A Spatial Agent-based Model for Assessment and Prediction of Woodchips Availability for Heating Plants in Austria

Johannes Scholz[1], Peter Mandl[2], Christian Kogler[2], Michael Müller[2]

[1]Research Studios Austria – Studio iSPACE, Schillerstrasse 25, 5020 Salzburg, Austria, johannes.scholz@researchstudio.at

[2]Department of Geography and Regional Studies, University Klagenfurt, Universitaetsstrasse 65-67, 9020 Klagenfurt, Austria, peter.mandl@aau.at, chris@edu.uni-klu.ac.at, m9mueller@edu.uni-klu.ac.at

https://giscience.aau.at/content/poster-giscience-2014

Idea

Idea of the study:

To use **energy from renewable sources** is a growing trend in Europe and all over the world to reduce greenhouse gases, which is a political goal according to the Kyoto Protocol. There is rarely a study that evaluates the **effects of the consumption of renewable energy resources with respect to the spatio-temporal dimension on a fine grained level of detail**. So far only studies exist that evaluate renewable energy projects on a global/local level - e.g. for a whole country or province (e.g. Arbeitsplattform Wald und Holz in Kärnten 2007, Möller and Nielsen 2007).

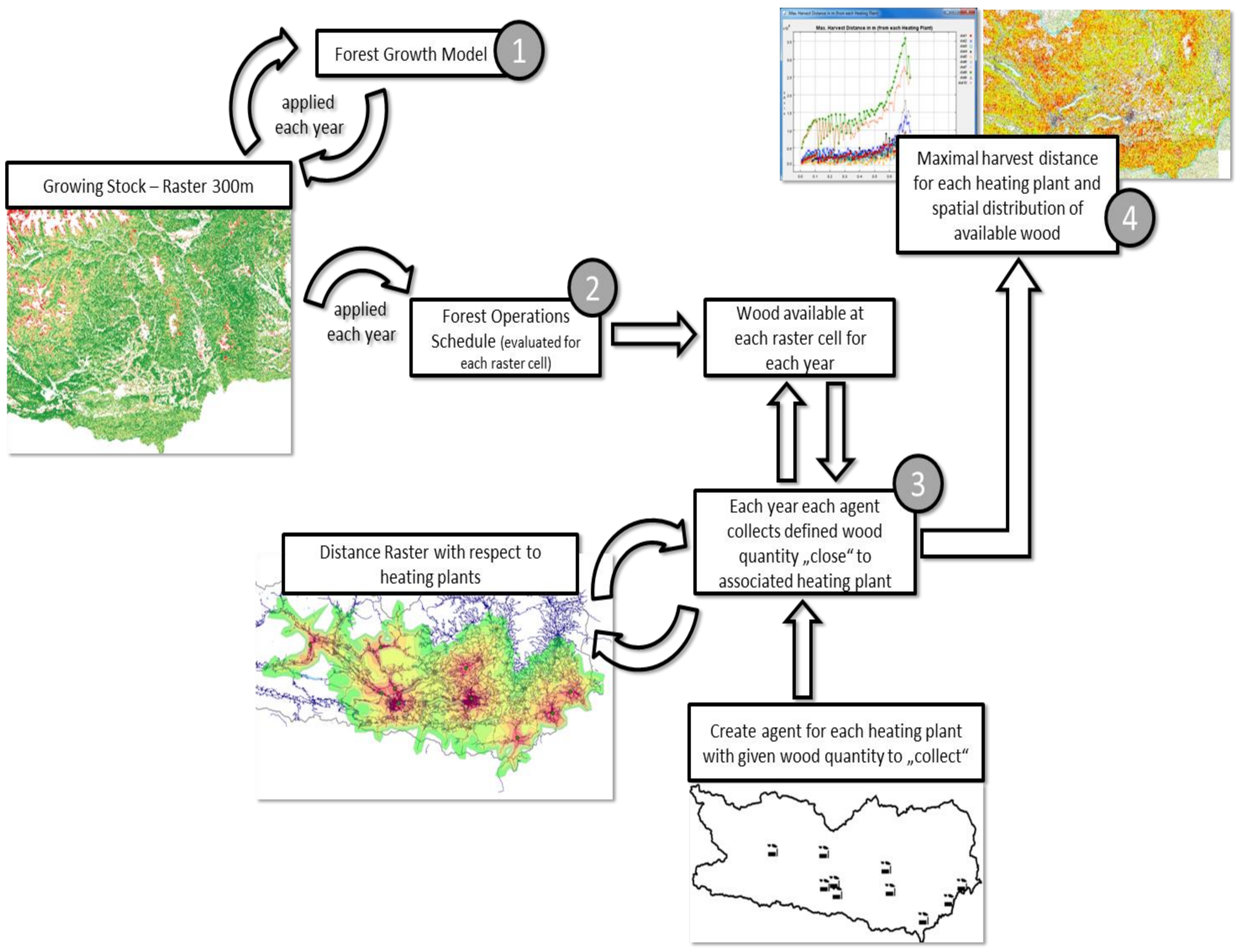
This study focuses on **effects of wood chip heating plants on the availability of lumber for wood chip production** on a fine spatial and temporal granularity. In order to model the "consumption" of timber for heating purposes, an **agent-based model coupled with a GIS** is used (Crooks and Heppenstall 2011, Johnston 2013, Mandl 2003).

