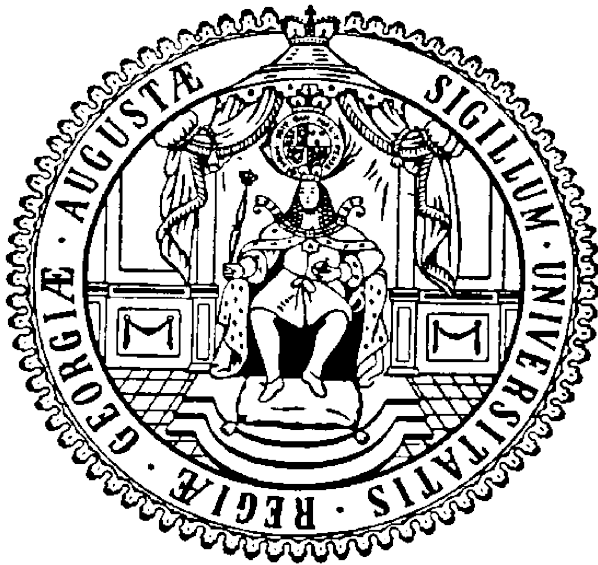# Data Analysis with R in Agricultural Economics - Mayday for future: Analyzing biodiversity effects on rubber and oil-palm plots in Jambi, Indonesia

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Master program: Development Economics

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Abstract

Biodiversity loss due to transformation of tropical rainforest into utilizable land is one of the most relevant environmental topics of our time.

Keywords: *Rubber, palm oil, Jambi, Indonesia, small-scale farming, species richness, lowland rainforest transformation*

1 Introduction

This seminar paper was written as a final paper of the course *Data Analysis with R in Agricultural Economics* which took place in March, 2019. Not withstanding the other topic options, e.g. Time Series, Panel Data or gravity models in trade, I chose to pursue my own seminar paper project. The data I use is about species, more precisely, plant richness in rubber and palm-oil plantations. More details about the data characteristics are provided in the first section of the main part.

The C01-project is only one of many projects that are conducted as part of the Collaborative Research Centre 990. The University of Göttingen describes its own research project as follows:

> "EFForTS is a Collaborative Research Centre 990 funded by the DFG Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) that investigates the ecological and socioeconomic effects of such transformation based on research carried out in the Bukit Duabelas and Hutan Harapan area in Jambi province focusing on smallholder systems."

Especially Palm-oil has been widely discussed in the media and it is often mentioned as one of the principal causes of rainforest clearing. The data we collected is highly relevant from an interdisciplinary point of view, bringing ecological, agricultural and socioeconomic problem sets together.

The research question asks: *Is there a negative trend of plant richness described by the data?*

2 Main part

2.1 Data structure

The data was collected in three rounds from 2012 to 2018 in Jambi Province in Sumatera, Indonesia. The last round, 2018, was collected by my colleague Bernhard Dalheimer, our Indonesian assistants and me. The C01 sample represents a subsample within the major C-group's sample of 831 plots of around 750 small-scale farmer households. Its size is around 200 households, whereas in each round c.a. 20 additional plots - which then cannot be used for the panel data analysis - were included.

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Table 1: Data extract

household ID	Number of species
12	18
15	6
22	12
25	9
29	13
34	13
37	14
39	17
40	5
44	7

The C-group sample was designed as a representative sample of the small-scale farmers in Jambi province, Indonesia. $\frac{3}{4}$ of the households are rubber farmers, roughly $\frac{1}{4}$ of the sample produces palm oil. The rubber farmers can be divided into jungle rubber and rubber plantation groups. The distinction of these two groups plays an important role concerning biodiversity on the plots, I will continue pointing this out in the biodiversity section. About the sampling framework, the responsible researchers (Faust et al. 2013: 16) wrote the following:

> "Five regencies, which comprise most of the lowland transformation systems of Jambi province, were selected purposively. These regencies are Sarolangun, Bungo and Tebo as the ones in proximity of the Bukit Duableas National Park as well as Batanghari and Muaro Jambi, representing the Harapan Rainforest research area. In order to capture geographical disparity and regional diversity, the number of villages per regency and district was fixed. From each of the selected regencies, five districts and four rural villages from each of these districts were selected randomly."

