Decision support for operational harvest planning

SKOGFORSK

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UNIVERSITÉ LAVAL

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Background to project

- Part of the FlexWood project
  - Skogforsk
  - Logica (CGI)
  - Korsnäs (BillerudKorsnäs)
- Then: model development and testing
- Now: model adjustment, testing and implementation


Pålgårds KÖR FÖR OHLSÉN
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VOLVO
HYO 620


KOMATSU
Valmet

Model for operational harvest planning

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- Create schedules for harvesting crews
- Create delivery plans ensuring
  - Right amount and assortment, in time, to the right cost
- Optimization model
  - Minimizing costs
  - Maximizing revenues
- Include reality
- Only model, no graphical user interface

$$\min \quad z = z_{production} + z_{traveling} + z_{moving} + z_{transport} + z_{inventory}$$

$$\text{s.t.} \quad \sum_{m \in M_i} \sum_{t \in T} y_{mit} = 1, \qquad i \in I \qquad (1)$$

$$\sum_{i \in I_M} \sum_{t' \in (t - n_{mi} + 1)..t} y_{mit'} \leq 1, \qquad m \in M, t \in T_B \qquad (1b)$$

$$\sum \sum t^{i} y_{mit} - \sum y_{mi0} \leq \sum t^{t} \qquad m \in M \qquad (1c)$$

What is reality?

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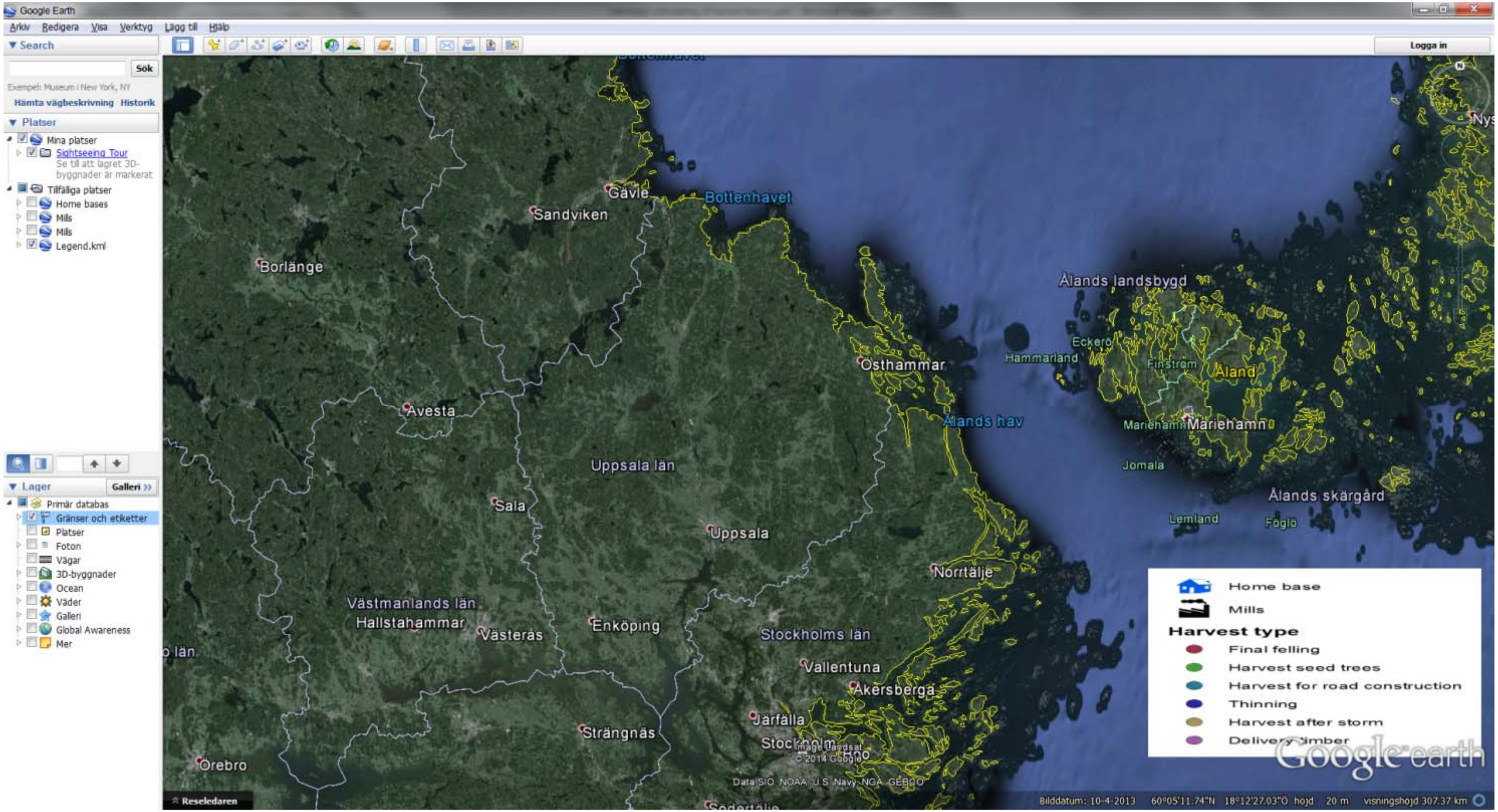
- Harvesting managers at forest companies
- Large areas with a large number of alternative stands
- 8-15 harvesting teams
  - Small, medium and large sized machines
  - Home bases and preferred working areas
- Short and long term planning
- Weekly delivery plans
- Choice of bucking pattern/ price lists
- Rain and thawing periods
  - Variation in accessibility
- Unforeseen happenings
  - Need of fast re-planning