Question

The **scientific question of the study** is to find out **if a spatio-temporal effect of competition for renewable energy resources exists**. The study investigates the question **in the context of the wood chip market** which serves as an energy source for heating plants in a given test area. The theoretical model is **applied to a data set of Carinthia**, a province of Austria.

The **innovations of this model** are not only the spatial resolution and the coupling of a GIS and an agent-based modelling environment using the Agent Analyst of ArcGIS but also the subject matter which **checks the hypothesis that the support of wood chips as fuel for heating plants is not a sustainable solution for renewable energy source projects in Central Europe.**

Approach



Approach to evaluate the wood chip availability with a given consumption of lumber by heating plants:

The **first procedure (# 1)** is a **forest growth model** based on empirical forest inventory data and a DEM, which represents the annual growth of the dominant two tree types (spruce and European beech) with respect to different altitude. This is done for all forest stands in Carinthia.

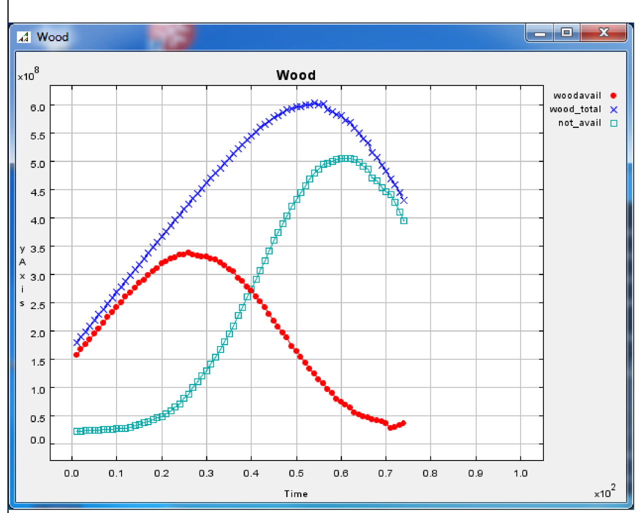
The **second procedure (# 2)** is an **estimation model for the amount of available wood chips** per raster cell (300m by 300m). Here the data of the forest inventory is used to define a forest operations schedule, based on the standing timber and the "history" of the standing timber (i.e. prior forest operations, age of forest). The forests in Carinthia are relatively old, which is similar all over Central Europe.

