Interaction effects of climate change and disturbance regimes on high latitude forest dynamics (in a dynamic vegetation model)

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Intensifying disturbance regimes under climate change

- **Disturbance regimes** are expected to i**ntensify due to climate change** in many regions of the world *(e.g. Seidl et al, 2017)*

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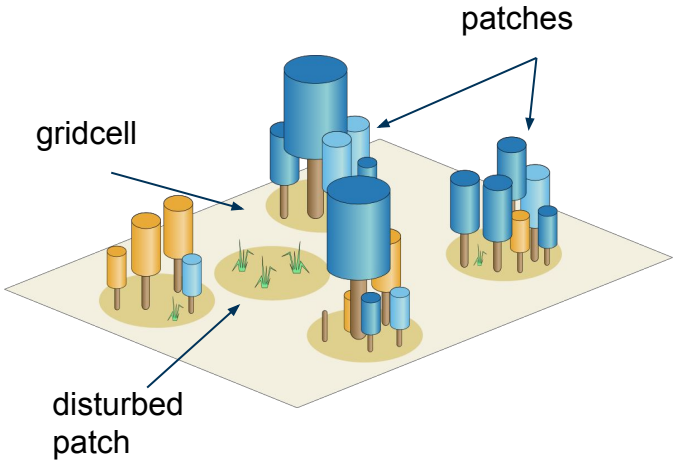
- **Disturbance regimes** are expected to i**ntensify due to climate change** in many regions of the world *(e.g. Seidl et al, 2017)*

- There still remain **uncertainties** around future disturbance regimes and their impacts *(e.g. McDowell et al, 2020; Ahlström et al, 2018)*

Disturbance-triggered vegetation shifts in boreal forests

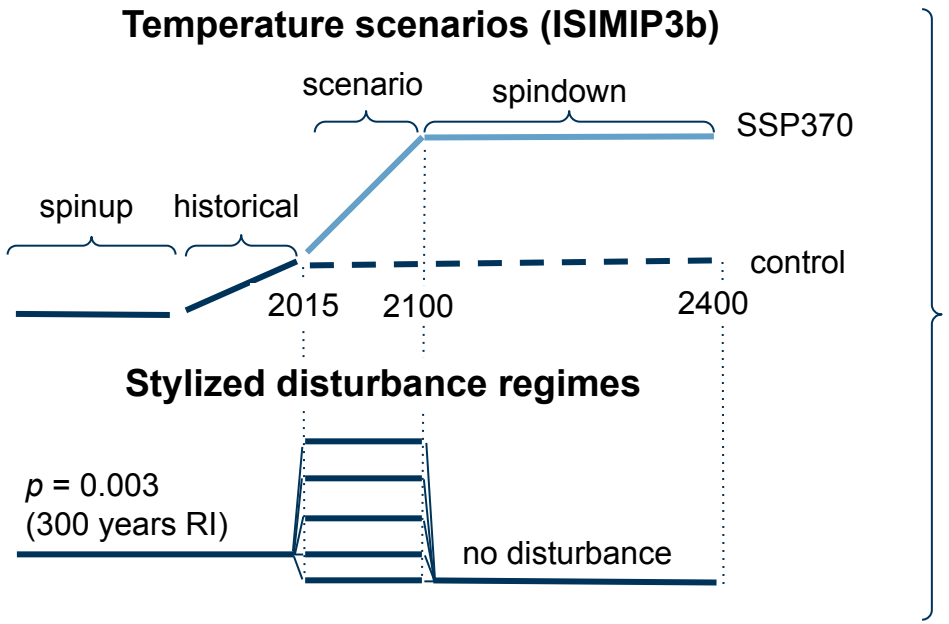
LPJ-GUESS model structure



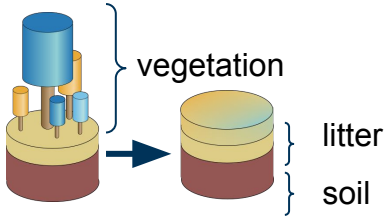
Research Questions

- How **sensitive** are simulation outcomes to **disturbance probability**?
- Do increasing disturbances trigger **shifts** from **needleleaf** evergreen to **broadleaf** summergreen species *(e.g Brice et al, 2020; Mekonnen et al, 2019, Johnstone et al, 2010)*?

Experimental design



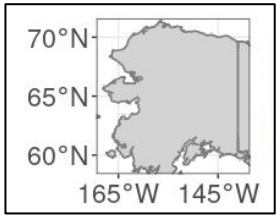
Patch-replacing disturbance
(with a given probability *p* each year)



Factorial experiments

1. **SSP370 & no disturbance**
2. **Control & disturbance**
3. **SSP370 & disturbance**
4. Control & no disturbance
   (not discussed here)

Study region: Alaska
(0.5 x 0.5°)



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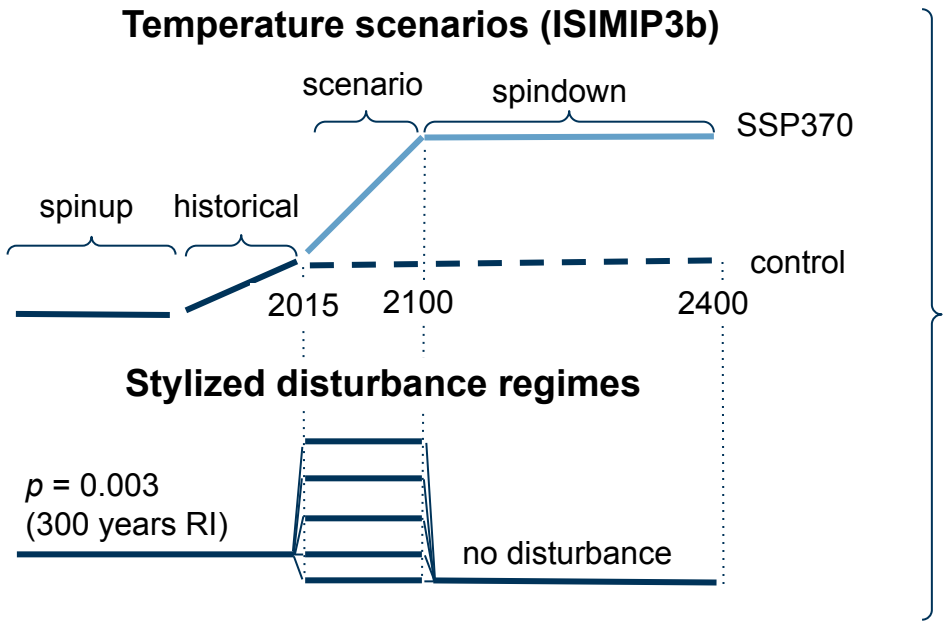

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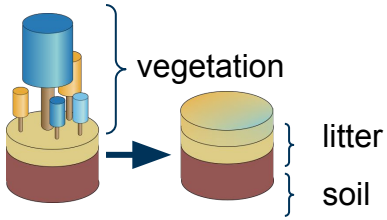

