# Drivers of dynamic zoning: the potential of a new zone assignment algorithm

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# Outline

- Objectives of the research
- The forest management context and economic, political and ecological perspectives of zoning
- Methodology
- Case study
- Results
- Conclusions and future research

# Objectives of the Research 1

- To improve our understanding of the mechanisms that may drive and shape zoning
- To assess how various economic and regulatory trends may affect the diffusion of zoning. In particular the focus in this presentation is on changes (increases) in the costs of energy and infra-structure.

# Objectives of the Research 2

- To assess the effects of various forest management constraints on  the underlying incentives to cluster activities (e.g. the impacts of “even flow” requirements on the tendency to cluster harvests).

- To explore whether clustering that emerges in a dynamic zoning framework can offer an effective mechanism to identify ‘good’ zoning assignments.

# Context of forest management and the zoning idea 1

- Increasing number of forest objectives.

- Many objectives are in conflict with each other. In particular, commercial extraction activities conflict with objectives that require intact forests. The recovery time of the forest system after a harvest is long, making management for multiple conflicting uses impractical.

# Context of forest management and the zoning idea 2

- Segregation of activities so as to cluster activities that are compatible are at the core of zoning strategies: the design of clusters seeks to minimize the negative impacts of one activity on other incompatible activities and search synergies.

- “The separation of competing objectives allows for more intensive production of each on their respective land bases” (Boyland *et al*. 2004)

# Economic and political perspectives of zoning 3

- The economics of density:
  - Lower infrastructure investment is required
  - Transportation costs are lower
  - Potential for intensive management (e.g. Binkley, 1999) and freeing land for more efficient “production” of conservation objectives (reduction of regulatory costs in commercial zones and decrease in monitoring and enforcement costs in conservation areas).

# Economic and political perspectives of zoning 4

- Political constraints depend on the degree of public acceptance of reduced regulatory constraints in commercial zones.

- In most locations intensive silviculture is not economically viable except in situations where introduction of exotic fast growing species is allowed.

# An ecological perspective: dynamic clustering of activities 1

- Forest management occurs in the context of dynamic systems including ecological, economic, social, and political systems (Gustafson 1998; Wiersun , 1995).

- From an ecological point of view, many interior species are thought to be sensitive to the size of forested blocks. The practice of dispersing cutting units has been identified as a major contributing factor to the reduction in forest habitat and increase in linear edge.

# An ecological perspective: dynamic clustering of activities 2

- Progressive cutting across the landscape has been proposed as an alternative to dispersed cutting units across the landscape.

- This leads to harvests that are clustered in both time and space allowing more interior habitat to be sustained.

# An ecological perspective: dynamic clustering of activities 3

- ‘Dynamic zoning is an approach where harvests are clustered in space and time across the landscape with long temporal period.’ It has been shown to increase timber production and reduce forest fragmentation without reducing the spatial extent of timber production (Gustafson, 1996)

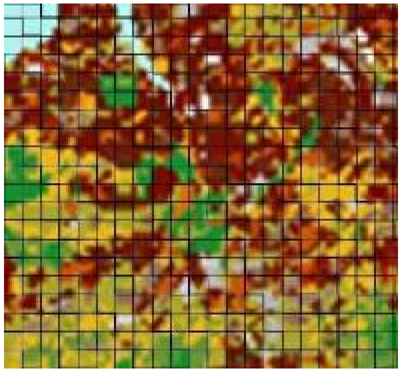
# An ecological perspective: dynamic clustering of activities 4

- The dynamic zoning strategy reduces the average measures of fragmentation even when periodically punctuated by dispersed cutting policies (Gustafson 1998)

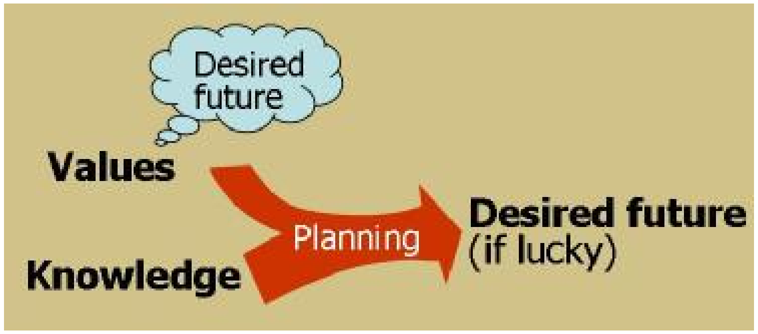
- Static pre-assignment of lands to zones is problematic given the incompleteness of understanding we have of biological processes.

**Methodology:**
# Decentralized forest planning with cellular automata (CA)

- Landscape is divided into cells
- For each cell a management use and harvest schedule is chosen
- Based on a local optimization function that accounts for:
  1) The suitability of a local cell to a given management
  2) The suitability of this management within the environment of the cell
  3) The suitability of the management actions in time



# Tradeoff evaluation
## with decentralized approaches




- Challenges of centralized planning tools:
  - Formulation
  - Solving
  - Inclusion of dynamism and complexity
- Decentralized planning tool:
  - Easy to formulate
  - Fast to solve
  - Intuitive way to conceptualize the world
  - Includes dynamism and complexity

# Achieving forest landscape level objectives

- A stand management decision is made
  - for each time period of the planning horizon
  - in knowledge of its local constraints,
  - its potential development through time,
  - the neighbors' decisions and
  - the level of satisfaction of forest constraints.

