Understanding carbon dioxide removal (CDR) for net zero

Opportunities, risks and benefits

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Acknowledging inputs from IPCC authors and colleagues: Joeri Rogelj, Pete Smith, Oliver Geden, Pep Canadell, Göran Berndes, Gert-Jan Nabuurs, Annette Cowie

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Outline

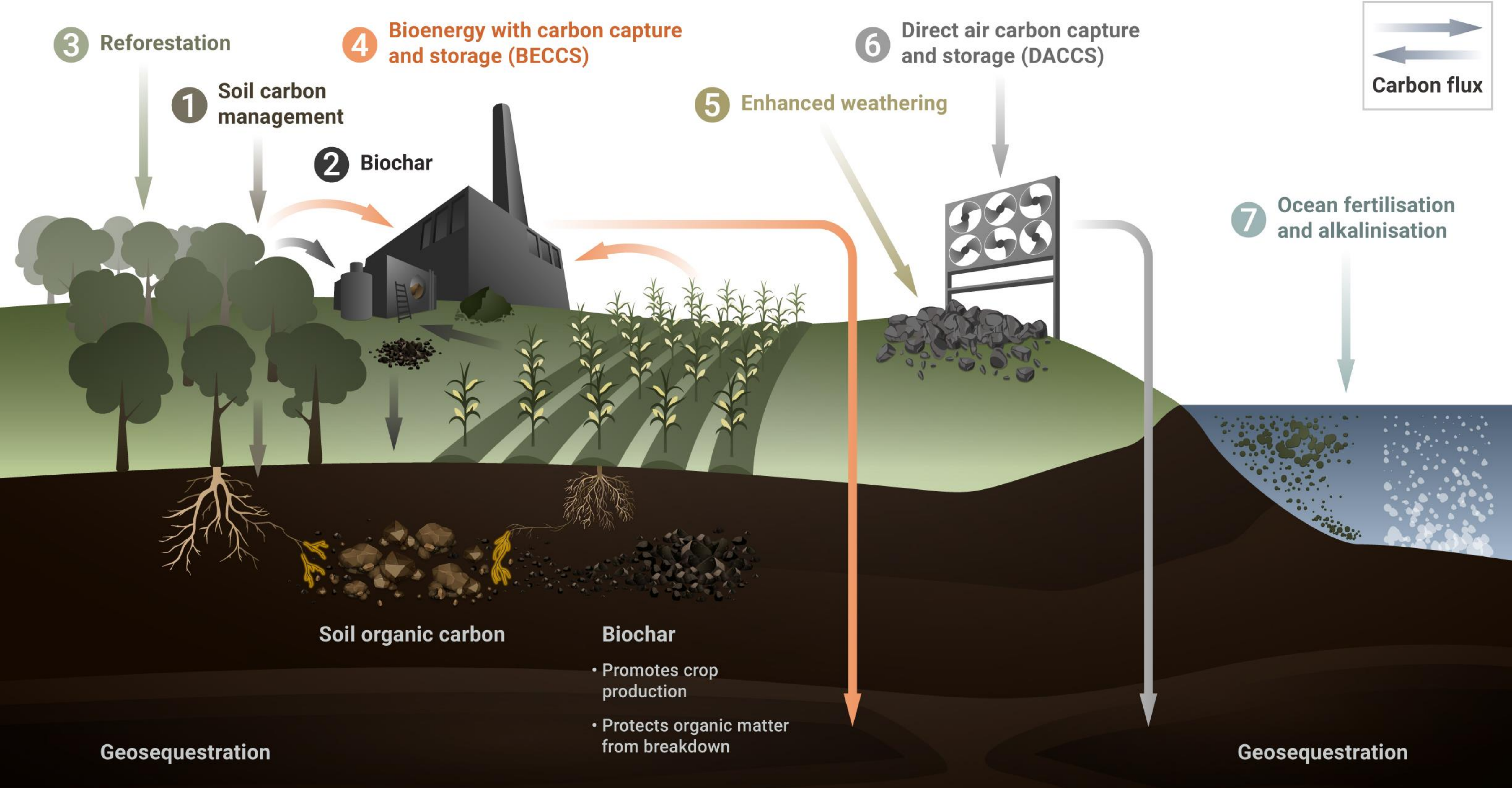
- CDR for net-zero CO_2 and for net-zero GHG
- Differentiated use of CDR in mitigation strategies
- Interactions with SDGs and other goals
- What happens after net-zero?

What is CDR?

Anthropogenic activities ***removing CO_2*** from the atmosphere and ***durably storing it*** in geological, terrestrial, or ocean reservoirs, or in products.

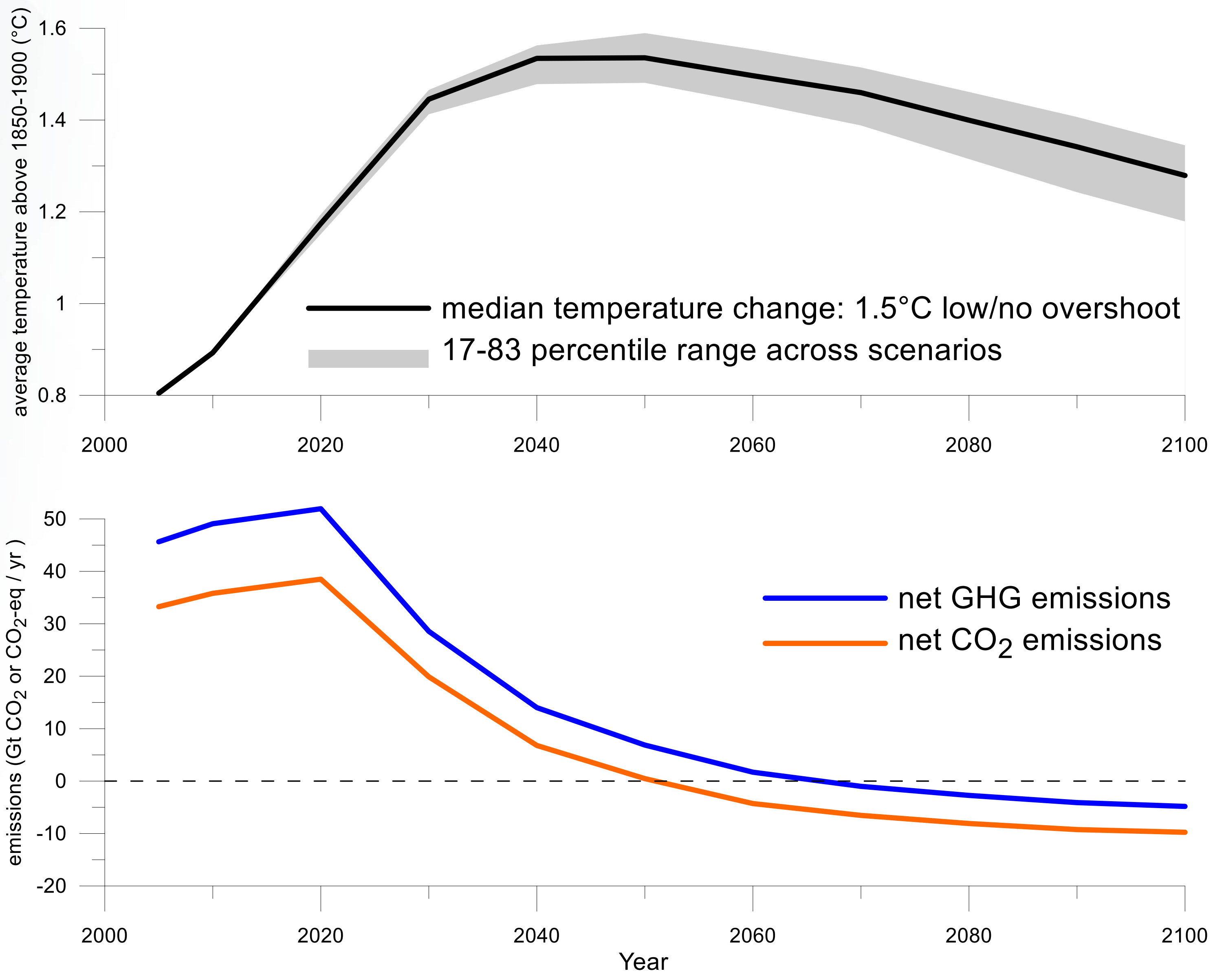
It includes existing and potential anthropogenic enhancement of biological or geochemical sinks and direct air capture and storage, but excludes natural CO_2 uptake not directly caused by human activities.

