THE NORTHERNMOST UNIVERSITY
of Technology in Scandinavia

# *A geographically explicit approach for price determination of forest feedstocks under different next generation biofuel production scenarios – The case of Sweden*

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# Outline

- Objective & Motivation
- Model description
  - Demand, Supply, Geography
- Soft linkage with BeWhere-Sweden
- Some initial results

# Objective & Motivation

- A price determination model
  - Based on a simple demand/supply framework
  - Geographically explicit at gridcell level
- Focus on Swedish forest feedstock markets domestically
  - No trade linkages, etc.
- ”Soft-link” to other high-end models
  - BeWhere-Sweden (primary focus)
  - PE, CGE, models

# ”Soft-Link” to BeWhere-Sweden

- Generate a matrix of new “market” prices;
- The “market” prices matrix is used as an input to the BeWhere-Sweden model
  - Represents an updated cost matrix for the forest feedstocks, which is geographically explicit
- Reiterate the process for all the scenarios in the BeWhere model
  - to simulate demand-side pressures on the forest feedstock markets

# Model description

## Supply & Harvest Cost

- Given at gridcell level for 7 feedstock types
  - 7 raw forest-based feedstock
    - Sawlogs, pulpwood, branches&tops, and stumps
    - Final felling and thinning

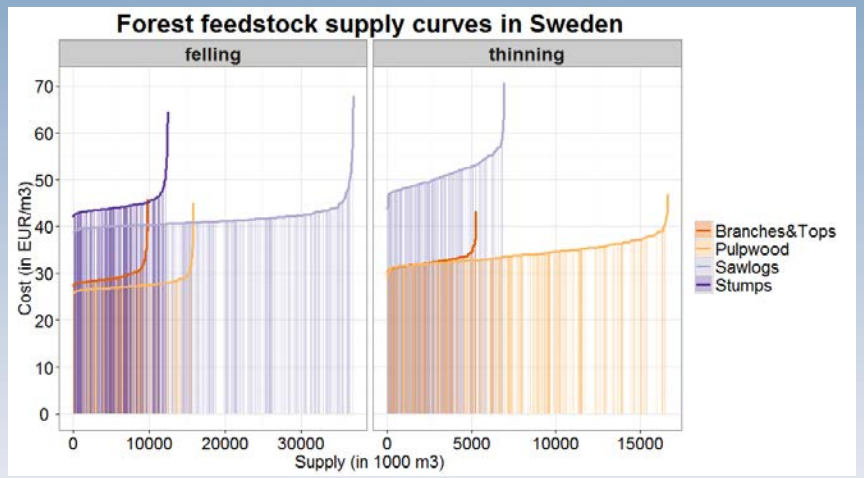
## Demand

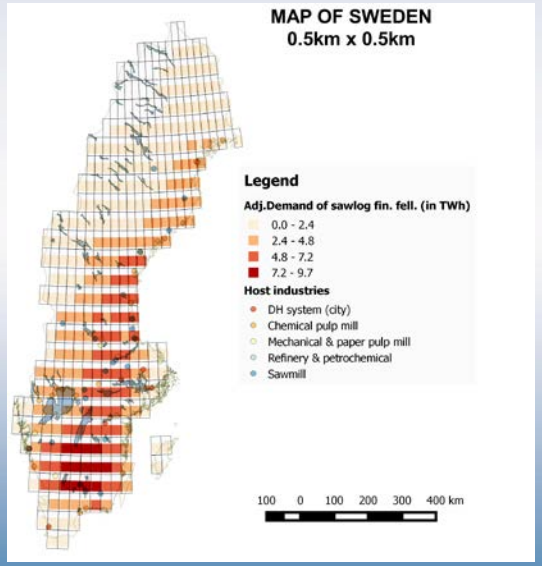
- Estimated via BeWhere-Sweden
  - Provides initial data to be calibrated using a *distance-decay* framework
  - Need to account for demand competition among different locations

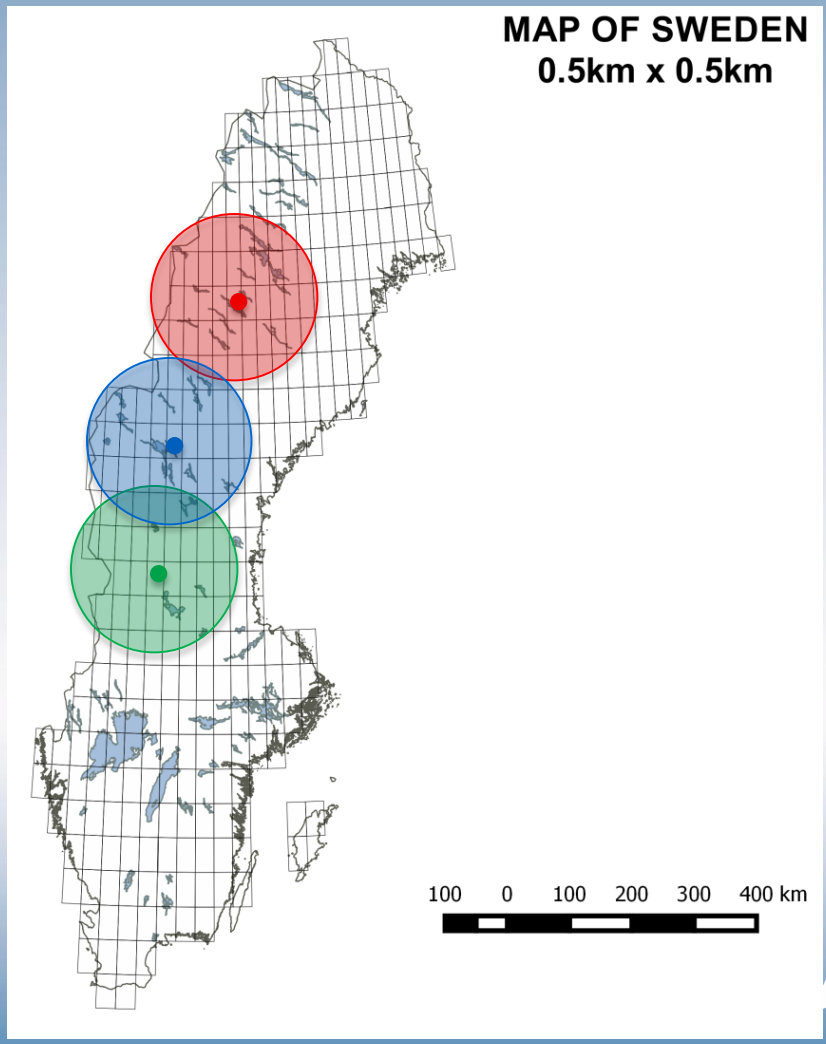
# Model description

- Regional supply curves are estimated based on gridcell-level data on
  - Forest biomass availability
  - Harvesting costs
- Regional supply curves constructed as a cumulative step-function of merit order
- Demand schedule at gridcell level from BeWhere-Sweden
  - Estimated using a distance-decay method

# Model description

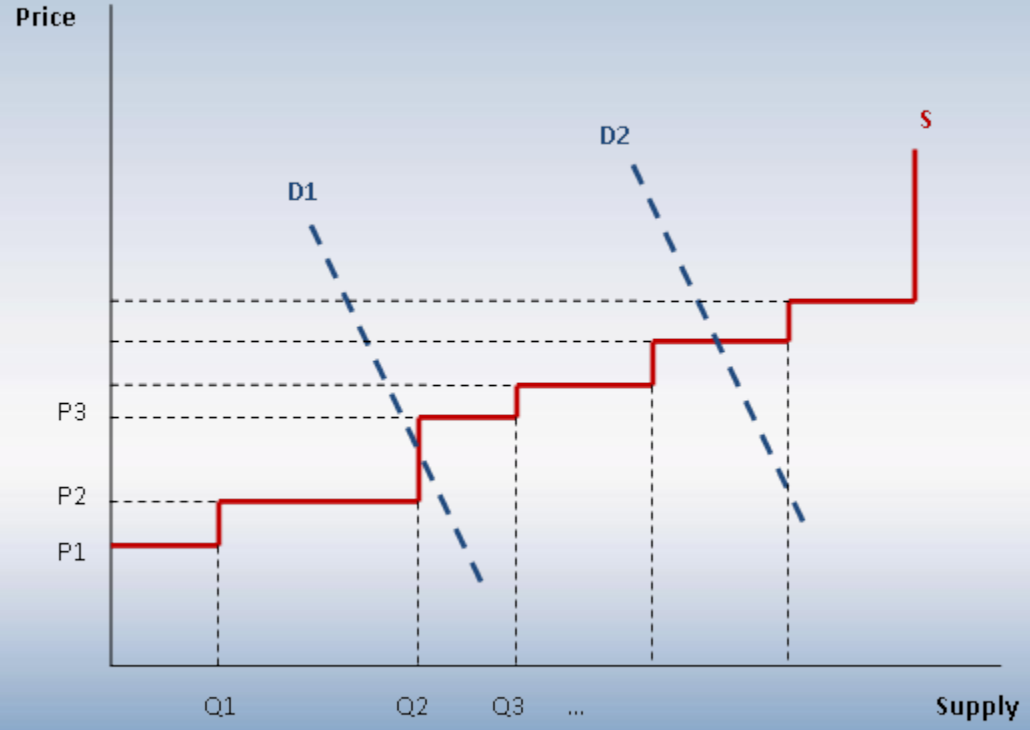


# Model description

- Prices are determined based on regionalized juxtaposition between gridcell demand and regional supply



# Model description

- Supply and cost of the forest feedstock assumed fixed initially
  - Can be potentially changed via alternative scenarios introduced as *"supply shifts"* (e.g. change in harvest technology, supply shocks due to climate change, etc.)
- The key element in the model is the *"distance-decayed"* adjusted demand
  - The concept of *"distance decay"* stems from Newtonian physics on gravity
  - Used extensively in "gravity models" of trade

# Model description

- The objective of introducing the *"distance-decay"* calibration is to account for the potential friction among different demand nodes
  - i.e. potential competition
- In the model, we compute the *"distance-decay"* calibrated demand as:

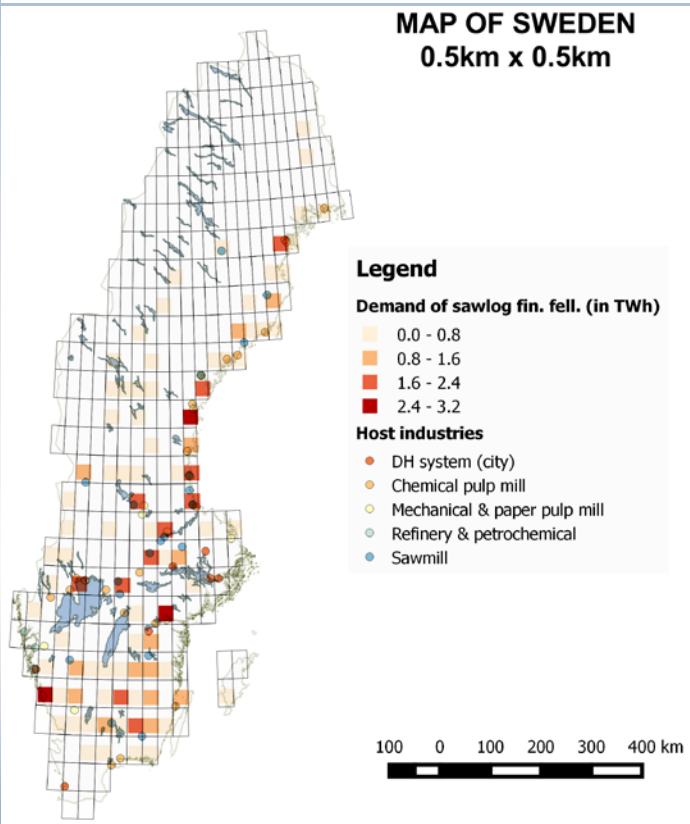
with

$$XD^{Adj}_{i,m} = XD_{i,m} + \sum_{n \neq m} XD^{decay}_{i,m}$$

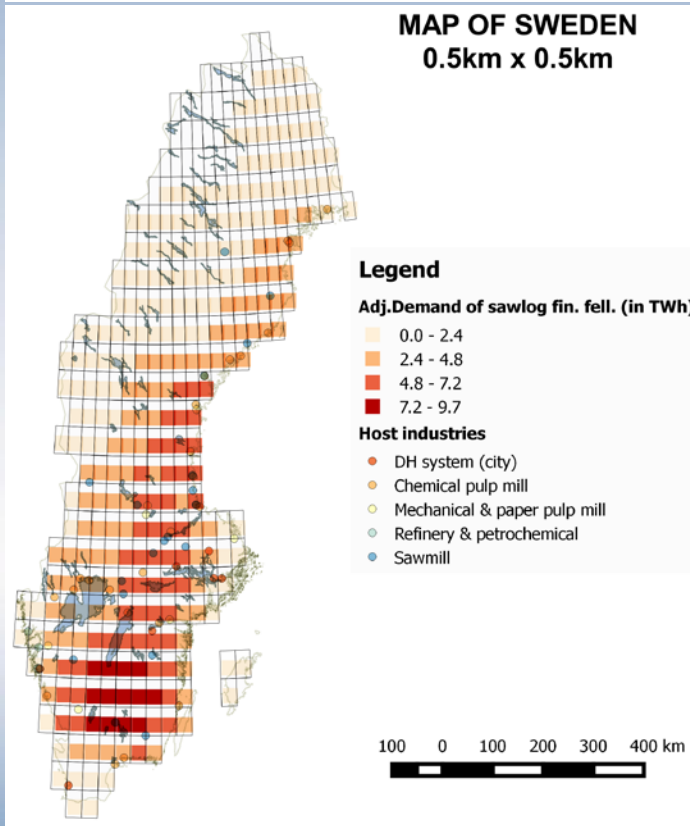
$$XD^{decay}_{i,m,n} = \alpha \times XD_{i,m} \times \left(1 - \left(\frac{d_{m,n}}{d_{max}}\right)^{\gamma}\right)$$

