Department of Conservation
Te Papa Atawhai

Toitū Te Whenua
Land Information New Zealand

Long-term Insights Briefing

How can we help biodiversity thrive through the innovative use of information and emerging technologies?

Te Kāwanatanga o Aotearoa
New Zealand Government

November 2022

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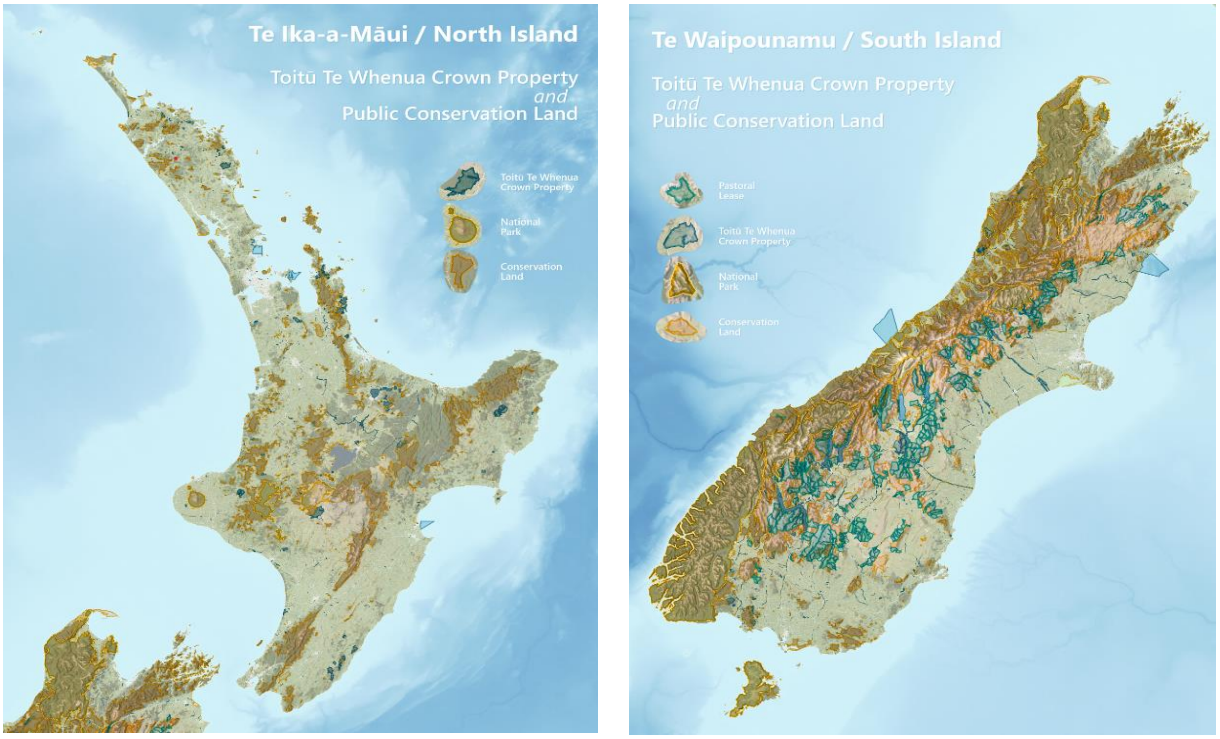
1. About this Long-term Insights Briefing

Agency responsibilities

Te Papa Atawhai Department of Conservation (DOC) and Toitū Te Whenua Land Information New Zealand (Toitū Te Whenua) are producing a joint Long-term Insights Briefing (LTIB). It examines how innovation in the way we use information and emerging technologies can help biodiversity thrive.

Both agencies have roles and responsibilities for protecting Aotearoa New Zealand's biodiversity on behalf of, and for the benefit of, present and future New Zealanders. DOC is responsible for conserving the natural and historic heritage of Aotearoa New Zealand while Toitū Te Whenua manages Crown lands including many of Aotearoa New Zealand's most iconic lakes and rivers, and significant parts of the South Island's high country pastoral land.

Together, DOC and Toitū Te Whenua manage about 40 percent of Aotearoa New Zealand's land, including areas of high biodiversity such as the South Island's high country and our marine reserves. Innovative ways of managing biodiversity on this Crown administered land can be rolled out to private land.



Land administered by DOC and Toitū Te Whenua

Identifying the topic and first consultation

The purpose of LTIBs is to stimulate debate while exploring the medium and long-term trends, risks and opportunities facing Aotearoa New Zealand, and potential options for responding to them.

DOC and Toitū Te Whenua originally proposed the topic of this briefing due to the opportunity new technologies present to scale up conservation efforts over the longer term. The key areas of interest identified as critical to supporting efforts to protect biodiversity included:

- Biotechnologies, with gene editing as a subsection of this group.
- Data, including satellites and remote sensing technologies as valuable tools for collecting data, with artificial intelligence (AI) as a powerful way to analyse this data.

Feedback from consultation

Public consultation on this proposed topic was undertaken in November 2021, with responses showing strong support for the topic. Submitters also noted:

- The importance of understanding risks associated with emerging technology (particularly genetic technologies) and the need for the use of emerging technology to be transparent, participatory, use robust science and information, and be responsive to areas of concern.
- A preference to explore nature-based solutions before considering gene editing.
- The need for a thorough consideration of how data is collected, managed and used, with mention of the value of technologies such as satellites, LiDAR and drones for data collection.
- The importance of finding ways to build understanding and expertise in using data and technology, and how to identify and manage opportunities and risks. AI was noted as a data-driven technology that can support biodiversity protection and restoration through faster and more efficient analysis of large amounts of data.
- The value of data and the importance of having proper oversight, transparency and coordination to ensure it was used safely and ethically.
- The importance of Māori data sovereignty, including the rights and interests that Māori have in the collection, ownership and use of digital information and knowledge that is about them, their culture, language and environment.

The consultation also included a futures-thinking workshop that was held in March 2022. The most common insight from this workshop was that the systems supporting the use of technology and information have a significant influence on its success or failure.

Refining the topic and second consultation

The process summarised above has informed the content of this document, which is now being released for public consultation. The confirmed topic is:

'How can we help biodiversity thrive through the innovative use of information and emerging technologies?'

Throughout the research and consultation process, three areas of transformation have stood out as having particular promise for biodiversity conservation:

- Satellite imagery and remote sensing (for much greater environmental monitoring and surveillance).
- AI and data-driven technologies (for collecting and analysing vast quantities of data).
- Genetic technologies (for new realms of environmental monitoring and management).

These areas are covered in depth in chapter 3, with a look at their current state, future opportunities, benefits and limitations. The briefing also considers, at chapter 4, options for making the most of continued developments in new technology.

Your input is welcomed

This briefing takes account of feedback received on 'the topic' during the first round of consultation and is now being released in draft for your response. Questions to guide your responses are included throughout the briefing and a copy of all the questions is provided at the end of the briefing.

In order for feedback to be taken into account for the final LTIB, it will need to be received by Monday 16 January 2023.

2. Our starting point

Lamenting our losses

Biodiversity is the variability among living organisms from all sources, including land, marine and freshwater ecosystems, and the ecological complexes they are part of.[1]

The biodiversity of Aotearoa New Zealand is seriously compromised. Since human settlement at least 81 plant and animal species, including 62 birds, have become extinct. Many species continue to decline or are just hanging on, with around 4,000 currently threatened or at risk of extinction. In 2021, 94 percent of reptiles were threatened with extinction or at risk of becoming threatened.[2]

A lot of New Zealanders are trying to change this situation. More people than ever are doing conservation work in their own suburbs, setting traps, recording bird numbers and replanting reserves. However, biodiversity continues to decline.