SR15 (2018) glossary; emphasis mine



Cowie et al., 2020, TheConversation https://theconversation.com/the-morrison-government-wants-to-suck-co-out-of-the-atmosphere-here-are-7-ways-to-do-it-144941

Net-zero emissions and global temperature



Illustrated for pathways with low/no overshoot of 1.5°C; scenarios from Rogelj et al (2018), data from Huppmann et al (2019)
Net-zero GHG calculated using GWP100

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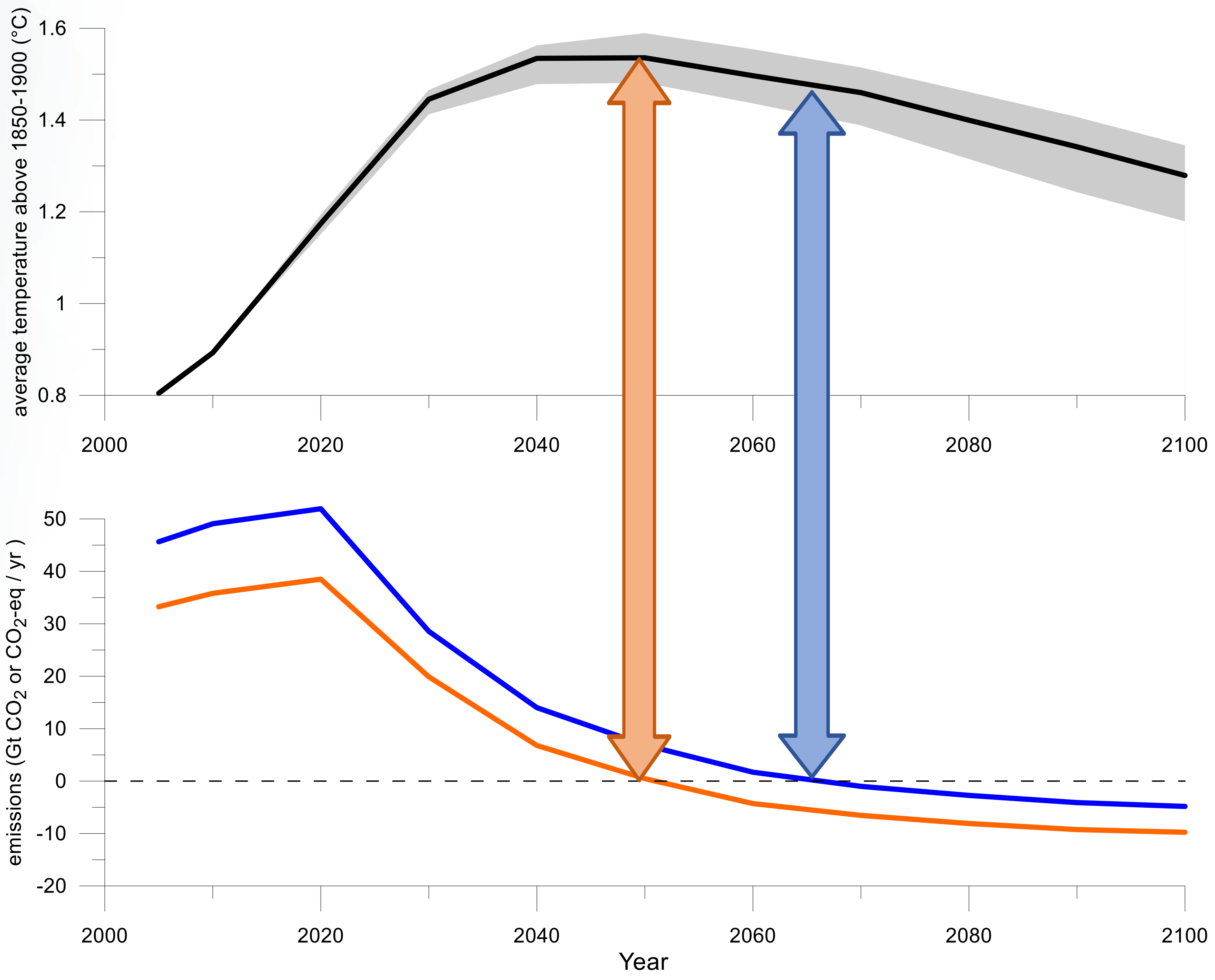
Net-zero emissions and global temperature