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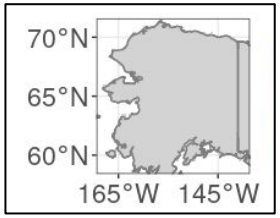
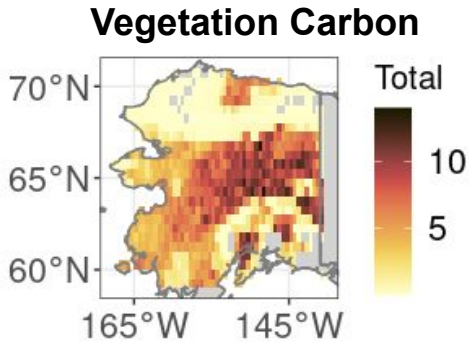
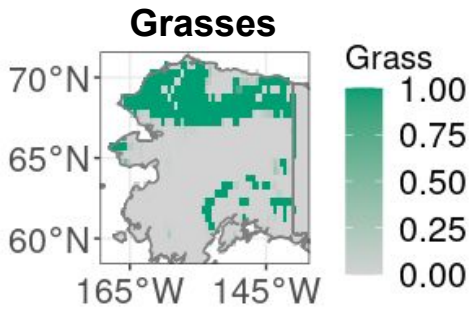
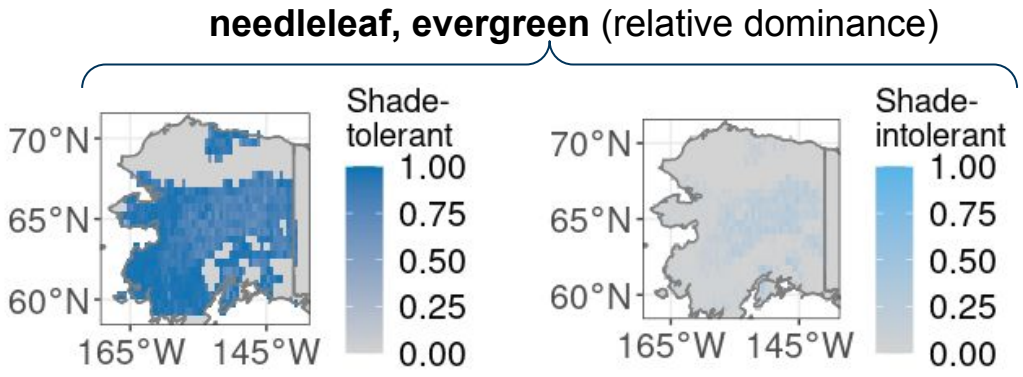
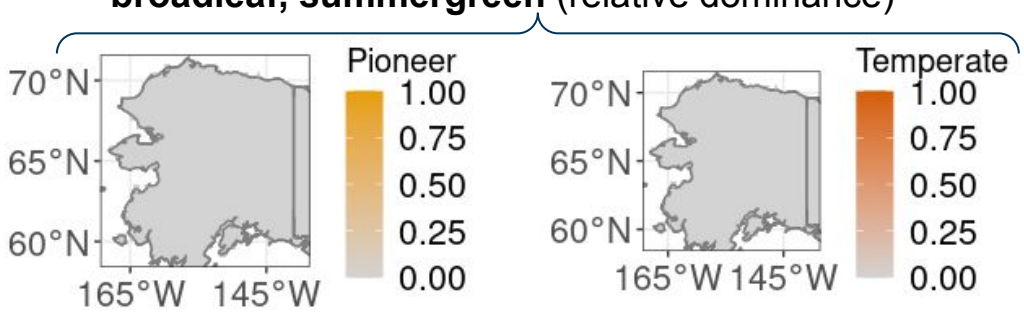