In this research framework, the C-groups are rather concerned about socioeconomic data, whilst the other supergroups are closer to natural sciences. The data collection for C01 consisted in:

- plant richness data collection
- soil data collection
- soil sample processing

Within this context, the field study lived up to its name, as for the data collection it was necessary to reach a specific spot deep into the rubber or palm oil plantations. We arrived to the exact same spot either thanks to GPS navigation, or to the farmers' memories about the last C01 visit. Subsequently, the 25m² square was built up and all the plants in this quadrant were counted and listed.

In the 2018 round, slightly less than 10% of the sample could not be visited, either because the farmer was unavailable or because he gave up his plot.

Table 2: Total number of species per year

Wave	Species
2012	541
2015	1477
2018	268

2.2 Literature insight

Both rubber and oil palm farmers have in common that most of them do not depend entirely on the earnings of their agricultural activity; many of them pursue further economic activities and have e.g. a small retail trade or work as a mechanic.

Sayer et al. (2012) formulates the four truths about palm oil, which "should be acknowledged in any meaningful debate about the topic:

1. the demand for oil palm will continue to increase in response to a growing and increasingly affluent global population
2. oil palm is one of the most profitable land uses in the humid tropics
3. oil palm plantations store more carbon than alternative agricultural land uses
4. native biodiversity within oil palm plantations is far lower than in the natural forests they often replace

However, biodiversity is always reducing substantially regarding any type of large scale agriculture which uses the same land than the former rainforest. Also rubber, banana or cocoa plantations have a negative biodiversity balance regarding autochthonous rainforests.

2.3 Methodology

Beyond descriptive statistics which are presented in this paper, a more analytical approach is the use of biodiversity measures. For our C01 dataset the use of species richness indices such as the Simpson and the Shannon Index are the most appropriate. For the mapping I will use the Shannon index, which is for the sake of comparableness of the plots or, in this case, of the regency means. The formula of the Shannon index is as follows:

$$H = -\sum_{i=1}^{s} p_i \ln p_i \tag{1}$$

Where s is the total number of species - in our case, we apply the total number of species found in each round. p is the proportion - as long as the formula is applied at plot level - of the species i found in one plot over all species. This proportion is then multiplied by the natural logarithm of the same. The index accounts for both abundance and evenness of the species found and the outcome of this index in one plot is comparable to the one of another plot in the same round.
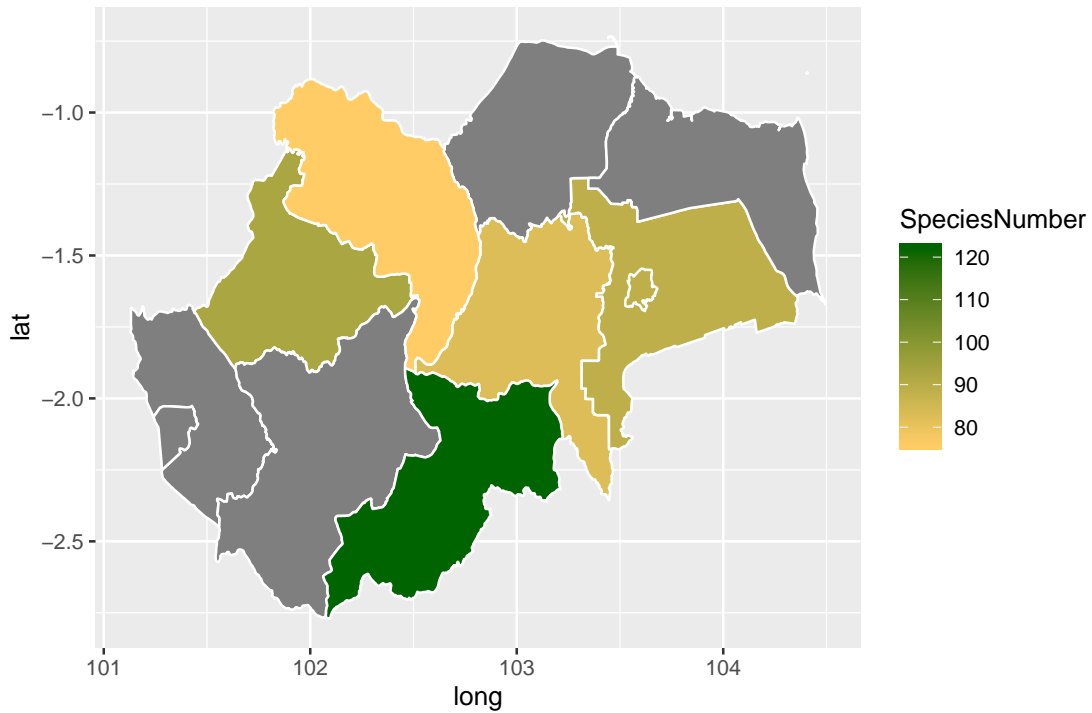
$$D = \frac{1}{\sum_{i=1}^{s} p_i^2} \tag{2}$$