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Home bases
Mills
Mills
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Mer
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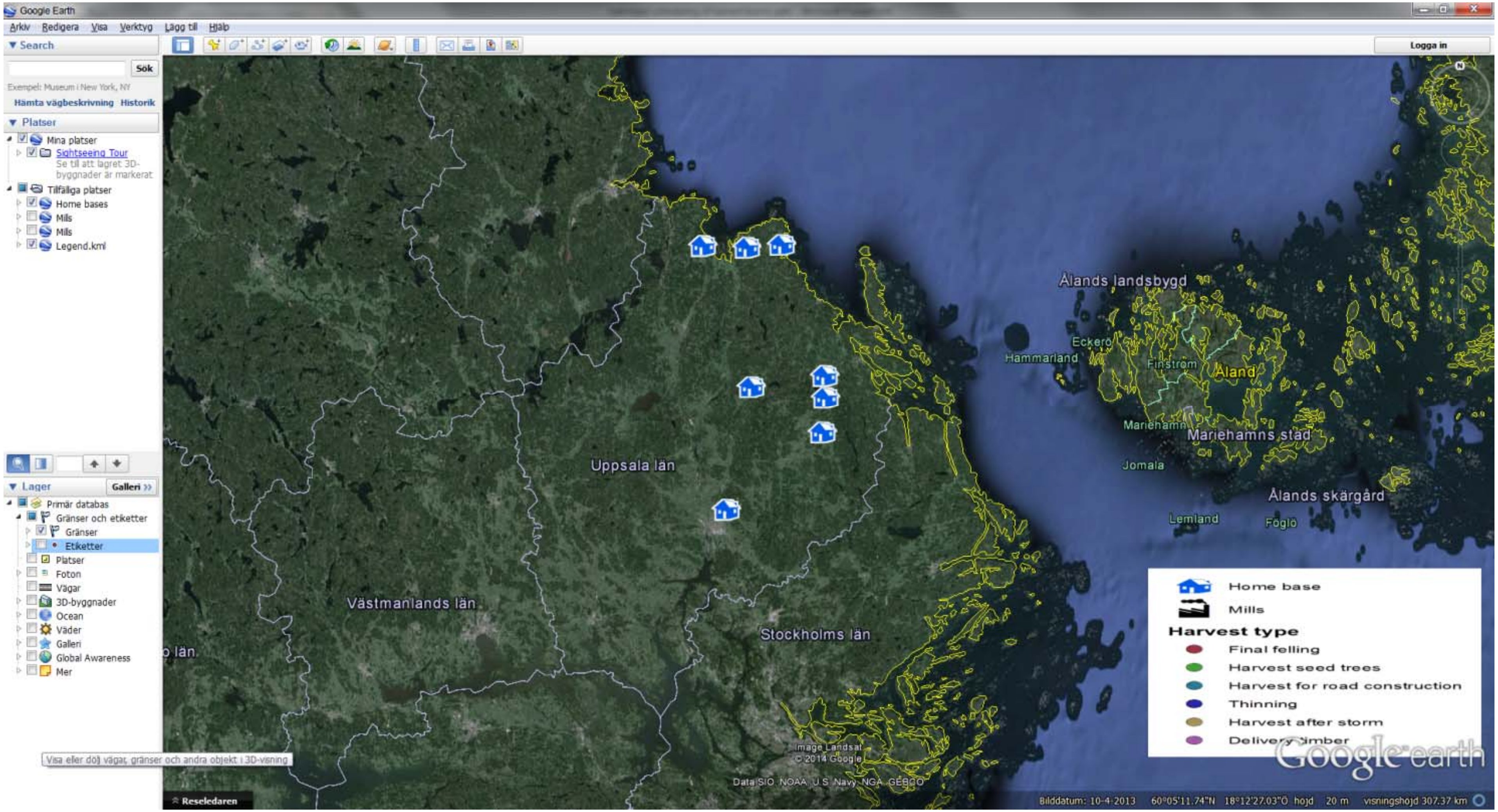
Hammarland
Finström
Åland
Östhammar
Ålands hav
Mariehamn
Avesta
Jomala
Uppsala län
Ålands skärgård
Sala
Lemland
Föglö
Uppsala
Norrtälje
Västmanlands län
Hallstahammar
Västerås
Enköping
Stockholms län
Vallentuna
Åkersberga
Järfälla
Strängnäs
Örebro
Stockholm
Home base
Mills
Harvest type
Final felling
Harvest seed trees
Harvest for road construction
Thinning
Harvest after storm
Delivery timber
Google earth
Reseledaren
Bilddatum: 10-4-2013