Rob McGowan is a rongoā Māori (traditional healing) practitioner. He describes the changes he's seen first-hand over a lifetime spent carefully observing the natural world.

Rob McGowan, also known as Pa Ropata, is Amo Aratu for Ngā Whenua Rāhui

"As I travel around I see that more and more areas are depleted and there is less and less biodiversity. A forest might seem nice and green but if you look for specific things that you need for rongoā and they're missing, you realise it's not in good shape.

"What is happening now is far in excess of what has happened in the past. It's really troubling. In some areas the land is incapable of being healthy. Possums have stripped the trees, and goats and deer have eaten out the undergrowth. Not only are the critically endangered plants gone – the ordinary plants are disappearing.

"Many people who are close to the land have an overwhelming sense of sadness, as if the land is physically crying out for us to notice and to help. I've seen people sobbing their hearts out because of the powerlessness they feel. It's like when you see someone in tremendous pain and you can't do anything to help – it's a rotten feeling."

"For biodiversity to thrive, all its different components need to thrive. The mauri (life force) of the whenua (land) is found within the connections between them. So when all the connections are in place the mauri thrives, but when they become fractured, the mauri starts to recede.

"If we are to be well, our whole landscape needs to be well. All the species, the connections and the whole support network needs to be put back so the land can heal itself."

[1] United Nations Convention on Biological Diversity 1992. https://www.cbd.int/doc/legal/cbd-en.pdf

[2] Environment Aotearoa 2022. https://environment.govt.nz/assets/publications/environment-aotearoa-2022.pdf

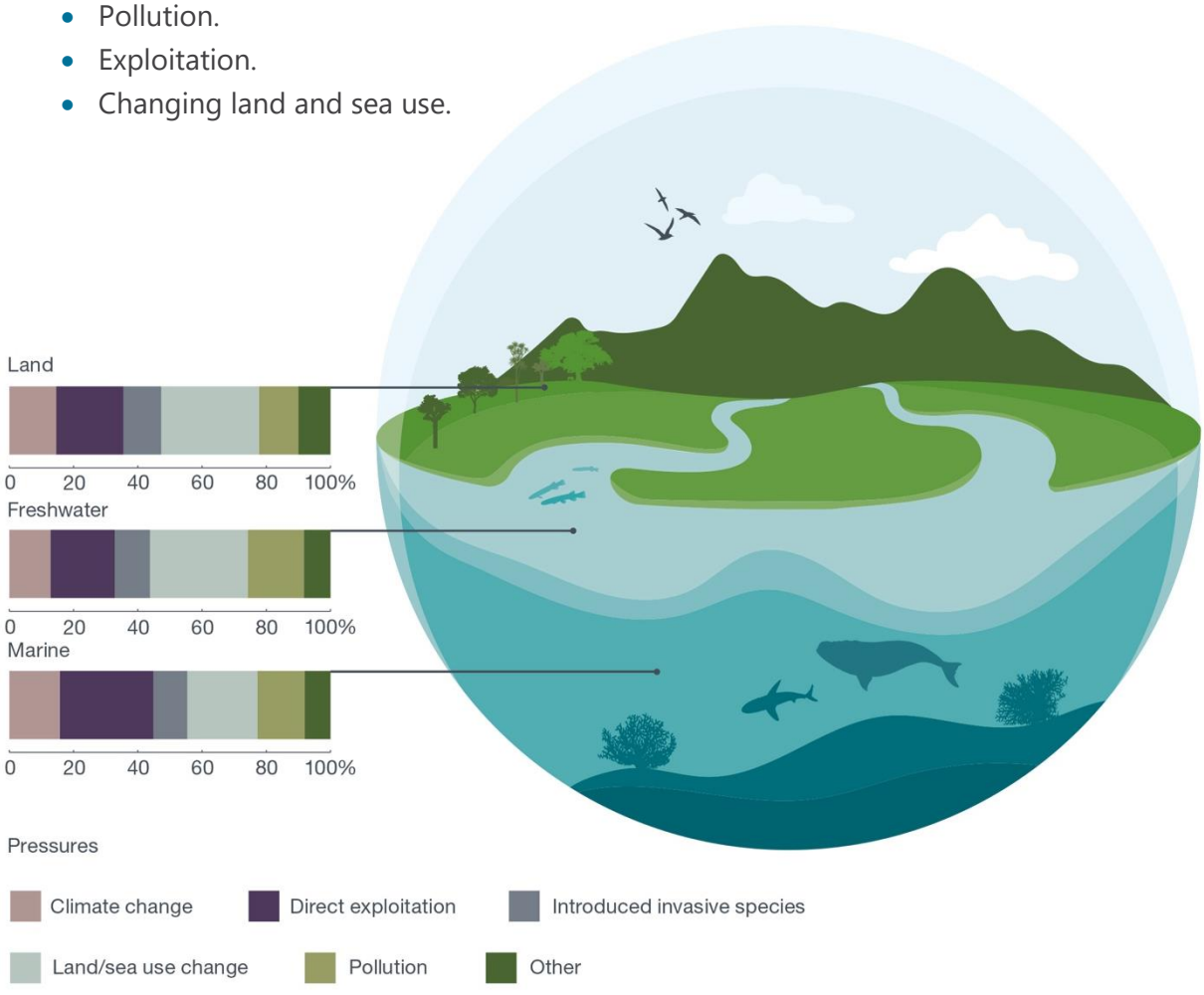
A vision for thriving biodiversity

Te Mana o te Taiao Aotearoa New Zealand's Biodiversity Strategy 2020 sets out a vision for biodiversity: te mauri hikahika o te taiao – the mauri of nature is vibrant and vigorous. It describes three pou (pillars) to guide nationwide actions at all levels to achieve the vision:

- **Tūāpapa** – getting the system right: having the right systems in place to tackle the biodiversity crisis.
- **Whakahau** – empowering action: getting all New Zealanders involved to help protect and restore our biodiversity.
- **Tiaki me te whakahaumanu** – protecting and restoring: addressing the direct pressures causing a decline in biodiversity, ensuring the sustainable use of biodiversity, and restoring biodiversity in areas where it has been lost.

While there are opportunities for new technologies to support all three pou, our draft LTIB is primarily focused on how emerging technologies can address the five main drivers of biodiversity loss:

- Invasive species.
- Climate change.
- Pollution.
- Exploitation.
- Changing land and sea use.



Actions that directly address the drivers of biodiversity loss are likely to make the biggest difference.

