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TraNSIT: Modelling the supply chain of Australia's plantation forestry



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ABARES

NSW Department of Industry – Lands VIC Department of Economic Development, Jobs, Transport and Resources SA Department of Primary Industries and Regions Qld Department of Agriculture, Fisheries and Forestry State Growth Tasmania Forest Products Commission Western Australia Timber NSW Forest Products Commission Western Australia (FPC WA) Timberlands Pacific HQ Plantations

Australian Forest Products Association (AFPA)

Executive Summary

Good transport infrastructure is essential to efficiently moving commodities and products across the nodes of the supply chain. About 80% or 657,000km of the nation's roads are managed by local governments (ALGA 2016) and about 11% of these roads are in poor condition. These poor road conditions contribute to higher transport costs by reducing average travel speeds and increasing maintenance costs of heavy vehicles. Australia's commercial forest plantations harvest a record high value of 29.5 million m³ of log volume with a value around \$2.3 billion. Transport infrastructure is essential to moving these large log volumes from plantations to a multitude of processing plants and export ports. CSIRO developed the Transport Network Strategic Investment Tool (TraNSIT) to provide a comprehensive view of transport logistics costs and benefits due to infrastructure investments and policy changes in agriculture supply chains in Australia. This report presents the findings of a baseline analysis from the application of TraNSIT to Australia's plantation forestry, along with case studies with HQPlantations and Forest Products Commission.

TraNSIT models transport along individual paths segments where each path represents the route between two nodes of the supply chain, e.g. between a specific plantation and a saw mill. For this report a total of 180,000 unique origin to destination paths were modelled. These transport movements represent 28 million vehicle trips over 25 years (2016-2041), transporting a total of about 800 million m³ of timber (~32m m³/yr) at an approximate total cost of about \$23 billion. The frequency of timber trucks on Australian roads varies spatially and depends on plantation locations, predicted timber harvests and location of processing plants. A map showing the estimated number of trailers (semi-trailer equivalents), as modelled in this analysis, is shown in the figure below.



The findings of the analysis are based on the current conditions of the road network and current estimates of the timber supply forecast until the year 2041. As such, the report will provide governments, the forest plantation industry and other stakeholders with a baseline of freight transport costs between Australian plantation forestry value chain enterprises, along with a capacity to identify and evaluate scenarios to minimise transport costs and maximise long-term profitability. The project has now provided the capacity to assess the impact of road investment in forestry, along with all other agricultural commodities included in TraNSIT.

1 Introduction

In 2014-15, Australia's commercial forest plantations covered an area of 1,973,400 ha (ABARES 2016). Most recent estimates of logs harvested for the financial year 2015-16 indicate a record high value of 29.5 million m³ of log volume, worth about \$2.3 billion (ABARES 2017). Transport infrastructure is essential to moving these large log volumes from plantations to a multitude of processing plants and export ports. While most highways and major roads are sealed, much of the sparse rural road network, particularly near production areas, is unsealed and in poor condition. About 80% or 657,000km of the nation's roads are managed by local governments (ALGA 2016), and about 11% of these roads are in poor condition. These poor road conditions substantially reduce average travel speeds to often less than 40km hour and increase maintenance costs of heavy vehicles. Unlike other agricultural resource commodities, forestry is characterised by much longer yield cycles (up to several decades) and interim management cycles (thinning), which result in interim yields before plantations are finally cleared. A multitude of potential processed products including structural timber, wood panels, posts, poles, packaging and paper results in a complex supply chain. Whereas the complexity of this supply chain was not captured in its entirety by this project, the initial parts were considered, comprising the movement of timber from forest plantations to the first processors including sawmills, pulp- and paper mills, particleboard and veneer mills as well as panel and plywood mills. Export of logs and woodchips via export ports was also considered.

With primary industry production generally increasing and the geographic extent shifting in Australia, the government has recognised the need to invest in the regional road network. A range of possible future industry scenarios is being developed by industry, local, state and federal governments to reduce costs of existing supply chains and to plan for new production and markets. To provide a comprehensive assessment of transport logistics costs and benefits due to infrastructure investments and policy changes in agriculture supply chains in Australia, CSIRO developed the Transport Network Strategic Investment Tool (TraNSIT). TraNSIT is a ground up approach that optimises transport routes between enterprises and their markets. The outputs inform operational, investment and regulatory decisions from small scale to freight and supply chain strategies at a national scale.

Through an initiative for "Building the infrastructure of the 21st Century" under the Agricultural Competitiveness White Paper (agwhitepaper.agriculture.gov.au/), TraNSIT was applied to 98% (by volume) of agricultural and horticultural supply chains across Australia. The current project further extends this application to all Australian plantation forestry.