Total number of C01 observations
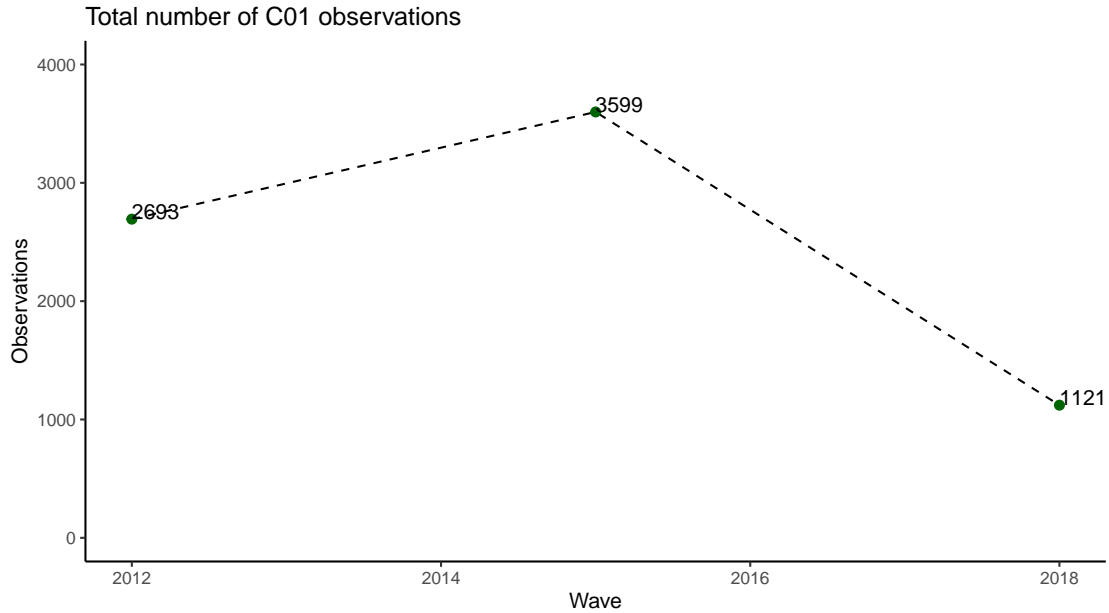

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## 1 465 103.4431 -2.064814     1 FALSE     1 465.1   IDN Indonesia IDN.8_1
## 2 465 103.4465 -2.062286     2 FALSE     1 465.1   IDN Indonesia IDN.8_1
## 3 465 103.4466 -2.087259     3 FALSE     1 465.1   IDN Indonesia IDN.8_1
## 4 465 103.4466 -2.106210     4 FALSE     1 465.1   IDN Indonesia IDN.8_1
## 5 465 103.4466 -2.113944     5 FALSE     1 465.1   IDN Indonesia IDN.8_1
## 6 465 103.4466 -2.133413     6 FALSE     1 465.1   IDN Indonesia IDN.8_1
##   NAME_1 NL_NAME_1     GID_2     NAME_2 VARNAME_2 NL_NAME_2    TYPE_2
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## 6  Jambi      <NA> IDN.8.1_1 Batang Hari      <NA>      <NA> Kabupaten
##   ENGTYPE_2 CC_2   HASC_2
## 1   Regency 1504 ID.JA.BA
## 2   Regency 1504 ID.JA.BA
## 3   Regency 1504 ID.JA.BA
## 4   Regency 1504 ID.JA.BA
## 5   Regency 1504 ID.JA.BA
## 6   Regency 1504 ID.JA.BA
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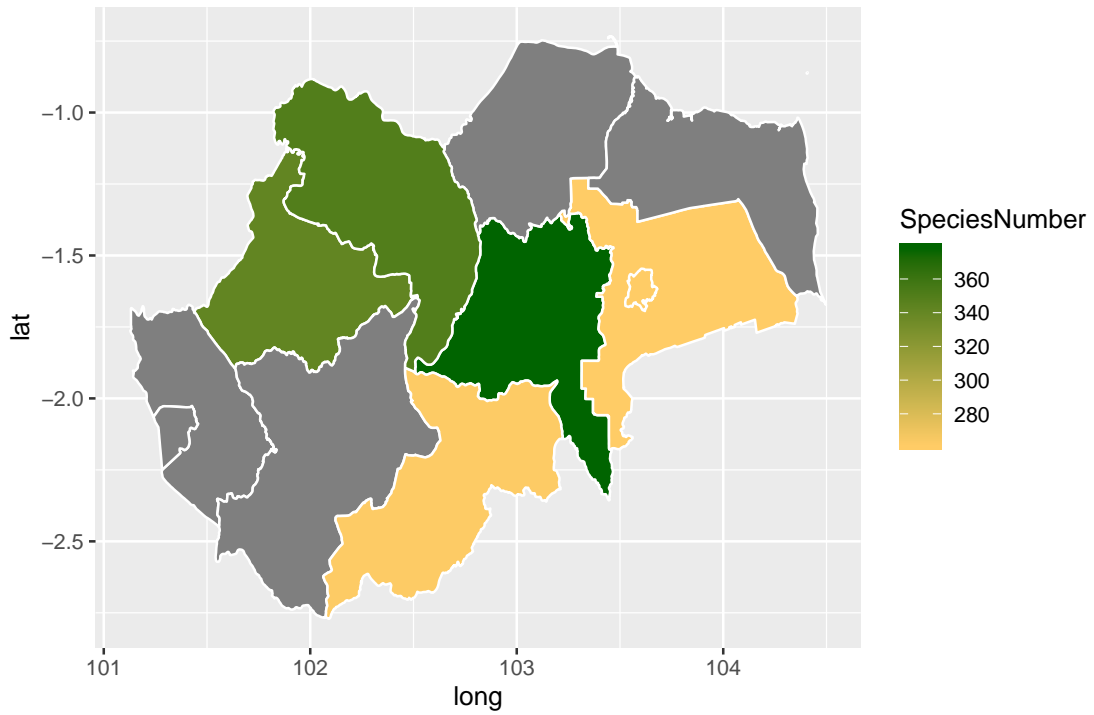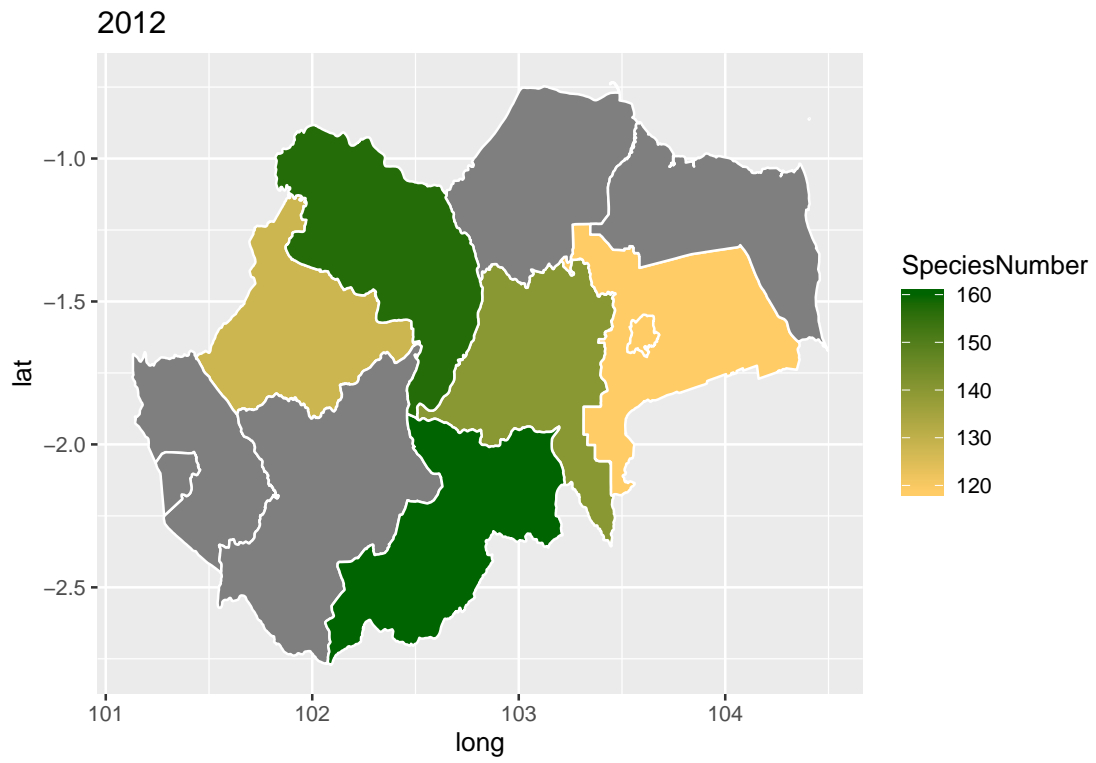
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##    id      long        lat order  hole piece  group GID_0   NAME_0   GID_1
