HOW TO GROW? -MODELING LAND USE CHANGE TO DEVELOP SUSTAINABLE PATHWAYS FOR SETTLEMENT GROWTH IN THE HINTERLAND OF COLOGNE, GERMANY

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ABSTRACT:

Urban sprawl, with its negative consequences for nature and agriculture, is one of the great challenges of the 21st century. A particular problem is the strong population growth in metropolitan regions and the associated need for new residential areas. For the study area presented in this article, the western part of the Cologne metropolitan region, an increase of up to 200,000 inhabitants (30% of the population in 2040) is expected by 2040. If planning practices remain unchanged, this would result in a need for up to 4,460 hectares of new residential areas by 2040. Much of this development would take place at the edge of existing residential areas which frequently are of high value for agricultural production. To simulate different scenarios for the allocation of the necessary residential areas in the study area, a land use model was developed based on an open software stack. To evaluate the results of the simulations, a set of 20 indicators covering aspects of agriculture, ecology, housing and economy was used to assess both the sustainability and quality of possible new residential areas.In this article, two scenarios were used to show the effects of different building densities and the protection of particularly high-quality agricultural land. While the increase in building density is expected to reduce the area needed for new residential areas, the protection of high value agricultural land has negative effects on species protection. Using two species as examples, the limitations of an indicator-based assessment of the model results are shown.

1. INTRODUCTION

Urban sprawl, with its negative consequences for nature and agriculture, is one of the great challenges of the 21st century (Hennig et al., 2015). For this reason, the United Nations called for sustainable urban development for the benefit of people and the environment in Goal 11 of their Sustainable Development Goals. A particular problem is the strong population growth in metropolitan regions and the associated need for new residential areas. For the study area presented in this article, the western part of the Cologne metropolitan region, an increase of up to 200,000 inhabitants (30% of the population in 2040) is expected by 2040 (Martschink, 2017). If planning practices remain unchanged, this will result in a need for up to 4,460 hectares of new residential areas by 2040. Much of this development would take place at the edge of existing residential areas which frequently are of high value for agricultural production. To simulate different scenarios for the allocation of the necessary residential areas in the study area, a land use model was developed as part of the research project “Nachwuchs”. To evaluate the results of the simulations, a set of 20 indicators covering aspects of agriculture, ecology, housing and economy was used to assess both the sustainability and quality of possible new residential areas. In this article, the land use model itself and important simulation results are presented. The following three questions are in the focus of this paper:

1. Is it possible to develop a land use model using only open sources software?
2. Is there a sufficient basis of open data for land use simulations in the case study region?
3. Which recommendations can be drawn for sustainable urban and regional planning in the region?

Since 1990, various land use models have been developed and published (Rienow and Goetzke, 2015; Saxena and Jat, 2019; Agarwal et al., 2002). These models apply a diversity of methodological approaches which involve micro-macro models, cellular automata, genetic algorithms or agent based models.

The use of existing models is, however, frequently complicated by the following issues:

1. The use of the models requires the use of fee-based and close source software
2. Many models are developed as part of research projects and not sufficiently maintained after the end of the research project.
3. The data acquisition requires expert knowledge in remote sensing, GIS and in the use of certain programming languages which might be over the head of the model user.
4. The model is not well suited for the problem at hands.

The last point is hard to avoid as different problems and analysis require different approaches. In line with the famous statement

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by box Box (1976) that all models are wrong but some are useful, it seems unrealistic that a single land use model would be capable to handle the wide range of model applications in land use science. The other three aspects touch on organizational and technical aspects that are easier to overcome. The development of the model presented here focused specifically on readily available open source software components.

2. MATERIALS AND METHOD

2.1 Study Area

The study region covers the western part of the Cologne metropolitan region: the city of Cologne, the Rhein-Erft district and the municipalities of Dormagen and Rommerskirchen (c.f. figure 1). The study area is characterized by a diversity of land use actors with resulting land use conflicts. The region is a highly productive agricultural location with a focus on the cultivation of cereals, vegetables and sugar beets. Chemical industrial production is of importance in the east of the region, especially near the Rhine. The importance as a chemical site is linked historically to the mining of lignite, which is still carried out today in an open-cast mine. Due to climate change mitigation lignite mining and its use in will be phased-out till 2030.Ministerium für Wirtschaft, Innovation, Digitalisierung und Energie et al. (2021) The city of Cologne is a well-known media, research, service and tourism location. Both the continued growth of Cologne as a research and services location and the structural change have led to a high demand for new and often specially trained skilled workers. This demand can currently only be met by an influx into the region.

