand's pip-fruit industries and wine industry.

Another consideration is for New Zealand as a clean, green, environmentally friendly nation. Bees are integral to the pollination of wild and natural plants and increased biodiversity is a product of this. Although there is a moral argument that biodiversity should be conserved because of its intrinsic value, an economic argument also exists. New Zealand's image is heavily intertwined with the diversity flora and fauna found here, and provides a significant tourism attraction. Therefore, bees are important in maintaining both New Zealand's reputation, and biodiversity as a tourism attraction.

The kiwifruit example illustrates the importance of bees in New Zealand and is motivation for acting to protect bee health, and stabilise population numbers. Trying to replace a natural pollination service for all of New Zealand's crop and plant-product production industries would be expensive and time consuming.

Therefore, if the international research on the harms of neonicotinoids applies in NZ, a change in practises will be necessary to prevent ecological and economic harm.

Conclusion

Pest management has existed for as long as humans have battled pests. Initial forms of pest management included botanical, biological and mechanical methods, but the most common in the 21st century is chemical. Insecticide use and regulation has a colourful international history with a cyclic pattern of invention of a chemical, discovery of harm caused by its use and banning or regulation of that chemical. The most recent class of chemicals to go through this cycle in the international field have been neonicotinoids. One of the most widely used class of insecticides, neonicotinoids, has recently been found to have harmful and negative

---

158 Science Learning Hub "Kiwifruit pollination problems" (6 June 2012) Science Learning Hub < https://www.sciencelearn.org.nz/resources/72-kiwifruit-pollination-problems >.

159 Science Learning Hub, above n 158.

effects on pollinators, and have been linked to the global decline in bees. This research has sparked concern in the international sphere and has prompted the EU to impose a stringent ban on three neonicotinoids.

The EU demonstrates some of the most ambitious and stringent practises in insecticide regulation and these practises can be learnt from. New Zealand currently has very little of its own research on bee populations and the effect of neonicotinoids. As a consequence, New Zealand is reluctant to make any changes to current pesticide practices. It was proposed that extensive research be conducted to determine whether New Zealand's bees are threatened by the use of neonicotinoids. While such research is being conducted, it was recommended precautionary measures be taken, such as national prioritising of risk reduction via NPAs, legislative bans, the establishment of a regulatory body and the initiation of education programs. Concerns with implementing the alternatives have been addressed and the need for bees in New Zealand has been established. Consequently, it is better to act now then to delay and deal with the potential drastic consequences bee decline would have on New Zealand's ecologies, primary industries and economy.

Bibliography

A Legislation

Hazardous Substances and New Organisms Act 1996.

Regulation 485/2013 amending Implementing Regulation (EU) No 540/2011, as regards the conditions of approval of the active substances clothianidin, thiamethoxam and imidacloprid, and prohibiting the use and sale of seeds treated with plant protection products containing those active substances [2013] OJ L13912.

The Plant Protection Products (Sustainable Use) Regulations 2012.

Environmental Protection Act 2011.

B Books and Chapters in Books

Clarence Cottam and Elmer Higgins "DDT and its Effect on Fish and Wildlife" in Thomas R. Dunlap *DDT, Silent Spring, and the Rise of Environmentalism* (University of Washington Press, Seattle, 2008).

Peter Hugh *The Global Politics of Pesticides: Forging Consensus from Conflicting Interests* (Earthscan Publications ltd, London, 1998).

P. Kraus "Global pest management in the Future" in *Pesticides: Food and Environmental Implications* (International Atomic Energy Agency, Vienna, 1988).

P. Müiller "Effects of Pesticide on Fauna and Flora" in *Pesticides: Food and Environmental Implications* (International Atomic Energy Agency, Vienna, 1988).

Peter D Stiling *An Introduction to Insect Pests and their Control* (MacMillan Publishers, London, 1985).

Gilbert Waldbauer *Insights from Insects: What Bad Bugs Can Teach Us* (Prometheus Books, New York, 2005).

C Journal Articles

Jennifer C. Geib and others “Bumble bee nest abundance, foraging distance, and host plant reproduction: implications for management and conservation” (2015) 25 Ecological Applications 768.

Rene Feyereisen “Insect P450 inhibitors and insecticides: challenges and opportunities” (2015) 71 PMS 793.

J. W. Huismans “The International Register of Potentially Toxic Chemicals (IRPTC)” (1980) 4 EES 393.

Daniel Kelemen and David Vogel “Trading Places: The Role of the United States and the European Union in International Environmental Politics” (2010) 43 CPS 427.