# Model description

## Demand
## Sawlog f.f. - BAU scenario



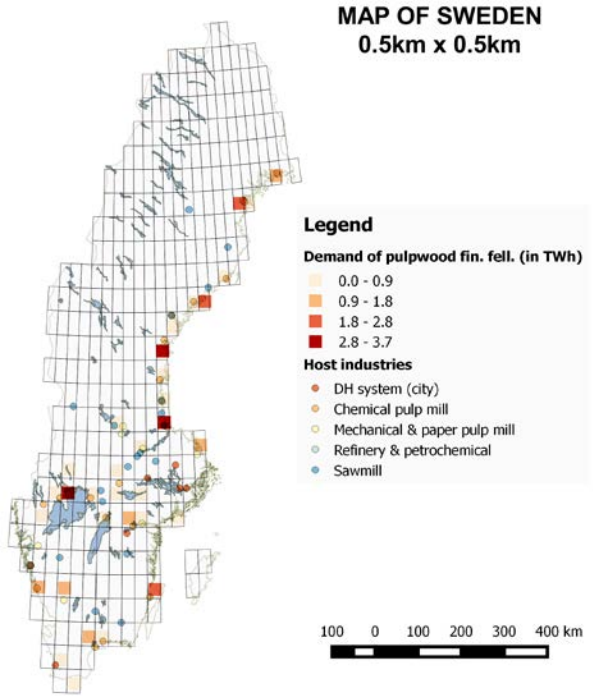

## Decay-adjusted Demand
## Sawlog f.f. - BAU scenario



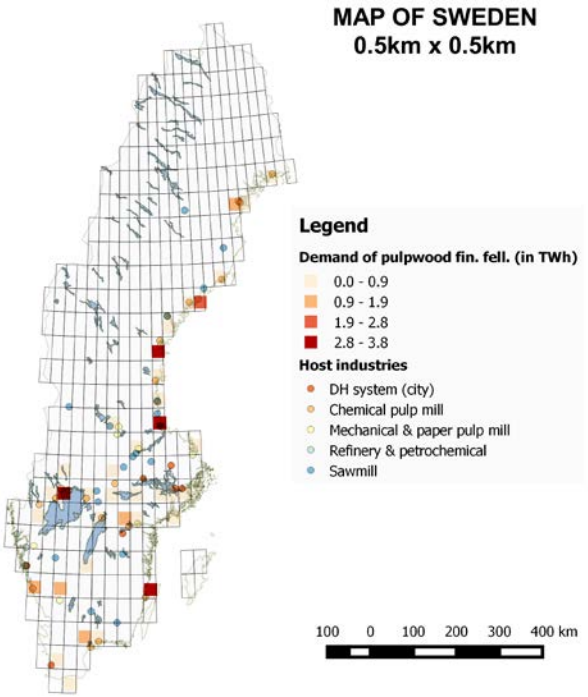
# Initial results

## Demand - Pulpwood final felling

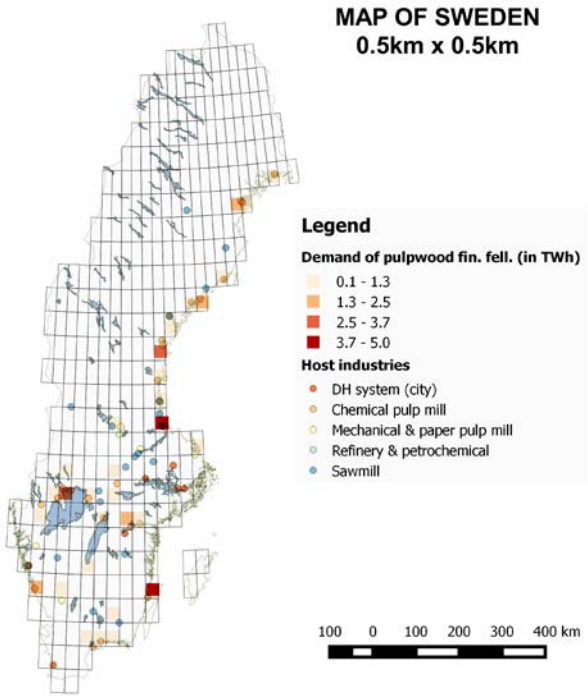
### BAU scenario




### 10TWh scenario



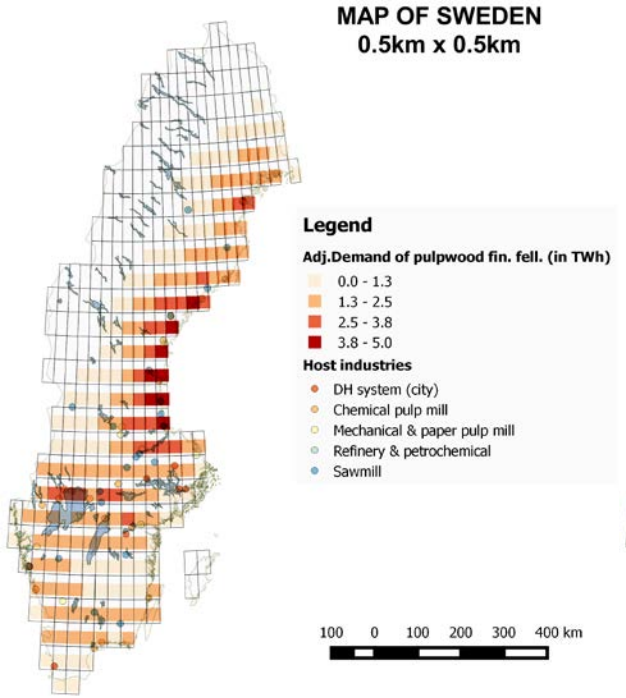

### 20TWh scenario



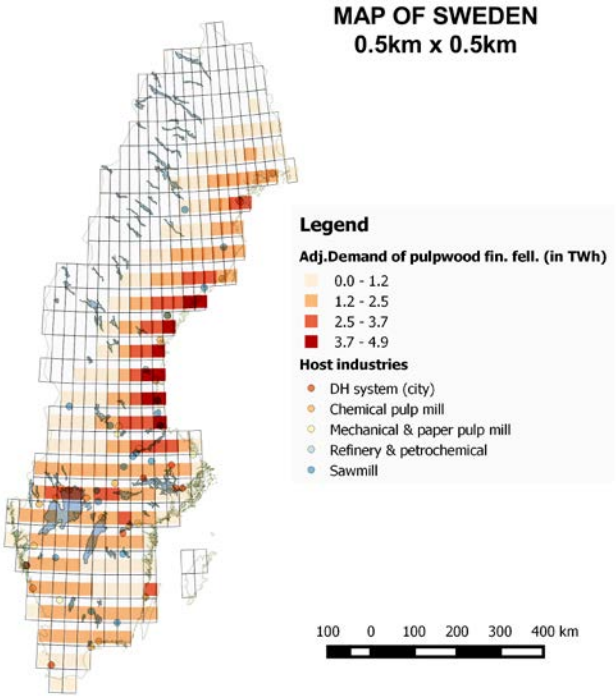
# Initial results

## Adjusted demand - Pulpwood final felling

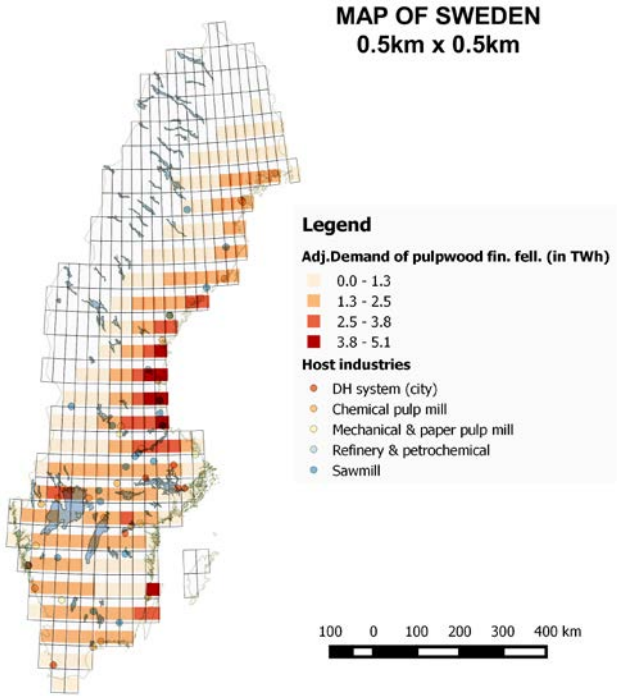
### BAU scenario




### 10TWh scenario



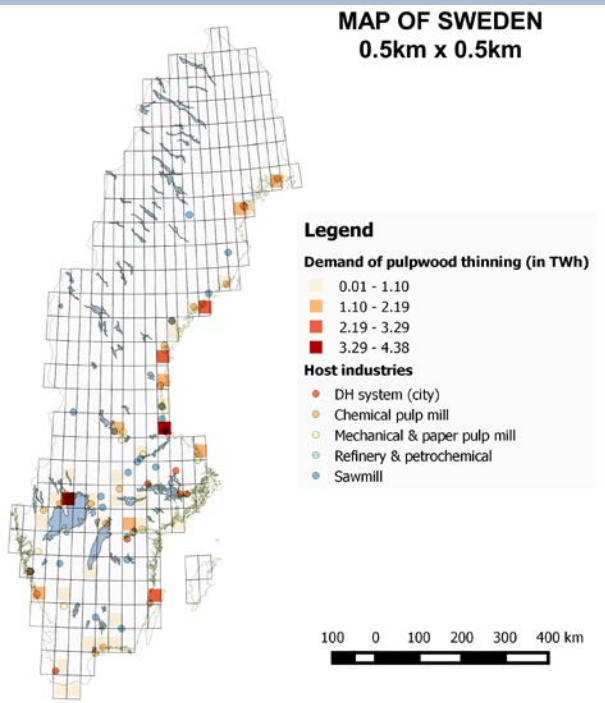

### 20TWh scenario



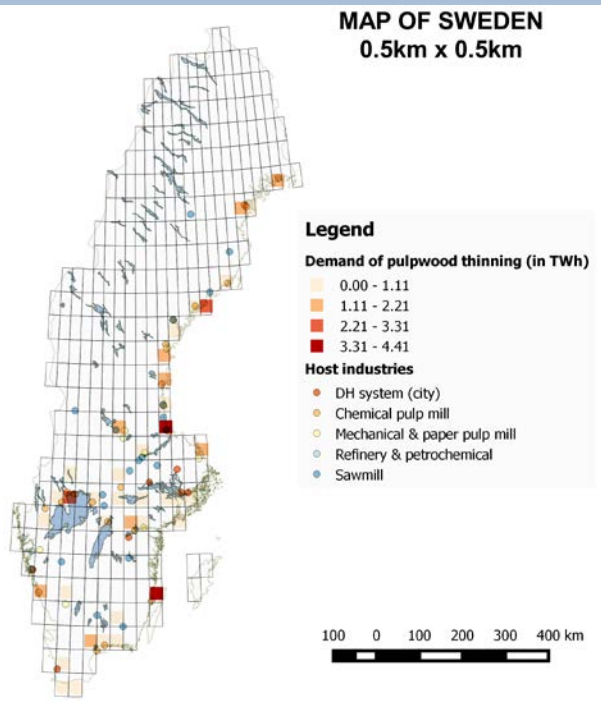
# Initial results

## Demand - Pulpwood thinning

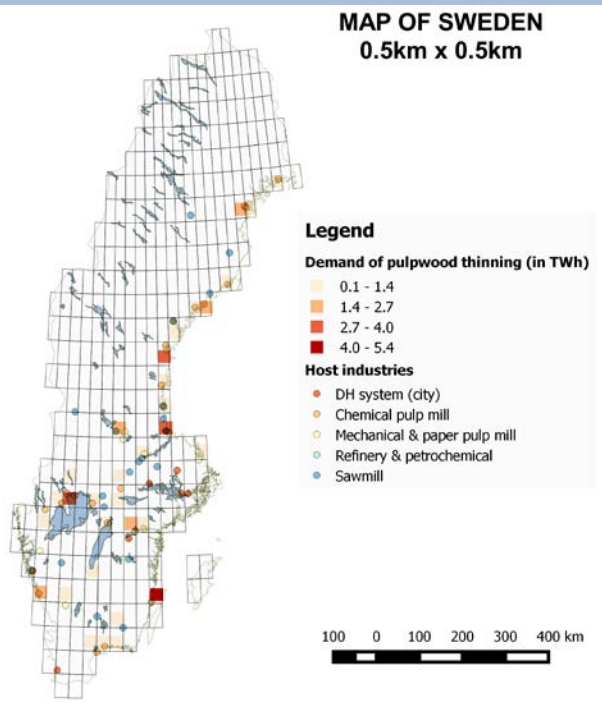
### BAU scenario




### 10TWh scenario



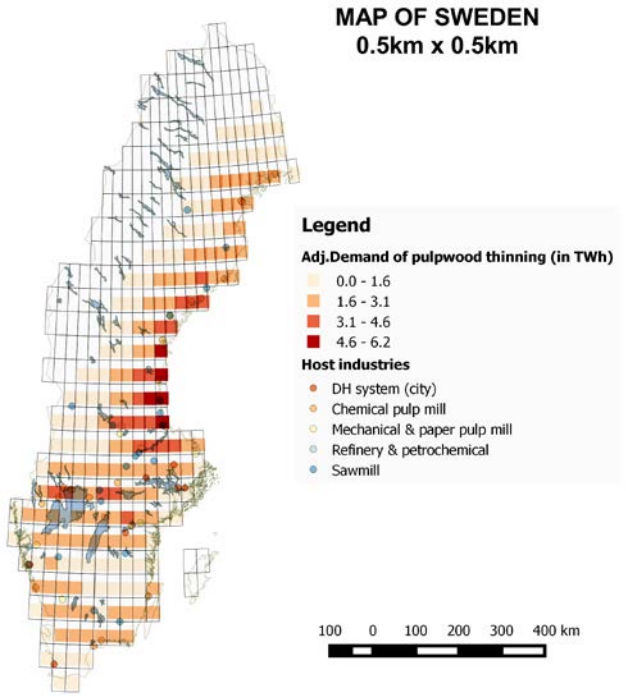

### 20TWh scenario



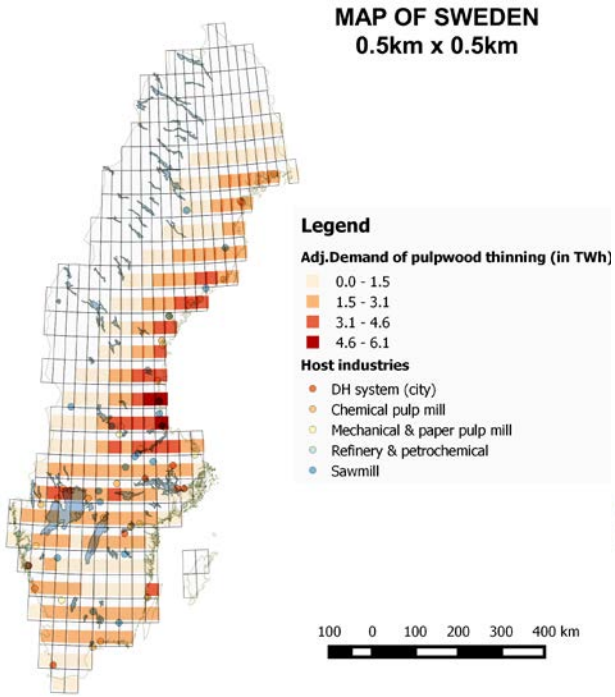
# Initial results

## Adjusted demand - Pulpwood thinning

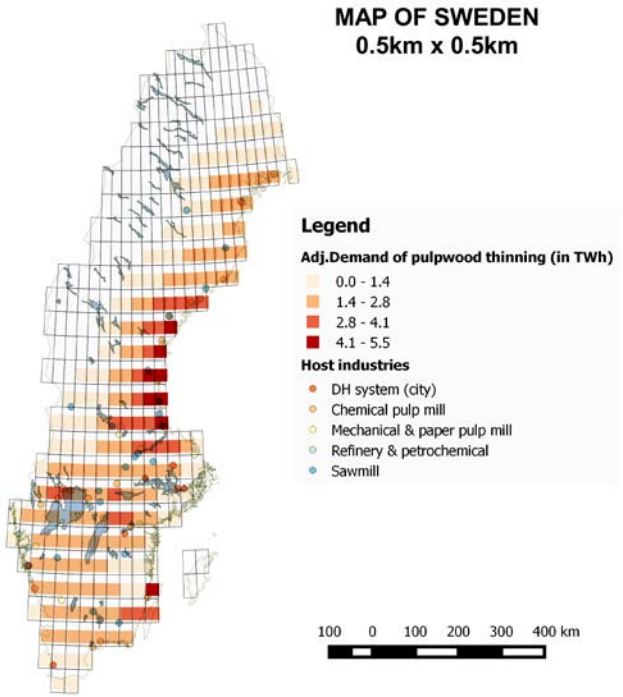
### BAU scenario




### 10TWh scenario




### 20TWh scenario



# Summary of findings
## Pulpwood from final felling and thinning

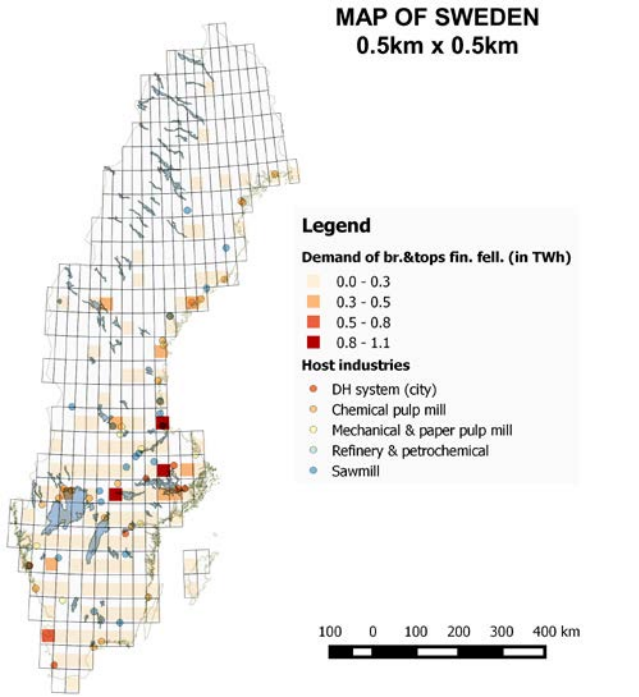
- Spatial distribution of demand for pulpwood displays substantial changes
  - BAU vs. 10TWh and BAU vs. 20TWh

- No substantial change observed in the case of 10TWh vs. 20TWh scenarios
  - Minor changes observed for a limited number of gridcells
  - Changes observed only in terms of magnitude of the level of demand