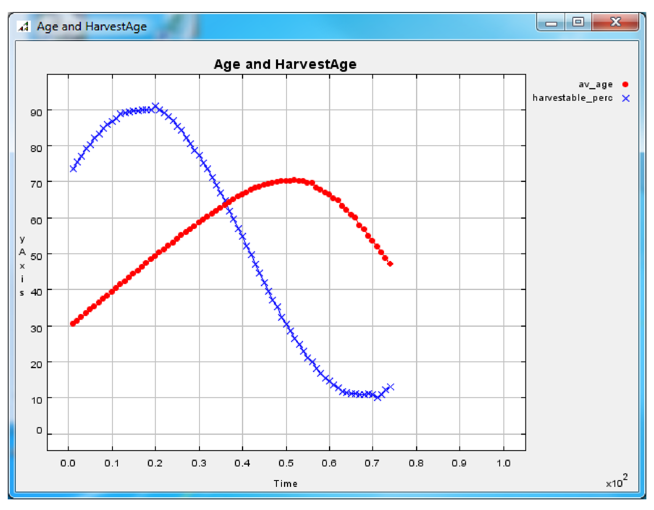
The **third procedure (# 3)** is the **simulation of the collection process for the prospector agents**which is based on a round trip concept to scan the landscape with respect to minimum trip distances along a road network and collect wood chip material as needed by each heating plant. The prospectors collect wood in a systematic way as long as there is a demand of the supplied heating plant.

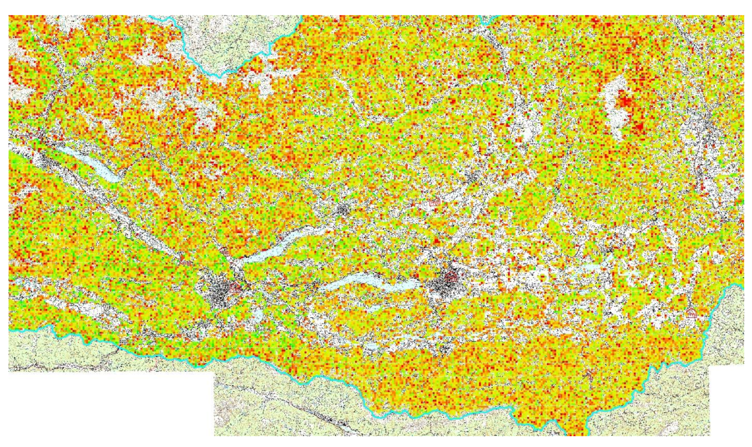
The **fourth and final procedure (#4)** is the **calculation of different statistical parameters** like the maximum harvest distance for each heating plant **and the generation of maps of the spatial distributions of available wood** for each of the simulation years.

