TreeSys

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Projected habitat suitability changes in a forest landscape under intensive forest fertilization

Introduction

A simulation model was used to investigate possible changes in habitat suitability in a forest landscape under an intensive fertilization regime scenario.

Data and method

Case data

The landscape analyzed is located in the Övertorneå municipality in northern Sweden and comprised 51 400 ha of forest land owned by Sveaskog. Heureka PlanWise version 2.7, a software developed by the Swedish University of Agricultural Sciences, was used for the analysis (www.slu.se/heureka). As input data, a compartment register with stand-level data was provided by Sveaskog, according to the data input requirement of Heureka, as well as a compartment forest map.

Fertilization is subject to a number of locational constraints (see table 1), for example closeness to a water stream or protection site. Sveaskog therefore provided additional GIS-data required to carry out a GIS-buffer analysis (see appendix 1).

Table 1. Location requirements that must be enforced when applying fertilization in a forest stand

Type	Buffer zone distance
Other ownerships	Fertilization is not allowed within 25 m from a forest that belongs to another owner
Water protection	Fertilization is not allowed within 20 m from lakes and water streams
Forest roads	Fertilization is not allowed within 10 m from public roads
Protected patches	Fertilization is not allowed within 10 m from protection patches (hänsynsytor)
Protected areas	Fertilization is not allowed within a 25 m from nature conservation protection sites

At the stand level, the following applicability conditions apply:

- Conifer dominated (>50% of tree basal area) production forest in Sweden.
- Site index T16-T26 and G18
- 1-3 fertilizations, with project start and the first fertilization carried out no later than the following years before the earliest permitted age at final felling, according to the Forestry Act:

Site index	Years before permitted age for final felling
T16	10
T18	10
T20	15
T22	15
T24	20
T26	20
G18	5

In this analysis, the maximum age limits were ignored in the first step to evaluate whether there was a difference in projected habitat suitability areas under a fertilization scenario and a scenario with no fertilizations, see section "Heureka scenarios" below.

Buffer zone tool

Heureka has a built-in tool for analyzing overlays and that automatically clips data that are intersected by one or more so called buffer zone layers. The result is a new forest map, with new stand borders. For a part of a stand that is overlapped by a buffer zone layer, a new stand and associated map object is created, and it is marked with a specific zoning attribute, that can be utilized in Heureka when making a forest simulation. For example, a site that is within a buffer zone, can be allowed only for selection felling, while the original stand may still be clear cut.

Habitat suitability models

Heureka has built-in habitat suitability model for six different indicator species that has been selected to represent different kind of forest habitat niches (Edenius & Mikusinski 2012[1]). The models are spatially explicit. To be classified as suitability habitat, a given site must meet certain requirements, and, for all models but one, also meet certain requirements within a given neighborhood of the site. The neighborhood size is typically represented by a circle with a radius of 200 to 800 m. The requirements for the models are expressed in terms of stand age thresholds, and tree species distribution. For one model, there is also an interior edge requirement, so that the habitat close to an edge to open land in considered inferior to the interior part of the stand.

The habitat models are raster-based, and forest stand polygons are converted to raster data when running a model. This means that different parts of a forest stand can be given different habitat scores, since each raster cell has a unique neighborhood.

The habitat models assign to each raster cell a value of 0, 0.5 or 1.0, where 0 means that a cell is not suitable habitat, either because the forest at the cell does not meet the requirements, or there is not enough area of suitable habitat within the neighborhood. Habitat score 1.0 means that a cell is perfectly suitable as habitat, and score 0.5 that it is suitable to a limit degree. Different stand-level criteria are used for score 1 and 0.5. For example, for Siberian jay, habitat score 1.0 requires a patch to be at least 60 years old, while 30 years is sufficient for habitat score 0.5, given the patch is dominated by coniferous trees. After the raster analysis is done, each forest stand is assigned a value

[1] Edenius, L. & Mikusinski, G. 2012. Framework for building models for species habitat suitability assessment in the biodiversity module of Heureka system. Stencil.
http://heurekaslu.org/mw/images/6/64/Heureka_Habitat_models.pdf

for the area of suitable habitat within the stand. For example, if each raster cell in a stand has habitat score 0.5, that habitat area is calculated as half of the stand's area.