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Se till att lagret 3D-byggnader är markerat
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Logga in
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Hammarland
Finström
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Mariehamns stad
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Image Landsat
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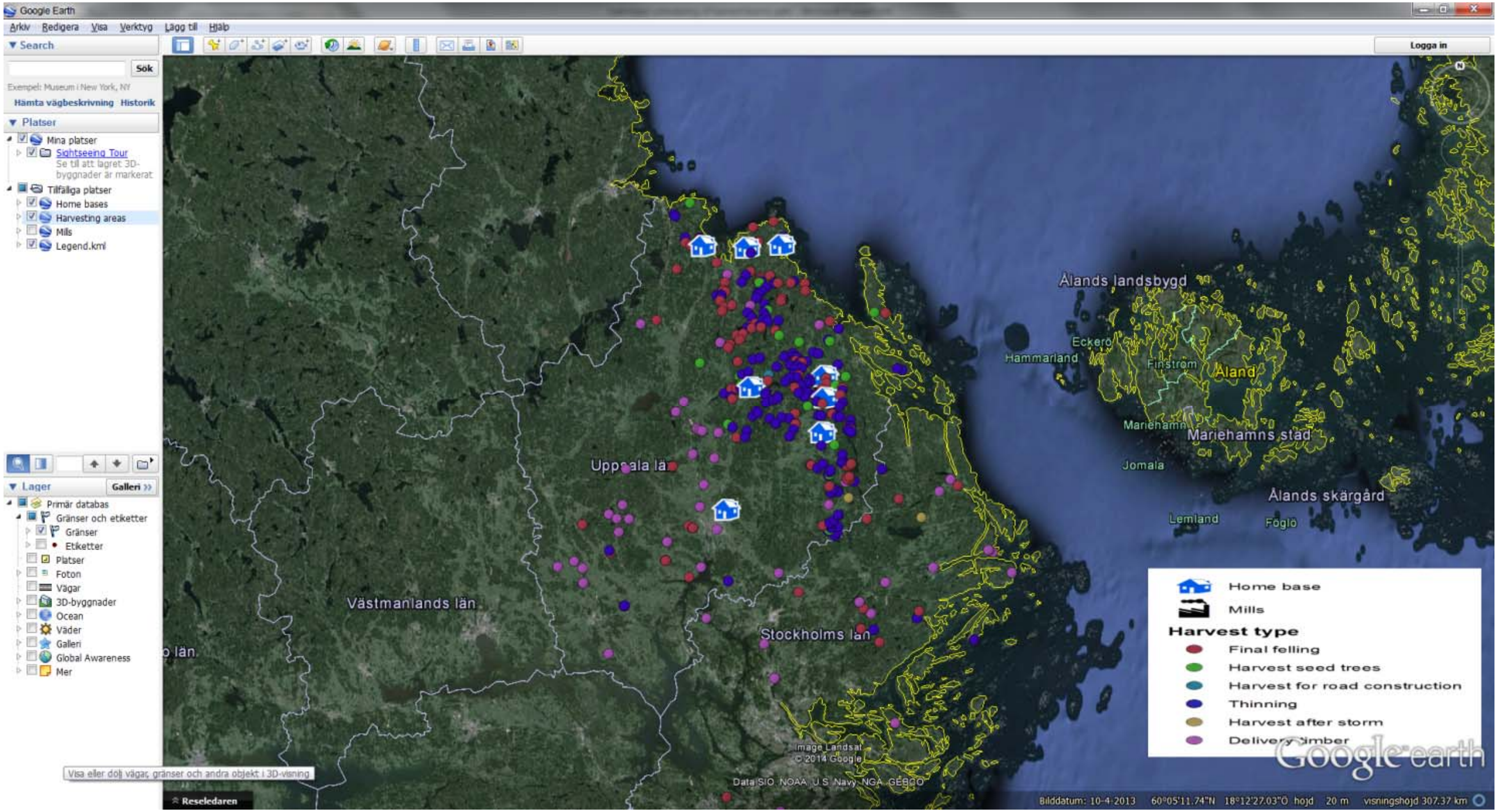
Reseledaren
Bilddatum: 10-4-2013 60°05'11.74"N 18°12'27.03"Ö höjd 20 m visningshöjd 307.37 km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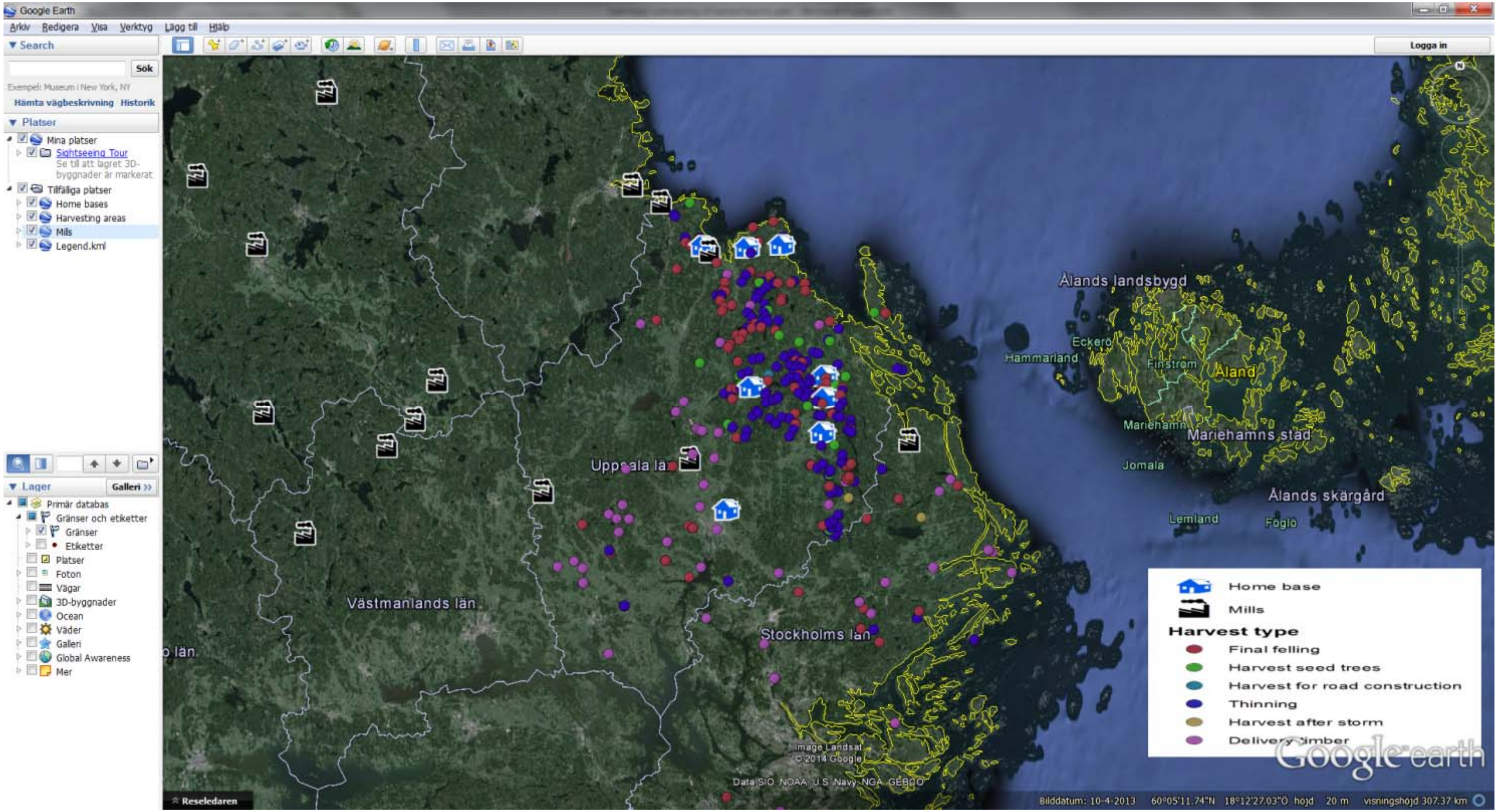
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Google earth