net-zero CO2 ≈ time of peak temperature

net-zero GHG ≈ temperature starts declining

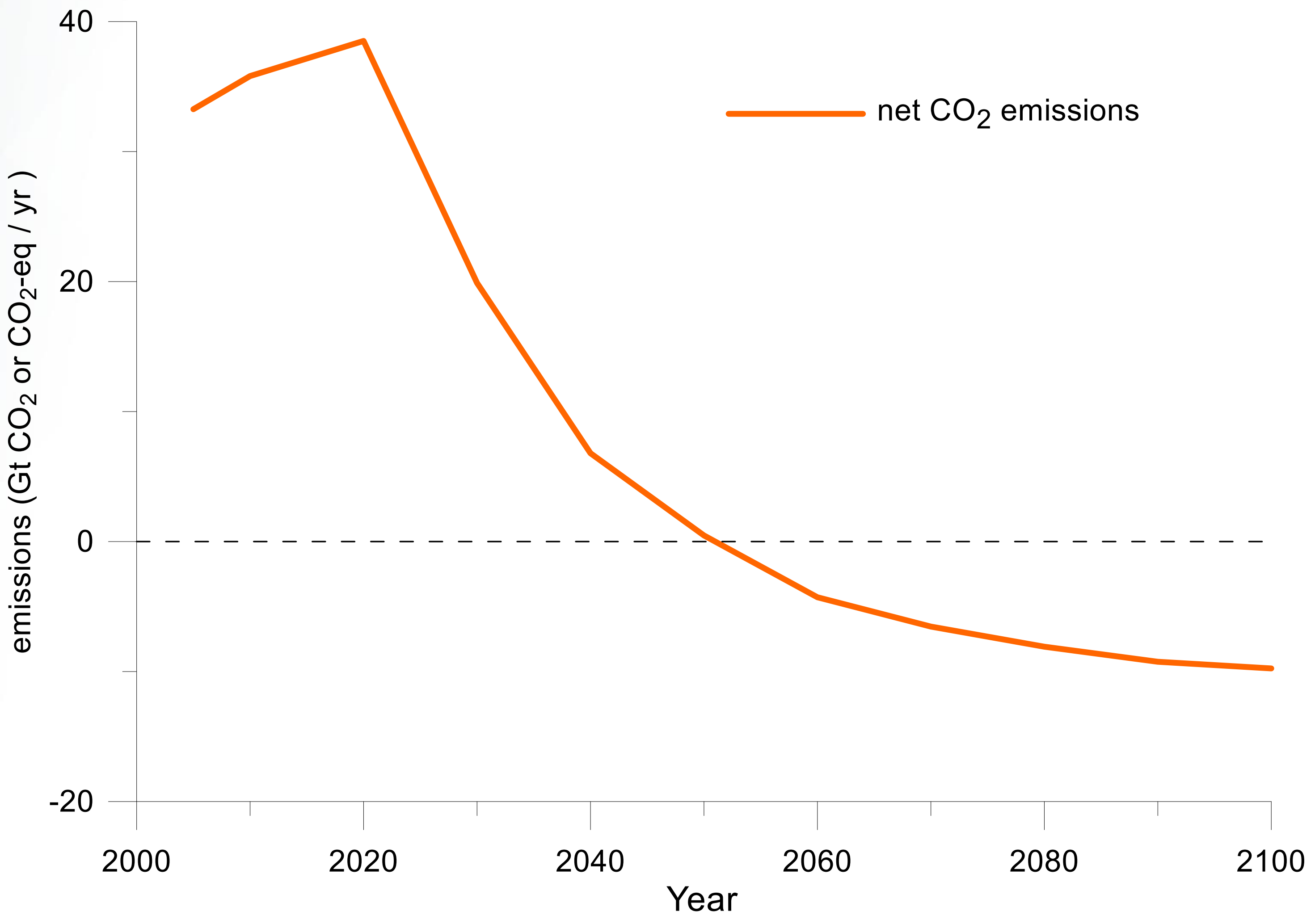
In 1.5°C scenarios, net-zero CO_2 occurs almost two decades before net-zero GHG (≈ 2050 vs 2067)

In 2°C scenarios, net-zero CO_2 occurs roughly three decades before net-zero GHG (≈ 2070 vs 2100)



Illustrated for pathways with low/no overshoot of 1.5°C; scenarios from Rogelj et al (2018), data from Huppmann et al (2019)
Net-zero GHG calculated using GWP100

CDR is necessary for net-zero CO_2 emissions



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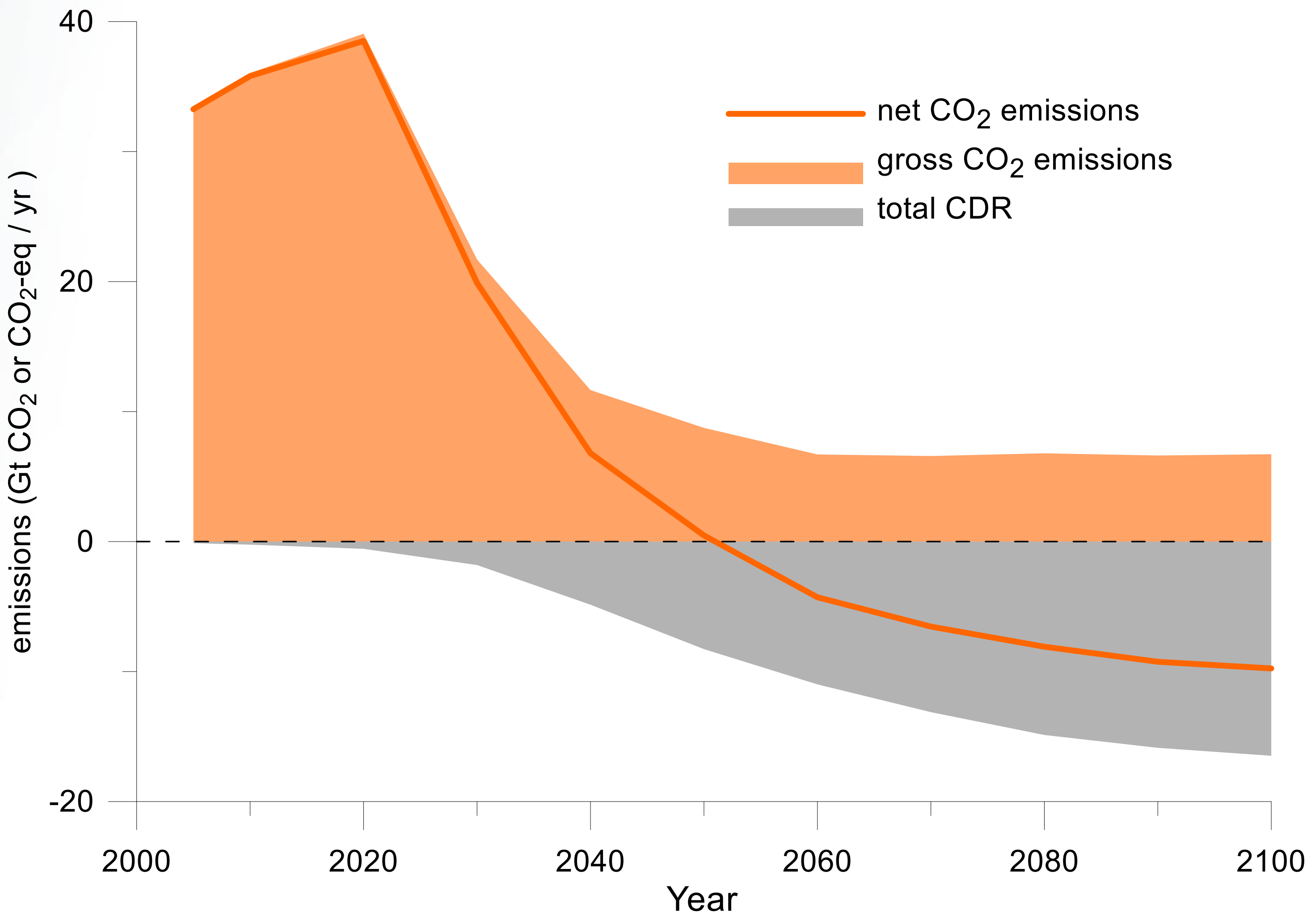
CDR is necessary for net-zero CO_2 emissions

