

**BEFORE THE INDEPENDENT HEARINGS PANELS APPOINTED TO HEAR AND MAKE
RECOMMENDATIONS ON SUBMISSIONS AND FURTHER SUBMISSIONS ON PROPOSED CHANGE 1
TO THE REGIONAL POLICY STATEMENT FOR THE WELLINGTON REGION**

UNDER Schedule 1 of the Resource Management
Act 1991 (the Act)

IN THE MATTER OF Hearing Submissions and Further
Submissions on Proposed Change 1 to the
Regional Policy Statement for the
Wellington Region

**REPORTING OFFICER RIGHT OF REPLY OF PAMELA ANNE GUEST
ON BEHALF OF WELLINGTON REGIONAL COUNCIL**

HEARING STREAM 3 – CLIMATE CHANGE:

CLIMATE-RESILIENCE AND NATURE-BASED SOLUTIONS

13 November 2023

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INTRODUCTION

1 My full name is Pamela Anne Guest. I am a Senior Policy Advisor for Greater Wellington Regional Council. I am the section 42A report author for the Hearing Stream 3 report: Climate Change: Climate-Resilience and Nature-Based Solutions (my section 42A report) and attended the hearings for this topic on 28-31 August 2023.

2 My qualifications and experience are set out at paragraphs 19-22 in my section 42A report, dated 31 August 2023. I repeat the confirmation given in that report that I have read and agree to comply with the Code of Conduct for Expert Witnesses.

SCOPE OF REPLY

3 This Right of Reply follows Hearing Stream 3 held from Monday 28 August 2023 to Thursday 31 August 2023.

4 On 8 September 2023, the Hearing Panels (the Panels) issued Minute 12 which provides direction for reply evidence and expert caucusing for Hearing Stream 3. This minute did not include any specific questions relating to the topic Climate-Resilience and Nature-Based Solutions but, it directed expert caucusing aimed at resolving areas of disagreement, to assist the Panels in their deliberations.

5 This Reply includes:

- responses to questions of Officers from the Panels that were not answered during the hearing;
- responses to matters raised by submitters during the hearing; and
- the outcomes reached at caucusing as they relate to climate-resilience and nature-based solutions, set out in the Joint Witness Statement of Planning Experts: Climate Resilience, Nature-Based Solutions and Natural Hazards, dated 16 October 2023.

6 Where I recommend further amendments to the provisions in this subtopic, these are shown in green underlined and ~~marked-up~~ text. I have also provided the updated recommendations to the provisions in Appendix 1 of this evidence.

RESPONSES TO QUESTIONS FROM THE PANELS

7 Following my s42A report presentation and summary, the Panels asked a number of questions seeking clarification of various points in my report and/or raised by submitters.

Responses to any questions not answered at the Hearing are set out below and amendments shown in full in Appendix 1.

Do you recommend any changes to the categorisation of provisions between the freshwater and non-freshwater processes?

8 As there was no new evidence presented or discussion had with submitters at the hearing regarding the categorisation of the Climate-Resilience and Nature-Based Solutions provisions between the freshwater planning process and standard Resource Management Act 1991 (RMA) Schedule 1 process, I have not changed my opinion on this matter as set out in Table 4 of my section 42A report.

Definition for Nature-based solutions. Should the heading in the Examples “Reducing greenhouse gas emissions” be replaced by reference to just ‘Climate Change Mitigation’, as neither example reduces greenhouse gas emissions.

9 Planting forests to sequester carbon reduces **net** greenhouse gas emissions, while protecting or maintaining peatland to retain carbon stores acts to **avert** the release of greenhouse gases. Rather than include this detail in the heading, I agree that it is simpler to amend the heading to refer just to Climate change mitigation:

~~Reducing greenhouse gas emissions~~ (Climate change mitigation):

Is there a need for a new definition for the term “climate-responsive”?

10 The term climate-responsive was added to the headings for Policies CC.4, CC.4A, CC.14, CC.14A because the addition of clauses to provide for climate change mitigation functions of ecosystems has broadened the policies beyond climate-resilience. As this term is only used in Change 1 in the title for these policies, I do not consider that a definition is necessary, as the term does not need to be interpreted to give effect to the substance of the provisions, but rather, is a description of the policy content.

