Proceedings of the 2018 Winter Simulation Conference
M. Rabe, A. A. Juan, N. Mustafee, A. Skoogh, S. Jain, and B. Johansson, eds.

DYNAMIC GENERATION OF A SPARSE FOREST BIOMASS ORIGIN POINTS NETWORK

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ABSTRACT

Forest biomass supply is scattered spatially and temporally. To have a realistic supply simulated by agent-based model, spatial analysis of supply is improved to include dynamic elements with stochastic distribution. The annual theoretical supply is obtained from static biomass database and it is allocated to the grid of supply points. To have realistic transport distances to demand point, the grid should be dense, but this generates too many points. There for a limited number of points are selected and the supply of these points are increased. The use of this model obligates the selected supply points being the same between runs having stochastic elements for other operations. With 2 km x 2 km grid and 120 km radius supply area feedstock volume and transportation distances were corresponding with real life conditions.

1 INTRODUCTION

Forest biomass supply depends on forest management plan, size, location and feedstock type of the stand. The producing cycle of stands variates from 15-100 years. This leads to forest biomass supply points being scattered apart from each other spatially and temporally. Transportation costs have a high effect on the costs of biomass and the feedstock procurement area of the power plant is limited (Allen et al. 1998).

The research objective of this paper was to generate dynamical supply points for the agent-based model (ABM) to simulate multiple years forest biomass supply system with realistic transportation distances and feedstock amounts. The generation of the points was accomplished by using a geographical information system (GIS) to estimate the theoretical annual supply of the area and importing results to the model. The model processes data to generate spatially and temporally sparse feedstock supply locations. The simulation model needs to be able to produce replication runs and this generate constraints for the supply points generation that have to be met.

2 MATERIAL AND METHODS

Two different feedstock types were selected: whole trees from young forest and harvest residue final felling. The annual theoretical supply of these biomass fractions was retrieved from Biomass Atlas (LUKE 2018a). Biomass Atlas database contains theoretical supply and these volumes are estimated by using the same methods as used by Nivala et al. (2016). Depending on the study area size and grid density, a number of supply points will be generated in the model. The supply used in the model is calculated by using theoretical supply as an initial value and cutting the volume base on selected availability scenario (e.g. forwarding distance, competition in the feedstock markets, etc).

The number of supply points needs to be reduced in the model to represent annually harvested stands realistically. To achieve this, a number of points are randomly selected from supply point population, representing harvested stands of simulation year.The harvesting day of these points is stochastically determined by using temporal variation in Finland's harvest statistics (LUKE 2018b). To have the annual supply correspond with the selected number supply points, the amount of feedstock has to be increased. This is done by multiplying the supply of one point by a fraction of the total supply point divided number of selected supply points. This will lead to a variation of the annual supply that is more realistic than a statistical annual average for every year.

As supply points are selected randomly and ABM simulations have to be run multiple times to account stochastics of the model, the seed of the random number generator (RNG) has to be known. As other operations need to be different between runs, two RNG's are created; one for supply points for which the seed is known and a second for other random events with their own seed.

3 RESULTS AND DISCUSSION

The generation of supply points was done with 2 km x 2 km grid surrounding of the power plant, which was located in Finland. The radius of 120 km was selected, leading to a 3883 total supply points. With 200 supply point selection, the average feedstock volume of whole trees was 392 m^3 per supply point. The harvest residue volume was 490 m^3 per supply point. As grid size was chosen to be 2 km x2 km it can be assumed that one supply point often represents more than one stand. This has to be accounted in the simulation model as it affects the number of transport vehicles and forest operations.

Supply point locations and harvesting times varied like it was intended, when the model was verified by creating 30 generations of supply points representing 30 different years. In comparison with the average transport distances in the entire supply point population the deviation with in the 30 generation was between -4% and 4%, the average deviation being -1%. Feedstock supply volume varied between the generations as in real life between different years. In comparison with annual harvest statistics the whole-trees volumes deviated by -22% - 10%, the average deviation being -1%. With harvest residues the deviation was -15% - 16%,the average deviation being -1%. Regarding whole trees, the dominantly negative deviation is explained by the fact that the points of the entire population supplying less volume than the population average is greater than the number of points supplying more than the average.

It can be concluded, that supply point generation method presented in this paper provides accurate transportation distances between annual supply points and demand points and realistic variation of the supply volume between different years. These properties are important to have in the dynamic model that analyses local demand points supply system during multiple years.

ACKNOWLEDGMENTS

This study is part of the project Improvement of forest chip quality and supply chain performance by means of a continuous quality measurement system (JATKUMO). Support from the European Unions Structural Funds has made it possible to conduct JATKUMO and this study. Special thanks to M.Sc Olli-Jussi Korpinen for helping in Geographical Information Systems analysis and my supervisor Prof. Tapio Ranta

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