Lack of reliable data is a major barrier to action in these areas. Many of our taonga (treasured) species have a threatened species classification of 'data deficient', meaning there is not enough information to assess their risk of extinction. Examples of where we are data deficient include:

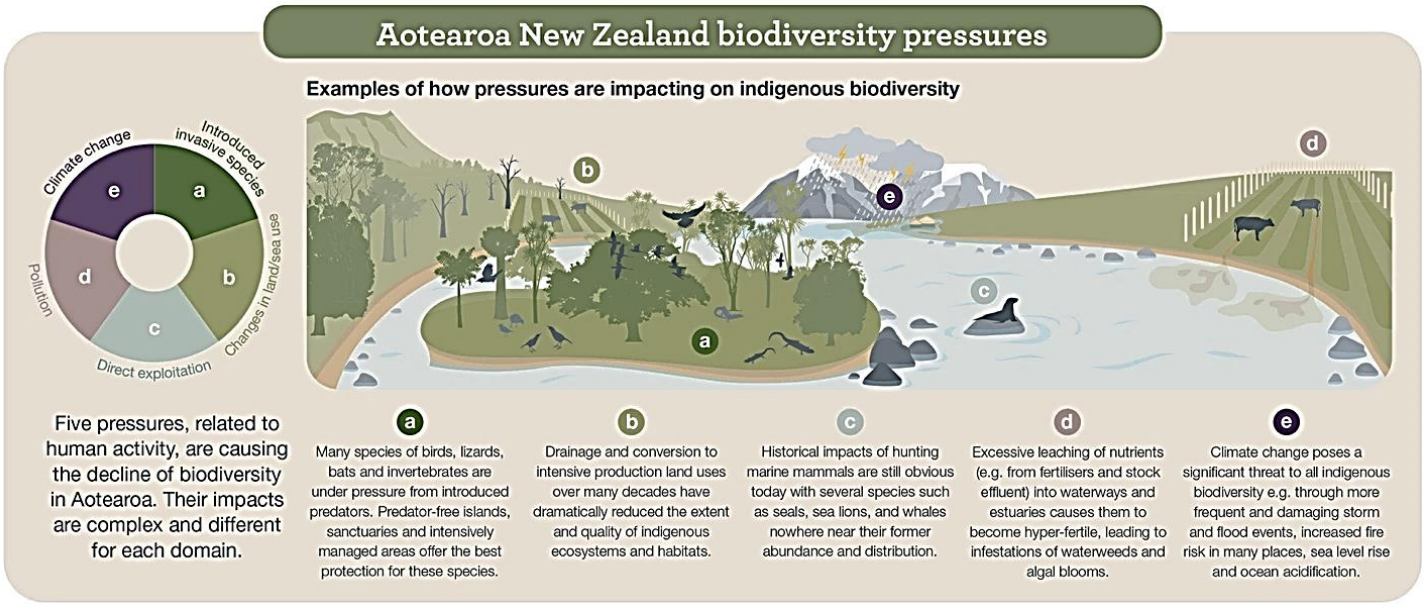
- More than 1 in 3 land invertebrates.
- Around 1 in 4 freshwater invertebrates.
- 2 of every 3 assessed indigenous marine mammal.

Information for marine species is particularly sparse. Mapping and monitoring oceans can be difficult and expensive, but without it we cannot know where protection and restoration would be most effective.

Placing Treaty partnerships at the centre of work for biodiversity

Te Mana o te Taiao Aotearoa New Zealand's Biodiversity Strategy 2020 recognises that Māori exercising rangatiratanga (authority) and kaitiakitanga (guardianship) is essential to the strategy's success.

Realising our obligation of partnership and protection under the Treaty of Waitangi will affect how decisions about indigenous flora and fauna are made, and how mātauranga, Māori culture, and other taonga are protected, used, and developed. Issues of importance to Māori will need to be at the centre of any conversations about the potential use of new information and technologies for biodiversity in the future.



3. Areas of transformation

To demonstrate the opportunities for biodiversity presented through innovation, information and emerging technology, this draft LTIB explores three areas of technological innovation that could be scaled up to improve biodiversity protection:

1. Satellite imagery and remote sensing, including the use of drones, can efficiently collect more – and more accurate – environmental data. These could enable large-scale monitoring and access to places that are currently very difficult to reach.

2. Data-driven technologies, including AI, can process and analyse vast quantities of data quickly and accurately, including data from drones and genomes. AI can also be used to analyse multiple types of data.

3. Genetic technologies allow for new ways to collect environmental data and provide innovative tools for addressing pressures on biodiversity. Genetic technologies expand the horizons for what is possible for biodiversity protection.

While these technologies are already in use, there is huge potential for development. Discussing the opportunities and considerations they present is intended to support a national conversation about how information and technology could support biodiversity in the future.

3.1 Satellite imagery and remote sensing

Satellite and remote sensing technology has helped us to better understand our environment. We use a wide range of satellites and remote sensing technologies such as drones and remote cameras to collect data, monitor the state of our environment and protect habitats and species.

Remote sensing is the science of obtaining information about objects or areas from a distance, typically from satellites, aircraft or drones.

Status and current uses

The first satellite, Sputnik 1, was launched in 1957 and sent a radio signal to Earth for three weeks before its batteries died. Satellites are now orders of magnitude smaller and cheaper. They carry a wide range of instruments and are used for data collection, telecommunications, safety, weather forecasts, navigation, defence and environmental monitoring. Satellite numbers have steadily increased, with a record 1,400 launched in 2021.

Historical satellite data was used by NIWA to track the amount of sediment reaching the coast in the past 20 years. The images show where the most sediment is coming from, so work to reduce erosion can be targeted to particular river catchments. Future images may show how restoration activities are making a difference.[3]

Plumes of damaging sediment are clearly visible along the South Island's east coast

Other current uses for satellite imagery include protected area management[4], species reintroductions[5] and population monitoring[6].

LiDAR (light detection and ranging) is the use of laser light to produce high definition, three-dimensional images of a landscape including the vegetation. Toitū Te Whenua is partnering with councils to map 80 percent of the country by 2025. The information is publicly available and is being used to accurately map environmental changes over time.

Drone use has grown rapidly in the past decade as the machines have become cheaper and equipped with a variety of sensors. Current uses include control of pest insects[7], monitoring habitat and managing wildlife.[8]

[3] Monitoring suspended sediment in New Zealand coastal waters. Monitoring suspended sediment in New Zealand coastal waters: satellite remote sensing and other tools: Sediment and our coasts (doc.govt.nz)

[4] Digital Observatory for Protected Areas. http://dopa.jrc.ec.europa.eu/

[5] Earth observation: overlooked potential to support species reintroduction programmes. https://onlinelibrary.wiley.com/doi/abs/10.1111/aje.12060

[6] For example, counting penguins from space. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0033751

[7] The processionary of the pine. https://www.fitostinger.com/en/pest-control-with-drone-technology/pine-processionary/

[8] Drone technology for monitoring protected areas in remote and fragile environments. https://www.mdpi.com/2504-446X/6/2/42/htm

Drones have been used in Marlborough to search for chalk cress, a tiny native plant with a conservation status of Nationally Critical.[9] Much of the plant's habitat is too dangerous for humans to survey, but the data can be collected by drones.

More accurate GPS information for Australasia

Many conservation and land management tasks depend on knowing the location of an object, like a riverbank, a trap, a wetland, a tree or where a pest fish was found. Current GPS systems are accurate to within 10 metres, but the new SouthPAN (Southern Positioning Augmentation Network) system will improve the precision of positioning to within 10 centimetres.

During the planning phase, agencies and organisations involved in conservation were asked how the new system would benefit their work.

Responses included:

- Greater precision would make it easier to monitor biodiversity in a plot of land.
- More accurate farm planning and animal management could reduce environmental impacts.
- Accurate location data for people and machinery could improve safety.
- Pollution sources could be pinpointed and dealt with more easily.
- The exact location of nesting birds or seed fall from specific trees could be mapped.
- Trapping and use of pesticides could be more accurate and efficient.
- Support compliance monitoring and enforcement of environmental standards.

SouthPAN has the potential to help us identify changes to habitats and species, thus improving decision making around conservation. In the long term, more precise global positioning could lead to new innovations and benefits we haven't even thought of yet.

SouthPAN is a partnership between Toitū Te Whenua Land Information New Zealand and Geoscience Australia.

While SouthPAN has already started operating, its capability will be progressively enhanced over the next five years as ground stations are established and the two new satellites come online.

