Departmental Briefing

Department of Conservation
Te Papa Atawhai

In Confidence

GS ref: 20-B-0877
DOCCM: 6509240

To:	Minister of Conservation	**Date:**	14 December 2020

Subject:	Responding to Climate Change in Te Papa Atawhai
Action sought:	Note Climate Change risks and opportunities
Time Frame:	17 December 2020

Risk Assessment:	Significant organisational and conservation risks if not well managed	**Department's Priority:**	Very High
		Level of Risk:	High

Contacts

Name and position	Cellphone	Contacts	Principal author
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Executive summary – Whakarāpopoto ā kaiwhakahaere

1. The impacts and implications of climate change in Aotearoa are diverse, complex, and will affect every aspect of the role, success, and delivery functions of Te Papa Atawhai.
2. This briefing explains the role and response of Te Papa Atawhai in relation to climate change and current opportunities and challenges.
3. Our climate change response and actions centre around three core areas of work:
   - Adaption to the impacts of climate change for resilience
   - Reducing our emissions footprint and influencing others to do the same
   - Protecting and enhancing the native carbon stocks of Aotearoa
4. This briefing provides you an overview and analysis on the trade-offs, risks, and opportunities associated with the role of Te Papa Atawhai in climate change.
5. A key risk is to ensure the focus on climate adaptation and resilience is not neglected at the expense of mitigation. While mitigation has clearer targets and focus, we must invest now to ensure long-term resilience of conservation land and infrastructure.
6. Another risk is Te Papa Atawhai is not currently considered a core climate change policy agency. Given we are responsible for adapting one third of Aotearoa's land area, and provide carbon storage, this may cause a disconnect between central government policy and conservation operations.
7. This briefing also provides key messages for your 17 December meeting with climate Ministers on potential budget bids. While we do not have specific climate change bids, the attached messages outline climate change benefits of conservation work.
8. Te Papa Atawhai staff are available to meet with you to discuss the prioritisation of the delivery of climate change actions considering the climate emergency declaration.

We recommend that you … (Ngā tohutohu)

		Paragraph Reference	Decision
(a)	Note the role of Te Papa Atawhai in climate change and current work underway	-	
(b)	Note the attached messages for your budget meeting with climate Ministers on 17 December 2020	Appendix A	
(c)	Agree that taking action to adapt and mitigate to the impacts of climate change must be a top priority for Te Papa Atawhai.	-	Yes/No
(d)	Note you will receive the Sustainability Strategy and Action Plan for Te Papa Atawhai before end of 2020	-	
(e)	Agree if you want to receive a briefing on this work in person early in 2021		Yes / No

Marie Long
Director Strategic Support

Hon Kiritapu Allan
Minister of Conservation

____ / ____ / ______

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For Director-General of Conservation

Purpose – Te aronga

1. The purpose of this briefing is to outline the role and response of Te Papa Atawhai in relation to the climate emergency.
2. It also provides you with messages for your meeting on budget initiatives with climate Ministers on the 17 December 2020 (attached in appendix A).
3. This briefing was referred to in, and supplements, the Briefing to the Incoming Minister.

Background and Context – Te horopaki

4. Our climate is changing and will continue to do so for the foreseeable future, matching global trends.
5. Extreme weather events, rising seas, and growing annual and seasonal temperatures are putting increasing pressures on already threatened wildlife, ecosystems, heritage, and landscapes.
6. Regardless of present and future efforts to limit the causes of climate change by reducing greenhouse gas (GHG) concentrations in the atmosphere, Aotearoa will continue to experience ongoing physical impacts related to climate change.
7. A two-pronged approach is needed that incorporates both climate change adaption and mitigation, whereby the impacts of climate change are reduced whilst resilience to its effects is enhanced.
8. In recognition of the adaptation challenge, the Government legislated a National Risk Assessment which was published in August 2020, and a National Adaptation Plan to respond to the assessment will be complete by August 2022.
9. To reduce carbon, the Government has legislated the Paris target of carbon neutrality by 2050. In December 2020 it also declared a Climate Emergency, and committed the public service being carbon neutral by 2025.
10. On 17 December you are attending a meeting of Ministers with portfolios that relate to climate change to discuss prioritising potential budget bids (key messages for this meeting are attached in appendix A).

The role and response of Te Papa Atawhai

11. Climate change is the greatest challenge of our time. If it is not addressed, it will be increasingly difficult for Te Papa Atawhai to fulfil its vision of Papatūānuku thriving.
12. To ensure Te Papa Atawhai is proactively taking action on climate change, we are addressing three core priorities:
    - Adapting to climate change
    - Reducing emissions
    - Protecting and enhancing carbon stocks
13. Climate change directly or indirectly affects every facet of our work. We will face shrinking ecosystems and movement of wildlife, our recreational assets will need to be moved or retired from changing landscapes, huts and buildings will need to be more

resilient and energy efficient, and we need to move away from carbon-intensive ways of doing conservation work.

14. There may also be increased focused on maintenance of existing native forest carbon sinks, for instance through pest control. The changes for our District and Regional staff will be significant.

Adapting to climate change

15. The changing weather and climate are already significantly impacting every aspect of our work and forcing us to adapt quickly. This includes loss of infrastructure and loss of wildlife from increased storm events, flooding, and drought.
16. As the effects of climate change increase, we expect that threatened species will become even more vulnerable. Existing issues such as invasive mammalian predators could get worse, and new problems may develop.
17. Increasing extreme weather events will more frequently affect Te Papa Atawhai-managed recreation, cultural heritage, conservation infrastructure, and experiences.

Climate Change Adaptation Action Plan

18. Te Papa Atawhai has developed the Climate Change Adaptat on Action Plan (The Adaption Plan) to increase the resilience of our biodiversity and Te Papa Atawhai heritage and visitor infrastructure.
19. This plan establishes a long-term strategy and plan for climate change research, monitoring, and action. It will guide the planning, prioritisation, and future operations of Te Papa Atawhai over the next five years so we can meet our conservation goals in a changing climate.
20. The plan works to intertwine a Te Ao Maori perspective by ensuring the focus of implementation will complement iwi-led adaption and mitigation strategies.
21. We will work to input our priorities into New Zealand's National Adaption Plan. This will ensure impacts on biodiversity are considered and promote the use of nature-based solutions such as coastal wetlands, mangroves, and dune planting for adaptation.
22. We have been deliberate in assuming a national leadership role to ensure positive outcomes for conservation. By being at the table early we are able to work collaboratively with other sectors to find better solutions for nature.
23. A copy of the Adaptation Plan is attached to this briefing.

Reducing emissions and influencing others

Reducing carbon by changing the way we work

24. Given the high profile and environmental mandate of Te Papa Atawhai, it is important that we are seen to play our role in meeting climate targets by reducing our own emissions.
25. As a large operational agency that manages a third of the country's land, we have a high and complex carbon footprint compared to other government agencies. Our emissions come from a large vehicle fleet, extensive helicopter use, regional travel, and energy use.
26. Te Papa Atawhai is currently developing an organisation wide sustainability strategy to cut our own carbon emissions. This partly involves reducing travel and introducing lower emission transport options such as through electric vehicles.

27. We are working with the independent third-party auditor Toitu Envirocare to measure and report our current emissions. This will help to establish where our largest emissions are being produced, and where the biggest changes are required.

28. The Toitu audit will be complete this financial year, with a reduction strategy plan to follow for the 2021/22 year.

29. Our carbon profile will allow us to optimise our current work by determining where to focus on improvements to deliver the greatest carbon reduction benefits.

30. Te Papa Atawhai will also work to embed low carbon practices throughout our entire business, including social change, new standards, procurement criteria, and practical tools.

31. We will need to take whole of life considerations for all investments. Some decisions we make today may still be in place in 2050 and can lock in carbon gains/losses for the long-term.

Regulatory change

32. Te Papa Atawhai regulates public and commercial activity on conservation land and waters through our statutory documents, permissions processes, and land management. We plan to have a climate change regulatory approach published by May 2021.

33. We are working to ensure climate change is considered in our statutory decision making to ensure low carbon use of conservation land and waters by all users. This means, for example, we will need to consider the carbon impact of a proposed operation when granting a permission, such as helicopter landings or grazing.

34. Regulatory change however also applies to adaptation and resilience concerns. For example, if a proposal to build a track is an area subject to sea inundation or crumbling moraine from a retreating glacier, it may be declined because of the climate risks.

35. Under the Climate Change Response Act we are required by law to consider climate impacts when we process concessions, and we are currently rolling this out to be considered in permissions applications by mid-2021.

Protecting and enhancing carbon stocks

36. Native forests cover around 7.8 million hectares of Aotearoa. Looking after these forests is an important part of our climate change efforts.

37. There are approximately 1.8 gigatons of carbon stored in them.[1] Arguably this is one of the largest contributions to combatting global climate change that Aotearoa makes.

38. It is estimated at a theoretical level that carbon sequestration on public conservation land alone could be increased by 698 Metric tons of carbon dioxide (Mt CO_2e).[2] We need to establish the viability of that potential, and Te Papa Atawhai is assessing what is practical. But to put this figure in context, the total emissions of Aotearoa in 2018 were 79 Mt CO_2e. That means the maximum potential of extra carbon storage on conservation land is up to nine years of New Zealand's entire carbon output. However, any carbon benefits of new planting will take decades or longer to fully realise.

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[1] Parliamentary Commissioner for the Environment 2020: *Farms, forests and fossil fuels: The next great landscape transformation*, pg 68.

[2] Through reforestation, the advance of existing shrubland successions, and recovery of existing forests from disturbances such as animal browsing. Note this is a total figure (not annual) and would take a very long time to achieve, the opportunity nonetheless is significant. For estimate see - *O'Donnell, C.F.J.; Christie, J.E.; Hitchmough, R.A.; Lloyd, B.; Parsons,* 2015 *S Wild Animal Control for Emissions Management Research Synthesis*, Landcare Research, *pg v*

39. The core business of Te Papa Atawhai is looking after the native forests and ecosystems that store carbon. We are looking at how we can support wider climate efforts by sequestering more carbon on public conservation land in ways that also support our biodiversity goals and our vision of Papatūānuku thriving.

40. We are ensuring alignment between biodiversity, environment, and climate policy. A particular focus is afforestation and carbon sequestration where current climate policies favour exotic species (e.g. pine trees).

Aligning the Government's Carbon Neutral programme 2025 with biodiversity gains

41. The Carbon Neutral Government Programme will require all Government departments to report on their emissions and set targets for 2025 and 2030 and require remaining emissions to be offset from 2025.

42. The target of a net-zero public sector from 2025 presents an opportunity to fund the restoration of indigenous ecosystems in a way that aligns with wider government biodiversity goals.

43. There is the potential for investment in carbon sequestration to happen on public conservation land. The approach of Te Papa Atawhai to understanding sequestration options on its own land is still at an early stage.

44. While it could help to fund ecosystem restoration that aligns with our biodiversity priorities, there is a risk that setting up such a programme could be resource intensive, particularly if the timeframes are tight. It would also require new funding.

45. Te Papa Atawhai will work with the MfE on this initiative, particularly on offsetting issues and how they relate to public conservation land. However, setting up restoration programmes to sequester carbon will take time. It is not something that can be set up overnight once we get to 2025 – it will require upfront funding and lead in time.

46. Outside of this proposal Te Papa Atawhai may investigate the potential to sequester carbon for its own activities while we transition to a low carbon model. For example, we will still need to be using helicopters for pest control. If there is not a public service offsetting scheme on conservation land, we can investigate the potential here.

47. We will keep you updated as this work progresses.

Supporting the national carbon target through greater use of indigenous vegetation

48. Current modelling for reaching Aotearoa's climate change targets involves significant use of exotic afforestation to offset gross emissions[3].

49. The social license for over a million additional hectares of exotic afforestation is likely to be challenged. In part, because of the risks to biodiversity and freshwater that this will create, including from erosion and fire. Pine plantations also have the potential to have social impacts in regional New Zealand.

50. This poses a serious challenge for climate change policy in Aotearoa. If we do not plant pine at the levels currently envisioned, it means we will need to look at stronger policy to reduce emissions and alternative ways to sequester carbon that have a greater social license, such as restoring and planting indigenous forests and other ecosystems.[4]

51. Te Papa Atawhai is providing input to MfE and MPI who lead the work in this area on how climate policy could better incentivise carbon sequestration from indigenous vegetation. These include:

[3] MPI estimates an additional 0.74 and 1.46 million hectares of afforestation will be needed by 2050 to reach our climate goals.
[4] Note – only forests are currently included in how we measure our targets, but other eco-systems also sequester carbon. We are investigating whether they should be counted towards our climate targets.

- the potential for native forests and vegetation to play a bigger role in the Government's Emission's Reduction Plan.
- looking at whether land that is regenerating into native forest but was planted before 1990 could be allowed into Emissions Trading Scheme (ETS) to provide a financial incentive for restoration. Also looking at whether native scrubland that is currently ineligible could be let in.
- Advocating for biodiversity outcomes to be included in the He Waka Eke Noa work that is looking at how on-farm sequestration could be incentivised and rewarded.

52. There is also potential in carbon storage in aquatic environments, such as wetlands and estuaries. DOC is currently investigating what is possible in this space. Carbon storage is also possible in marine environments such as through kelp forests, however these options do not currently contribute to our national climate targets.

Risk assessment – Aronga tūraru

53. Climate change is one of the most significant risks Te Papa Atawhai and Aotearoa faces. It is already having significant effects on our biodiversity, outdoor recreation experiences, natural landscapes, and cultural heritage and will continue for many decades to come.
54. There are high expectations both publicly and internally that Te Papa Atawhai, as the conservation agency of Aotearoa, will be a leader in climate change response.
55. A key risk for us to manage will be to ensure the focus on climate adaptation and resilience is not neglected at the expense of mitigation. While mitigation has clearer targets and focus, we must invest now to ensure in the long-term that conservation values are safeguarded.
56. Key risks (with risk ratings) associated with Te Papa Atawhai not taking action for mitigation and adaptation are:
    - An extreme environmental risk that the biodiversity crisis is significantly exacerbated due to the inability to identify, plan, and respond to climate change impacts
    - High health and safety risks to visitors as a result of conditions and events created or intensified by climate change being poorly understood and managed.
    - A high risk that cultural heritage sites and assets managed by Te Papa Atawhai are degraded or lost due to lack of understanding and planning for climate change impacts and related events.
    - A high reputational risk that climate change inaction see's Te Papa Atawhai viewed as a poor manager and regulator of Public Conservation Lands and Water.
    - A high legal risk that Te Papa Atawhai will be judicially reviewed for not taking appropriate consideration of the Climate Change Response (Zero Carbon) Amendment Act 2019 in its statutory decision making
57. Heavy reliance on exotic afforestation in climate policy risks further fire fuel loading the landscape, exacerbating the spread of wilding conifers, and increasing erosion and sedimentation issues.
58. Limited input or exclusion of Te Papa Atawhai in the development and governance of the National Adaptation Plan risks the development and implementation of adaptive actions that will negatively affect the natural environment.