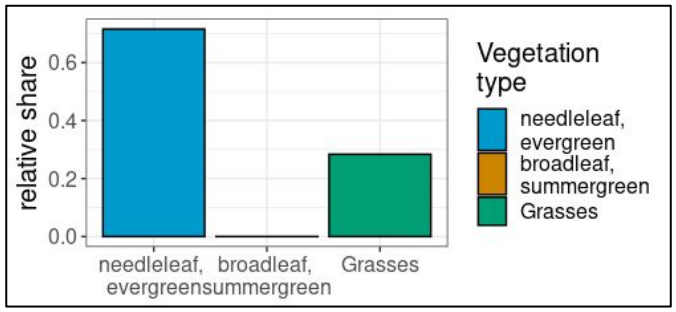
Spatial patterns at start of scenarios



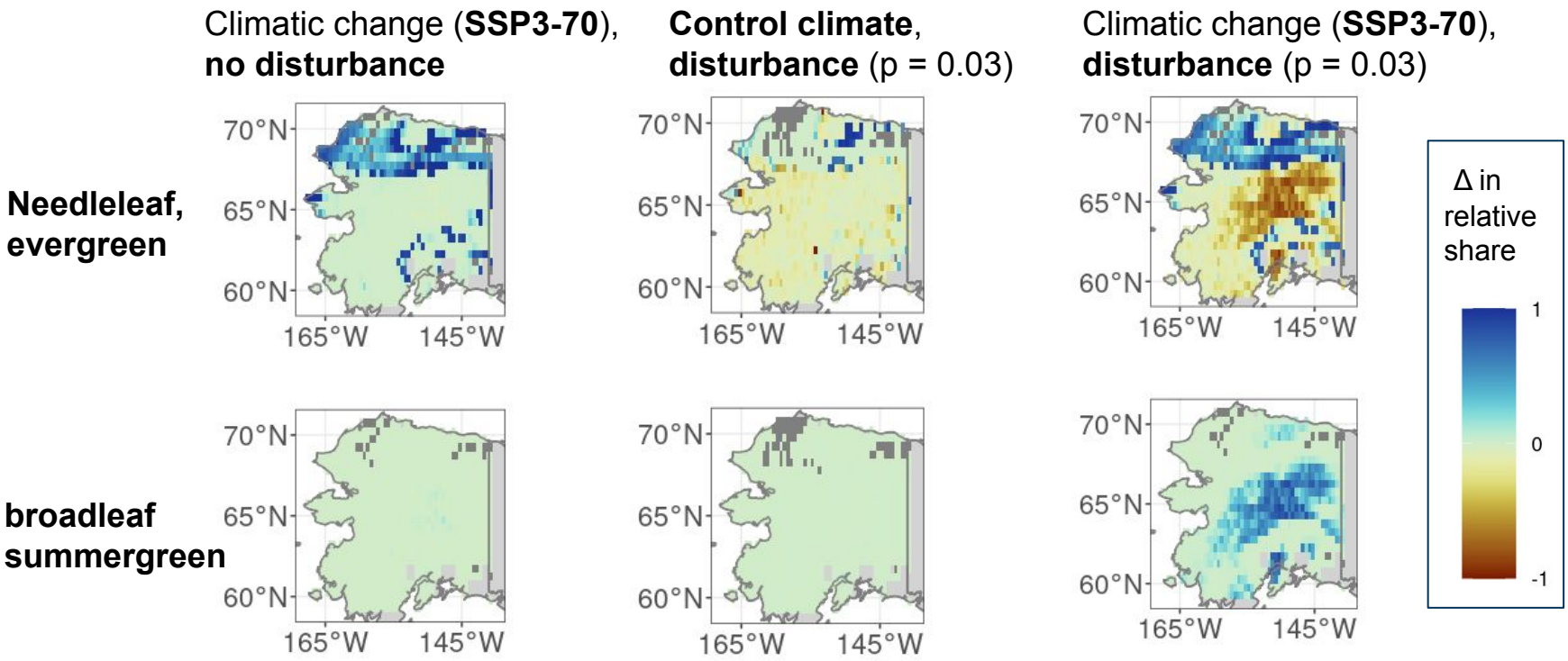








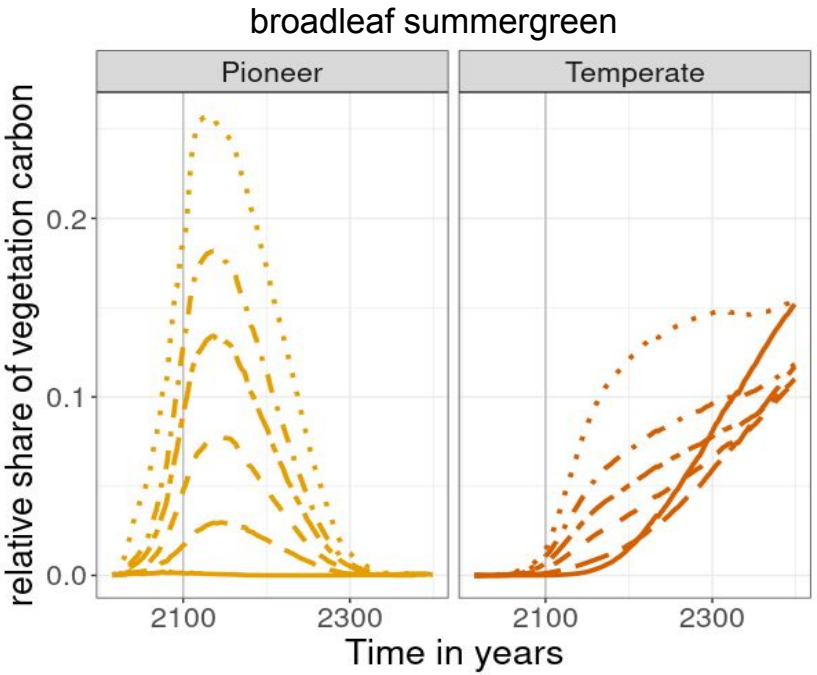
Changes in relative dominance by 2100

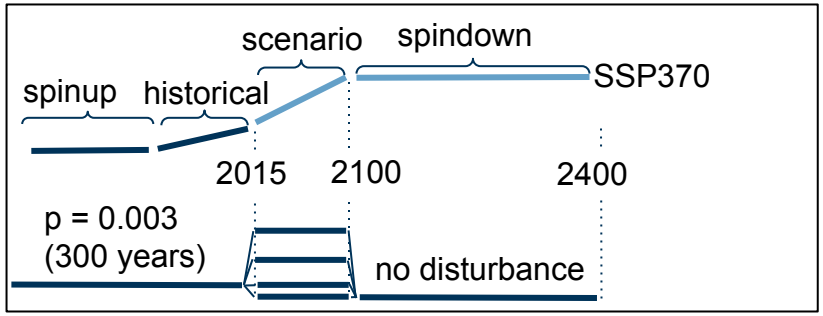


→**increase in needleleaf, evergreen species is driven by climate & disturbance**

→**increase in broadleaf, summergreen species is driven by climate x disturbance**

