Climate Change Mitigation Policy: The Effect of the New Zealand Emissions Trading Scheme on New Radiata Pine Forest Plantations in New Zealand

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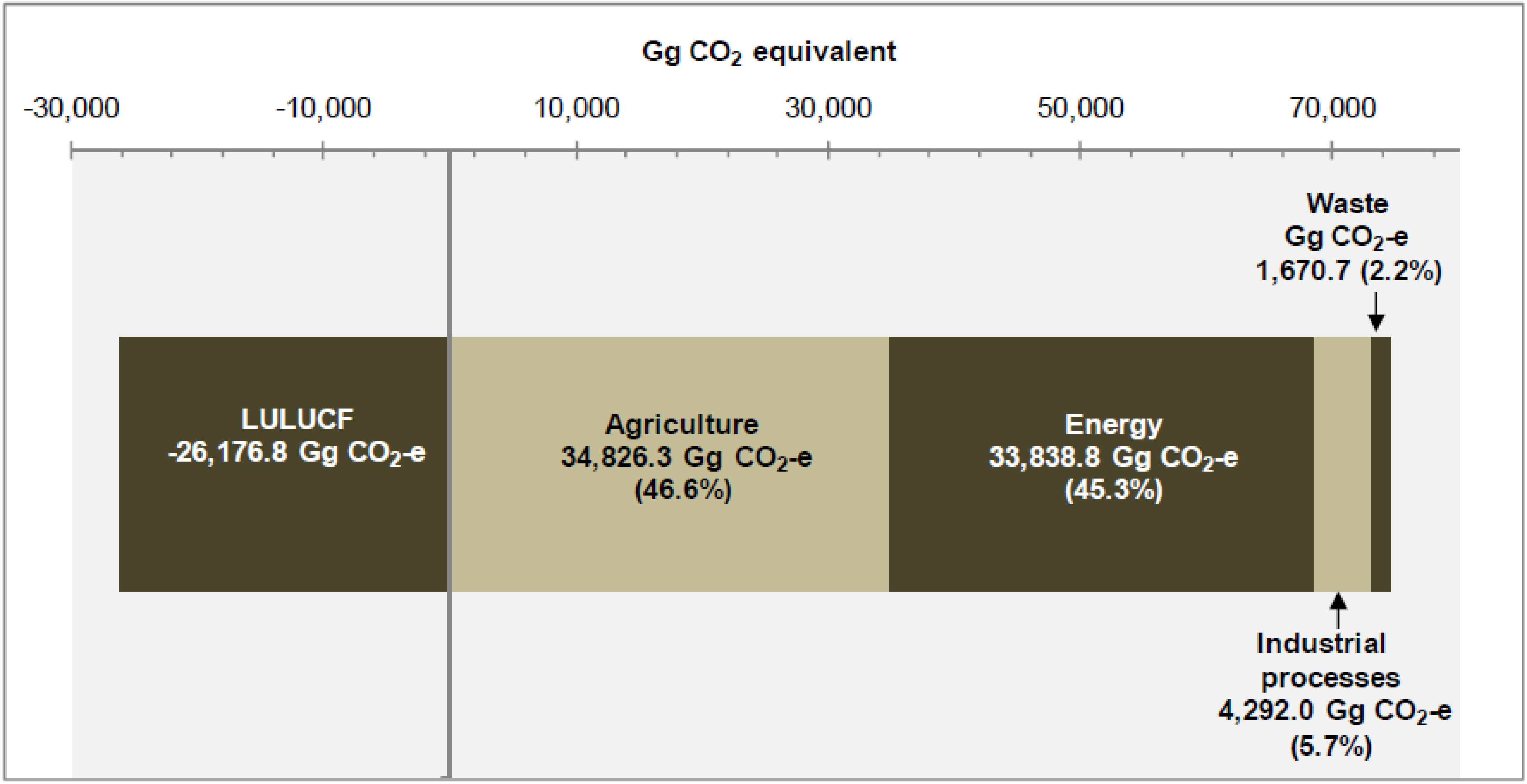
New Zealand's Greenhouse Gas (GHG) Emissions



New Zealand Emissions Trading Scheme (NZETS)

- New forests planted on and after 1st Jan 1990
- Earn carbon credits for incremental carbon stock increases, starting 1st Jan 2008
- Harvest liabilities
- New cash flow alters traditional timber-only forestry business model

Forestry Valuation Methods

Fixed Rotation

- Pre-determining harvest age at planting
- NPV/LEV model (Faustmann)

Flexible Rotation

- Determined by timber price at harvest age
- Real Options model
  - Partial Differential Equations
  - Simulations
  - Binomial Trees (Binomial Option Pricing Model)

Why Real Options?