- One stand’s decisions affect its neighbors decisions and so on and so forth

- Stands decisions co-evolve until the forest as a whole has improved objectives

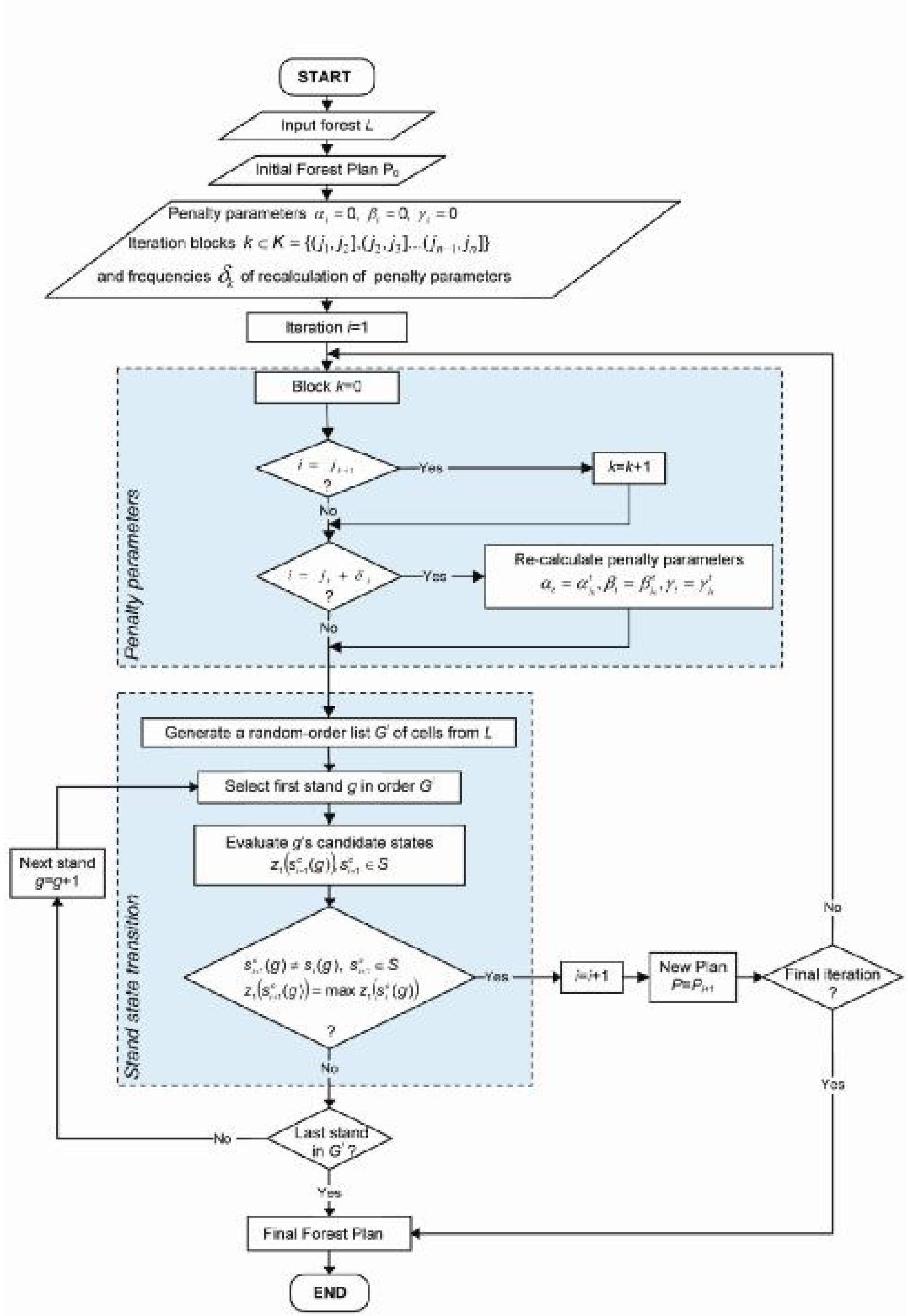
# Co-evolutionary algorithm

§ Cell's decision more influenced by direct neighbors than by distant neighbor

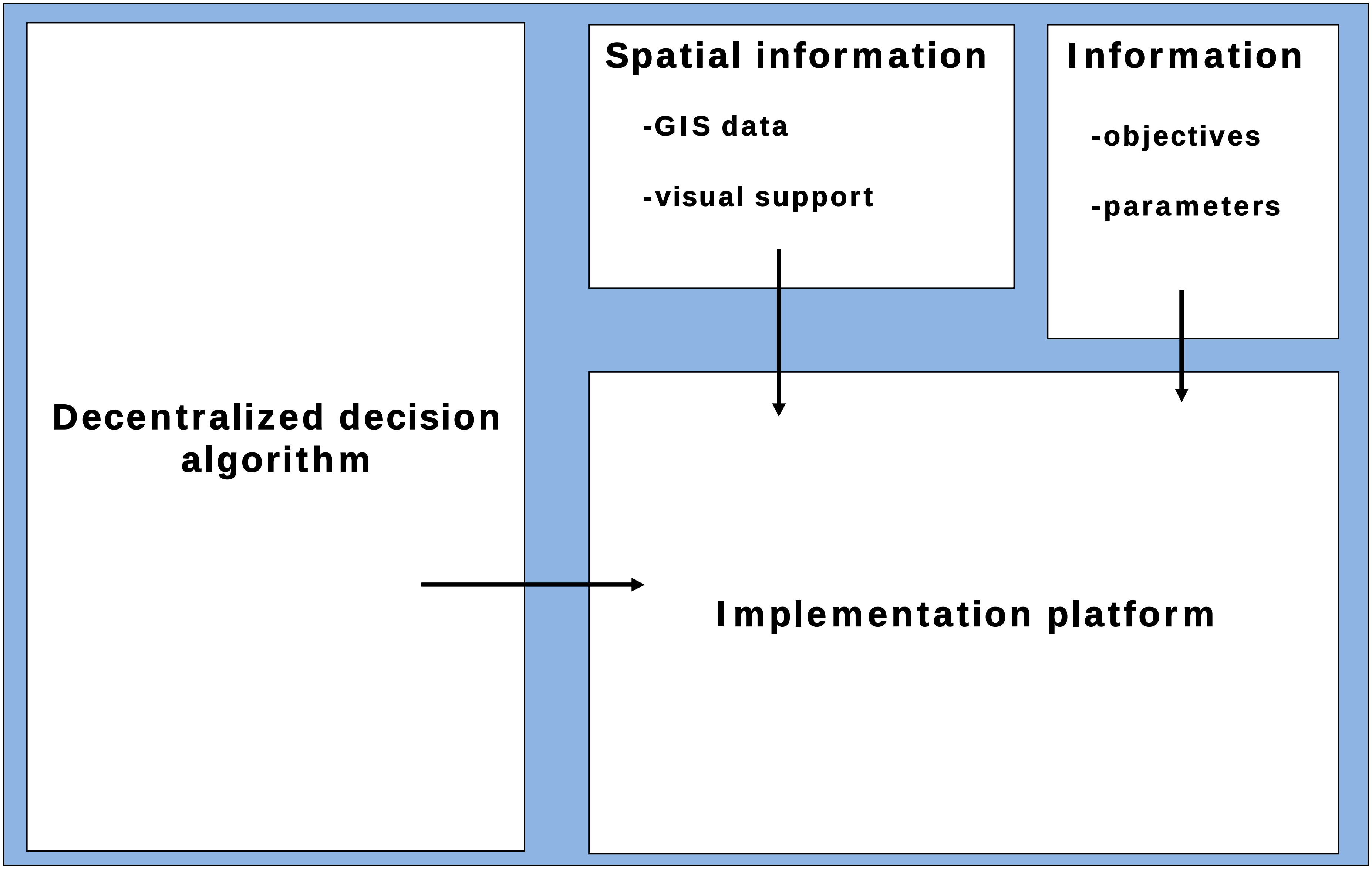