All mitigation pathways rely on CDR

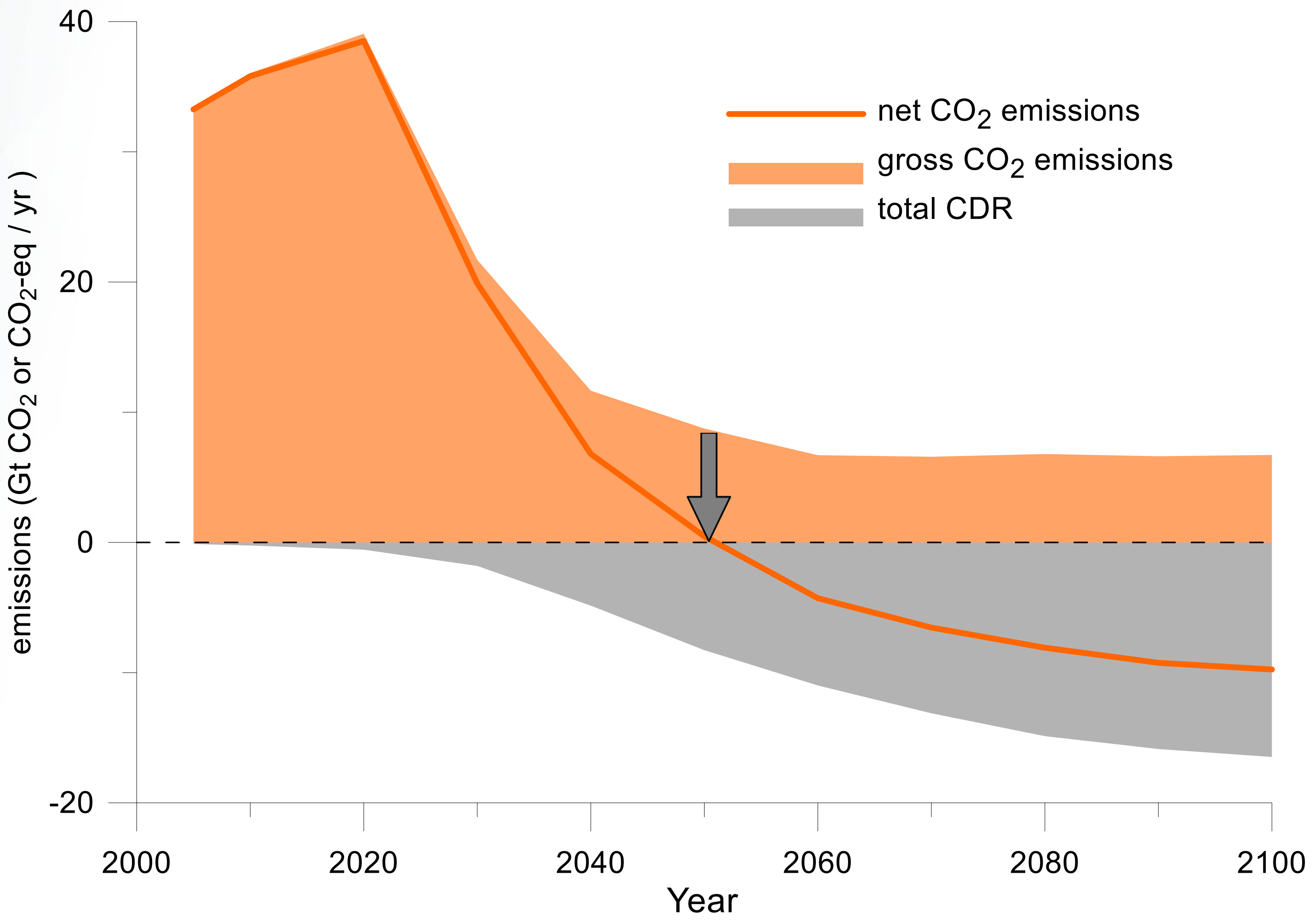


Illustrated for pathways with low/no overshoot of 1.5°C; scenarios from Rogelj et al (2018), data from Huppmann et al (2019)

CDR is necessary for net-zero CO_2 emissions

All mitigation pathways rely on CDR

- to achieve net-zero CO_2
  (compensate for residual CO_2)



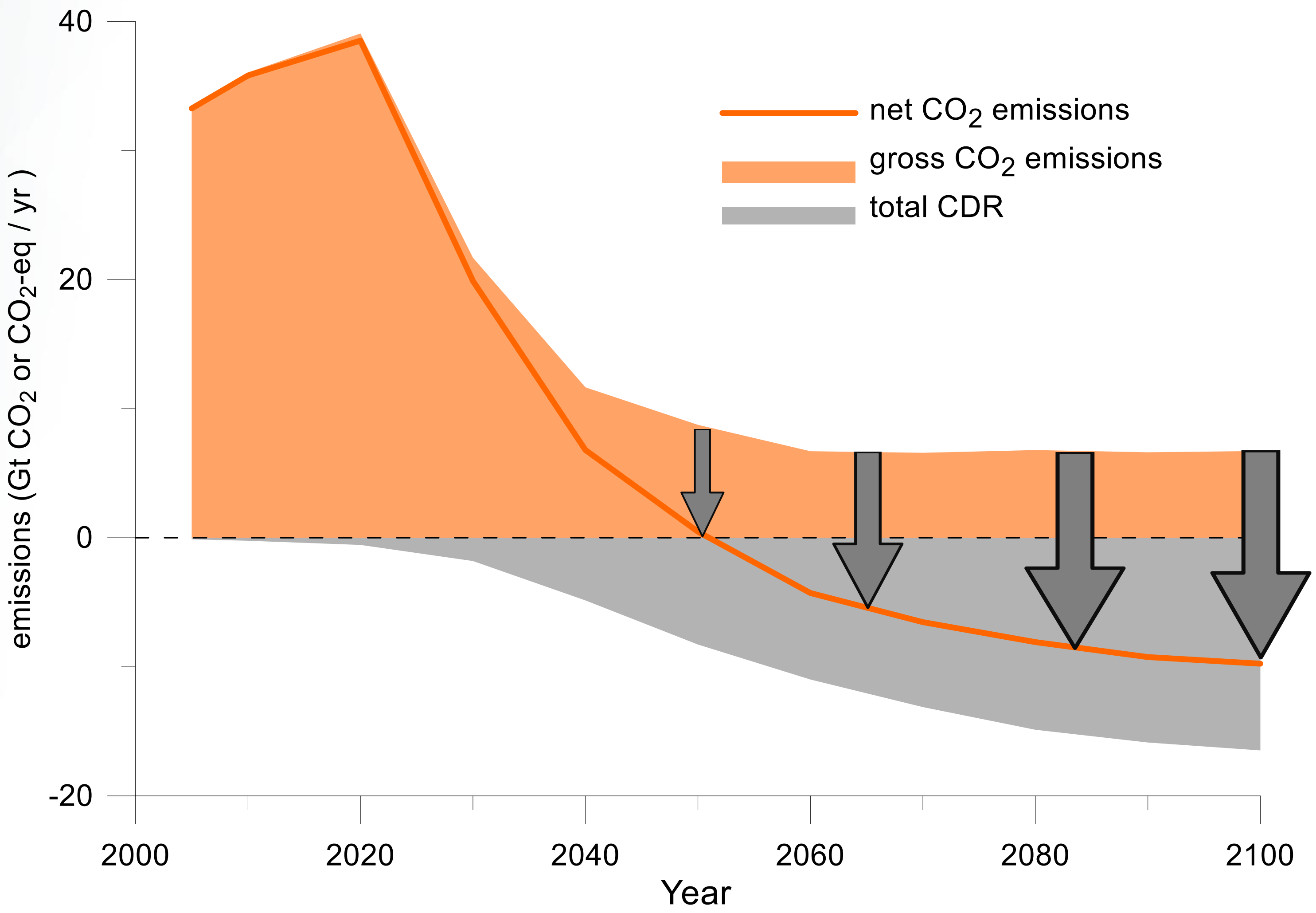
Illustrated for pathways with low/no overshoot of 1.5°C; scenarios from Rogelj et al (2018), data from Huppmann et al (2019)