2 Background

The CSIRO TraNSIT tool was initially built to model livestock supply chains in northern Australia in 2012/13, through an initiative of the Office of Northern Australia and with co-funding from Northern Territory, Western Australian and Queensland governments. In 2014, TraNSIT was extended to all beef transport in Australia through a Meat and Livestock Australia initiative (Higgins et al. 2015). In 2014/2015, the tool was used to inform various road upgrades and regulatory changes for the beef industry, including sealing of roads in north Queensland and tick clearing regulations for transport of cattle direct to abattoirs.

The largest application of TraNSIT to date was to inform the \$100 million Beef Roads Programme: an initiative in the White Paper on Developing Northern Australia. The Beef Roads Programme was the first of its type in Australia to use an optimisation tool like TraNSIT to evaluate the transport cost savings for a large number of submissions. TraNSIT evaluated the transport savings for 60 road upgrade submissions, where the total construction cost was estimated to exceed \$3 billion. A report outlining the application of TraNSIT to the Beef Roads Programme and the resultant transport cost savings for each road upgrade can be accessed via csiro.au/transit.

TraNSIT is readily extendable to other commodities and road users by incorporating information representing the locations of enterprises and data describing their new supply chains. These data include volumes of commodity moved between enterprises (origins and destinations) and transport characteristics (e.g. vehicle types, vehicle access) relating to these commodities.

The range of scenarios TraNSIT can examine includes:

- Analysing the impact of road upgrades, e.g. sealing, widening, resolving first/last mile constraints, improving roads for higher productivity vehicles and bridges. This has previously been undertaken for the northern Australian beef industry and the report can be accessed from csiro.au/transit;
- Testing potential outcomes for changes in policy, e.g. driver fatigue, changing truck limitations for road classes;
- Comparing infrastructure investment and regulatory-change opportunities that maximise transport cost reductions for a given investment budget;
- Assessing potential for incorporation of rail transport in to commodity value chains. Although rail transport is currently less relevant to the timber industry, TraNSIT can include potential railroad transport options if required.

TraNSIT evaluates a baseline scenario which, in the current project, was based on current forecasts of timber production and harvesting schedules. The baseline also integrated existing infrastructure including processing plants and their capacities, and a road network incorporating detailed data provided by participating government and industry partners. The results of this baseline scenario provide transport volumes and costs related to hardwood and softwood plantation forestry over a 25 year period, from 2016 to 2041.

The baseline scenario can be compared to subsequent scenarios where changes to the baseline settings are made. Such changes could include a road upgrade or the establishment of a new timber processing facility of a given capacity. Comparing the results of subsequent scenarios to the baseline not only allows for the computation of changes to the total transport cost and time travelled; but TraNSIT also captures and maps the change of truck movements that certain infrastructure investments would cause.

This report outlines an initiative funded by the federal Department of Agriculture and Water Resources to model the baseline scenario for hard- and softwood plantation forest supply chains in Australia, as well as to highlight applications to case studies in Queensland and Western Australia. Native forestry production is not considered.

3 Objectives

This project modelled the supply chain of Australia's plantation forestry industry. Its objective was to provide governments, the plantation forest industry and other stakeholders with a baseline of freight transport costs between Australian plantation forestry value chain enterprises, along with a capacity to identify and evaluate scenarios to minimise transport costs and maximise long-term profitability. This was achieved by adapting the TraNSIT tool to the specifics of Australia's plantation forestry industry supply chain.

The baseline of freight costs captures the transport volumes of hard- and softwood timber originating from their respective plantations until the export port or first major processing node in the supply chain (Figure 1). This project did not model movement of products further down the supply chain which includes packaging products (e.g. cardboard), newsprint, furniture, timber for residential dwellings, landscape products and more. While these parts of the supply chain were not included in this project, it is technically feasible to extend TraNSIT to include them. This extension could include the retail chain and would require engagement with other industry players.

The results were developed for a national scale assessment. The data used for the large scale national assessment represent predominantly regionally aggregated information, which had to be disaggregated down to the plantation level. Locations of major processing plants were digitised from a high resolution national map, so exact locations of the major processors at a finer scale remain unknown. Furthermore, the locations of smaller processing plants were not available. While some information regarding processing plants could be sourced from state government forestry agencies, not all of the records provided included information regarding a processing plant's capacity. Further information that was missing includes the transport volumes between processing plants. The results of the national level assessment are therefore regionally indicative, rather than precise at a finer scale.