§ Each decision is made for each time period of the planning horizon in knowledge of its local constraints, its potential development through time, the neighbors' decisions and the level of satisfaction of forest constraints

§One cell's decisions affect its neighbors decisions and so on and so forth

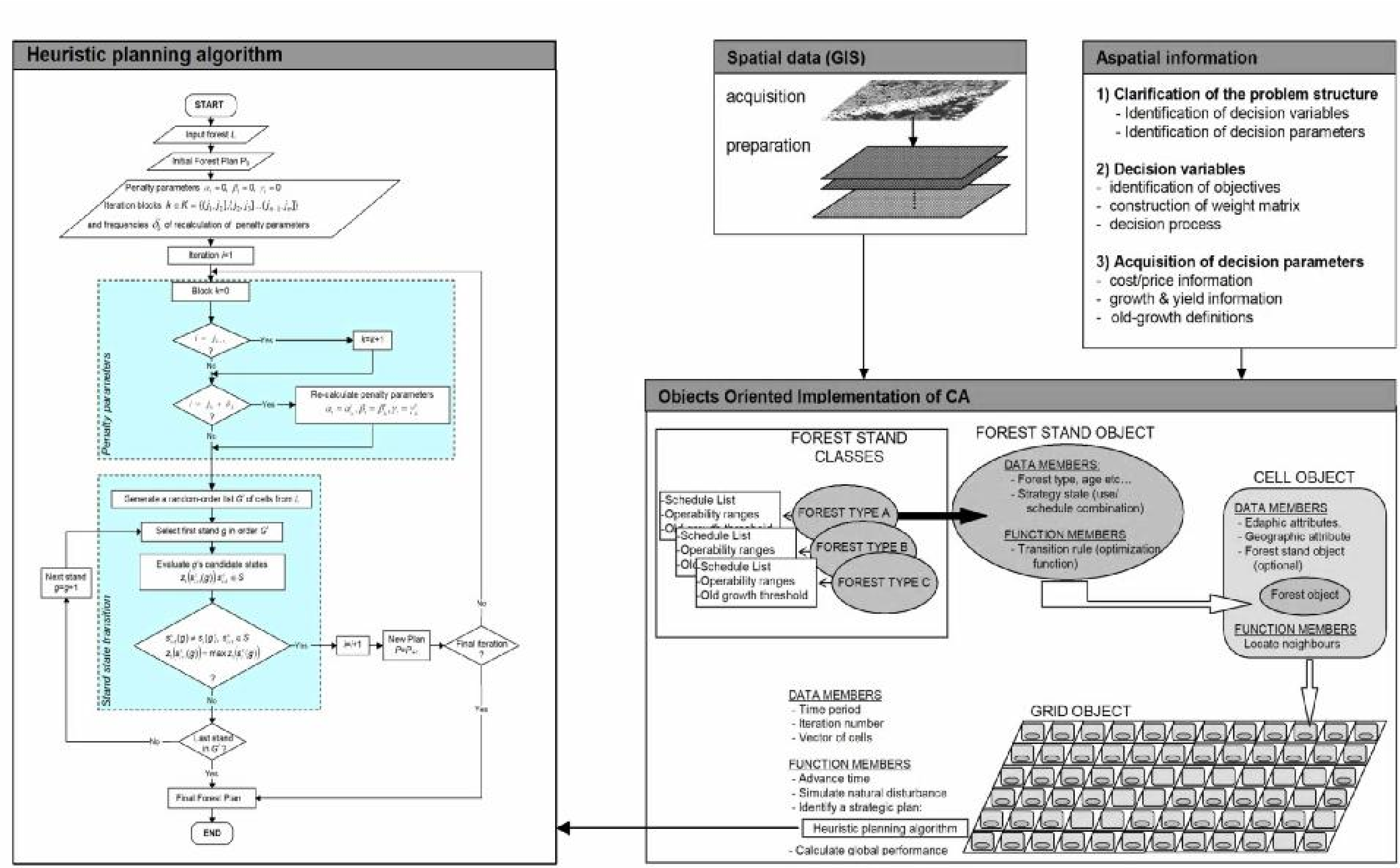
§Cells co-evolve until the forest as a whole has improved objectives



