

# Plantation Management and the Forest Life Cycle: Spatial Solutions to Non-Spatial Problems

**Anthony J. Baker**

Forestry Corporation of NSW  
[anthony.baker@fcnsw.com.au](mailto:anthony.baker@fcnsw.com.au)

## ABSTRACT

*Forestry is defined as the practical application of scientific, economic and social principles used in the establishment and management of forests. The Forestry Corporation of NSW is the largest manager of commercial native and plantation forests in NSW with more than two million hectares under management. These plantation forests have been planted with specific varieties of trees for the purpose of timber production and make up approximately 250,000 ha within the state forest estate. Softwood plantations comprise about 85% of this area with radiata pine being the dominant species in the cooler parts of the state, and minor species and hybrids grown in the northern regions. All of these varieties follow the forest life cycle from establishment to harvesting and re-establishment within each rotation. The Corporation is committed to ensuring the supply of timber from NSW state forests today and into the future, while also protecting other forest values such as biodiversity, clean air and water, and public access for recreation. These competing interests present several challenges for forest planners, harvesting supervisors, haulage schedulers and fire protection managers. Spatial information is used on a daily basis within the forest management process and assists with providing answers to key forest management questions. Several of these solutions include the use of Global Navigation Satellite System (GNSS) tracking to monitor monthly harvesting operations and the use of slope class analysis to determine the safe working limits for harvesting machine types. This paper will outline several of the spatially related solutions being used by the Corporation within the forest life cycle as applicable to softwood plantations in NSW.*

**KEYWORDS:** *Forestry, plantations, GIS.*

## 1 INTRODUCTION

The Forestry Corporation of NSW (the corporation) manages more than two million hectares of native and plantation forests for the economic, environmental and social benefit of the people of New South Wales. Its purpose is to (1) ensure the immediate and ongoing production of timber today and into the future, (2) protect other forest values such as biodiversity, clean air and water, and (3) provide public access for recreation (Forestry Corporation, 2015).

Competing interests are dealt with on a daily basis through the corporation's role as not only a timber producer but also a land manager. This paper provides an overview of the corporation's softwood timber production activities, summarises the forest life cycle as applicable to those activities, and outlines several of the methods used which enable the corporation to meet its purpose.

## 2 SOFTWOOD TIMBER PRODUCTION

Plantation forests are those areas that have been planted with specific varieties of trees for the purpose of timber production. Radiata pine forms the basis of the corporation's plantations on the tablelands and in the southern areas of NSW with hybrids that are more suited to a warmer climate being used in the northern forests around Grafton (Figure 1). The softwood plantation estate totals just over 200,000 ha with approximately 3% being harvested and re-established annually, producing 3.2 million tonnes of logs.