Long-term dynamics after 2100 in SSP370 scenario

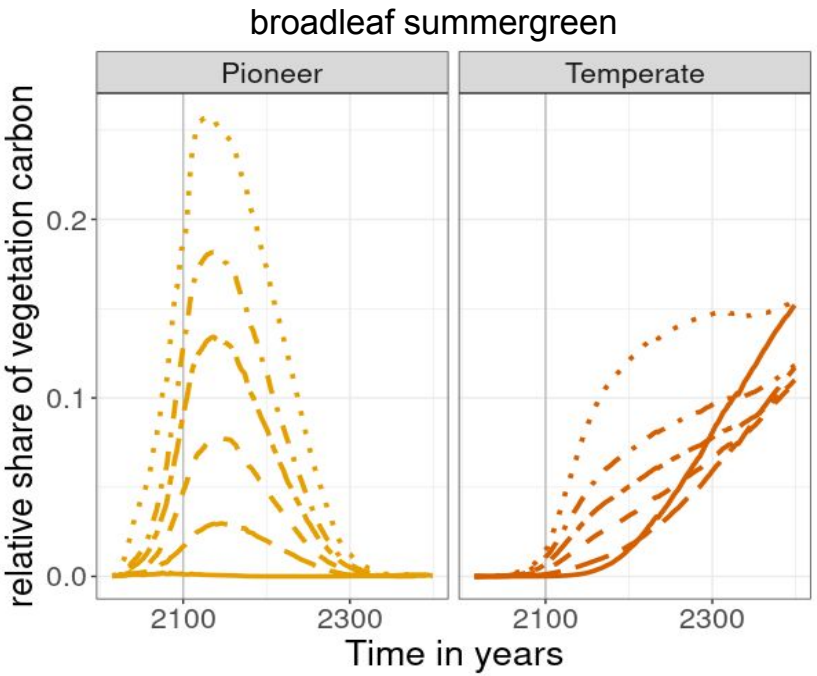


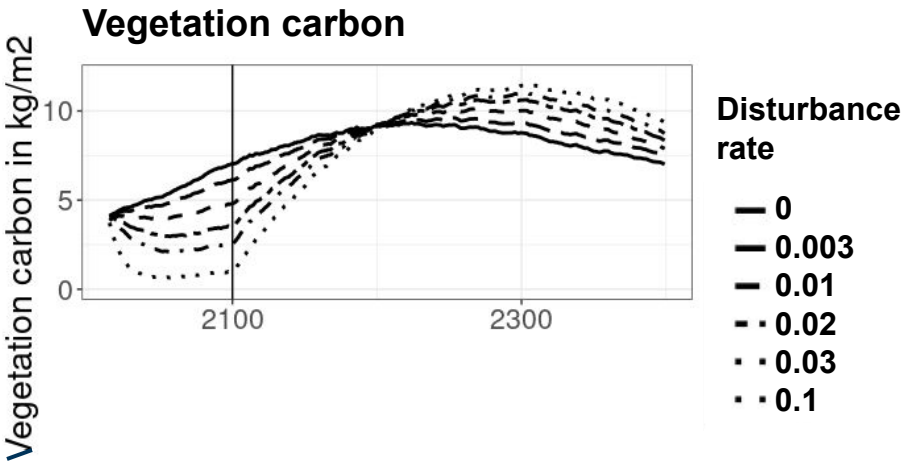


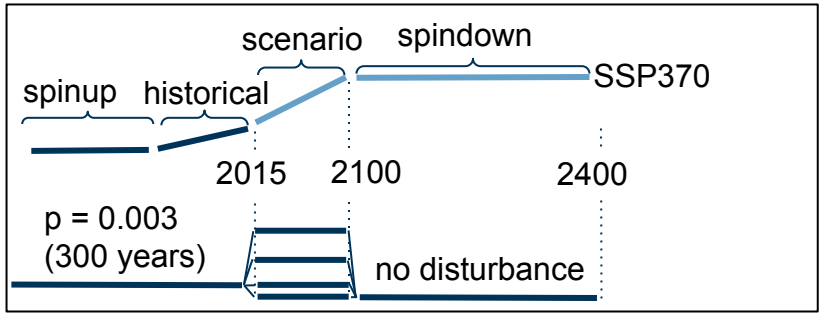
Disturbance rate

- **0**
- **0.003**
- **0.01**
- **0.02**
- **0.03**
- **0.1**

Long-term dynamics after 2100 in SSP370 scenario







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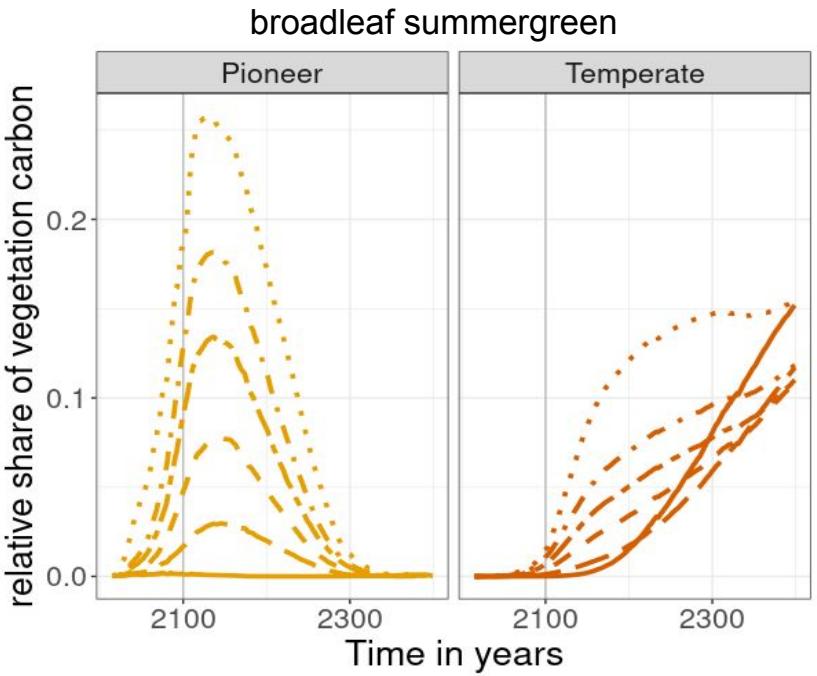

