Enabling a Regional Bioeconomy: A Developing Australian Biomass Supply Chain Case Study

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Biomass Supply Chain Project Suite Overview

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High Level Project Deliverables:

- **Goal – Work with Stakeholders to Develop & Initiate A Viable Supply Chain by 2020**
- **Focus – Enable Sustainable Supply of Biomass to Enable the Emerging Bio-Economy in Queensland**

Project Collaborator(s):

- HQPlantations - Southern Pine plantation resource in south-east Queensland, Australia
- Laminex Australia
- Altus Renewables

Overview

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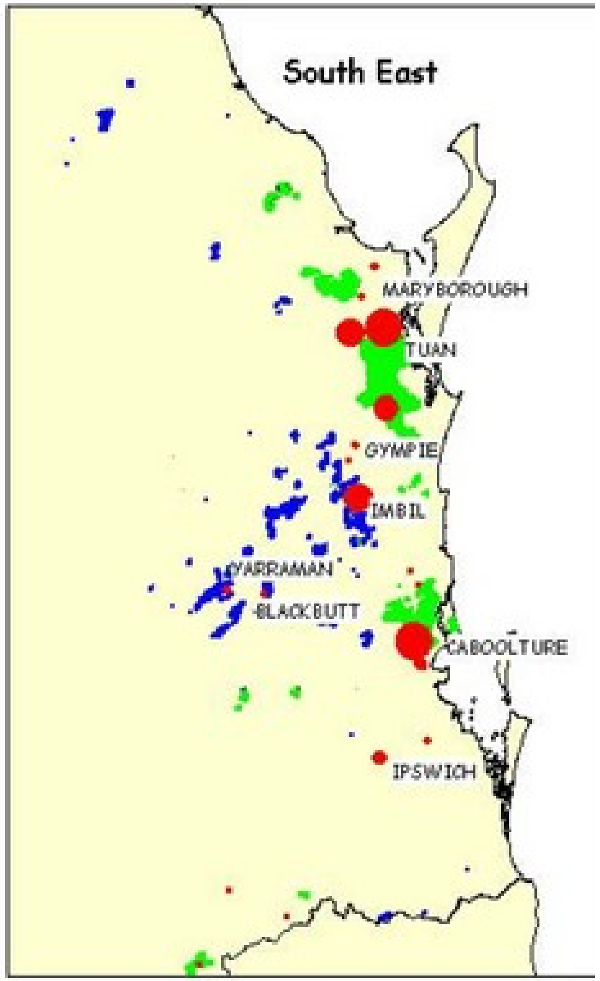
4 Projects – 4 Key Research Question(s):

1. What is the current biomass availability and composition?
2. What are the operational considerations and site preparation implications of biomass removal?
3. What are potential recovery options & costs?
4. What is the optimal supply chain?

Regional Context: High Energy Costs | Local Co-Gen Interest | Emerging Pellet Market