59. Te Papa Atawhai has not been considered as a core climate change policy agency. Given we are responsible for adapting one third of Aotearoa's land area, and provide carbon storage, this may cause a disconnect between central government policy and conservation operations.

Treaty principles (section 4) – Ngā mātāpono Tiriti

60. The climate change response of Te Papa Atawhai will be implemented in a way that gives full effect to the principles of the Treaty of Waitangi under section 4 of the Conservation Act.

61. Through our work in adaptation, we are actively engaging with mana whenua across the country to ensure cultural values are represented in how we assess risks and mātauranga Māori is effectively used to support and enable adaptation.

62. Wider government engagement on forestry policy has indicated support from Māori for incentives to protect, restore and plant native forests. Iwi also have significant interests (including settlement assets) in exotic plantation forestry so any policy changes will need to consider how Treaty rights are affected.

Financial implications – Te hīraunga pūtea

63. As an organisation over the next 5 – 10 years there will need to be significant reprioritisation of resourcing and conservation work to adjust to the climate emergency. Every investment that we make now however will save us increased costs in coming years and reduce our financial risk.

64. 9(2)(g)(i) [redacted] a recent risk exposure assessment identified 331 assets and 420 archaeological sites located within the coastal inundation zone due to sea-level rise.

65. Enhancing our resilience now will also support decisions for management of vulnerable infrastructure, as with Lake Howden Hut. 9(2)(g)(i) [redacted]

66. Given the pressure a changing climate is putting on indigenous wildlife, reprioritisation of biodiversity work may also need to be considered over time. As the risk of fire and flood increase as well, there may need to be a general reprioritisation of resourcing across DOC's work towards these efforts. Conservation work as a whole is likely to look very different towards 2030 than it is now.

67. In terms of preparing for carbon neutrality and lower emissions, the costs over the next 4 years will be significant. There will be capital costs as we quickly replace carbon intensive equipment (such as switching to EVs, electric chainsaws, and other tools).

68. There will also be significant ongoing operational costs as we roll out changes in the way we work. That's across adaptation, reducing emissions, and investigating carbon storage options.

Meeting with Climate Ministers on 17 December

69. On the 17th December 2020 you are meeting with other climate-related Ministers for a budget meeting.

70. It is critical for you and for DOC to ensure we are involved in climate budget and policy settings. They have a direct impact on our mahi, and we have significant tools available to give effect to All-of-Government outcomes.

71. Some messages for you to consider for this meeting are attached to this briefing (in appendix A). These outline the carbon sequestration and adaptation benefits of investing in conservation work.

Next steps – Ngā tāwhaitanga

72. In 2021 Te Papa Atawhai will begin to roll out significant changes outline to meet the climate change challenge.

73. We will continue to engage with MfE on the development and inclusion of conservation considerations in the National Adaptation Plan and research strategy.

74. Te Papa Atawhai has begun working with Toitu to measure our emissions and is developing a carbon dashboard to assist with reporting our emissions.

75. We are seeking to engage with mana whenua to develop adaptation tools and processes that reflect a Te Ao Māori view and enable to use of Mātauranga Māori

76. We will engage other government agencies, crown research institutes, universities and other research provider to influence and leverage climate change research needs.

77. You will receive a copy of Te Papa Atawhai's Sustainability strategy before end of 2020.

78. We welcome any feedback on prioritisation or detailed information requests from you, either in person early in 2021 or in writing.

Attachments

Appendix A: Key messages for Climate Minister's budget meeting 17 Dec 2020

Appendix B: Climate Change Adaptation Action Plan, DOC, 2020

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Document 2

Read

Departmental Memo

Department of Conservation
Te Papa Atawhai

GS ref: 21-B-0966
DOCCM: 6854571

In Confidence

Date: 20 January 2022
To: Minister of Conservation
From: Meg Rutledge, Director Biodiversity Threats
Subject: **Further advice on Forest and Bird recommendations on browsing pest control**

Executive summary – Whakarāpopoto ā kaiwhakahaere

1. This memo provides further advice regarding the Forest & Bird 'Improving browsing pest control' report following your feedback to DOC on 25 November 2021.
2. The memo details the costs and inputs required to complete the Forest & Bird recommendations and describes how browser impacts and restoration plantings are monitored.
3. To implement Forest & Bird's recommended actions, advances in research, monitoring, detection, and management methods are required for the work to be feasible, along with additional funding. The costs to do this work is likely to be hundreds of millions of dollars.
4. Given the cultural, recreational, and economic value to local communities and mana whenua of many of the proposed species, significant engagement and collaboration would be needed to codesign suitable solutions.
5. The Land Use and Carbon Analysis System (**LUCAS**) programme monitors and reports on carbon stock with respect to change in NZ forests and shrublands. Additional investment would be required into the programme to determine impacts of browsers on carbon and biodiversity in future.
6. Two budget bids have been submitted to Treasury to increase browsing pest control and maximise carbon storage in indigenous ecosystems by increasing natural sequestration. These bids, led by DOC and MPI respectively, are under consideration as per the budget bid process. Should these be successful, they will contribute to addressing some of the Forest & Bird recommendations.

Purpose – Te aronga

7. This memo provides advice on the three areas regarding the recent Forest & Bird report 'Improving browsing pest control – Briefing to agencies with pest control responsibilities'.

Background and context – Te horopaki

8. Forest & Bird released two reports relevant to pest control and carbon sequestration in 2021:

- 'Protecting Our Natural Ecosystems' Carbon Sinks, (June 2021), highlighting the important carbon storage and sequestration role native ecosystems has and the threat that browsing pests present.
- 'Improving browsing pest control' (September 2021), providing recommended browsing pest control actions and targets for government agencies.

9. You responded to the Forest & Bird Chief Executive on the recommendations of the latter briefing [CORM-505 refers].

10. This memo provides further advice in relation to the three areas regarding the 'Improving browsing pest control' briefing:
    - What costs and inputs would be required for DOC to complete all recommended actions?
    - How is DOC monitoring the impacts of browsing pests on carbon and biodiversity values?
    - How is restoration planting of native ecosystems being monitored?

Costs and inputs required for DOC recommended actions

11. In the 'Improving browsing pest control' report, Forest & Bird provided four recommended actions for DOC:

<u>Increase baseline landscape scale aerial 1080 control annually by 100,000 ha for the next ten years.</u>

12. The recommended increase to landscape scale aerial 1080 is feasible but would cost approximately an additional $5 million year on-year above baseline resourcing. By year 10, this increased investment would be approximately $50 million per annum.

13. Any significant increase in landscape scale 1080 control should be co-ordinated with other complementary programmes, such as OSPRI's TB vector control programme and Predator Free 2050 landscape projects.

<u>Eradicate feral wallaby and goats, reduce feral deer, pigs, possums, and chamois to the lowest possible numbers.</u>

14. This recommendation is currently unfeasible, requiring significant advances in the development of new methods for detection and control.

15. It is difficult to estimate the funding required to eradicate feral goats and wallabies and to reduce feral deer, pigs, possums, and chamois numbers. Even with the development of new detection and control tools, it would cost more than several hundred million dollars to reduce to the lowest possible animal numbers and maintain gains as they are achieved.

16. For example, the MPI-led national wallaby programme received $27.4 million spanning from 2020-2024. However, this funding is for locating and eradicating wallaby outside the identified containment zones and buffers, not for national eradication. It is highly likely that further work will be needed after 2024 to eradicate wallabies.

15\. As many of these animals also have significant cultural, recreational, and economic value to local communities and mana whenua, significant engagement and collaboration is needed to codesign suitable solutions.

16\. A budget bid is being proposed within the Biodiversity and Biosecurity investment package for Budget 2022 to increase deer management and goat control nationally [21-B-0767 refers]. The 'preferred' option is costed at $40 million over four years and includes resourcing the Game Animal Council, mana whenua, regional councils, and others to fulfil their roles.

17. If successful, this funding will increase deer and goat management by approximately 1,290,000 additional hectares controlled for goats and by approximately 532,000 additional hectares controlled for deer. DOC is also considering how to realign existing baseline funding to increase deer and goat management over the next 4 years.

Control tahr to comply with the 1993 Himalayan Tahr Control Plan by 2025.

18. The Himalayan Tahr Control Plan 1993 (**HTCP**) sets a maximum population of 10,000 tahr across all land tenures in the feral range.

19. As required under the HTCP, the Department's tahr control is delivered through an annual Tahr Control Operational Plan (**TCOP**) developed in consultation with the Tahr Plan Implementation Liaison Group, of which Forest & Bird is a member.

20. The Department has undertaken substantial tahr control cover the last three years in response to population estimates over the 2016-2019 period. Annual expenditure on tahr management in 2020/21 was approximately $1.4 million including a range of work in addition to direct control.

21. Alongside control, improving the understanding and impacts of tahr populations is a key goal of the HTCP. We expect current research and monitoring work will inform control targets and approaches in future TCOPs.

22. Without the additional knowledge provided the by the research and monitoring work currently underway, it is difficult to estimate the funding required to control tahr to comply with the HTCP by 2025. The Department is committed to continue working towards the goals of the HTCP.

Ensure management of Public Conservation Land (**PCL**) under feral browsing animal control contributes to national greenhouse gas emissions reductions.

23. For New Zealand to claim additional carbon storage from changes to how PCL is managed (i.e., through increased browsing pest control), research is required to better understand and measure the carbon storage contribution of native ecosystems and how these change with different management activities.

24. Alongside MfE and MPI, DOC has contributed to a Budget 2022 cross vote initiative into the Climate Emergency Response Fund (**CERF**). The aim of this initiative is to maximise carbon storage by increasing natural sequestration to achieve New Zealand's future carbon goals. MPI is the lead agency for this bid.

25. This initiative seeks a total of $106.4 million, of which $4.1 million is DOC led. It includes research and management to better understand and enhance carbon storage in pre-1990 native forests.

Monitoring of browser impacts on carbon and biodiversity values

26. The MfE LUCAS programme monitors and reports on carbon stock and change in NZ forests and shrublands. Building on this, DOC's Tier 1 programme integrates monitoring of biodiversity (vegetation and birds) and mammal pests on all PCL. DOC and MfE work as a central government collective to complete both programmes as there is considerable overlap in data required.

27. Each year, data from the programmes are analysed and published in online factsheets to provide underpinning evidence for DOC's Annual Report. You can review these at https://www.doc.govt.nz/our-work/monitoring-reporting/national-status-and-trend-reports-2020-2021.

28. Evidence shows numbers of wild deer, goats, chamois, tahr, and sheep (ungulates) are increasing in New Zealand. Ungulate abundance across PCL rose by 48% between 2013 and 2020 and they are becoming more widespread, now occurring on 82% of sites.

29. Impacts on biodiversity are evident. Tree species avoided by goats or deer have higher recruitment than mortality. In contrast, the tree species deer prefer, have similar recruitment and mortality, (stable populations). Tree species goats prefer, have lower recruitment than mortality (declining populations).[i]

30. The latest analysis of data for MfE climate change reporting provides an estimate of carbon stock and change in natural forests in New Zealand. Forests are in carbon balance, they are neither a carbon sink nor source, although some regenerating forests are sequestering carbon.

31. While it is possible that widespread pest control could increase carbon stocks in New Zealand's natural ecosystems, it is very difficult to quantify and attribute any additional sequestration to pest control.

32. Additional investment will be required to determine the impacts of browsers on carbon and biodiversity in future. The priority areas for DOC's investment include the Tier 1 programme and re-measuring local permanent plot networks and ungulate pellet monitoring lines with an initial focus on kāmahi forest to fill critical information gaps.

Monitoring of restoration planting

33. DOC currently has no measures to record the number of plants planted on PCL by DOC or by volunteers.

34. In the short-term, native planting off PCL may be recorded in the Emissions Trading Scheme (**ETS**) registration tables by the landowner.

35. Restoration projects enabled by Jobs for Nature are required to report on the number of plants planted.

36. In the mid-term (10-15 years), some larger scale monitoring of regenerating indigenous shrubland and forest would be picked up by the LUCAS monitoring programme.

37. A new monitoring programme would need to be designed and initiated to monitor the carbon storage of new and smaller scale native restoration or replanting projects.

Next steps – Ngā tāwhaitanga

38. Treasury officials are reviewing two relevant budget initiatives for Budget 2022:

- Within the Biodiversity and Biosecurity investment package, an initiative to increase deer management and goat control nationally
- Within the Climate Emergency Response Fund, an initiative to increase natural carbon sequestration to achieve New Zealand's future carbon goals.

39. DOC is working with the Game Animal Council to finalise the Te Ara Ki Mua Framework for adaptive management of wild animals in early 2022 [21-B-0767 refers].

Contact: Meg Rutledge, Director Biodiversity Threats, phone: s.9(2)(a) [redacted]

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[i] https://www.doc.govt.nz/our-work/monitoring-reporting/national-status-and-trend-reports-2020-2021/tagged-stems-2020-2021/

Document 3

Read [redacted]

Department of Conservation
Te Papa Atawhai

Events Memo

Forest & Bird meeting

GS ref: 22-M-0028
DOCCM: 6917420

In Confidence

Date: 16 February 2022

To: Minister of Conservation

From: Meg Rutledge, Director Threats

Subject: **Forest & Bird meeting, Date TBD 2022**

Executive summary – Whakarāpopoto ā kaiwhakahaere

1. Forest & Bird Chief Executive Kevin Hague request a meeting to discuss four recommendations (labelled 'agency goals') for DOC in the 'Improving browsing pest control' report provided to you and other Ministers in September 2021. Your office is organising for this meeting to take place.
2. DOC Director Threats Meg Rutledge is available to support you at the meeting.
3. The recommendations are impo tant to DOC's animal pest management (Tiakina Ngā Manu, Predator Free 2050, and DOC's programmes for wild animal management) and our support for animal pest management led by others (e.g., MPI national wallaby management programme).
4. The report is part of Forest & Bird's advocacy for more action to enhance native carbon sinks as part of the Emissions Reduction Plan to be published in May 2022. Minister Shaw and Minister Parker may also receive meeting requests to discuss this report.
5. DOC is progressing toward the four recommendations in the report, however none of the goals are likely to be met in the timeframes recommended by Forest & Bird. Advances in research, monitoring, detection, and management methods are required for the work to be feasible, along with additional funding.
6. Both this report and an earlier report ('Protecting Our Natural Ecosystems' Carbon Sinks') focus significantly on mature native forests and do not address the potential for carbon storage in regenerating native forest and planted native restoration projects. Importantly, controlling browsing pests could have significant, measurable benefits to carbon storage in regenerating and restored native forest.

