

CREATING MAPS IN R (CASE STUDY: NATIONAL PARK “FRUŠKA GORA”)

MILENA LAKIĆEVIĆ*

Faculty of Agriculture, University of Novi Sad, Trg Dositeja Obradovića 8, 21 000 Novi Sad, Serbia

*Corresponding author: milenal@polj.uns.ac.rs

SUMMARY

This paper aims to present the possibilities for creating maps in the programming language R. Even though R is primarily developed as a statistical program, its application in the area of mapping and spatial statistics is becoming frequent and highly relevant. Many R packages make the mapping process easier and user-friendly, and this paper presents the most commonly used ones: “leaflet”, “ggplot2” and “ggmap”. The selection of the R package depends on the user’s proficiency in R programming but also depends on the visual quality of the map the user wants to gain. Based on the questionnaire conducted in this research, the paper recommends application of the “leaflet” package for the beginners, the “ggplot2” package for medium proficient users, and the “ggmap” package for the most advanced R users. After creating maps in R it is possible to conduct additional analysis related to processing of the spatial data contained within, and this would be a recommendation for future research. In this paper, the mapping process is demonstrated on the case study of the National Park “Fruška gora” in Serbia, and different types of maps are presented.

Key words: R program, mapping, landscape planning, National park “Fruška gora”

INTRODUCTION

Creating maps is a common and important part of landscape planning tasks (Wende et al., 2020). Maps are usually created by using GIS tools, but in recent years R programming language has also become an important tool for mapping assignments (Rahlf, 2017). The R program offers many packages that support mapping procedures and these packages require different levels of programming proficiency (Lakicevic et al., 2020). There are packages suited for the beginners and the ones that require a higher level of programming skills, which are therefore suitable for advanced users only (Brus, 2019). This paper presents the most commonly applied R packages, including “leaflet”, “ggplot2” and “ggmap”. The “leaflet” package can be used without much previous experience in working in the R environment, “ggplot2” requires medium proficiency, while “ggmap” is the most advanced one. The goal of the paper is to present outlook of the obtained maps and to analyze the strengths and weaknesses of each R package. The selected case study is the National Park “Fruška gora” in Serbia. The results section presents the maps of the National Park created in these three R mapping packages. In addition to previewing and analyzing the maps of the National Park “Fruška gora”, the paper also provides the results of a questionnaire conducted with the third-year students of Landscape Architecture study program at the Faculty of Agriculture, University of Novi Sad. The questionnaire included inquiries regarding the time effectiveness, the required proficiency in R programming, the visual quality of the maps created in different packages, etc. The paper can be a guideline for future mapping assignments in landscape planning of diverse areas and zones. Besides, the paper is relevant for all scientists that need maps for presenting the study area they work on, conducting their field measurements, etc. In these terms, the paper aims to help users in selecting the most appropriate R package according to the type of a map they want to produce, as well as their programming and mapping competencies and skills.

MATERIAL AND METHODS

The selected case study is the National Park “Fruška gora” (Serbia), and the goal of this paper is to create several maps presenting this protected area by using the R program, and the appropriate R packages: “leaflet” (Cheng et al., 2018), “ggplot2” (Wickham, 2016) and “ggmap” (Kahle & Wickham, 2013). The input data were the geographic coordinates (longitude and latitude), and there were 382 pairs of coordinates, imported from Google Earth. These pairs of geographic coordinates were introduced into the R environment first and then further processed in each R package. As a result, there are several maps created and the following section will discuss some of their main features. The first map presents the position of the National Park “Fruška gora” on the map of Serbia, while the others present the borders of the National Park on different base maps. In addition, the research included the questionnaire completed by 20 third-year students of Landscape Architecture at the Faculty of Agriculture in Novi Sad. The questions are presented in Tab. 1. The students used the R program and analyzed the packages during one semester of the course Environment and Sustainable Development. The survey was conducted at the end of the semester after they had got acquainted with the program. None of the students had any previous experience in working in R before the course.

Table 1. Questionnaire, R mapping packages (“leaflet”, “ggplot2” and “ggmap”)

Questions	Scale	Explanation
Requirement for previous R programming experience	1-5	1 (none), 5 (high)
Time effectiveness (time needed for producing maps)	1-5	5 being the most effective
User-friendly commands	1-5	5 being the most user-friendly
Flexibility of the preview (interactive maps)	1-5	5 being the most flexible
Visual quality of the map	1-5	5 being the highest quality

Students answered each question by assigning scores from 1 to 5 for each feature for all three packages. The results section presents the average score for each assessment (Tab. 2).

RESULTS AND DISCUSSION

The input data i.e. geographic coordinates enable creation of different types of maps. The first map presented shows the spatial disposition of the National Park “Fruška gora” on the map of Serbia (Fig. 1). This map was created by using the “ggplot2” package, and the outlook of the map can be easily modified, the colors can be easily changed, all annotations can be placed differently, a legend can be added, etc. The presented output is the most commonly used one.