Project 1 - Biomass Assessment

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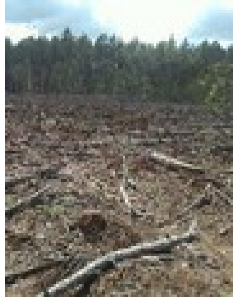
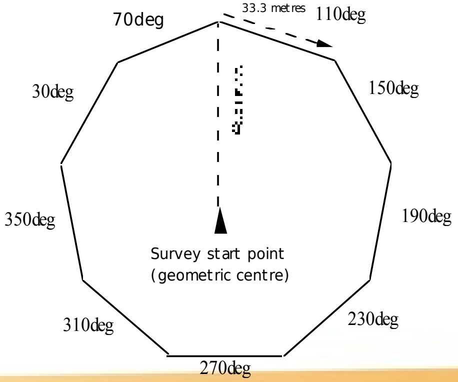
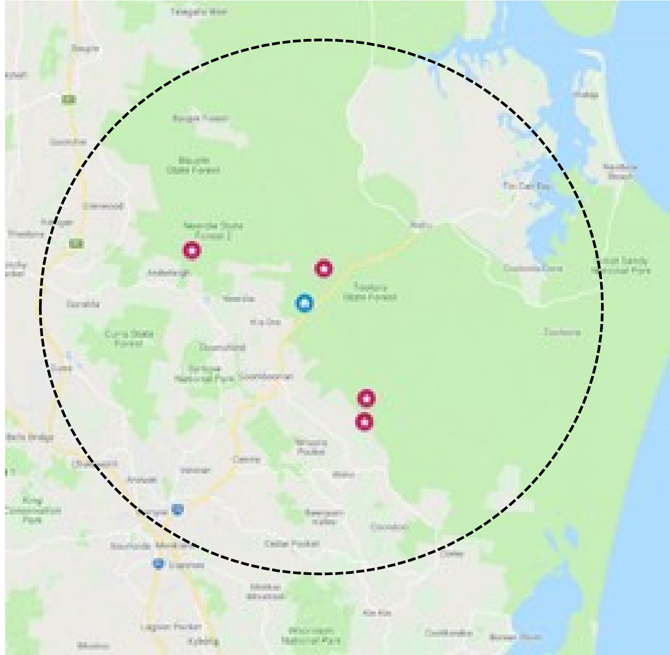
<u>Question:</u> What is the current biomass availability and composition?

<u>Study</u>: Post Harvest Residue Assessment

- **2 – Systems (CLT & WT)**
- **5 – Sites (Varying Biomass Conditions)**
- **3 – Evaluation Techniques (CRC Method, Line Intersect, Pile Decomposition)**





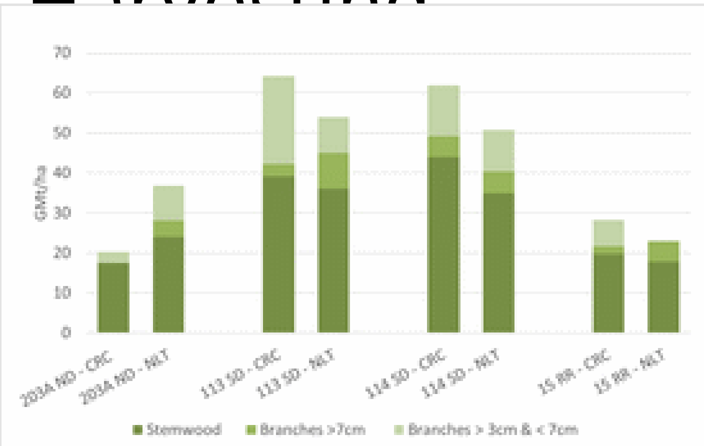


Establishing Robust Methodologies for Assessment & Evaluation

Project 1 - Biomass Assessment

Composition and Volume of Forest Harvest Residues depend on Harvesting Technique and local markets.