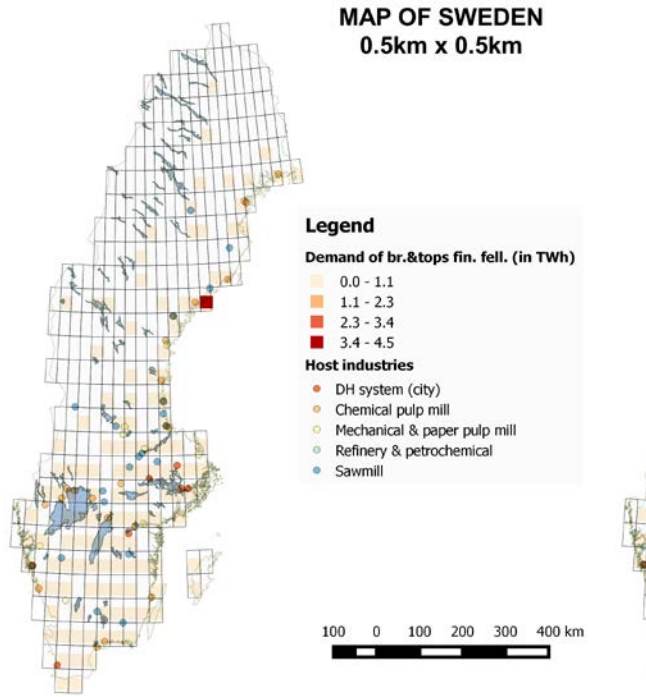
# Initial results

## Demand – Branches&Tops final felling

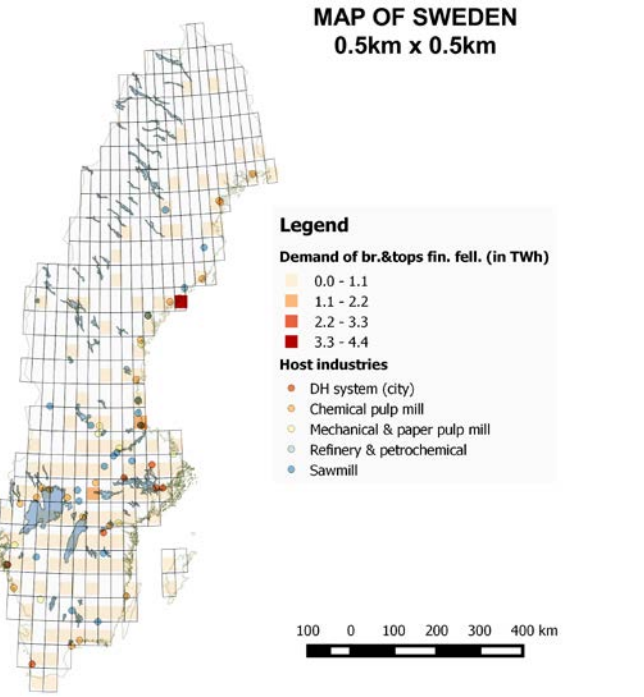
### BAU scenario




### 10TWh scenario



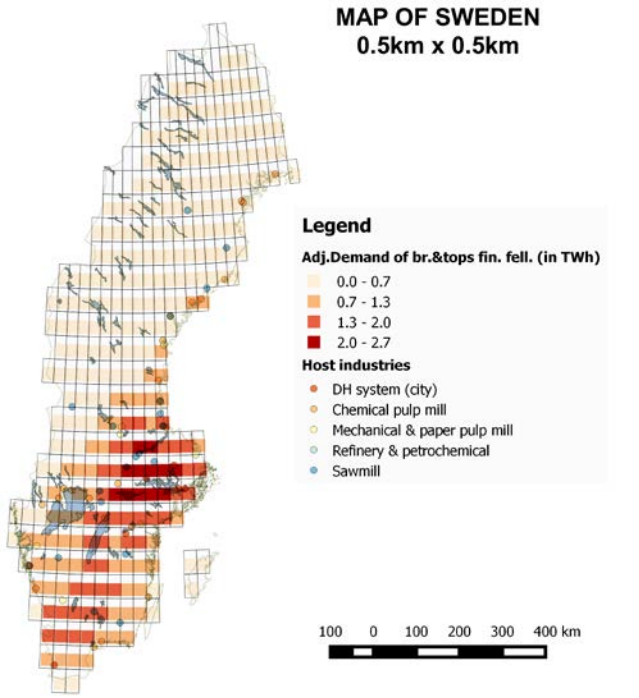

### 20TWh scenario



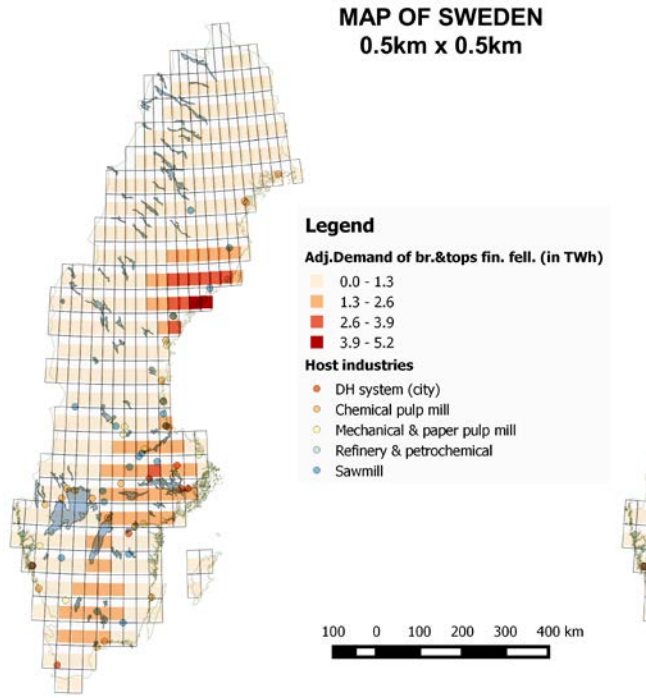
# Initial results

## Adjusted demand – Branches&Tops final felling

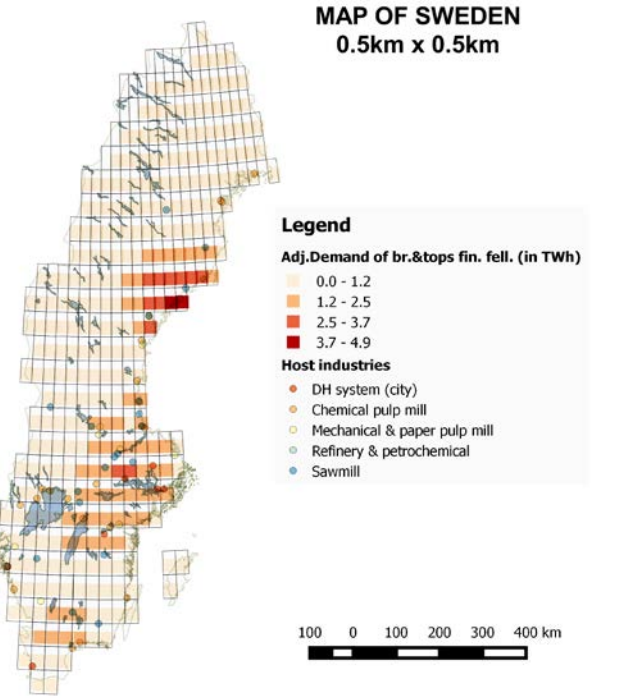
### BAU scenario




### 10TWh scenario



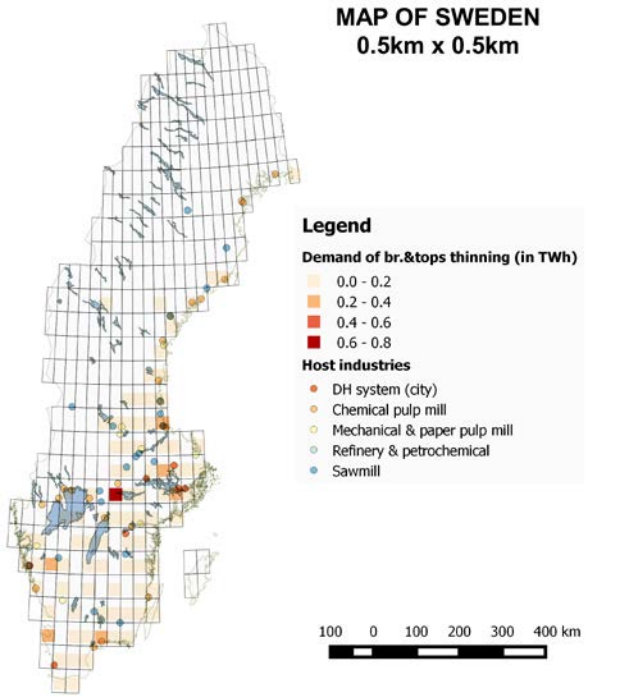

### 20TWh scenario



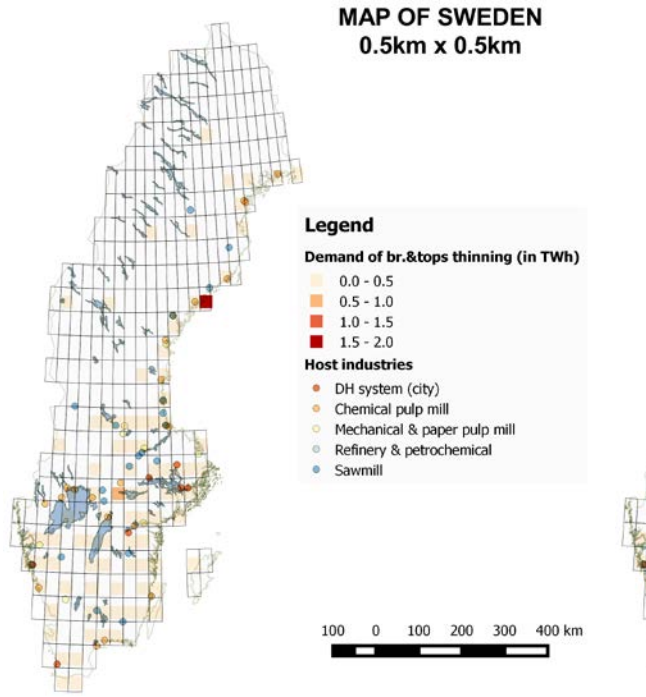
# Initial results

## Demand – Branches&Tops thinning

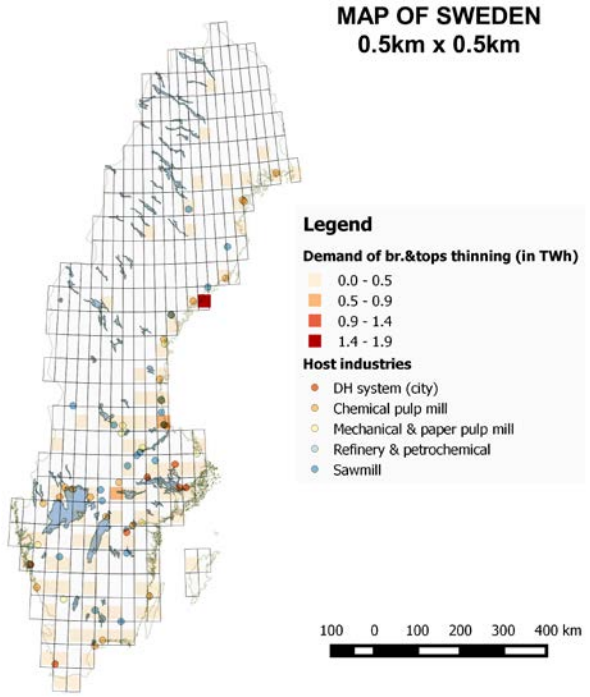
### BAU scenario




### 10TWh scenario



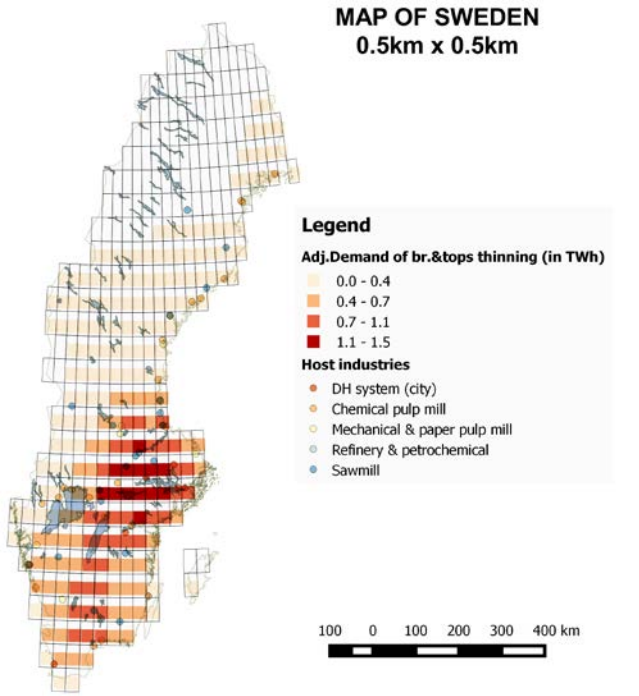

### 20TWh scenario



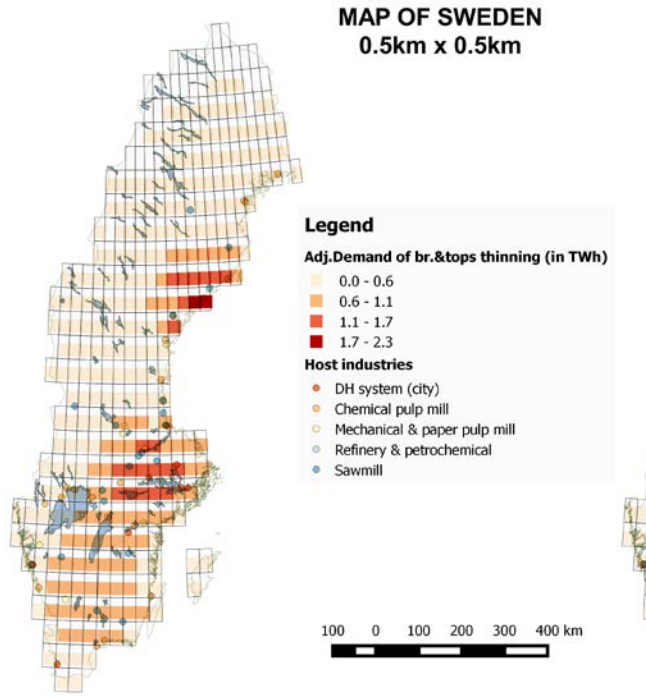
# Initial results

## Adjusted demand – Branches&Tops thinning

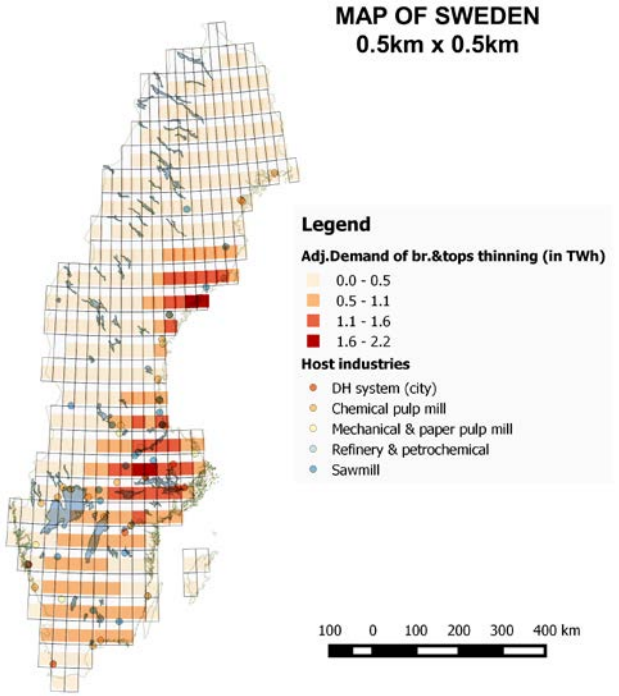
### BAU scenario




### 10TWh scenario




### 20TWh scenario



# Summary of findings

## Branches&Tops from final felling and thinning

- Spatial distribution of demand for branches&tops displays substantial changes
  - BAU vs. 10TWh and BAU vs. 20TWh

- No substantial change observed in the case of 10TWh vs. 20TWh scenarios
  - Minor changes observed for a limited number of gridcells
  - Changes observed only in terms of magnitude of the level of demand

# Initial results

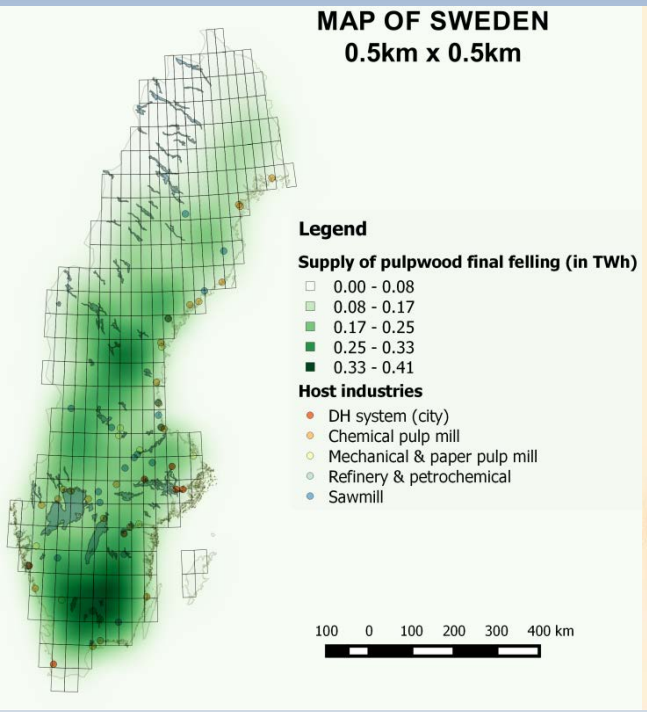