# Decentralized planning



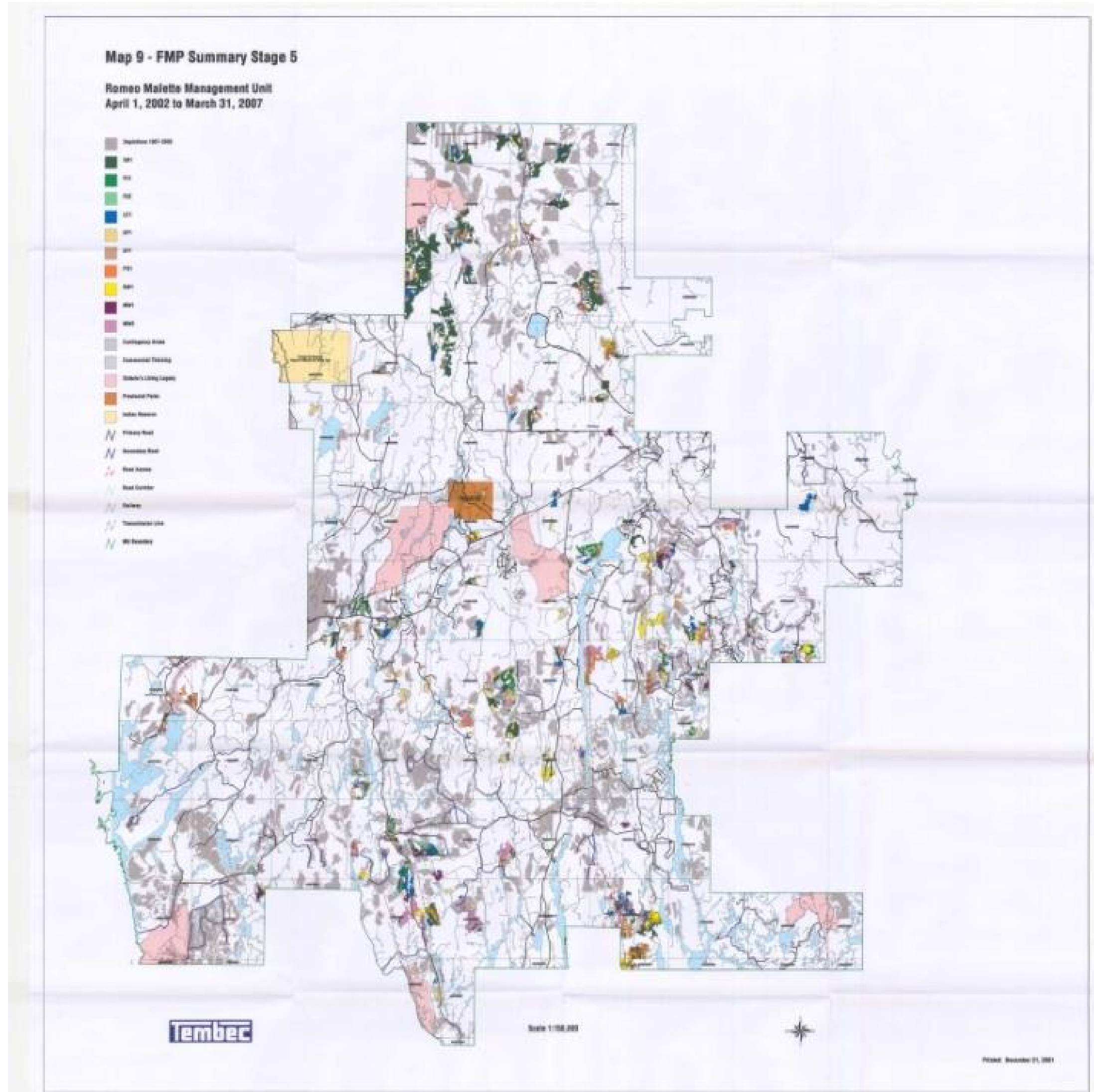
# Object-oriented implementation platform




Mathey et al. (2008) Ecol. Model. ; Mathey et al. (2007) For. Ecol. Man. 239:45–56.

# CASE STUDY: northern Ontario

- 6000 km$^2$
- 100-year planning horizon (10-year periods)
- 16 forest ecosystems
- 8 management uses
- Many many combinations of schedule x use
- Older forest
- Large road network