Decisions

- Which stands to harvest and when
- Which bucking pattern/ price list to use
- By which team
- Where and when to deliver
- How to control inventory

Our model

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- Objective to minimize costs for
  - Harvesting
  - Transportation of round wood
  - Relocation of machines
  - Employee travel
- Maximize profit when delivering to customer
- Up to one year planning horizon
- Detailed plan of the first month (day by day)
  - Business period
- Then aggregated plans on monthly level
  - Anticipation periods

Our model

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- A sequence of models are solved

Initial allocation of stands to teams

⇩

Allocation of stands to aggregated business period

⇩

Initial schedule in business periods

⇩

Detailed schedule in business periods

⇩

Full plan in business periods and anticipation periods including all flows and inventories

Our model

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- A sequence of models are solved
- Possibility to give weights to
  - Revenue
  - Transportation cost
  - Harvesting cost
  - Relocation cost

Our model

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- The result includes
  - a scheduling of all machines of the first 30 days
  - a note about what apt-file to be used in each stand
  - a description of the volumes that will be allocated to which mill
  - a summary of the costs (harvesting, relocation, transportation and other)
  - flows
  - inventories
  - summaries of how well the demand is achieved with the current solution

Case study

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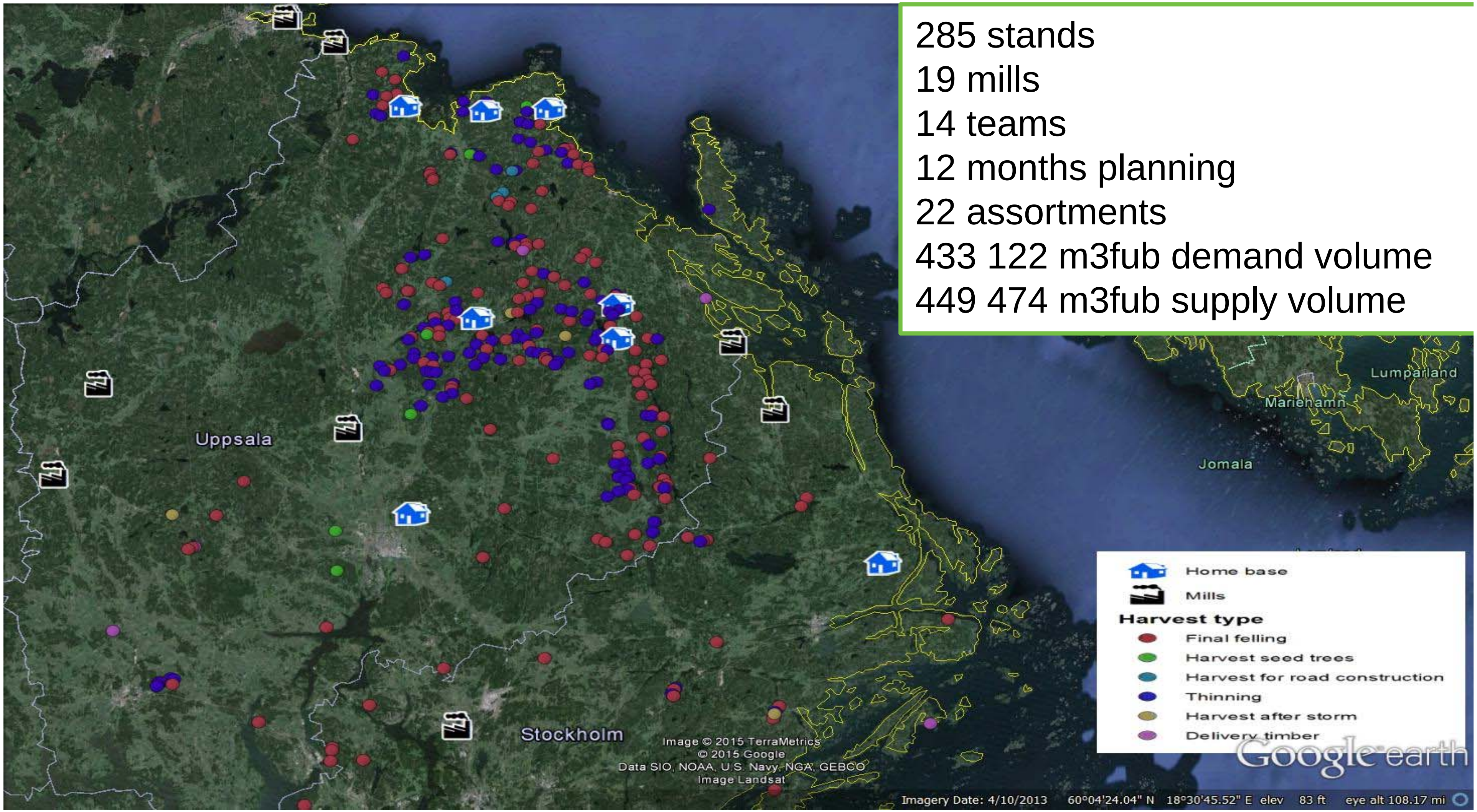
285 stands
19 mills
14 teams
12 months planning
22 assortments
433 122 m3fub demand volume
449 474 m3fub supply volume