[9] How drones are helping our threatened plants. https://blog.doc.govt.nz/2021/09/30/how-drones-are-helping-our-threatened-plants/

Oblique imagery – a new angle on ecology

Because oblique imagery is captured at an angle, it provides more detail than a standard aerial photograph

Dr Paul Dutton, Waikato Regional Council scientist, says oblique imagery has been useful for identifying and managing forest fragments along the Waikato River. "No council has enough money to visit every site, and access is always an issue – if you're lucky, you could visit one site per day. But with oblique imagery, one person can review the pictures and classify hundreds of forest types and locations in a day. It's very efficient."

The information we now have because of the oblique imagery and the analysis/classification done can be used to inform decisions around restoration projects. "In one project, we're trying to join up the tiny fragments of kahikatea forest that were found using oblique imagery, and fence and buffer what's left. It's an ecosystem type with only 1 percent of its original cover left in the region, so it's a priority to protect it."

The work was commissioned by Toitū Te Whenua, with 400,000 photos taken from an aeroplane along the length of the river. The data is publicly available and could also be used for farm plans and other monitoring and restoration work.

Future trends

Technological innovation means the tools we use to study the natural environment will continue to become smaller, more precise and accessible.

As GPS receivers shrink, they could be used to monitor smaller species and learn more about their movements.

Increased precision would help in monitoring the growth or shrinking of wetlands on conservation land and farmland, for example. This could allow the more accurate application of pesticides, weedkillers and fertiliser, reducing the amount used while increasing their effectiveness.

More accurate GPS could protect biodiversity by fitting collars to cattle to create a virtual fence

The area of Aotearoa New Zealand that has been mapped by radar and LiDAR is steadily increasing. Toitū Te Whenua is partnering with local councils to map 80 percent of the country with LiDAR by 2025, providing a three-dimensional image of the landscape including its vegetation. This can be used to map changes over time, such as the effects of climate change and land management.

Measuring sensors are becoming cheaper and are in the hands of more people. For example, some phones already have LiDAR systems built into them[10], giving millions of people the opportunity to report data and contribute to community conservation projects.

Improvements to the hardware used in satellites has massively increased the resolution of satellite imagery. At the same time, huge amounts of this imagery are now widely available online.

Aerial drones also have the potential to improve and automate data collection for biodiversity monitoring, particularly in areas where traditional survey techniques are expensive or impractical.

[10] LiDAR is one of the iPhone and iPad Pro's coolest tricks: Here's what else it can do.
https://www.cnet.com/tech/mobile/lidar-is-one-of-the-iphone-ipad-coolest-tricks-its-only-getting-better/

The future of drones

Drones could become a useful tool to support biodiversity work in the future

Drones and unmanned aerial vehicles have proliferated over the past decade and are used in a variety of areas, such as wildlife management, habitat monitoring and other areas in biodiversity. They can carry a variety of sensors, making them a versatile tool/hardware to collect information. Drones have also become cheaper and can be great tools for citizen science[11] and other programmes.

One area where progress has happened is the use of drones in fighting pests. For example, drones are currently used to inject pesticides into the nests of pine processionary, a moth that damages coniferous forests.[12] In Aotearoa New Zealand, drones are starting to be used for baiting, being more cost-efficient compared with helicopter and hand-baiting, and not requiring hiking through dense forest.

The future could hold much more for drones. Drones, operating without a human pilot or operator and in an autonomous manner, could actively be used for taking out pests and weeds. Drones using AI could recognise a pest or weed, such as a stoat or the golden dodder, independently and accurately, and remove them from the environment. Such a method, when all the workings are ironed out, could outpace manual eradication and would be much cheaper to run.

Drones could also be used for observation, protection, and policing. For example, an array of drones could monitor illegal fishing in the Kahurangi Marine Reserve. They would be able to cover larger areas than an enforcement officer in a vehicle or boat, making them very cost-efficient. Because of their size and speed, they would be harder for offenders to spot, making detection of illicit activities easier for the regulators.

[11] 'Citizen science' refers to public participation in science projects. Toward an international definition of citizen science | PNAS.

[12] The processionary of the pine. https://www.fitostinger.com/en/pest-control-with-drone-technology/pine-processionary/

Considerations

Satellite and remote sensing technology can be used across large areas and diverse environments. They have the potential to give fast, accurate results and are not invasive or destructive, providing an excellent complement to field observations.

Despite advances in technology, some limitations to their use may continue.
If a satellite is not flying overhead, it may fail to capture the data at the exact moment we need it. Depending on the satellite, there might also be weather limitations.

Cost may also be an issue. Most satellites in orbit are privately owned and operated. Receiving data from them is expensive due to the cutting-edge technology, uncompetitive nature of the market and other operational limitations, such as orbit and the location of the satellite and its suitability to capture data.

When SouthPAN becomes fully operational in a few years, it could start the discussion about whether Aotearoa New Zealand needs its own fleet of observation satellites or drones specifically designed and operated for our needs.

How data will be collected, curated and stored is another key consideration. Combining data from different sensors helps ensure full coverage of an area, such as using satellite imagery as well as LiDAR to map a forest. Using satellites and remote sensors with other technologies also provides better and more accurate analysis, for example by mapping the extent of a forest and using GPS tracking to ensure it is large enough that an endangered species is not forced to leave the area in search of food. Data quality can be improved by creating standards to ensure data gathered by different teams can easily be combined (for example, images are in the same format and the same resolution), and teams are aware of any gaps in one dataset so these can be filled.

3.2 Artificial intelligence and data-driven technologies

> Artificial intelligence is the theory and development of computer systems that can perform tasks which normally require human intelligence.

Artificial intelligence (AI) is a tool that can achieve positive environmental outcomes and results for biodiversity protection. Having access to relevant and timely data is critical for making decisions about protecting and restoring biodiversity. AI can analyse fragmented or large quantities of data quickly and effectively, allowing insights to be gained much faster than when done by humans alone.

The value of AI tools for good biodiversity outcomes has been well-documented in many reports, including a 2022 report from the AI Forum of New Zealand.[13] Our own earlier

[13] AI Forum New Zealand, AI for the Environment in Aotearoa New Zealand https://aiforum.org.nz/reports/ai-for-the-environment-in-aotearoa-new-zealand/

consultation for this draft LTIB highlighted AI as one of the technologies with the most promise for supporting biodiversity effort. Commenters mentioned the value of data, and the importance of having proper oversight, transparency and coordination of AI and data use.

Status and current use

Other countries provide a range of examples for how AI tools can be used to support biodiversity outcomes:

- In California, ProjectSharkEye is using machine learning models to detect individual sharks and help with conservation efforts.[14]
- In Australia, koalas are being identified, counted and protected with data being collected by drones and analysed by AI.[15]
- Satellite data and AI analysis is being used in Brazil to understand the scale of climate change and water loss in waterways and wetlands.[16]
- In Australia, the Great Barrier Reef Marine Park Authority uses AI-enabled drones to identify damage caused by climate change, and the presence of any pollution that is threatening the reef.[17]

Māui dolphins. Photo credit: University of Auckland and Department of Conservation

In Aotearoa New Zealand, current applications include:

- The development of machine learning, a type of AI, to analyse video footage from fishing vessels and identify possible seabird captures.[18]
- The MAUI63 project involves flying a drone over the sea and using AI to locate Māui and Hector's dolphins.[19] Data on the habitat, size, location and behaviour of the dolphins is collected, and can then be used to protect the species.

New advances in data collection, processing and management are making it possible to increase the monitoring of biodiversity and allowing us to scale and speed up our efforts in protecting and maintaining our species. Data can come from a multitude of places, including from the public. This array and spread of data feeds AI and gives us exciting and effective ways to protect and manage our biodiversity.