Faustmann method ignores annual price fluctuations and prescribes harvest at fixed age

Given uncertainties in prices, a better approach is to remain flexible on the harvest age

If timber prices are low at "expected" harvest age, foresters may want to delay harvest until the price is high

If timber prices are unusually high before "expected" time of harvest, foresters may want to harvest earlier

The Real Options approach offers such flexibility.

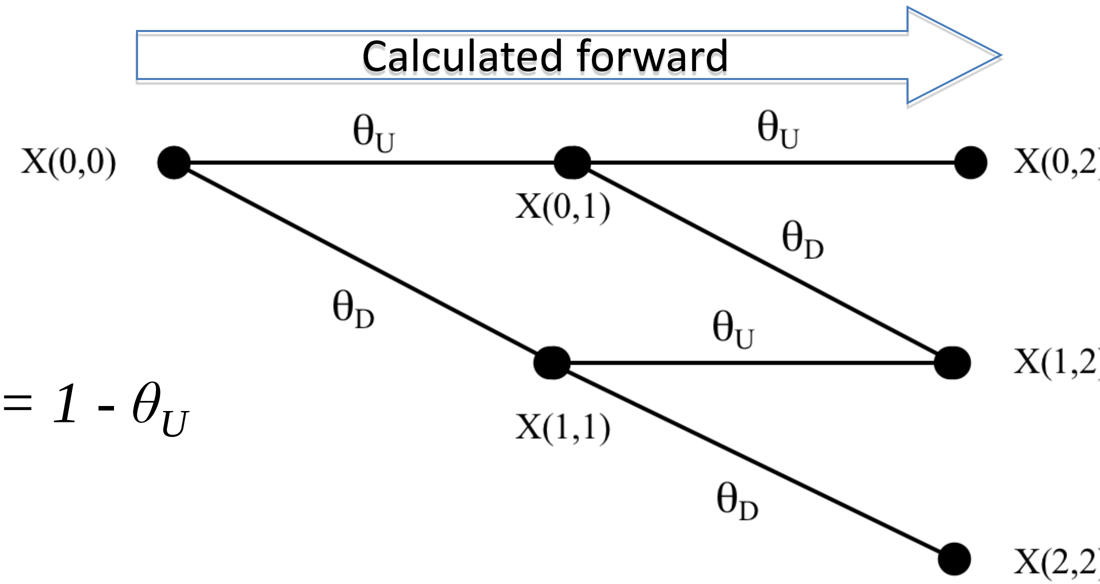
Recent Forestry Valuation Works in New Zealand

<table>
<tr><th colspan="2"></th><th colspan="2">Timber-only forestry (i.e. no carbon price)</th><th colspan="2">Timber and carbon forestry (NZETS)</th></tr>
<tr><td rowspan="3">Three approaches to Real Options</td><td>Simulations
powerful, offers little insights on relationships between variables</td><td></td><td rowspan="2"></td><td colspan="2">Meade, Fiuza & Lu (2008)</td></tr>
<tr><td>Partial Differential Equations
continuous time, mathematically elegant, complex</td><td rowspan="2">Manley & Niquidet (2010)</td><td colspan="2">Guthrie & Kumareswaran (2009)</td></tr>
<tr><td>Binomial Tree
discrete time, efficient, simple algebraic equations</td><td rowspan="2">Tee, Scarpa, Marsh & Guthrie (2010)</td><td></td><td rowspan="2">Tee, Scarpa, Marsh & Guthrie (2011)</td></tr>
<tr><td colspan="2">NPV/LEV (Faustmann)</td><td></td><td>Turner et al (2008)</td></tr>
</table>

Price Binomial Tree

U = *Size of Up move*
D = *Size of Down move = 1/U*

θ_U = *Probability of Up move*
θ_D = *Probability of Down move = 1 -* θ_U



Labelling convention:

$$X(i,n+1) = X(i,n)U$$

$$X(i+1,n+1) = X(i,n)D$$

Multiplicative properties:

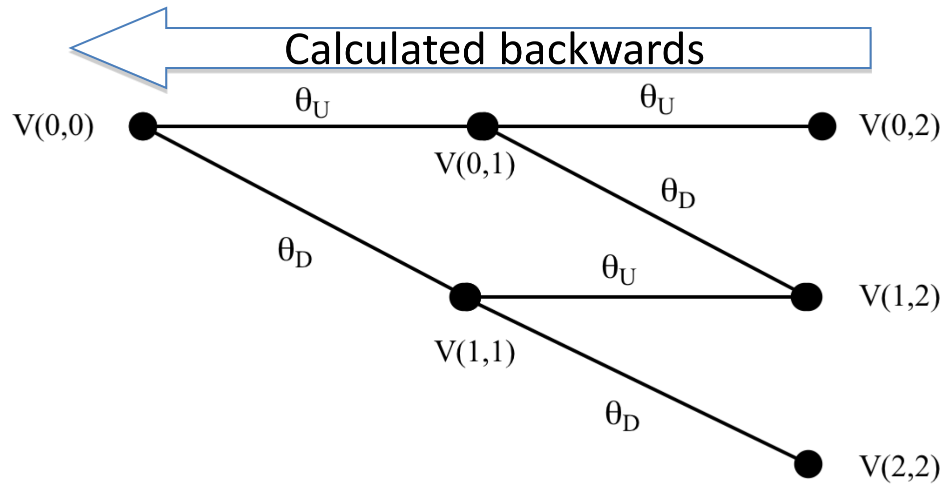
$$X(0,0) * U * D = X(0,0) * D * U = X(0,1) * D = X(1,1) * U = X(1,2)$$

Estimating U and θ_U using OLS regression

$$U = e^{\hat{\sigma}\sqrt{\Delta t_m}}$$

$$\theta_u(i,n) = \begin{cases} 0 & if\ \frac{1}{2} + \frac{(1-e^{-\hat{a}\Delta t_m})(\hat{b} - \log(X(i,n))}{2\hat{\sigma}\sqrt{\Delta t_m}} \leq 0 \\ \frac{1}{2} + \frac{(1-e^{-\hat{a}\Delta t_m})(\hat{b} - \log(X(i,n))}{2\hat{\sigma}\sqrt{\Delta t_m}} & if\ 0 < \frac{1}{2} + \frac{(1-e^{-\hat{a}\Delta t_m})(\hat{b} - \log(X(i,n))}{2\hat{\sigma}\sqrt{\Delta t_m}} < 1 \\ 1 & if\ \frac{1}{2} + \frac{(1-e^{-\hat{a}\Delta t_m})(\hat{b} - \log(X(i,n))}{2\hat{\sigma}\sqrt{\Delta t_m}} \geq 1 \end{cases}$$

Valuation Binomial Tree



Valuation is calculated backwards from terminal nodes V(i,N) to V(0,0):

$$V(0{,}1) = \frac{\theta_U V(0{,}2)}{R_f} + \frac{\theta_D V(1{,}2)}{R_f} \quad \textit{where } R_f = (1 + \textit{discount rate})$$

Harvest valuation function at terminal node N:

$$V(i,n) = \max \left\{ \begin{array}{l} (1-T)\left([X_T(i,n) - H_T]Q_T(n) - X_C Q_C(n-1) - M_C\right) + B, \\ (1-T)\left(-M_T - M_C + X_C[Q_C(n) - Q_C(n-1)]\right) + \dfrac{\Pi_u(i,n)V(i,n+1) + \Pi_D(i,n)V(i+1,n+1)}{R_f} \end{array} \right\}$$

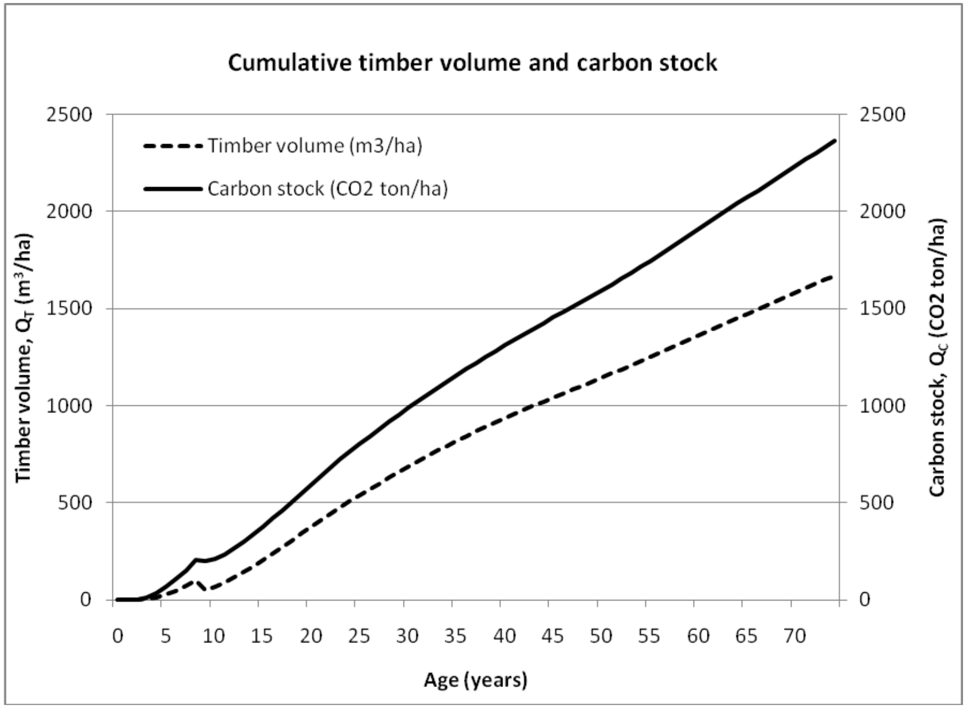
where X_T *= timber price,* X_C *= carbon price,* H_T *= harvesting cost,* Q_T *= timber volume,* Q_C *= carbon stock, B = bareland value,* M_T *= forest maintenance costs,* M_C *= ETS compliance costs, T = Tax rate*