CDR is necessary for net-zero CO_2 emissions

All mitigation pathways rely on CDR

- to achieve net-zero CO_2 *(compensate for residual CO_2)*
- to achieve net-negative CO_2 emissions afterwards

  (compensate for hard-to-abate residual non-CO_2 emissions, to achieve net-zero GHG)



Illustrated for pathways with low/no overshoot of 1.5°C; scenarios from Rogelj et al (2018), data from Huppmann et al (2019)

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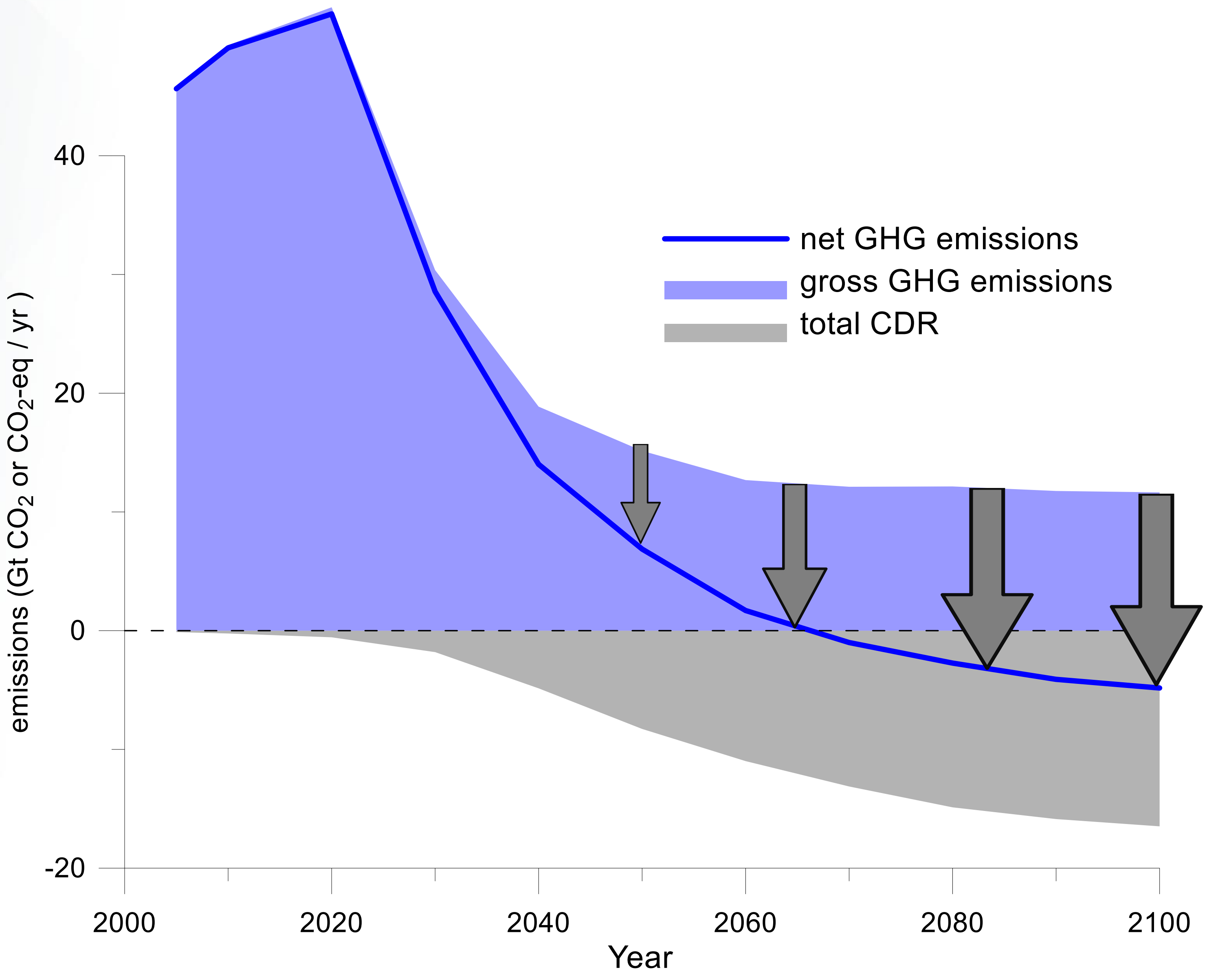
CDR is necessary for net-zero GHG emissions

All mitigation pathways rely on CDR

- to achieve net-zero GHG *(requires greater amount of CDR)*
- to achieve net-negative GHG emissions afterwards

