Sveriges lantbruksuniversitet
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Simulating mill service levels for combined road and rail transport

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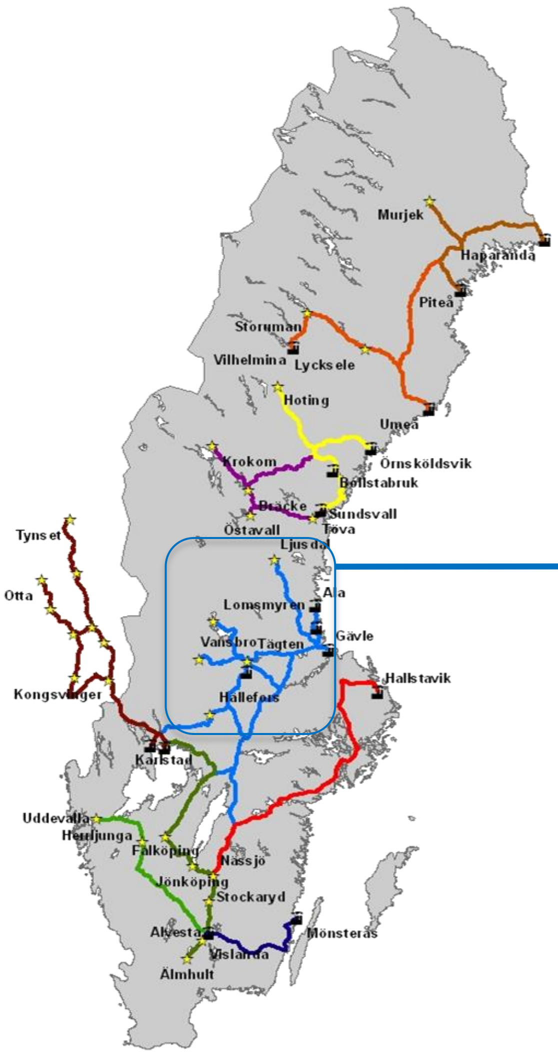
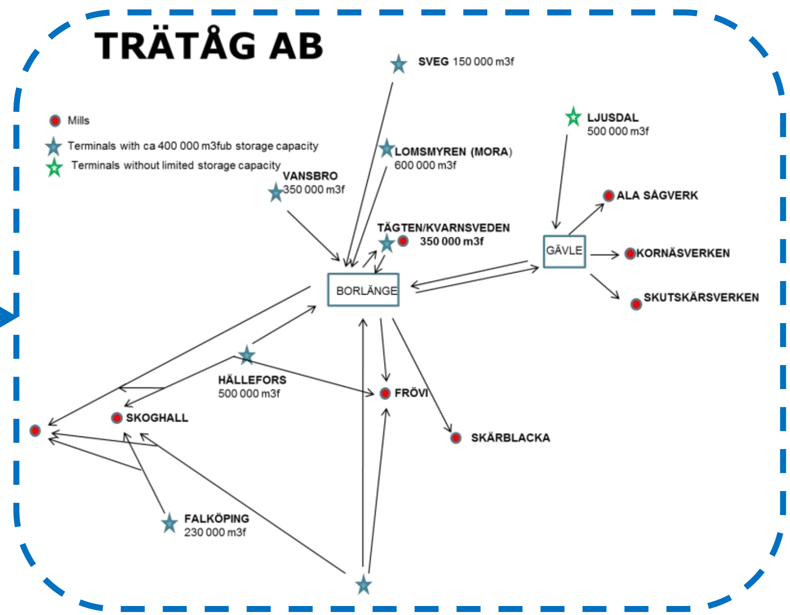
Photo Green Cargo

Trends in pulpwood supply

Structural development towards fewer and larger pulp mills results in longer transport distances, requiring an increased use of rail system solutions (typical b/e with road transport at 100-150 km).





Research question

- how does this development influence mill service levels?

Studies of mill service levels and transport system simulation

Developing pulpmill service levels in Swedish wood supply
- Bäckström & Åström (2002), Andrén & Fjeld (2004). Hedlinger et al. (2005)

Mill service levels within pulpwood supply range from:
I) Low costs
II) With high delivery precision
III) While maintaining freshness
IV) To I-III including transfer of responsibility for mill stock management to wood supply organization

Empirical studies with reference to mill service dimensions

Delivery precision – Nilsson (2008)
Lead times – Lukka (1994), Puodziunas & Fjeld (2002), Haartveit et al. (2004), Carlsson & Rönnqvist (2005), Roth (2010), Zilo (2013)

Meeting goals for delivery precision and lead times/freshness is still a challenge

Simulation studies of transport sytems

Road – Weintraub et al. (1996), Marques et al. (2012). Fjeld (2012), Beaudoin et al (2012),
Rail – Saranen & Hilmola (2007), Korpinen (2013), Etlinger et al (2014), Wolfrsmayr et al. (in prep)

+ overview of hybrid approaches (Simulation + LP) given by Marques et al. (2014)

Most studies were focused primarilly on costs alone, with initial studies examining road transport alone and later intermodal studies often examining forest fuels

Study goal

To map how different configurations of multimodal (road + rail) systems can influence mill service dimensions in pulpwood supply.