[14] Project SharkEye. https://sharkeye.org/

[15] Cutting-edge technologies to amplify insights drawn from digital surveys of the landscape. https://conservationai.net/

16 Map Biomass Brazil. https://mapbiomas.org/en

[17] Drones, AI and e-DNA keeping tabs on Great Barrier Reef and animal health. https://www.barrierreef.org/news/news/drones-ai-and-edna-keeping-tabs-on-great-barrier-reef-and-animal-health

[18] Catching birds on film. https://www.dragonfly.co.nz/news/2022-06-29-fishing-video-analysis.html

[19] Saving the world's rarest dolphin with technology. https://www.maui63.org/

Everyone is a scientist

Dr Monica Peters with Wētā

People power enables more data to be collected, including data that wouldn't otherwise be gathered. The quality has proven to be just as good as professionals collect.

Many citizen science projects are focussed on observations of the natural world. In Aotearoa New Zealand you can share an observation of a lizard, a moth or patch of old man's beard, report a predator kill, count cockles, contribute a bird sighting and much more. Citizens can also help with co-designing studies and processing data.

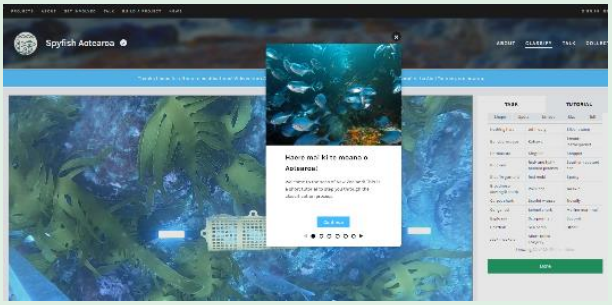
Dr Monica Peters, co-chair of the Citizen Science Association of Aotearoa New Zealand, believes enabling community members to go out and get a better understanding of their environment is critical. "With the right support and enough resourcing, citizen science can be an amazingly powerful way for communities to collect much-needed data."

"What's missing, though, is support, funding and having a plan in place to support the field as it grows. It's critical to ensure funding for citizen science is included in policy."

A well-informed and connected approach is also required. "There's an exciting future ahead with scientists, communities and policy makers working together to manage, monitor and protect our ecosystems. But we need to connect up so we don't duplicate effort."

"Enabling community members to go out and get a better understanding of their environment I think is really, really critical. With the right support and enough resourcing, citizen science can be an amazingly powerful way for communities to collect much-needed data."

A DOC project, Spyfish Aoteoroa, uses volunteers to identify and count fish recorded on video for monitoring marine reserves. About 2,500 people have used it in just over a year. The goal is to be able to share the platform with regional councils and iwi, hapū and whanau, so they can monitor their local marine environment and make decisions about limiting catches if necessary.



Spyfish Aotearoa

SpyFish takes the data generated by the volunteers and feeds it into AI models, helping train them on what fish look like. The more data it has, the more ability the AI tool gains in recognising common species, and the more sophisticated its analysis will be.

Future trends

In the future we can expect to see:

- AI being applied to environmental problems that were previously too hard to solve.
- Data from many different sources, including historical data, being combined to discern patterns and develop solutions.
- AI being used to build more accurate models of the environment than was possible with previous data analysis methods.
- Growth in citizen science projects involving collecting or analysing data.

Exciting progress is being made overseas, where databases are combining data from different sources to protect biodiversity. In the BioDT project,[20] modelling, simulation and prediction are used to model interactions between species and their environment. The resulting information guides decisions about the best actions to take.

One path for Aotearoa New Zealand could see a large database being developed that brings together several data sources that would feed AI and other technologies. This would combine information we already have and use with data from a wide array of sensors and inputs across the country. The connected datasets would use the same standards, giving an understanding of what is happening in the biodiversity realm in one portal, and presented in a way that shows a compelling story about our biodiversity.

AI can help in smaller ways, where running algorithms over different datasets can improve decision-making. Researchers from Sweden, Switzerland and the United Kingdom developed software to analyse biodiversity and climate change data, together with information on the funding available for wildlife protection projects. The software can identify places where creating protected areas would have the most benefit.[21]

Considerations

AI can play a big role in supporting biodiversity, helping provide real time and accurate information. To be fully successful, several considerations must be taken into account:

- Gaining the trust and agreement of the public. There are a range of ethical and legal considerations with the use of data-driven technologies. Work is underway globally and domestically in this area, with the Government Chief Data Steward (Stats NZ) leading work within government on data ethics. Aotearoa New Zealand is also a part of several global organisations that have designed worldwide standards and principles (for example, OECD and Global Partnership on AI).
- The inherent rights and interests that people have in their data. This is particularly important when looking at Māori data sovereignty, where Māori have existing systems and protocols around the protection and sharing of collective knowledge and may wish to adapt this tikanga to digitised data about their people, language, culture, resources or environments.

[20] A Digital Twin prototype to help protect and restore biodiversity. https://biodt.eu/

[21] AI can help preserve biodiversity. https://www.gu.se/en/news/ai-can-help-preserve-biodiversity

- AI is only as good as the data fed into it. Incomplete or biased data can lead to conclusions that may not have been intended. Human oversight is necessary if AI is used as the basis for decisions that have significant implications.
- Collection, storage and use of data, how data is kept safe, the way it can be made interoperable, and ownership of the data.
- Data silos and fragmentation, and access to high quality data are also issues that will need to be addressed to fully utilise AI and other data-driven technologies.
- Building understanding and capabilities in data and AI use, strengthening relationships and increasing collaboration.

Interoperability is about making sure that data generated by – or held in – different formats can be used together. The government digital standards catalogue contains digital standards and guidance that should be used by New Zealand government organisations to support interoperability and transformation – but data comes from a number of places, not just government, and is currently governed by a wide range of different standards. A key issue in the use of data-driven technologies is how we standardise all these different sources of data so it can easily flow across multiple systems.

3.3 Genetic technologies

Genetic technologies are anything to do with understanding, making or adapting genetic material.

The development of genetic technologies has created opportunities to protect and restore biodiversity, and many more are expected in the future. Our consultation showed general acknowledgement that exploring how genetic technologies could improve Aotearoa New Zealand's biodiversity tool kit was valuable.

Status and current uses

Genetic technologies are a modern branch of biotechnology. They focus on genetic material (such as DNA) which is the material found in cells that carries information about an organism's characteristics and functions. Genetic technologies allow us to examine and alter the genetic material of plants, animals, bacteria and ourselves.

Genetic technologies are advancing rapidly. The human genome (the full set of genetic instructions found inside a cell) was mapped in the 1990s. In 2012, the CRISPR-Cas-9[22] system enabled precise changes to the genes of living cells. Today, the opportunities presented by genetic technologies, including for conservation, are being actively researched worldwide.[23,24,25,26]

In Aotearoa New Zealand the genomes of ship rats[27] and stoats[28] were mapped in 2020. This knowledge will contribute to research into controlling these predators. Brent Beaven from Predator Free 2050 describes the project, "We have the book, now we just have to learn how to read it and what the words mean. When we do, it will open a whole raft of opportunities to explore and look for weaknesses."

[22] A gene-editing technology we can harness to modify, delete or correct precise regions of DNA.