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## 2 465 103.4465 -2.062286     2 FALSE     1  465.1   IDN Indonesia IDN.8_1
## 3 465 103.4466 -2.087259     3 FALSE     1  465.1   IDN Indonesia IDN.8_1
## 4 465 103.4466 -2.106210     4 FALSE     1  465.1   IDN Indonesia IDN.8_1
## 5 465 103.4466 -2.113944     5 FALSE     1  465.1   IDN Indonesia IDN.8_1
## 6 465 103.4466 -2.133413     6 FALSE     1  465.1   IDN Indonesia IDN.8_1
##   NAME_1 NL_NAME_1      GID_2     NAME_2 VARNAME_2 NL_NAME_2    TYPE_2
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## 4  Jambi      <NA> IDN.8.1_1 Batang Hari      <NA>      <NA> Kabupaten
## 5  Jambi      <NA> IDN.8.1_1 Batang Hari      <NA>      <NA> Kabupaten
## 6  Jambi      <NA> IDN.8.1_1 Batang Hari      <NA>      <NA> Kabupaten
##   ENGTYPE_2 CC_2   HASC_2
## 1   Regency 1504 ID.JA.BA
## 2   Regency 1504 ID.JA.BA
## 3   Regency 1504 ID.JA.BA
## 4   Regency 1504 ID.JA.BA
## 5   Regency 1504 ID.JA.BA
## 6   Regency 1504 ID.JA.BA
```

2015


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##    id     long       lat order  hole piece group GID_0    NAME_0   GID_1