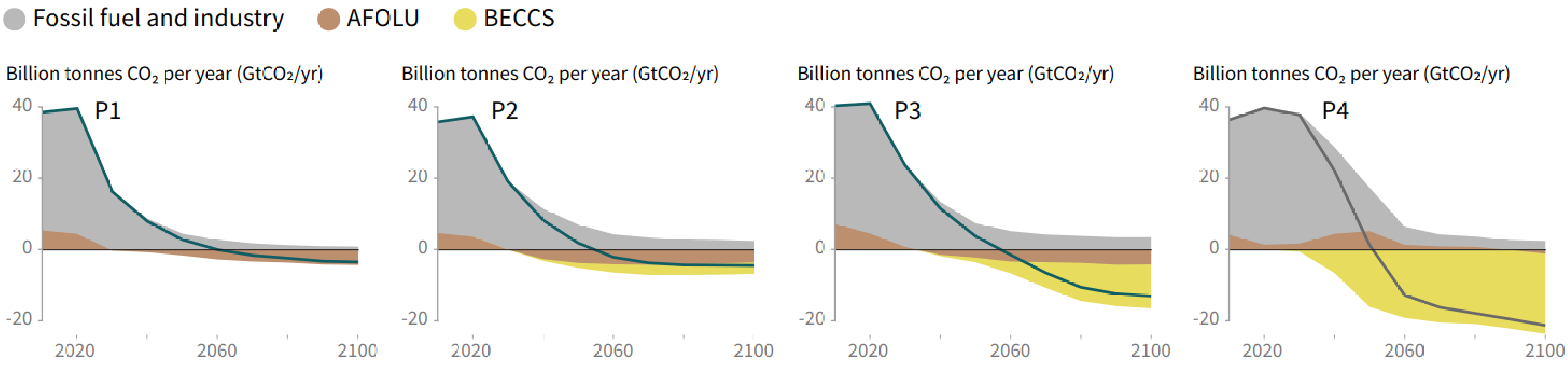
(to achieve a faster rate of temperature decline)



Illustrated for pathways with low/no overshoot of 1.5°C; scenarios from Rogelj et al (2018), data from Huppmann et al (2019)

Strategies for net-zero differ in their reliance on CDR

- timing and scale of abatement of gross emissions
- rate of decline after the temperature peak
- mix of CDR technologies (AFOLU, BECCS, DAC, other …)



Illustrative pathways from IPCC SR15: Rogelj et al (2018)

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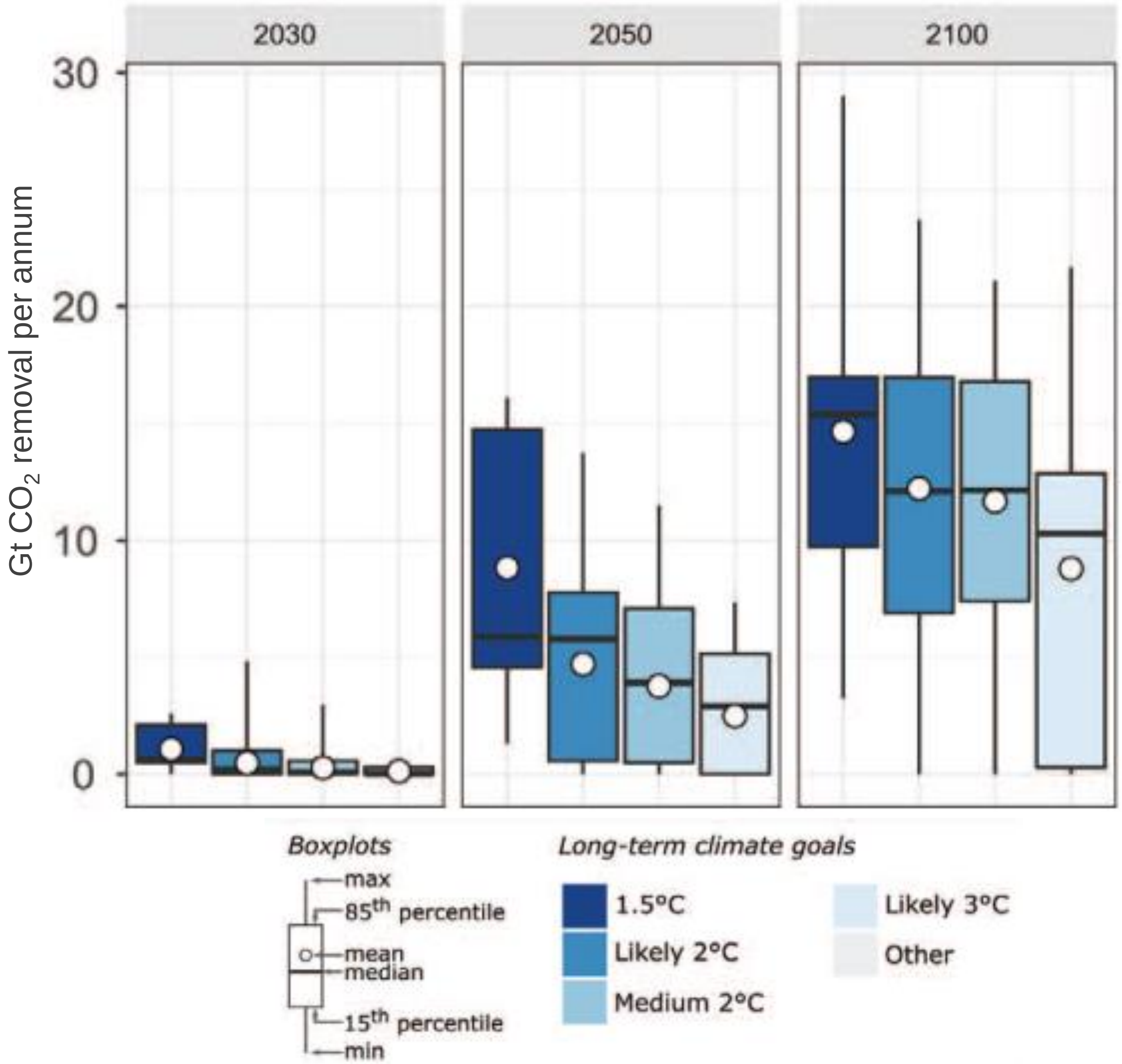
Strategies for net-zero differ in their reliance on CDR

- depends on the temperature goal
- lower temperature targets imply
  - ✓ earlier, and
  - ✓ more CDR
- … but with significant variations

