Einfluss des Klimawandels auf Ökosysteme und Artengemeinschaften

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Die Absterberate ist der Anteil der Bäume in der Stichprobe, die zur Zeit der Erhebung noch stehen, jedoch seit der vorhergehenden Erhebung abgestorben sind. Wie die folgenden drei Abbildungen zeigen, war die Absterberate 2020 überdurchschnittlich hoch. Vor allem die Fichte und die Gruppe der anderen Laubbäume sind 2020 von einer im Vergleich zu den restlichen Baumarten sehr hohen Absterberate betroffen. Bei der Buche konnte eine geringere Absterberate als im Vorjahr festgestellt werden.

Abbildung 35: Absterberaten bei Laub- und Nadelbäumen sowie insgesamt
concentrations have declined (21). Several 2.6 °C warmer than late 20th century temperatures

Fig. 1. Temperature trends for the past 65 Ma and potential geohistorical analogs for future climates. Six geohistorical states (red arrows) of the climate system are analyzed as potential analogs for future climates. For context, the center of the meteorological instrumental period that is the modern observations, and future temperature projections for four emissions pathways (RCPs), RCP4.5 and RCP8.5, and find geohistorical analogs using climate simulations produced by Earth system models (ESMs). We focus on two Representative Concentration Pathways (RCPs), RCP4.5 and RCP8.5, and find geohistorical analogs for RCP4.5 climates, but its prevalence and the ranking of the Mid-Pliocene is consistently one of the best analogs for RCP4.5 throughout the entire 2020 decade from 2020 to 2280 CE. Future climates that exceed closest analogs for RCP4.5 throughout the entire 2020 future decade from 2020 to 2280 CE. Future climates that exceed similar climate). We apply this global similarity assessment to each periods (providing 18.1 and 16.8% of analogs at 2280 CE, respectively), while the Mid-Holocene and the LIG provide 16.2 and 2). By 2040 CE, they are replaced by the Mid-Pliocene, which best analogs for 21st century climates for both RCP scenarios (Fig. 2). Hence, RCP4.5 is most akin to a Pliocene commitment scenario, with the planet persisting in a climate state most periods (22), there was no permanent ice, and atmospheric CO

Die Welt wird sich verändern!

Burke et al. 2018 PNAS
Global fossil CO$_2$ emissions: 34.8 ± 2 GtCO$_2$ in 2020, 53% over 1990

- Projection for 2021: 36.4 ± 2 GtCO$_2$, 4.9% [4.1%–5.7%] higher than 2020

The 2021 projection is based on preliminary data and modelling.
Source: Friedlingstein et al 2021; Global Carbon Project 2021
Tree species and biome data

As response variable we used species distribution data from a pan-European, regularly distributed monitoring dataset from the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forest), depicting presence or absence of 139 tree species for a wide range of climatic conditions. Figure 2 shows the spatial allocation of plots over Europe. Each country has set up a 16 km regular network, with plots allocated in forests only. The only exception of the 16 km rule is in northern Sweden, where plots were allocated in a 32 km network.

Figure 2: Distribution of the ICP Forest Level I Plots over Europe representing a 16x16 km grid (except northern Fennoscandia with a 32x32 km grid). A total of 6129 plots were used, encompassing 139 tree species.

We extracted the data from the inventory years 2004, with some updates from 2005 for countries that did not report in 2004. In summary, we had 139 tree species available.
Einige Hauptbaumarten

Historic  
RCP 4.5  
RCP 8.5

Projected relative abundance probabilities for the four most abundant tree species *Pinus sylvestris*, *Picea abies*, *Fagus sylvatica*, and *Quercus robur* for current analogs (left panels), RCP 4.5 analogs (mid panels), and RCP 8.5 analog (right panels). Relative abundance probability increases from gray over yellow to green colors.
FIGURE 2 | Projected relative abundance probabilities for the four most abundant tree species Pinus sylvestris, Picea abies, Fagus sylvatica, and Quercus robur for current analogs (left panels), RCP 4.5 analogs (mid panels), and RCP 8.5 analog (right panels). Relative abundance probability increases from gray over yellow to green colors.
Winter temperatures, by contrast, are very similar between the variants. This makes the low variants more oceanic and the high variants more continental compared to the mean variant. From a geographic perspective, the twin regions of the low variant should, therefore, shift northwards and of the high variant southwards compared to the mean variants. From a time perspective, the twin regions of the low variant should shift towards later times and of the high variant towards earlier times compared to the mean variant. In both the RCP 4.5 and the RCP 8.5 variants, the time shift is clearly visible: areas that are green (2040) or yellow (2060) in the low variant become blue (2020) or green (2040) in the high variant. The upper Rhine valley, for instance, is a 2060 twin region in the low RCP 8.5 variant but a 2040 twin region in the high variant. In the low RCP 4.5 variant, the valley is even dark red (2100) while green (2040) in the high variant. The geographic north-south shift, however, is hardly observable. More obvious is a west-east (continentality) shift between the variants. In the low RCP 8.5 variant, e.g., oceanic regions like the French Gascogne become twin regions. The twin regions in the lower Po-valley in the high RCP 8.5 variant are both the result of the higher summer temperature and continentality.

Figure 4. Twin region maps for site Roth (a) low RCP 4.5 variant, (b) low RCP 8.5 variant, (c) high RCP 4.5 variant, (d) high RCP 8.5 variant.