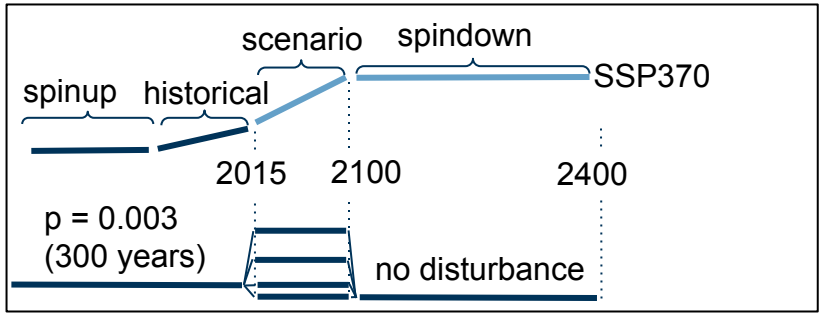

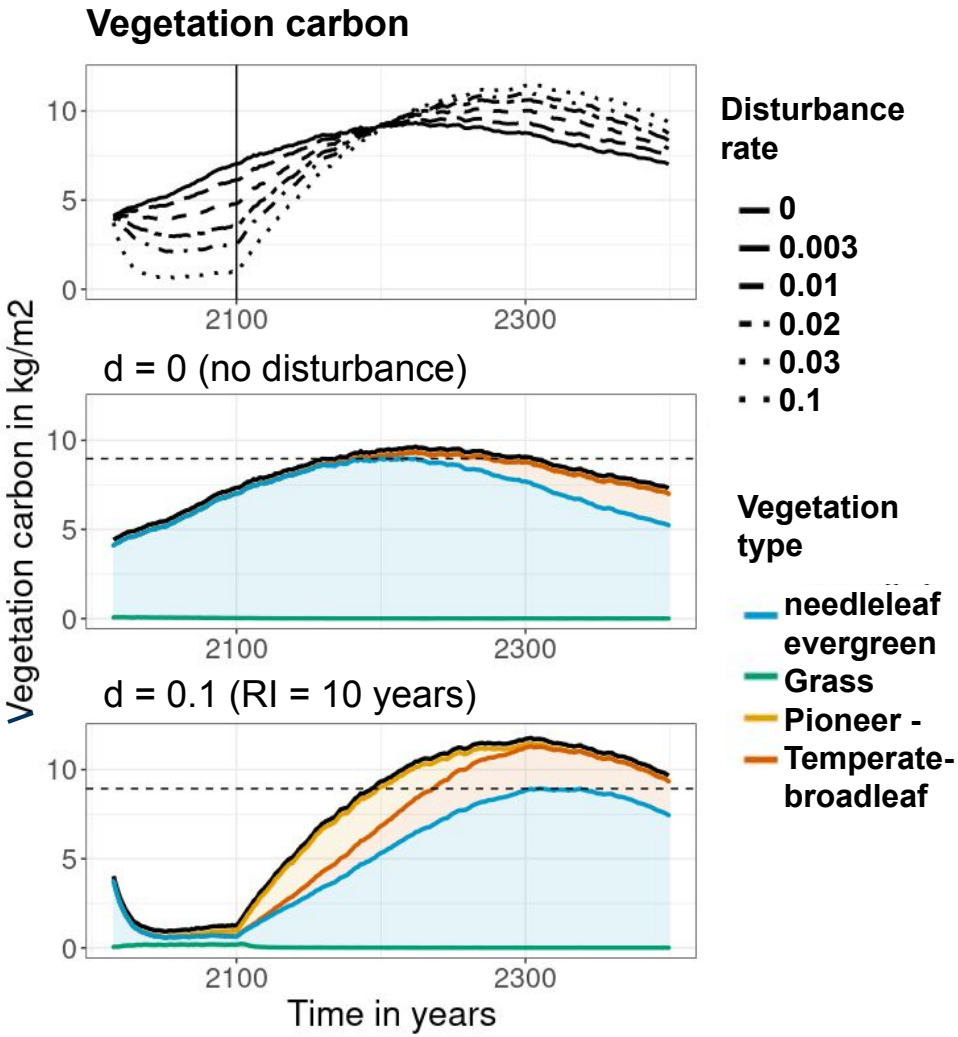

Conclusions

- The **interaction effect** of climate change and disturbances catalyze **shifts to more deciduous forests** in LPJ-GUESS



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- While some changes are **transient on centennial time** scales, **legacy effects** of different disturbance regimes **persist** for centuries



Conclusions

- The **interaction effect** of climate change and disturbances catalyze **shifts to more deciduous forests** in LPJ-GUESS
- While some changes are **transient on centennial time** scales, **legacy effects** of different disturbance regimes **persist** for centuries
- Dynamics happen on the **patch level** through changes in post-disturbance trajectories (*not shown today but happy to discuss further!*)



Thank you for your attention!

Feel free to reach out, I am happy to answer any questions

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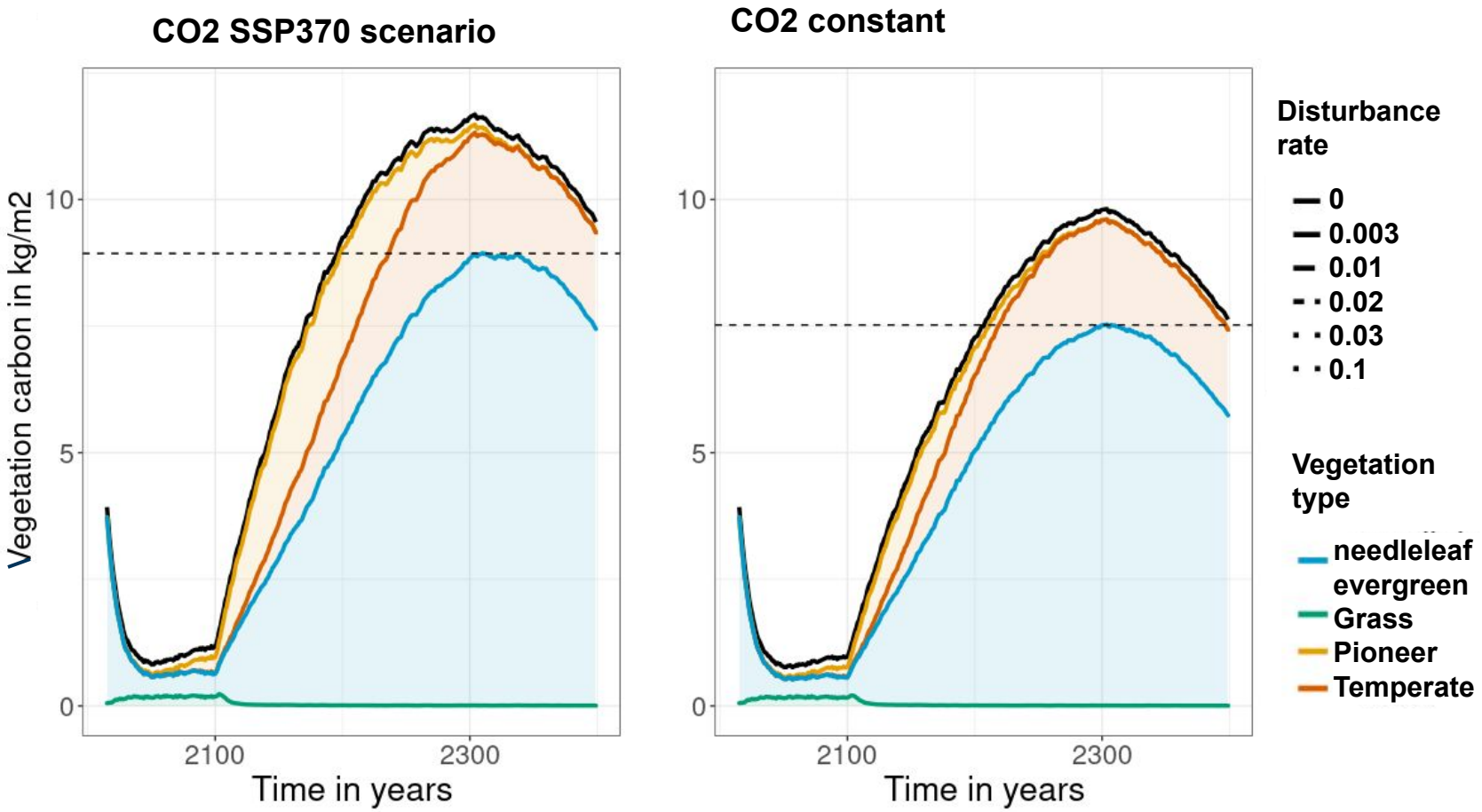
HEINRICH BÖLL STIFTUNG