Purpose – Te aronga

7. The purpose of the meeting is to discuss the goals that Forest & Bird recommend for DOC in the 'Improving browsing pest control' report (September 2021, 21-B-0966 refers).

Background and context – Te horopaki

8. In September 2021, Forest & Bird provided you and other Ministers with a briefing 'Improving browsing pest control' (CORM-505 refers). Chief executive Kevin Hague requested to meet with you to discuss four DOC-specific goals recommended in the report.

9. The first recommendation is for DOC to increase baseline landscape scale aerial 1080 control annually by 100,000 ha for the next ten years. This recommended increase is feasible but would cost approximately an additional $5 million year-on-year above baseline resourcing. By year 10, this increased investment would be approximately $50 million per annum.

10. The second recommendation is for DOC to eradicate feral wallaby and goats and reduce feral deer, pigs, possums, and chamois to the lowest possible numbers by 2030. This recommendation is currently unfeasible, requiring significant advances in the development of new methods for detection and control. There has been recent media coverage of Forest & Bird's concern about the impacts of wild animals

11. The third recommendation is for DOC to control tahr to comply with the 1993 Himalayan Tahr Control Plan by 2025. Current research and monitoring is underway to improve the understanding and impacts of tahr populations. Until this research and monitoring is progressed, it is difficult to estimate the funding required to meet this recommendation. Forest & Bird are a member of the Tahr Plan Implementation Liaison Group.

12. The fourth recommendation is for DOC to ensure management of Public Conservation Land (**PCL**) under feral browsing animal control contributes to national greenhouse gas emissions reductions. For New Zealand to claim additional carbon storage from browsing pest control, research is required to more accurately measure the carbon storage contribution of native ecosystems in relation to pest management.

13. The Land Use and Carbon Analysis System (**LUCAS**) programme monitors and reports on carbon stock with respect to change in New Zealand forests and shrublands. The latest analysis from Ministry for the Environment indicates that forests are in carbon balance, they are neither a carbon sink nor a source, although some regenerating forests are sequestering carbon.

14. While widespread pest control could increase carbon stocks in New Zealand's natural ecosystems, it is currently difficult to quantify and attribute additional carbon sequestration to pest control. This is due to the uncertainty associated with estimating additional carbon storage resulting from browsing pest control in pre-1990 forest. Carbon storage and benefits of pest management could be easier to measure for regenerating native forest and planted native restoration projects than for mature native forest.

Risk assessment – Aronga tūraru

15. Forest & Bird may ask for increased investment in monitoring to determine the impacts of browsing pests on carbon and biodiversity in the future, including via the LUCAS programme. A budget bid for 2022 led by Ministry for Primary Industries has been submitted to Treasury to increase natural sequestration in indigenous ecosystems. If successful DOC investment would prioritise monitoring improvements.

16. Forest & Bird may raise concerns that DOC currently does not record native planting on public conservation land by volunteers or staff. However, the Crown is unable to enter restoration planting in the Emissions Trading Scheme. In the medium term, some larger

[1] https://www.stuff.co.nz/environment/126887807/deer-decimating-southland-forests 14 January 2022

scale restoration projects would be picked up by the LUCAS monitoring programme (done under MOU with the Ministry for the Environment). A new monitoring programme would need to be designed and initiated to monitor carbon storage of new and smaller scale native restoration projects.

17. Forest & Bird may also raise that the economic value of native forest is currently increasing due the rising price of carbon.

18. Forest & Bird have an interest in Te Ara ki Mua Framework for adaptive management of wild animals. Concern may be raised over how ecological values will be balanced with recreational and economic values as the framework is implemented. Directors have briefed Forest & Bird managers during the development of the Framework. DOC has submitted a bid for budget 2022 to Treasury to increase browsing pest control.

Attachments – Ngā Tāpiritanga

- Summary Sheet for Forest & Bird meeting, February 2022
- Talking Points for Forest & Bird meeting, February 2022

Contact: Meg Rutledge, Director Biodiversity Threats, s.9(2)(a) [redacted]

MEMO ENDS

Meeting with Forest & Bird Chief Executive Kevin Hague

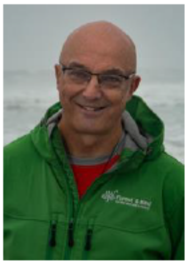
Time – date – location TBD

DOC staff accompanying: Meg Rutledge Director Threats s.9(2)(a) [redacted]

Purpose – Te aronga

- The purpose of the meeting is to discuss the goals that Forest & Bird recommend for DOC in the 'Improving browsing pest control' report (September 2021, 21 B-0966 refers).

You will be meeting

Name and position	Organisation	Bio highlights
 Kevin Hague Chief Executive	Forest & Bird	Kevin joined Forest & Bird as Chief Executive in October 2016. He has held leadership roles in business, and in the Government and community sectors. Before joining Forest & Bird Kevin served as a Member of Parliament for eight years. Kevin has also been extensively involved in various human rights issues and has a strong commitment to honouring Te Tiriti o Waitangi. A previous member of the West Coast Tai Poutini Conservation Board, Kevin has also been involved in conservation advocacy and campaigning, as well as practical conservation work including planting and pest control.

Background and context – Te horopaki

- You are meeting with Forest & Bird Chief Executive Kevin Hague at his request, to discuss four recommendations (labelled 'agency goals') for DOC in the 'Improving browsing pest control' report provided to you and other Ministers in September 2021.
- DOC Director Threats Meg Rutledge is available to support you at the meeting.
- The report is part of Forest & Bird's advocacy for more action to enhance native carbon sinks as part of the Emissions Reduction Plan to be published in May 2022. Minister Shaw and Minister Parker may also receive meeting requests on this report.
- DOC is progressing toward the four recommendations in the report, however none of the goals are likely to be met in the timeframes recommended by Forest & Bird. Advances in research, monitoring, detection, and management methods are required for the work to be feasible, along with additional funding.
- Forest & Bird may ask for increased investment in monitoring to determine impacts of browsing pests on carbon and biodiversity in future, including via the LUCAS programme. A 2022 budget bid led by Ministry for Primary Industries has been submitted to Treasury to increase natural sequestration in indigenous ecosystems. If successful DOC investment would prioritise monitoring improvements.
- Forest & Bird may raise that DOC currently does not record native planting on public conservation land by volunteers or staff in the Emissions Trading Scheme. In the medium term, some larger scale restoration projects would be picked up by the LUCAS monitoring programme. A new monitoring programme would need to be designed and initiated to monitor carbon storage of new and smaller scale native restoration projects.

- Forest & Bird may raise that the economic value of native forest is currently increasing due the rising price of carbon.
- Forest & Bird have an interest in Te Ara ki Mua Framework for adaptive management of wild animals. Concern may be raised over how ecological values will be balanced with recreational and economic values as the framework is implemented. Directors have briefed Forest & Bird managers during the development of the Framework. DOC has submitted a budget bid to Treasury to increase browsing pest control.

Risk assessment – Aronga tūraru

- There are no know risks to attending this meeting.[RJ1]

Talking Points for Meeting with Forest & Bird Chief Executive Kevin Hague, February 2022

<table>
<tr><td colspan="2">Hon Kiritapu Allan, Minister for Conservation Meeting with Kevin Hague
Date, Time, Venue TBD</td></tr>
<tr><td>Introductions</td><td>You are meeting with the following individuals:
• Forest & Bird Chief Executive Kevin Hague
The following Te Papa Atawhai officials are available:
• Meg Rutledge (Director Threats, Biodiversity)</td></tr>
<tr><td>Topic</td><td>Talking points</td></tr>
<tr><td>Acknowledgement of Forest & Bird report</td><td>9(2)(g)(i) [redacted]</td></tr>
<tr><td>Overview of DOC response</td><td>9(2)(g)(i) [redacted]</td></tr>
<tr><td>Recommendation – aerial 1080</td><td>9(2)(g)(i) [redacted]</td></tr>
<tr><td>Recommendation – browsing pest eradication</td><td>9(2)(g)(i) [redacted]</td></tr>
</table>

Recommendation – Himalayan Tahr Control Plan	9(2)(g)(i) [redacted]
Recommendation – Carbon storage from pest control	9(2)(g)(i) [redacted]
Current status of carbon in New Zealand forests	9(2)(g)(i) [redacted]
If questions are raised about investment in monitoring to determine impacts of browsing pests	9(2)(g)(i) [redacted]
If any questions are raised about monitoring carbon from native planting on public conservation land	9(2)(g)(i) [redacted]

	9(2)(g)(i) [redacted]
If questions are raised about deer management and goat control	9(2)(g)(i) [redacted]
Kevin Hague's retirement	9(2)(g)(i) [redacted]

Aotearoa indigenous ecosystems and climate change

Overview

This paper will outline how looking after and restoring Aotearoa's native vegetation could play a more significant role in our climate change policy.[1]

All the current modelling for reaching our climate change targets involves significant use of plantation forestry to offset gross emissions. MPI estimates an additional 0.74 and 1.46 million hectares of afforestation will be needed by 2050 to reach our climate goals. [2]

Recent small levels of afforestation have prompted concern from a wide range of interests including farming groups, environmental groups and rural communities. Relying on exotic forestry has also been criticised by the Parliamentary Commissioner for the Environment and Dame Ann Salmond (amongst others).

The social license for over a million additional hectares of exotic afforestation seems likely to be challenged - given the reaction to the relatively small levels of afforestation that have recently happened. This poses a serious challenge for climate change policy in New Zealand. If we are unable to plant pine at the levels currently envisioned, it means we will need to look at stronger policy to reduce emissions and alternative ways to sequester carbon that have a greater social license.[3]

Enhancing New Zealand's indigenous ecosystems is one of the options we have available to sequester additional carbon. There appears to be greater public and sector support for promoting native afforestation and regeneration, if natives were a larger part of the mix this could help with social buy-in for climate forestry policy.

There are a number of tools that could be utilised to make greater use of native carbon sequestration, such as looking at how we can promote ecosystems other than forests to sequester carbon. This is of particular relevance as these ecosystems will often be in areas which are not appropriate for farming or forestry.

Another option is to look at how to sequester more carbon in our existing native forests. There is also the potential for afforestation and regeneration of native forests to complement exotic afforestation.

To give a sense of the scale of the opportunity, it is estimated that sequestration on public conservation land alone could be increased by 698 Mt CO2e, [4] through reforestation, the advance of existing shrubland successions, and recovery of existing forests from disturbances such as animal browsing. To put this in context New Zealand's total emissions in 2018 were 78.9 Mt CO2-e.

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[1] It covers indigenous vegetation on both public and private land.
[2] This will have been modelled on primarily exotic forestry so the hectares needed would be higher for indigenous forestry.
[3] Another option is the use of international credits which we currently do not have access to and the use of which has been problematic in the past. It is also a risky strategy to rely on through to 2050 as if the Paris agreement works, and all countries look to significantly reduce emissions, the supply of international credits should dry up or become prohibitively expensive.
[4] This is a total figure rather than an annual one- see *Wild Animal Control for Emissions Management Research Synthesis*, Landcare Research, 2015.

This paper will cover these issues in three sections:

- Afforestation and restoration
- Indigenous forests
- Wider indigenous co-systems
- Policy options are outlined in appendix 1.

Afforestation & regeneration

Manaaki Whenua [5] has estimated that there is 740,000 hectares of land that could potentially be suitable for native regeneration. DOC is working through how much public conservation land could be suitable for afforestation or revegetation. [6]

While there is currently considerable interest from community, philanthropic and business groups in planting native trees and some government support to do this. Planting and regeneration is not yet at the scale that it will play a prominent role in our climate efforts. There have been calls from a wide range of sectors for there to be more support for native afforestation.

Exotic forestry is incentivised over native forestry

Current policy settings are geared around using exotic afforestation to meet our climate goals. This is because many exotics tree species sequester carbon more quickly in the short term and have the added bonus of being a cash crop. Given the public reaction to potential exotic afforestation, the long-term viability of this approach could be under threat as can be evidenced in the Cabinet directive to look at potential options to limit afforestation.

The criticism of using exotic forestry for reaching our climate goals is coming from a number of fronts. The Parliamentary Commissioner for the Environment has argued that the reliance on forestry delays making the systemic changes needed to reduce our gross carbon emissions.[7] Expanding exotic forestry also risks fire loading our landscapes at a time when we know that climate change is increasing the risk of fires and drought. The recent Pukaki and Lake Ohau fires are good examples of this with the Pukaki fires being a direct result of wilding spread from exotic plantations.

There is also criticism that large-scale exotic afforestation could compromise biodiversity outcomes, and lead to further erosion and sedimentation issues[8]. It could also potentially reduce employment in rural communities by encouraging forestry over sheep and beef farming. Interestingly these critiques have come from both farming and environmental interests. On the other hand, there seems to be widespread support for increased native afforestation.

The forestry sector is also pushing back against these critiques by highlighting historic deforestation and conversion to other land-uses, the economic benefits of the industry and landowner's private property rights. In developing any policy interventions, it will be important to take a step back from an increasingly fraught debate and look at the various pros and cons.

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[5] Criteria for this assessment: Privately owned land, not in forest, marginal for agriculture, suitable for trees, not suitable for exotic plantation forest, could regenerate tall forest. *Page 12 and appendix 1, Native Planting Resetting the balance, Aotearoa Circle 2020.*

[6] Rough initial estimates suggest it is in the tens of thousands of hectares and could be up to 100,000 hectares. A lot of this is under grazing license which raises its own set of issues.

[7] *Farms, forests and fossil fuels: The next great landscape transformation*, Parliamentary Commissioner for the Environment 2020.

[8] Both freshwater and coastal sedimentation issues.