Does the definition for “permanent forest” unintentionally exclude forest that is not being actively managed, for example natural indigenous forest and regional parks?

11 The definition for Permanent Forest in Change 1 is: Forest actively managed to maintain continuous canopy cover.

12 The Change 1 provisions relating to permanent forest (Objective CC.5, Policies CC.6 and CC.18, and Method CC.4) seek an increase in the area and health of *permanent forest* to achieve the concept of “right tree-right place”. The intent of the provisions, including the definition, is thus to direct the type of new forest sought, rather than apply to existing

forest that may be reserve land or unmanaged blocks. The requirement for active management (such as the control of browsing pests) is to ensure that this new forest will establish and thrive in the long-term. I therefore do not consider that the inclusion of active management in the definition for permanent forest will result in unintended outcomes.

Are increasing CO₂ emissions beneficial for vegetation growth?

- 13 Jake Roos, Climate Change Manager GWRC and Mélanie Barthe, Senior Climate Change Advisor GWRC have provided a detailed technical response to this question, attached as Appendix 2. The short answer is that: Overall, increasing CO₂ emissions as part of global climate change will not be beneficial for vegetation growth. While some areas will see increases in plant growth, others will see serious declines. Globally, the negative impacts of climate change on the health of ecosystems, biodiversity and food production will become more severe as the world warms in response to rising CO₂ emissions, exceeding any benefits from CO₂ fertilisation (the increase in plant photosynthesis that results from increased levels of atmospheric CO₂).

Should Objective CC.4 refer to people and communities to be consistent across provisions?

- 14 While reference to just “people” is not incorrect, broadening Objective CC.4 to refer to “people and communities” reflects the well-beings that nature-based solutions provide for the wider community, at community and city scales, such as those associated with green infrastructure and systems that provide flood protection, access to more open and green space, and that protect water sources. This would also be consistent with the definition for climate-resilience which refers to both people and communities.

Objective CC.4: Nature-based solutions are an integral part of climate change mitigation and climate change adaptation, improving the health, well-being and resilience of people and communities, indigenous biodiversity, and the natural and physical resources environment.

Why are Policies CC.4 and CC.14 inconsistent with Policies CC.4A and CC.14A – referring to hydrological controls rather than stormwater volumes?

- 15 The term ‘hydrological controls’ was deliberately included in Policy CC.4(b) and Policy CC.14(b) through my s42A report, on the basis of consultation with the Council’s stormwater management specialists and Mr Farrant who provided expert evidence on the Climate-Resilience and Nature-Based Solutions provisions, as being an appropriate method that territorial authorities should require of developers to manage the predicted increases

in rainfall intensity associated with climate change. Hydrological controls are also referred to in several Change 1 freshwater policies that I understand are subject to evidence and potential amendments as part of Hearing Stream 5. For this reason, I consider it would be most efficient to defer responding to this question until Hearing Stream 7: “Small topics, Wrap up and Integration” to ensure that reference to hydrological controls across Change 1 align appropriately and are not inconsistent.

Policies CC.14 and CC.14A –

- **should these policies provide stronger direction than “seek” e.g. “require”?**
- **why does the Explanation refer only to urban communities - suggest this should refer more broadly, reflecting the text to “take all opportunities”?**

16 I agree that the direction in Policies CC.14 and 14A should align with the direction in Policies CC.4 and CC.4A, which is to require that all new development and infrastructure be located, designed and constructed in ways that provide for climate change, rather than using the weaker verb “seek” as the attributes required in the clauses to these policies are all critical matters to provide for climate-resilience. Change shown for Policy CC.14:

When considering an application for a resource consent, notice of requirement, or a change, variation or review of a district ~~or regional~~ plan, ~~require~~ seek that

17 I also agree that the Explanation should apply regardless of location and therefore recommend that “urban communities” is replaced to refer more generally to “...the resilience and well-being of ~~urban~~ communities and natural ecosystems”.

Should policies CC.4, CC.4A, and CC.6 refer to “other” or “non-regulatory” methods in the chapeau?