[23] New powers granted to research gene editing in plants. https://www.gov.uk/government/news/new-powers-granted-to-research-gene-editing-in-plants

[24] New genomic techniques European Commission study and first reactions. https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/698760/EPRS_BRI(2021)698760_EN.pdf

[25] Australians open to using genetic technology to manage feral cats. https://www.csiro.au/en/news/news-releases/2022/australians-open-to-using-genetic-technology-to-manage-feral-cats

[26] GMOs and the American Chestnut Tree. https://gmo.uconn.edu/gmos-and-the-american-chestnut-tree/#

[27] Significant milestone in New Zealand's Predator Free 2050 research reached. Rattus rattus genome sequenced. https://pf2050.co.nz/news/significant-milestone-in-new-zealands-predator-free-2050-research-reached-rattus-rattus-genome-sequenced/

[28] New Zealand's most devastating predators' genomes sequenced. DNA codes broken for stoat and ship rat. https://oldwww.landcareresearch.co.nz/about/news/media-releases/new-zealands-most-devastating-predators-genomes-sequenced-dna-codes-broken-for-stoat-and-ship-rat

The Kākāpō125+ project mapped the genomes of almost all living kākāpō in 2018.[29] This information will guide breeding programmes so genetic diversity and desired traits are passed on to future generations.

Genetic technologies are also being researched to help combat kauri dieback[30] and to control wasps.[31] Methods to use CRISPR-Cas9 for malaria control[32] and coral conservation[33,34] are being studied overseas.

A very different technology is environmental DNA (eDNA) analysis, a powerful tool for identifying which species can be detected in an area. It is already being used in waterways, and work is being done to deploy it in wetlands, estuaries and the ocean.

Critically endangered Kākāpō. Crown Copyright

[29] Kākāpō125+ gene sequencing. https://www.doc.govt.nz/our-work/kakapo-recovery/what-we-do/research-for-the-future/kakapo125-gene-sequencing/

[30] Fighting back with science. https://www.scionresearch.com/about-us/about-scion/corporate-publications/scion-connections/past-issues-list/issue-21,-september-2016/fighting-back-with-science

[31] The potential for a CRISPR gene drive to eradicate or suppress globally invasive social wasps. https://doi.org/10.1038/s41598-020-69259-6

[32] Self-destructing mosquitoes and sterilized rodents: the promise of gene drives. https://www.nature.com/articles/d41586-019-02087-5#ref-CR1

[33] CRISPR/Cas9-mediated genome editing in a reef-building coral. https://www.pnas.org/doi/full/10.1073/pnas.1722151115

[34] Gene editing is revealing how corals respond to warming waters. It could transform how we manage our reefs. https://theconversation.com/gene-editing-is-revealing-how-corals-respond-to-warming-waters-it-could-transform-how-we-manage-our-reefs-143444

https://www.pnas.org/doi/full/10.1073/pnas.1722151115

The genetics of stream water

Dr Shaun Wilkinson with an eDNA testing kit

The method is simple. Take a litre of water, squirt it through a syringe with a filter and send the filter to a lab. The result is spectacular – an identification of thousands of known species that have been in contact with the water: bird, fish, plant, mammal, insect, worm, alga and bacteria.

The technology relies on sequencing machines to identify a signal from a fraction of the DNA of each species, right down to trace levels. It's transforming environmental monitoring, biosecurity and how we manage threatened species.

Dr Shaun Wilkinson is the founder of Wilderlab, a Wellington-based company that provides environmental DNA (eDNA) analysis. "It's a very powerful biodiversity tool. Because of the sensitivity, it's really well suited to picking up things in extremely low abundance that are hard to survey visually."

Many of Wilderlab's samples are for biosecurity, with clients looking for pest species like rodents, stoats, fish, plants, and invasive alga such as didymo.

"You can detect tiny traces of DNA left by a single invasive predator in an otherwise clear area. That's a real frontier for eDNA, and we're working with researchers from the University of Otago and ZIP (Zero Invasive Predators) to confirm the limits of detection for their landscape predator control work."

While uses for the technology are diverse and growing, Shaun believes that so far we've just scratched the surface of what's possible.

"It's such an easy method to use that you don't have to be a seasoned monitoring professional to go and take samples. We're seeing more and more conservation groups sampling their local waterways. It's a new lens for people of all ages to engage with their environment."

The Wilderlab website enables people to share eDNA data if they wish, via a map with thousands of sample points. You can find eels, sandflies, possums, moths, frogs, snails and countless other species.

"There's lots to explore. People are using it to study the spread of invasive fish, map the distribution of lizards, discover where disease is present – and probably lots more."

After sample analysis, the DNA and the data are archived for perpetuity. "By freezing the DNA, there's always an opportunity to go back and use another assay to detect different things. Same with the data. As more and more reference data comes online we can retroactively assign old datasets and update the webpage. The reports become more powerful as time goes on."

A new population of Clutha flathead galaxias (Nationally Critical) was discovered in a DOC eDNA survey of a stream in Otago in 2022. The population was surveyed (as pictured) and measures to protect the fish from trout predation were put in place. Project team is from DOC, Otago Regional Council, Fish & Game, Wai Wānaka and the University of Canterbury.

Future trends

By developing a better understanding of our biodiversity at the genetic level, we can create a more detailed picture than ever before. Genome mapping and eDNA analytics are examples of how genomic data can inform biodiversity management decisions.

Genomic data can also fuel innovation and the development of new tools and ground-breaking opportunities to reduce a range of pressures on biodiversity. For example, scientists are working to better understand the genetics of disease resistance in Kauri trees, with the goal of using genetic technologies to help protect Kauri from Kauri dieback infection.[35]

The report '*Current applications and future promise of genetic/genomic data for conservation in an Aotearoa New Zealand context*' recently published by DOC, explores in greater depth the use of genetic and genomic data to improve biodiversity outcomes.[36]

Kauri dieback dead branches. Crown Copyright

Increasing genomic data is allowing for developments in gene editing technologies. Gene editing tools like CRISPR-Cas9 can be used to change a particular gene and introduce a specific trait. CRISPR-Cas9 could make changes to genes to build resilience to the effects of climate change or switch off genes that make a species more susceptible to infection or disease.

[35] Fighting back with science. https://www.scionresearch.com/about-us/about-scion/corporate-publications/scion-connections/past-issues-list/issue-21,-september-2016/fighting-back-with-science

[36] Current applications and future promise of genetic/genomic data for conservation in the Aotearoa New Zealand context. https://www.doc.govt.nz/globalassets/documents/science-and-technical/sfc337entire.pdf

CRISPR-Cas9 has not yet been used for conservation, but its potential has been studied overseas for malaria control,[37] coral conservation,[38,39] and in New Zealand to control wasps.[40]

CRISPR gene editing can also be used to make a gene drive, to spread a gene through a targeted population.[41] Gene drives could offer a humane way of managing invasive populations and protecting the species they endanger. For example, introducing genes that supresses fertility into the DNA of an invasive species, and then spreading through the population with gene drive technology, could be a powerful, cost-effective way to reduce or eradicate that species in New Zealand.