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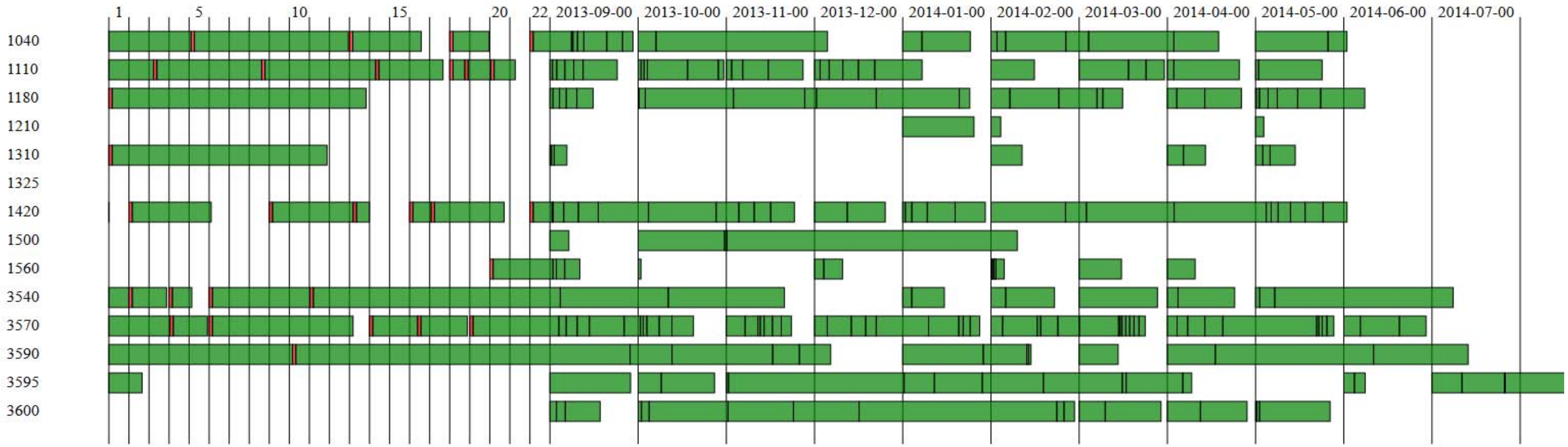
Case information

	P1	P2	P3	P4	P5
solution time	60 seconds	150 seconds	3 hours	3 seconds	>36 hours*
# binary variables	3 300	10 000	28 000	10	83 000
# continuous variables	300	565 000	18 000	114 000	689 000
# constraints	300	52 000	66 000	14 000	211 000

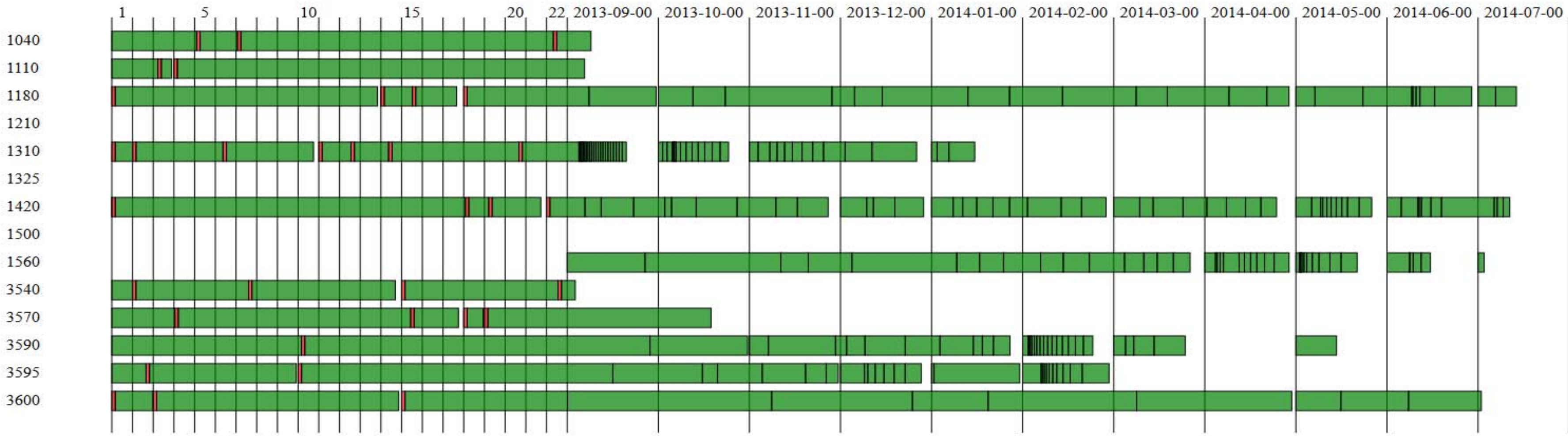
* a heuristic is applied which takes 15 seconds to solve, with 6% gap