18 As rules are a method, then I agree that it is more correct to refer to “...rules and non-regulatory methods” in policies CC.4, CC.4A, and CC.6.

Should Method CC.6 be expanded to include other stakeholders when identifying ecosystems in the Wellington Region that should be prioritised as nature-based solutions to climate change?

19 There will be a range of stakeholders that should be consulted or partnered with to identify priority ecosystems for providing nature-based solutions to climate change and therefore I agree that the chapeau of Method CC.6 should refer more broadly to: “and other stakeholders as appropriate”.

How are Te Ao Māori, Mātauranga Māori and Te Mana o te Wai given effect through the package of provisions for Climate Resilience and Nature-Based solutions?

20 A key focus in developing Change 1 was to take an integrated management approach, recognising the critical interconnections between issues and between policy direction across topics. A core decision was made to establish an overarching integrating objective, (Objective A), policy (Policy IM.1) and method (Method IM.1) to ensure that Te Ao Māori, Mātauranga Māori and key principles, such as partnership and ki uta ki tai, were given sufficient weight in decision-making, from governance through to implementation, and applied to all provisions, meaning that these concepts did not need to be repeated across RPS provisions. This approach is explained in the Change 1 Section 32 Report:¹

“It is not one specific policy package that will achieve the New Objective A. Many existing policies in the RPS, and new and amended policies through Change 1 will contribute towards achieving this objective. The integration and how the provisions across the RPS work together will collectively contribute to achieving the New Objective A. However, there is a suite of new policies that specifically address the ineffectiveness of the non-regulatory approach to the integrated management of natural resources. They provide greater clarity of what is considered the key components of integrated management in our region, and what it is required to achieve that. The new provisions also enhance the holistic approach to providing Te Ao Māori and Mātauranga Māori with the appropriate and respectful place in resource management and decision making.”

These new provisions are:

Objective A: Integrated management of the region’s natural and physical resources built environments: guided by Te Ao Māori and:

- (a) is guided by Te Ao Māori; and
- (b) incorporates mātauranga Māori in partnership with mana whenua/tangata whenua; and
- (c) recognises and provides for ki uta ki tai – the holistic nature and interconnectedness of all parts of the natural environment; and
- (d) recognises and provides for the relationship of mana whenua/tangata whenua with te taiao and protects and enhances mana whenua / tangata whenua values, in particular mahinga kai and the life-supporting capacity of ecosystems; and
- (e) is informed by the input of communities; and
- (f) protects and enhances the life-supporting capacity of ecosystems; and
- (g) recognises the dependence of humans on a healthy natural environment; and
- (h) recognises the role of both natural and physical resources, including highly productive land and regionally significant infrastructure, in providing for the characteristics and qualities of well-functioning urban and rural areas environments and improving the resilience of communities to climate change; and

¹ [RPS-Change-1-Section-32-Report-August-2022.pdf](#). Refer, in particular, to the evaluation on pages 115-121,

- (i) recognises the benefits of protecting and utilising the region's significant mineral resources; and
- (j) responds effectively to the current and future ~~effects pressures~~ of climate change, ~~and~~ population growth, and development ~~pressures and opportunities~~.

Policy IM.1: Integrated management - ki uta ki tai – consideration

When considering an application for a resource consent, notice of requirement, or a change, variation or review of a regional or district plan, ~~particular regard shall be given to~~ local authorities shall adopt an integrated approach to the management of the region's natural and ~~physical resources~~ built environments, including by:

- (a) Partnering ~~or engaging~~ with mana whenua / tangata whenua to provide for mana whenua / tangata whenua involvement in resource management and decision making; and
- (b) recognising the interconnectedness between air, freshwater, land, *coastal marine areas*, ecosystems and all living things – ki uta ki tai; and
- (c) recognising that the effects of activities may extend beyond immediate and directly adjacent area, and beyond organisational or administrative boundaries; and
- (d) recognising the interrelationship between natural ~~and physical~~ resources ~~and the built environments~~; and
- (e) making decisions based on the best available information, improvements in technology, ~~and~~ science, and mātauranga Māori; and
- ~~(f) — upholding Māori data sovereignty; and~~
- (g) requiring Māori data and mātauranga Māori to be interpreted within Te Ao Māori ~~while upholding Māori data sovereignty;~~ ~~and~~
- ~~(h) — recognising that the impacts of activities may extend beyond immediate and directly adjacent area, and beyond organisational or administrative boundaries.~~