Exotic forestry and environmental outcomes

There are risks to biodiversity from exotic afforestation, notably wildings which become a pest weed when they spread. Exotic forestry can also increase fire risk and intensity, as well as reducing catchment water yield by 20 – 50%. [9] On the other hand, exotic forests can provide limited habitat for some indigenous species.[10]

While there are well-documented issues with erosion and slash from pine forestry, farming operations on steep hillsides can also have serious sedimentation issues.

What often doesn't get stated in this debate is there are twin benefits from a climate perspective from moving land used for ruminant agriculture into forestry. There is the carbon sequestration from the forestry, and the removal of methane that the animals would have produced. Reaching our methane targets without land-use change will be difficult.

It is clear that there will continue to be a role for exotic forestry in our climate policy. Equally, it seems clear that the social license to plant pine at the scale envisioned by current climate models may be contested, and large scale planting is likely to face significant pushback. Having a greater role for native sequestration could help with getting buy-in to climate forestry policy.

Can indigenous regeneration and afforestation help?

Indigenous restoration has the potential to fill some of the sequestration gaps if we cannot rely on pine. Natives have a much greater social license, which in part, flows from New Zealanders deep emotional connection to native bush. More prosaically, it is also because they provide a wide range of co-benefits.

These co-benefits include promoting biodiversity outcomes and being a better option for permanent forestry than pine forest in terms of water quality, erosion and sedimentation issues. There is also a diverse range of groups such as large corporates, Iwi, agricultural groups, environmental and community groups that supporting native tree planting. There is potential to leverage this good will to develop a more ambitious programme for supporting native sequestration.

One of the draw backs of using native sequestration is that it costs more. There is an urgent need to address this and bring down the planting costs of natives by addressing issues in supply and looking at options like bare root and direct seeding propagation.

Another key issue with using native regeneration instead of pine is that it sequesters less carbon in the short to medium term (but more over the long term). This issue is exacerbated by having ETS look-up tables that are geared to pine and other exotic species. The native look-up table in the ETS is based on a low average from across the country (heavily biased towards areas such as mountains and foothills with unfavourable growing conditions). There is clear evidence that some species can sequester significantly more carbon if planted in favourable environments. There has been some work to look at specific species and regional look-up tables for natives, but it doesn't seem to be progressing.

The initial slow sequestration rates of natives raises the issue of the appropriate time scales for considering forests contribution to climate efforts. One option is that the emissions budgets for

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[9] Dymond et al. 2012: https://www.sciencedirect.com/science/article/pii/S0301479711003501
Fahey & Jackson 1997: https://www.sciencedirect.com/science/article/pii/S0168192396023763
[10] *Managing the impacts of plantation forestry on indigenous biodiversity*, Natural Solutions 2020

reaching our 2050 target could be structured so that forestry sequestration is weighted more in the 2040-2050 budgets than in earlier budgets to reflect the longer lead-in time needed for natives.[11]

It is also worth looking beyond 2050 at the role that forestry needs to play, maintaining our net-zero status will require additional sequestration occurring post 2050 in the likely event that there continues to be gross emissions. Under the Paris Agreement, New Zealand will also need to go net-negative in the second half of this century. Native afforestation has the potential to play an important role as forests will continue to sequester additional carbon well past 2050.

Native sequestration could also help assuage the criticism around relying on forestry at the expense of reducing gross emissions. The slower short-term sequestration rates of natives aligns with doing more now and using sequestration later to offset the unavoidable or hardest to reduce emissions. This lessens the risk of the systemic changes needed being continually deferred as has happened in the past.

Another potential downside is that plantation forestry creates jobs in a way that permanent forests do not[12]. The widespread use of permanent forestry could also potentially have a significant impact on rural communities.[13] It is possible that issues around the social license for native afforestation could arise if it is increased at scale, though any critique would probably come from fewer sectors[14] and would come up against New Zealanders affinity for native bush.

The analytical frame used when considering the economic benefits of the different type of afforestation is also relevant. Taking a wider ecosystem services or natural capital lens may give a different result. For example, an ecosystem services case study has indicated that indigenous forest can return $600 dollars more per hectare per year than exotic forestry (in terms of the value of the services provided).[15]

Where to from here?

Deciding the right mix between exotic and native afforestation will need to consider the social license for afforestation and how to weight financial and short-term sequestration benefits and wider biodiversity and environmental benefits. A wider goal could be to develop a diverse and holistic approach to land use and forestry that supports better biodiversity and community wellbeing. This would in turn help foster the social license for climate forestry policy that is needed for it to be to be effective over the long-term.

One approach, that to an extent is already underway, is to look at policy options for removing barriers to native sequestration to make it easier for those who are committed to native afforestation. This could be complemented by providing support through government funding.[16]

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[11] Emission budgets will be developed by the Climate Commission, but it is worth government agencies thinking through what they think would work in the forestry space.
[12] It is also worth looking at alternative to clear- felling such as continuous cover forestry which can create jobs and better environmental outcomes.
[13] In theory you could have native plantation forestry which could be a half-way house in between native permanent forestry and exotic plantation forestry. This would be in terms of a trade-off between financial outcomes and environmental outcomes. But creating a viable native forestry industry seems difficult.
[14] For example, environmental groups are unlikely to be critical.
[15] *Ecosystem Services in the Ōhiwa Catchment* Scion 2014
https://www.boprc.govt.nz/media/395767/ecosystem-services-in-the-ohiwa-catchment.pdf

[16] There is currently work looking at incentivising carbon sequestration in pre-1990 forests – including indigenous forests.

This would help foster the role of native afforestation as a complementary measure to exotic plantation forestry. Potentially with a focus on native afforestation and restoration in erosion prone land which is well suited for permanent forestry.

Another approach that has featured in public debate is to actively try and change the balance between the incentives for exotic afforestation and native afforestation. This can be seen in the Aotearoa Circle recent Native Forests Report – Resetting the Balance.[17]

There is of course a spectrum between these two approaches, and it would be useful to explore what a complementary approach that draws on both exotic and native afforestation could look like.

Outlined in the appendix are some policy levers that would help with encouraging native sequestration that are worth further exploration and discussion. Some of these levers are already under active consideration.

Transitioning exotic to native forestry

The idea of planting exotic nurse crops and then transitioning the land into native forests has been raised as a way of generating biodiversity and carbon sequestration benefits. The approach combines the short-term carbon sequestration of the faster growing exotics with the longer-term sequestration and biodiversity benefits of natives.

This approach would face some challenges. Long term ecological outcomes will be affected by planting exotic trees as they will change the long-term composition of the soil, forest structure and biodiversity. [18] As such it is not an appropriate option for planting on public conservation land or for planting where the aim is ecological restoration.

From a commercial perspective there could be challenges with the cost of managing any transition and deforestation liabilities. Any system that was set up to facilitate this approach would need to ensure participants do not walk away after banking profits from the exotic carbon sequestration.

Increasing carbon sequestration in indigenous forests

Indigenous forests have an important role to play in reducing carbon in our atmosphere and in providing resilience to the impacts of climate change.

Aotearoa's native forests cover around 7.8 million hectares. Looking after these forests is an important part of our climate change efforts. There is approximately 1.8 billion tonnes of carbon stored in them. Arguably this is one of the largest contributions to combatting global climate change that New Zealand makes.[19]

This creates a climate rationale for looking after these forests in addition to the wider benefits they provide from a biodiversity, environmental, economic and social perspective.

When developing policy for how we best look after our mature forests, it would be useful to factor in how we can encourage additional sequestration and minimise the risk of loss. This is likely to

[17] Aotearoa Circle is a partnership of private and public sector leaders.

[18] Where exotic shrubland already exists in a regenerating landscape it has been shown that it can be successfully used a nurse crop, this is different to planting exotics trees that will grow to large size.

[19] p 68, *Farms, forests and fossil fuels: The next great landscape transformation*, Parliamentary Commissioner for the Environment 2020.

involve better management and protection of our existing forests which will also create jobs in rural communities at a time when we face an economic downturn.

Research has shown that existing forests carbon sequestration is impacted by disturbances such as animal browsing.[20] Another example is our at-risk kauri forests which hold significant carbon stocks.[21] Finding ways to protect vulnerable species and forests will also be important.

Worryingly some recent evidence has indicated that our mature native forests as a whole might be losing carbon. It would be worth understanding whether and why this is happening and what the implications for policy are. [22]

On the positive side there is limited research that suggests indigenous forests can continue to sequester more carbon once mature rather than being, at best, steady state as has traditionally been assumed. [23] Again, it would be useful to better understand why this is happening and whether it can be encouraged via policy interventions.

Wider indigenous ecosystem sequestration

Currently forests are the only ecosystem that is really considered and factored into New Zealand climate policy. Most, if not, all ecosystems can sequester carbon – mangroves, seagrass, wetlands, shrub and tussock land can sequester significant amounts. Coastal wetlands have been estimated to sequester up to 100 times the amount of carbon that forests do.[24] These ecosystems often exist in places which are not suitable for forestry or farming so provide an opportunity to address the sequestration gap.

The potential for the role of other ecosystems to support our climate change efforts has yet to be properly quantified. This could be a first step in analysing the role they could play and what policy settings would support that.

As with native afforestation these ecosystems can also provide a wider range of benefits such as supporting biodiversity, water quality and building resilience to the impacts of climate change. For example, using mangroves and coastal wetlands as protection against sea-level rise is one way of both mitigating climate emissions and protecting against its impacts.

One area with rich potential is investment in the restoration and protection of coastal wetlands. Given their ability to sequester large amounts of carbon and the vital role they play in ecosystems in terms of storm surge protection, water quality and biodiversity. The risk of loss from fire compared with forests is also less of an issue.

Some initial scoping has been carried out on the potential of blue carbon[25], but this would benefit from greater resourcing and attention. Taking a wider ecosystem services or natural capital lens,

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[20] *Wild Animal Control for Emissions Management research synthesis,* Landcare Research, 2015
[21] Silverster 1999
[22] *Carbon Stocks and Change in New Zealand's Natural Forests*
Estimates from the first two complete inventory cycles 2002-2007 AND 2007-2014, Scion 2020
[23] *Atmospheric CO2 observations and models suggest strong carbon uptake by forests in New Zealand*, Steinkamp et al 2017 - https://acp.copernicus.org/articles/17/47/2017/acp-17-47-2017.pdf
[24] https://niwa.co.nz/news/muddy-sinks
Worth noting that freshwater wetlands, also produce methane, so the net benefit it less from a greenhouse gas perspective. Manaaki Whenua research suggests there is a benefit from peatland wetlands as well, especially from those on peat land – *Carbon Sequestration potential of non-ETS land on Farms, 2018.*
[25] Blue carbon is carbon sequestered in the marine environment.

coastal wetlands can return as much as US$193,843/ha/yr compared with US$3,137 for temperate forests[26]. Given New Zealand has 15,000 km of coastline (the 9th longest in the world) and over 300 estuarine systems this opportunity warrants further investigation.

There is also work looking at allowing shrubland into the ETS. This would be useful for providing an incentive to protect native shrubland that is an important ecosystem that also sequesters carbon. [27]

Considerable investment is being made by the Government in the restoration and protection of indigenous ecosystems through the Jobs for Nature programme. There is an opportunity to also realise potentially significant carbon sequestration through this work that can help us realise our climate goals.

Carbon reporting and accounting

A technical issue in this area is that the carbon sequestration from other types of ecosystems is not accounted for in reaching our targets under the Paris Agreement.[28] If it were it would in theory create a financial flow to incentivise protecting and restoring these ecosystems, as doing so would lessen our reliance on international credits.[29]

An alternative approach could be to develop a carbon credit scheme for native biodiversity credits for ecosystems that are not covered in our target accounting.[30] This could sit outside the ETS.

Wetlands

Another relevant issue is that peatland that has been converted from wetlands will continue to emit carbon over a long time period. Manaaki Whenua found that:

Wetland conversion has disturbed large stocks of C, and it is estimated that the current loss from 146,000 ha of farmed organic soils is between 0.5 and 2 $Mt \cdot CO_2 \cdot yr^{-1}$*, equivalent to 1–6% of the total greenhouse gas emissions from the New Zealand agriculture sector (Ausseil et al. 2015).*

Policy incentives to disincentivise the conversion of peatlands would be worth considering. It is also worth investigating the potential to rewet peatlands that have been drained.

Policy incentives for famers to protect and restore coastal wetlands (e.g. by managing barriers to tidal flow or restricting grazing) will also be valuable especially given rising seas and storm surge will make some of these areas increasingly unproductive.

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[26] Costanza et al. (2014) Changes in the global value of ecosystem services. Global Environmental Change 26(1):152–158. https://www.sciencedirect.com/science/article/pii/S0959378014000685

[27] Noting that some of what we generally think of as shrubland is already eligible eg mānuka/kānuka, matagouri of the appropriate height and density.

[28] Technically our NDC is silent on what types of vegetation are covered, but the current position seems to be we will report on forestry, and potentially add other types of vegetation at a later point.

[29] Ideally, we wouldn't use international credits but that is a whole different paper.

[30] Having an offsetting scheme that relies on ecosystems not in our NDC accounting would help with potential issues around double counting that forestry has. A small wetlands restoration carbon scheme has successfully been implemented in Germany - https://www.planup.eu/en/resources/good_practice/germany_case_study_%E2%80%93_moor_futures_[sep_2019]/517

Appendix one – policy options

Possible policy levers for supporting native afforestation and regeneration

Option one – making current regulatory settings more native friendly

- Opening ETS to pre-1990 native forests that continue to sequester (with management interventions).
- Species-specific look up tables for key indigenous species. Potentially differentiating across regions if and when data is available.
- Allowing post -1989 native shrubland into the ETS.
- Native specific forestry categories such as permanent native.
- Tagging of native forestry units to help enable a market premium to develop
- Support with marketing native carbon credits.
- Averaging of carbon for indigenous forestry (e.g. if the forest gets to 1500 tonnes after 300 years, give the landowner an average of 5NZUs per year). This would be different from current averaging changes to the ETS that have a lead in period before averaging kicks in.
- Providing look up tables over a longer time frame than 50 years.
- Support for measuring native carbon for forests of over 100 hectares. Or exempting them from FMA requirements.
- Enable exotic to native transition under the ETS. It is currently disincentivised by deforestation liabilities.
- Information/assistance from Te Uru Rakau for landowners on native forestry under ETS and wider.
- 1 Billion trees grant funding more targeted at native forestry. This could include looking at how jobs for nature and wider funding pools support indigenous biodiversity.
- Encouraging native restoration and protection via the on-farm sequestration work (He Waka Eke Noa workstream)
- Addressing issues around native nurseries – both scale and price.
- Using the RMA to only allow natives for permanent planting on erosion prone land (this is also better for limiting erosion and sediment run off).
- Investigating options to support agro-forestry.
- Invest in predator control and fencing off ruminants from grazing on regenerating native bush.