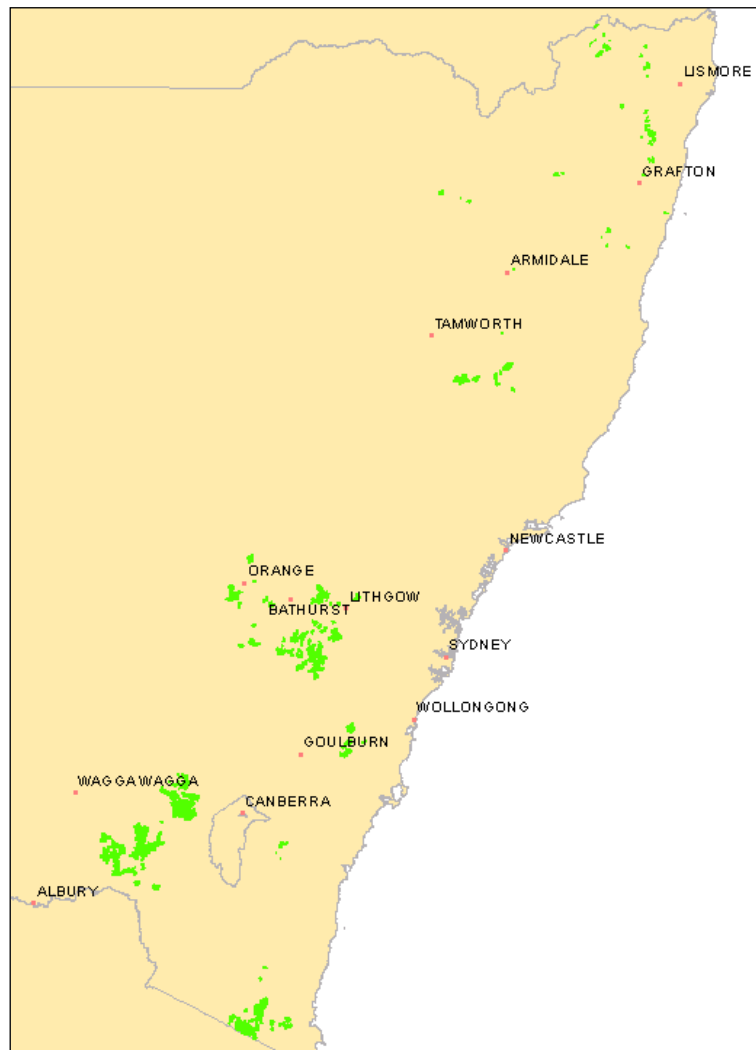


Figure 1: Forestry Corporation softwood plantations.

## 3 FOREST LIFE CYCLE

Each planted rotation follows a generally predetermined process known as the forest life cycle (Figure 2) and takes approximately 30 years to complete. This section provides an overview of the relevant processes in the forest life cycle.

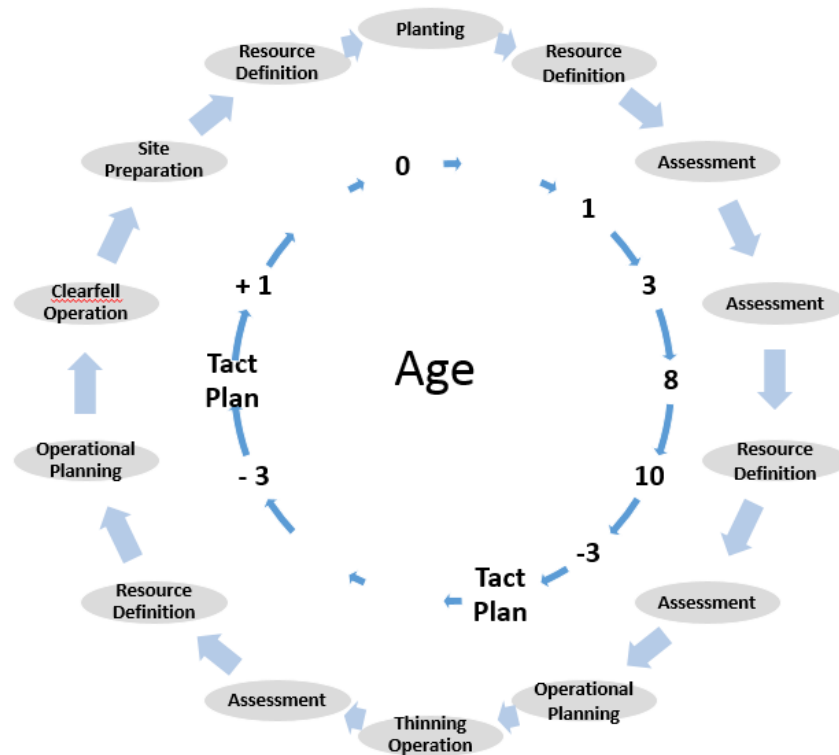


Figure 2: Forest life cycle.

### 3.1 Age 0: Planting

The young seedlings arrive at the forest ready for planting after being grown at the nursery for approximately 8 months. Seedlings are organised into trays according to the nursery location, seed type and overall genetics. These details are recorded against the areas established and form the basis of the historical records for the life of the crop. Additional records will be added over time with each significant event being recorded within the forest management system.