For this reason, approximately 134,000 new housing units will have to be built by 2040 according to current estimates Martschink (2017). Of these, 30% can presumably be covered by brownfield development. The remaining 70% must be realised by greenfield development. Assuming a development density of 30 housing units per hectare, this corresponds to a demand of 3117 hectares of new residential areas by 2040, i.e. approximately 142 hectares per year. The required land for the greenfield development needs to be almost entirely allocated by the transformation of agricultural land, as the conversion of forest areas is prohibited.

In order to study the impact of this transformation process on agriculture and ecology, and the quality of the new residential areas, two scenarios were simulated. The areas considered for greenfield development in the first scenario (*current practice*) were all agricultural areas outside legally protected areas, such as nature reserves (value for species conservation III and IV)Protected Area Categories (2016). For the second scenario (*maintaining agriculture*), all agricultural areas with a particularly high agricultural production value were additionally excluded.

2.2 Data

To simulate the conversion of agricultural land to residential areas information on the current land use and a set of predictors for the suitability of new housing areas were used. Developments were assessed by means of a set of 30 indicators. The current land use was taken from ALKISALKIS Grundrissdaten | Open.NRW (2018), the official property cadastre of the Federal Republic of Germany. For North Rhine-Westphalia this is available under the Data licence Germany - Zero - Version 2.0 zero-2-0 - GovData (2020) as an Open Data dataset. Were possible open datasets were used for predictors and indicators. Due to data protection issues, some datasets were freely accessible.

Dataset	Source	License
train station	VRS	CC BY 4.0
light rail stop	VRS	CC BY 4.0
retail shops	openstreetmap	ODbL
primary school	openstreetmap	ODbL
motorway slip road	openstreetmap	ODbL
kindergarten	openstreetmap	ODbL

Table 1. Open datasets used for predictors and indicators. For VRS see VRS - Opendata and Open Service - (2022).

To validate the results and to check whether the presented model can potentially transferred to in other regions of Europe, the same scenarios were also simulated on the basis of the land uses of the Corine Land Cover dataset of the European Union from 2018 Corine Land Cover 2018 (raster 100m). Although the ALKIS data of NRW and the Corine Land Cover dataset differ fundamentally in the procedure for determining the land use of individual areas, the delimitation of individual land uses was 80% congruent. The ALKIS dataset is updated more frequently (every six months) than the Corine Land Cover dataset, which is updated every five years. However, the process of incorporating a change in land use into the ALKIS data takes about 2.5 years due to the complex procedure. This does not matter for the validation of the presented model, as the ALKIS data and Corine Land Cover dataset from 2018 were used.

The indicators were derived by a rule based approach based on expert and stakeholder input. We focus here on only two indicators: the ecological value of an area and the value for species conservation. The species protection indicator was based on seven protected and endangered flagship species. The results for two species (Natterjack Toad and European Green Toad) are presented as examples. Due to their habitat requirements, both species are exposed to particular risks from the conversion of agricultural land into settlement areas.

All indicators have a uniform scale with six classes ranging from zero (lowest) to five (highest). For the indicators presented here, indicator values of five are particularly important for species conservation or have a particularly high ecological value.

A common 100 x 100 m grid, as used by the German Federal statistical agencyZENSUS2011 - Homepage (2022), was used for the modelling. All input data and indicator values were resampled to this grid.

The storage of all data necessary to carry out simulations, to evaluate the results and to visualise the results was performed in a Postgresql database with a Postgis extension. In this database, the complete pre- and post-processing of the model was realised with the help of SQL scripts. Within the preprocessing, the data is brought to a uniform projection, clipped to the study area and finally transferred to the 100 m x 100 m grid with the help of intersections. If necessary, geometric and topological errors can be corrected at the beginning of pre-processing with the help of the PostGis function st_makevalid. However, this step was computationally and time intensive.