Sub-goal 1: to develop a simulation model which manages the allocation of pulpwood and transport resources to maintain delivery precision, stock levels and follow-up lead times.

Sub-goal 2: using this model, compare the effects of typical system disturbances on service dimensions with different rail system configurations.

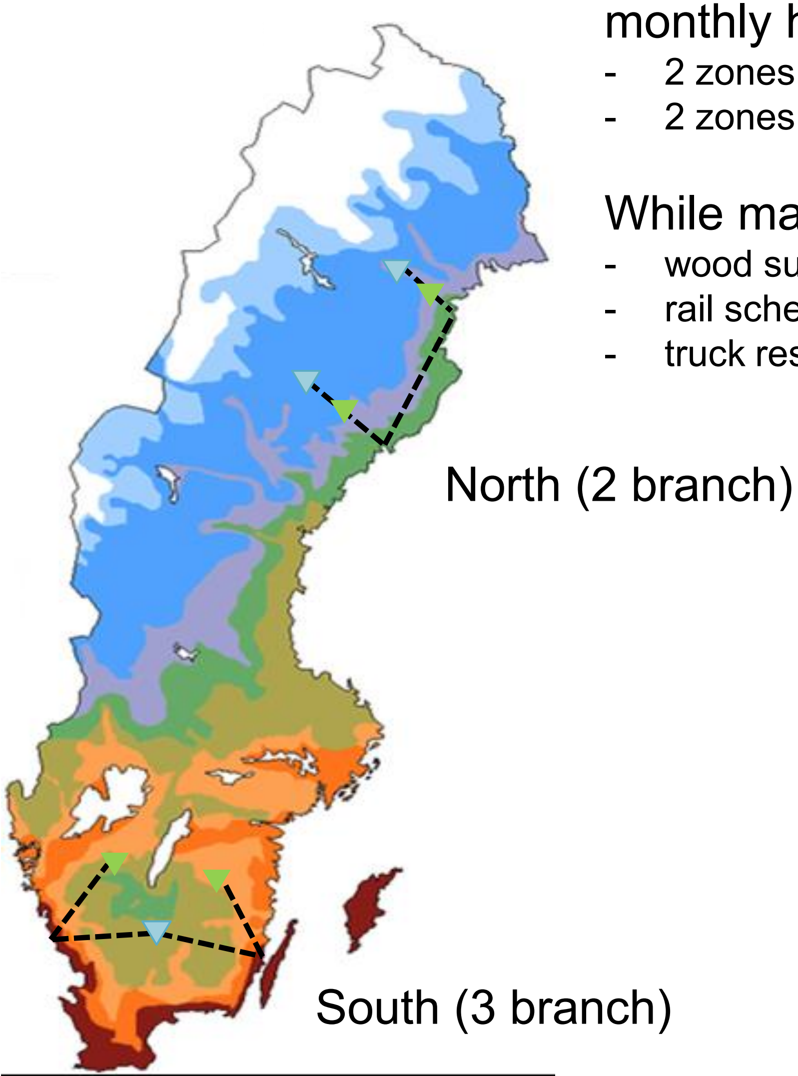
Method

Object-oriented discrete event simulation (OODES) enabling

- analysis of present and future multimodal systems under varying scenarios
- tracking of individual entities through whole system with multiple inventory points
- follow-up of lead times per individual entity

With varying decision logic for entity and resource management

Material – 2 rail systems

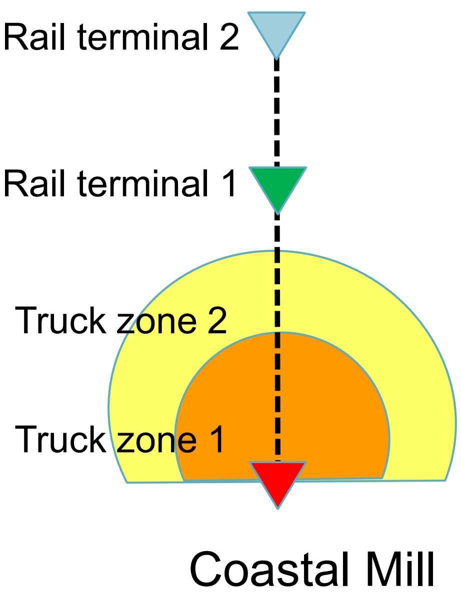


Each system supplies 2 coastal mills based on monthly harvesting production plans to

- 2 zones for road transport (near/far)
- 2 zones for rail transport (near/far)

While maintaining mill stock interval by redistribution of

- wood supply between rail branches (weekly)
- rail schedules per branch (weekly)
- truck resources between zones (daily)