The seedlings are planted in rows (Figure 3) according to the establishment plan – this takes place in the coolest quarter of the year, when the seedlings are dormant and the ground is moist. Fertiliser is applied, giving the seedlings a growth boost in order to counter competing vegetation. In the 2014 planting season, the corporation planted almost 9.3 million seedlings across NSW.



Figure 3: Planting operations.

### 3.2 Resource Definition

Defining the spatial extent of the crop initially occurs at the conclusion of planting. The redefinition process occurs several times throughout the life of the crop:

1. At age 8, prior to age 10 assessments and inclusion in the tactical plan.
2. At the conclusion of thinning operations.
3. At age 20, prior to age 23 assessments and inclusion in the tactical plan for clearfell.
4. During the operational planning stage.
5. At the conclusion of site preparation activities, which define the available planting area.

A combination of GPS and remotely sensed data (Figures 4 & 5) is used during this process with the desired accuracy for the outside perimeter being  $\pm 4$  m. Light Detection and Ranging (LiDAR) data has also been found to be particularly useful in the re-mapping of roads and drainage lines.



Figure 4: Resource boundaries prior to redefinition.

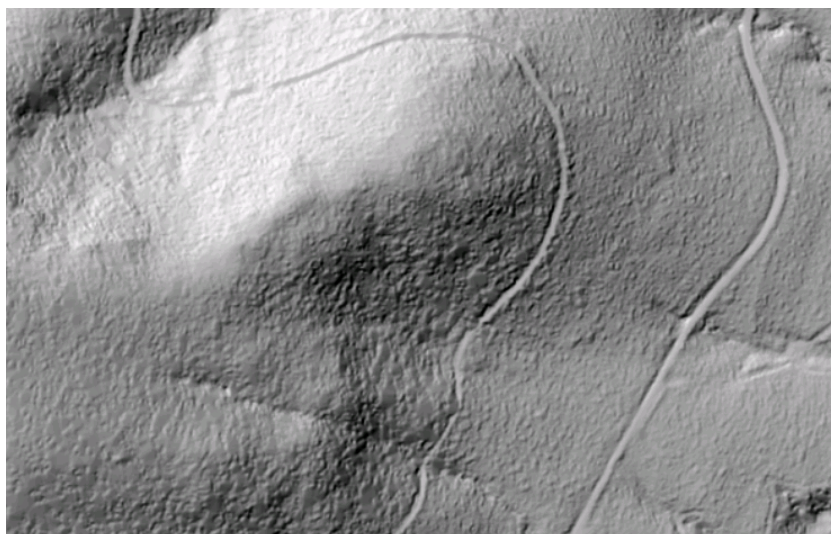


Figure 5: LiDAR-generated Digital Terrain Model (DTM).



Trials have begun in the Canobolas State Forest using LiDAR data to generate areas of ‘difficult movement’, i.e. thick vegetation between 0.5 and 1.5 m in height (Figure 6). These areas are being assessed for weed infestation (e.g. blackberry and wattle) and will be classified as not suitable for re-establishment until the weeds are appropriately treated.



Figure 6: LiDAR-generated difficult movement areas.

The corporation has been developing an iDevice application for use by staff for mobile data collection. Modules specifically designed for use during fire fighting and for the collection of biological data by ecologists allow for nightly downloads whenever in mobile phone range. This data is integrated with the corporate and regional datasets once verified.

### 3.3 Assessments

Assessments are undertaken at various stages within the life of the crop (Table 1) with the initial assessment used to measure seedling and planting quality, and to estimate seedling survival. Future assessments are used to assess the crop for product allocation whilst also estimating stocking per hectare and timber volume at maturity. The assessment locations are randomly placed within the stand and provide a valuable indication of the state of the forest.

Table 1: Assessment schedule.