Case study

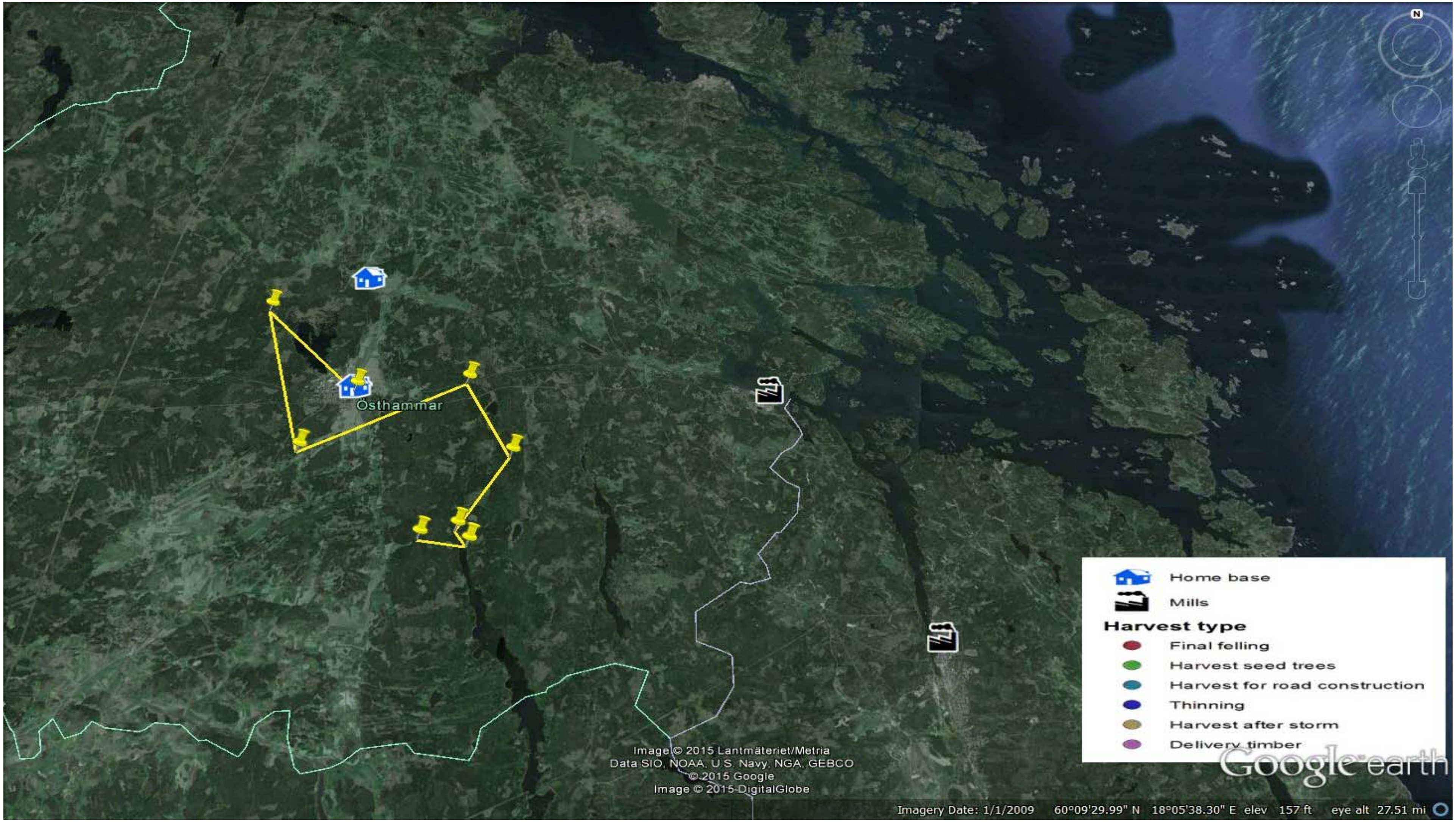
manual



optimized



Case study



Östhammar
Home base
Mills
Harvest type
Final felling
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Harvest for road construction
Thinning
Harvest after storm
Delivery timber
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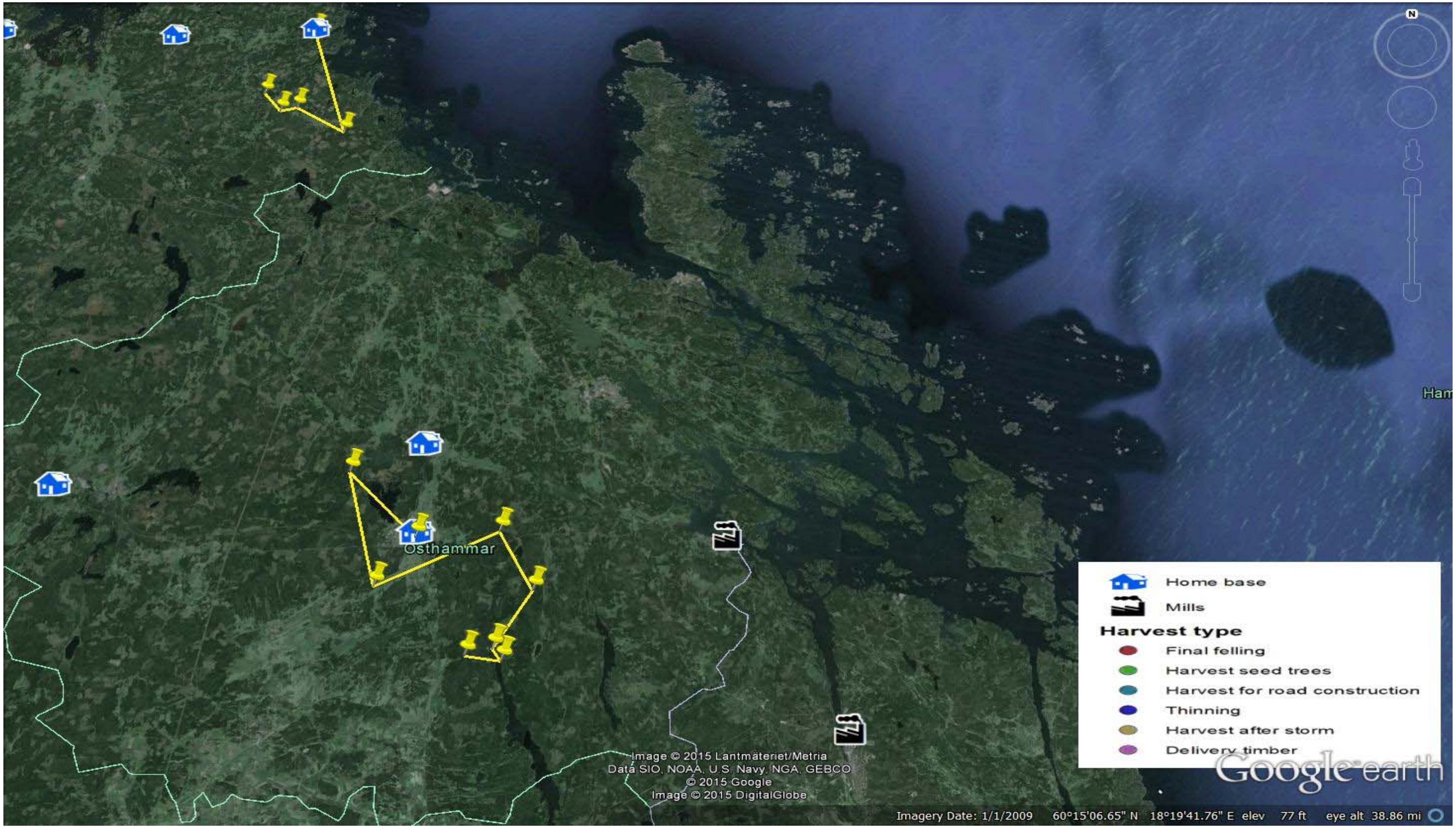