Material - data

- Seasonal wood supply patterns build on historic data per region from SDC/Skogforsk
- Monthly supply and consumption patterns adjusted according to typical system-specific conditions
- Typical disturbances in supply (spring break-up) and demand (mill break-down or market-stop) mapped

Monthly patterns & typical disturbances developed in discussion with company representatives (below)

System	Company	Representative
General practices	Trätåg	CEO Olle Pettersson
North	SCA	Customer supply manager Henrik Sakari
South	Södra	Raw material logistician Tomas Frick

Delivery planning

- Wood supply patterns used to describe harvesting and truck transport – new patterns needed for rail transport
- Model developed to mimic the planning process within swedish forest companies – minimize stock variation.

$$min \sum_{p=1}^{p} \left(\sum_{n=1}^{n} (Vt_n * X_{np} + Vb_p) - K_p \right) - \left(\sum_{n=1}^{n} (Vt_n * X_{np-1} + Vb_{p-1}) - K_{p-1} \right)$$

Subject to:

$$(1) IL_{min} < IL_p < IL_{max}$$
$$(2) \Delta X_{min} < \Delta X_{np} < \Delta X_{max}$$
$$(3) L_{np} > 0$$

Disturbance scenarios

Sc 1. Base case – no disturbances other than typical monthly patterns

Sc 2. Spring break-up – harvesting production to road-side and terminal stocks reduced by 25 % during two weeks within typical seasonal interval

Sc 3. Mill break-down or market-stop – mill consumption reduced by 100 % during two weeks at random point in time

All three scenarios run with both current and increased proportions of rail transport.

Definitions of mill service KPIs

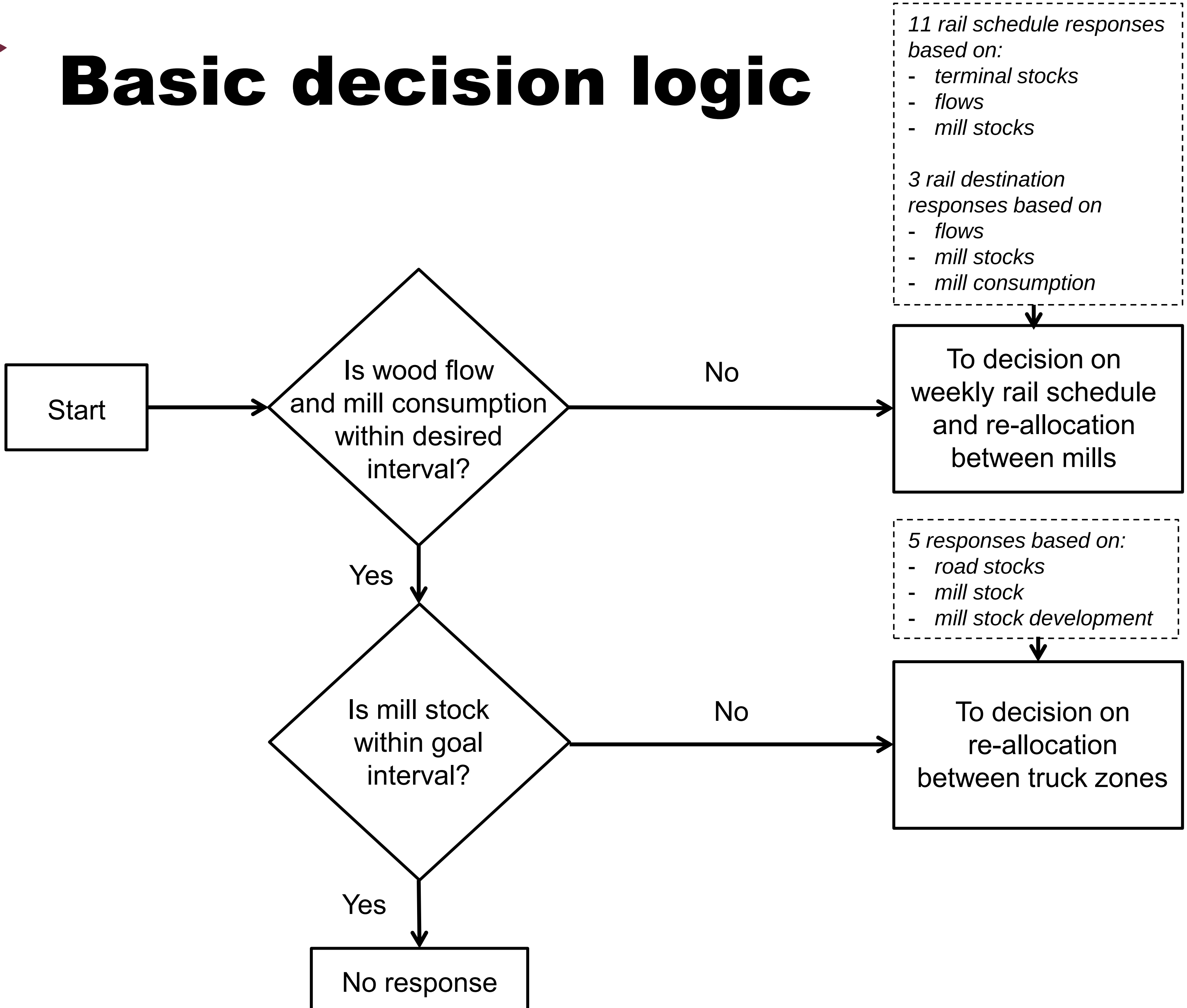
Delivery precision for internal supply responsibility (%)

$$\frac{\text{delivered volume per month}}{\text{consumed volume per month (with desired stock adjustment)}}$$