- Cut to Length Harvesting



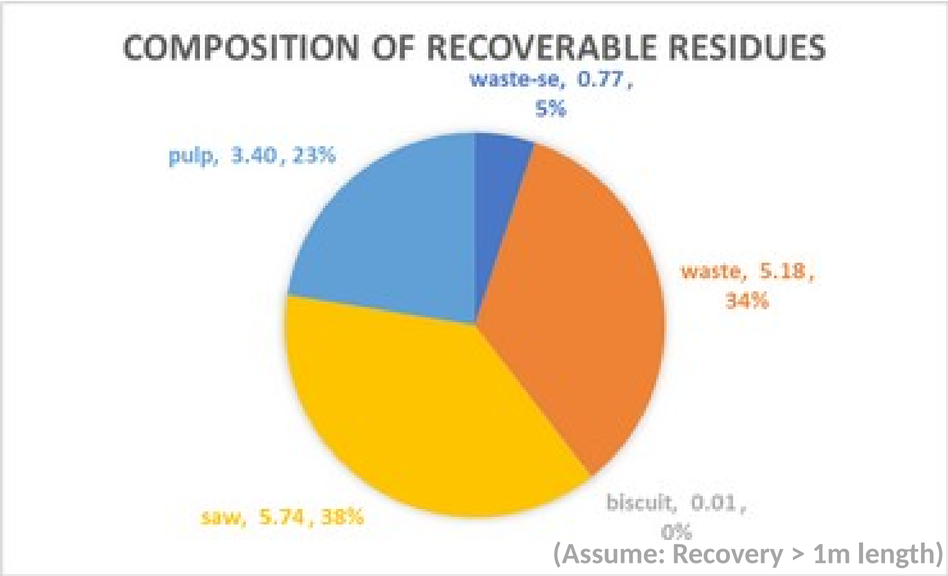
	Site			
	203A ND	113 SD	114SD	15 RR
Average Residue (GMt/ha)	56.3	97.6	100.4	51.5
Recovery (%)	20%	20%	20%	20%
Extractable Biomass (GMt/ha)	11.3	19.5	20.1	10.3
Residues Left on Site (GMT/ha)	45.0	78.1	80.3	41.2

What is truly Recoverable?

In-Field Biomass

Roadside Biomass

- Whole Tree Harvesting



Lost Value Considerations

Recoverable Biomass likely 10-20 GMt/ha

Project 2 – Operational Considerati

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<u>Question:</u> What are the operational considerations and site preparation implications of biomass removal?

Site Characteristic	CTL System	WT System
Area (ha)	0.31	0.32
Mean DBHOB (cm)	37.8	40.9
Mean Height (m)	27.8	30.3
Mean Tree Volume (m^3)	1.19	1.38
Stems per hectare (sph)	394	293

<u>Study</u>: (2) Harvest Systems

- **1 – Mimic Biomass Recovery (WT)**
- **2 – In-Field Biomass Dispersal (No Recovery) (CLT)**
- **3 – Evaluate Operational & Site-Preparation Costs**

IEA Bioenergy

Project 2 - Operational Assessment: Harvesting

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Operational Analysis

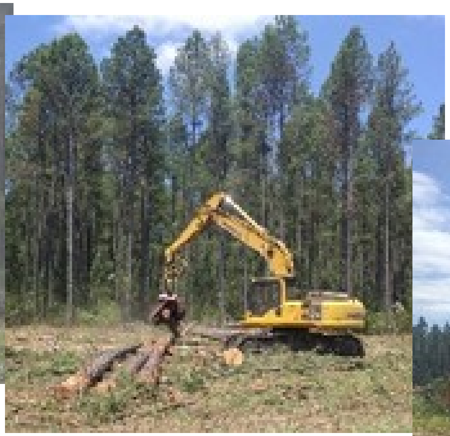
Harvesting Method	Equipment
Cut to Length (CTL)	Harvester/ Processor - Komatsu 951 with Komatsu S172 Head
	Forwarder - Komatsu 8903
Whole Tree (WT)	Feller Buncher - Tigercat 860C with Hotsaw Tigercat Head model 5702
	Processor - Komatsu PC 270LC with Waratah 623C Head
	Grapple Skidder - Tigercat model 632E

Cut-to-Length

(left) Harvester/ Processor (right) Forwarder

In-Field Biomass

Whole-Tree Harvesting



(left) Feller Buncher, (Centre) Processor, (right) Grapple Skidder

Roadside Biomass

Project 2 - Operational Assessment Site Preparation

Contractor Surveys

Range of Left Slash:
CTL: 20-70 GMT/HA Dispersed
WT: 10-30 GMT/HA at Roadside

(left) Chopper Roller, (Centre) Excavator conducting CTL windrow, (right) Roadside pile after excavator manipulation prior to burning.