2.3 The Model

The model follows the well-known approach of micro-macro modelling as implemented in well-known models such as

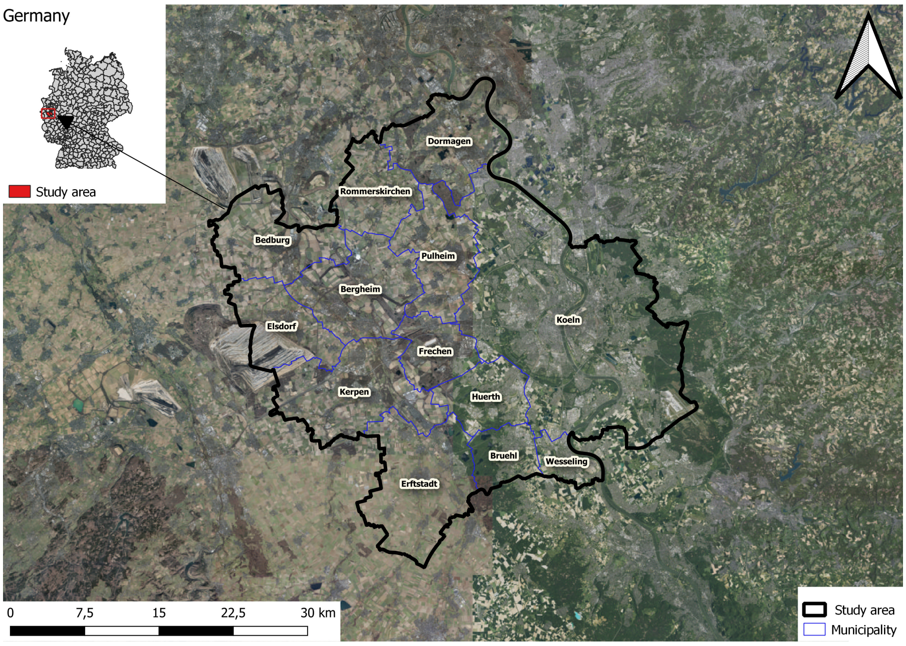

Figure 1. The study area is located in western Germany, covering several municipalities and the city of cologne which are labeled for reference. Large parts of the area are used for agriculture. Also visible at the satellite image is the ongoing open pit mining in the western part of the area.

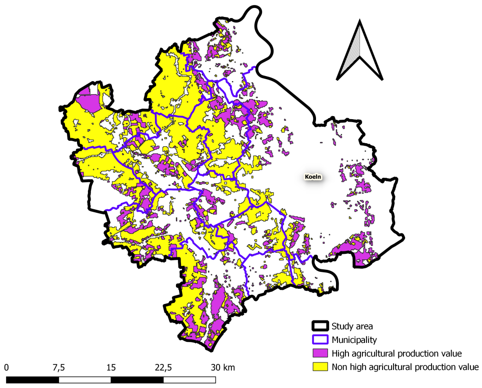

Figure 2. Agricultural areas in the study region. Large shares of the farmland are highly productive. Conversion of those areas to residential areas therefore faces high trade-offs with respect to agricultural productivity.

CLUMondo Van Asselen and Verburg (2013). At the macro level, additional demand for new residential areas is calculated based on the projected population development. The demand for new residential areas to be distributed on a micro level is influenced by the parameters share of brownfield development and the for newly developed areas.

The suitability of areas for new residential areas at the micro level was based on the distance to the nearest feature of the following feature classes:

- train station
- light rail stop
- supermarket
- retail shop area
- motorway slip road
- primary school
- kindergarden

The suitability of grid cells for new housing areas was estimated by a random forest model (Breiman, 2001; Geurts et al., 2006) which was trained on current land use data, taken from ALKIS (ALKIS Grundrissdaten | Open.NRW, 2018). The areas available for the model to allocate new housing areas depend on the scenario assumptions (c.f. table 2). Based on the suitability score new cells are used for new housing areas as long as the demand for a time period is met. The model was run with a time step of one year. The simulation was run from 2018 to 2040 .