## 1 465 103.4431 -2.064814     1 FALSE     1 465.1   IDN Indonesia IDN.8_1
## 2 465 103.4465 -2.062286     2 FALSE     1 465.1   IDN Indonesia IDN.8_1
## 3 465 103.4466 -2.087259     3 FALSE     1 465.1   IDN Indonesia IDN.8_1
## 4 465 103.4466 -2.106210     4 FALSE     1 465.1   IDN Indonesia IDN.8_1
## 5 465 103.4466 -2.113944     5 FALSE     1 465.1   IDN Indonesia IDN.8_1
## 6 465 103.4466 -2.133413     6 FALSE     1 465.1   IDN Indonesia IDN.8_1
##   NAME_1 NL_NAME_1     GID_2     NAME_2 VARNAME_2 NL_NAME_2    TYPE_2
## 1  Jambi      <NA> IDN.8.1_1 Batang Hari      <NA>      <NA> Kabupaten
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## 3  Jambi      <NA> IDN.8.1_1 Batang Hari      <NA>      <NA> Kabupaten
## 4  Jambi      <NA> IDN.8.1_1 Batang Hari      <NA>      <NA> Kabupaten
## 5  Jambi      <NA> IDN.8.1_1 Batang Hari      <NA>      <NA> Kabupaten
## 6  Jambi      <NA> IDN.8.1_1 Batang Hari      <NA>      <NA> Kabupaten
##   ENGTYPE_2 CC_2   HASC_2
## 1   Regency 1504 ID.JA.BA
## 2   Regency 1504 ID.JA.BA
## 3   Regency 1504 ID.JA.BA
## 4   Regency 1504 ID.JA.BA
## 5   Regency 1504 ID.JA.BA
## 6   Regency 1504 ID.JA.BA
```

2012

2.4 Discussion of the findings

3 Conclusion