4 Adaptation of TraNSIT to plantation forestry

The extension of TraNSIT to Australian plantation forestry was conducted with support, input and validation from a variety of organisations, agencies and associations, as listed in Table 1 and Table 2. Ongoing engagement throughout the project ensured the highest quality data was used and thorough validation of outputs occurred, enhancing industry's confidence in TraNSIT being able to deliver robust results.

Where available from industry organisations, de-identified GIS plantation location layers were used as representative production locations. Within plantation inventory regions for which detailed industry data was not available, a national plantation dataset, produced by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), was used to identify the locations of hardwood and softwood plantations. Information on average yields for predominant hard- and softwood species within individual National Plantation Inventory (NPI) regions was sourced from ABARES (2012). These yields include the volumes of harvested timber at different management stages over the lifecycle of a plantation (several thinning stages and one harvest stage) and an average plantation age when harvesting will occur. An overview and a list of the data sources is provided in Section 5.

4.1 Supply chain

The supply chain for the Australian plantation industry as incorporated into TraNSIT is shown in Figure 1. It captures the volumes of hard- and softwood timber originating from their respective plantations until the export port or first major processing node in the supply chain. Volumes of hard- and softwood are distributed between the available processors based both on the predominant type of timber processed at a facility and a facility's processing capacity.



Figure 1 Modelled supply chain paths for plantation forestry, showing the volume in million cubic meters (m m³) transported over 25 years (2016–2041).

5 Data availability

5.1 Plantation datasets

The national dataset provided by ABARES comprises the locations of 49,000 plantations covering a total area of 1.94 million ha, of which 919,000 ha are covered by hardwood and about 1.03 million ha by softwood. A total of about 12,000 ha are categorised as mixed species, unknown or fallow, which weren't used in the analysis. These values closely approximate the official area statistics for the years 2014-15 as provided by ABARES (2016). Where data was available, spatial datasets from state government agencies or from industry were prioritised over the ABARES data due to the higher spatial granularity of location, crops rotations and species.

Table 1 Sources of data for plantation locations

Governmental datasets		
State	Source	Remarks
NSW	NSW – Department of Industry - Lands	A GIS compatible dataset showing plantation locations in NSW; spreadsheet with plantation IDs and age class
WA	FPC WA	A GIS compatible dataset showing hardwood and softwood plantations in WA
National	ABARES map showing Australia's forestry industry as at 2015	Approximate locations of all hardwood and softwood plantations in Australia.
Case study datasets		
QLD	HQ plantations	Plantation datasets in South East Queensland, spatially granular road network
WA	Forest Products Commission of Western Australia (FPC WA)	Softwood plantation datasets of WA

The geographic distribution of hardwood and softwood plantations (as of 2014-2015) across Australia and by National Plantation inventory (NPI) region was provided by ABARES and is shown in Figure 2.



Figure 2 Left: Hard and softwood plantations across Australia. Right: NPI (National Plantation inventory) regions of Australia (ABARES 2016).

Mapping of processing plants

Information on processing plants and their capacities was sourced from state government agencies or, in the case of the case studies, from the forestry industry. An overview of the data by state is contained in Table 2. Figure 3 shows the location of the "post harvest" supply chain enterprises used in TraNSIT for the baseline analysis.

Table 2 Sources of data f	or processing i	plants and other	supply chain	enterprises
Table 2 Jources of uata in	or processing p	plants and other	supply chain	enterprises

Governmental datasets					
State	Source	Remarks			
NSW	No data about processing plants				
VIC		Vic RoadsSpreadsheet with coordinates, processing type and processing capacity			
QLD		Queensland spatial catalogue (QSpatial, qldspatial.information.qld.gov.au/catalogue/custom/index.page Shapefile with coordinates and wood type processed (hard-softwood)			
SA	No data	No data			
WA	FPC WA	Spreadsheet with addresses and capacities of processors			
TAS	State Growth TAS, Private Forests TAS	Spreadsheet with coordinates, address and processing type			
NT	No information available				
National	ABARES map showing Australia's forestry industry as at 2015	Used to digitise approximate locations of largest wood processing plants in Australia.			
Case study datasets					
QLD	HQ plantations	Processing locations and processing capacities relevant for the case study.			
WA	Forest Products Commission of Western Australia (FPC WA)	Processing locations and processing capacities across WA.			

Of relevance to the TraNSIT model are volumes transported from the plantations to processing plants and also volumes shifted between processing plants. At the time of the analysis for this study, there was limited high-granularity data available to model the transport volumes between processors at a national scale. Highly granular data, however, was available only for South East Queensland.



Figure 3 Map of available timber processing plants used for the baseline analysis in the project.