	Scenario	
	Current practice	**Maintaining agriculture**
Share of brownfield development [%]	30	30
Building density [1/ha]	50	30
Exclusion areas	protected areas	protected areas, highly productive agricultural areas

Table 2. Scenario settings. Allocation of new residential areas was limited to agricultural land.

The entire model was implemented in Python on the basis of the Anaconda distribution (Anaconda Software Distribution, 2020), using Numpy (Harris et al., 2020), Pandas (McKinney and others, 2010) and scikit-learn (Pedregosa et al., 2011). The model can be used with the QGIS Python libraries up to QGIS version 3.22. The model itself, the functions needed to train the random forest, to communicate with the corresponding PostgreSQL/PostGis database and for necessary tests are encapsulated in object-oriented modules.

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3. RESULTS AND DISCUSSION

The model reached a reasonable goodness of fit (precision: 83%, recall: 90%, f1-score: 87%) for the prediction of residential areas. When the model was trained on the Corine Land Cover data set results, validation against the Corine Land Cover dataset reached a similar model quality (precision: 82%, recall: 87%, f1-score: 85%). The new residential areas predicted by models based on the Corine Land Cover dataset and ALKIS were 90% congruent. In order to further increase the model quality, additional predictors will be included in the future. First of all, the distance to the next bus stop and its frequency of use should be integrated, using data provided by VRS - Opendata and Open Service - (2022).

The different predictors did not differ too much in respect to their feature importance Louppe (2014) (c.f. figure 3). The distance to the nearest train or light train stations had the highest feature importance, highlighting the importance of access to public transport for urban development in the region. These two stations types and the motorway slip road were less evenly distributed across the case study region than the other feature classes which were considered for the distance based predictors.

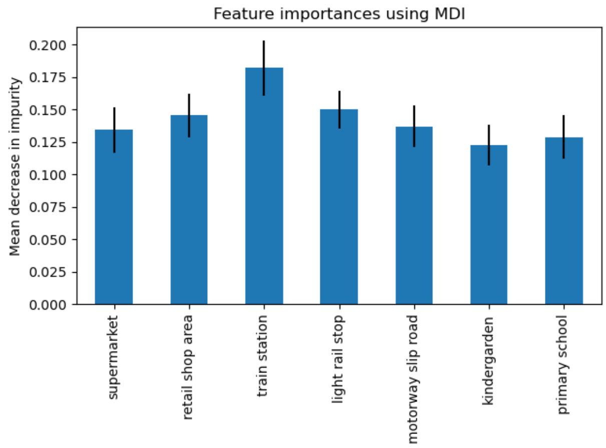

Figure 3. Feature importance of the random forest model, measured by the mean increase in impurity. The vertical bars indicate the standard deviation of the impurity decrease across the trees.

	Scenario	
	Current practice	**Maintaining agriculture**
New residential areas [ha]	1987	3268
Areas with high ecological area value	480	481
Areas with high value for species conservation	765	1207

Table 3. Aggregated results for the two scenario runs. Results are aggregated over the whole case study region and over the complete analysis period (2018 -2040). For both ecological value and species conservation the two highest classes (four and five) were aggregated into a 'high value' class.

Both scenarios assumed the same population growth and the same amount of brownfield development. However, the 'maintaining agriculture' scenario assumed a lower building density

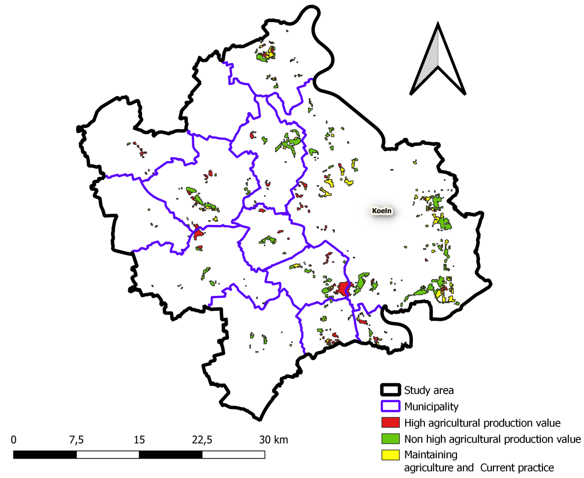

Figure 4. Additional residential areas allocated in the two scenarios.