Volodymyr Volodymyrovych Oberemok, Kateryna Volodymyrivna Laikova, Yuri Ivanovich Gninenko, Aleksei Sergeevich Zaitsev, Palmah Mutah Nyadar, Tajudeen Adesoji Adeyemi, “A short history of insecticides” (2015) 55 JPPR 221.

Jeroen P van der Sluijs, Noa Simon-Deso, Dave Goulson, Laura Maxin, Jean-Marc Bonmatin and Luc P Belzunces “Neonicotinoids, bee disorders and the sustainability of pollinator services” (2013) 5 Curr. Opin. Environ. Sustainability 293.

N. Tsvetkov, O. Samson-Robert, K. Sood, H. S. Patel, D. A. Malena, P. H. Gajiwala, P. Maciukiewicz, V. Fournier, A. Zayed “Chronic exposure to neonicotinoids reduces honey bee health near corn crops” (2017) 356 Science 1395.

Marci Vecchiato, Elena Argiriadis, Stefano Zambo, Carlo Barbante, Giuseppa Toscano, Andrea Gambaro and Rossano Piazza “Persistant Organic Pollutants (POPs) in Antarctica: Occurrence in continental and coastal surface snow” (2014) 119 MicroChem. J. 75.

Paul H. Williams and others *Bumble Bees of North America: An Identification Guide* (1st ed., Princeton University Press, Princeton, 2014).

B.A. Woodcock and others “Country-specific effects of neonicotinoid pestcides on honey bees and wild bees” (2017) 356 Science 1393.

“Eagle population soars” (1994) 263 AAAS 922.

D Reports

P. Brown, Landcare Research *New Zealand Colony Loss Survey Report – 2016* (Ministry of Primary Industries, MPI Technical Paper No:2017/16, February 2017).

European Commission *Member State National Action plans and on progress in the implementation of Directive 2009/128/EC on the sustainable use of pesticides* (European Commission COM(2017) 587 Final, October 2017).

European Food Safety Authority *Q&A: Conclusions on neonicotinoids 2018 (*European Food Safety Authority, 28 February 2018).

Ministry of Agriculture and Forestry *MAF Biosecurity New Zealand Pest Management National Plan of Action* (Ministry of Agriculture and Forestry February 2011).

United Nations Environment Programme *UNEP Emerging Issues; Global Honey Bee Colony Disorders and other Threats to Insect Pollinators* (United Nations Environment Programme, 2010).

E Internet Resources

Allan Gillingham “New Zealand’s bees species” (24 November 2008) Te Ara The Encyclopedia of New Zealand < https://teara.govt.nz/en/diagram/15740/new-zealands-bee-species >.

Alsion Popay “Insect pests of crops, pasture and forestry, DDT spraying” (25 November 2008) Te Ara The Encyclopedia of New Zealand < https://teara.govt.nz/en/photograph/17969/ddt-spraying >.

BioForce Ltd “Integrated Pest Management” BioForce Ltd < https://www.bioforce.co.nz/Sustainable+Practices++IPM/IPM.html >.

Environmental Protection Agency “Bees and other pollinators – protecting our environment” Environmental Protection Authority, Te Mana Ruhi Taiao < https://www.epa.govt.nz/everyday-environment/animals-and-insects/bees/ >.

European Commission “Current Status of Neonicotinoids in the EU” European Commission - Plants < https://ec.europa.eu/food/plant/pesticides/approval_active_substances/approval_renewal/neonicotinoids_en >.

European Commission “Main Actions” (29 March 2018) European Commission – Plants <https://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides/main-actions_en >.

European Commission “Neonicotinoids” (28 March 2018) European Commission – Plants < https://ec.europa.eu/food/plant/pesticides/approval_active_substances/approval_renewal/neonicotinoids_en>.

European Commission “Search Active Substances” Plants (7 March 2016) EU Pesticides Database < http://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=activesubstance.selection&language=EN >.

European Food Safety Authority “Neonicotinoids: risks to bees confirmed” (28 February 2018) European Food Safety Authority < https://www.efsa.europa.eu/en/press/news/180228 >.

Foundation for Arable Research “Integrated Pest Management ”Foundation for Arable Research < https://www.far.org.nz/research/weeds_and_pests/integrated_pest_management >.

Kenneth Kimutai “Is DDT still being used?” (25 April 2017) World Atlas < https://www.worldatlas.com/articles/is-ddt-still-being-used.html >.

Ministry for the Primary Industries "Exporting – New Zealand produces a little and exports a lot" Ministry for Primary Industries Manatu Ahu Matua < https://www.mpi.govt.nz/exporting/overview/growing-exports/ >.