Volumes exported – Export ports

The tonnage of exported volumes of logs and wood chips through Australia's export ports was sourced from portsaustralia.com.au and/or annual reports published by individual ports. Although these export volumes vary from year to year, they were assumed constant from 2016 to 2041 for the purposed of the baseline analysis undertaken.

Port	Wood chips	Timber	Logs
Albany	1,398,000		30,000
Bunbury	1,505,000	22,000	67,000
Esperance			
Portland	2,269,000	45,000	1,292,000
Geelong	931,000		
Burnie	419,000	140,000	130,000
Bell Bay	1,457,000		65,000
Brisbane	310,000	140,000	50,000
Mourilyan	83,000		
Port Adelaide			78,000
Hobart		48,000	61,000
Gladstone			500,000

Table 3 Annual tonnages of wood products exported through each port, as used in TraNSIT

5.2 Association of yields to individual forest plantations

TraNSIT requires input yields that can be associated with individual points of production (i.e. plantations) but the lack of highly granular spatial data makes it not possible. For the national scale baseline scenario a process was developed to allow for the disaggregation of ABARES data and thus infer timber yields at individual plantations to overcome the absence of the highly granular data. The ABARES dataset included information on ABARES plantation statistics (ABARES 2016) as well as ABARES sawlog/pulpwood yield forecasts (m³/ha) for defined age classes of hardwood/softwood for NPI regions (ABARES 2012). ABARES (2012) also provide typical ages for hardwood/softwood plantation management stages per NPI region.

As plantations are not harvested on a yearly basis but over much longer harvest cycles, timber yields and transport volumes vary spatially and temporally. With this project covering a time frame of 25 years (2016–2041), TraNSIT modelled the truck numbers and timber transport volumes over this entire period. This required knowledge of the spatial distribution of age classes in the year 2016. When not known, age classes were randomly and uniformly distributed amongst plantations within individual NPI regions. The upper bounds of age classes within NPI regions were equated to a representative age of the clearfall stage for soft- and hardwood for each region. This information was sourced from ABARES (2012).

To cover the time period of 25 years, the distributed age classes were iteratively increased by one year over 25 iterations. When a plantation reached a management stage, the yield associated with that stage was assigned to that plantation. This procedure not only allowed for yield estimates of individual plantations but also ensured that TraNSIT accounted for the spatial and temporal variability of timber harvests within each NPI region.

6 Baseline analysis

A baseline analysis provides information on the number of vehicles travelling along each road/rail segment, and needs to be undertaken before case studies can be tested. The main outputs from the baseline analysis for this project were:

- number of vehicles using each road segment by commodity, month of year, origin and destinations routes;
- detailed cost of road transport for every vehicle trip.

The baseline was representative for the years (2016-2041) and covered plantation forestry for both hardwood and softwood.

Before producing the baseline analysis, information about enterprises was first used by TraNSIT to produce a set of representative vehicle trips between enterprises. The method used is presented in Appendix A. There was a total of 180,000 unique origin to destination (O-D) paths (e.g. a path can be a specific plantation to a specific storage or processor), representing 28 million vehicle trips (semi-trailer equivalents) over 25 years, transporting a total of about 800 million m³ of timber.

Baseline transport density based on these 28 million vehicle trips is shown in Figure 4. Nearly all of the transport occurs on Performance Based Standard (PBS Level 2A) roads, which is limited to 26 metre B-Double access. Examples for south Western Australia and south east Australia are shown in Figure 5 and Figure 6 respectively.

A cost breakdown of this transport activity is shown in Figure 7. Transport cost per m³ is impacted by distance and road conditions (e.g. average speed, sealed vs unsealed). It includes the costs related to the transport of hardwood and softwood and all activities associated with it, for parts of the value chain modelled in this study. It thus includes the travel costs as well as the costs for loading and unloading and costs related to driver fatigue. These summary transport costs can be disaggregated by state, LGA, individual roads, truck type or linked back to individual plantations.



Figure 4 Baseline of transport density (number of semi-trailer equivalents on roads) for plantation timber over 25 years (2016-2041).



Figure 5 Baseline of transport density (number of semi-trailers equivalents on roads) for plantation timber over 25 years (2016-2041) - south west Western Australia.



Figure 6 Baseline of transport density (number of semi-trailers equivalents on roads) for plantation timber over 25 years (2016-2041) – south eastern Australia.



Figure 7 Modelled transport costs for the forestry supply chain in million dollars and per m³ for 2016-2041

7 Case Studies

Two regionally specific applications of TraNSIT were identified by industry and government. These case studies were included in this report to demonstrate TraNSIT's ability to model the timber supply chain with spatially more granular data and a more regional and local focus. The case study sites do not represent any measure of importance over those areas not included in this report.

