# Engineering the transition to a non-energy intensive freight transportation system Part A: Modelling Freight Distribution

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## Motivation

- Economies driven by a slightly regulated transport industry, allowed trucks to overtake the freight business by providing faster, cheaper and easier door-to-door deliveries. The sector turned heavily dependent on oil and is nowadays one of the major contributors to global warming.
- New Zealand has a 2050 target to reduce Greenhouse Gas (GHG) emissions to 50 per cent below 1990 levels. A long term strategy that aligns with future commitments is needed and it needs to be informed by sound-science based analysis.

## Objective and research questions

Develop modelling tools to characterize freight transport activity and identify cost effective interventions at the strategic level that will enable to deliver a more resilient freight transportation system using New Zealand as a case of study.

- Is there enough enough capacity to support a substantial shift to more energy efficient modes?
- What are the most cost-effective interventions?
- What would be the impact on GHG emissions?
- What are the features and resources of a fully intermodal system?

## Hypothesis

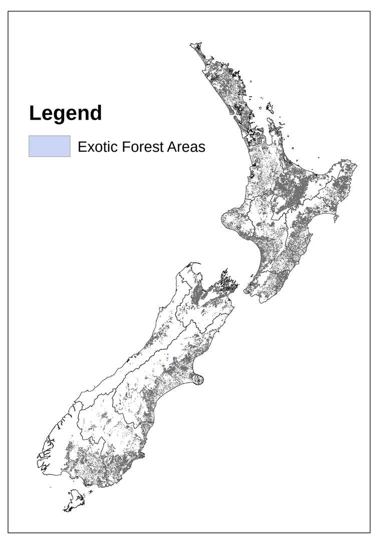
Current adaptive capacity of freight transportation systems can be shifted towards more sustainable levels by means of modal shifts and freight consolidation.

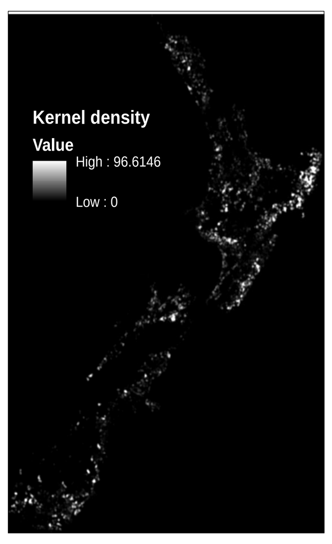
## Background

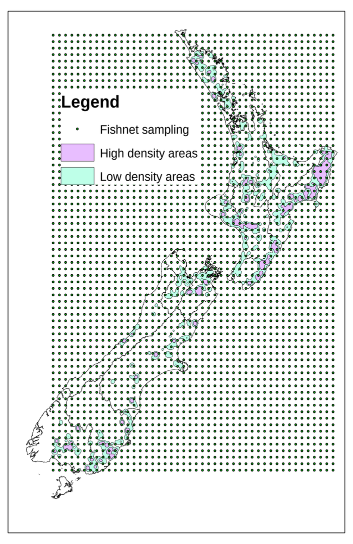
- Transport planning often assumes that mobility is not constrained by the availability of fossil fuel resources.
- Transition engineering recognizes these limitations and is emerging in response to complex global problems like climate change and resource depletion.
- The conventional approach has an aggregated nature which limits the ability to study and to effectively characterize the heterogeneity of actors and objects in freight chains.
- Freight Transport Models have traditionally lacked a logistics component that can be enhanced through Agent-Based Modelling (ABM). ABM is an emerging modelling approach that distinguishes the different actors within the freight system and has already been applied to assess supply chain logistics.

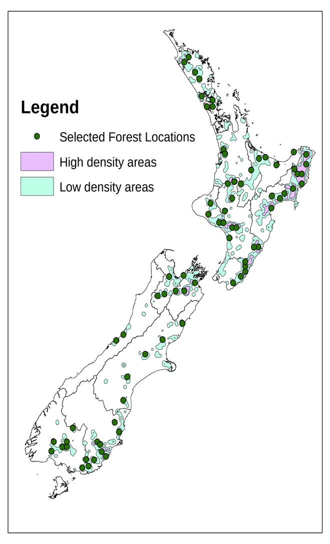
## Methods

- ***Part A:*** Freight Distribution: Programmatic application of linear programming (LP), iterative proportional fitting procedure (IPFP) and calibration of spatial interaction models.
- Iterative Proportional Fitting: Adjust OD matrices from Freight Demand Study to known totals (i.e. Total Exports by port).
- Use Land Cover Database and Google API to get geographic coordinates of facilities involved (i.e. processing plants).