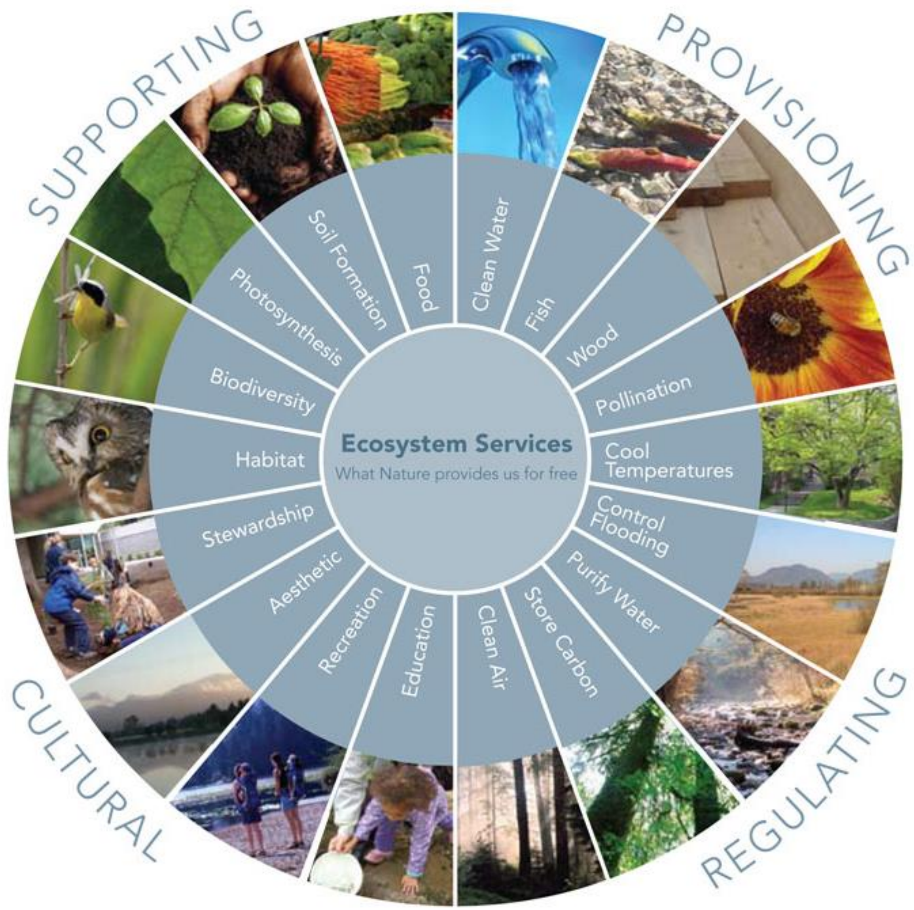


Fuss et al (2018) Environ. Res. Lett. 13 (2018) 063002

Interaction of CDR with ecosystem services

All CDR options rely on one or several of the following:

- Land
- Water
- Energy
- Marine net primary production



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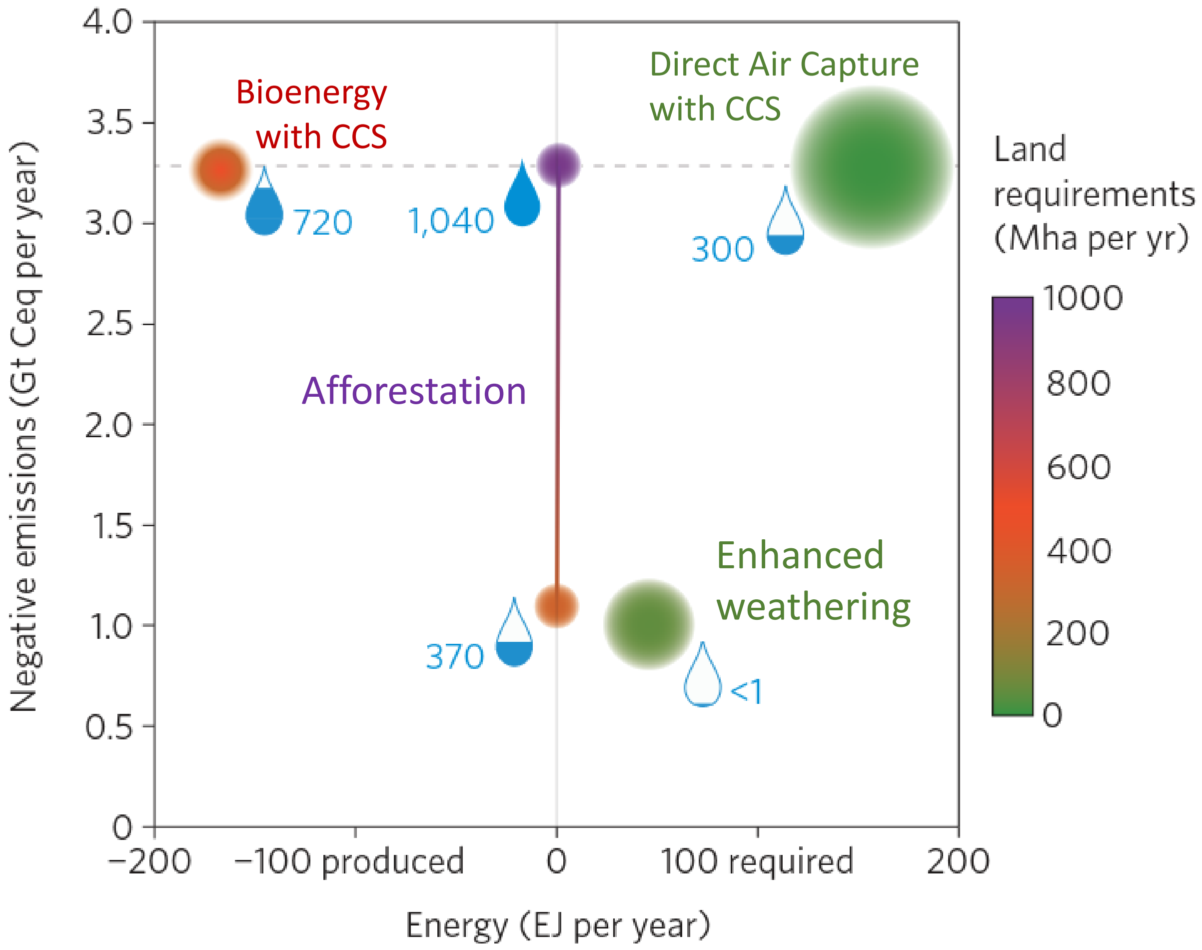
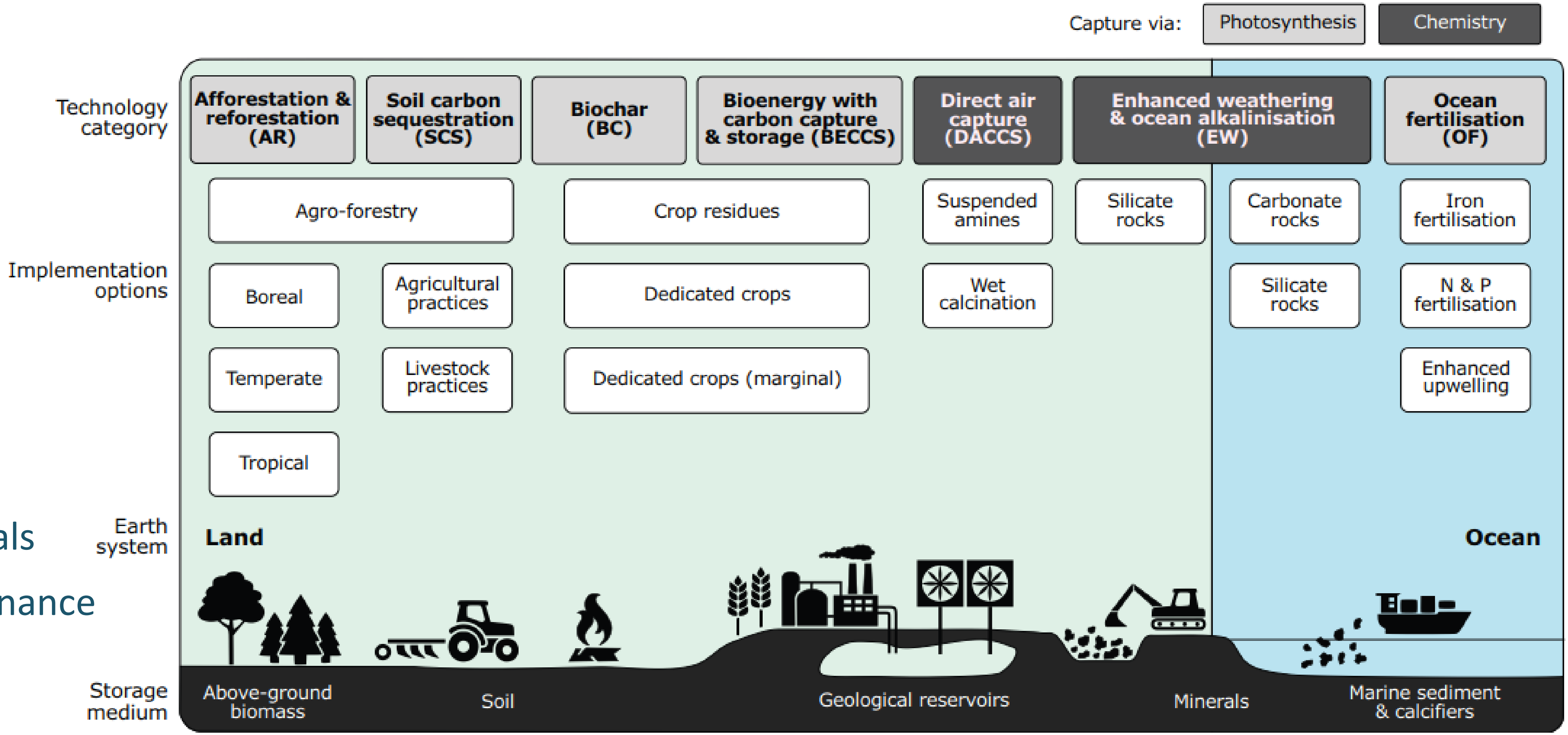