- **<u>Chopper Roller (CR)</u>, a dozer-based machine towing a multi-tonne drum roller with blades to break up slash material,**
- **<u>Excavator used to windrow the material</u> (move material into lanes away from the planting locations),**
- **<u>Excavator to move roadside material</u> (either to collect and burn or spreading roadside piles to allow for future planting [lane clear])**

Rise, and shine.

Project 2 – Operational Assessment: Economic Incentives for Biomass Harv

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How much site prep. savings if switch from CTL to WT & Biomass Harvested?

Slash Level	Economic Incentive ($/ha) Full Treatment	No Pile
WT: High - No Burn CTL: High	230	500
WT: High - Burn CTL: High	400	500
WT: Medium CTL: High	384	600
WT: Low CTL: Medium/Low	-116	100

Secondary: Operational cost savings of WT (vs. CTL): ~ $5/m^3

May save $100-600/ha (0.2-1.3 $/m^3) | Whole Tree Biomass Harvest (~200-400/ha)

Project 1 & 2 - Conclusions

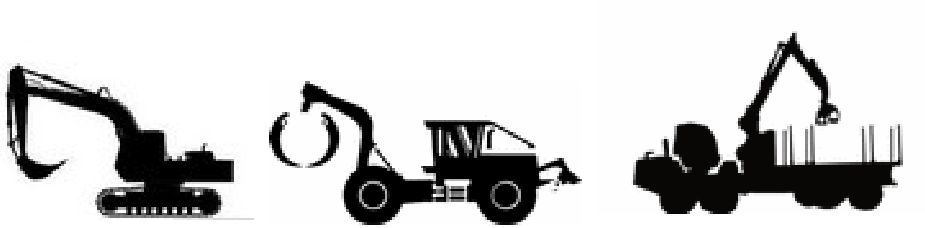
- **Viable amounts of recoverable Biomass**
- **Whole Tree Harvesting sites are most favorable for extraction**
- **There is an economic incentive to reduce on-site biomass**
  - Biomass must be handled with prior to next generation planting
- **Potentially Lost Value due to inefficient Harvesting Operations**
- **Net Revenue = Revenue – Costs (Costs are only piece of information)**
  - Other Incentives may be greater than savings due to site-preparations
  - Market Considerations, Contractual agreements, logistical considerations, etc.
  - Soil Nutrient Load should be considered

Whole Tree Harvesting (Higher Volumes & More Easily Accessible!)
Need for a Supply Chain Analysis

Project 3 –Supply Chain Options Whole Tree Harvesting

Desktop Study & Literature Review

Step #1: Moving Raw Material



Considerations	Excavator	Skidder	Front End Loader	Forwarder - Slash	Forwarder - Logs
Pros	cheap, low impact	on site, flexible	cheap, robust	on site, flexible	on site, flexible, High quality
Cons	short distance, dirty?	only large pcs	heavy, disturb, only large pcs	expensive, need to modify?	Expensive, Low Quantity

Optimal Pile Placement? Onsite Equipment? Contamination?

Step #2: Processing (Chip/ Grind)

Piece Size? Utilization? Pile Configuration?

Step #3: Transport

Raw vs. Processed? Accessibility?

Costing Assumptions Developed for Each Alternative (40+)