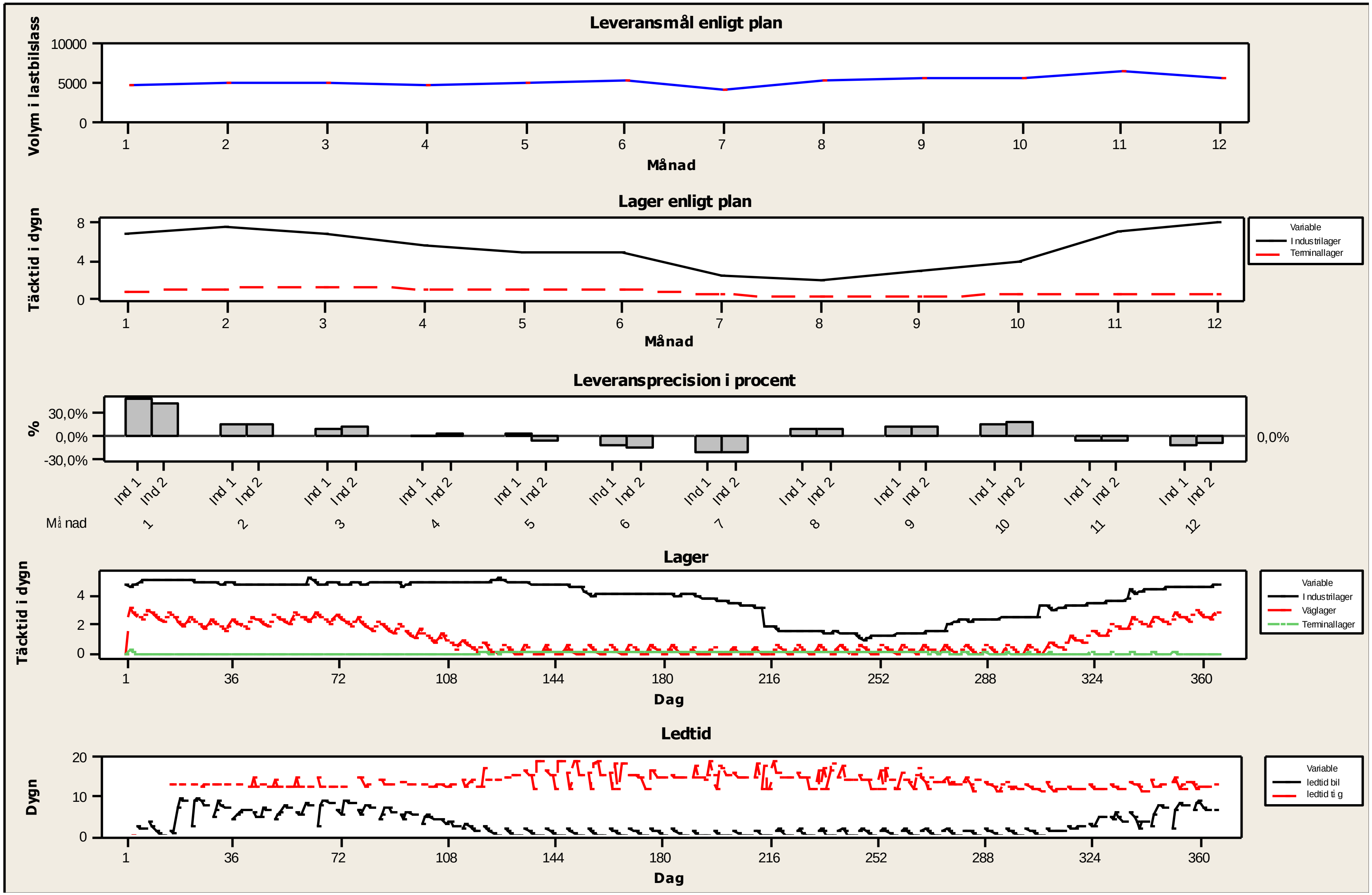
Stock levels – measured in terms of both volume and cover time (equivalent to days of consumption)

Lead time – time from harvesting to mill consumption (days)

Basic decision logic



Results – tracking KPIs (base case)