(c.f. table 3). This increase in building density from 30 to 50 buildings per hectare led to a 40% reduction in land consumption by 2040 (c.f. table 3). The additional protection of particularly high value agricultural land in the 'maintaining agriculture' scenario resulted in the following effects (c.f. figure 4):

1. A stronger fragmentation of the new residential areas in the landscape.
2. A concentration of new residential areas in the south-east of Cologne.
3. A shift of the new residential areas to locations at a greater distance from existing urban centres and thus poorer connections to existing infrastructures.

Comparing the two scenarios on the basis of indicators, it is noticeable that in the "maintaining agriculture" scenario the consumption of particularly valuable land for species protection was 1.5 times greater than for the "current practice" scenario, while the consumption of particularly valuable ecological land was the same in both scenarios. There are two potential explanations for this seemingly contradictory result: first, typical species of the agricultural landscape, such as the lapwing or skylark, had their centre of distribution outside protected areas, or second, many particularly valuable ecological areas were located in protected areas for which conversion to residential areas was prohibited in the model. But even, if residential areas were allocated outside of areas of high value for nature conservation this might still impact nature conservation by an increasing habitat fragmentation (c.f. figure 5 for an example). Fragmentation was higher for the maintaining agriculture scenario. For the effects of habitat fragmentation not only for Natterjack Toads and Green Toads but for all amphibians see Sinsch (1992).

From a technical point of view, there are several interesting results. The entire model, including pre-processing, can be run on a modern desktop in a reasonable amount of time. With 16 GB of RAM and an Intel I7-3.4 GHz from 2017, the total runtime was 2:34 hours, with 32 GB of RAM and a Ryzom 7 from 2021 1:35 hours and with 64 GB of RAM and Intel Xeon from 2018 2:02 hours. However, the pre-processing runtime was strong effected by necessary data quality checks and data curation. At

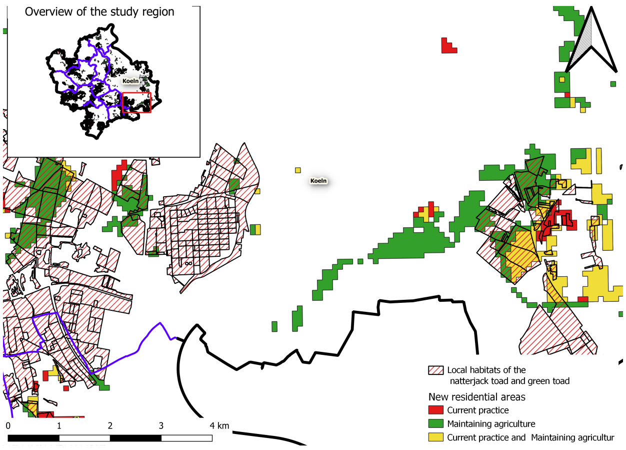

Figure 5. Example of fragmentation of areas with high value for nature conservation by new residential areas. The example area is located in the south of Cologne. Nature conservation value is expressed at the example of the Natterjack Toad and the Green Toad.

the time of the first import in October 2018, the currently used ALKIS dataset on land use had 50 topological and geometric errors per 1000 entries. At the last import in March 2022, there were still 24 errors per 1000 entries. The correction of these errors with the help of the PostGis function st_makevalid extended the runtime of the pre-processing and thus the total runtime of the model by a factor of twelve. Due to the regular updates of the ALKIS data set by the surveying administration, new pre-processing has to be carried out before each simulation. From a sample of twelve data sets from opengeodata.nrw.de seven showed topological or geometric errors - affected were datasets with complex polygon structures. It can be assumed that there is a fundamental problem in the data preparation routines of opengeodata.nrw.de.

4. CONCLUSION

It was possible to develop a useful land use model based on free software. Such a model can be used in combination with an evaluation system for the model results, e.g. to identify possible ecological conflicts already in early phases of regional planning processes and to give the responsible politicians and administrators the opportunity to start searching for solutions and strategies to avoid conflicts in good time.