Survival
Age 3
Age 10
Post Harvest – Thinning
Age 23
Pre Harvest – Clearfell
Residue (post Clearfell)

### 3.4 Operational Planning

Prior to harvesting operations taking place, the planning team for the region undertakes an operational planning process in order to ensure that the operation is completed sustainably and economically. The factors considered during this phase include:

1. Method of harvesting and number of machines involved/required.
2. Access requirements for harvesting machines.
3. Neighbours.
4. Movement of product to roadside.
5. Roadside storage of timber, i.e. size, design and composition.
6. Movement of product to customer, i.e. state of roads – gravelling, additional drainage, B-double access and permissions, swept path analysis for intersections.

Additional factors will influence the seasonal timing of the operation. These include slope, geology and soil type (moisture retention), and understorey vegetation (weeds) which influence trafficability and time of the year that harvesting machines may be able to safely work on the site. All spatial information related to the operational site and forest location is reviewed during this stage.

### 3.5 Thinning Operation

When the trees are about 14 years old, the stand may be thinned in order to allow the stronger trees more room to grow (Figure 7). The remaining trees get more light, nutrients and water with the harvested trees being used for pulp, which is used in newspapers or as chip for particle board.

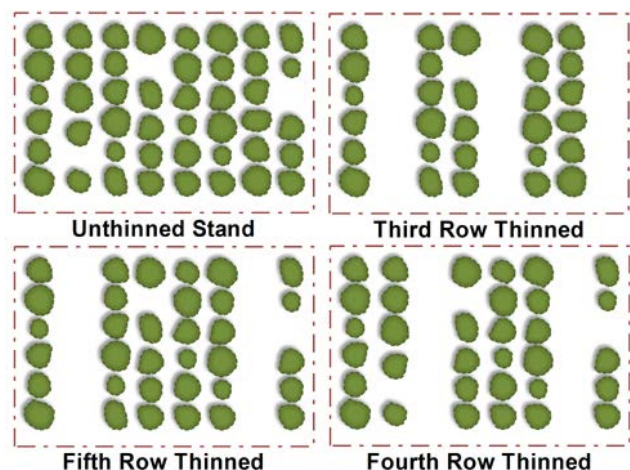


Figure 7: Harvesting options for thinning operations.

At the conclusion of the operation, the affected resource is remapped to define the boundary between the thinned and unthinned stands. This is required to accurately determine the products available at clearfell within the remaining trees.

### 3.6 Clearfell Operation

The tactical planning process (see section 4) identifies the optimum time for harvesting that sustainably meets the product delivery commitments of the corporation. Harvesting the site during a clearfell operation involves more than just cutting down the trees. Each log is cut up according to a schedule depending on the customer's requirements, e.g. 480 t @ 6.1 m long, 120 t @ 4.2 m long. Where fitted, the harvesting operation can be followed using the GPS track, which records the cuts made by the harvester (Figure 8).



Figure 8: GPS-recorded harvesting cuts with remaining patch.

The logs are moved to the roadside and placed in stacks (Figure 9) according to delivery point and product configuration. At the conclusion of the clearfell operation, the remaining resource is remapped to assist in determining the available plantable area that will undertake site preparation activities.



Figure 9: Logs at the roadside.

### 3.7 Site Preparation

At the conclusion of the clearfell operation, the area is assessed for its re-establishment suitability with a program of works being undertaken depending on topography, proximity to major drainage lines and sensitive vegetation, soil type, previous rotations, and overall forest health. These factors will influence the design of the planting programs and planned stocking rates. An area with a planned stocking of 900 seedlings per hectare will be prepared differently, possibly due to its steep topography, compared to a flatter area with a planned stocking of 1,100 seedlings per hectare. During this stage the corporation's nurseries are also growing the seedlings, which are sown in early September in preparation for next year's planting season.

Herbicide is applied to reduce competition with additional planning being undertaken to take future access and fire protection requirements into account. GPS tracks are recorded for all operations in site preparation to assist in the determination of the plantable area and the total number of seedlings required from the nursery.