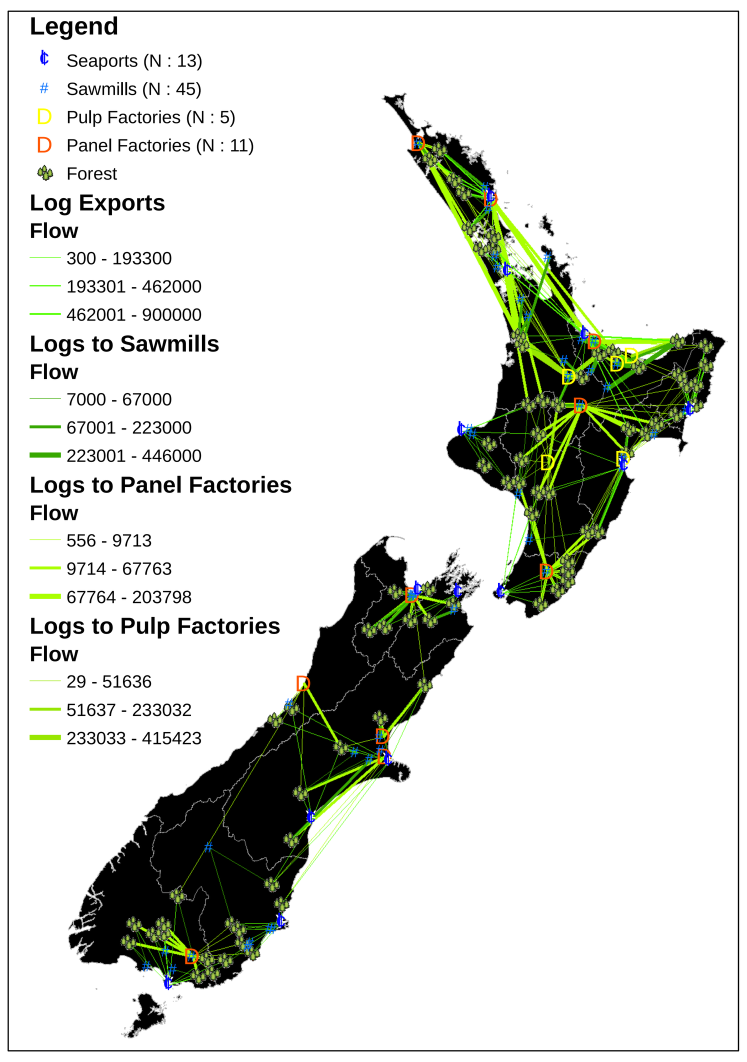



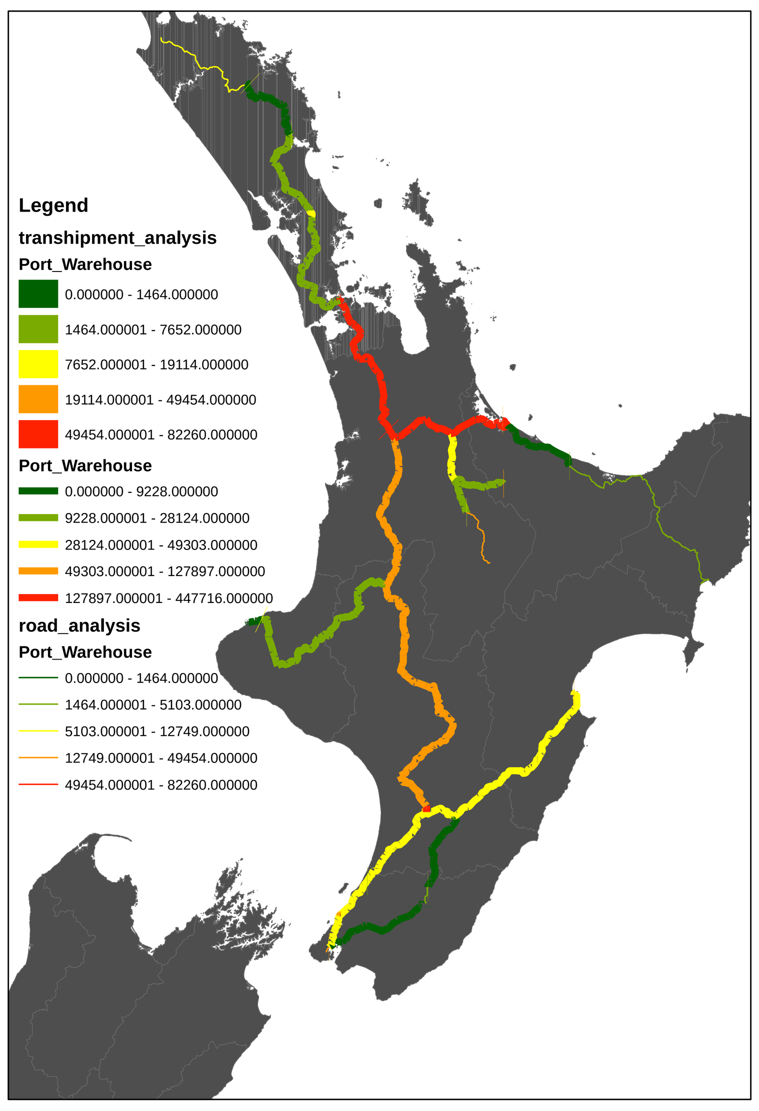

- Calibrate a spatial interaction model (i.e. Production Constrained Gravity Model) using total exports by port and regional statistics (i.e. Employment numbers by industry by region). The model predicts flows ($b''_{i,j}$) and includes an intercept (k), a set of origin fixed effects coefficients ($\mu_i$), a destination fixed effect coefficient ($\alpha$) and a distance decay coefficient ($\beta$).

$$b''_{i,j} = \exp(k + \mu_i + \alpha * \ln(E_j) - \beta * \tilde{d}_{i,j})$$

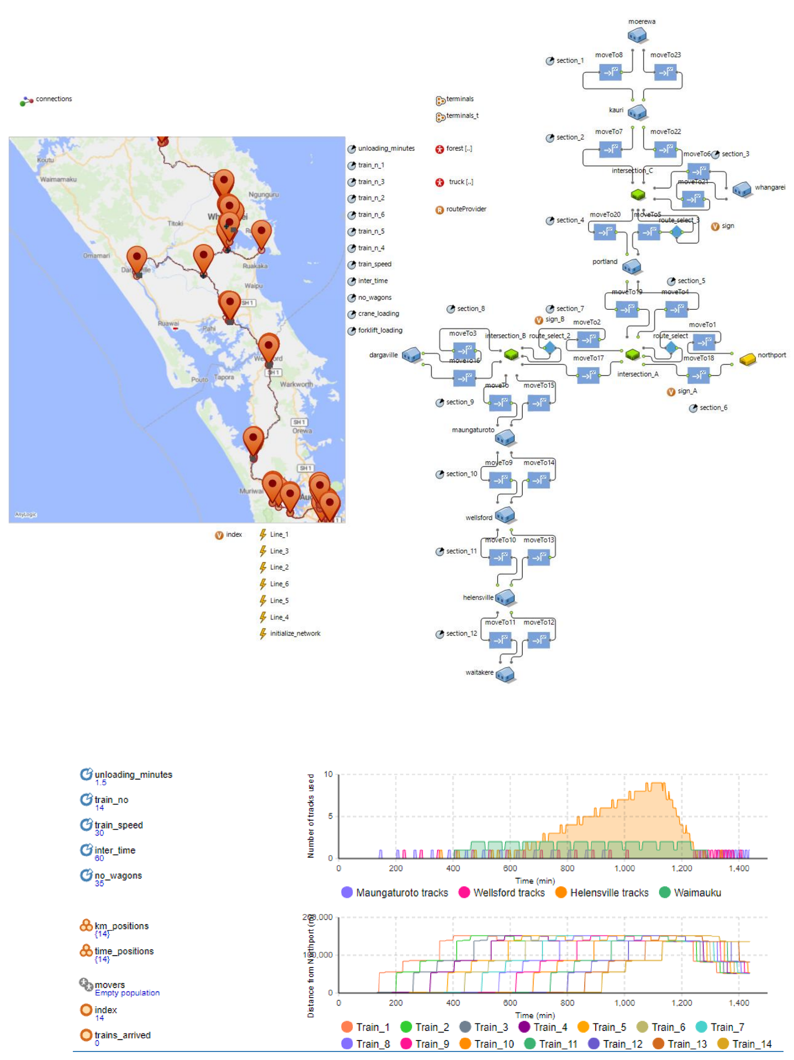
- Disaggregate interregional flows into facility to facility flows through the execution of a linear programming problem. Formulation allocates flows in proportion to total outputs reported in official documents.
- ***Part B:*** Multimodal Network Analysis: Setup multimodal network, consisting of roads, railway spurs and transhipment points. Every link of network is assigned a cost. Transhipment points are modelled as artificial or virtual features. Route and mode selection based on energy use criteria.
- ***Part C:*** Agent Based Model: Is executed within a discrete event framework. Cognitive agents correspond to key decision makers: shippers, port operators, terminal operators, transport companies, and a central freight forwarder; Non-cognitive agents: trucks, trains, ships, cranes, etc. Interaction between agents may or may not affect the overall status of the system which is updated on a discrete basis.




**Part A**




**Part B**



**Part C**