Explanation: This policy requires that a holistic, integrated view is taken when making resource management decisions. It also requires both regional and district councils to provide for mana whenua / tangata whenua ~~are to be~~ actively involved in ~~in~~ resource management and decision making, including the protection of mātauranga Māori and Māori data.

Method IM.1: Integrated management - ki uta ki tai

To achieve integrated management of natural ~~resources and physical resources~~ built environments, the Wellington Regional Council, district and city councils shall:

- (a) partner with and provide support to mana whenua / tangata whenua to provide for their involvement in resource management and decision making; and
- (b) partner with and provide support to mana whenua / tangata whenua to provide for mātauranga Māori in ~~natural~~ resource management and decision making; and
- (c) work with communities to achieve effective integrated management outcomes; and
- (d) work together with other agencies to ensure consistent implementation of the objectives, policies and methods of this RPS; and
- (e) enable connected and holistic approach to resource management that ~~looks~~ ~~extends~~ beyond organisational or administrative boundaries; and
- (f) recognise that the impacts of activities extend beyond immediate and directly

- adjacent area; and
- (g) require Māori data, including mātauranga Māori, areas and sites of significance, wāhi tapu, and wāhi tūpuna are only shared in accordance with agreed tikanga and kawa Māori; and
 - (h) share data and information (other than in (f) above) across all relevant agencies; and
 - (i) incentivise opportunities and programmes that achieve multiple objectives and benefits.
- 21 In considering whether the Climate-Resilience and Nature-Based Solutions provisions give sufficient weight to Māori values and relationships, I have reviewed the submissions from mana whenua/tangata whenua on the provisions addressed in this topic. Ngāti Toa and Rangitāne o Wairarapa support these provisions and did not seek any amendments. Ātiawa ki Whakarongotai supports the intent of the provisions that recognise and address the impacts of climate change on the environment and “are pleased that this chapter recognises te ao Māori and mātauranga Māori.” They requested an amendment to Objective CC.4 to refer to “Nature-based solutions and mātauranga Māori are an integral part of climate change mitigation and adaptation...”. Taranaki Whānui supports the principle of new Policy CC.4 but suggests specific cross reference to Policy CC.17: Iwi climate change adaptation plans, to ensure alignment with mana whenua values, and seeks the following addition to Policy CC.14: (x) enabling mana whenua / tangata whenua to provide for their relationship with their culture, land, water, wāhi tapu and other taonga.
- 22 The provisions addressed in the Climate-Resilience and Nature-Based Solutions topic are part of the wider package of Climate Change provisions (including Policies 52 and CC.12 and Method CC.1) and are to be given effect to in conjunction with the Integrated Management provisions set out above; applying the principles in these provisions is not discretionary. They also link closely to the Indigenous Ecosystem provisions, including Objective 16A, Policies IE.1, IE.2 and IE.3 and Method IE.3 which all provide specific reference to giving effect to mana whenua/tangata whenua roles and values. As per the approach outlined in the Change 1 Section 32 Report, I do not consider that these core principles need to be repeated across all of the Climate-Resilience and Nature-Based Solutions.
- 23 I have reviewed the specific amendments requested by mana whenua/tangata whenua and remain of the opinion set out in my section 42A report that adding “enabling mana whenua / tangata whenua to provide for their relationship with their culture, land, water,

wāhi tapu and other taonga” to Policy CC.14 is not appropriate for this policy. If added to Policy CC.14 it would also need to be added to the other policies in this suite, being Policies CC.4, CC.4A and CC.14A. I do agree that mātauranga Māori can often helpfully inform the identification and implementation of nature-based solutions and the provision of climate-resilience features but consider this is best provided for at a policy level, rather than as part of Objective CC.4. I therefore recommend amendments to Policies CC.4, CC.4A, CC.14 and CC.14A to provide for this.