## 4 TACTICAL PLANNING

Each of the corporation's customers requires different products depending on their section of the forest product industry. These products (Figure 10) come from different sections of the tree, which can be categorised into three main parts:

1. Log suitable for sawn products (Figure 11).
2. Log suitable for pulp.
3. Biomass waste.

A tactical plan is created using the Woodstock modelling software, which predicts the sustainable cutting strategy for the next 70 years.

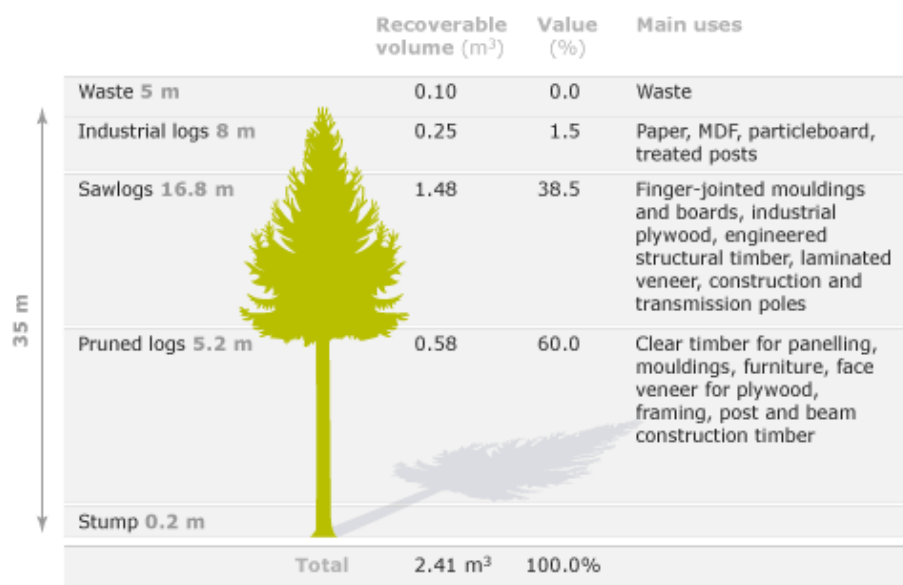


Figure 10: Potential products at clearfell.



Figure 11: Potential sawlog products.

The tactical plan (Figure 12) relies on accurate yield predictions, which in turn rely on accurate areas, accurate growth models and yield tables, and accurate stocking.

Additional factors influencing the plan include:

1. Redefinition activities, e.g. remapping and assessments.
2. Proximity to other harvesting operations.
3. Delays due to wet weather.