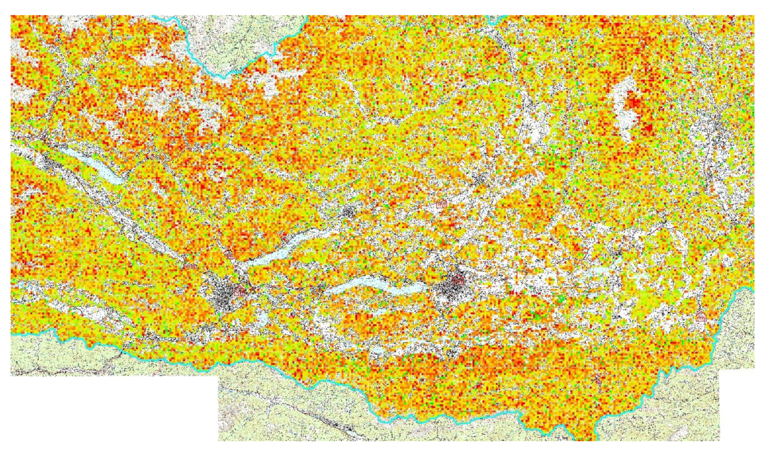
Results

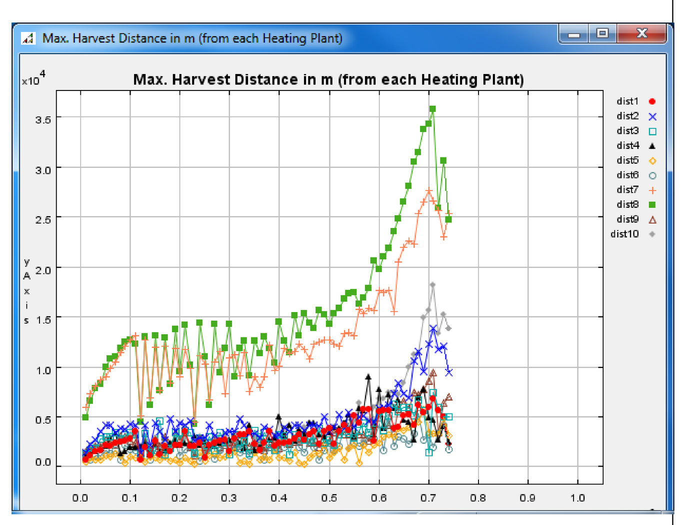
The **results of the spatial agent-based model** are maps of the available amount of wood chips and statistics for the distance of timber haulage at each time step (from forest to heating plant).











The **left figure** shows the amount of the total (blue), the available (red) and the not available wood (lightblue) for all of Carinthia. The **right figure** shows the average age (red) and the total percentage of the harvestable forest stands (blue). **In these figures the proposition that the age of the stands is the main reason for a massive decrease in wood chips availability during the next decades is confirmed.**

The **maps** show the **spatial distributions of available wood (red)** in Carinthia **within a time span of 10 years**. The **decrease** of availabble wood in the vicinity of the power plants in the central area and the **increase** in the periphery can be seen.

The **figure** shows the **maximum transport distance** from the forest to every heating plant for each simulation year. **The graph reveals that the maximum transport distance increases the longer the simulation runs. This is due to the fact that forests in the vicinity of a heating plant cannot supply the heating plants accordingly, and timber has to be transported over longer distances.**

Conclusions

Conclusions:

The paper describes an **approach** to model the impact of wood chip heating plants on the availability of lumber for wood chip production. The **model** operates on a fine spatial and temporal granularity. In order to model the "consumption" of timber for heating purposes, an agent-based model coupled with a GIS is employed. The **results reveal** that the approach is capable of modelling the impacts of heating plants on forest and transport distances. Additionally **it is indicated that**, within Carinthia, one cannot fully rely on wood chips from local forests in order to fulfil the heating energy demand.

In **further projects** the presented model can be used to simulate additional scenarios. The problems which will be worked on are **the change of the types of forest operations and their timing**, the **influence of wood chip imports from other countries** on the model results, the **optimum of the number and the location of power stations** which get along with the available amount of timber in Carinthia as well as the **combination of the biomass power plants with other renewable energy sources**. Furthermore the development of a simulation methodology supporting the Energy Master Plan for Carinthia (http://www.energie.ktn.gv.at/) is in progress.

References

- Arbeitsplattform Wald und Holz in Kärnten, 2007, Bilanz und Strategieplan über Aufkommen, Nutzen und Potentiale. Landwirtschaftskammer Kärnten, Klagenfurt.
- Crooks A T and Heppenstall A J, 2011, Introduction to Agent-Based Modeling. In Heppenstall A, Crooks A T, See L M, Batty M (eds.), Agent Based Models of Geographical Systems, Dordrecht, Heidelberg, London, New York: Springer.
- Johnston K M, 2013, Agent Analyst: Agent-Based Modeling in ArcGIS, Esri Press, Redlands. (available under http://resources.arcgis.com/en/help/agent-analyst/)
- Mandl P, 2003, Multi-Agenten-Simulation und Raum – Spielwiese oder tragfähiger Modellierungsansatz in der Geographie? Klagenfurter Geographische Schriften, 23:5-34.
- Möller B and Nielsen P S, 2007, Analysing transport costs of Danish forest wood chip resources by means of continuous cost surfaces. Biomass and Bioenergy, 31(5): 291-298.

Acknowledgements

This study was supported by the Austrian Research Centre for Forests (BFW), which is greatly appreciated. In detail, the authors were given access to a general forest map, forest type and forest growth data for the province Carinthia. The authors would like to thank Mr. Bruno Regner of BFW for his efforts to support this research work.