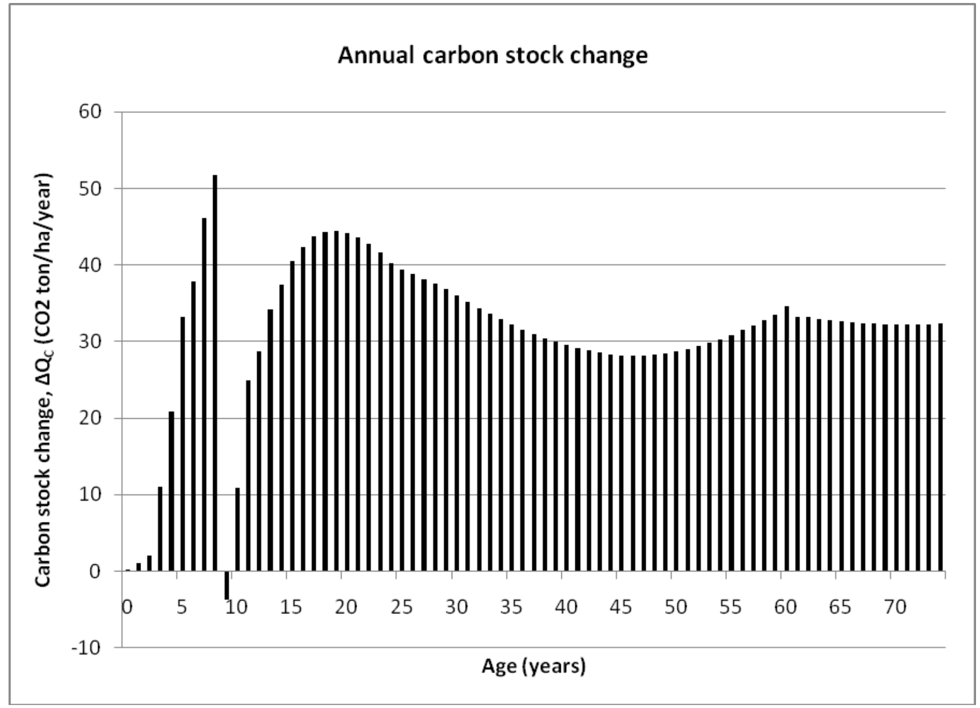
Timber Price and Forest Management Costs

The forest management costs are assumed to be:

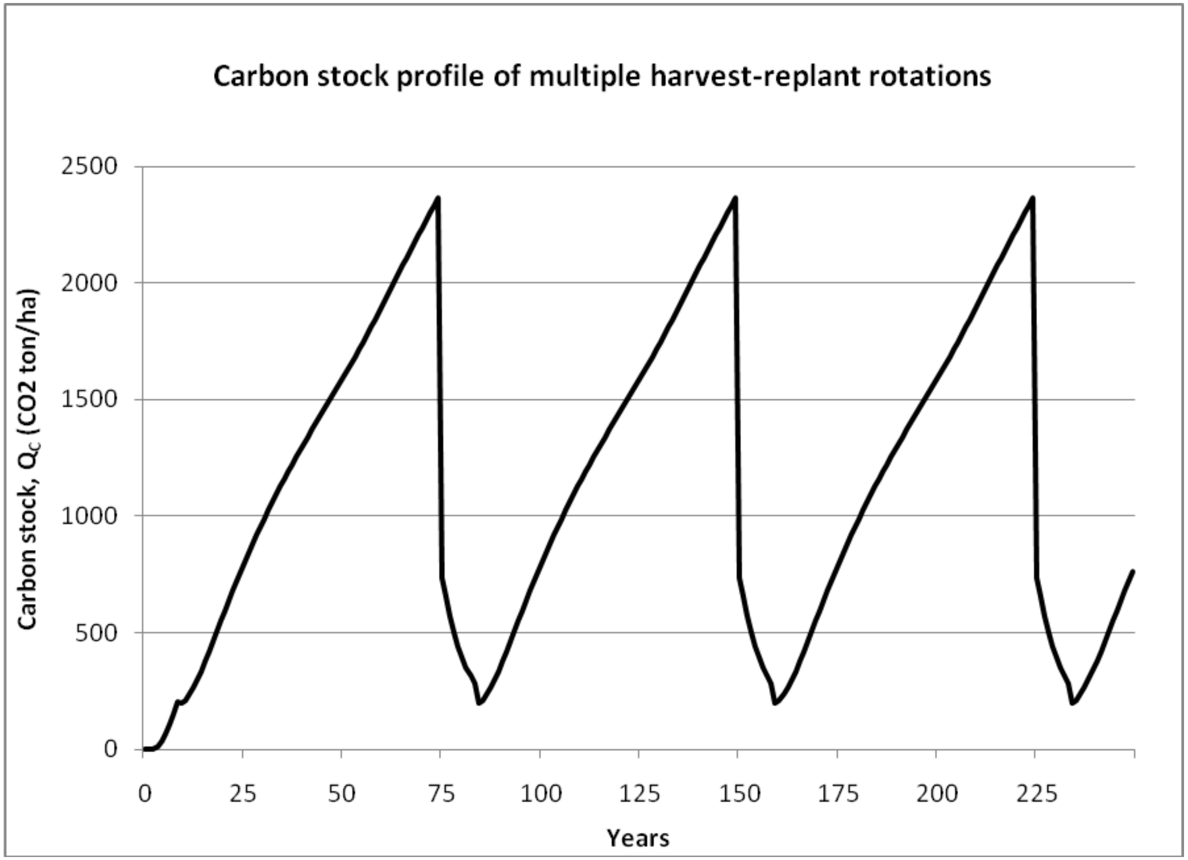
Planting costs, G	= $1,251/ha
Pruning costs	= $473/ha (age 6), $674/ha (age 7), $684/ha (age 8)
Thinning costs	= $370/ha (age 9)
Forest maintenance cost, M_T	= $50/ha
ETS compliance cost, M_C	= $60/ha/year
Harvesting cost (clearfell logging), H_T	= $40/m^3