Option 2 – more actively trying to change the balance between exotics and natives[31]

- Restrictions on the amount of exotic forestry in the ETS, this could include:
    - Permanent forestry being limited to natives.
    - No new exotic forestry in the ETS.
    - A cap on forestry units that emitters can purchase.
- Use RMA national direction to limit where exotic forestry can be planted.

[31] See MPI paper on *Options for afforestation July 2020* for more analysis of these options.

- Further limit overseas investment in exotic forestry.
- Highlighting the role of agroforestry as eligible in the current ETS settings.
- Encouraging the retirement of water catchments from exotic forests and planting them up as natives, this will improve freshwater values and also act as a fire break.

Wider indigenous ecosystem sequestration possible interventions

- Investigate potential contribution of carbon sequestration from coastal wetlands.
- Consider including wetlands in our NDC accounting
    - An alternative approach could be to develop a carbon credit scheme for native biodiversity credits for ecosystems that are not covered in our target accounting.
- Policy incentives to disincentivise the conversion of peatlands.
- Investigate the potential to rewet peatlands.
- Allowing post -1989 native shrubland into the ETS.

Climate benefits of wild animal management

Key messages

Managing wild animals and other browsing pests protects critical habitat for threatened species and supports forest resilience to climate change.

In mature native forest, it is difficult to quantify and attribute any additional sequestration removal of deer, goats, and other browsing pests. This is because the uncertainties associated with measuring carbon are larger than the measured impact of browsing pests.

Regenerating shrublands and restoration plantings need protection from wild animals and other browsing pests. Reducing browsing pressure in these situations could support carbon gains over time as tree seedlings establish and open habitats regenerate to tall forest.

The Climate Emergency Response Fund (Budget 22) supports a new government research programme 'Increasing Natural Sequestration to Achieve New Zealand's Future Carbon Goals.' This research will help us to better understand and measure the carbon storage contribution of native ecosystems and how this is affected by browsing pressure. DOC is part of this programme.

Extreme weather events such as storms and drought are predicted to become more frequent because of climate change. Intensively browsed forests are more susceptible to large shifts in structure and composition after these extreme events. Managing wild animals and other browsing pests will reduce this risk by allowing forest understory to regenerate and improving ecological resilience to disturbance.

Additional messages

Te Ara ki Mua Framework

Te Ara ki Mua Framework supports the implementation plan for Te Mana o te Taiao Aotearoa New Zealand Biodiversity Strategy (ANZBS). The key action is to reduce browsing pressure to support ecosystem resilience to disturbance including climate change impacts.

The relevance of wild animal management to climate change is acknowledged in Te Ara ki Mua values. The ecological values refer to the role of wild animal management in climate adaptation, by improving ecosystem resilience to extreme weather events. Managing deer and goats helps to protect the 'future forest' of tree saplings, associated ground cover and soil organisms from climate change.

The economic values refer to investment in regenerating and planted native forests and shrublands as nature-based solutions for increasing carbon storage. The success of these nature-based solutions, in terms of young trees thriving and storing carbon, requires protection from browsing pressure.

Other research and monitoring

The Ministry for the Environment is the central government agency responsible for reporting on New Zealand's Greenhouse Gas Inventory and to the United Nations Framework Convention on Climate Change ("**UNFCCC**"). This includes reporting on the carbon stock and change that occurs in

New Zealand's forest land. The MFE LUCAS (Land Use and Carbon Analysis System) programme monitors and reports on carbon stock and change in NZ forests and shrublands. DOC's national biodiversity monitoring programme works with MfE to integrate LUCAS with its monitoring of biodiversity (vegetation and birds) and mammal pests on public conservation land. Recent analysis from Ministry for the Environment indicates that forests are in carbon balance, they are neither a carbon sink nor a source, although some regenerating forests are sequestering carbon.

Carbon Watch NZ is a collaboration between NIWA, GNS Science, Manaaki Whenua Landcare Research, Auckland Council and the University of Waikato. This project is working with the Raukumara Pae Maunga project to better understand the carbon implications of forest recovery and are selecting possible field sites for data collection.

Resources:

February 2022 22-M-0028 - Event memo - Forest & Bird meeting DOC-6917420

February 2022 21-B-0966 - Memo - Request - Information about recommendations made by Forest and Bird DOC-6854571

July 2021 SLT memo on F&B carbon sinks report DOC-6716885

Conservation land potentially suitable for adding carbon sequestration

Note that this is an internal working paper and does not represent a DOC position or policy.

1 Background

A number of previous analyses have used geospatial methods to estimate the potential for additional carbon sequestration through planting and/or management of existing vegetation, often in the context of sustainable use of erosion-prone and damaged land. Some included estimates of the potential on conservation land. Most were not ground-truthed.

Two processes sought to identify specific sites on conservation land suitable for planting and/or management to increase carbon sequestration above 'business as usual' levels. In 2006-2007 DOC used geospatial analysis and ground-truthing to identify a list of sites, some of which were adopted for the Carbon Neutral Public Service (2007-09) and 5-iwi Afforestation (2008-12) programmes. Other were adopted for DOC's carbon sink tender process (2008-12) and some community-based programmes (eg Motutapu Island). Recently, DOC used a site-led approach to identify land and partnership opportunities suitable for funding through the MPI-run Billion Trees Programme.

2 Our analysis

Conservation land is held under strict legislation that means that in most places, only planting for ecological restoration is clearly permitted.[1] Consequently any planting and/or management for additional carbon sequestration must also meet this standard. We used a desktop geospatial analysis to estimate the area of conservation land that could naturally be forested but is currently under other types of vegetation. We did not look for sequestration opportunities through restoration of non-forest ecosystems on land or in wetlands ("blue carbon") or through restoration on land which already meets the definition of forest land.

We have followed DOC's 2007 project classification of sites into two broad types of intervention;

- 'Type A' sites are focused on new planting of tree and other species that would naturally occur there, with management to prepare the land and protect plantings;
- 'Type B' sites are focused on management of existing vegetation to increase sequestration rates through enhanced condition and faster regeneration, and may include some planting of tree species which would naturally be present but are now rare or absent.

Activities that comprise these intervention are explained further in Attachments 1 & 2.

2.1 Napalis register of conservation land interests

Our analysis is based on Napalis data for Crown-owned and managed conservation land.

We excluded Chatham and offshore islands; Crown reserves that are vested or formally managed by others; Marginal Strips; DOC covenants; Waitangi Endowment forest, and statutory overlays. We did not exclude areas under grazing licence, mining access, easements or other concessions.

Although council-owned or managed reserves, regional parks and covenants may offer significant restoration opportunities, they are not managed by DOC and have been excluded in this analysis.

2.2 Land Cover Database v.5 (2018)

We used LCDB version 5 to identify areas of vegetation where some form of planting or management could initiate or accelerate regeneration and carbon sequestration. We targeted vegetation classes that are least likely to have value as indigenous vegetation or habitat for native species, or to be valued for recreation or other values (such as tussock landscape).[2]

[1] Afforestation is provided for on Recreation, Government Purpose and Local Purpose reserves in certain circumstances, basically for the betterment of the reserve where no conservation values would be affected.
[2] LCDB5 vegetation classes are described here and an illustrated guide to LCDB2 classes can be found here.

Class	"Open" land - high potential of suitable sites, but total area is limited - Type A	
6	Surface Mine or Dump	Site recovery often patchy, if any
12	Landslide	High erosion & pest management co-benefits
40	High Producing Exotic Grassland	Dominated by or exclusively non-native species
44	Depleted Grassland	High erosion & pest management co-benefits
	"Marginal" land - moderate potential of sites, but class covers large area - Type A or B	
41	Low Producing Grassland	Diverse class with varying objectives (see below)
	Successional shrubland - moderate potential, but classes cover large areas - Type B	
51	Gorse / Broom	Co-benefits for pest plant management
56	Mixed Exotic Shrubland	Co-benefits for pest plant management
50	Fernland	
52	Mānuka / Kānuka	
54	Broadleaved Indigenous Hardwoods	
	Exotic forest - no new sequestration from replanting in native trees - Excluded	
64	Forest - Harvested	
68	Deciduous Hardwoods	Often riparian & wetland, high restoration benefits
71	Exotic Forest	

Low Producing Grassland merges into High Producing Exotic Grassland and Depleted Grassland and is often mosaiced with them on the ground. Attribution to these classes may depend on season and rainfall at the time satellite imagery was acquired. The class includes:

- low quality exotic pasture which may be suitable for planting [Type A];
- grassland near forest or shrubland that wil revert if pastoral management is ended [Type B],
- short tussock and other indigenous non-forest ecosystems with significant conservation values and/or non-forest futures, which would not therefore be suitable for planting trees.

Restoration or reversion of native forest on areas currently under exotic forest is likely to have biodiversity and other conservation benefits but would not add new sequestration as it is already forest land. This class includes some of the oldest and densest wilding conifer infestations.

2.3 Potential Vegetation (2012)

We refined this analysis using Landcare Research's 'Potential Vegetation' layer to exclude areas where forest is not the expected outcome of regeneration (ie a forest future). This model takes account of various factors including species distribution, latitude, altitude, and climatic severity.[3] It identifies 24 potential vegetation types of which 20 are forest futures.

We excluded land with non-forest futures: 'Duneland'; 'Scrub, tussock-grassland, & herbfield above treeline'; 'Scrub, shrubland, & tussock-grassland below treeline'; 'Wetland', unclassified and blank.

2.4 Other important factors

We chose not to refine this analysis further because it is only practicable to address a few sources of uncertainty in a desktop analysis. On-the-ground knowledge is essential. Factors affecting the actual availability and suitability of a potential site include the following.

[3] Leathwick, J, McGlone, M & Walker, S (2012?) New Zealand's potential vegetation pattern

Proposal evaluation	***What is an appropriate land use / restoration target at site?***
Management objective	Legal classification, use as recreation & archaeological areas
Natural regeneration	Confidence that intervention can demonstrably add sequestration
Existing projects	Some of the best sites are already committed to restoration projects
Land attributes	*How hard is it to get trees to grow, especially planted trees?*
Landscape	Altitude, slope, aspect, erosion, soils
Climatic limits	Wind, frost days, seasonal drought or saturation
Ecological processes	*Can the benefits of intervention be sustained, cost-effectively?*
Biosecurity	Browsing animals, weeds / tree weeds, predators, disease
Condition	Pollinators, seed sources & vectors, habitat connections
Community factors	*Would there be conflict with other community uses of the area?*
Social	Iwi & community preferences, existing use eg grazing, hunting
Economic	Cost v benefits, balance of benefits for CC and other objectives
Workforce	Availability, access, hazards

3 Results

3.1 Minimum area

We used a one hectare minimum area because it is the minimum area for carbon accounting (where shape criteria are also met). Also, in practice, restoration programmes, particularly those working at landscape or catchment scale, will work on multiple sites which are reasonably close together. Setting a low minimum helps to offset the inability of our analysis to group different opportunities.

3.2 Summary of results

LCDB classes have been grouped by intervention type as in paragraph 2.2. Attachment 3 provides more detailed result for each LCDB class.

The most obvious prospect for additional carbon sequestration is the “open” land area currently grassland, mines and dumps, and landslides, which is potentially suitable for restoration planting. A substantial but unquantified area of “marginal” land - low producing grassland - is also potentially suitable for planting or reversion depending on the site. Carbon sequestration on this land is easily accountable as it would be new.

Although the potential is widely recognised, we do not yet have good methodologies to account for additional sequestration in successional shrublands. However, a number of current workstreams are now looking at this and similar requirements (for example, in pre-1990 indigenous forests).

Existing vegetation / **Potential vegetation**	**Forest future > 1 ha**	**Primary intervention type**
“Open” land classes	55 868	A - Planting
“Marginal” land class	128 304	A or B - Site-specific
Successional shrubland classes	529 244	B - Management
	713 416	**TOTAL hectares**

Notional carbon sequestration gains from intervention on this land are presented in Attachment 4.

3.3 Other opportunities

Some potential opportunities don't show up in LCDB, such as:

- fire scars (similar issues and co-benefits to landslides);
- where dense wilding infestations been sprayed (to control weeds and reinfestation);
- Indigenous Forest class where intervention could increase regeneration and sequestration rates;
- to secure carbon stock in existing forest (particularly where deer and goat numbers are high).

Attachment 1 - Typical activities comprising intervention

'Open' land and some 'marginal' land offer the main opportunities for clearly additional sequestration. Although there are also opportunities in regenerating forest (included in the Indigenous Forest class) there are doubts about the demonstrability of sequestration gains. We have included interventions on forest land for completeness although there is no short term increase in sequestration.

Intervention in existing LCDB classes -	**Typical activities (conservation land only)**
"Open" land (including landslides, fire scars)	***Intervention Type A***
Planting for reversion to shrubland (eg pasture. Trees may be rare / absent) Direct seeding for reversion to forest/shrubland (eg slips & wilding conifer control areas; pasture. Wanted trees may be rare / absent)	Fencing & stock exclusion Intensive planting / seeding (nurse crop or mix) Local browsing animal control (plantings) Local weed control (plantings)
"Marginal" land (Low-Producing Grassland)	***Intervention Type A or B***
As above, or if reverting naturally - Enhanced reversion to shrubland (eg pasture. Trees may be rare / absent)	Fencing & stock exclusion Some strategic planting (missing / rare species) Local browsing animal control Local weed control Extensive browsing animal control (landscape)
Successional shrublands (including exotic)	***Intervention Type B***
Enhanced regeneration to native forest (Large tree species may be rare / absent)	Some strategic planting Canopy manipulation (gap creation) Extensive browsing animal control Extensive predator control (bird seed vectors)
Exotic forest (including harvested)	***Intervention Type B***
Exotic plantation to forest of mainly native trees Permanent exotic-native forest mixtures	Some strategic planting Local browsing animal control Local weed control Extensive browsing animal control Extensive predator control Progressive tree removal (lightwells, safety)
Indigenous forest	***Intervention Type B***
Enhanced regeneration ('Normal' range of large tree species present) Rehabilitation of 'mature' native forest ecosystems (including tall / primary forest) Native plantation (single - simple - diverse mix)	Extensive browsing animal control Extensive predator control

Note:

Effective fire suppression is always a requirement. Wilding conifer control may be required.