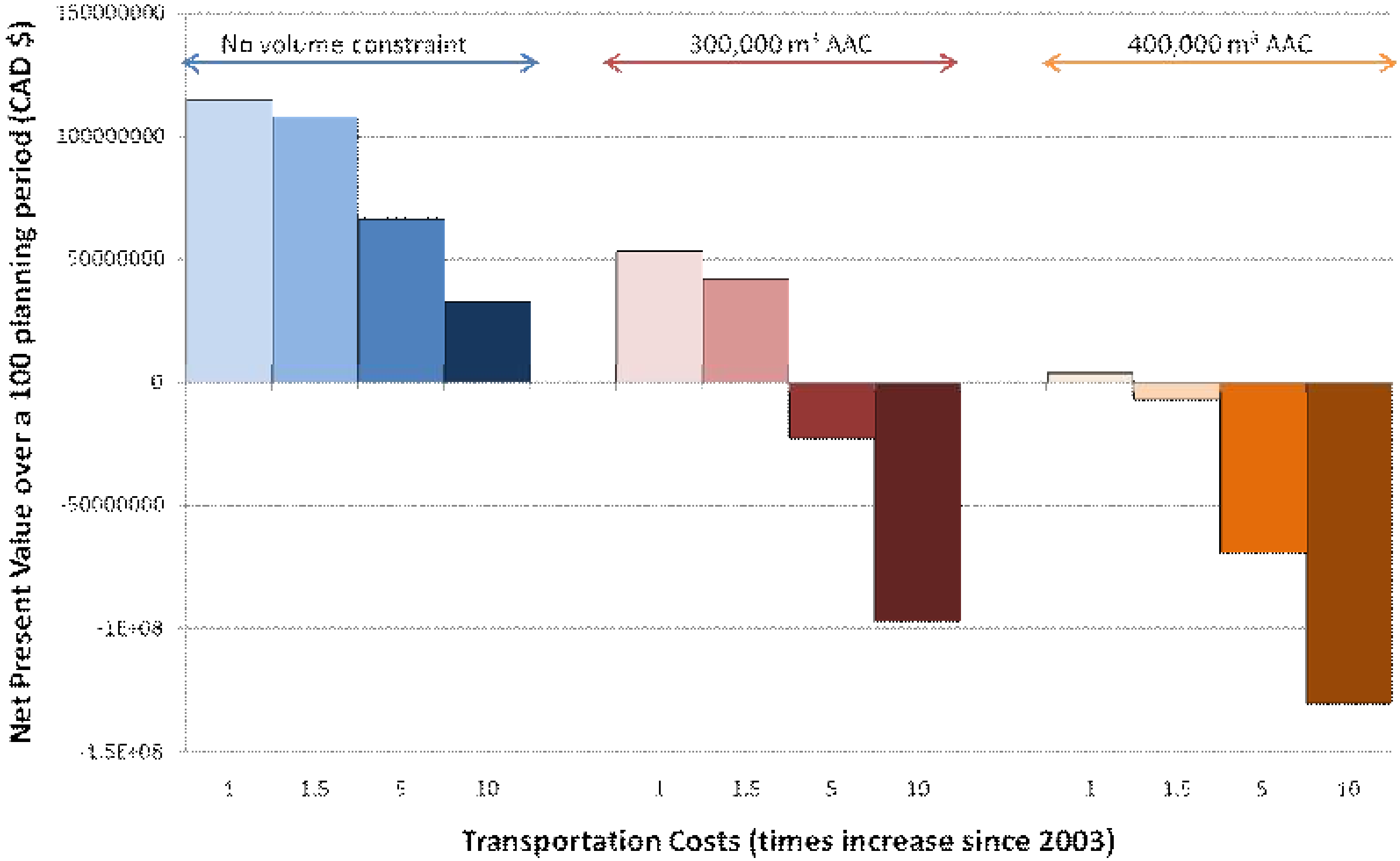


# CASE STUDY: Emergent zoning from economies of scale and transportation costs

- Management scenarios
  - **Objectives:**
    - Financial benefits (discounted net revenue)
    - 12% Old growth conservation
    - Stand-level (buffer etc…) concerns
  - **Varying requirements**:
    - Transportation costs
    - Annual allowable cut

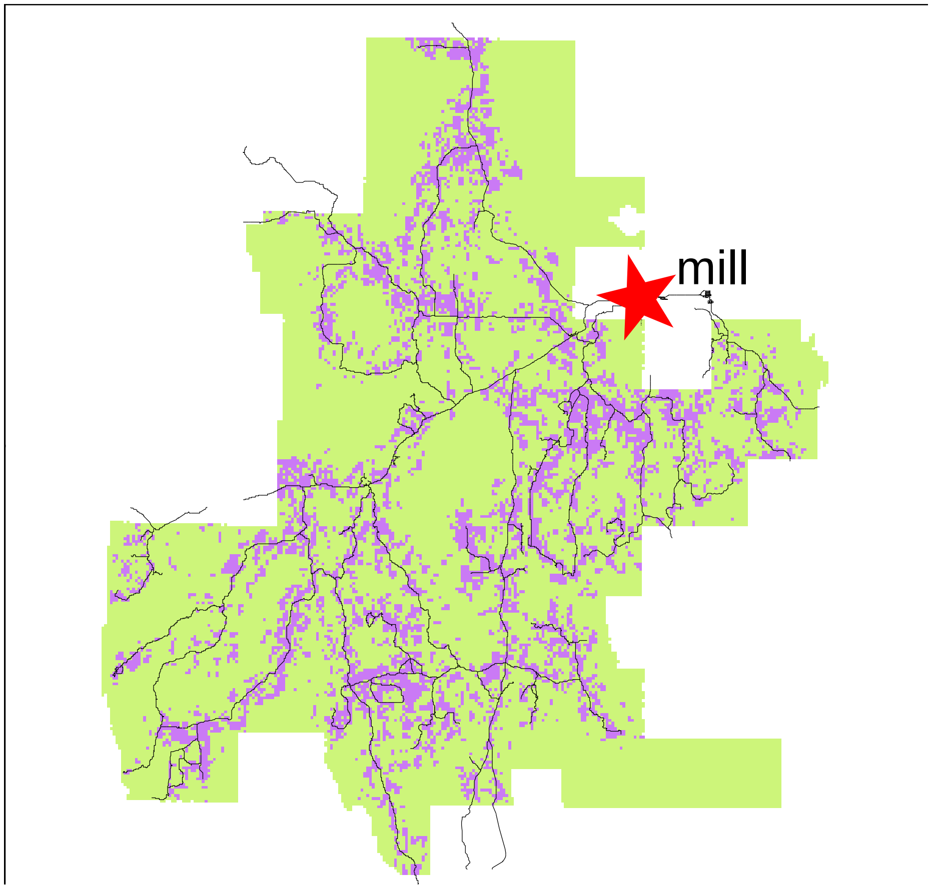
Mathey et al. (2008) Canadian Journal of Forest Research