7.1 Case study 1 – HQPlantations, South East Queensland

HQPlantations is Queensland's largest plantation company and manages an area of approximately 340,000 ha of which about 210,000 ha are hardwood and softwood plantations. For the purposes of this case study, a spatially more granular dataset of about 9,700 softwood plantation units covering an area of about 108,000 ha was used. All plantations are located in south east Queensland. In contrast to the national scale evaluation which used Australia's major road network as transport links between plantations and further nodes down the supply chain, the road network dataset obtained by HQPlantations provided the spatial granularity required to model transport movements from individual subunits within plantations to nearest processing points. To accommodate the higher spatial granularity, a new baseline separate to the national evaluation was run. This case study baseline, too, covers a 25 years horizon. The findings thus represent the outcome of just one possible scenario which is based on current domestic demand and a trend towards an increase in export. The forest trail network supplied by HQPlantations was incorporated in the TraNSIT road network for this case study. The forest trails are unsealed roads and were attributed with Performance Based Standard (PBS Level 2A) vehicle access.

Baseline scenario

For the HQPlantations baseline, a total of 56.7 million m³ of timber products was transported across the supply chain from 2016 to 2041. The total cost of transport was \$1,038 million or \$39.8 million per year. Freight density maps (Figure 8, Figure 9 and Figure 10) show the number of vehicles carrying timber (and timber products). Figure 8 shows that the most dense vehicle movements were chips and timber exports along the main highway to the Ports of Gladstone and Brisbane. Figure 9 and Figure 10 highlight the traffic volumes along the forest trails, which are mostly movements from plantations to the saw mills and to the main highway enroute to the ports.

Figure 11 shows the costs of transport between each segment of the supply chain for HQPlantations. The largest costs are to the ports, the movements highlighted in Figure 8. Compared to the national supply chain map (Figure 7), the cost per m³ to the saw mills is significantly lower, with the largest saw mill conveniently located within the main plantations are between Gympie and Maryborough.



Figure 8 Baseline of transport density (number of semi-trailers equivalents on roads) for plantation timber over 25 years (2016-2041) – HQPlantations supply chains.



Figure 9 Baseline of transport density (number of semi-trailers equivalents on roads) for plantation timber over 25 years (2016-2041) – HQPlantations region west of Bribie Island.



Figure 10 Baseline of transport density (number of semi-trailers equivalents on roads) for plantation timber over 25 years (2016-2041) – HQPlantations region south of Maryborough.



Figure 11 Modelled transport costs for the HQPlantations supply chain in million dollars and per m³ for 25 year period between 2016-2041

7.2 Case study 2 – Forest Products Commission (FPC) Western Australia

The Forest Products Commission (FPC) Western Australia is responsible for the sustainable management and development of Western Australia's timber industry using native forest, plantation and sandalwood products on land owned or leased by the State. FPC manages about 108,000 ha of plantations in south west Western Australia. Similar to the HQPlantations case study in south east

Queensland, this case study is based on a spatially more granular road dataset than was used for the national scale evaluation; in this case not plantation tracks (as was available and used for the HQPlantations case study), but a dense network of lower rank and local roads including roads within communities. This dataset was provided by the Western Australian Department of Main Roads. The spatial locations of the FPC plantations were not sourced through ABARES but were downloaded through SLIP - an open data platform for location-based information in Western Australia (slip.landgate.wa.gov.au/). The plantations included in this case study are softwood plantations covering an area of about 60,000 ha and up to a maximum age class of 30 years, representing the maximum age for which yield data were available. As with the HQPlantations case study, a baseline analysis was run for this dataset. Data for subsequent road upgrade scenarios were not available.

Baseline scenario

For the FPC baseline, a total of 14.04 million m³ of timber products was transported across the supply chain from 2016 to 2041. The total cost of transport was \$357 million or \$14.3 million per year. The costs are based on a load capacity of 42 tonnes (

Table 5) for Performance Based Standard (PBS Level 2A) vehicle access. A freight density map showing the number of vehicles carrying timber (and timber products) is shown in Figure 12. To facilitate woodchip export through the Port of Esperance, a woodchip plant with a capacity of up to 500,000 m³/yr commenced operations in 2017. The projected life span of this plant is seven to nine years, based on the projected timber yields of the regional hardwood plantations which, once cleared, will not be replanted. Given this case study covers FPC's softwood plantations, any resulting truck movements from the transport of these hardwood chips do not appear in Figure 12.