The habitat models operate automatically, so that a user must only select a certain scenario generated with Heureka, and one or more time periods to be evaluated. This means that you can study how the habitat area in a landscape develops over time under different management scenarios in relatively a simple way.

Heureka scenarios

Four scenarios were evaluated, with and without even-flow constraints for harvest volume, each with and without fertilization. In the fertilization scenarios, all stands available for fertilization were allocated a fertilization schedule, and in the other scenarios no fertilization was allowed.

Table 2. Scenario specifications

Scenario	Even-flow constraints?	Fertilization
A-NoFert	No	No
A-Fert	No	Yes
B-NoFert	Yes	No
B-Fert	Yes	Yes

A fertilization regime means that a stand is fertilized ten years before every thinning and final felling (in this first analysis, see above concerning applicability conditions).

In PlanWise, a scenario is obtained by letting the program generate a number of different management program alternatives for each stand. A management program can also be a program with no activities, which is used for stands that should not be managed but left as set asides. An alternative for a stand is unique with respect to the timing of treatments, and/or what species are used when regenerating, and whether fertilization is done or not. In this study, both alternatives with and without fertilizations were generated for those stands where fertilization was allowed.

After the generation of alternatives, a built-in optimization tool is used to formulate and solve a forest-level optimization problem. The result from this is a scenario, or plan, that consists of one selected management program for each stand. The optimization model allows, for example, to add even-flow temporal constraints for timber outputs. Such even-flow constraint were used here, implying the harvest volumes could vary with at most 10 percent from one five-year period to the next. Apart from these, constraints for how large areas may be fertilized were imposed. This set up makes it easy to create different fertilization scenarios, without rerunning the rather time-consuming simulation of stand-level alternatives.

Results

The area available for fertilization was 15 851 ha (table 3), of which 15 108 ha was pine-dominated stands and 743 spruce-dominated.

Table 3. Areas available for fertilization per management class. Management classes refer to predefined class as registered by Sveaskog for each stand.

Management Class*	Productive area (ha)	Set aside area due to locational constraints (buffer zones)	Area available for fertilization
NO and NS	10 361	8552	0
PF and PG	40 934	6089	15 851** (Pine stands: 15 108) (Spruce stands: 743)
Sum	*51 295*	*14641*	*15 851*

**"Management Class" refers to a widely used classification system used in Swedish forestry. The management class indicate the long and short term management objective for a specific forest stand. Classes NO and NS imply that biodiversity is the main objective, either by setting aside (NO) or applying forestry activities that aim at increasing biodiversity (NS). PF and PG imply that forest production is the main objective, with a varying degree of care for nature conservation.*

** With 7 % area reduction for PG and PF for ordinary biodiversity consideration ("generell hänsyn")

Harvest volumes, final felling areas and habitat suitable areas are presented in the figures below.