Extensive browsing animals control focuses on large herbivores, particularly goats, deer, possums and pigs, because of their effects on long term ecosystem health.

Local browsing animal control is required to protect plantings from small herbivores such as hares, rabbits and even pukeko until they are well established.

Attachment 2 - Managing existing vegetation for additional sequestration

Management of existing regenerating forest and shrubland to restart or accelerate succession to tall forest should increase carbon sequestration as well as benefiting biodiversity and erosion control. The restoration of large forest trees is also culturally important to Maori. Management at site will normally involve multiple activities that contribute to multiple objectives. Economies and benefits are most likely to be achieved by large-scale interventions across landscape units or catchments (which will also contribute to the security of existing carbon stocks in native vegetation).

There is very little quantitative data on potential sequestration gains in NZ shrubland or forest land. While the benefits of strategic planting into shrubland can be broadly compared to planting on open land, the effects of browsing animal control appear to be complex and indirect.[4,5] Site selection and monitoring design will be key to establishing carbon sequestration benefits from management.

Strategic planting

Regeneration of shrublands can be stalled due to depleted and missing species (especially large trees)[6] and can be accelerated by strategic planting of these in favourable habitats such as streamsides. Browsing animal and weed control may be needed locally to protect new plantings. Plantings eventually provide seed sources and food sources for wildlife able to act as seed vectors.

Numerous large native tree species can be described as long-lived pioneers and readily establish on early successional sites. Increased abundance of large trees at an early stage will increase sequestration above ETS Lookup Table rates. A national survey of planted stands found native trees including kauri, totara and beeches achieved far higher sequestration rates than the ETS table (which is based on pasture reverting to manuka / kanuka).[7,8]

Extensive browsing animal control

The effects of browsing animals include direct consumption of biomass, increased seedling mortality and changes in successional trajectory, increased canopy mortality, soil feedbacks, and seed predation and dispersal. Effects of control on carbon sequestration have been little studied but demonstrable gains are considered most likely where regeneration would be relatively rapid but for high browsing animal impacts, particularly if control promotes the establishment of large trees.[9]

The main cost is knockdown of existing populations. DOC has had some areas under sustained management of various species for many years (eg possums at Otira for southern rata). Current pest control programmes are working to increase effectiveness while reducing costs, and economies of scale are evident.

Extensive browsing animal control will also be required where large-scale planting is implemented.

Extensive predator control

Low bird numbers depress seed dispersal for many trees. Predator control will contribute most to regeneration where seed sources are available and predation, rather than the extent and quality of existing habitat, is the limiting factor on bird populations.

Kereru and tui are particularly important seed vectors and fortunately their populations bounce back quickly with predator control. Kereru are the largest remaining vector and disperse seeds of some 70 plant species including 16 large trees and the largest seeds. Tui disperse seed of 10 large trees.

Improved seed dispersal, together with reduced seed predation and improved seedling survival, can be expected to accelerate regeneration in shrubland and increase sequestration rates over time.

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[4] Carswell et al (2015) Wild Animal Control for Emissions Management (WACEM research synthesis. DOC contract report
[5] Holdaway RJ et al (2012) NZJE 36(2):252
[6] See for example Forbes et al (2020) NZJE 44(1):3404
[7] Tane's Tree Trust Technical Handbook Part 10.5 and Part 10.1
[8] MPI (2017) A Guide to Carbon Look-up Tables for Forestry in the ETS section 2.5
[9] Holdaway (2012) ibid

Attachment 3 - Geospatial analysis in detail

Existing vegetation (LCDB class)		Potential vegetation All futures > 0 ha	 All futures > 1 ha	 Forest future > 1 ha	
"Open" land - Intervention Type A					
6	Surface mine or dump	1131	1069	822	
12	Landslides	14756	13085	9707	
40	High-producing exotic grassland	47198	44332	34010	
44	Depleted grassland	42394	42151	11329	
		105479	100637	**55868**	**TOTAL "Open" land**
"Marginal" land - Intervention Type A or B					
41	Low-producing grassland	217089	213847	**128304**	**TOTAL "Marginal" land**
Successional shrublands - Intervention Type B					
51	Gorse / broom	19196	18484	14864	
56	Mixed exotic shrubland	6656	6473	4373	
		25852	24957	19237	**Subtotal exotic**
50	Fernland	15453	15188	13287	
52	Mānuka / kanuka	319678	316114	282248	
54	Broadleaved indigenous hardwoods	234364	230420	214472	
		569495	561722	510007	**Subtotal native**
		595347	586679	**529244**	**TOTAL Successional shrublands**
Exotic forest land - Excluded (refer 2.2)					
71	Exotic forest	23490	22257	19604	
64	Forest - harvested	1064	937	900	
68	Deciduous hardwoods	7938	7533	3033	
		32492	30727	**23537**	**Total Forest land**

Attachment 4 - Potential additional carbon sequestration

Potential sequestration gains over the first 10 years (2030) and first 30 years (2050) from the start of intervention can be modelled from ETS table rates for "Indigenous Forest". A shortcoming for our purposes is that ETS table rates are modelled on natural mānuka-led reversion from pasture [10] which means that over the short term (20 years plus) carbon stock change is dominated by mānuka / kānuka with little input from large trees such as kauri, totara and beech, although these show substantially higher sequestration rates in planted stands on favourable sites.[11]

Land descriptors group LCDB classes as in paragraph 2.2.

Ruminant methane emissions will also be reduced by sustained browsing animal control, particularly of wild deer and feral goat populations.

Assumptions -

- half of the identified land area is found to be suitable, available and practicable;
- "marginal" land is split evenly between planting and management for reversion;
- successional shrubland has an average age of 20 years at start;
- improved management produces 5% additional sequestration in woody vegetation over the next 10 years. This figure is notional, based on the estimated 10-13% increase in above-ground vegetation biomass benefit over 25 years cited in the 2008 Whanganui goat control pilot project request for tender document.[12]

2020-2030	**ETS table values (tCO$_2$e/ha)**				**Total tCO$_2$**
10 year span	**Year 0 stock**	**Year 10 stock**	**Change**	**Hectares**	**Added**
"Open" land - planted	0	40.2	40.2	27934	1.1 m
"Marginal" land - planted	0	40.2	40.2	32076	1.3 m
"Marginal" land - reversion	0	40.2	40.2	32076	1.3 m
	Year 20 stock	**Year 30 stock**	**Change +5%**		
Successional - managed	158.7	270.0 (257.5 + 5%)	12.5	264622	3.3 m
				Total added	**7.0 m**

For the 2050 figures the following additional assumptions have been applied:

- on "Open" and "Marginal" land we have made no allowance for potential additional sequestration if a richer species mix was planted, or more intensive management was undertaken, than is assumed in the ETS Lookup Table scenario referred to above;
- the estimate for additional sequestration in successional shrubland after 30 years (Year 50) is the 13% over 25 years from the Whanganui tender document.

[10] MPI (2017) A Guide to Carbon Look-up Tables for Forestry in the ETS section 2.5
[11] Tane's Tree Trust Technical Handbook Part 10.5 and Part 10.1
[12] Available from DOC. No primary reference.

2020-2050	ETS table values (tCO_2e/ha)				Total tCO_2
30 year span	**Year 0 stock**	**Year 30 stock**	**Added**	**Hectares**	**Added**
"Open" land - planted	0	257.5	257.5	27934	7.2 m
"Marginal" land - planted	0	257.5	257.5	32076	8.3 m
"Marginal" land - managed	0	257.5	257.5	32076	8.3 m
	Year 20 stock	**Year 50 stock**	**Change +13%**		
Successional - managed	158.7	365.4 (323.4 + 13%)	42.0	264622	11.1 m
				Total added	**34.9 m**

Document 7

Daniel Ohs

From: Asher Cook <Asher.Cook@mfe.govt.nz>
Sent: Monday, 26 July 2021 4:26 pm
To: Meredith McKay; Elaine Wright
Cc: Kathrin Affeld; Charlie Clark; Disee Anorpong; Deborah Burgess
Subject: Net emissions and removals from woody vegetation on PCL

Kia ora Meredith and Elaine,

We have now completed the analysis on the net emissions and removals from woody vegetation on public conservation land. In total, you'll see that woody vegetation on PCL is estimated to be a net source of emissions (926 kt ± 3,893 CO_2-e yr^{-1}). This estimate has a high associated uncertainty (421 per cent).
We undertook the analysis using methods consistent with New Zealand's Greenhouse Gas Inventory and the 2006 IPCC guidelines for reporting.

Pre-1990 natural forest was the largest source of net emissions. This was driven by carbon losses across a large area of tall forest and carbon gains across a smaller area of regenerating forest. Note that we have provided estimates for the tall and regenerating components using two separate classification approaches (one using species composition and the other using landcover).

We have also attached the PCL plot data which was used to calculate carbon stock and stock change for pre-1990 natural forest. This includes the carbon stocks by pool (above ground biomass, below ground biomass, coarse woody debris and litter) and carbon stock change for each plot over the first two measurement rounds (2002 – 2007 and 2009 – 2014).

Let us know if you have any questions and we can organise a teams call if you'd like to talk further.

P.S. As I have mentioned to Meredith, Disee Anorpong has recently started at MfE as the new LUCAS manager. I will organise a catch-up over Teams sometime in the coming weeks.

Much thanks,
Asher

Asher Cook – Analyst, LUCAS
Ministry for the Environment – Manatū Mō Te Taiao
Mobile: s.9(2)(a) [redacted] Email: Asher.cook@mfe.govt.nz Website: www.mfe.govt.nz
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Please note: I work Monday - Thursday

Links to files that were attached to this message:

PCL - pre-1990 natural forest plot data.xlsx Microsoft Excel Worksheet, 157 KB
https://doccm.doc.govt.nz/cs/idcplg?IdcService=GET_FILE&dDocName=DOC-7271548&RevisionSelectionMethod=LatestReleased&allowInterrupt=1

Net emissions and removals from woody vegetation on PCL land.docx Microsoft Word Document, 300 KB
https://doccm.doc.govt.nz/cs/idcplg?IdcService=GET_FILE&dDocName=DOC-7271549&RevisionSelectionMethod=LatestReleased&allowInterrupt=1

Open WebCenter Content Server

Document 8a

Ministry for the Environment
Manatū Mō Te Taiao

Net emissions and removals from woody vegetation on public conservation land

Report prepared by Asher Cook and Charlie Clark

New Zealand Government

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This document may be cited as: Ministry for the Environment. 2021. *Net emissions and removals from vegetation on Department of Conservation land*. Unpublished. Wellington: Ministry for the Environment.

Contents

Tables

Summary

1. This report estimates the net emissions and removals from woody vegetation on public conservation land (PCL) administered by the Department of Conservation (DOC), using methods consistent with New Zealand's Greenhouse Gas Inventory (MfE, 2021) and the 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines for reporting (IPCC, 2006b).
2. Woody vegetation on PCL is estimated to be a net source of emissions, emitting an estimated **926 kt** ± 3,893 CO_2-e yr^{-1} into the atmosphere in 2019. This estimate has a high associated uncertainty (421 per cent).
3. Pre-1990 natural forest was the largest source of net emissions at 1,379 ± 3,882 kt CO_2-e yr^{-1}. This was driven by carbon losses across a large area of tall forest and carbon gains across a smaller area of regenerating forest (classified using a land cover approach).
4. Carbon dioxide (CO_2) removals from woody vegetation were driven by regenerating pre-1990 natural forest, pre-1990 planted forest, post-1989 planted forest and post-1989 natural forest.
5. The high uncertainty in the estimate of net emissions from pre-1990 natural forests mean that they do not statistically differ significantly from zero. This can make it difficult to determine if the observed decline in carbon stocks is a trend that will continue or if it is due to natural variation in the plot data.
6. Continuous monitoring and up to date analysis, incorporating the most recent pre-1990 natural forest plot measurements from 2015 onwards, are needed to determine if the current slight decline in carbon stocks will continue and to identify other emerging trends.

Net emissions, removals and carbon sequestration

The terms net emissions, removals and carbon sequestration describe how greenhouse gases may be increasing or decreasing in the atmosphere. They are expressed as carbon dioxide equivalents (CO_2-e).

An **emission** represents a release of CO_2-e to the atmosphere. This can be due to a loss of carbon in vegetation or soil, for example through respiration, decay or burning.

A **removal** represents a withdrawal of carbon dioxide from the atmosphere, usually due to an increase in carbon stored in vegetation or soil.

Net emissions represent the overall sum of emissions and removals occurring, expressed a CO_2-e. This includes carbon gains from vegetation growth; carbon losses due to harvesting, vegetation clearance, and deforestation; and carbon gains and losses in soils.

Carbon sequestration is the process of capturing and storing carbon dioxide. Usually, this refers to increasing carbon stocks in vegetation or soil. It represents a removal from the atmosphere.

Harvesting, deforestation and clearance of vegetation

Harvesting typically refers to the harvest of planted production forests for timber, which are then replanted.

Deforestation occurs when forest land is cleared for another land use.

Clearance of vegetation, in this report, refers to land use change from grassland with woody biomass to a new land use (often pasture). It involves the removal of the existing woody vegetation. Note: the partial removal of vegetation, which does not result in a detected land use change, is not included in this definition.

Introduction

The purpose of this report is to estimate the net emissions and removals from woody vegetation on PCL in New Zealand. The approach takes into account carbon gains and losses and applies measurement principles consistent with New Zealand's Greenhouse Gas Inventory (MfE, 2021) and the Intergovernmental Panel on Climate Change (IPCC) guidelines for reporting (IPCC, 2006a).

Net emissions from vegetation and soils are reported each year in the land use, land use change and forestry sector (LULUCF) of New Zealand's Greenhouse Gas Inventory (MfE, 2021). Net emissions from New Zealand's LULUCF sector are estimated by mapping land use and land use change, and then determining the net emissions and removals associated with each activity. This approach is underpinned by wall-to-wall spatial mapping of all land uses at a national scale.

This spatially explicit national approach can be downscaled to sub-national areas of interest where the mapped boundaries of the area of interest are available, and the area of interest is of sufficient size. This allows for an estimate of net emissions and removals from the land for a specific sector or land use, that is consistent in approach with New Zealand's national estimate for the LULUCF sector.