- 24 The Panel requested that I consider addition of reference to “giving effect to Te Mana o te Wai and Te Rito o te Harakeke” to these provisions. I consider while this will sometimes be the case, it is not exclusively so and setting these outcomes at an objective level risks limiting the broad range of nature-based solutions options that are available.

Are all relevant policies listed in Table 1.A?

- 25 The report authors for Hearing Stream 3 have all reviewed Table 1.A to ensure that it provides a comprehensive list of policies and methods that give effect to each objective. The updated table is provided as Appendix 3.

OTHER MATTERS RAISED BY SUBMITTERS

Several questions or points were raised by submitters presenting on behalf of the Peatland Focus group that I would like to respond to:

- (i) Could the example of “protecting peatland to retain carbon stores” be replaced by reference to “protecting/maintaining areas of peatland that are actively sequestering carbon”?**

- 26 While the protection of actively functioning peat wetlands is an example of a nature-based solution, I do not consider this to be reason to delete the example of protecting/maintaining peatland to retain carbon stores. Drained or modified peatlands can be a significant source of greenhouse gas emissions, leading in years to the loss of carbon that has accumulated over centuries or millennia. As discussed in my section 42A Report, managing modified peatlands in a way that avoids the break-down or oxidation of peat soils and the associated release of greenhouse gases, also avoiding soil loss and associated land subsidence, and is an important example of a nature-based solution that is relevant to the Wellington Region.

- 27 As discussed in my section 42A report, the examples of nature-based solutions were provided to assist understanding of this relatively new concept, using examples relevant to

the Wellington Region, and noting the Council’s work to restore degraded peatland at Queen Elizabeth Park. The critical matter for landowners is the policy approach that directs how nature-based solutions are to be given effect to at an ecosystem scale which is a non-regulatory one (refer Policy CC.7 as discussed in paragraph 27).

(ii) Is the intent of the Council to require rewetting/restoration of peatland, specifically the Mangaroa peatland?

28 The Council has no intention, nor legislative ability, to require the rewetting or restoration of modified peatlands. Policy CC.7, as recommended amended in my section 42A report, is a non-regulatory policy to “Work with and support landowners, mana whenua/tangata whenua, and other key stakeholders to protect, restore, or enhance ecosystems that provide nature-based solutions to climate change.” This would require working with the willing and be supported by science to ensure positive outcomes for the natural environment, people and communities.

(iii) ‘Maintain’ used as a verb in the examples for “Nature-based solutions” (~~protecting~~ maintaining peatland to retain carbon stores) is too strong, noting the new definition of ‘maintaining indigenous biodiversity’ in the National Policy Statement for Indigenous Biodiversity (NPS-IB).

NPS-IB Section 1.7(1) is that “Maintaining indigenous biodiversity requires:

- (a) the maintenance and at least no overall reduction of all the following:
 - (i) the size of populations of indigenous species:
 - (ii) indigenous species occupancy across their natural range:
 - (iii) the properties and function of ecosystems and habitats used or occupied by indigenous biodiversity:
 - (iv) the full range and extent of ecosystems and habitats used or occupied by indigenous biodiversity:
 - (v) connectivity between, and buffering around, ecosystems used or occupied by indigenous biodiversity:
 - (vi) the resilience and adaptability of ecosystems; and
- (b) where necessary, the restoration and enhancement of ecosystems and habitats.”

29 The intent of the recommendation in my section 42A report to replace “protecting” with “maintaining” in the definition for “Nature-based solutions” was to avoid any inference of an active requirement. With respect to the NPS-IB definition, maintenance is used specifically in relation to outcomes for indigenous biodiversity; as this is an RPS example of

a resource management concept, the intent was not to tie it to a regulatory response. I note that the changes to the definition for nature-based solutions agreed by a number of experts during expert caucusing (refer to paragraph 29) included replacing the clause “Actions to protect, enhance, or restore” with “Use and management”. A similar approach could be taken with the example, referring to the outcome sought which is that peatland is used or managed in a way that retains its carbon stores, and removing any inference of a policy requirement or link to other legislation; I therefore recommend that the example be reframed as “protecting maintaining managing peatland in a way that retains its carbon stores”. This example could also be extended to identify additional benefits such as, “avoids soil loss and associated land subsidence.” Consequential to this, I consider it would be helpful to add a clause to Policy CC.7 to include the concept of sustainable management:

Policy CC.7: Protecting, restoring, ~~and~~ enhancing or sustainably managing ecosystems and habitats that provide nature-based solutions to climate change – ~~district and regional plans non-regulatory~~

Work with and support landowners, mana whenua/tangata whenua, and other key stakeholders to protect, restore, ~~or~~ enhance or sustainably manage ecosystems that provide nature-based solutions to climate change.

RESPONSES TO OUTCOMES OF CAUCASING

30 At the expert witness caucusing for the Climate-Resilience and Nature-Based Solutions provisions, held on 16 October, the experts did not reach consensus on amendments for any provisions still in contention. However, several amendments to the definition and Note for Nature-Based Solutions, as set out in the Joint Witness Statement of Planning Experts (JWS), were agreed by all experts, except for Michael Rachlin representing Porirua City Council. For the reasons set out in the JWS, I continue to support these amendments and have included them as recommended amendments in Appendix 1.

Definition: nature-based solutions -

~~Actions to protect, enhance, or restore~~ Use and management of natural ecosystems and processes, ~~or and the incorporation of natural elements into built environments use of engineered systems that mimic natural processes,~~ to reduce greenhouse gas emissions, support climate change adaptation and/or strengthen the resilience and well-being of humans people, indigenous biodiversity, and the natural and physical resources environment to the effects of climate change.

Note that “nature-based solutions” is an umbrella term that encompasses concepts such as green infrastructure (including as defined in the National Planning Standards), green-blue infrastructure, and water-sensitive urban design.

Note, Examples could include: ...

CLAUSE 16 AMENDMENT

31 New National Environmental Standards for Commercial Forestry, which amend the National Environmental Standards for Plantation Forestry 2017, came into force on 3 November 2023. These include a minor amendment to the chapeau of the definition for **plantation forestry**, which I recommend be included in Change 1 for national consistency:

Definition - Plantation Forest: A forest deliberately established for commercial **harvest** purposes, being:

DATE:

9 November 2023

Pamela Anne Guest

Kaitohutohu Matua/Senior Policy Advisor

Greater Wellington Regional Council

Appendix 2: Response to Panel question: “Are increasing CO₂ emissions beneficial for vegetation growth?”

Prepared by Jake Roos, Climate Change Manager GWRC and Mélanie Barthe, Senior Climate Change Advisor GWRC (17 October 2023)

Summary

Overall, increasing CO₂ emissions as part of global climate change will not be beneficial for vegetation growth. While some areas will see increases in plant growth, others will see serious declines. Globally, the negative impacts of climate change on the health of ecosystems, biodiversity and food production will become more severe as the world warms in response to rising CO₂ emissions, exceeding any benefits from CO₂ fertilisation.

Detail

The IPCC reports that satellite observations have shown vegetation greening over the last three decades in parts of the world (including Southeast Australia) (IPCC, *Special Report on Climate Change and Land, 2019*). This greening is partially due to increased CO₂ concentration in the atmosphere and increased CO₂ fertilisation of the vegetation (IPCC, *AR6, The physical science basis, 2021*).

However, it would not be correct to assume that vegetation growth will keep increasing with an increasing CO₂ concentration in the atmosphere. CO₂ fertilisation of plant growth will be reduced by the acclimatisation of photosynthesis to long-term CO₂ exposure, temperature, drought, and nutrient availability (IPCC, *AR6, The physical science basis, 2021*).

The IPCC stated in its 2019 special report:

“Future net increases in CO₂ emissions from vegetation and soils due to climate change are projected to counteract increased removals due to CO₂ fertilisation and longer growing seasons (high confidence)”

Presently the yield of some crops are negatively affected in many lower-latitude regions by climate change, while in many higher-latitude regions, yields of some crops have been affected positively over recent decades (IPCC, *Special Report on Climate Change and Land, 2019*). Note that increased CO₂ concentrations promote crop growth and yield but reduce the density of important nutrients in some crops (IPCC, *Impacts, Adaptation and Vulnerability, Technical Summary, 2022*).