In the field of ecology and species protection, the evaluation of model results with the help of indicators reaches its limits when negative impacts on species with small local populations or with low dispersal rates or high site persistence are to be expected. One of the points mentioned above applies to most species in Annex IV of Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (2013), such as the Natterjack Toad and the Green Toad. If such species occur in the study region, an assessment of the model results using habitat analysis for the species concerned is required in addition to an indicator-based assessment of the model results.

With the validation with the Corine Land Cover dataset data we can show that the model is in principle also applicable in other regions of Europe. In order to achieve an equally high predictive quality in other regions, an extension of the predictor set is necessary. For example, in northern Norway or Finland, it is not the distance to the nearest railway station that is of interest, but the distance to the port with regular ferry connections.

In addition, with the help of Corine Land Cover dataset data sets from the years 1990-2012, it is basically possible to examine past residential development. However, such investigations are made difficult by the lack of information on the historical location of e.g. retail sites or former railway stations with long-distance ferry connections.

From a technical point of view, it should be emphasised that the model can be used on modern desktop hardware for less than three hours. However, these times can only be achieved if the input data are free of geometric and especially topological errors. Currently, more and more government agencies, but also companies and private organisations, are publishing geodata under open licences. In order to use this data within a land use model, good data quality must be ensured. This means, among other requirements, that the data must be free of topological and geometric errors. As the example of Opengeodata.nrw.de shows, there is still a need for improvement and research in this area.

In the next research step, it is planned to integrate further land use data sets into the model and to create the possibility to automatically calculate the required distance variables with the help of the Openrouteservice(Openrouteservice, 2022). In order to be able to apply the model in the future to regions for which no regularly updated land use data are available, it is planned to train a neural network on the basis of the Setinel-2 Drusch et al. (2012) data at Corine Land Cover dataset 2018 in order to always have up-to-date land use information available for these regions. In order to keep the development effort low, an already implemented u-net milesial (2022) will be used. This has been successfully used for the detection and classification of wilderness areas. See also Stomberg et al. (2021)

To facilitate the accessibility of the model for practical applications, the model will be integrated into QGIS in the form of plugins. In addition, the results will be made available as a web mapping and a web feature service with the help of a geoserverGeoServer (2021).

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REFERENCES

Agarwal, C., Green, G. M., Grove, J. M., Evans, T. P., Schweik, C. M., 2002. A review and assessment of land-use change models: dynamics of space, time, and human choice. Technical Report NE-GTR-297, U.S. Department of Agriculture, Forest Service, Northeastern Research Station, Newtown Square, PA.

ALKIS Grundrissdaten | Open.NRW, 2018. https://open.nrw/dataset/407373a2-422c-469c-a7e9-06a62b4d7d9a.

Anaconda Software Distribution, 2020. https://docs.anaconda.com/. Publication Title: Anaconda Documentation Version Number: Vers. 2-2.4.0.

Box, G. E. P., 1976. Science and Statistics. *Journal of the American Statistical Association*, 71(356), 791-799.

Breiman, L., 2001. Random forests. *Machine learning*, 45(1), 5–32.

Corine Land Cover 2018 (raster 100m) - version 20, Jun. 2019, 2019. https://sdi.eea.europa.eu/catalogue/srv/api/records/c6b90e1a-314e-40bb-a54d-a8737b071e4e.

Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, 2013. http://data.europa.eu/eli/dir/1992/43/2013-07-01/eng. Legislative Body: OP_DATPRO.

Drusch, M., Del Bello, U., Carlier, S., Colin, O., Fernandez, V., Gascon, F., Hoersch, B., Isola, C., Laberinti, P., Martimort, P., Meygret, A., Spoto, F., Sy, O., Marchese, F., Bargellini, P., 2012. Sentinel-2: ESA's Optical High-Resolution Mission for GMES Operational Services. *Remote Sensing of Environment*, 120, 25–36. https://www.sciencedirect.com/science/article/pii/S0034425712000636.

GeoServer, 2021. https://geoserver.org/.

Geurts, P., Ernst, D., Wehenkel, L., 2006. Extremely randomized trees. *Machine Learning*, 63(1), 3–42. Place: Dordrecht Publisher: Springer WOS:000236850500001.