Timber Volume and Carbon Stock

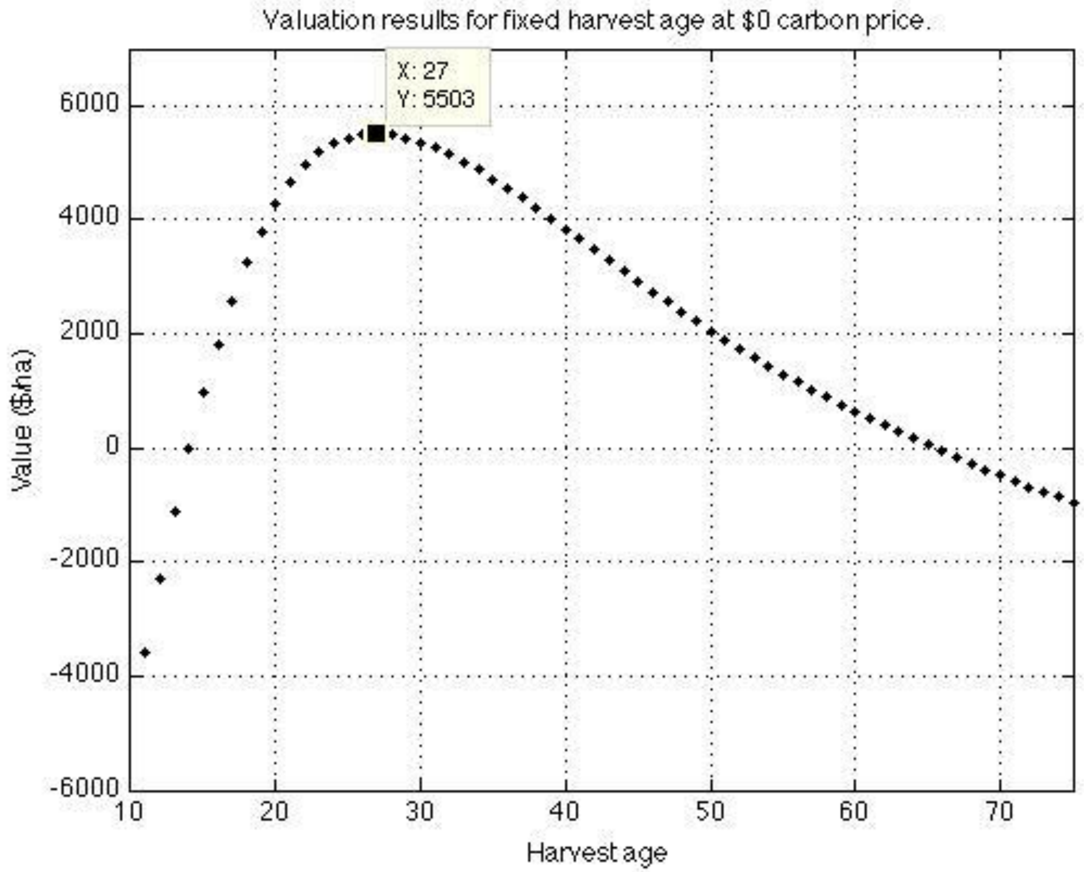




Carbon Stock Profile of Multiple Harvest-Replant

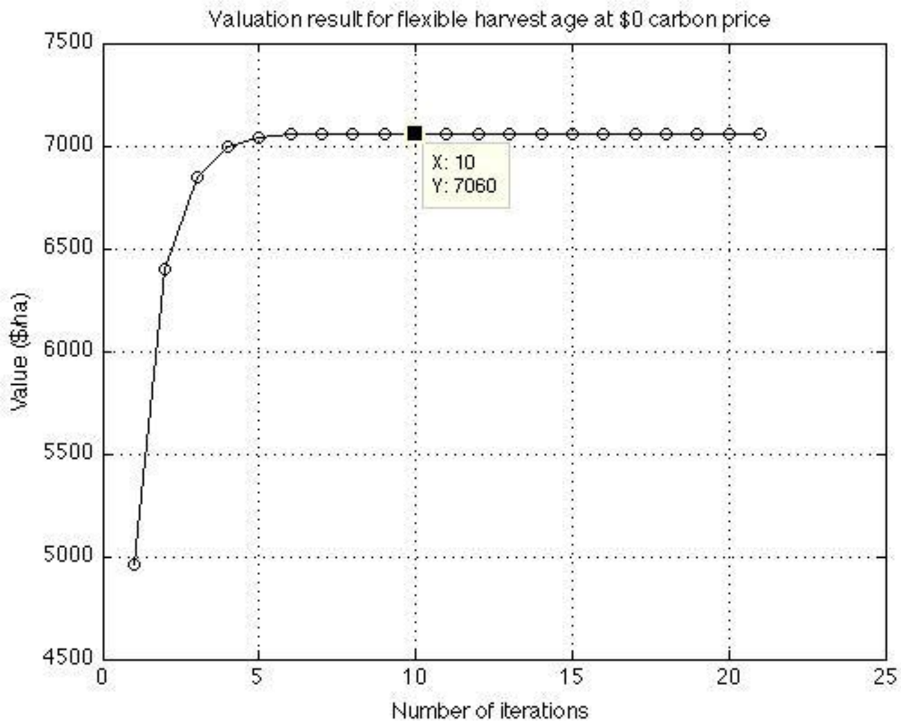


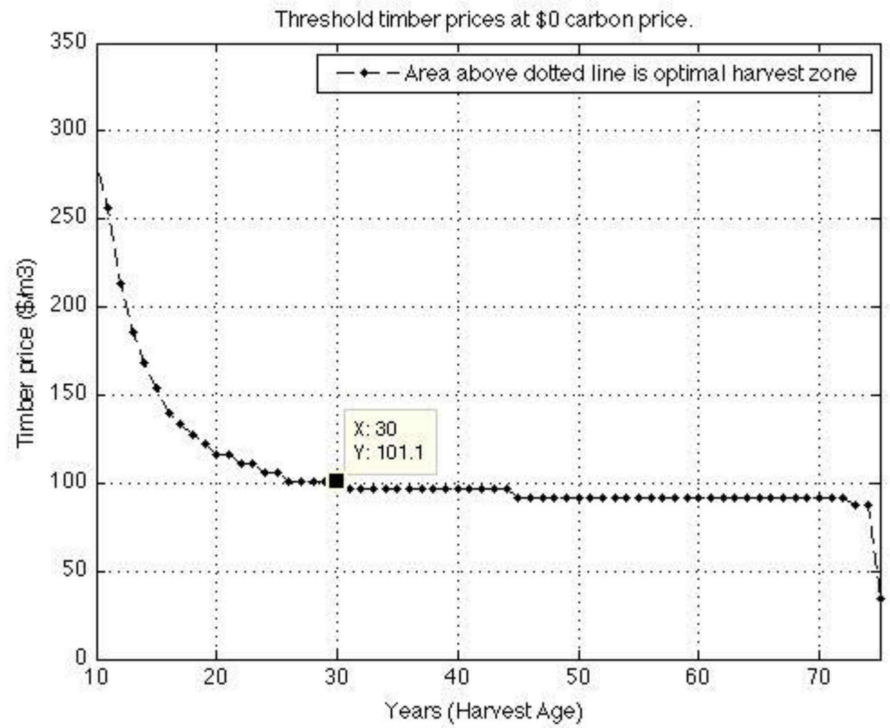
Results: LEV, Timber-only Forestry ($0 carbon price)