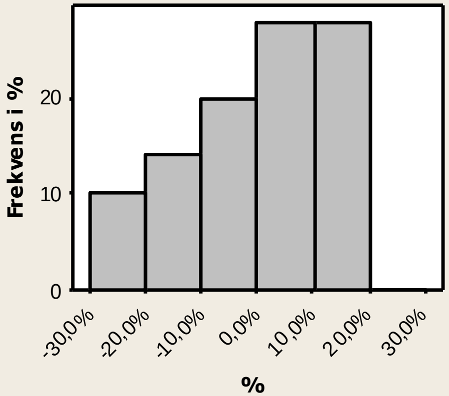


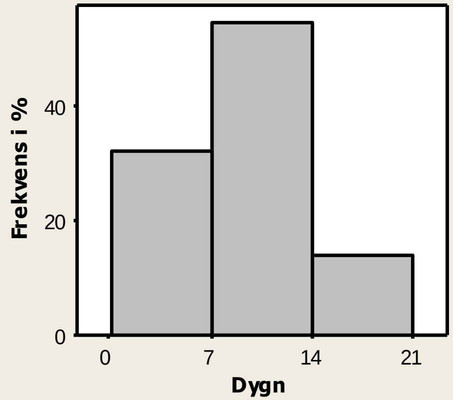
Monthly delivery precision

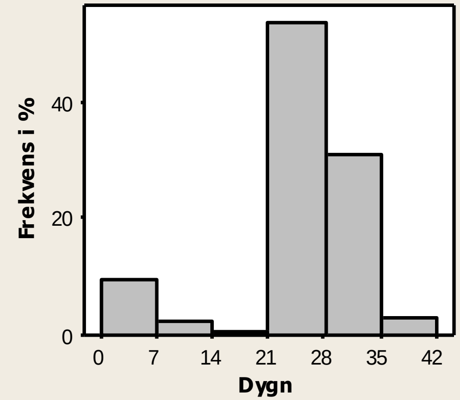
Stock cover time

Lead times