4. Resource becoming unavailable, e.g. fire.
5. Customer's required product ratios.
6. Timing of re-establishment.

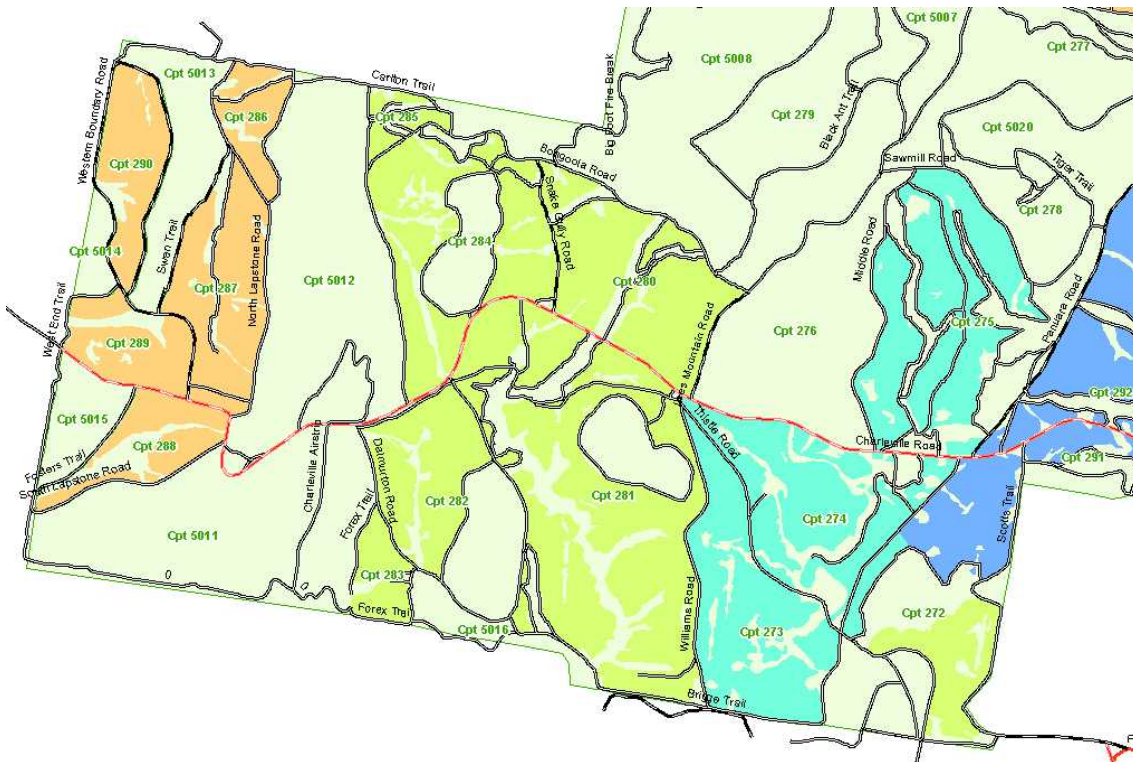


Figure 12: Typical tactical plan breakdown by year.

## 5 LAND MANAGEMENT

As a land manager, the corporation is mindful of its ongoing responsibilities and regularly liaises with stakeholders to address land management issues as they arise. A selection of the current issues is listed in Table 2. The regional stewardship team also monitors the current and future operational needs of the organisation and produces a series of entry restrictions and exclusion maps for the safety of the general public.

Table 2: Land management issues.

<b>Pest Management</b> <ul style="list-style-type: none"> <li>• Weed spraying</li> <li>• Baiting programs</li> </ul>	<b>Monitoring</b> <ul style="list-style-type: none"> <li>• Illegal dumping</li> <li>• Water quality</li> </ul>	<b>Neighbours</b> <ul style="list-style-type: none"> <li>• Noise</li> <li>• Road access</li> <li>• Fencing</li> <li>• Encroachments</li> </ul>
<b>Public Access</b> <ul style="list-style-type: none"> <li>• 4WD</li> <li>• Motorbike</li> <li>• Bushwalking</li> <li>• Bird watching</li> <li>• Mushroom picking</li> </ul>	<b>Organised Events</b> <ul style="list-style-type: none"> <li>• Orienteering</li> <li>• Car rally</li> </ul>	<b>Permits</b> <ul style="list-style-type: none"> <li>• Firewood collection</li> <li>• Fossicking</li> <li>• Grazing</li> <li>• Bees</li> <li>• Mining</li> </ul>
<b>Fires</b> <ul style="list-style-type: none"> <li>• Hazard reduction</li> </ul>	<b>Fauna</b> <ul style="list-style-type: none"> <li>• Endangered</li> </ul>	<b>Flora</b> <ul style="list-style-type: none"> <li>• EECs</li> </ul>

## 6 SELECTED SPATIAL SOLUTIONS

### 6.1 Wood Movement

One of the questions regularly asked of the Geographical Information System (GIS) team relates to predicting the movement of wood around the state depending on the changing needs of our customers. For example, how many tonnes of wood are moved over a particular section of road over the 6 years of the tactical plan? Whilst the answer is not a spatial one, it requires spatial solutions to enable its answer.