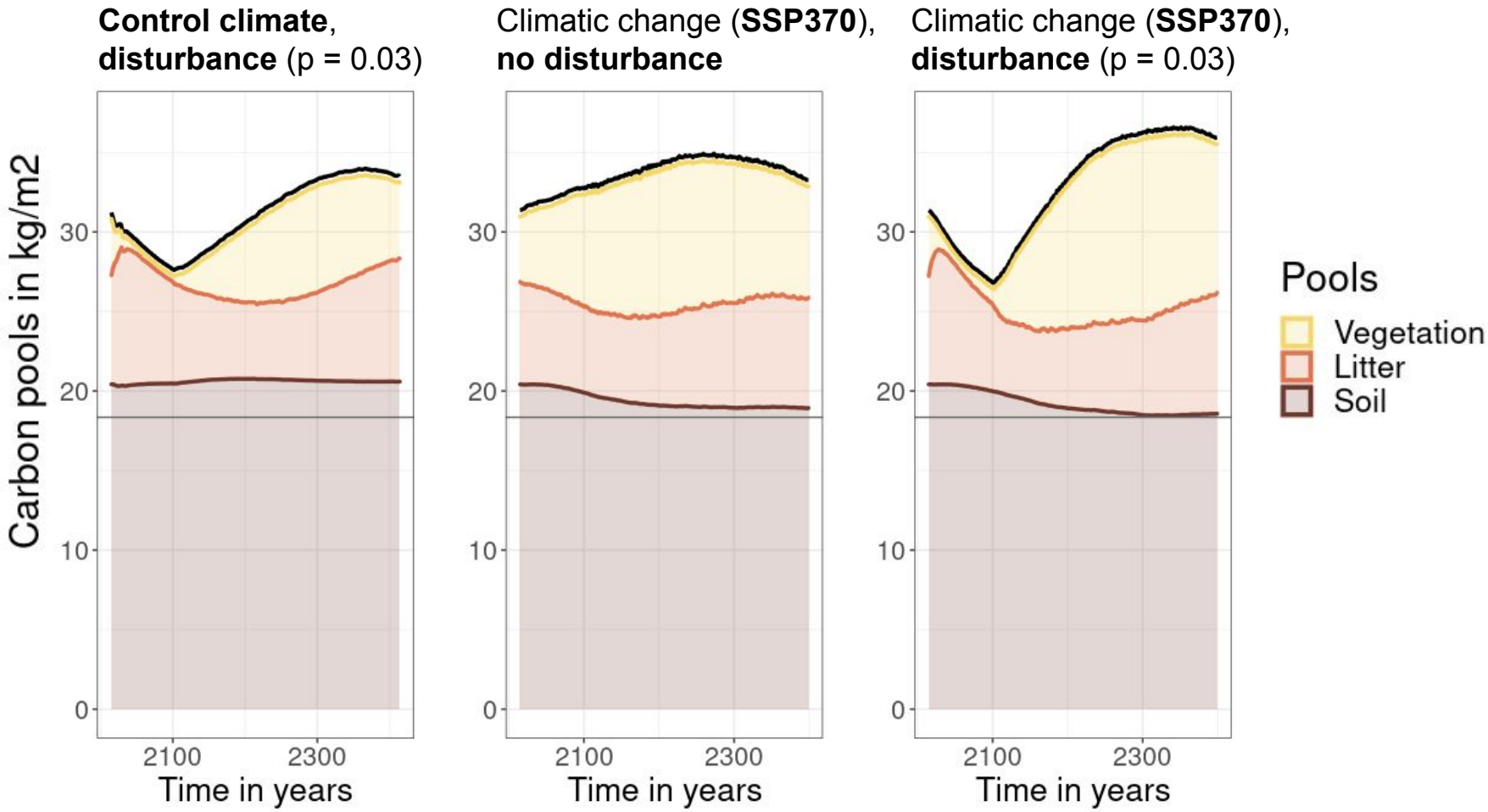
Professorship for Land Surface-Atmosphere Interactions