Smith et al (2015) Nat. Clim. Change doi: 10.1038/NCLIMATE2870

Implementation of CDR

Asymmetries:

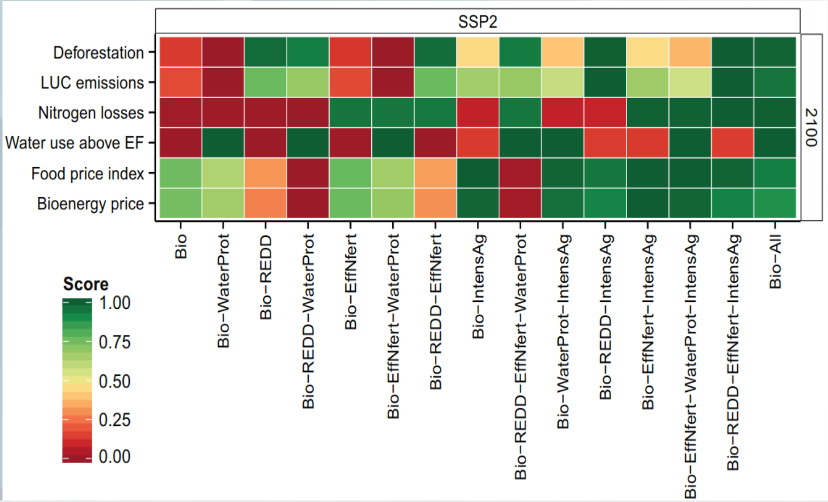
- Maturity
- Permanence
- Effectiveness
- Cost and potentials
- Actors and governance



Minx et al (2018) Environ. Res. Lett. 13 (2018) 063001

Interaction of CDR with SDGs and other objectives

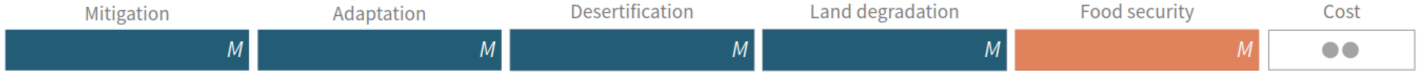
Global assessments provide limited guidance, as interactions depend on local context and both mode and scale of implementation



Bioenergy and BECCS

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts, assuming carbon dioxide removal by BECCS at a scale of 11.3 $GtCO_2$ yr^{-1} in 2050, and noting that bioenergy without CCS can also achieve emissions reductions of up to several $GtCO_2$ yr^{-1} when it is a low carbon energy source {2.6.1; 6.3.1}. Studies linking bioenergy to food security estimate an increase in the population at risk of hunger to up to 150 million people at this level of implementation {6.3.5}. The red hatched cells for desertification and land degradation indicate that while up to 15 million km² of additional land is required in 2100 in 2°C scenarios which will increase pressure for desertification and land degradation, the actual area affected by this additional pressure is not easily quantified {6.3.3; 6.3.4}.

Best practice: The sign and magnitude of the effects of bioenergy and BECCS depends on the scale of deployment, the type of bioenergy feedstock, which other response options are included, and where bioenergy is grown (including prior land use and indirect land use change emissions). For example, limiting bioenergy production to marginal lands or abandoned cropland would have negligible effects on biodiversity, food security, and potentially co-benefits for land degradation; however, the benefits for mitigation could also be smaller. {Table 6.58}



Reforestation and forest restoration

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of reforestation and forest restoration (partly overlapping with afforestation) at a scale of 10.1 $GtCO_2$ yr^{-1} removal {6.3.1}. Large-scale afforestation could cause increases in food prices of 80% by 2050, and more general mitigation measures in the AFOLU sector can translate into a rise in undernourishment of 80–300 million people; the impact of reforestation is lower {6.3.5}.

Best practice: There are co-benefits of reforestation and forest restoration in previously forested areas, assuming small scale deployment using native species and involving local stakeholders to provide a safety net for food security. Examples of sustainable implementation include, but are not limited to, reducing illegal logging and halting illegal forest loss in protected areas, reforesting and restoring forests in degraded and desertified lands {Box6.1C; Table 6.6}.

IPCC SRCCL: Smith et al (2018); Humpenöder et al (2018) Environ. Res. Lett. 13 (2018) 024011

What happens after net-zero is reached?

- th...

Which actors have targets for sustained net-negative emissions, and by what date?

- global/national net-zero implies some actors have to be sustained net-negative while others are still net-positive

Conclusions

- CDR is absolutely necessary for net-zero …
- … but timing and scale differs for net-zero CO_2 or net-zero GHG
- Reliance on CDR grows with every tonne of emission
- All CDR options have limits and potential for negative side-effects that grow with the scale of implementation
- Choices around how much CDR, when, and what need to become core parts of climate policy to reduce over-reliance and forced trade-offs
- Investments in R&D, pilots, up-scaling, institutions, governance, embedding in development plans do not match our reliance on CDR

Thank you! andy.reisinger@mfe.govt.nz

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