This particular problem was tackled using a multi-step process. In summary:

1. The tactical plan defined the areas to be harvested using both thinning and clearfell operations. Yield information was assigned to loading bays by customer and harvest year.
2. Roads were assessed according to their suitability for haulage:
  - a. Surface
  - b. Lanes
  - c. Grade / visibility limitations
  - d. B-double permissions – RMS, NHVR
    - i. General access
    - ii. 19 m B-doubles operating at full axle loads
    - iii. 23 m B-doubles
    - iv. 25/26 m B-doubles
3. The roads were assigned to a transport network in ArcMap.
4. The customer destinations were allocated to also calculate lead distances for haulage costs.
5. Models were created in ArcMap, generating the routes using the Network Analyst extension which also assigned the yields to the route.
6. A new feature class (Figure 13) was created using a model that summed the yields over each line segment of the network.

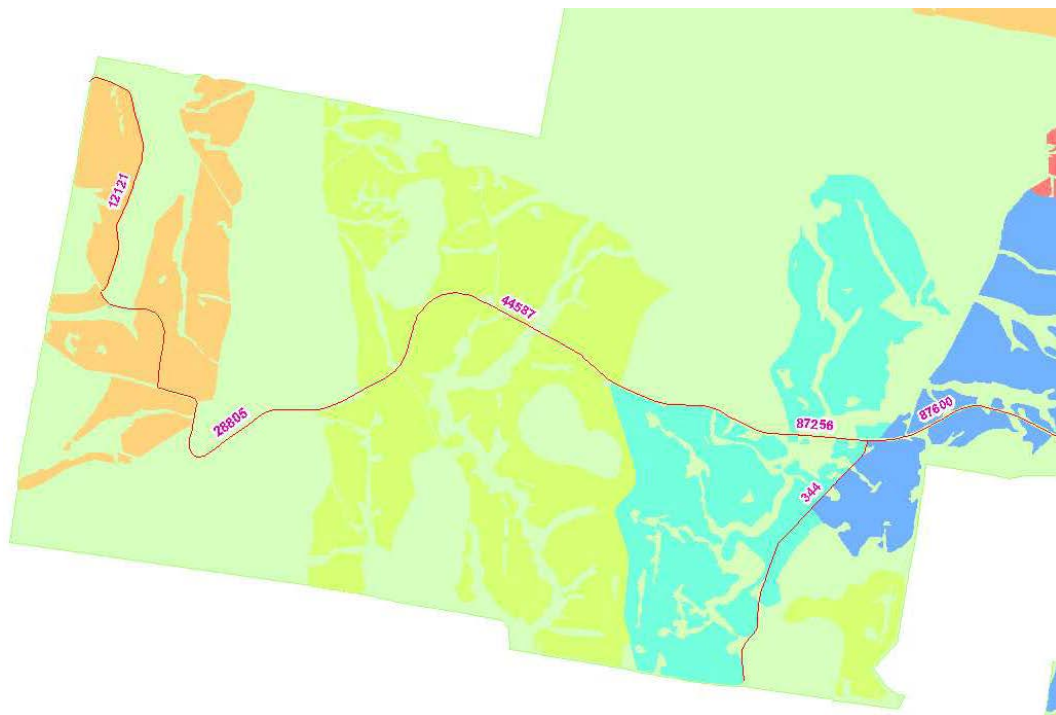


Figure 13: Tactical plan with predictive volume analysis for period F15-F20.

## **6.2 Site Safety**

Softwood forests are usually sighted in areas that are often described as mostly undulating and sometimes steep. The safe working limits of harvesting machines are a determining factor in deciding on appropriate machine type and use within a harvesting site. LiDAR-generated slope information is used to determine the percentage of area within certain slope classes for each product type. These slope classes are also used to determine contractor payments as different rates are applicable depending on the machines used and the slope of the plantation area.

## **7 CONCLUDING REMARKS**

The Forestry Corporation of NSW is responsible for the sustainable production of timber within its plantation forests as well as protecting forest values and providing access for the public. This paper has summarised the forest life cycle in relation to the corporation's operations whilst also outlining the current land management issues and spatial solutions being used to provide solutions on a regular basis.

## **REFERENCES**

Forestry Corporation (2015) Forestry Corporation, <http://www.forestrycorporation.com.au/> (accessed Jan 2015).