This report aims to estimate the net emissions and removals from woody vegetation occurring on PCL in New Zealand. Using approaches consistent with New Zealand's Greenhouse Gas Inventory (MfE, 2021) to determine a robust and comprehensive estimate.

Methods

Determining vegetation area

The area of woody vegetation, vegetation clearance and vegetation age on PCL was assessed by intersecting land classed as DOC administered land (https://koordinates.com/layer/754-doc-public-conservation-areas/), with the Land Use and Carbon Analysis System (LUCAS) land use map (LUCAS LUM 2016 v8).

The LUCAS LUM 2016 v8 was used to assign the area and area change (ie, deforestation) of woody vegetation land use classes. The 2016 map year was used to determine the area of each land use class present on PCL. This was combined with previous map years (1990, 2007, 2012), to determine how the age and clearance of vegetation has changed through time.

Estimating carbon stock change

The area of each land use and land use change category from LUCAS LUM 2016 v8 was assigned an emission factor associated with that land use type. Emissions factors in the LULUCF sector are used to represent the net emissions or removals per unit area of land. Emissions factors can represent the rate of sequestration per unit area, expressed as t CO_2-e ha^{-1} yr^{-1}. These methods and carbon accounting principles are consistent with the IPCC guidelines for greenhouse gas measurement and reporting (IPCC, 2006b).

We estimated an average emissions factor for each land use type and associated activity, using either:

- a bespoke, plot-based estimate for vegetation on PCL (for pre-1990 natural forest), or
- data from New Zealand's 1990–2019 Greenhouse Gas Inventory (MfE, 2021).

Each emission factor was then applied to the area of a given land use type to estimate total net emissions and removals.

This approach enables estimates of net emissions and removals to be consistent with New Zealand's national estimate (MfE, 2021). The emissions factors used in New Zealand's Greenhouse Gas Inventory undergo robust quality assurance and represent the best current available estimate for each land use category (MfE, 2021). They are continually updated as the data improves or as changes are detected through time.

Classifying woody vegetation

The LUCAS LUM has three main categories for woody vegetation:

- natural forest (pre-1990 and post-1989)
- planted forest (pre-1990 and post-1989)
- grassland with woody biomass.

Forest land

Mapped areas of forest land are divided into:

- areas that were forest land at 31 December 1989 (pre-1990)
- areas that became forest (either self-sown of planted) on or after 1 January 1990 (post-1989)

This split allows for a comparison of new and existing forests to a 1990 base year in determining how these forests will be treated in international target accounting and domestic policies. It also gives more accurate estimates of carbon stock and stock change, specific to each of these categories.

To be defined as forest land, mapped areas of woody vegetation must meet, or have the potential to meeting the following criteria:

- have 30 per cent or greater canopy cover
- cover a minimum area of 1 hectare, with a 30 metre minimum width (canopy-edge to canopy-edge)
- have a height of 5 metres or more, or the potential to reach this height within a 30 to 40 year timeframe or under current land management.

Grassland with woody biomass

Grassland with woody biomass is defined as areas of land covered by woody vegetation that does not meet the forest definition and is not expected to do so under current ecological, management or environmental conditions.

This vegetation type may not meet the forest definition because it is already growing at its environmental limits, or biotic pressure such as grazing may be preventing the successful transition into forest.

Pre-1990 natural forest

Pre-1990 natural forest carbon stock and stock change per hectare were derived using plot level carbon stock change calculations from Paul et al (2021). This includes data from the first two measurement cycles of the LUCAS and Tier 1 natural forest plot network (2002-2007 and 2009-2014).

To determine which natural forest plots occur on PCL, the LUCAS and Tier 1 plot network was intersected with the mapped extent of PCL. Recent mapping improvements to the LUCAS LUM 2016 v8 resulted in a few plots being removed from the list for analysis that were originally included in Paul et al (2021), as they were no longer mapped as pre-1990 natural forest. This gave 745 pre-1990 natural forest plots on PCL with at least one measurement to calculate carbon stock and stock change.

Carbon stock change was calculated as the average rate of change across the two measurement periods (2002-2007 and 2009-2014). The annual rate of change was calculated by dividing the average carbon stock change between measurements by the average measurement interval (approximately 7.7 years), as in Paul et al (2021); also known as the ratio-of-means. Annual carbon stock change was then converted to net carbon dioxide emissions based on their molecular weights (ie, multiplying by −44/12).

Carbon stock and stock change for pre-1990 natural forest was estimated for all PCL pre-1990 natural forest plots and when partitioning these into the tall and regenerating sub-categories. Two approaches to sub-classify tall and regenerating forest were used:

1. Species composition classification

This approach uses a quantitative national vegetation classification (Wiser, 2016; Wiser et al, 2011) and was the original basis for defining 'tall' and 'regenerating' (Holdaway et al, 2014). Based on an ecological understanding of species assemblages, forest alliances were aggregated into broad physiognomic groups following Wiser et al (2011) with shrublands and other forests, together termed 'regenerating forest' and four forest groups, together termed 'tall forest' (Paul et al, 2021).

The area of tall and regenerating forest is estimated from the proportion of measured plots in each forest type, relative to the total pre-1990 natural forest area.

2. Landcover classification

The land cover classification approach classifies all pre-1990 natural forest mapped within the LUCAS land use map (LUM) as either tall or regenerating, using a thematic classification of land cover according to the New Zealand Land Cover Database version 5 (LCDB5v5). Tall forest comprises of the 'Indigenous Forest' and 'Broadleaved Indigenous Hardwoods' classes. Regenerating forest comprises all other land cover categories.

Plots were classified based on their actual measured coordinates (ie, the coordinates recorded in the field). Where coordinates for a given plot differed among re-measurements resulting in a different land cover classification, the coordinates of the most recent collection period were preferentially used (assuming the accuracy of GPS readings improving through time).

Tall and regenerating forest areas are mapped from LCDBv5 polygons (within the LUM pre-1990 natural forest class). The area estimate of each forest type is independent of plot measurements. This avoids any potential bias in area estimate introduced by the measurement rate of plots in each forest type.

Post-1989 natural forest

Biomass removals from post-1989 natural forest are estimated as the average net removals per hectare occurring on this forest type across all New Zealand in 2019. This was calculated using estimates of carbon stocks and yield table values for post-1989 natural forest (Paul et al, 2020a), combined with forest age to determine net emissions per year.

For reporting purposes, the post-1989 natural forest area was divided into further categories of wilding pines and naturally regenerating forest. These were both assigned the same sequestration rate.

Grassland with woody biomass

Grassland with woody biomass was divided into two subcategories based on age since establishment. This is to reflect that land recently converted to this category is considered to result in sequestration up to the long-term average carbon stock. Land that has remained grassland with woody biomass, without transitioning into forest, is assumed to have its further growth limited by the environment (eg, altitude) or management (eg, grazing) and therefore not sequestering any additional carbon. The classifications are:

- **in transition:** land mapped as grassland with woody biomass in 2016 that has been newly established since 1990.
- **steady:** land classed as grassland with woody biomass in 1990 that remains in that class in 2016.

This assumes a 26-year transition based on map years, similar to the 28-year transition used in the greenhouse gas inventory (MfE, 2021).

Grassland with woody biomass in transition is considered to be sequestering carbon over a 28-year period, starting at the carbon stock value for low-producing grassland (2.87 t C ha^{-1}) up to an average carbon stock value of 13.05 t C ha^{-1} (Wakelin and Beets, 2013).

Steady grassland with woody biomass (existing for more than 26 years) is assumed to not be sequestering any additional carbon. This approach assumes a linear increase in carbon after vegetation is established, up to the national average carbon stock. Any other fluctuations in carbon stocks (eg, burning or clearance resulting in the loss and subsequent regrowth of vegetation) do not result in long-term net change in carbon and are therefore not included.

If areas of scrub are expected to transition into forest (under current management or environmental factors), they are reported in the forest category with the corresponding rate of sequestration.

Planted forest (pre-1990 and post-1989)

Carbon dioxide removals from forest growth and emissions from harvesting in pre-1990 and post-1989 planted forest are estimated by pro-rating the net emissions and removals per hectare for all of New Zealand's planted forest estate (MfE, 2021), to the area of that forest type on PCL. Removals from forest growth include the net increase in carbon stocks as the forest grows. Emissions from harvesting include carbon losses from timber removed at the time of harvest and the subsequent losses from deadwood decay.

This approach assumes that the management, age profile and harvesting activity for these forest types on PCL are equivalent to New Zealand's national estimate.

Deforestation and clearance of grassland with woody biomass

The area of deforestation and clearance of grassland with woody biomass for 2019 was estimated from the average annual land use change for each category between 2013 and 2016 (as detected in the LUCAS LUM (LUCAS LUM 2016 v8)) and projected forward to 2019. This annual estimate was then multiplied by an emissions factor.

The emission factor for deforestation of pre-1990 natural forest was estimated from the carbon stock values for tall and regenerating forest when classified using the land cover approach. The emissions factors for all other forest types were estimated as the average emissions per hectare associated with the deforestation of that forest type in 2018 (MfE, 2021).

The emissions factor for the clearance of grassland with woody biomass was estimated from the carbon stock change per hectare for the conversion of grassland with woody biomass (13.05 t C ha^{-1}) into low-producing grassland (2.87 t C ha^{-1}). Non-CO_2 emissions from vegetation burning, such as controlled burning to clear scrub or forest wildfires, were not included; there is limited data to assign this activity to PCL, and these emissions only contribute a relatively small amount to New Zealand's national emissions estimate (MfE, 2021).

Uncertainty

The uncertainty estimates for the emissions factors and area for each land use were determined from the calculations of carbon stock change for pre-1990 natural forest on PCL and from the estimates use in New Zealand's Greenhouse Gas Inventory (MfE, 2021). A further adjustment was made to these uncertainties to account for scaling this estimate to PCL. The uncertainty in the emissions factors and area for each land use were combined using the approaches outlined for error propagation in the IPCC guidelines (IPCC, 2006b). In this report, the uncertainty represents the 95 per cent confidence interval, expressed as a percentage.

Results

Pre-1990 natural forest

Plot measurement rates in pre-1990 natural forest

There is a measurement rate of 93.5 per cent of the projected theoretical 8km plots for pre-1990 natural forest. The measurement rate for tall forest (94.2 per cent) is higher than in regenerating forest (81.8 per cent) (Table 1). It is not possible to determine the measurement rate for forest strata when using the species composition classification.

Table 1. The number of measured plots, projected theoretical plots and the measurement rate for pre-1990 natural forest plots on the 8km grid on PCL.

Forest Type*	Measured plots	Theoretical plots	Measurement rate (%)
Regenerating	36	44	81.8
Tall	709	753	94.2
Total	**745**	**797**	**93.5**

*Forest type is classified into regenerating or tall forest based on the Land cover classification.

Carbon stock and stock change in pre-1990 natural forests

Pre-1990 natural forest carbon stock and stock change estimates per hectare are provided when sub-classifying into tall and regenerating strata using the land cover approach (Table 2) and the species composition approach (Table 3).

Over the average 7.7 years between measurements, regenerating forest gained 1.77 ± 9.08 t C ha^{-1} under the land cover approach (Table 2) or 5.13 ± 3.59 t C ha^{-1} under the species composition approach (Table 3). The biggest gains in carbon occurred in the above ground biomass pool.

Tall forest lost carbon over the measurement period under both the land cover (−0.7 ± 1.57 t C ha^{-1}) and species composition classifications (−0.91 ± 1.63 t C ha^{-1}), though this is not statistically significant in either case (Table 2 & 3). The biggest carbon losses occurred in the above ground biomass pool, which were partially offset by gains in coarse woody debris.

When all plots are considered together, pre-1990 natural forest on PCL is estimated to have lost carbon across the measurement period (−0.58 ± 1.56 t C ha^{-1}). However, this loss is statistically insignificant (Table 2 & 3).

Table 2. **Carbon stock and stock change per hectare in pre-1990 natural forest on PCL, using the land cover (LCDB) approach to classify tall and regenerating forest.**

Forest Type	Carbon Pool	Carbon Stock*		Carbon Stock Change†	
		t C ha^{-1}	95% CI	t C ha^{-1}	95% CI
Regenerating (*n* = 36)	Above ground biomass	47.7	15.7	2.67	3.29
	Below ground biomass	11.3	3.7	0.61	0.77
	Coarse woody debris	20.5	17.6	−1.52	6.45
	Litter	10.7	2.2		
	Total	**93.9**	**31.2**	**1.77**	**9.08**
Tall (*n* = 709)	Above ground biomass	153.0	9.0	−1.05	1.23
	Below ground biomass	35.9	2.2	-0.25	0.29
	Coarse woody debris	46.9	12.4	0.56	1.55
	Litter	23.4	0.7		
	Total	**259.8**	**16.1**	**0.70**	**1.57**
All (*n* = 745)	Above ground biomass	147.9	8.8	0.87	1.19
	Below ground biomass	34.7	2.2	-0.21	0.28
	Coarse woody debris	45.7	12.1	0.46	1.50
	Litter	22.8	0.7		
	Total	**252.1**	**15.8**	**−0.58**	**1.56**

*Carbon stock per hectare is estimated from the 2009-2014 measurement period.
† The average carbon stock change per hectare between measurement periods (approximately 7.7 years).

Table 3. **Carbon stock and stock change per hectare in pre-1990 natural forest on PCL, using the species composition (Wiser, 2016) approach to classify tall and regenerating forest.**

Forest Type	Carbon Pool	Carbon Stock*		Carbon Stock Change†	
		t C ha^{-1}	95% CI	t C ha^{-1}	95% CI
Regenerating (*n* = 40)	Above ground biomass	37.0	13.0	3.69	2.86
	Below ground biomass	8.7	3.1	0.85	0.67
	Coarse woody debris	5.5	5.6	0.71	1.12
	Litter	8.8	1.8		
	Total	**61.2**	**19.0**	**5.13**	**3.59**
Tall (*n* = 705)	Above ground biomass	154.2	9.0	-1.13	1.24
	Below ground biomass	36.2	2.2	-0.27	0.29
	Coarse woody debris	47.9	12.6	0.45	1.59
	Litter	23.6	0.7		
	Total	**262.2**	**16.2**	**−0.91**	**1.63**
All (*n* = 745)	Above ground biomass	147.9	8.8	-0.87	1.19
	Below ground biomass	34.7	2.2	-0.21	0.28
	Coarse woody debris	45.7	12.1	0.46	1.50
	Litter	22.8	0.7		
	Total	**252.1**	**15.8**	**−0.58**	**1.56**

*Carbon stock per hectare is estimated from the 2009-2014 measurement period.
† The average carbon stock change per hectare between measurement periods (approximately 7.7 years).