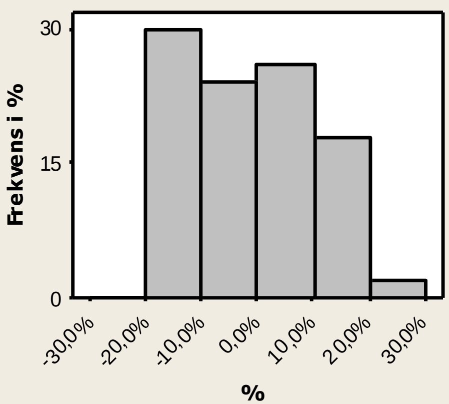
Northern Sweden

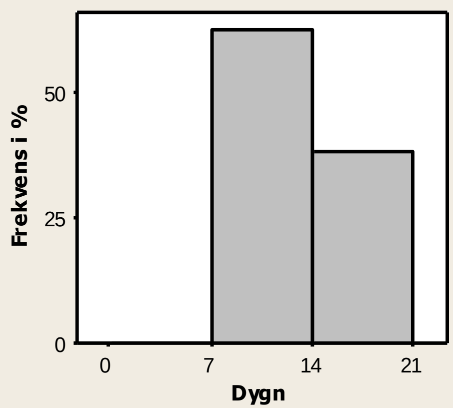


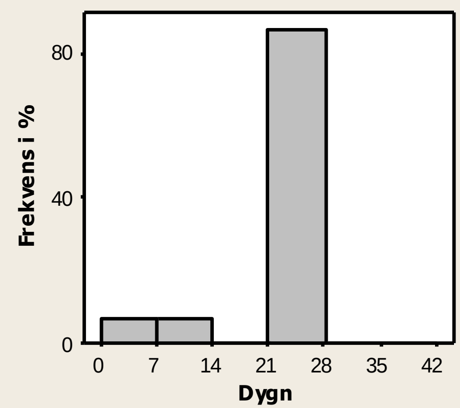




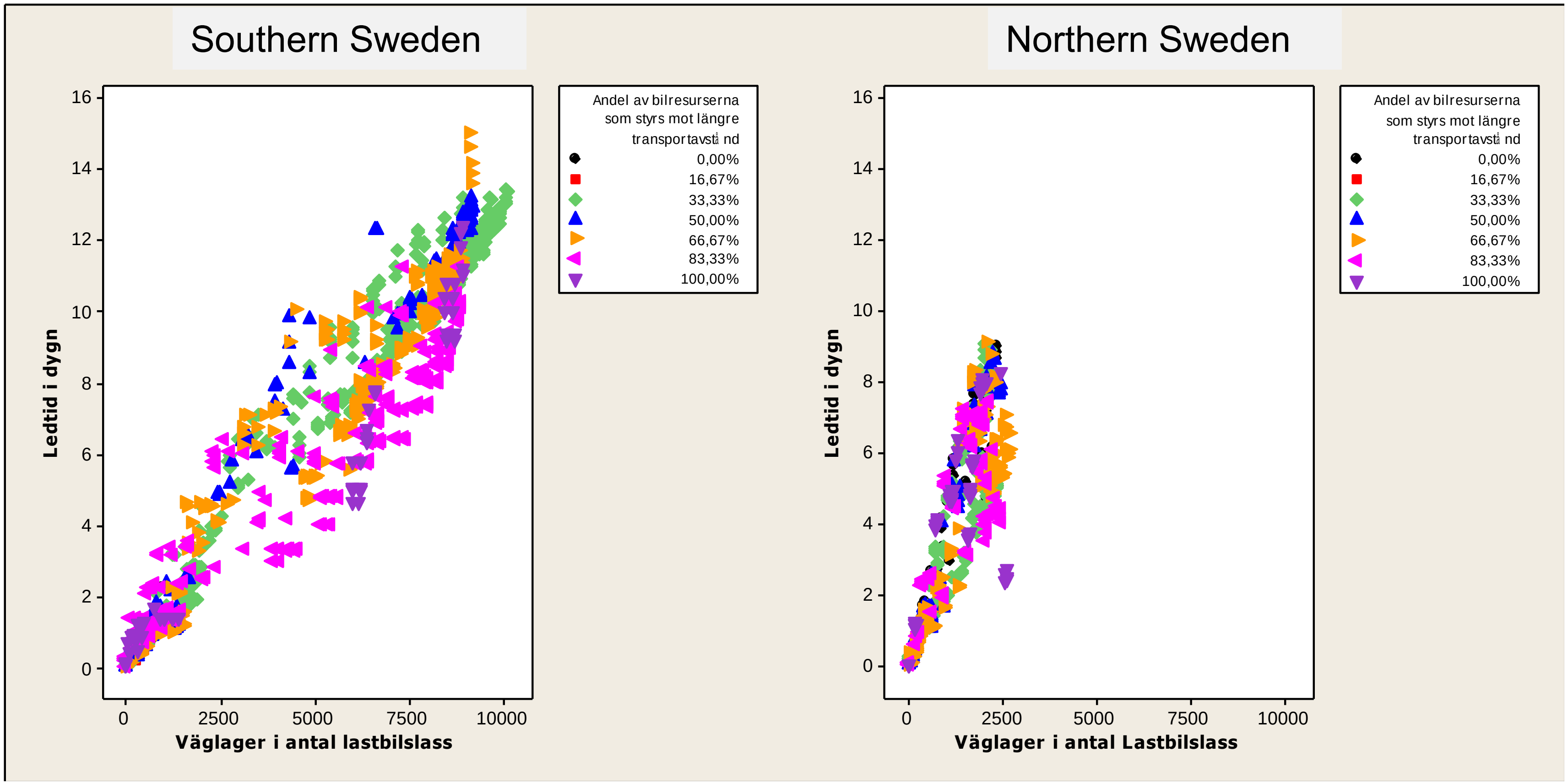