# RESULTS:
# Increasing the cost of transportation…

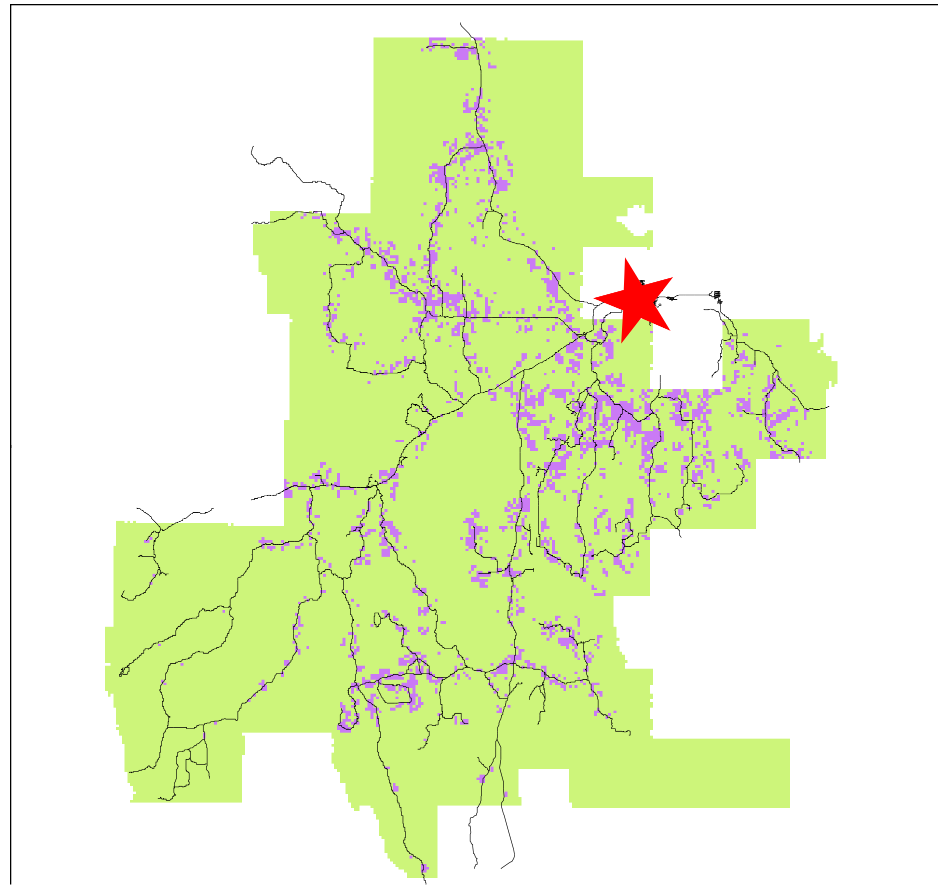


# Spatial distribution of management activities of unconstrained management (financial objective, 12% old growth requirement, no AAC)

Regular transportation costs (2003)