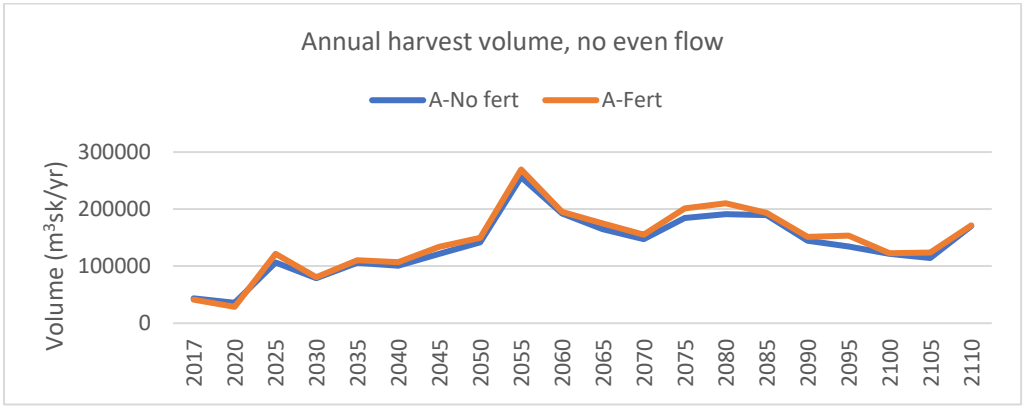


Figure 1. Harvest volume in scenarios without even-flow constraints

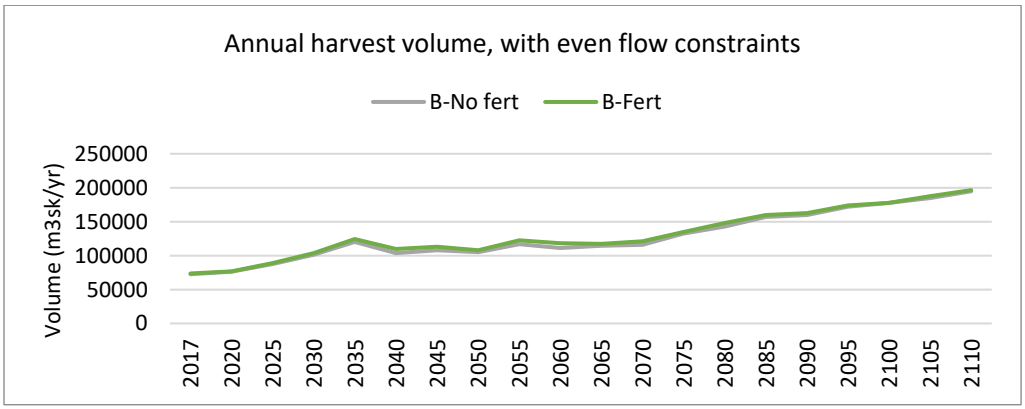


Figure 2. Harvest volume in scenarios that include even-flow constraints

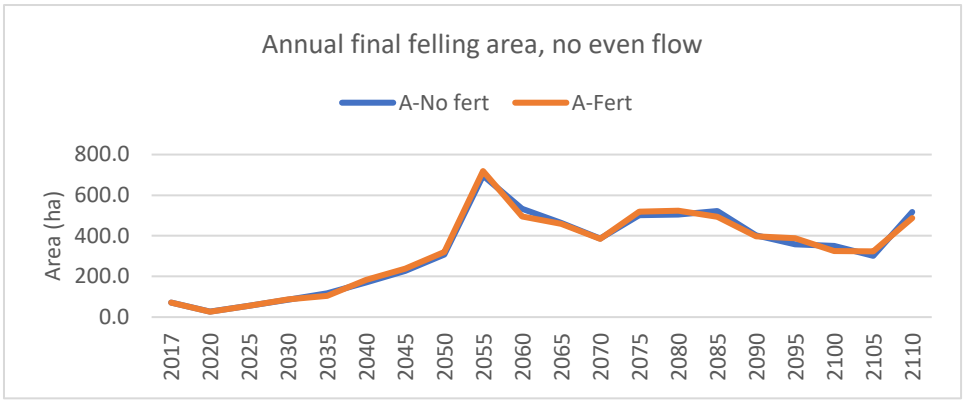


Figure 3. Annual final felling areas in scenarios that include even-flow constraints

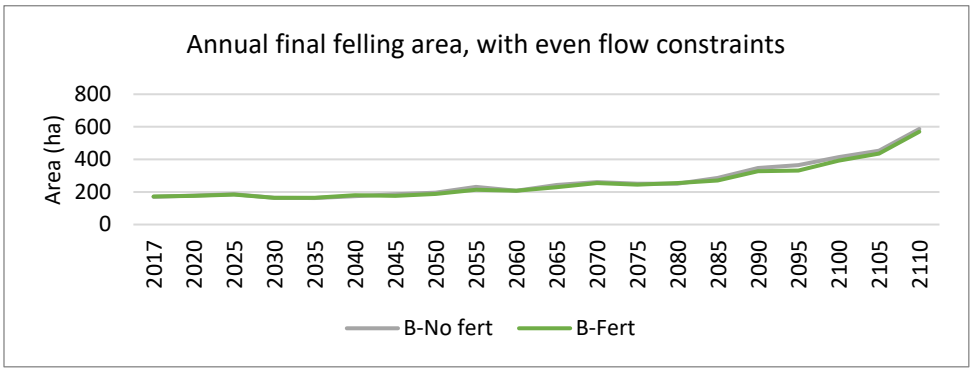


Figure 4. Annual final felling areas in scenarios that include even-flow constraints