In Figure 13, the costs per cubic metre between different stages of the supply chain are less expensive than the national average shown in Figure 7. This is due to: 1) shorter transport distances between plantations and processing and export ports; 2) integrated supply chains in the case study; and 3) a more detailed mapping of the supply chain enterprises and the annual throughputs than the "non-case study" regions in Australia based on ABARES data.



Figure 12 Baseline of transport density (number of semi-trailers equivalents on roads) for plantation timber over 25 years (2016-2041) – FPC supply chains.



Figure 13 Modelled transport costs for the FPC supply chains in million dollars and per m³ for the 25 year period from 2016-2041

8 Next Steps

8.1 Forestry

The application of TraNSIT to forest plantations and supply chains within this study was primarily based on national data sets. Precision was improved for the case studies through the provision and use of data (plantation spatial layers, saw/panel/ply mill production volumes, integrated supply chains, etc) by the participating organisations. Access to high-granularity data to produce highly granular supply chain and freight flow outputs for forestry across all Australia will require broad participation of organisations, commissions and corporations. This will progressively be achieved beyond the life of the current project through application of TraNSIT through projects with other forestry supply chain organisations and regions. Future demand for TraNSIT in forestry will include native forestry and likely be at a regional level to address bottlenecks to local supply chains.

The scope of the supply chain in this study was limited to primary processing (saw mills, paper mills, export) and did not consider secondary processing (end use products) and movements to retail chains. These supply chains will be added in the future on a regional basis or as required by specific supply chain components (e.g. Bunnings). Beyond the HQPlantations dataset in Queensland, private forest trails have not been included in the TraNSIT road network. It will be progressively added for other forest regions through the provision of spatial layers from participating organisations.

8.2 Extension to rain and flood hazards

Some major innovative developments to the TraNSIT tool have been identified by industry and government partners, which would substantially increase its value for government investment, industry and road users. A priority is to incorporate the Bureau of Meteorology's (BoM) weather, climate and flood data. This would provide additional insight to inform infrastructure investments and economic impact assessments, through for example establishing the impact due to heavy rain / flood events. This is particularly important for the north of Australia, where there is limited road access to markets.

8.3 National Freight and Supply Chain Strategy

The Australian Infrastructure Plan, released by Infrastructure Australian in February 2016 provided a long term plan and list of recommendations for infrastructure reform and investment. These recommendations included the better use of technologies to support more efficient regional supply chains. Recommendation 4.5 noted the development of the proposed National Freight and Supply Chain Strategy should be informed using TraNSIT. The Australian Government's Response to the Australian Infrastructure Plan (November 2016) supported TraNSIT as a key tool to support ongoing work on the national freight strategy by the COAG Transport and Infrastructure Council.

8.4 Web based version of TraNSIT

TraNSIT is a valuable tool that assists Federal and State agencies determine infrastructure investments, freight strategies, regulatory changes and planning for future industry scenarios. To maximise the benefits achieved from TraNSIT, a version needs to be created for use by these agencies. A project is being proposed to develop a web version of TraNSIT that can be used by key Federal and State agencies (e.g. Department of Agriculture and Water Resources, Department of Infrastructure and Regional Development, State Departments of Transport and Main Roads, National Heavy Vehicle Regulator). The proposed web based version would protect access to confidential input data, production of outputs revealing sensitive enterprise level information, and use for competitive commercial advantage, while providing flexibility to test a range of infrastructure and regulatory scenarios.

9 Sensitivities

TraNSIT is a computer based model, requiring technical expertise and training to set up for different types of applications. TraNSIT uses a large supply chain dataset across Australian agriculture and forestry, and a large proportion of the industry data was provided under confidentiality agreements. As a result, the current version of TraNSIT is only accessible by the CSIRO project team.

Due to the sensitive nature of industry data provided and used in TraNSIT, the model cannot be used in applications that allow an organisation to gain competitive commercial advantage. A proposed future version of TraNSIT will remove this sensitivity and allow an organisation to input its own data or forecasts, and use the model to optimise its own logistics.

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Appendix - Overview of TraNSIT

TraNSIT is a modularised tool (Figure 14) where data for each agriculture sector is an input to the core engine, along with the infrastructure or regulatory scenarios to test. TraNSIT is programmed in Python (python.org) and uses the ESRI ArcGIS network analyst capability while accommodating multiple features about the road network and individual segments. Road network data are critical and roads ranked as primary, secondary and minor (including unsealed) roads are included. The road layer, represented in Figure 15, was constructed using shape files defining location, ranking, access restrictions and other road information (breakdown pads, biosecurity restrictions, rest stops) from several sources. Road layer characteristics were supplied by Geosciences Australia (ga.gov.au), each state government's roads department, various regional councils and the National Heavy Vehicle Regulator (NHVR) – nhvr.gov.au. The NHVR provided information on access limitations for different types of heavy vehicles across the road network. The roads were classed as primary, secondary and minor (Figure 15), with these roads further broken into segments with attributes containing surface type, width, speed limit and any special limits (e.g. one-way bridges). These data were collected from the transport departments of each state/territory in mainland Australia. All of these attributes affect average speed and transport cost per kilometre. The road layer required enhancements (e.g. creating connections, correcting locations of some roads) to provide a fully routable road layer.