Figure 1. National Park “Fruška gora”, “ggplot2” package

The following figures present the outlook of the maps showing the borders of the National Park “Fruška gora”. The easiest procedure for creating maps in R involves using the “leaflet” package, and the result is shown in Fig. 2.

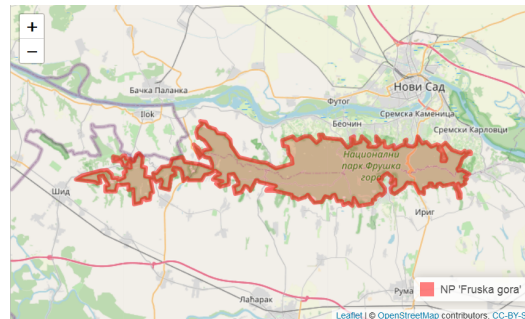


Figure 2. National Park "Fruška gora", "leaflet" package

The map in Fig. 2 is interactive, i.e. it is possible to zoom in or zoom out the obtained preview (signs "+" and "-" at the top left), and this is one of the main strengths of this package. The visual quality of the map can be assessed as medium, but this package is recommended when starting to work on mapping in R. The following map (Fig. 3) is created in the "ggplot2" package and required knowledge of the basic commands and syntax for working in the R environment.

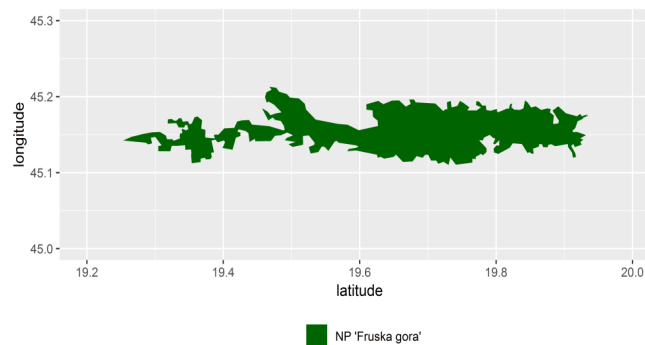


Figure 3. National Park "Fruška gora", "ggplot2" package

This preview presents only the borders of the National Park, without previewing the surrounding area, toponyms, etc. However, the preview is placed in the grid, showing the values for the latitude and longitude, as well as the spatial disposition of the area.

The following two maps (Fig. 4 and Fig. 5) are created in the "ggmap" package and required full command of R. The visual quality of the maps created in this package is high, and they can be plotted on the different types of maps. Fig. 4 presents the map plotted on the terrain map, with the names of nearby settlements, and with the values for the longitude and latitude.

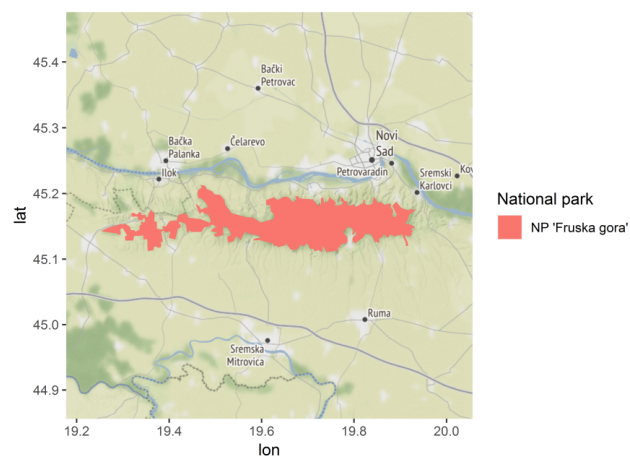


Figure 4. National Park "Fruška gora", "ggmap" package, terrain map

Fig. 4 provides a detailed preview of the surrounding area, but the coordinates are fixed, i.e. the package “ggmap” requires defining the scale right away, and the maps created cannot be additionally zoomed in or zoomed out later on.

Fig. 5 is also created by using the “ggmap” package, but the base map is a satellite map. This type of presentation is the most common one among R users.

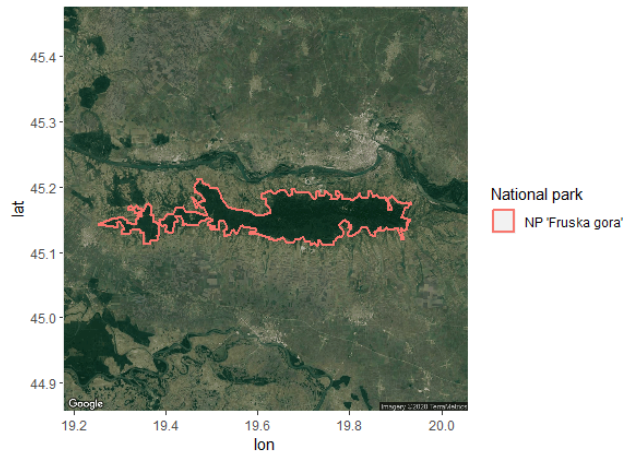


Figure 5. National Park "Fruška gora", "ggmap" package, satellite map

In addition to previewing the outlook of the maps created in different R packages, the research included the questionnaire and the results are presented in Table 2.