Southern sweden



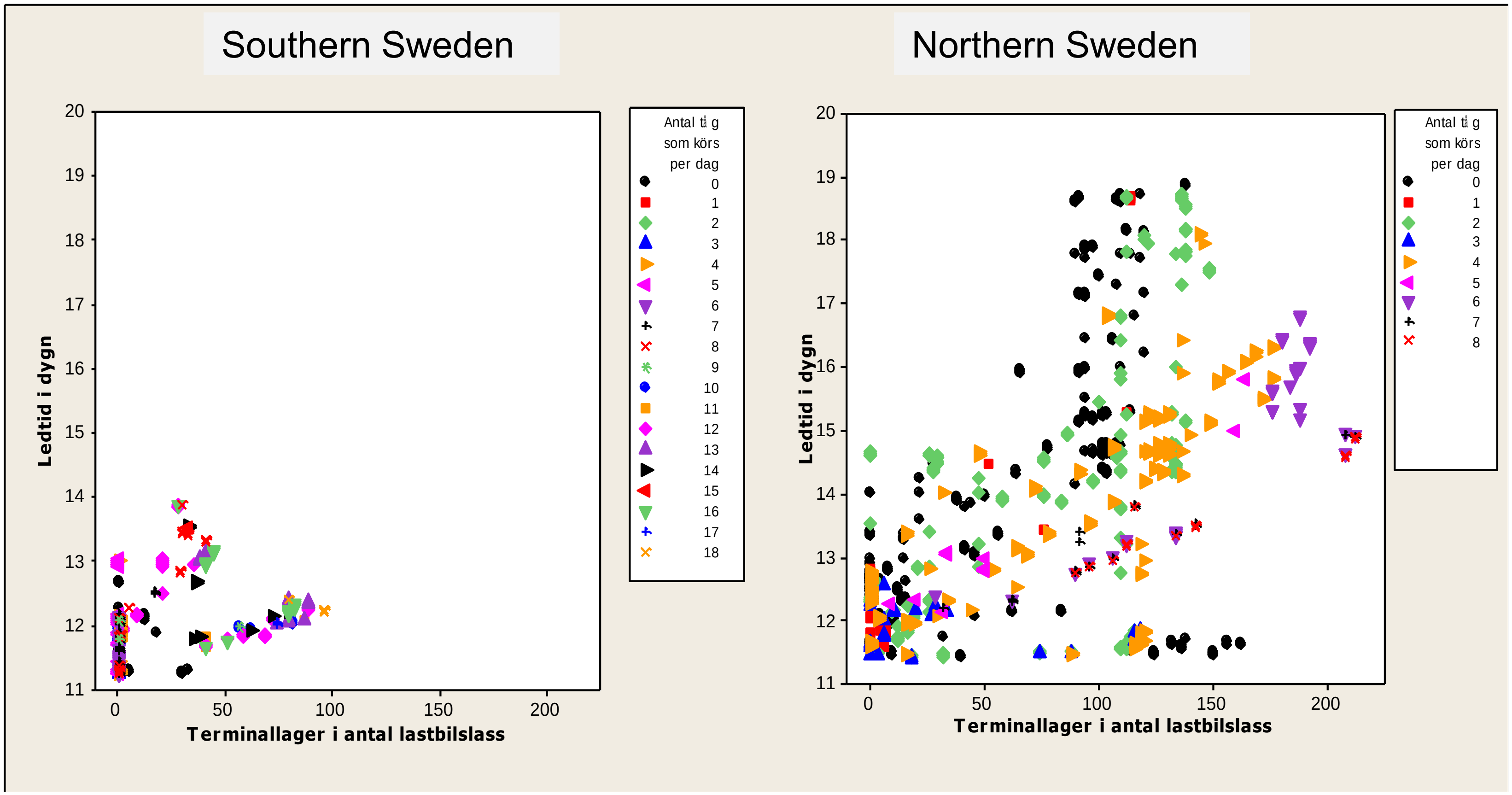




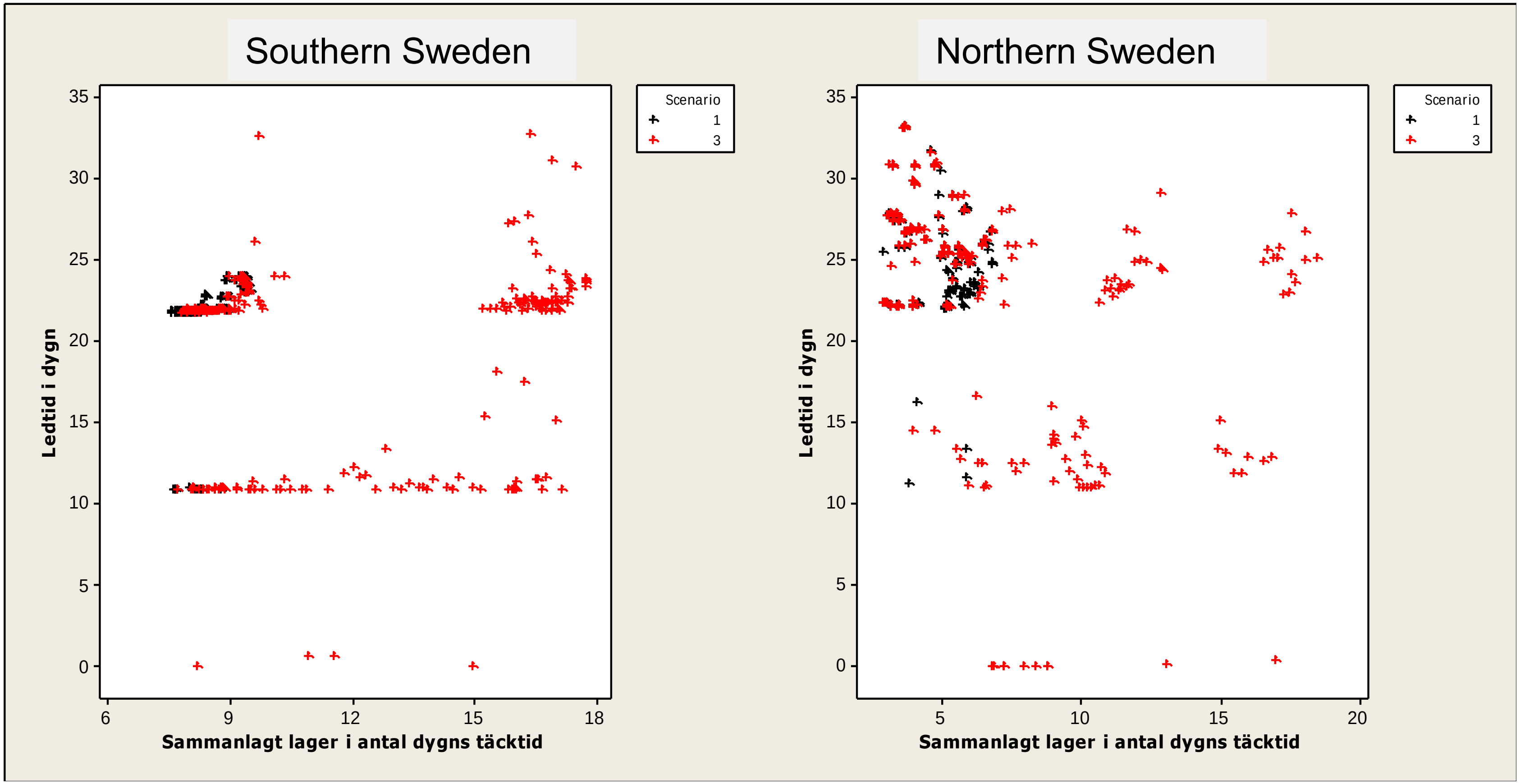
Results – road-side stocks and lead times for truck transport (base case)