BACK-UP

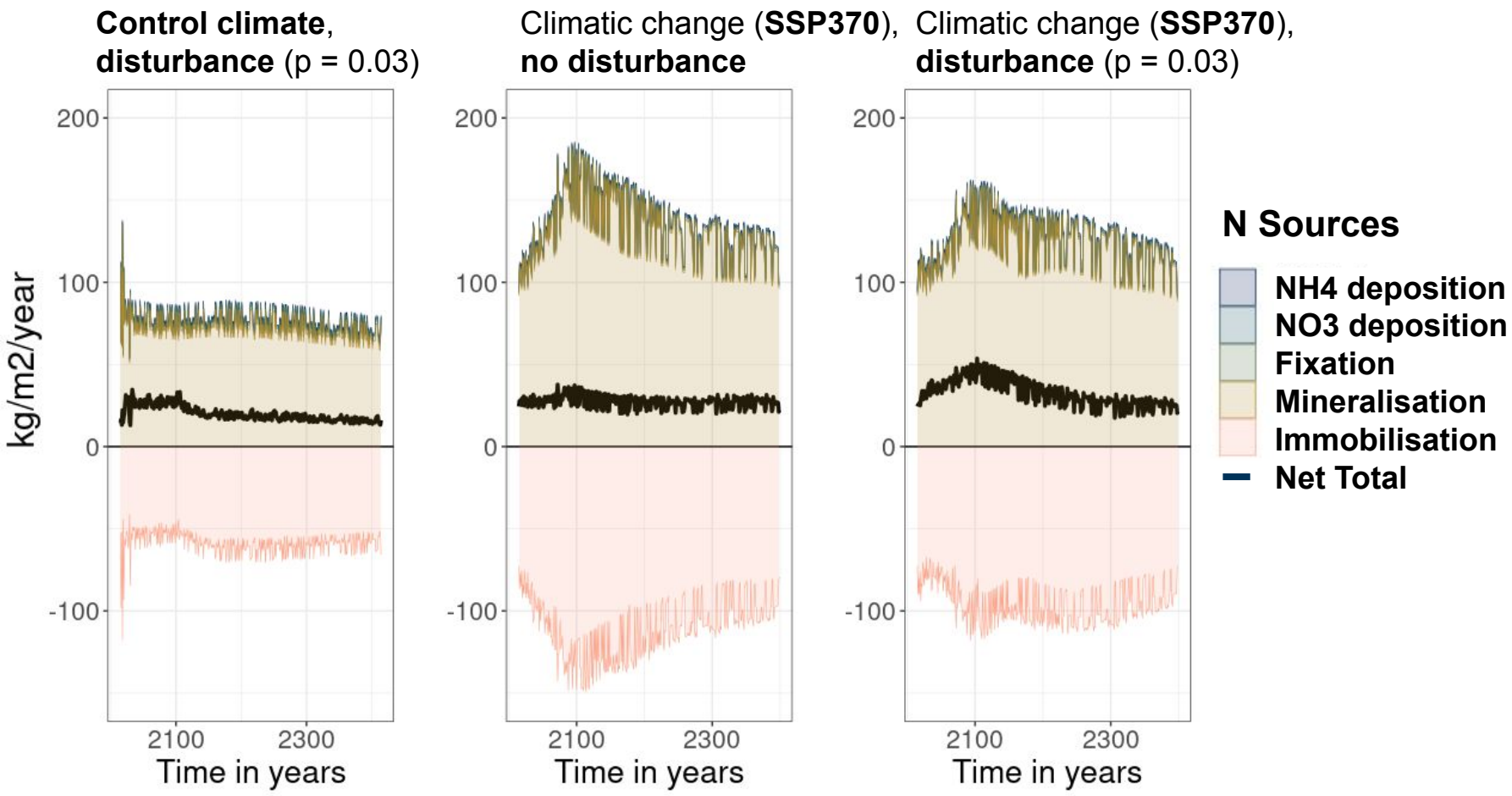
CO2 Fertilization



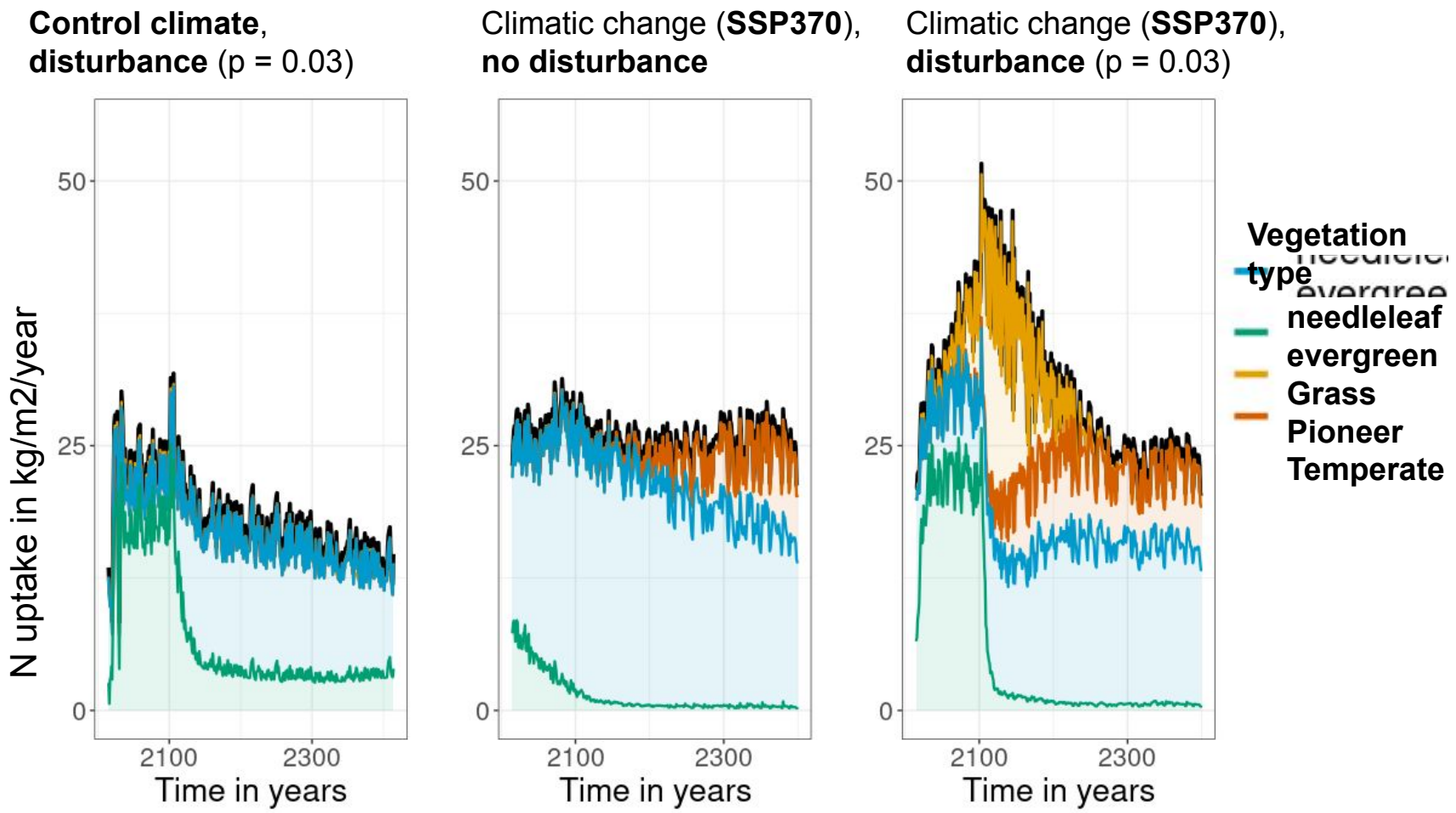
Carbon Pools



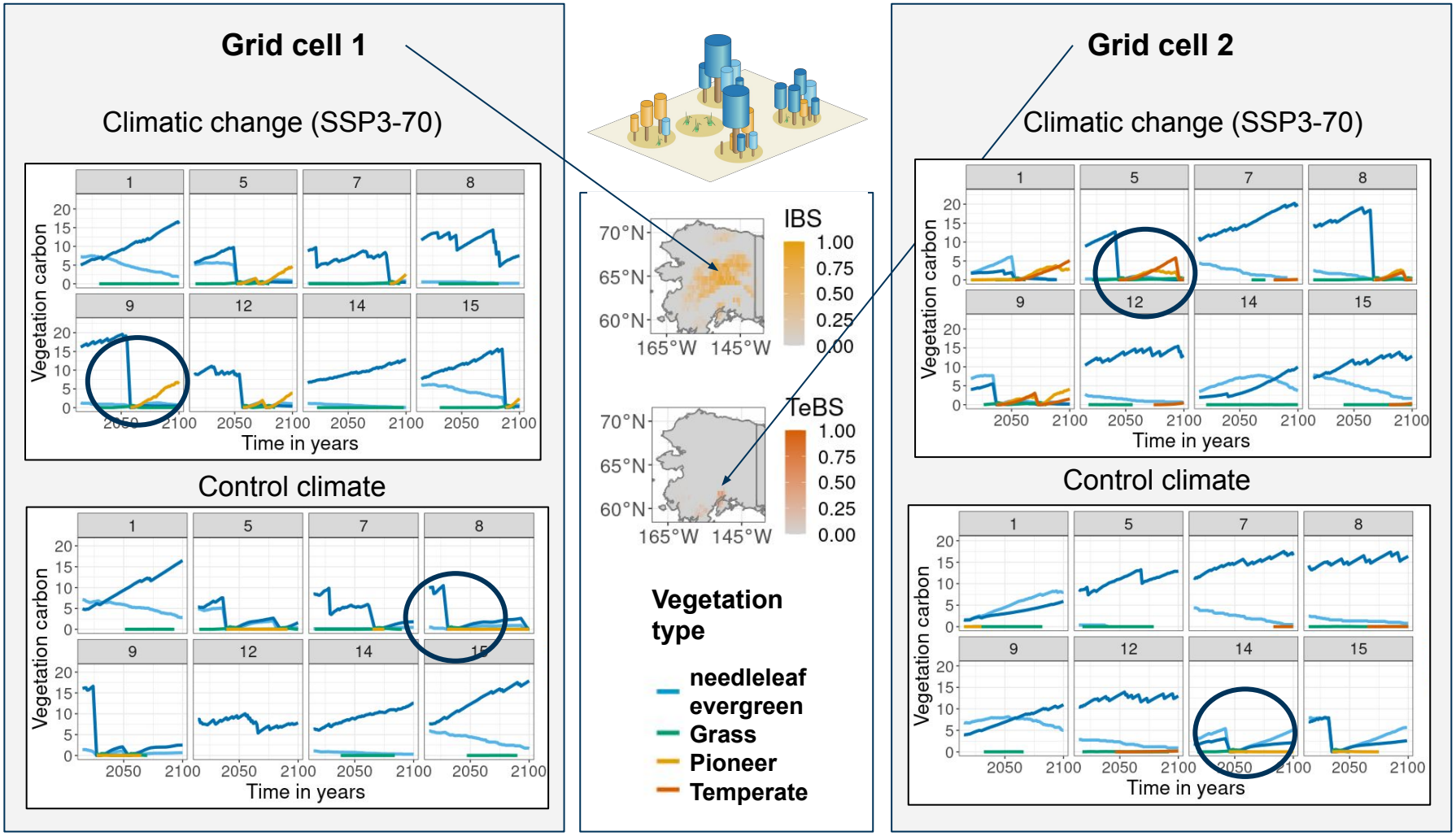
Nitrogen sources



Nitrogen uptake

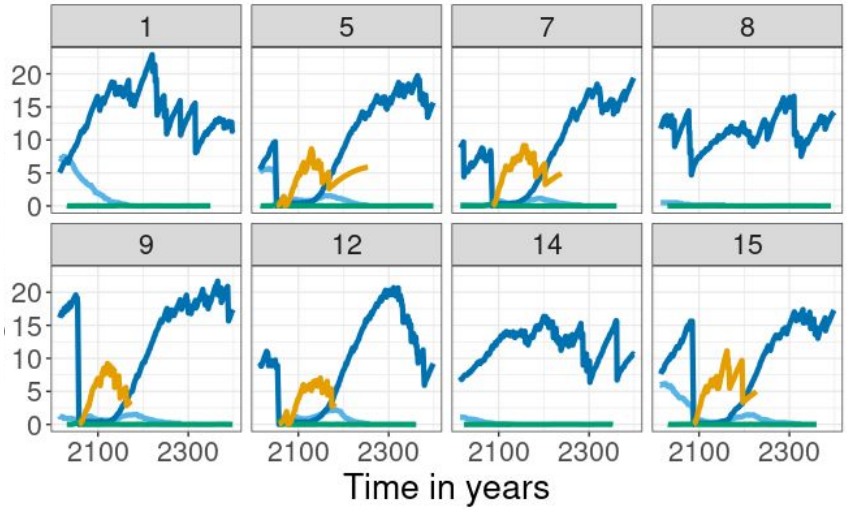


Patch level dynamics



Long-term dynamics towards equilibrium (after 2100)