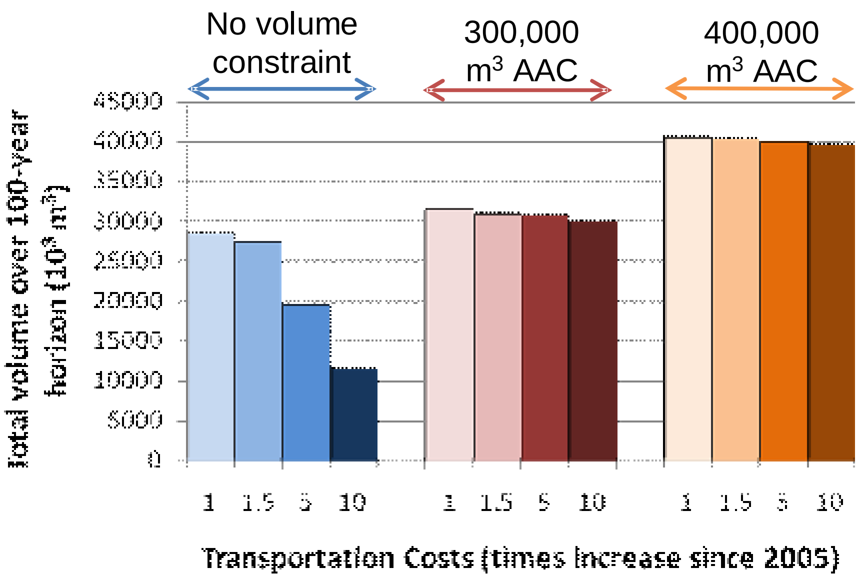

10X increase in transportation costs

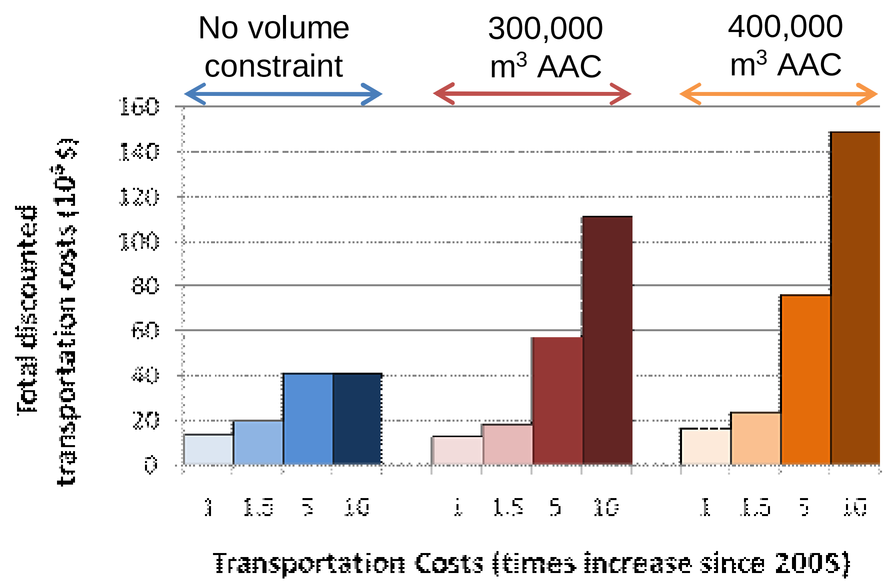


Areas harvested at least once over the planning horizon (100 years)

Areas never harvested

Increase in transportation costs when there is a volume flow requirement

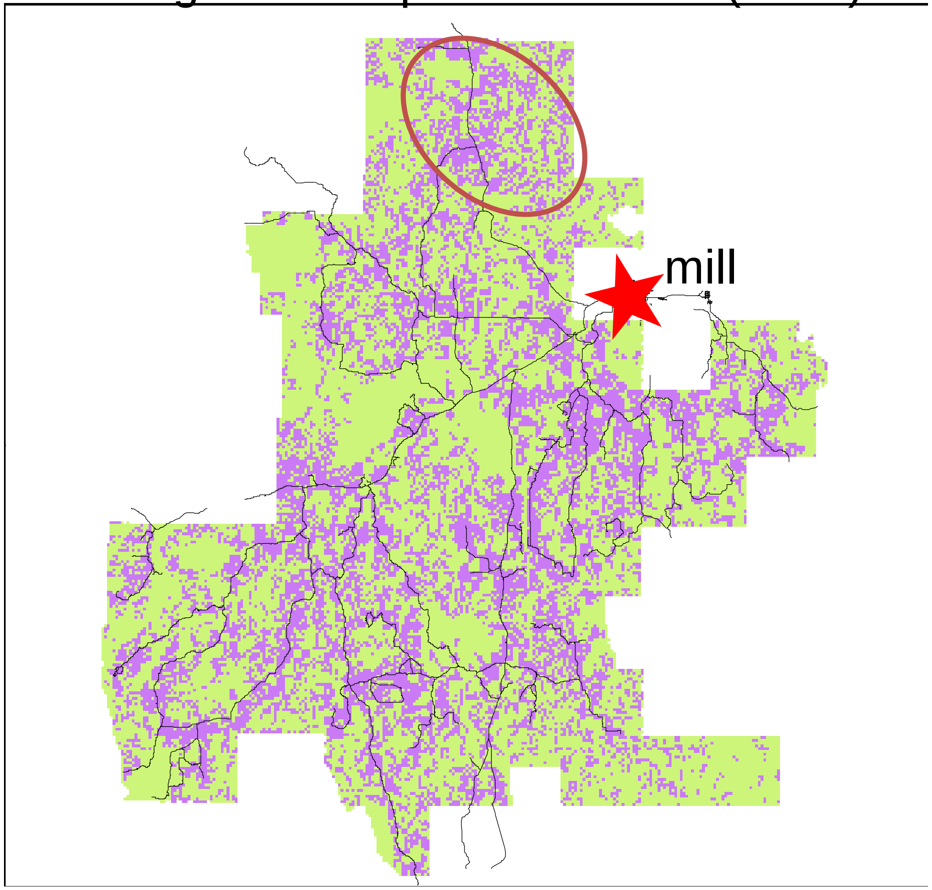


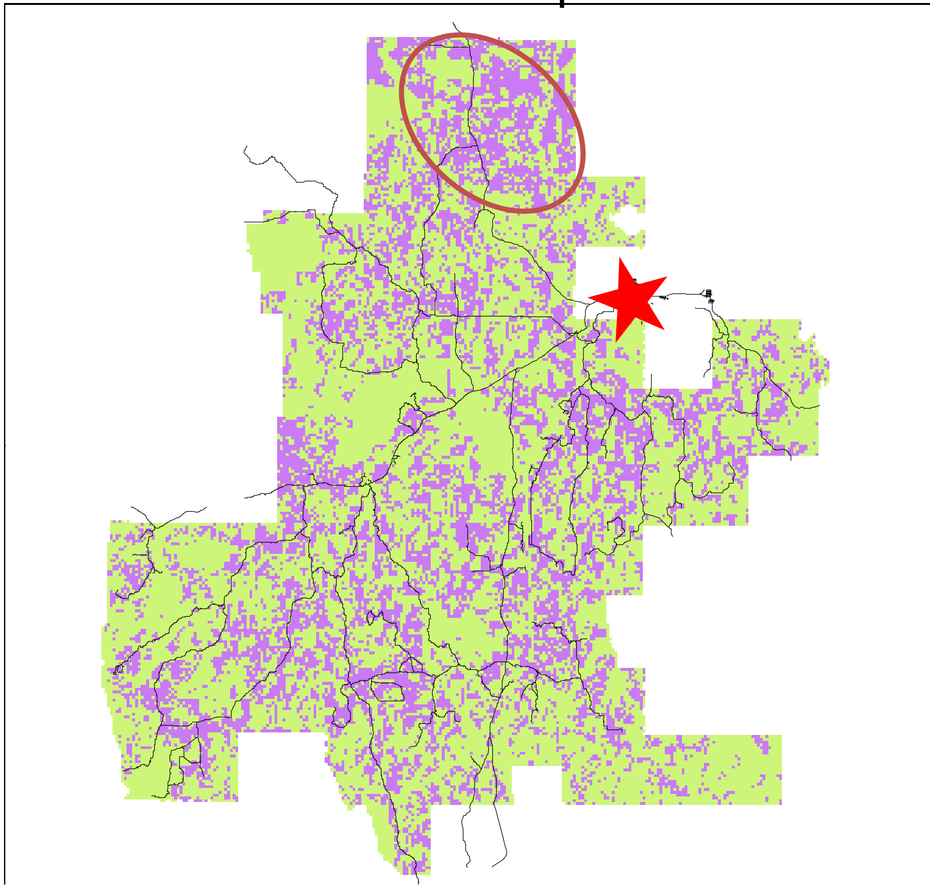
# Spatial distribution of harvest for constrained management (financial objective - 12% OG - 400,000 $m^3$ AAC)