An international collaboration, the Genetic Biocontrol of Invasive Rodents programme,[42] is researching the use of gene drives to manage rodent populations. This could be a breakthrough opportunity for biodiversity in Aotearoa New Zealand because rodents kill approximately 26.6 million chicks and eggs of native bird species each year.[43]

Considerations

A key consideration in the collection of genetic genomic data, is how data and insights are managed and understood. Many eDNA samples, for example, are collected without clear understanding of how it relates to indigenous knowledge. Accordingly, there is opportunity to interweave different knowledge systems to guide our approach to collection and management of genetic and genomic data. New Zealand eScience Infrastructure and Genomics Aotearoa are investigating how a data repository for genomic data generated from taonga species could support Māori interests.[44]

Gene altering technologies could provide breakthrough opportunities for conservation. Deciding how and if they should be used in the future also provides an opportunity for cross-disciplinary and global collaboration. This is because there are complex ecological, social and cultural issues to consider – what could (and what should) be done to protect and restore biodiversity? This was highlighted in our consultation, with a preference expressed by some contributors, to explore the potential of nature-based solutions before

[37] Self-destructing mosquitoes and sterilized rodents: the promise of gene drives. https://www.nature.com/articles/d41586-019-02087-5#ref-CR1

[38] CRISPR/Cas9-mediated genome editing in a reef-building coral.

https://www.pnas.org/doi/full/10.1073/pnas.1722151115

[39] Gene editing is revealing how corals respond to warming waters. It could transform how we manage our reefs. https://theconversation.com/gene-editing-is-revealing-how-corals-respond-to-warming-waters-it-could-transform-how-we-manage-our-reefs-143444

https://www.pnas.org/doi/full/10.1073/pnas.1722151115

[40] The potential for a CRISPR gene drive to eradicate or suppress globally invasive social wasps. https://doi.org/10.1038/s41598-020-69259-6

[41] The use of gene editing to create gene drives for pest control in New Zealand. https://royalsociety.org.nz/assets/Uploads/Gene-editing-in-pest-control-technical-paper.pdf

[42] The Genetic Biocontrol of Invasive Rodents program. https://www.geneticbiocontrol.org/

[43] Predator-Free New Zealand: Conservation Country. https://academic.oup.com/bioscience/article/65/5/520/323246

[44] Building a treaty-compliant data archive for New Zealand's taonga species. https://www.nesi.org.nz/news/2021/09/building-treaty-compliant-data-archive-new-zealands-taonga-species

considering gene editing. Outlined below are some key considerations posed by gene altering technologies.

Ecological considerations

There is uncertainty about how organisms that have been genetically altered will affect ecosystems here and overseas. Fulfilling our obligation of kaitiakitanga (guardianship) of the natural world requires careful consideration of the risks that we are willing to take to protect biodiversity and research in controlled conditions where appropriate.

Social considerations

Aotearoa New Zealand tends to be hesitant about new biotechnology,[45,46] which could make it difficult to develop and use genetic technologies.[47] There is a need to work out how to respect and address the underlying concerns leading to hesitancy while ensuring that biodiversity can benefit from the opportunities that could come from genetic technologies.

Cultural considerations

Māori, as tangata whenua and kaitiaki, have a wide range of knowledge, information and aspirations related to biodiversity. Consideration of how specific technologies can align with te ao, mātauranga and tikanga Māori supports our obligation of partnership and protection under the Treaty of Waitangi. For example, we need to consider how gene altering technologies affect whakapapa. Gene editing that does not transfer genes between species could maintain and enhance the whakapapa of species.[48]

Technical considerations

Legislation would need to be updated to support the safe and effective use of some gene altering technologies.[49] The current law around genetic technologies is out of date and therefore restricts Aotearoa New Zealand's ability to be able to effectively respond to the risks and opportunities the technologies provide.

[45] Towards a bioeconomic vision for New Zealand - Unlocking barriers to enable new pathways and trajectories. https://www.sciencedirect.com/science/article/pii/S1871678420301783?via%3Dihub

[46] Aotearoa New Zealand boosted by Biotech: Innovating for a sustainable future. https://biotechnz.org.nz/wp-content/uploads/sites/16/2020/11/Biotech-Report-2020_online.pdf

[47] The burden of proof within the scope of the precautionary principle: International and European perspectives. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2101613

[48] Indigenous Perspectives and Gene Editing in Aotearoa New Zealand. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6470265/

[49] Gene editing in Aotearoa: Legal considerations for policy makers. https://ojs.victoria.ac.nz/vuwlr/article/view/5990

Tame Malcolm: gene technology

Tame Malcolm, Te Arawa, is deputy director-general of Treaty relationships at DOC. Despite years of research, interviewing people and in wānanga, he has not found any precedent that gene editing is against tikanga (tradition).

"We often talk about features of the landscape that define us. They can be maunga, lakes and rivers, but for some of us it was the trees that gave us life. For us in Ngāti Tarāwhai, we wouldn't be here without the rātā – it's part of our whakapapa.

"I loved learning about different trees when I was young – I couldn't get enough of it! As I grew up I realised we had to control pests to protect the trees. I started a pest control business but quickly found there wasn't enough time to cover everything. It needed to be supercharged across the whole country.

"When CRISPR-Cas9 gene editing technology came up, I thought it was interesting and potentially very useful. Some people were saying it wasn't compatible with te ao Māori, and that manipulating genes compromises or undermines whakapapa.

"But in my view, tikanga often impacts whakapapa, including through marriage. And te ao Māori is not inconsistent with new technology. You can also see this in our oral histories – for example, according to Māori, kererū were once plain white but when Māui saw his mum wearing a nice dress, he liked the colour so much he gave it to all kererū, just like a gene drive could push a trait through the population.

"I can understand some Māori being hesitant over editing the genes of our taonga species but introduced species like possums don't belong to us. We should be talking to the indigenous people in their home and seeing what they think about it.

"The conversation about gene tech needs to be led by Māori with a Māori approach, which includes lots of genuine engagement. If Māori communities don't feel that gene editing is right for taonga species, the government should take that on board.

"Within 200 years of arriving in Aotearoa, our tūpuna saw the demise of moa and other species. They lamented this loss, and its learnings were stitched into our culture. If we lose more species we lose more of our culture and our sense of identity. Our opportunity is not just to save what we have, but to put systems in place so there's an abundance of species that are scarce today."

"A whakataukī from our iwi sums it up for me: Ko te whenua te kura, kia kura te whenua – learn from the whenua and there will be so many rātā that the land is red from their flowers. If rātā are flowering then everything else is flourishing as well."

We suggest that these technologies (satellite imagery and remote sensing, artificial intelligence and data-driven technologies, and genetic technologies) provide potential to support the protection of biodiversity. What other technologies could be game changing for biodiversity?

What aspects of these technologies should be taken into account when considering their use?

How could these tools be used at an iwi or community level?

4. Options for getting the foundations right

This section outlines options to lay the groundwork for the use of new tools and technologies for biodiversity protection.

The options focus on central government as it stewards the systems that enable the protection of the wider biodiversity system, including the use of new technologies. It also supports others in the biodiversity system, including communities and tangata whenua, to be better connected and contribute more effectively.

Everyone can play a role in biodiversity protection, including individuals, iwi, communities, councils and government at many levels. We are interested in ideas about how the wider biodiversity system can use new tools and technologies that protect biodiversity. This includes how communities can engage with government to ensure a strong voice in decisions about the use of new technologies, and the role that new tools and technologies may play to support biodiversity protection at the community level.

Elevate mātauranga Māori and the role of mana whenua

Māori, as tangata whenua and kaitiaki, have a wide range of knowledge, information and aspirations related to biodiversity. Many of these are laid out in the Waitangi Tribunal flora and fauna claim (Wai 262). Realising the aspirations of Wai 262 and our obligation of partnership and protection under the Treaty of Waitangi will affect how decisions about indigenous flora and fauna are made, and how mātauranga, Māori culture, and other taonga are protected, used, and developed. This will have implications for the potential use of new and improved information and biotechnologies for biodiversity in the future.

For example, the need to respect aspirations for Māori data sovereignty, whilst also allowing for accessibility of data as open data, is likely to become an important area of consideration as the response to Wai 262 progresses.

We could partner with tangata whenua to consider:

1. How specific technologies can align with te ao, mātauranga and tikanga Māori.
2. The kaitiakitanga role that Māori, iwi, hapū and whānau play in relation to traditional Māori data when used for biodiversity action, including respecting aspirations for Māori data sovereignty.