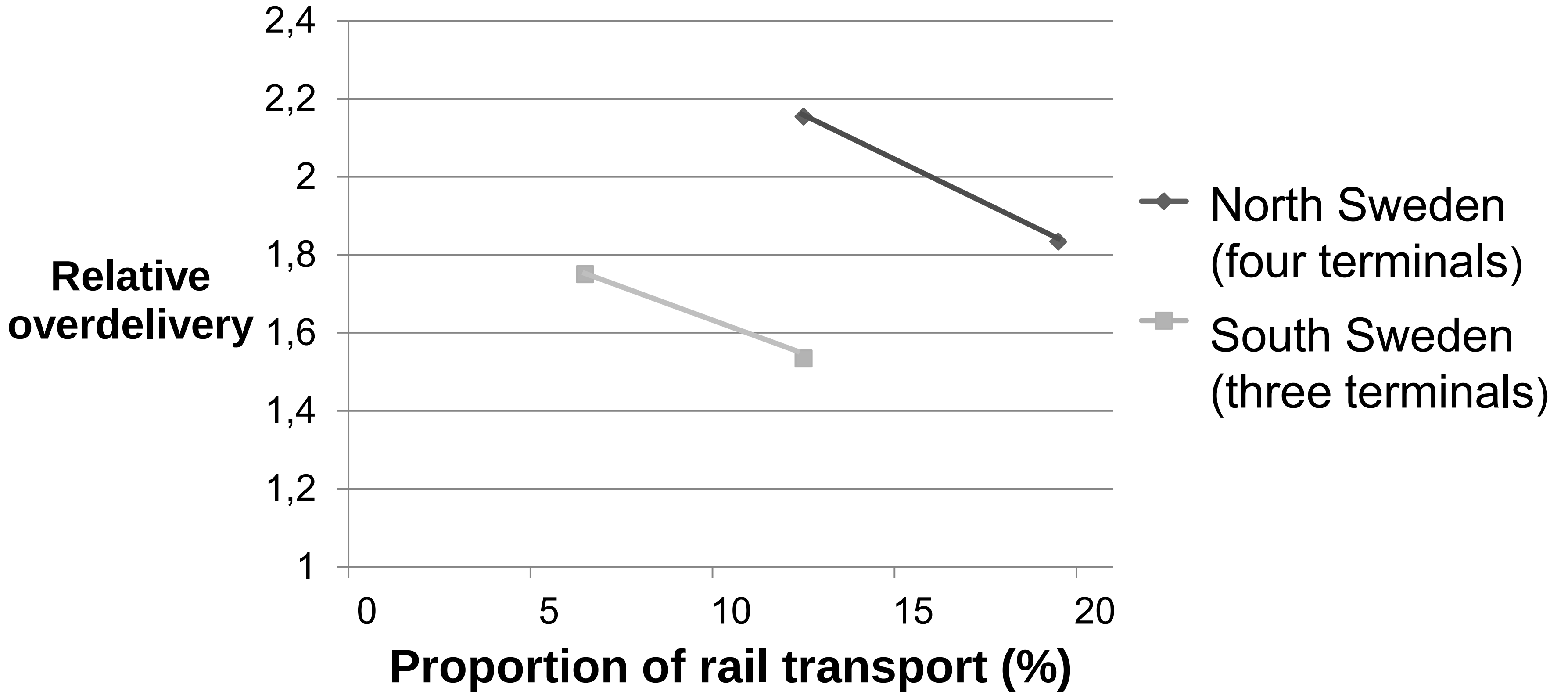
Results – terminal stocks and lead times for rail transport (base case)



Result – comparison of total lead time during mill break-down or market stop (base case vs. sc. 3)



Results – system adaptability to mill break-down or market-stop (sc 3) with increased rail transport



Conclusions

More work is required to mimic a realistic transport management response (”fingertip tweaking”)

OODES is a method which is useful for exploring mill service dimensions

The results also suggest that an increased proportion of rail transport enables a greater responsiveness to system disturbances (structural flexibility)

A hybrid approach (OODES + LP) seems suitable and even necessary to solving this type of problem!

Thank-you

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- Bo Rydins Stiftelsen
- Sveaskog

Photo University of Minnesota

Photo StoraEnso