## Price for biomass

| | | Scenario 1: 10 TWh | | | | | | Scenario 2: 20 TWh | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Level (in MEUR/TWh) | | | Percent change (in %) | | | Level (in MEUR/TWh) | | | Percent change (in %) | | |
| | | Avg | Max | Min | Avg | Max | Min | Avg | Max | Min | Avg | Max | Min |
| Final felling | Sawlogs | 19,84 | 20,71 | 19,08 | 0,23 | 1,13 | 0,002 | 19,84 | 20,71 | 19,08 | 0,23 | 1,13 | 0,002 |
| | **Pulpwood** | **13,28** | **16,73** | **12,66** | **0,93** | **18,95** | **0,004** | **13,28** | **16,73** | **12,66** | **0,93** | **18,95** | **0,004** |
| | **Branches & Tops** | **13,94** | **15,68** | **13,60** | **0,45** | **7,17** | **0,003** | **13,94** | **15,68** | **13,60** | **0,45** | **7,17** | **0,001** |
| | Stumps | 21,23 | 22,08 | 20,75 | n.a. | n.a. | n.a. | 21,23 | 22,08 | 20,75 | n.a. | n.a. | n.a. |
| Thinning | Sawlogs | 24,05 | 25,74 | 22,50 | n.a. | n.a. | n.a. | 24,06 | 25,74 | 22,50 | n.a. | n.a. | n.a. |
| | **Pulpwood** | **16,36** | **20,51** | **14,95** | **0,99** | **14,19** | **0,01** | **16,36** | **20,51** | **14,95** | **0,99** | **14,19** | **0,01** |
| | **Branches & Tops** | **15,57** | **16,80** | **14,87** | **0,38** | **1,91** | **0,01** | **15,57** | **16,80** | **14,87** | **0,38** | **1,91** | **0,01** |
| | Stumps | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |

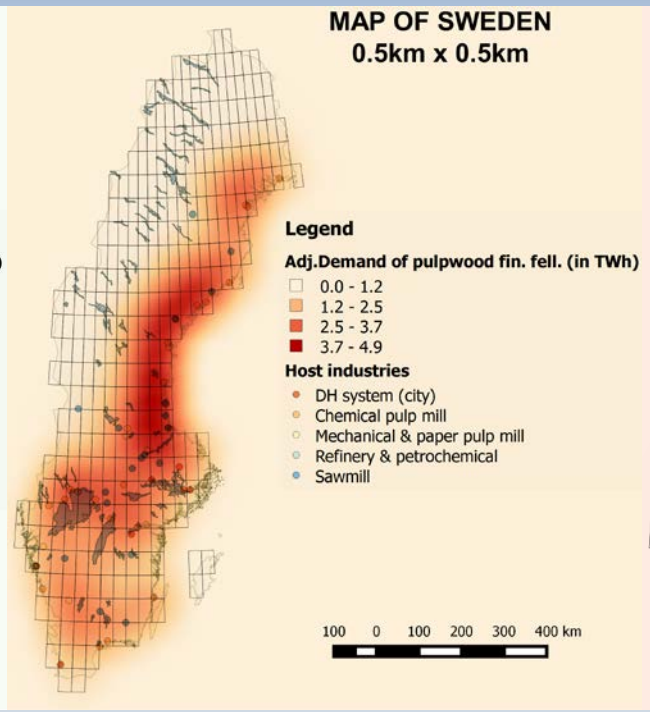
# Initial results – Price

## Pulpwood final felling – 10TWh

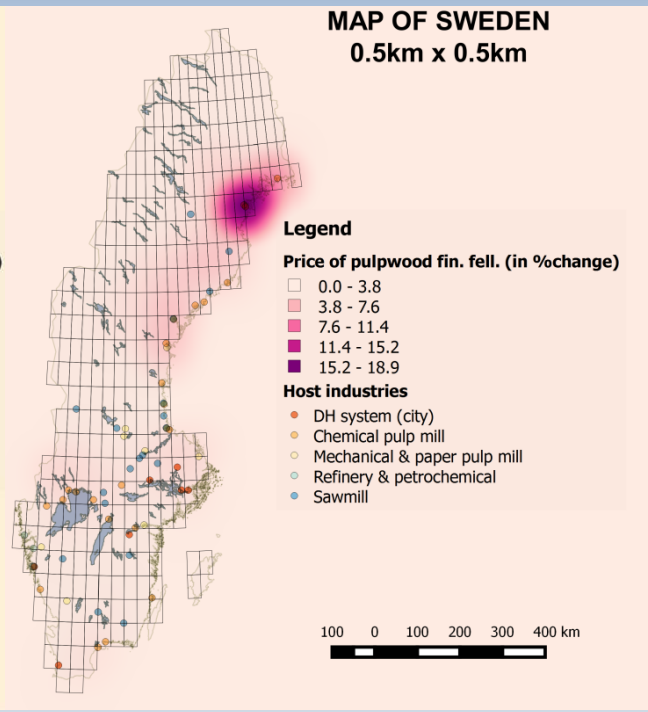
### Supply




### Demand



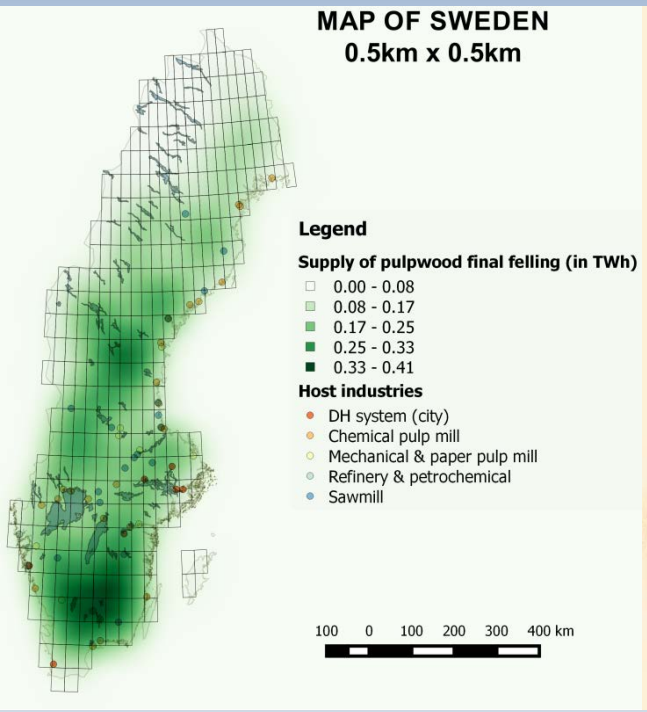

### Price (%change)



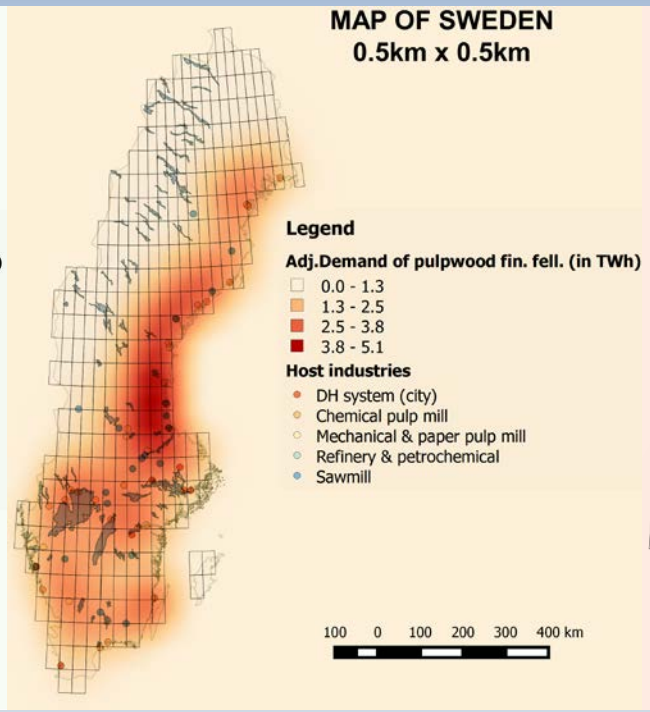
# Initial results – Price

## Pulpwood final felling – 20TWh

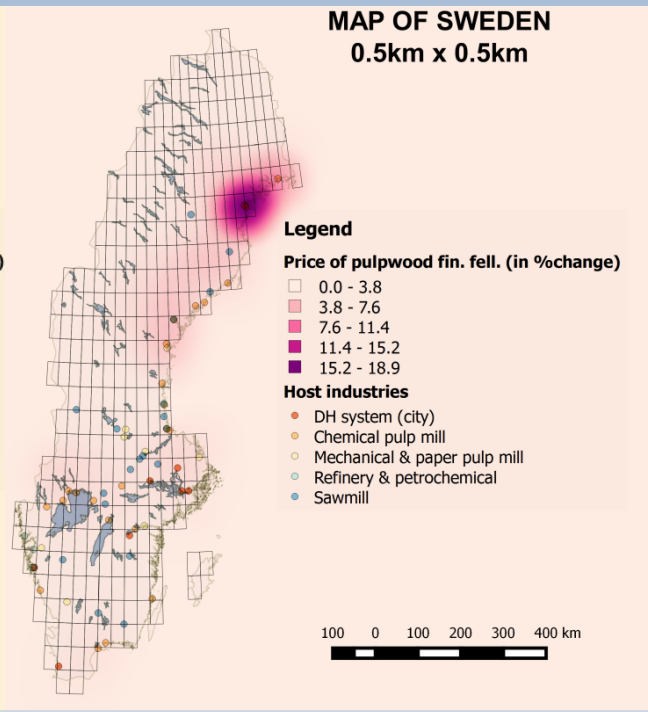
### Supply




### Demand



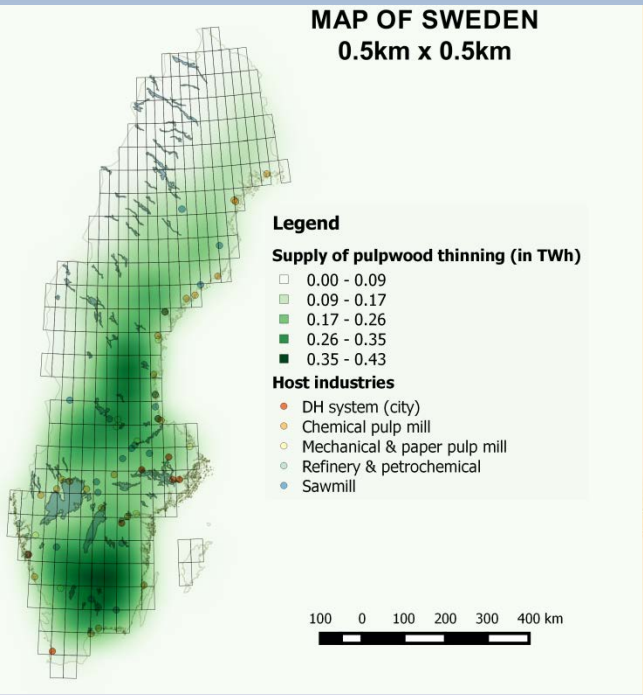

### Price (%change)



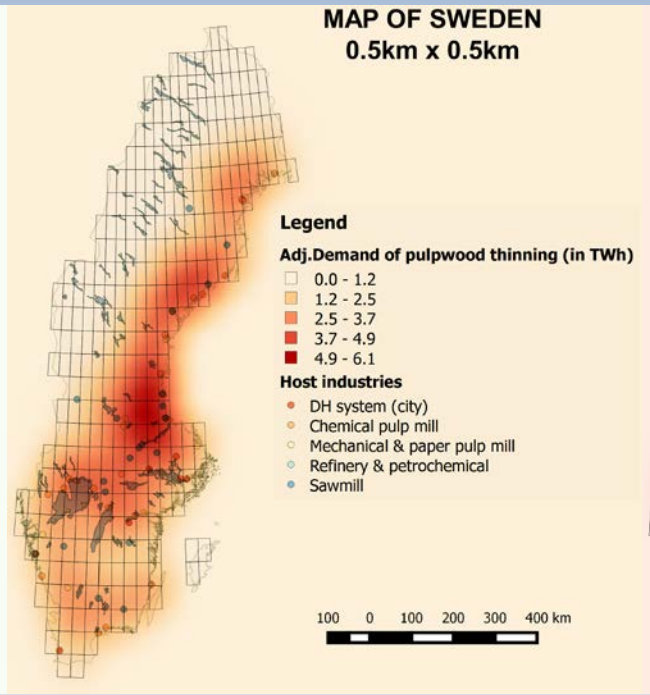
# Initial results – Price

## Pulpwood thinning – 10TWh

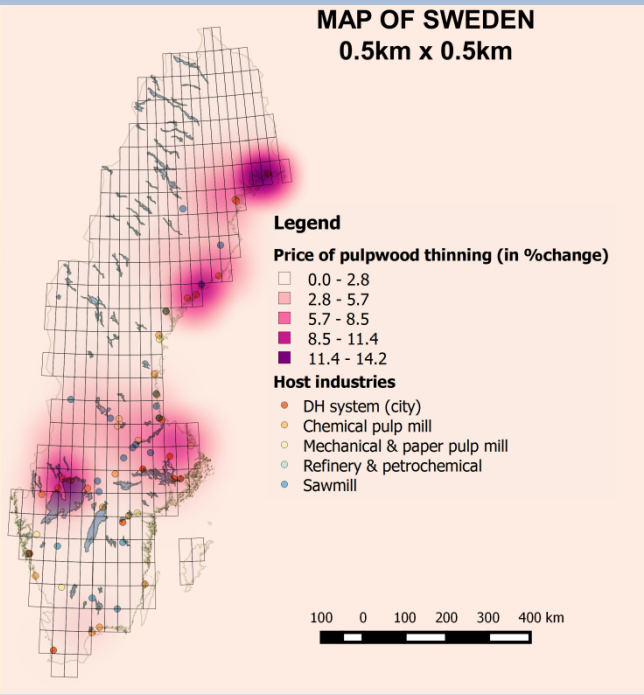
### Supply




### Demand



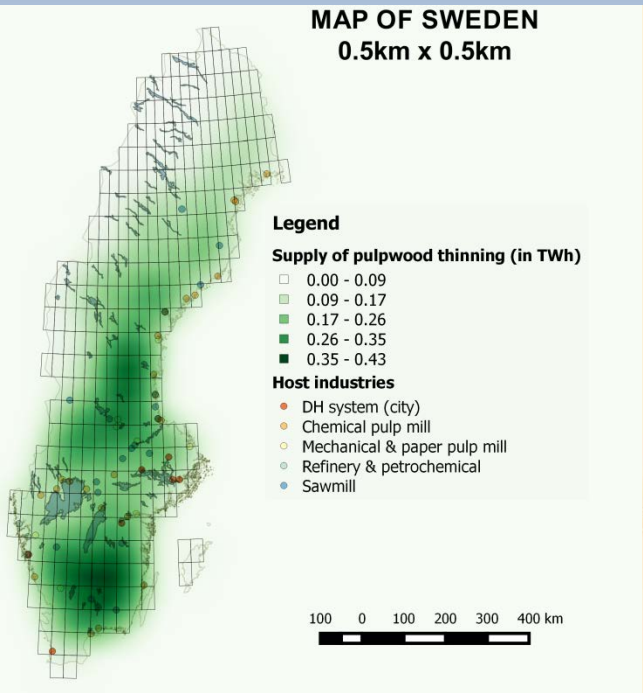

### Price (%change)



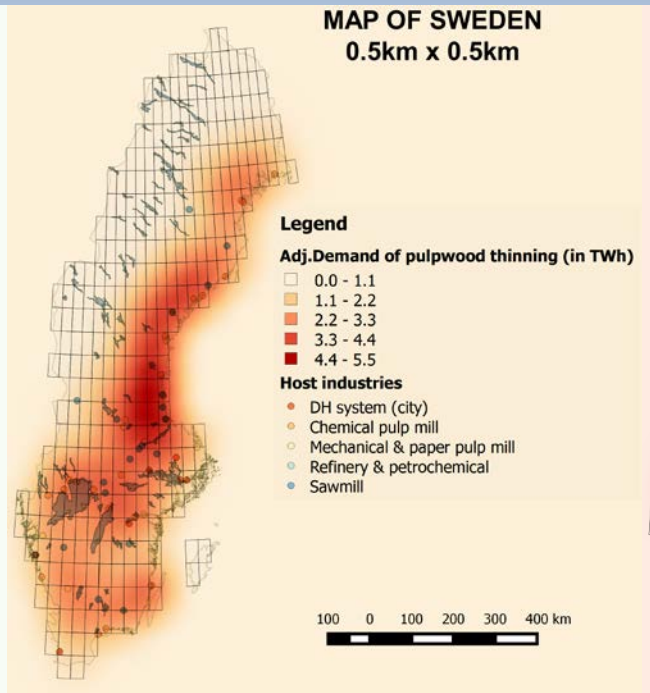
# Initial results – Price

## Pulpwood thinning – 20TWh

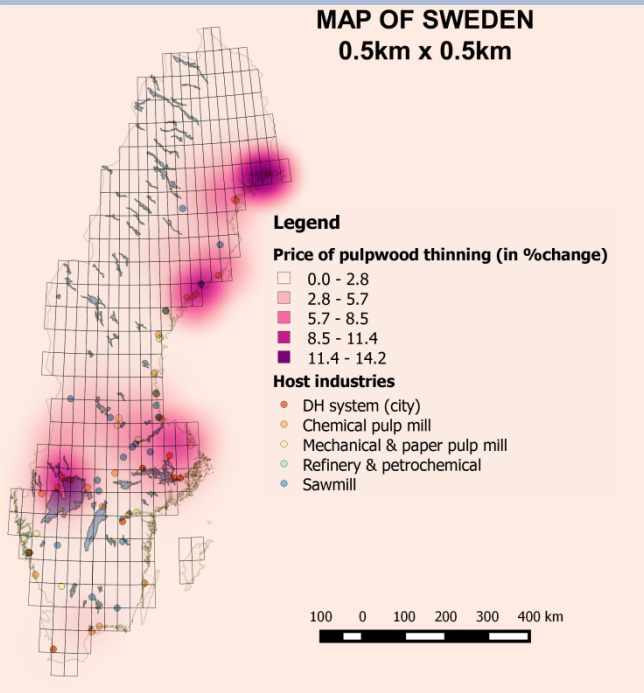
### Supply




### Demand




### Price (%change)



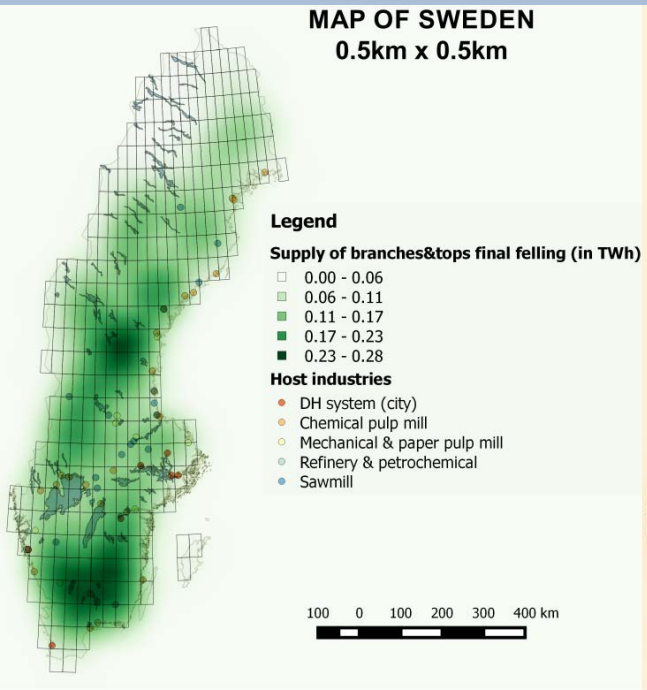
# Summary of findings
## Pulpwood from final felling and thinning

- Spatial location of price changes matches expectations
  - Driven primarily by the spatial distribution of supply and demand
- Spatial distribution of price changes varies little across simulation scenarios
  - Price changes more pronounced for pulpwood from final felling vs. thinning
  - The spatial distribution more dispersed for pulpwood from thinning vs. final felling