Google earth
Imagery Date: 1/1/2009 60°09'29.99" N 18°05'38.30" E elev 157 ft eye alt 27.51 mi

Case study



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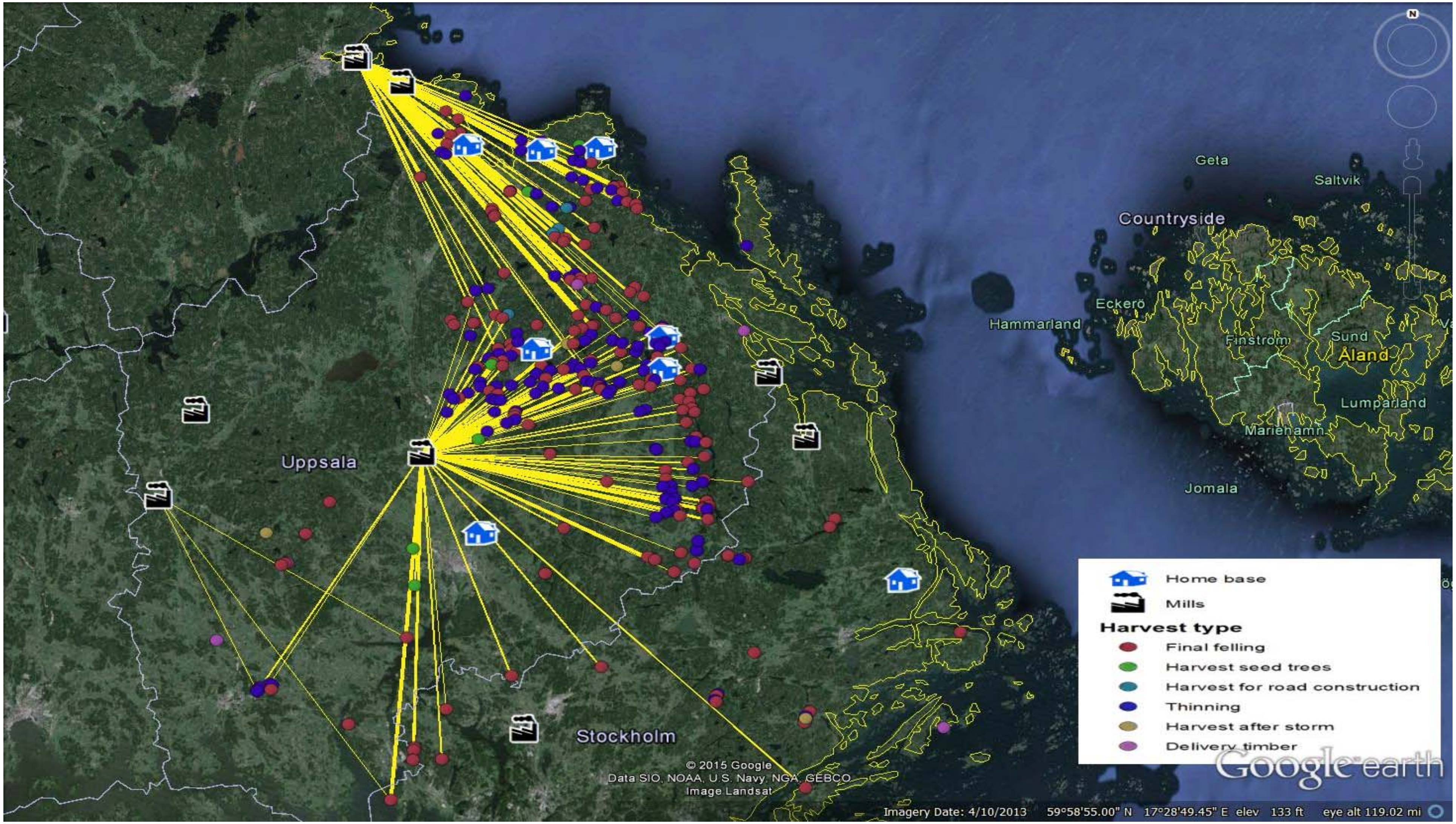
Imagery Date: 1/1/2009 60°15'06.65" N 18°19'41.76" E elev 77 ft eye alt 38.86 mi