Project 3 –Supply Chain Options Pathway Summary

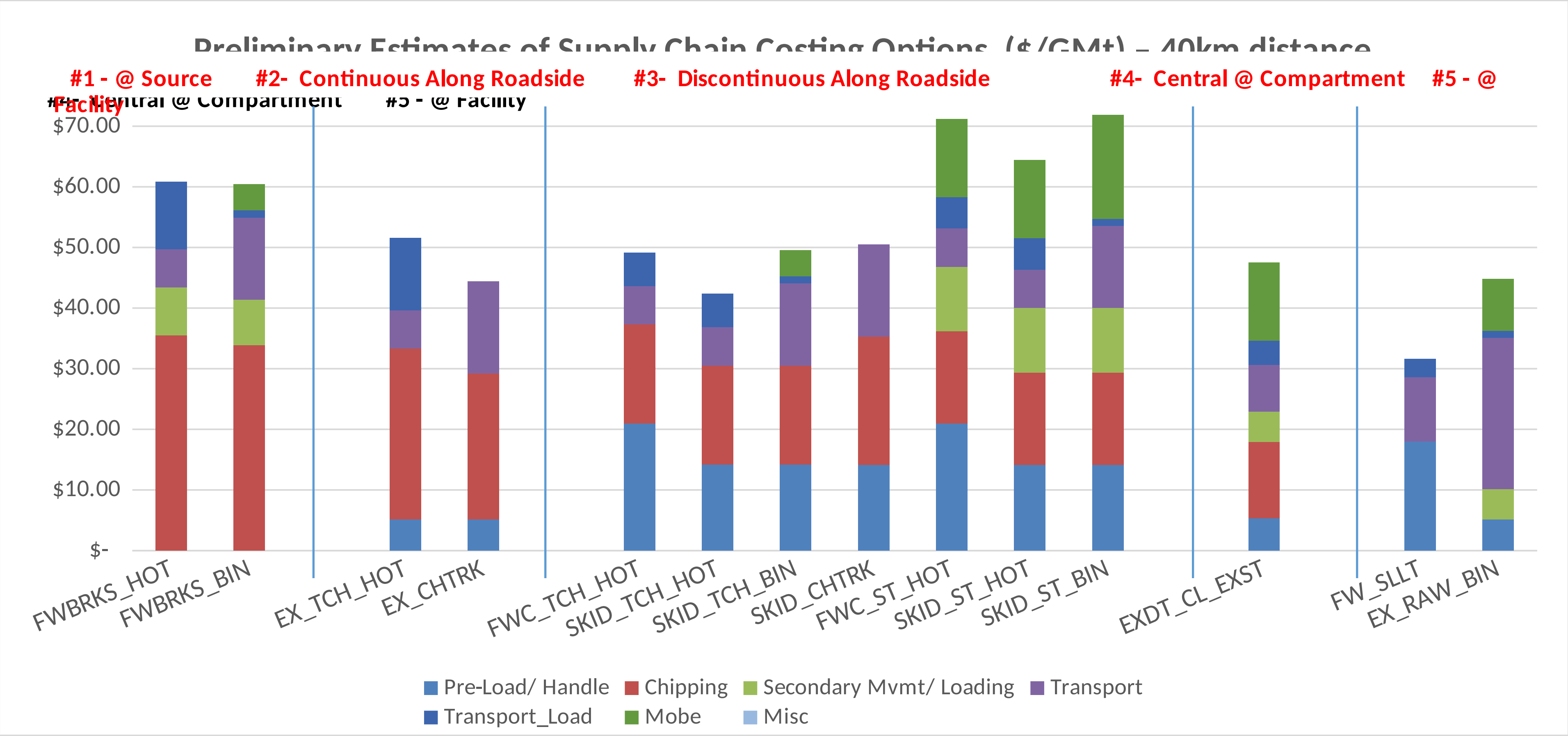
Pathway	Location of chipping	Example	Comments / Variations
1	**At source**	In-field chipper (e.g. Bruks unit on forwarder)	Empty into waiting truck or pre-positioned bins
2	**Continuous along roadside**	Self-contained chipper truck with chip bin +/- chip trailer (or Truck Mounted Chipper)	Needs excavator or similar to move residues from source (~ 20 m away) to roadside
3	**Discontinuous along roadside**	Truck, Trailer or Track-mounted chipper moves from roadside pile to roadside pile	Excavator (Skidder or Fwdr?) moves residues to roadside Chip into waiting truck or pre-positioned bins
4	**Centralised chipping at compartment level**	Larger static chipper set up at each compartment	Modified Fwdr moves residues to central chipper (Alternatively modified dump/bin trucks shuttle material). Chip into waiting truck or bins
5	**Chip at facility**	Raw residues delivered in ‘bin wood’ trucks	May be suitable for very short haul distances