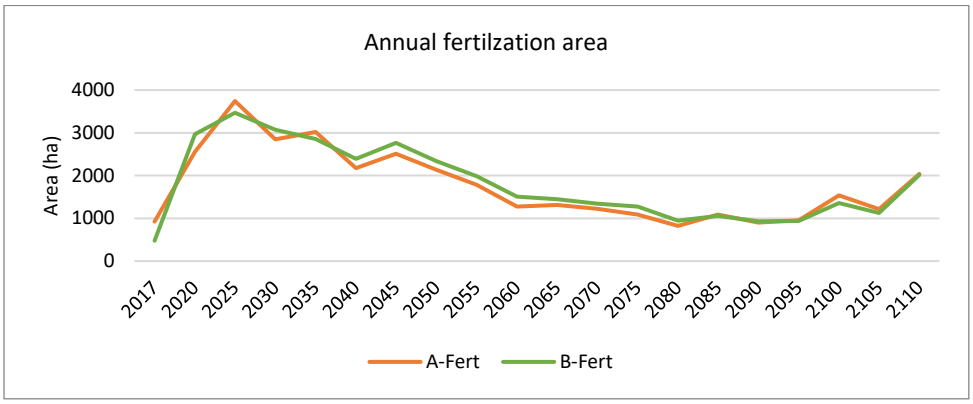


Figure 5. Annual fertilization areas in scenarios with fertilization.