Case study



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Case study

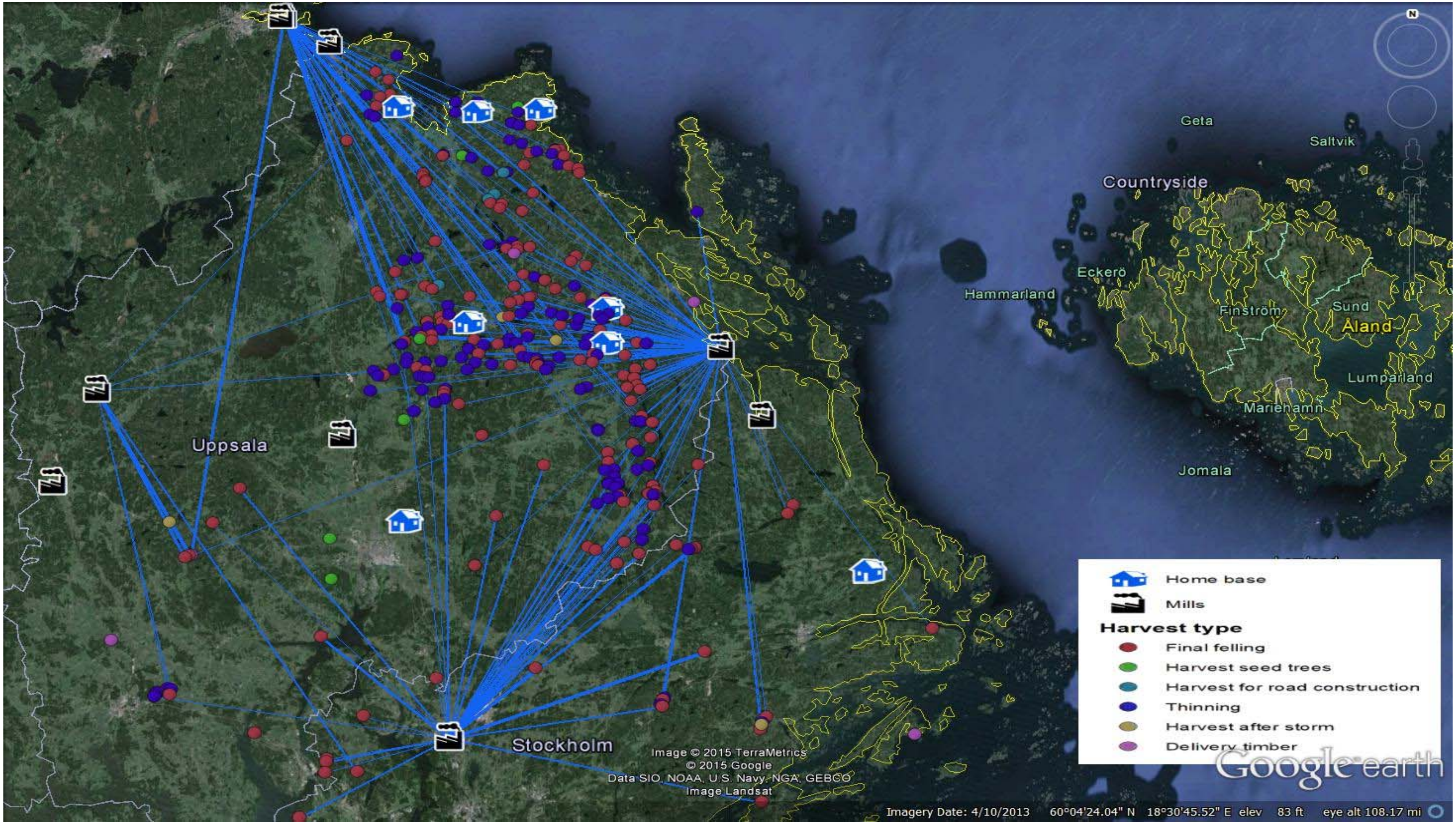
Uppsala
Stockholm
Geta
Saltvik
Countryside
Eckerö
Hammarland
Finström
Sund
Åland
Lumparland
Mariehamn
Jomala
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Image © 2015 TerraMetrics
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
Imagery Date: 4/10/2013 60°04'24.04" N 18°30'45.52" E elev 83 ft eye alt 108.17 mi
Google earth

Comparison

	manual	optimized
harvester costs	1.94E+07	1.55E+07
harvester costs/m3	45.4	37.6
forwarder costs	2.14E+07	1.62E+07
forwarder costs/m3	50.2	39.3
team traveling costs (home)	5.47E+05	4.58E+05
moving costs	1.40E+06	1.54E+06
totalTransportationCosts	2.84E+07	2.86E+07
total costs	7.12E+07	6.24E+07

Project status and future work

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- Testing on real case data together with BillerudKorsnäs and CGI
- Model adjustments
- Managing data quality with respect to e.g. productivity functions
- Connecting the model to VSOP (CGI harvest planning software)
- Discussions with other forest companies and software suppliers
- General model and defined data specifications

Questions?