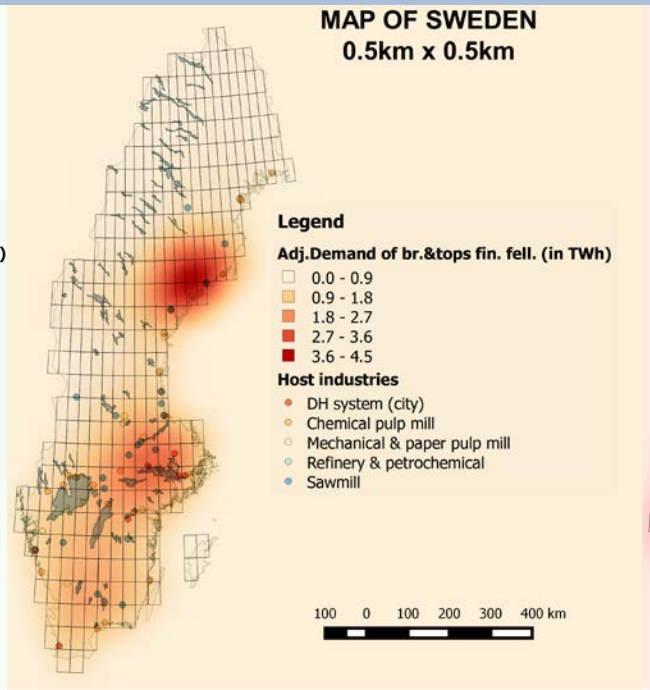
# Initial results – Price

## Branches&Tops final felling – 10TWh

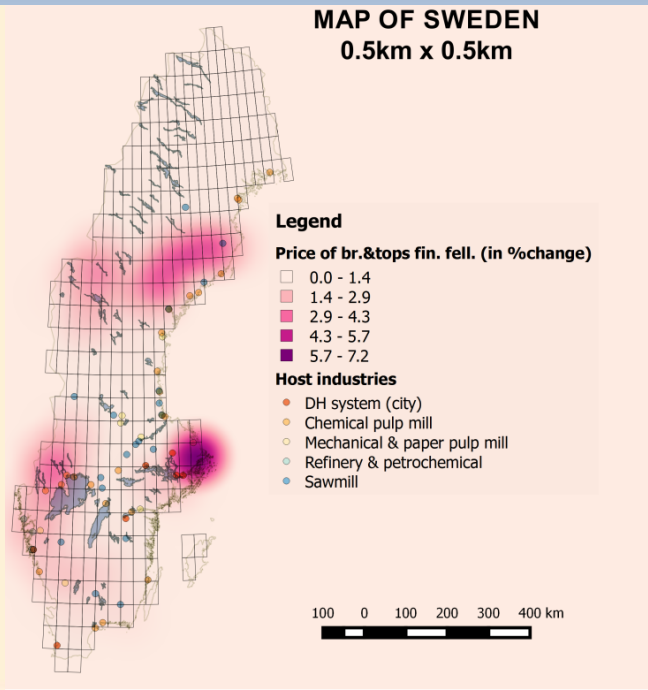
### Supply




### Demand



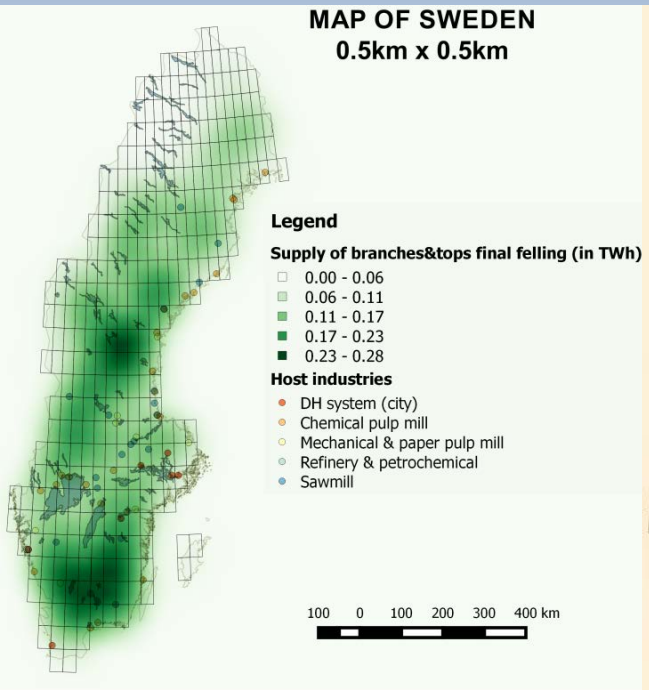

### Price (%change)



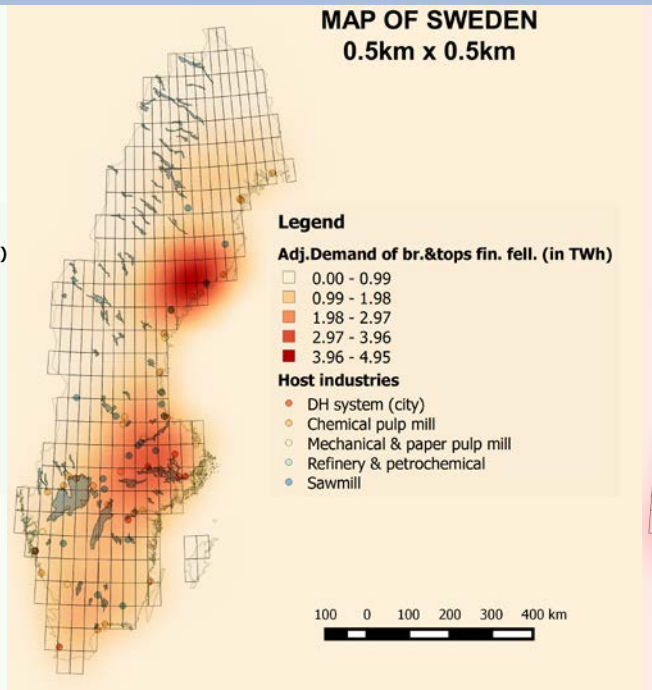
# Initial results – Price

## Branches&Tops final felling – 20TWh

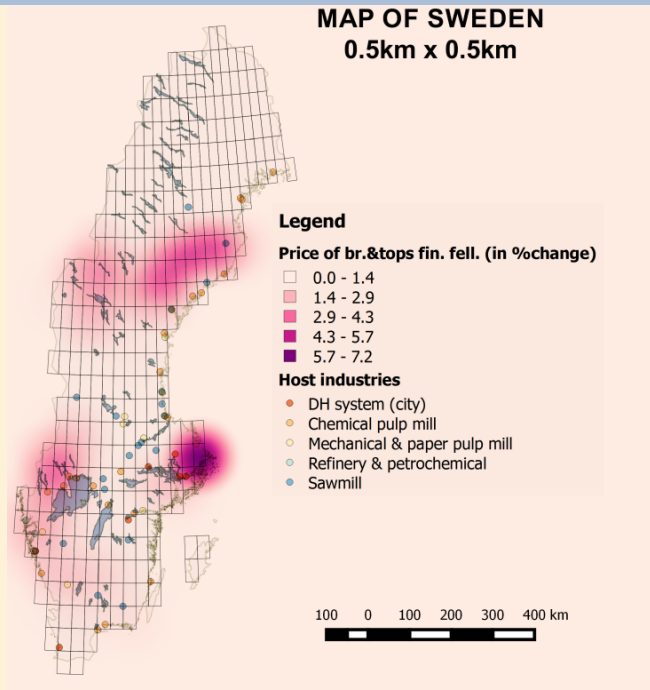
### Supply




### Demand



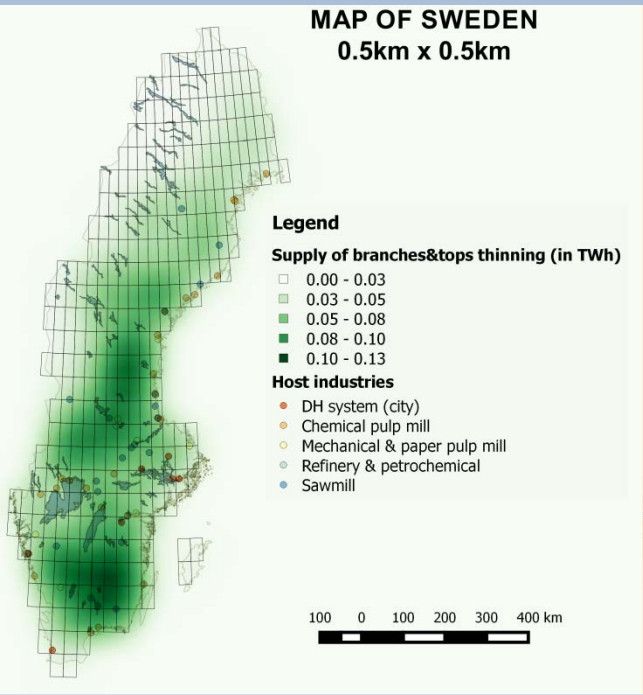

### Price (%change)



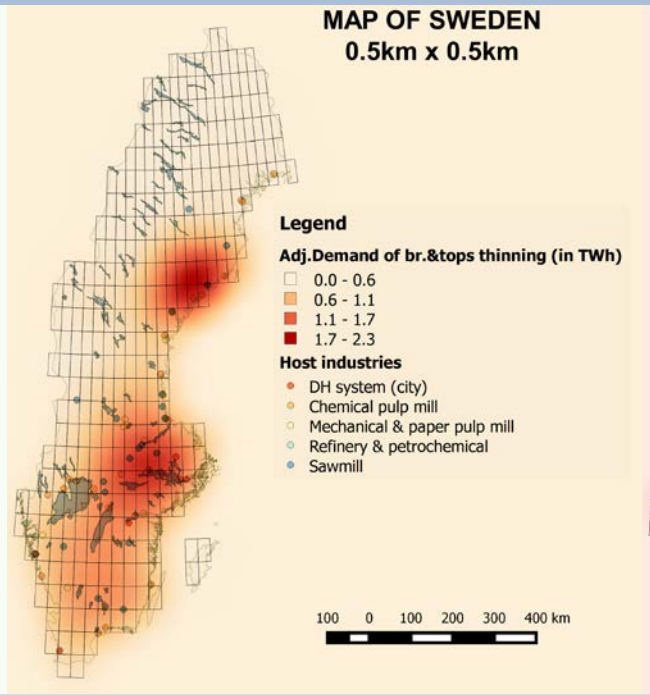
# Initial results – Price

## Branches&Tops thinning – 10TWh

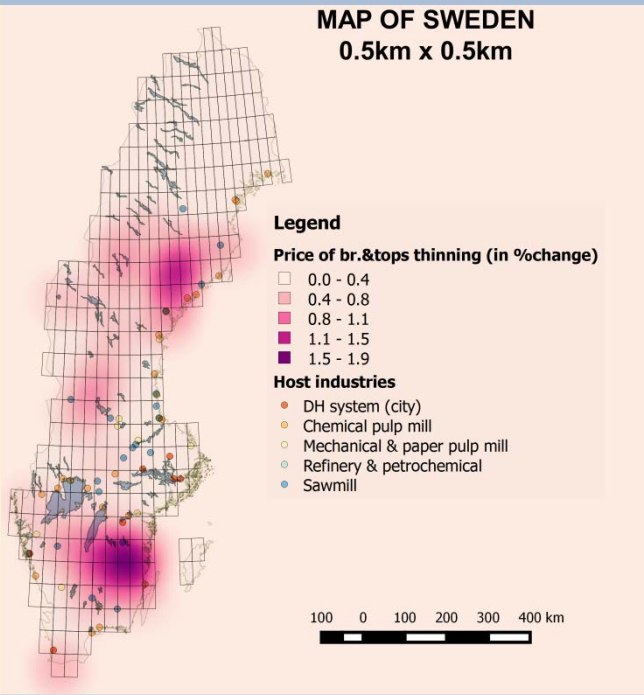
### Supply




### Demand



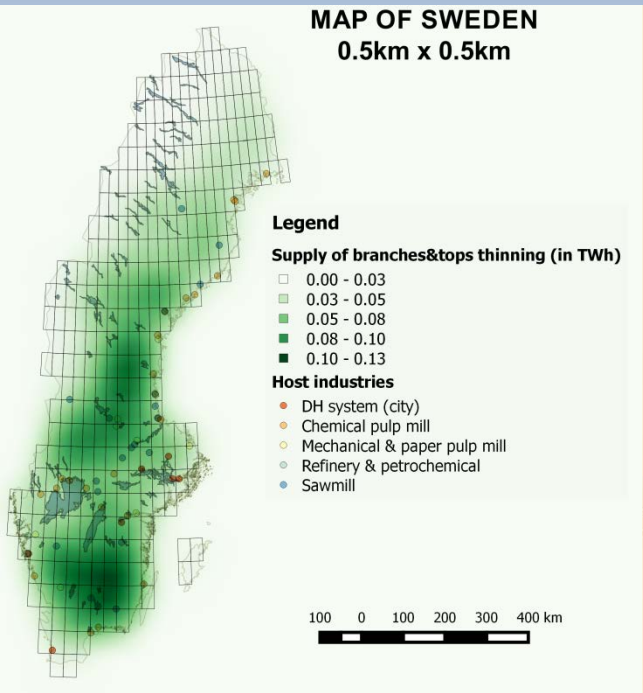

### Price (%change)



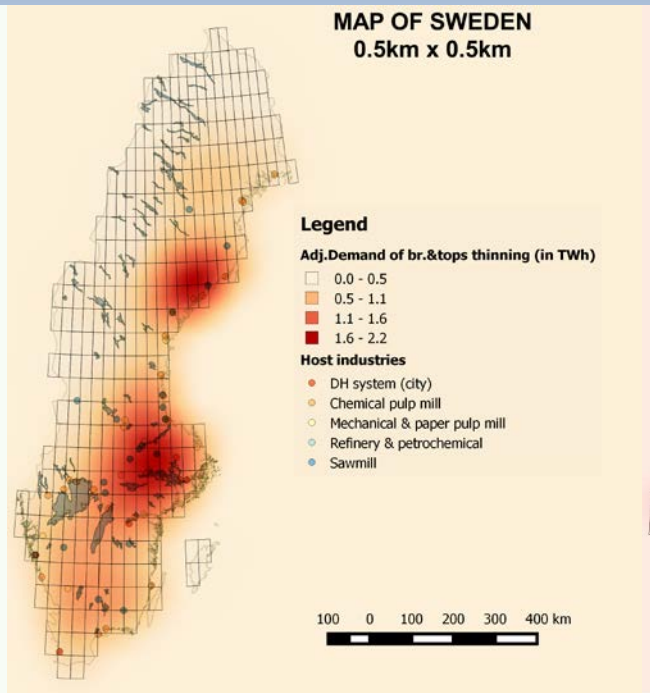
# Initial results – Price

## Branches&Tops thinning – 20TWh

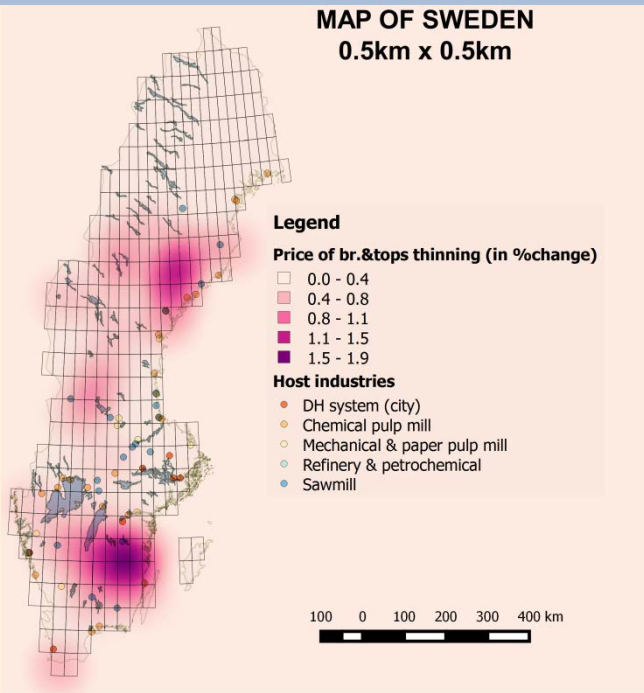
### Supply




### Demand




### Price (%change)



# Summary of findings
## Branches&Tops from final felling and thinning

- Similar results to pulpwood
  - Spatial location of price change driven by the spatial distribution of supply and demand
- Spatial distribution of price changes varies little across simulation scenarios