Harris, C. R., Millman, K. J., Walt, S. J. v. d., Gommers, R., Virtanen, P., Cournapeau, D., Wieser, E., Taylor, J., Berg, S., Smith, N. J., Kern, R., Picus, M., Hoyer, S., Kerkwijk, M. H. v., Brett, M., Haldane, A., Río, J. F. d., Wiebe, M., Peterson, P., Gérard-Marchant, P., Sheppard, K., Reddy, T., Weckesser, W., Abbasi, H., Gohlke, C., Oliphant, T. E., 2020. Array programming with NumPy. *Nature*, 585(7825), 357–362. https://doi.org/10.1038/s41586-020-2649-2. Publisher: Springer Science and Business Media LLC.

Hennig, E. I., Schwick, C., Soukup, T., Orlitová, E., Kienast, F., Jaeger, J. A. G., 2015. Multi-scale analysis of urban sprawl in Europe: Towards a European de-sprawling strategy. *Land Use Policy*, 49, 483–498.

Louppe, G., 2014. Understanding Random Forests: From Theory to Practice.

Martschink, L., 2017. Bevölkerungsprognose für Köln bis 2040 - Wie belastbar sind die Entwicklungsgrundlagen für das Wachstum der Stadt? *Stadtforschung und Statistik : Zeitschrift des Verbandes Deutscher Städtestatistiker*, 30(2), 15–20.

McKinney, W., others, 2010. Data structures for statistical computing in python. *Proceedings of the 9th Python in Science Conference*, 445, Austin, TX, 51–56.

milesial, 2022. U-Net: Semantic segmentation with PyTorch. https://github.com/milesial/Pytorch-UNet. original-date: 2017-08-16T12:17:08Z.

Ministerium für Wirtschaft, Innovation, Digitalisierung und Energie, des Landes Nordrhein-Westfalen, Ministerium für Wirtschaft, Innovation, Digitalisierung und Energie, 2021. Leitentscheidung Braunkohle 2012. ttps://www.wirtschaft.nrw/sites/default/files/documents/leitentscheidung_2021.pdf.

Openrouteservice, 2022. https://openrouteservice.org/.

Pedregosa, F., Varoquaux, G., Gramfort, A., Michel, V., Thirion, B., Grisel, O., Blondel, M., Prettenhofer, P., Weiss, R., Dubourg, V., Vanderplas, J., Passos, A., Cournapeau, D., Brucher, M., Perrot, M., Duchesnay, E., 2011. Scikit-learn: Machine Learning in Python. *Journal of Machine Learning Research*, 12, 2825–2830.

Protected Area Categories, 2016. https://www.iucn.org/theme/protected-areas/about/protected-area-categories.

Rienow, A., Goetzke, R., 2015. Supporting SLEUTH – Enhancing a cellular automaton with support vector machines for urban growth modeling. *Computers, Environment and Urban Systems*, 49, 66–81.

Saxena, A., Jat, M. K., 2019. Capturing heterogeneous urban growth using SLEUTH model. *Remote Sensing Applications: Society and Environment*, 13, 426–434.

Sinsch, U., 1992. Structure and Dynamic of a Natterjack Toad Metapopulation (Bufo calamita). *Oecologia*, 90(4), 489–499. Place: New York, Publisher: Springer.

Stomberg, T., Weber, I., Schmitt, M., Roscher, R., 2021. JUNGLE-NET: Using explainable machine learning to gain new insights into the appearance of wilderness in satellite imagery. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, V-3-2021, 317–324. https://www.isprs-ann-photogramm-remote-sens-spatial-inf-sci.net/V-3-2021/317/2021/.

Van Asselen, S., Verburg, P. H., 2013. Land cover change or land-use intensification: simulating land system change with a global-scale land change model. *Global Change Biology*, 19(12), 3648–3667. Place: Hoboken Publisher: Wiley WOS:000326836000009.

VRS - Opendata and Open Service -, 2022. https://www.vrs.de/fahren/fahrplanauskunft/opendata-/-openservice.

ZENSUS2011 - Homepage, 2022. https://www.zensus2011.de/EN/Home/home_node.html;jsessionid=AFAA46B8B018DD19A0B788A61CA95441.2_cid380.

zero-2-0 - GovData, 2020. https://www.govdata.de/dl-de/zero-2-0.