The road network has been updated (particularly for southern Australia) to accommodate minor roads linking farms to storage facilities and processors. Figure 15 and Figure 16 shows the latest version of the road layer used in TraNSIT. The layer also contains additional features including average speeds (by vehicle type), road conditions (sealed, narrow sealed, unsealed), and other features (decoupling locations, bridge limits, tick lines) that impact travel costs and vehicle routes.



Figure 14 Components of TraNSIT



Figure 15 Current road layer used in TraNSIT showing road rankings and heavy vehicle access. A denser (Rank 3) road layer has been added at some locations, when required for some case studies



Figure 16 Average maximum speed across the road network used in TraNSIT (minor Rank 3 roads not shown)

TraNSIT uses a ground-up costing model for both road and rail. For road, it is based on the Freight Metrics (freightmetrics.com.au) tool, and additional vehicle types (e.g. refrigerated, heavy rigid) have being incorporated within TraNSIT to accommodate vehicles used for different types of agriculture and post processing supply chains. A snapshot of the transport costs for different speeds and vehicles is contained in Table 4. The costing model has been enhanced for different types of unsealed roads, accommodating additional maintenance costs for vehicles. Greenhouse Gas emissions are also calculated using information on heavy vehicle fuel usage published by the Australian Trucking Association (ATA 2016) and emissions factors for different fuel combustion published in the National Greenhouse Accounts Factors (DEE 2016)

Table 4. Overview of the vehicle transport costs

	Modelled cost (\$/km) per travel speed		travel speed	Additional maint (\$/km)		
PBS Scheme	100 km/h	60 km/h	20km/h	Good Unsealed	Poor Unsealed	ldle cost (\$/hr)
Level 1 (Semitrailer)	1.91	2.58	6.11	0.09	0.26	119
Level 2A (B-Double)	2.35	3.13	7.36	0.13	0.39	141
Level 3A (Type 1)	2.71	3.54	6.81	0.16	0.49	169
Level 4A (Type 2)	3.43	4.36	8.22	0.24	0.72	177

Table 5. List of vehicle combinations that can be selected, depending on road access at origin

TraNSIT Cost Model	Road– Access Class PBS Level				
	4A	3A	2A	1	
Mod 1	4A	3A	1	1	
Mod 2	4A	2A	2A	1	
Mod 3	3A	3A	1	1	
Mod 4	2A	2A	2A	1	
Mod 5	1	1	1	1	
Cap Tonnes^	84	56	42	28	
Length (m)	53.5	36.5	26	19	

^ Depends on bulk density and axel load limits

TraNSIT simulates the number of vehicle trips per month moved between origin and destination enterprises. The goal of the TraNSIT module is to optimise the transport route and vehicle selection along the road/rail network for each of these trips from origin to destination, and then calculate the cumulative impacts at the enterprise or regional scale while evaluating against constraints on the number of vehicle trips on each route. To determine the optimal route, the analysis takes into account parameters such as costs, vehicle access, vehicle types and hierarchical value of the road segments. The least cost vehicle combination selected depends on heavy vehicle access restrictions throughout the journey from origin to destination. These restrictions define where road trains can decouple and influence the cost of operating larger versus smaller vehicle combinations for each part of the journey. For example, if the first 50km of the journey is PBS Level 4A vehicle access, and the last 800km is B-Double vehicle access, the least cost option would be to use a PBS Level 2A for the entire journey, due to the high cost of decoupling after 50km.

Table 5 shows the list of models for vehicle selection for a trip between an origin and destination. TraNSIT will select the least cost model depending on the vehicle access limitations between origin and destination and volume transported. Models 1 to 2 apply to trips where that allow a PBS Level 4A road train for at least part of the journey, but will accept smaller vehicles. Model 1 is typical for triple road trains that would normally decouple into PBS Level 3A double road trains or semitrailers for roads that are limited to smaller vehicles. Other vehicle types (e.g. BAB Quads, AB triples, A-Doubles) can readily be added. Model 3 are for trips where the maximum vehicle is a PBS Level 3A for any part of the journey. The vehicle selected may also affect the optimal route taken. For example, the use of a semitrailer vehicle from the origin could take the shortest travel time path and would not need to decouple. Commencing travel from the origin in a PBS Level 3A or 4A vehicle may take a longer travel time path to increase the proportion of the trip in the higher performance vehicle before decoupling into smaller vehicles, to minimise costs. It is essential for all these parameters to link together logically, to allow proper solving of optimal routes.