Grid cell 1



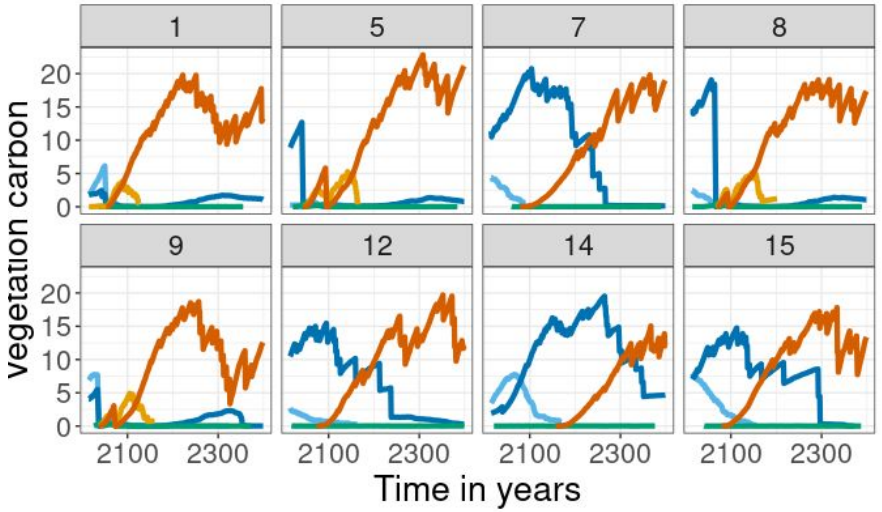
Vegetation type

- needleleaf evergreen
- Grass
- Pioneer
- Temperate

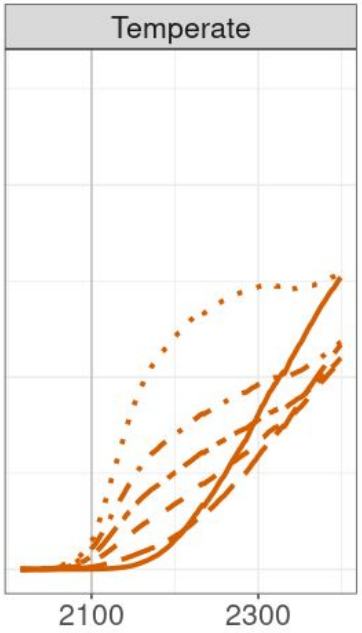
Disturbance rate

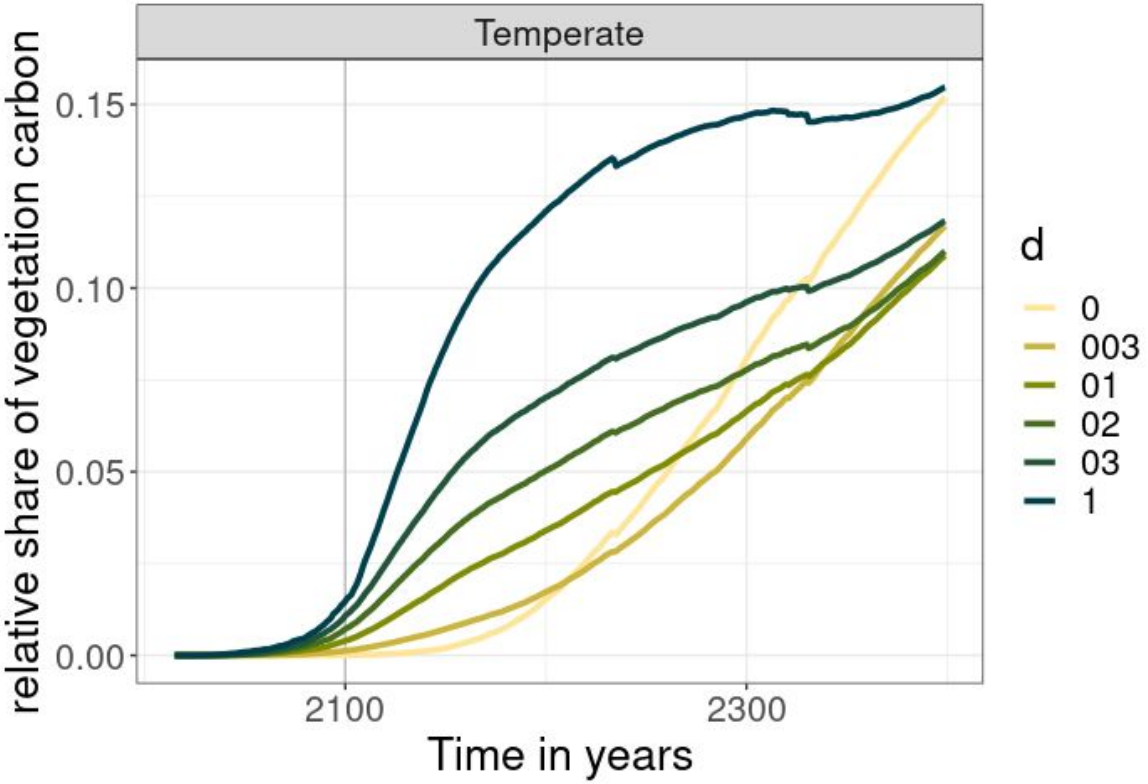
- 0
- 003
- 01
- 02
- 03
- 1

Grid cell 2

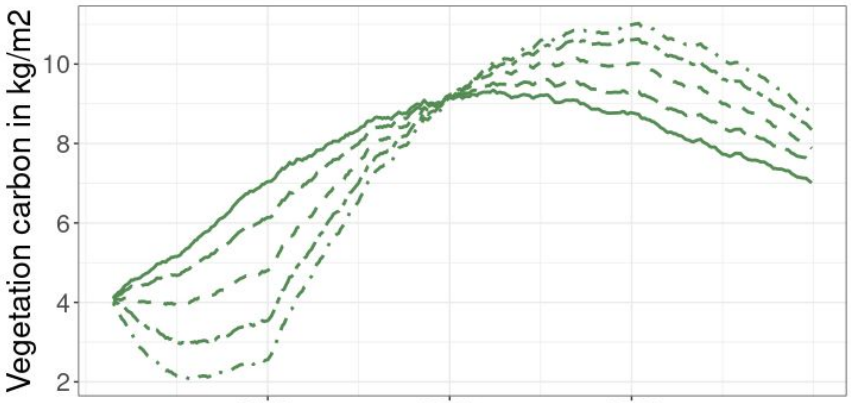


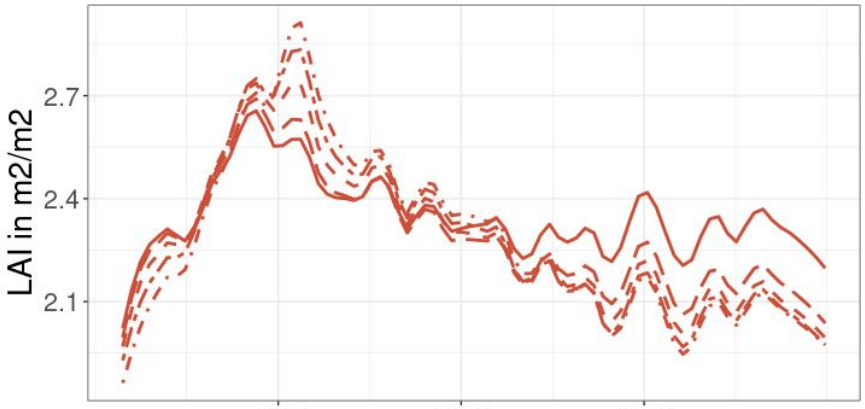
Long-term dynamics after 2100

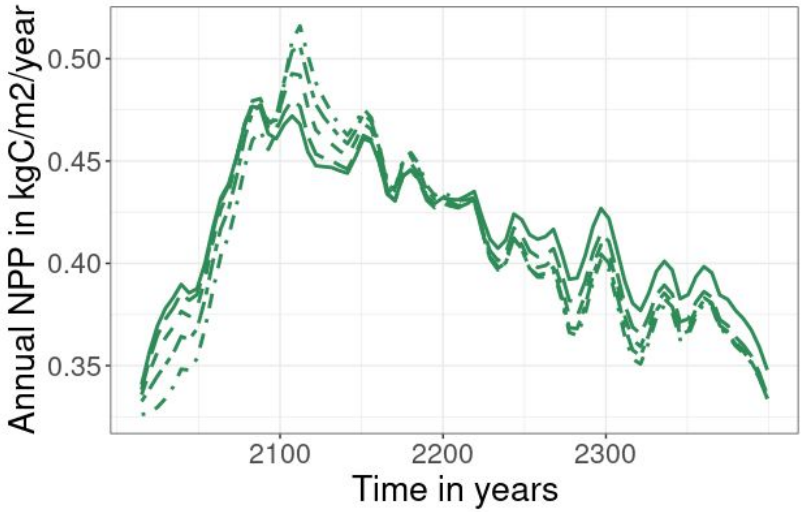


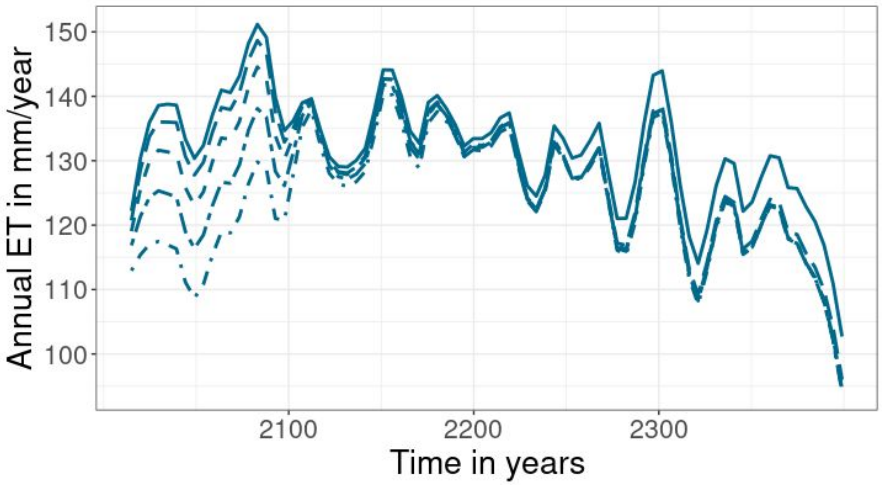


Carbon-cycle and climate-relevant impacts



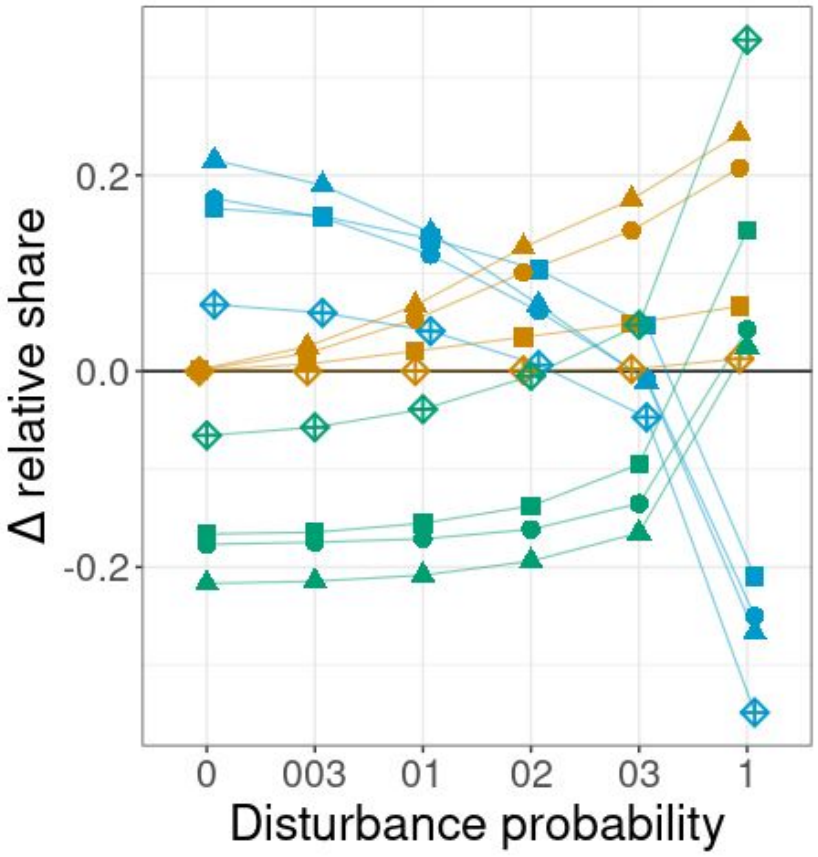






Changes in relative share by 2100

absolute changes vegetation carbon



absolute changes ET