Project 3 –Supply Chain Options Deterministic Model Development

Conceptual Evaluation

Early Preference: More Mobile & Less Capital Intensive

<u>Key Assumptions:</u>
- Volumes
- Piece Size
- Pile Placements
- Chipping Productivity
- Utilization Rate
- Distance from Market
- Equipment Costing
- Mobilisation
- Moisture Content



Many Assumptions – Need for Refinement & Testing

Lower Bound = $/GMt
Upper Bound = $/ BDMT

Project 4 –Optimal Supply Chains
Refinement of Regional & Market Constraints

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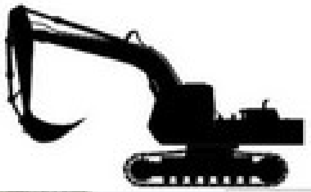
Landscape Optimization & Field Trials

1. In-Field Processing

- In-Field Biomass Harvesting (BRUKS Style Chipper) + No Pre-Field Manipulation

2. Roadside Processing with Arrang
Piles

- Truck-Mounted BRUKS Style Chipper (B
- Roadside Track-Mounted Grinder or Chipper



3. Central Processing at Compartm

- Trailer or Track-Mounted Grinder or Ch

Key Concept: Sensitivity for Productivity Assumptions

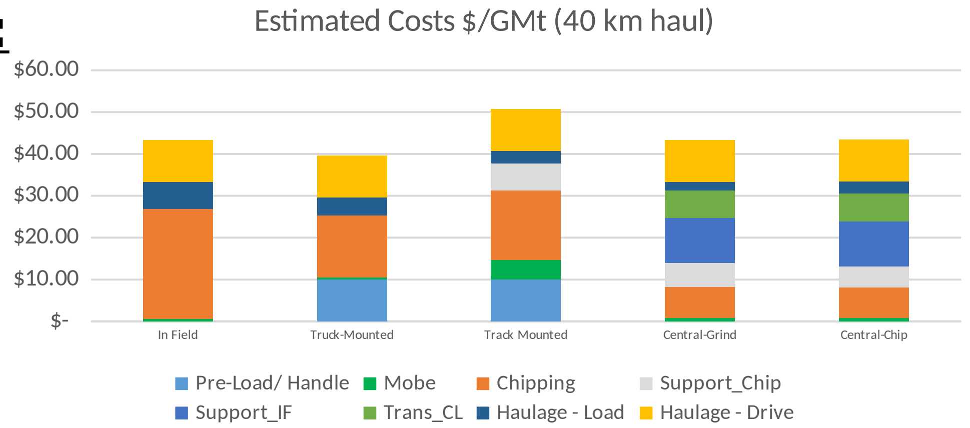
Project 4 –Optimal Supply Chains Supply Catchments & Refinements

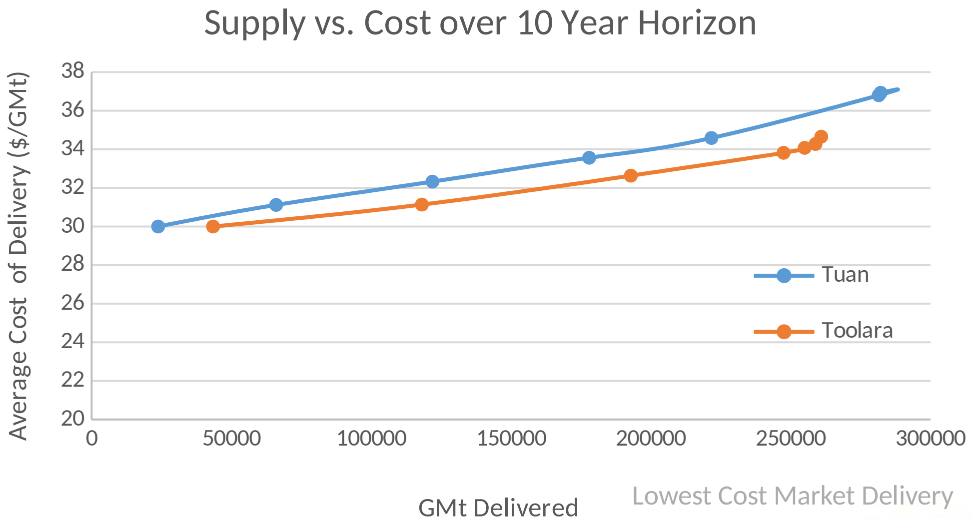
For a Chosen Pathway:

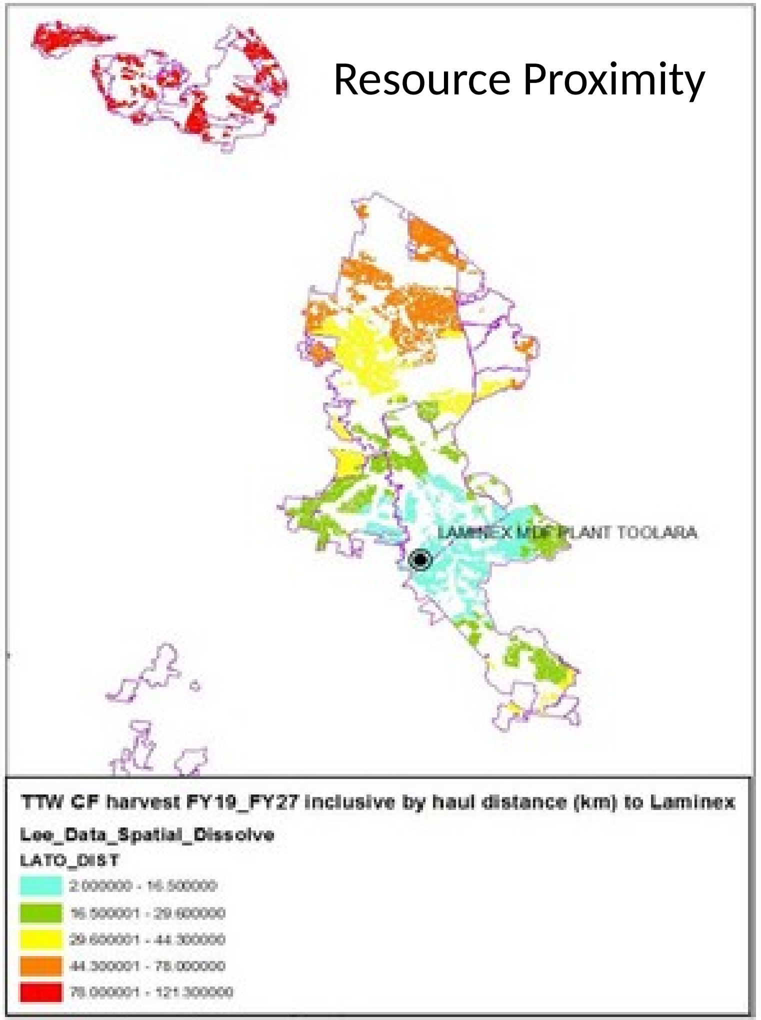
- Competing Markets
- Sourcing Radius
- Trucking Availability

Modelling – Next Steps:

- MIP Model Development
- Time Series Analysis
- Market Constraints
- Costing Refinements
- Site Prep. Allocation







Development of Optimisation model built on refined assumption and regional constraints

Research – Next Steps

Waste To Biofutures (W2B) Grant – Ongoing!

Queensland Government

<u>Next Step:</u> Strategic Field Trials, Refine Model Assumptions

<u>GOAL:</u> Corporate Investment in Equipment & Begin Delivery

- Enhanced Value Recovery – Minimize Existing Biomass Stocks
- Modified Harvest Trials – Integrated Support (Excavator/ Processor)
- Residue P ctivity (In-Field, Cen
- Transporta)