Table 2. Results of the questionnaire, R mapping packages (scores 1-5)

Questions	"leaflet"	"ggplot2"	"ggmap"
Requirement for previous R programming experience	1.6	2.8	4.6
Time effectiveness (time needed for producing maps)	4.4	3.8	3.2
User-friendly commands	4.7	3.5	2.9
Flexibility of the preview (interactive maps)	4.9	2.7	2.7
Visual quality of the map	3.8	4.5	5.0

Table 2 shows that the package “leaflet” is assessed as the least demanding in terms of having previous R experience (the average score is equal to 1.6), while the “ggmap” is the most demanding one (the average score is 4.6). This result confirms that “leaflet” can be useful for the beginners, while more advanced packages can be used after gaining some mapping practice in R. The similar conclusion can be drawn by analyzing the answers for the following question which is related to the time effectiveness: the “leaflet” package has the best score, but it should be noted that the scores for the “ggplot2” and “ggmap” packages are also assessed as good (3.8 and 3.2, respectively). The scores for user-friendly commands and flexibility of the preview, in terms of possibilities for additional zooming in and out of the preview and creating interactive maps are the highest for the “leaflet” package. When analyzing the visual quality of the maps created, the highest and maximum score (5.0) has been assigned to the “ggmap” package, and the general recommendation would be to use this R package when the appearance of the map is important.

CONCLUSION

Creating maps is an integral part of the process of landscape planning and defining landscape management strategies. In addition, maps are important in different agricultural research studies, for example when conducting fieldwork at different locations which should be presented and stored in appropriate spatial databases. Different programs can be used for mapping purposes, and GIS tools are the most commonly used ones. However, in recent times many maps have been created in the programming language R, as it offers great flexibility in terms of map appearance and its further processing. This paper analyzes three most commonly used R packages, “leaflet”, “ggplot2” and “ggmap”, and provides a general recommendation on the choice of the package depending on the user’s proficiency in programming and previous work in R, but also based on the features of the maps obtained as the output. Based on the

conducted questionnaire, the recommendation would be to use the “leaflet” package when starting to work in R, the “ggplot2” package after acquiring medium proficiency in R programming, while the “ggmap” package would be recommended for the most advanced R users. When considering the visual quality of the maps, the “ggmap” package is the leading one for producing high-quality maps, providing many options for diverse graphical representations and plotting final maps on different base maps such as satellite, terrain, hybrid, etc. The “ggplot2” package is an appropriate substitute for the maps produced in the “ggmap” package, when the mapping task implies producing maps only in the geographic coordinates grid, without names of nearby toponyms, preview of surrounding relief, etc. The “leaflet” package enables producing a map of medium visual quality, but this package can be used when the task is to produce an interactive map, that can be additionally zoomed in or zoomed out. The feature of creating an interactive map is provided exclusively by the “leaflet” package, i.e. the “ggplot2” and “ggmap” packages do not have this option available.

The recommendation for future research would be to include numerical spatial-related data and demonstrate the possibilities of R application for spatial analysis and spatial statistics.

REFERENCES

- Brus D.J. (2019): Sampling for digital soil mapping: A tutorial supported by R scripts. *Geoderma*, 338, 464-480. <https://doi.org/10.1016/j.geoderma.2018.07.036>.
- Cheng J., Karambelkar B., Xie Y. (2018): leaflet: Create Interactive Web Maps with the JavaScript 'Leaflet' Library. R package version 2.0.2. <https://CRAN.R-project.org/package=leaflet>
- Kahle D. & Wickham H. (2013): ggmap: Spatial Visualization with ggplot2. *The R Journal*, 5(1): 144-161.
- Lakićević M., Povak N., Reynolds K.M. (2020): *Introduction to R for Terrestrial Ecology*. Springer, Basel, Switzerland.
- Rahlf T. (2017): *Data Visualisation with R*. Springer, Basel, Switzerland.
- Wende W., Walz U., Stein C. (2020): Evaluating municipal landscape plans and their influence on selected aspects of landscape development – An empirical study from Germany. *Land Use Policy*, 99, 104855, <https://doi.org/10.1016/j.landusepol.2020.104855>.
- Wickham H. (2016): *ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag, New York.

Submitted: 09.10.2020.

Accepted: 29.10.2020.