Support a future focus

Approaches to biodiversity management will continue to change, and changes in technology and information practices may offer breakthrough opportunities for biodiversity protection.

We could:

3. Continue to strengthen global partnerships (for example, through focusing on our biodiversity accountabilities, and participating in the global exchange of ideas about advancements in information and technology and biodiversity).

How should we build stronger international relationships?

What areas could Aotearoa New Zealand provide global leadership in?

Are you aware of any particularly good work underway overseas that we could think of adopting or adapting here in Aotearoa New Zealand?

Build an understanding of new tools and approaches

To make the most of the opportunities that information and emerging technologies offer, we need to build trust and create social and cultural licence for their use. To do this we could:

4. Seek views and support to use specific information and technology tools that support biodiversity, and work with iwi and communities to help improve understanding of the trade-offs between risks and benefits.
5. Strengthen community engagement in decisions about the use of new tools or approaches.
6. Build understanding of new tools and their uses in biodiversity protection and maintenance.

There is a range of innovative engagement tools and approaches that could help improve understanding and participation, such as national conversations, town halls and expert forums.

Te Tari Taiwhenua Department of Internal Affairs has prepared an LTIB focused on how digital technology can connect communities and promote engagement in participatory processes. This work, alongside other work done by the New Zealand government on public engagement, provides useful tools for any future engagement we may wish to undertake.[50]

If we decide to use emerging technologies, how can we build social licence, cultural licence and trust to support their safe and effective use for biodiversity?

[50] WEF / NZ Government, AI National Conversations Playbook.
https://digitaltechitp.nz/2021/07/21/ai-playbook/; DPMC Policy Project, Community Engagement https://dpmc.govt.nz/our-programmes/policy-project/policy-methods-toolbox/community-engagement

Encourage community participation

Technologies can help raise awareness of key issues and problems, as well as help people engage in data collection and initiatives to protect biodiversity (for example, citizen science).

To promote this, we could:

7. Strengthen community participation in solving biodiversity challenges, including expanding the use of citizen science.
8. Find technology and data expertise in digital communities and other expert groups, and use this to support biodiversity initiatives.

How much of a role should government have in biodiversity protection? How involved do you think community and iwi groups should be?

How can government best collaborate with others?

Apply rules and oversight

The innovative use of data and emerging technologies needs rules and oversight to guide and monitor their use. During consultation, submitters noted that a decision-making model for biotechnologies should be transparent, participatory in nature, use robust science and information, and be responsive to areas of concern.

We could:

9. Consider what mechanisms need to be in place to support the safe, ethical use of new technological tools or approaches in the collection and use of data (such as legislative protections, governance or oversight mechanisms).

How can we ensure the diverse voices and views of the community are represented in biodiversity conversations?

What could the guiding principles for decision-making about information and biotechnology look like, and who should be involved in developing these?

Gather and manage data

There is currently a large amount of data being collected from a wide range of sources, and this will increase as technologies advance. Looking at ways to bring data together, ensure it is high quality, and turn it into better information could help strengthen biodiversity management.

We could:

10. Develop a data repository or platform where all sources of data useful for biodiversity could be collected, maintained and made available.
11. Work with conservationists, scientists and other users to ensure data can be easily shared and stored, with best practice guidelines to help guide responsible use and sharing.

What are the key data issues that the government will need to think about to get the foundations right for using data-driven and emerging technologies?

Strengthen funding and investment

A recent review of environmental research funding in Aotearoa New Zealand identified the need for defined research priorities, informed by regular monitoring, the right research approaches to deliver on these priorities, and adequate investment in environmental research that secures critical research capability – both human and technical.[51]

Further investment to support the opportunities outlined in this briefing will need to be considered in light of strategic research priorities, including the developing Environment and Climate Research Strategy.[52]

We could:

12. Gain a better understanding of how the research system can help identify and assess opportunities for emerging data and technology in biodiversity protection.
13. Ensure that funding includes consideration of monitoring, capability and infrastructure needs.
14. Ensure that funds are allocated by people familiar with what environmental research entails, according to criteria that fit the sort of research required to understand our highly dynamic environment.
15. Ensure that allocation integrates mātauranga Māori in a way that allows both mātauranga and science to prosper.

What areas should we put funding or resourcing into, and why?

[51] A review of the funding and prioritisation of environmental research in New Zealand. https://www.pce.parliament.nz/media/197111/report-environmental-research-funding-review-pdf-32mb.pdf

[52] Environment and Climate Research Strategy. https://environment.govt.nz/facts-and-science/science-and-data/environment-and-climate-research-strategy/

5. Closing thoughts

Biodiversity is declining globally at an increasing rate. Much of this is due to human activities, including changes in how we use land, as well as pollution and climate change. As more pressure is put on our natural environment, we lose more of our biodiversity.

To protect Aotearoa New Zealand's biodiversity, we need to make well-informed decisions for the long-term. This draft LTIB suggests that new data-driven technologies and better information can provide solutions for some of the biggest threats to our biodiversity. By starting a nationwide conversation now, we can all understand and think about the best ways to use these new tools.

Our hope is that we can all work together to create the pathways and changes needed to save our biodiversity, and ensure a thriving and strong future for our country's flora and fauna.

A starting point

We began our briefing with a look at where we are starting from, and the current state of biodiversity. While the outlook is bleak, all is not lost. Many people are hopeful we can turn this loss around and help the land regenerate itself.

Vision, ambition and action

Te Mana o te Taiao Aotearoa New Zealand's Biodiversity Strategy 2020 provided us with the vision we need to see success through the three pou of getting the system right, empowering action, and protecting and restoring. We believe that better use of technologies and information can support and enhance the work already underway, and provide us with new opportunities.

Areas of transformation

The briefing has identified three areas where there will be opportunities to do more to protect biodiversity: satellite imagery and remote sensing, artificial intelligence and data-driven technologies, and genetic technologies. We discussed the current use of these tools and future opportunities and trends, as well as some of the considerations that may need to be taken into account to go down this path.

Options for government direction

We ended with a look at the areas where action might occur in the use new and emerging technologies and information.

We welcome your views on this consultation document.

The questions we have asked you to look at throughout the document are below. They are a guide only, and we welcome any comments you would like to make on this topic.

Questions to consider

We suggest that these technologies (satellite imagery and remote sensing, artificial intelligence and data-driven technologies, and genetic technologies) provide potential to support the protection of biodiversity. What other technologies could be game changing for biodiversity?

What aspects of these technologies should be taken into account when considering their use?

How could these tools be used at an iwi or community level?

How should we build stronger international relationships?

What areas could Aotearoa New Zealand provide global leadership in?

Are you aware of any particularly good work underway overseas that we could think of adopting or adapting here in Aotearoa New Zealand?

If we decide to use emerging technologies, how can we build social license, cultural licence and trust to support their safe and effective use for biodiversity?

How much of a role should government have in biodiversity protection? How involved do you think community and iwi groups should be?

How can government best collaborate with others?

How can we ensure the diverse voices and views of the community are represented in a biodiversity conversations?

What could the guiding principles for decision-making about information and biotechnology look like, and who should be involved in developing these?

What are the key data issues that the government will need to think about to get the foundations right for using data-driven and emerging technologies?

What areas should we put funding or resourcing into, and why?

The feedback you provide will shape and develop our final briefing and provide valuable information on possible future steps for the protection of biodiversity in Aotearoa New Zealand.

Te Kāwanatanga o Aotearoa
New Zealand Government