Net emissions from pre-1990 natural forests

Pre-1990 natural forests had an estimated total area of 5,187,723 hectares on PCL. The slightly negative rate of carbon stock change results in this land use being a net source of 1,438 ± 3,848 kt CO_2-e yr^{-1} (when estimated as a single strata; Table 4).

A similar magnitude of total net emissions was found when stratifying forest area by the land cover (1,379 ± 3,882 kt CO_2-e yr^{-1}) and species composition (1,434 ± 3,842 kt CO_2-e yr^{-1}) classifications. The slight differences in total net emissions are due to the differing measurement rates for different forest strata (See Table 1).

Regenerating pre-1990 natural forest is a net sink under both classification approaches (land cover = −253 ± 1,300 kt CO_2-e, species composition = −683 ± 478 kt CO_2-e). Tall pre-1990 natural forest is a source under both classification approaches (land cover = 1,632 ± 3,658 kt CO_2-e, species composition = 2,117 ± 3,812 kt CO_2-e) (Table 4).

The uncertainty for both tall and regenerating forest strata was much lower using the species composition classification compared to the land cover classification. However, this lower uncertainty for each strata does not have a large impact on the overall uncertainty when combined for the total area of pre-1990 natural forest.

Table 4. Annual carbon stock change and net emissions from pre-1990 natural forest on PCL, calculated from the land cover classification (LCDB), species composition classification (Wiser, 2016), and for all forest.

Forest type	t C ha^{-1} yr^{-1}	95% CI	Area (ha)	Net emissions (kt CO_2-e yr^{-1})	Uncertainty (%)
Land cover (LCDB)					
Regenerating (*n* = 36)	0.23	1.16	303,966	−253	514
Tall (*n* = 709)	−0.09	0.20	4,882,757	1632	224
Total			**5,186,723**	**1379**	**281**
Species composition (Wiser, 2016)					
Regenerating (*n* = 40)	0.67	0.47	278,482	-683	70
Tall (*n* = 705)	−0.12	0.21	4,908,241	2117	180
Total			**5,186,723**	**1434**	**268**
All Forest					
Total (*n* = 745)*	**−0.08**	**0.20**	**5,186,723**	**1438**	**268**

* The total for All Forest is estimated when considering as a single strata.

Net emissions and removals from woody vegetation on public conservation land

The total area of woody vegetation on PCL is estimated to be a net source of 926 kt CO_2-e in 2019 (Table 5). This estimate has a high associated uncertainty, at 421 per cent.

Emissions were mainly driven by carbon stock losses in tall pre-1990 natural forest and a small amount of vegetation clearance. Removals from woody vegetation were driven by regenerating pre-1990 natural forest as well as smaller contributions from pre-1990 planted forest, post-1989 planted forest and post-1989 natural forest (Table 5).

Pre-1990 natural forests on PCL are estimated to be emitting 1,379 kt CO_2-e in 2019 (using the land cover approach). The regenerating component was responsible for removals of 253 kt CO_2-e, while the tall component was responsible for emissions of 1,632 kt CO_2-e (Table 5).

Post-1989 natural forest has a higher sequestration rate (–9.95 t CO_2-e $ha^{-1} yr^{-1}$) than pre-1990 natural forest, as it comprises younger, faster-growing trees. Post-1989 natural forest was partitioned in natural regenerating and wilding pine subcategories (based on the LUMv8). Post-1989 natural regenerating forest cover a small area, resulting in total removals of 27 kt CO_2-e, while post-1989 wilding pines cover a larger area and result in removals of 89 kt CO_2-e (Table 5).

Grassland with woody biomass was identified from the LUCAS LUM as having 17,126 hectares in transition (ie, newly established since 1990), contributing to 23 kt CO_2-e of removals. A total of 512,666 hectares of grassland with wood biomass is in steady state and assumed to not be contributing to emissions or removals (Table 5).

Planted forests removed an estimated at 373 kt CO_2-e in 2019. This was largely driven by **post-1989 planted forest** (with removals of 236 kt CO_2-e). **Pre-1990 planted forests** removed 137 kt CO_2-e (Table 5).

Table 5: **Net emissions and removals from woody vegetation biomass on PCL in 2019**

Land use	Land use subcategory	Area (ha)	Mean emission factor ($t\ CO_2\text{-e}\ ha^{-1}\ yr^{-1}$)	Net emissions ($kt\ CO_2\text{-e}$)	Uncertainty (%)	Source
Land remaining						
Pre-1990 natural forest	Tall	4,882,757	0.33	1,632	224	This report (derived from Paul et al, 2021)
	Regenerating	303,966	−0.83	−253	514	This report (derived from Paul et al, 2021)
Post-1989 natural forest	Wilding pines	8,969	−9.95	−89	34	MfE, 2021; Paul et al, 2020a
	Natural regenerating	2,755	−9.95	−27	34	MfE, 2021; Paul et al, 2020a
Grassland with woody biomass	In transition	17,126	−1.33	23	112	MfE, 2021; Wakelin and Beets, 2013
	Steady	512,666	0	0	112	MfE, 2021; Wakelin and Beets, 2013
Pre-1990 planted forest		22,275	−6.15	−137	191	MfE, 2021; Paul and Wakelin, 2020
Post-1989 planted forest		14,724	−16.05	−236	34	MfE, 2021; Paul et al, 2020b
Total		**5,765,239**		**866**	**450**	
Land converted from						
Pre-1990 natural forest	Tall	27	911.6	25	22	This report (derived from Paul et al, 2021)
	Regenerating	22	213.4	5	34	This report (derived from Paul et al, 2021)
Post-1989 natural forest	Wilding pines	9	172.1	2	20	MfE, 2020; Paul et al, 2020a
Grassland with woody biomass	Scrub clearance	42	37.3	2	112	MfE, 2020; Wakelin and Beets, 2013
Pre-1990 planted forest		33	724.8	24	24	MfE, 2020; Paul et al, 2020b
Post-1989 planted forest		8	441.2	4	27	MfE, 2020; Paul and Wakelin, 2020
Total		**141**		**60**	**14**	
Total						
Total net emissions				**926**	**421**	

Note: Net removals are expressed as a negative value, to clarify that the value is a removal of CO_2-e from the atmosphere. Columns may not total due to rounding. Emissions and removals from pre-1990 natural forest have been calculated using the land cover classification (LCDB)

Discussion

Natural forests

Pre-1990 natural forest

Pre-1990 natural forests on PCL are estimated to be a net source of 1379 kt CO_2-e per year, when using the land cover approach to classify tall and regenerating forest sub-types. The net emissions are driven by losses in the tall forest component and are partially offset by removals in regenerating forest. In tall forest the biggest losses are occurring in above ground biomass. These losses in the living biomass pools (above ground and below ground biomass), are partially offset by gains in the coarse woody debris carbon pool.

Two approaches were used to stratify pre-1990 natural forest into tall and regenerating forest subtypes, the landcover classification and species composition classification. Either of these classifications may be appropriate to use, depending on the overarching purpose of stratifying the forest into tall and regenerating sub-types.

The landcover approach classifies forest types based on satellite imagery and is independent of the plot measurements. An advantage of this approach is that estimating the total area of tall and regenerating forest is unaffected by the plot measurement rates. When applying the land cover classification to plots on PCL, the measurement rate is greater for tall forest (93.5 per cent) than for regenerating forest (81.8 per cent). This means that a slight bias is introduced if the area of tall and regenerating forest is estimated by scaling the number of plots in each stratum to the total forest area, as is required for the species composition approach (Easdale et al, 2020). As the landcover approach is based on satellite imagery, it can also be used to determine if deforestation has occurred on tall or regenerating forest.

The species composition approach is based on measured characteristics at the plot level, which required plots to be measured in order for it to then be classified as tall or regenerating forest. When using the species composition classification, the carbon stock change estimates in tall and regenerating forest had greater rates of change and lower uncertainty than the land cover classification. This suggests that this classification may be more ecologically meaningful, and better at detecting distinct forest types with differing rates of carbon stock change.

The two approaches produced different carbon stock change and associated uncertainty estimates for each tall and regenerating forest sub-class. However, when these sub-classes are aggregated together, the estimated net emissions and associated uncertainty across the entire pre-1990 natural forest was similar when using either approach. This suggests that the lower measurement rate of regenerating forest does not introduce a significant bias for estimating total net emissions on PCL, and that either approach can be appropriate to use.

As the landcover approach allows for better representation of unmeasured plots and for spatially classifying forest types to determine losses from deforestation, it is the preferred approach for reporting net emissions at the national level. This has a greater impact for forest on private land, where measurement rates are lower. For this reason, this approach was also used to estimate the total net emissions across PCL in this report.

The carbon stock change estimate for pre-1990 natural forest on PCL has a high associated uncertainty irrespective of classification approach used (268 – 281 per cent). This is due to large plot-to-plot variation in the direction and magnitude of carbon stock change (ie, some plots showed large losses while some plots showed large gains over the measurement period), relative to the mean carbon stock change estimate.

Carbon stock change per hectare in tall and regenerating forest on PCL is similar in magnitude and direction to the estimate for the entire pre-1990 natural forest estate (Paul et al, 2021) when using the species composition classification. Paul et al (2021) found that the carbon gains from regenerating forest roughly balanced out the losses from tall forest, concluding that the total estate was roughly in carbon balance. As there is a greater proportion of tall forest on PCL than on private land, this leads to pre-1990 natural forest on PCL being a slight net source of emissions. However, due to the high uncertainty in this estimate, it is not possible to determine if this trend is significantly different from the variation in the plot data.

Carbon stock change in this report is estimated from the first two natural forest inventory measurement cycles (2002 – 2007 and 2009 – 2014). As the last plot measurement was in 2014, this data is now slightly out of date for estimating current rates of carbon stock change. A third measurement cycle is currently ongoing (2014 – 2024), with an analysis of the first half of this measurement cycle scheduled for completion in June 2022. This analysis will add to the existing timeseries to provide up to date information on carbon stock and stock change and further insight into how carbon stocks are changing through time.

Post-1989 natural forest

Post-1989 natural forest is a small sink on PCL. It has a low contribution to removals due to its small area, with the majority of New Zealand's post-1989 natural forest occurring outside the PCL (74,695 ha of 86,689 ha).

National estimates of carbon stock and stock change currently do not differentiate between post-1989 natural regenerating and post-1989 wilding pines, which are currently considered within the same category (Paul et al, 2020a). This has been identified as an area for improvement, which could leave to a better estimate of net emissions for each of these sub-categories.

Grassland with woody biomass

Grassland with woody biomass was identified from the LUCAS LUM as having 17,126 hectares in transition (newly established since 1990), contributing to 23 kt CO_2-e of removals. A total of 512,666 hectares of grassland with woody biomass is in steady state (established before 1990) and therefore assumed to be neither a source nor sink. Most of the vegetation will be constrained by biotic (e.g. browsing pressure) and abiotic factors (e.g. temperature, exposure) that limit growth rates and prevent them from transitioning into forest land. Further work could be done to improve the classification between 'in-transition' and 'steady' grassland with woody biomass.

Deforestation and vegetation clearance

Based on the annual average rate of land use change between 2013-2016, an estimated total of 99 hectares of deforestation occurred on PCL in 2019, contributing to 60 kt CO_2-e emissions. Of the deforested land, 50 ha occurred in planted forest and post-1989 wilding pines. A total of 49 ha of deforestation occurred in pre-1990 natural forest. As natural forests include naturalised exotic species it is likely that much of this deforestation would have involved the clearance of exotic species (such as wilding pines).

An estimated 42 ha of grassland with woody biomass was cleared. It is possible that this represents the clearing of exotic scrub and shrub vegetation. While clearing of wilding pines or exotic shrub vegetation is carried out to stop the spread of invasive species, this still results in a loss of carbon from vegetation biomass and generates an emission.

As deforestation emissions are based on the carbon stock values for tall and regenerating forest, it is possible that these are not representative of the small area of vegetation cleared on PCL. This could potentially result in an overestimate of emissions from deforestation. Deforestation and land use map polygons collected by the Ministry for the Environment could be inspected in detail to determine what type of vegetation is being cleared and where this is occurring (Indufor Asia Pacific, 2018).

Emissions and removals not included in this analysis

This report did not include an estimate of net emissions and removals from soils, non-woody vegetation (ie, grasses), wetlands, or woody vegetation under 1ha in size. This is due to limited data availability for these categories and difficulty in applying some to a subset of the total national area. These categories are considered to have low rates of carbon stock change, and thus a potential small contribution to overall net emissions and removals.

The net emissions and removals from these categories, estimated using current methods in New Zealand's greenhouse gas inventory, are driven primarily by land use change. As land use change may be expected to occur at a lower rate on PCL than across the rest of New Zealand, it is likely that these land uses would have a low contribution to net emissions on PCL using current available data

Uncertainty

The total estimated net emissions of 926 kt CO_2-e on PCL have an associated uncertainty of 421 per cent (Table 5). This indicates that the expected net emissions may range between -2967 kt CO_2-e and 4819 kt CO_2-e. The estimates include the uncertainty associated with each emissions factor, the land use area, and an adjustment to scale these estimates to PCL land.

The land use that contributed most to overall uncertainty is pre-1990 natural forest. This is because this category had the highest contribution to net emissions and removals, because of the uncertainty associated with these estimates.

Conclusion

Woody vegetation on PCL is estimated to be a net source of 926 ± 3,893 kt CO_2-e in 2019. There is a high uncertainty associated with this estimate, at 421 per cent, which does not statistically differ significantly from zero.

The methods are consistent with New Zealand's National Greenhouse Gas Inventory (MfE, 2020) and international guidelines (IPCC, 2006b). By applying a consistent methodology and land use classification, net emissions and removals from land use types can be further examined in the context of New Zealand's total net emissions and climate change, land use and conservation policy.

Net emissions were driven primarily by carbon losses across the large area of pre-1990 natural forest. Carbon stock change in this land use class has a high associated uncertainty, which makes it difficult to determine if this is a trend that may continue or if it is due to natural variability. Continuous monitoring and more up to date analysis, incorporating the most recent pre-1990 natural forest plot measurements from 2015 onwards, are needed to determine if this current slight decline in carbon stocks is continuing or identify any other emerging trends.

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