LEV valuation = $5,503 at 27 year rotation age

Results: Real Options, Timber-only Forestry ($0 carbon)





Real Options valuation = $7,060

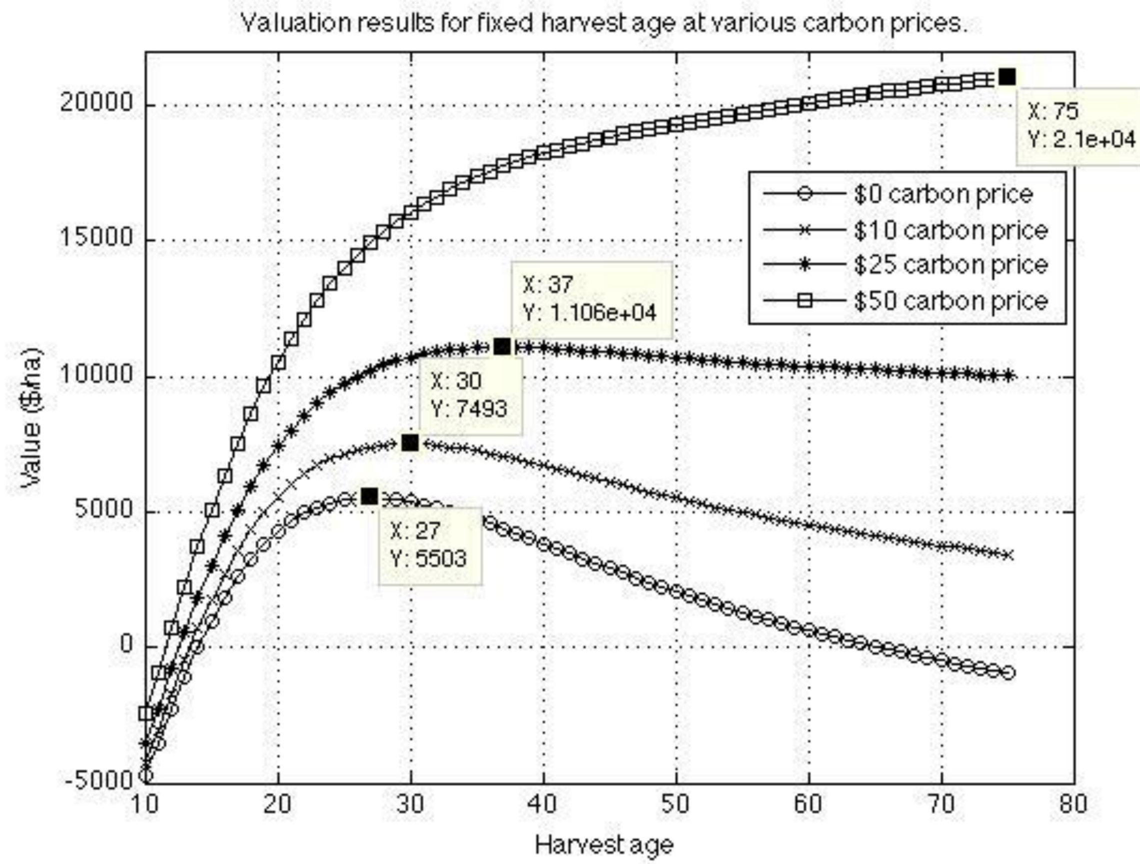
Price thresholds for optimal flexible harvesting