3.2. Prevalence Trajectory Graphics

The prevalence trajectory graphics in Figure 5 display the relative prevalence of 23 major tree species in the twin regions along the geographic trajectories of the RCP 4.5 and RCP 8.5 mean variant for the site Roth (corresponding to Figure 3). The graphics of the low and high RCP variants can be viewed in the supplement (Figure S2). The grey numbers below the axis indicate that the number of plots in the twin regions are highest for 2000 and 2020 and decrease towards 2100—in the RCP 8.5 much stronger than in the RCP 4.5. The grey numbers on the right vertical axis are high especially for species with high prevalence between 2000 and 2060. Low counts are typical for species with low prevalence in general or a high prevalence in the much scarcer 2080- and 2100-twin regions.
Die projizierten Niederschlagsänderungen im Sommer (Abb. 7.5, links) und Winter (Abb. 7.5, rechts) zeigen unterschiedliche Signale.

For latest results see also Coppola et al. 2020 Journal of Geophysical Research - Atmospheres
Dürregeschädigte und –tolerante Individuen unterschieden sich systematisch an mindestens 80 Genorten.
Frankfurter Stadtwald vor 120 Jahren

„Ich habe in diesen Mittelgebirgen keinen einzigen Baum gefunden, der stark genug gewesen wäre, um einen Förster daran aufzuhängen“

(ein namentlich nicht bekannter hessischer Oberförster um 1800; Backhaus et al. 2000, Seite 22)

Wer hält mit und wer nicht?

Geißklee-Bläuling  
*Plebejus argus*

Waldbrettspiel  
*Pararge aegeria*

C-Falter  
*Polygonia c-album*

Die Generalisten werden gewinnen!

Schwarz: Vorkommen 1970-82  
*Rosa*: Kolonisation bis 1995-99  

Viele Insekten halten mit!
(hier 85 Spinnenarten in Großbritannien)

![Histogram showing observed latitudinal shifts](Chen-et-al-2011-Science.png)

The diagram illustrates the percentage of species showing observed latitudinal shifts in kilometers. The x-axis represents the observed latitudinal shifts, while the y-axis shows the percentage of species.

Chen et al. 2011 Science.
Neue Arten kommen aus dem Süden

Abb. 1: Der wärmeliebende Bienenfresser (*Merops apiaster*) aus dem Mittelmeerraum brütet inzwischen in vielen Regionen Deutschlands. © lucaar/Fotolia

**HLNUG 2019: Auswirkungen des Klimawandels auf hessische Arten und Lebensräume – Liste potentieller Klimaverlierer**
Die Welt brennt überall außer bei uns.
Values in Millions of ha

Value in 1987: 153 Mha yr⁻¹
Value in 2008: 211 Mha yr⁻¹

The flow of cropland associated with interregional trade increased from 44% in 1987 to 58% in 2008 of the total area related to interregional trade. Values are 3-year means around the respective year. Figure S3 presents the same picture for crop products aggregated in terms of dry matter biomass.

Table 1. Global trends in cropland area and the amounts of cropland associated with international, inter- and intraregional trade. Values are 3-year means around the respective year. Table S5 presents the same results for crop products aggregated into dry matter biomass.

Area harvested (%) Annual changes rates (%)

<table>
<thead>
<tr>
<th>Year</th>
<th>Global cropland area (Mha)</th>
<th>For domestic use</th>
<th>For export</th>
<th>Interregional trade</th>
<th>Intraregional trade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>1172</td>
<td>995</td>
<td>178</td>
<td>153</td>
<td>25</td>
</tr>
<tr>
<td>1997</td>
<td>1217</td>
<td>1012</td>
<td>205</td>
<td>157</td>
<td>48</td>
</tr>
<tr>
<td>2008</td>
<td>1321</td>
<td>1049</td>
<td>272</td>
<td>211</td>
<td>52</td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>

For domestic use:
- 1987: 995 Mha yr⁻¹
- 1997: 1012 Mha yr⁻¹
- 2008: 1049 Mha yr⁻¹

For export:
- 1987: 178 Mha yr⁻¹
- 1997: 205 Mha yr⁻¹
- 2008: 272 Mha yr⁻¹

Interregional trade:
- 1987: 153 Mha yr⁻¹
- 1997: 157 Mha yr⁻¹
- 2008: 211 Mha yr⁻¹

Intraregional trade:
- 1987: 25 Mha yr⁻¹
- 1997: 48 Mha yr⁻¹
- 2008: 52 Mha yr⁻¹

Global population (Mio capita):
- 1987: 5030
- 1997: 5887
- 2008: 6740

Table 2 reveals that such an approach can cover just over two thirds of the cropland area linked to international trade. The absolute magnitude of this effect almost doubled during the two decades covered in this study, from 43 to 88 Mha yr⁻¹.

The effect of crop product trade on global area efficiency is estimated by calculating how much land would have been needed to meet global demand based only on domestic production, i.e. assuming domestic yields. This calculation yields a cropland demand significantly larger than the actual global extent of cropland (table 2, 7% in 2008). The numbers reveal that presently crop product trade flows from nations with higher yields to nations with lower yields: in 2008, yields of importers were, on average, 30% lower than those of exporters. The absolute magnitude of this effect almost doubled during the two decades covered in this study, from 43 to 88 Mha yr⁻¹.
Zusammenfassung

• Ca. 300-500 km Verschiebung der Klimazonen (aus Südwesten)

• Mehr Extremereignisse (Dürren und Überschwemmungen)

• Wir brauchen diverse Landschaften zur Risikostreuung

• Verteidigung des Status Quo nicht immer eine Option

• Klimaanpassung, Klimaschutz und Biodiversitätsschutz sind kein Gegensatz!