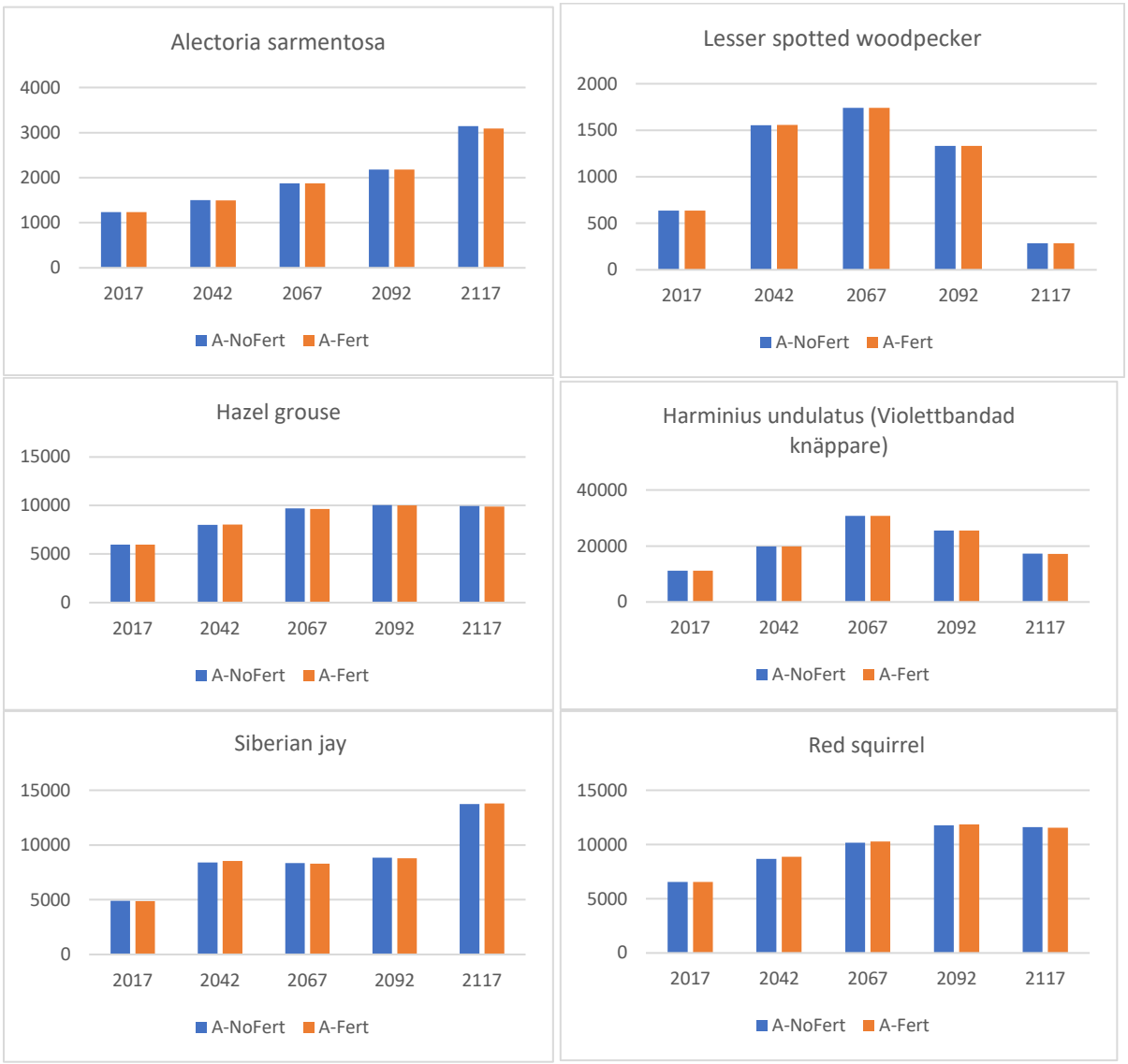


Figure 6. Suitable habitat areas as predicted by the habitat suitable models in scenarios without even-flow constraints

Figure 7. Suitable habitat areas as predicted by the habitat suitable models in scenarios that include even-flow constraints

Conclusion

According to the habitat models used, the area of suitable habitat was not significantly affected by fertilization. This means that the fertilization neither lead to a changed age composition development of the landscape, nor the occurrence of deciduous trees. However, Heureka is only handling the tree vegetation layer, and possible effects on biodiversity due to, for example, changes in ground vegetation composition and water quality, are not taken into account in this analysis.

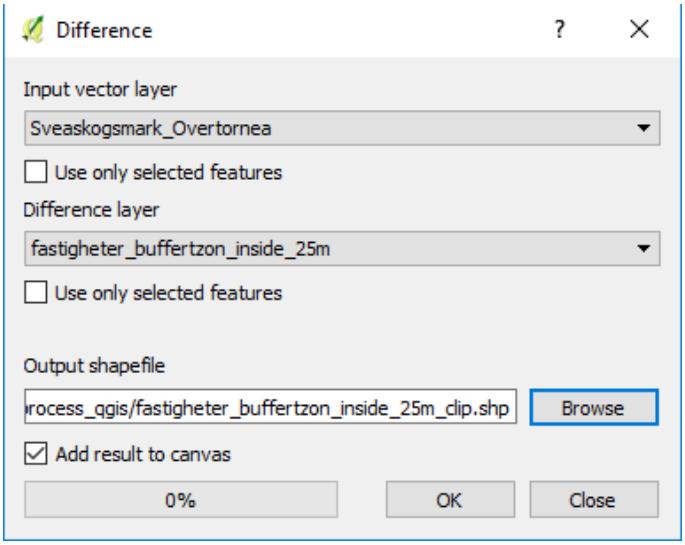
Appendix: Calculation of buffer zones (in Swedish only)

Fastighetsgränser

Restriktion: Ingen gödsling inom 25 m från andra fastigheter.

QGIS:

1. Skapa buffertzon med värdet -25 (minus 25) för skikt Sveaskogsmark_Overtornea
2. Använd Difference-operation mellan Sveaskogsmark_Overtornea och buffertzonen för att spara endast själva buffertzonen.

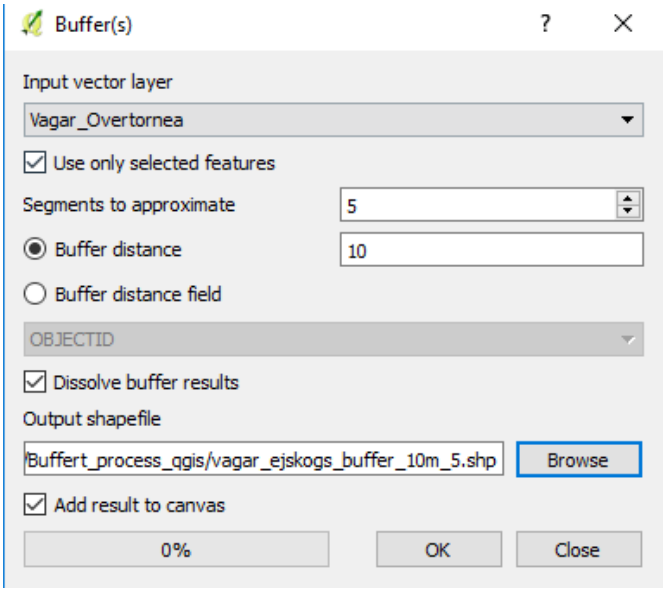


Vägar

Restriktion: Ingen gödsling inom 10 m från allmän väg

QGIS:

1. Lägg till skiktet Vagar_Overtornea
2. Högerklicka och välj Open attribute table
3. Skapa Select-uttyck Klass <= 6
4. Kör Buffetzon 10 m, markera “Use only selected features” och “Dissolve buffer results”:



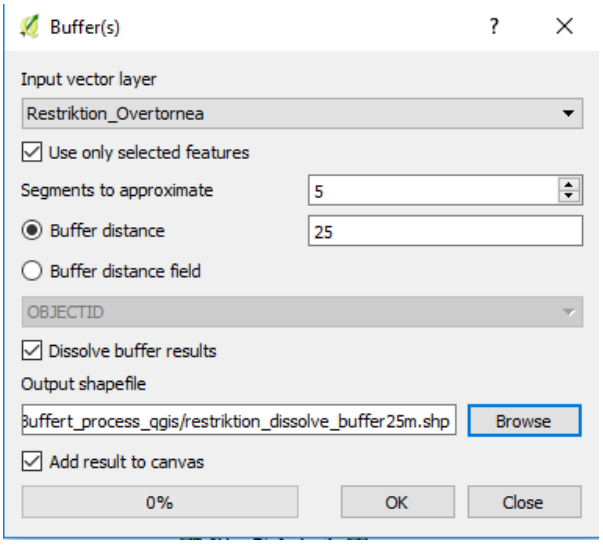
Skyddade områden, nyckelbiotoper och våtmarker med höga naturvärden

Restriktion: Ingen gödsling inom 25 m

Shapefil: Restriktion_Overtornea.shp

Koder: Typ in (101,102,105,112,113,107)

QGIS:

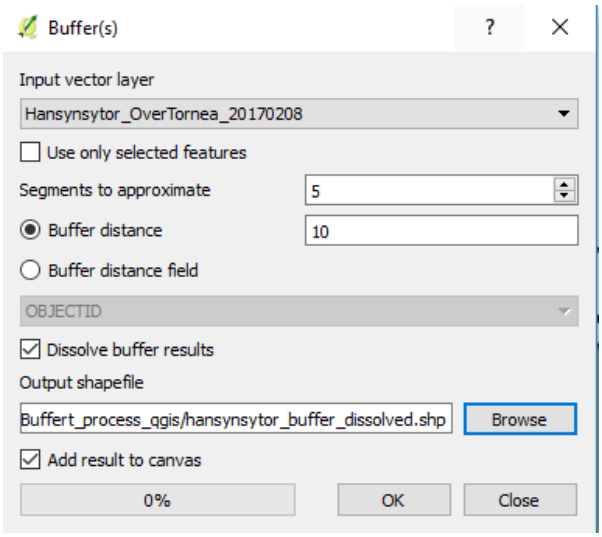


Hänsynsytor

Restriktion: Ingen gödsling inom 10 m

Shapefil: Hansynsytor_Overtornea_20170208.shp

QGIS: Bufferzon 10 m



Sjöar och vattendrag

Restriktion: Ingen gödsling inom 25 m

Shapefiler: Vatten_overtornea.shp samt Vattendrag_overtornea.shp

QGIS:

1. Skapa buffertzon för vart och ett av dessa.
2. Använd Union och sedan Dissolve för att slå ihop dem.

Sammanslagning till ett buffertskikt

Alla resultatfiler från analyserna slogs ihop genom att addera ett i taget med Union-funktionen i QGIS. Sparades som final_merge.shp.

Heureka BufferZones

Resultatfilen från beräkningar ovan användes i vertyget BufferZones i Heureka. Buffertzons-bredden sattes till 0 m eftersom alla buffertzoner redan är beräknade enligt beskrivning ovan. Verktyget skapar egna behandlingsenheter för de avdelningar som överlappas av bufferskiktet.