Results: LEV, Carbon Forestry (NZETS) at various carbon prices

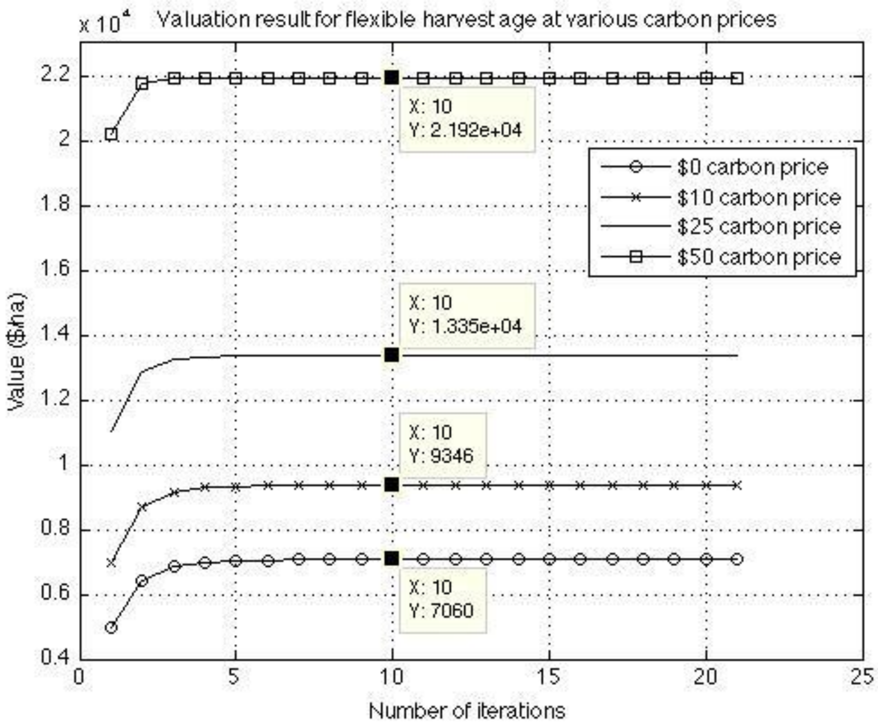
LEV for $10 carbon price = $7,493@30 years

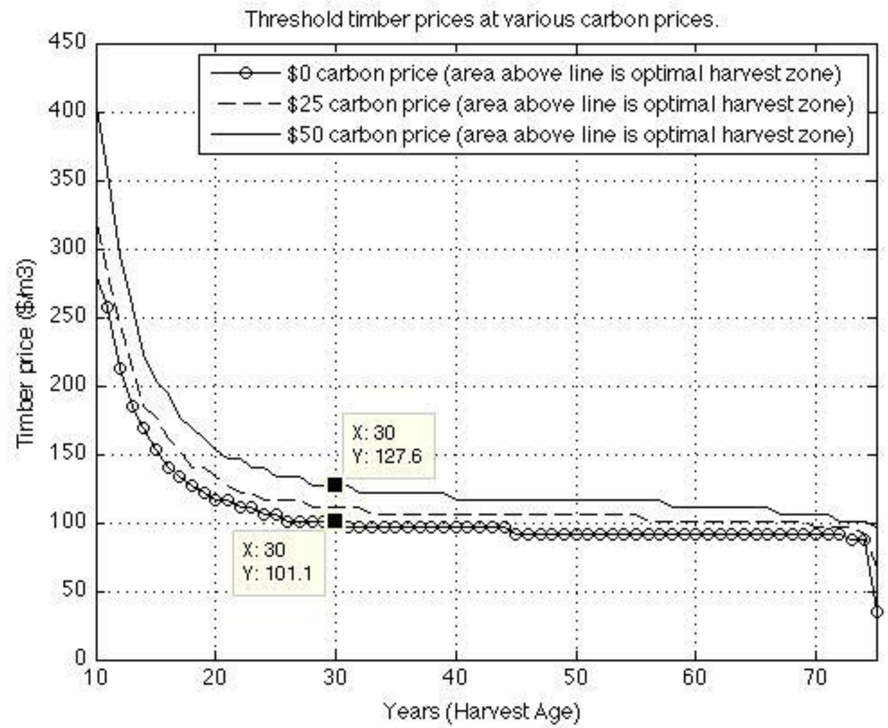
LEV for $25 carbon price = $11,060@37 years

LEV for $50 carbon price = $21,000@75 years



Results: Real Options, Carbon Forestry at various carbon prices





RO for $10 carbon = $ 9,346
RO for $25 carbon = $13,350
RO for $50 carbon = $21,920

Price thresholds for optimal flexible harvesting

Conclusions

- NZETS provides a strong economic incentive to foresters to plant new forests, providing a significantly higher return compared to traditional timber forestry.

- As carbon prices increase over time, it will contribute positively towards climate change mitigation in New Zealand.

- Due to the long investment cycle, it is crucial for the NZ government to provide policy certainty in order to encourage carbon forestry investments. This can be provided by ensuring that the NZETS remains in place for the foreseeable decades ahead.