It is also important to account for the other risks associated with climate change such as:

- increased pests, weeds and disease
- changing distributions of pollinators
- water scarcity and flood
- wildfire

All these factors are projected to impact negatively vegetation growth in the future (IPCC, *Special Report on Climate Change and Land, 2019* and IPCC, *Impacts, Adaptation and Vulnerability, Technical Summary, 2022*). The IPCC projects that global tree mortality is expected increase as the global surface temperature increases as shown in the figure 1.

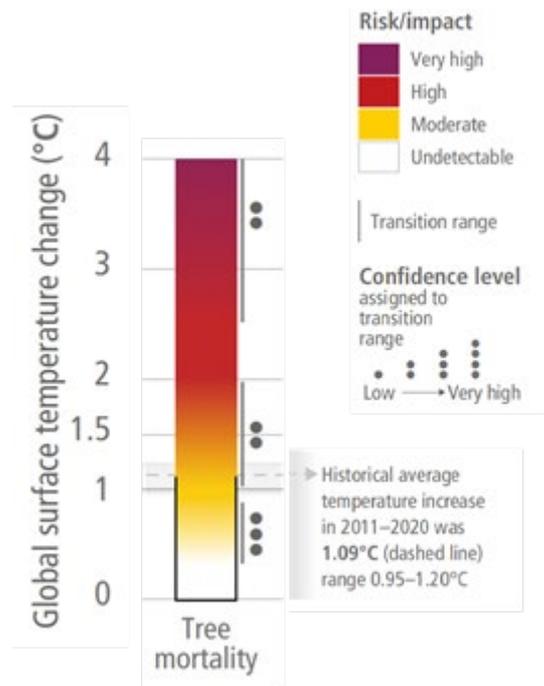


Figure 1: Impacts and risk to trees

Source: IPCC, AR6, 2022: *Climate Change 2022: Impacts, Adaptation, and Vulnerability – Technical summary*

Globally, climate change is projected to have an impact on ecosystems, biodiversity and food production.

- **Ecosystems and biodiversity impacts:** Risks to ecosystem integrity, functioning and resilience are projected to escalate with increasing global warming. Beginning at 1.5°C warming, natural adaptation faces hard limits, driving high risks of biodiversity decline, mortality, species extinction and loss of related livelihoods. At 1.6°C, over 10% of species are projected to become endangered, increasing to over 20% at 2.1°C, representing severe biodiversity risk. Beyond 4°C warming, projected impacts expand, including biome shifts (changes in the major vegetation form of an ecosystem) across 35% of global land area (IPCC, *Impacts, Adaptation and Vulnerability, Technical Summary, 2022*).
- **Food production impacts:** Climate change will increasingly add pressure on terrestrial food production systems with every increment of warming (high confidence). Some current global crop and livestock areas will become climatically unsuitable depending on the emissions scenario (10% globally by 2050, by 2100 over 30% under SSP-8.5, the highest emissions scenario used by the IPCC, versus below 8% under SSP1-2.6, their lowest emissions scenario). The adverse effects of climate change on food production will become more severe when global temperatures rise by more than 2°C. At 3°C or higher global warming levels, exposure to climate hazards will grow substantially, further stressing food production (IPCC, *Impacts, Adaptation and Vulnerability, Technical Summary, 2022*).

Finally, it is also important to note that continuing damage and degradation of ecosystems (through pollution, inappropriate land use practices, habitat fragmentation, etc.) will exacerbate the projected impacts of climate change on biodiversity and vegetation growth (IPCC, *Impacts, Adaptation and Vulnerability, Technical Summary, 2022*).

References:

- [IPCC, 2019: Special report on Climate Change and Land – Chapter 5](#)
- [IPCC, AR6, 2021: Climate Change 2021: The Physical Science Basis](#)
- [IPCC, AR6, 2022: Climate Change 2022: Impacts, Adaptation, and Vulnerability – Technical summary](#)