New Zealand Environmental Protection Authority "Bees and Other Pollinators" New Zealand Environmental Protection Authority, Te Mana Rauhi Taiao < https://www.epa.govt.nz/everyday-environment/animals-and-insects/bees/ >.

New Zealand Environmental Protection Agency "Pesticides" Environmental Protection Agency, Te Mana Rauhi Taiao < https://www.epa.govt.nz/industry-areas/hazardous-substances/guidance-for-importers-and-manufacturers/pesticides/>.

Plant & Food Research "Integrated Pest & Disease management" Plant & Food Research Rangahau Ahumara Kai < https://www.plantandfood.co.nz/page/our-research/bioprotection/products-systems/ipdm/ >.

Science Learning Hub "Kiwifruit pollination problems" (6 June 2012) Science Learning Hub < https://www.sciencelearn.org.nz/resources/72-kiwifruit-pollination-problems >.

Secretariat for the Rotterdam Convention "Annex III Chemicals" United Nations – Rotterdam Convention < http://www.pic.int/TheConvention/Chemicals/AnnexIIIChemicals/tabid/1132/language/en-US/Default.aspx >.

Secretariat for the Rotterdam Convention "Chemical Review Committee - Overview" United Nations – Rotterdam Convention <http://www.pic.int/TheConvention/ChemicalReviewCommittee/OverviewandMandate/tabid/1059/language/en-US/Default.aspx >.

Secretariat for the Rotterdam Convention "Country Profiles" United Nations – Rotterdam Convention < http://www.pic.int/Countries/CountryProfiles/tabid/1087/language/en-US/Default.aspx >.

Secretariat for the Rotterdam Convention “How it works” United Nations – Rotterdam Convention < http://www.pic.int/TheConvention/Overview/Howitworks/tabid/1046/language/en-US/Default.aspx >.

Secretariat for the Rotterdam Convention “Labelling and Trade” United Nations – Rotterdam Convention < http://www.pic.int/Implementation/Customs/LabelingTrade/tabid/1612/language/en-US/Default.aspx >.

Secretariat for the Rotterdam Convention “Overview” The United Nations – Rotterdam Convention < http://www.pic.int/TheConvention/Overview/tabid/1044/language/en-US/Default.aspx >.

Secretariat for the Rotterdam Convention “Text of the Convention” The United Nations – Rotterdam Convention < http://www.pic.int/TheConvention/Overview/TextoftheConvention/tabid/1048/language/en-US/Default.aspx >.

Secretariat for the Stockholm Convention “Acceptable Purposes: DDT” United Nations – Stockholm Convention < http://chm.pops.int/Implementation/Exemptions/AcceptablePurposes/AcceptablePurposesDDT/tabid/456/Default.aspx >.

Secretariat for the Stockholm Convention “Country Profiles” United Nations - Stockholm Convention < http://chm.pops.int/Countries/CountryProfiles/tabid/4501/Default.aspx>.

Secretariat for the Stockholm Convention “Overview” The United Nations – Stockholm Convention < http://chm.pops.int/TheConvention/Overview/tabid/3351/Default.aspx >.

Secretariat for the Stockholm Convention “The 12 initial POPs under the Stockholm Convention” United Nations - Stockholm Convention <

http://chm.pops.int/TheConvention/ThePOPs/The12InitialPOPs/tabid/296/Default.aspx >.

Secretariat for the Stockholm Convention “The New POPs under the Stockholm Convention” United Nations - Stockholm Convention < http://chm.pops.int/TheConvention/ThePOPs/TheNewPOPs/tabid/2511/Default.aspx >.

Secretariat for the Stockholm Convention “What are POPs” The United Nations – Stockholm Convention < http://chm.pops.int/TheConvention/ThePOPs/tabid/673/Default.aspx >.

United States Environmental Protection Agency “DDT – A brief History and Status” EPA United States Environmental Protection Agency < https://www.epa.gov/ingredients-used-pesticide-products/ddt-brief-history-and-status >.

F Other resources

Michael Eisenstein “Pesticides: Seeking answers amid a toxic debate” Nature News (online ed., 20 May 2015).

Sharon Levy “The pollinator crisis: what’s best for bees” Nature News (online ed., 9 November, 2011).

Ben Webster “Farmers plot their return to bee-killer pesticides” The Times UK (online ed., UK, 5 May 2015) at 1.

“Humans must change behaviour to save bees, vital for food production – UN report” *UN News* (online ed, 10 March 2018).