k transportation costs= k clustering in areas closer to mill

Regular transportation costs (2003)



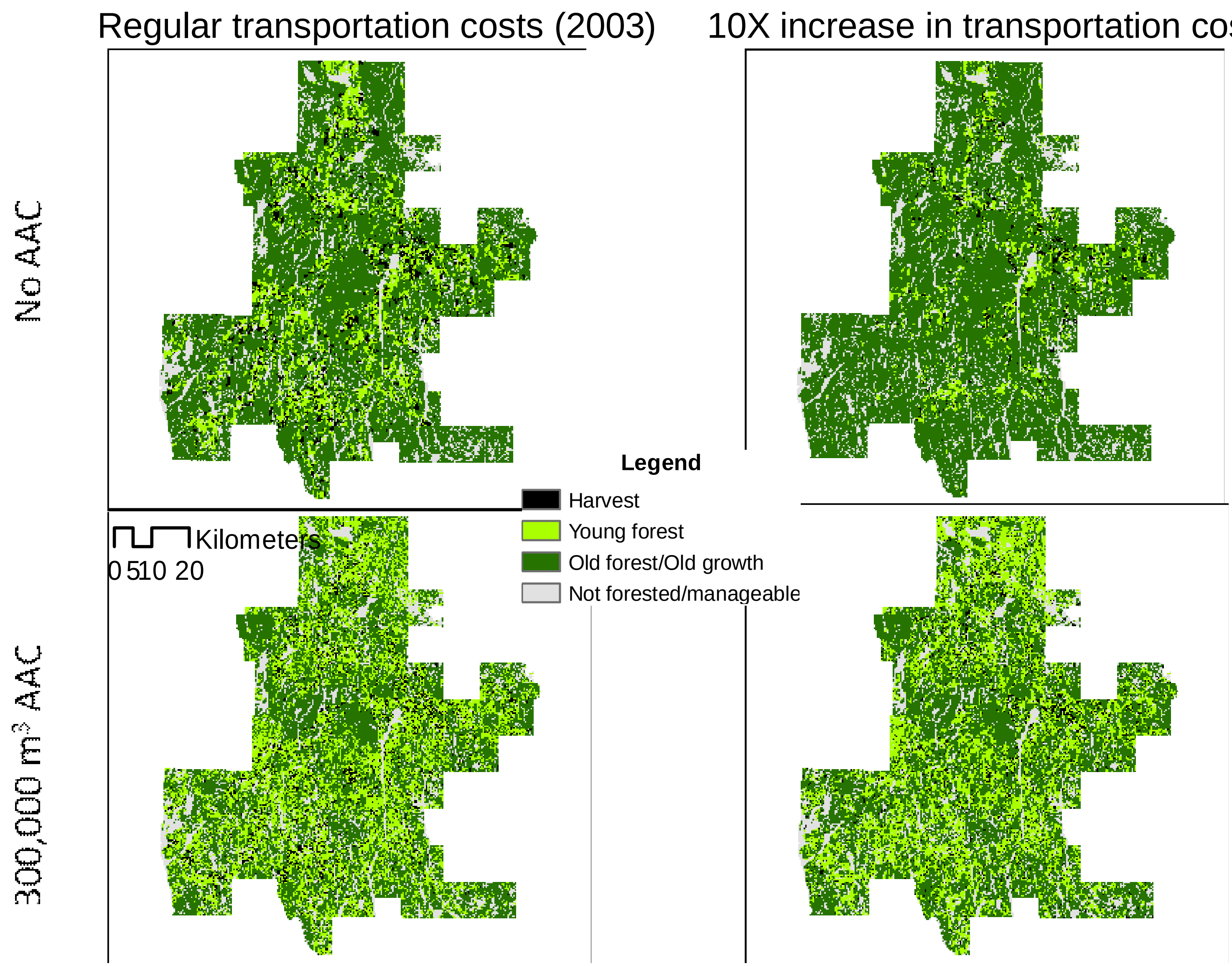

10X increase in transportation costs



Areas harvested at least once over the planning horizon (100 years)

Areas never harvested

- Increase in AAC decreases not only the OG area but also its compactness
- At equal AAC, increase in transportation costs increases compactness of OG



# Conclusions and future research

- The effects of economic drivers
  - Increasing energy (transportation) costs leads to rapid evolution of zoning (concentration near mills and major roads).
  - High infrastructure ecological and financial costs lead to the clustering of harvesting activities near existing road systems.
  - Regulatory monitoring and enforcement costs drive consolidation of conservation area.

# Conclusions and future research

- Even flow constraints encourage fragmentation.
- Intensification of silviculture to free land for conservation or meet demands for increased wood supply are largely uneconomic unless the introduction of exotic fast growing species is sanctioned.
- Future research
  - Assess the effectiveness of an algorithm for zone assignment which utilizes clusters that emerge in response to economic and ecological drivers.