  - Price changes more pronounced for pulpwood from final felling vs. thinning
  - The spatial distribution more dispersed for pulpwood from thinning vs. final felling

# Summary & Conclusions

- Spatial location of price changes matches expectations for pulpwood and branches&tops
  - Primary driver is the spatial distribution of supply and demand

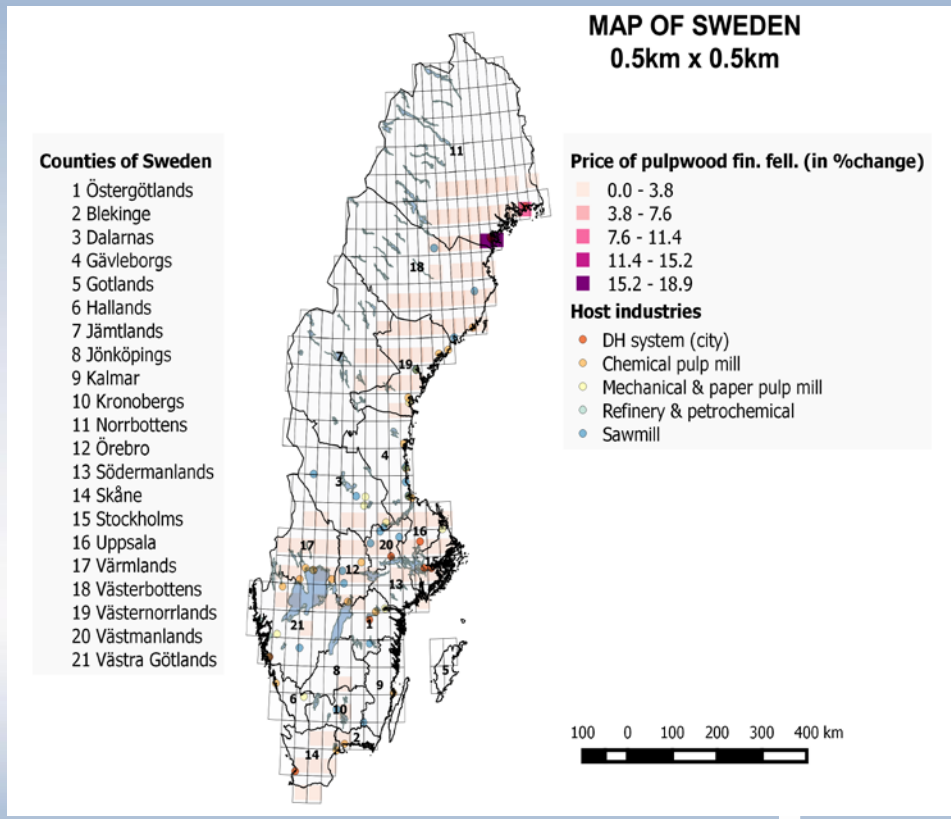
- Spatial distribution of price changes differs for pulpwood and branche&tops based on the harvesting operation
  - i.e. final felling or thinning

# Summary & Conclusions

- Spatial distribution of price changes remains unchanged between the energy scenarios
  - i.e. 10TWh and 20TWh
- Price changes more pronounced for pulpwood from final felling vs. thinning
- The spatial distribution more dispersed for pulpwood from thinning vs. final felling

# Potential future work

- ”Soft-link” with more complex economic models
  - I-O, PE, CGE models
- Geographically explicit
  - But at higher degree of aggregation (e.g. county-level)
- Allows for more complex analysis
  - Welfare impact evaluation
  - Tax and/or subsidy policy
  - Second-degree effects
  - Etc.



# THANK YOU