Since a property is not always geographically attached to a road in the road network, a trip from an origin to destination (O-D) is modelled to travel from the closest road segment to the origin, and finish at the closest point on a road segment to the destination point. This process is repeated for all routes, always searching for the minimum cost route (including penalty costs), and selecting it as the optimal route.

Figure 17 represents a process diagram of TraNSIT. The first processing stage of TraNSIT is to construct a set of vehicle and train trips between enterprises across the supply chains. Once the set of movements has been produced, TraNSIT finds the optimal route (based on transport cost) and selection of vehicle types, for each Origin-Destination (O-D) pair input. Optimal road sections travelled for each O-D pair are saved. These road sections can be constrained by access restrictions such as vehicle size/load limit which will determine the route final set of route segments. The optimal route selected may not necessarily be the actual route taken by the driver in the existing network but rather the route that would be taken should the driver be seeking a least travel cost option. Once the optimal set of segments for all O-D pair. These are then aggregated over all O-D pairs to provide a total cost of transport for the scenario. It currently takes about 10 hours (on 25 cores - Dual Xeon CPU 3.3GhZ processor) to run all of steps of TraNSIT shown in Figure 17 for the 182,000 different O-D's across all plantation forestry.



Figure 17 Process diagram of TraNSIT, comprising the stages from set up to running of each model component

Synopsis of Authors

Andrew Higgins

Andrew is a Principal Research Scientist at CSIRO, based in Brisbane. He joined CSIRO in 1996, with a passion in developing novel methods to optimise agriculture transport and logistics to increase profitability across supply chains. Andrew has worked closely with various Australian agriculture industries (particularly sugar and beef) for over 15 years, improving strategic and operational logistics across all segments between farming and marketing.

From 2012, Andrew led development of the Transport Network Strategic Investment Tool (TraNSIT) and its application to the Beef Roads Programme as part of the White Paper for Developing Northern Australia. The results demonstrated significant transport cost savings for many road upgrades. Andrew has a background in operations research and received his PhD from Queensland University of Technology on the topic of optimising rail freight schedules.

Stephen McFallan

Stephen is a mathematical modeller and statistical analyst with high-level skills in software development. He joined CSIRO in 1998 and has applied his skills to develop decision support tools which enable decision makers to carry out a range of activities such as forecasting, scheduling, and optimal investment. The tools allow decision makers to compare outcomes for often conflicting policy objectives using simulation to provide robust informative data. He has applied this expertise to transport logistics in the agricultural sector, in particular leading the technical development of TraNSIT.

Oswald Marinoni

Oswald is a computational geologist with a focus on complex spatial analysis to optimise planning across various scales. He has delivered a variety of projects both in Australia and overseas including suitability assessments for mining, industrial planning, urban planning and optimisation of portfolios of environmental investments. Oswald's part in this project involves the development of a log supply forecast model for individual plantations, reconciliation of national scale data with regional data as well as ensuring the overall spatial consistency of plantation and processing plant data. He is based in Brisbane.

Libby Pinkard

Dr Pinkard is a tree physiologist with extensive experience in the effects of drought, nutrient and water stress, pest damage, and climate change, on woody vegetation productivity. She has led a number of projects examining the direct and indirect consequences of climate change for vegetation, and examining adaptation strategies for reducing vulnerability to climate change. She has contributed to the development of models and decision support tools to transfer research outputs into practice, and has applied these tools to understand risks of climate change to Australia's forests, and adaptation strategies to build resilience. She currently focuses on identifying the risks and impacts of drought, fire and pests for forest productivity and survival, and the genomic basis of tree responses to elevated atmospheric CO₂.

Adam McKeown

Adam is a researcher based in Cairns, with 25 years' experience with CSIRO. He has experience in a wide range of areas, including population and spatial ecology. For the TraNSIT project, his focus is in modelling and network analysis.

Caroline Bruce

Caroline assists with project coordination, mapping and data collection for the TraNSIT project. She joined CSIRO in 2001 to research the changing landscape of Australia's Wet Tropics region. She later focused on the use of GIS to map and model environmental issues within the region, and then moved in to large project coordination. She is based in Cairns, Queensland.

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