Forests Multiple Use Management

Renato Rosa, FEEM

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1. Literature

Hartman, R., 1976. The harvesting decision when a standing forest has value. Economic Inquiry 14, 52 -58.

- Exogenous timber prices
- Exogenous land prices
- Static framework

M. Bowes and J. Krutilla,1985, Multiple use management of public forestlands, in ”Handbook of Natural Resource and Energy Economics” (A. Kneese and J. Sweeney, Eds.), Vol. 11, pp. 531-569, Elsevier, New York (1985).

1. Literature

Tahvonen, Olli., 2004, “Timber production versus old-growth preservation with endogenous prices and forest age-classes”, Canadian Journal of Forest Research, 34: 1296-1310.

Calkin, D. E., C. A. Montgomery, N. H. Schumaker, S. Polasky, J. L. Arthur, D. J. Nalle. 2002. Developing a production possibility set of wildlife species persistence and timber harvest value. *Canadian Journal of Forest Research* 32 :1329–1343

Nalle, D., Montgomery, A. C., Arthur, J., Polasky, S., and Schumaker, N. 2004. Modelling joint production of wildlife and timber. Journal of Environmental and Economic Management 48: 997-1017

1.

Literature

Modelling Literature:

- Salo, S. and O. Tahvonen, 2002, “On Equilibrium Cycles and Normal Forests in Optimal Harvesting of Tree Vintages”, *JEEM*
- Salo, S. and O. Tahvonen, 2003, “On the Economics of Forest Vintages”, *JEDC*
- Salo, S. and O. Tahvonen, 2004, “Renewable Resources with Endogenous Age Classes and Allocation of Land”, *Amer. J. Agric. Econ*

2. Contribution

Multiple Species	- Optimal species mix
	- Invasive species
Land Use	- Biodiversity Loss
Age Classes	- Old Growth (…)

2.1.

Biodiversity Literature.

Burton,P.J., A.C. Balisky, L.P. Coward, S.G. Cumming, D. D. Kneeshaw. 1992, ”The value of managing for biodiversity”. The Forest Chronicle.68: 225-237

Hunter, M.L.,Jr. 1990, ”Wildlife, Forests, and Forestry: Principles of Managing Forests for Biodiversity” Prentice-Hall, Inc. Englewood, NJ.

Buongiorno, J.,. Dahir, H. C. Lu, C. R. Lin, 1994, ”Tree size diversity and economic returns in uneven-aged forest stands” , Forest Science, 40: 83-103

Onal, H., 1997, ”Trade-off between Structural Diversity and Economic Objectives in Forest Management”, Amer. J. Agric. Econ. 79, 1001-1012

Forest Structural Diversity – age classes and species distribution

2. Contribution

Analytical proof for the steady state allocation when management is extended to include Forest Structural Diversity

Numerical Simulations – transition dynamic analysis

The Model

Endogenous Variables

Vector X^l_t=[$x^l_{1,t}$; $x^l2_{,t}$; ...$x^l_{n,t}$]
x^l_{st} - the area of forest land allocated to the age class s in period t for species l

where s - trees age class - 1,...,n

yt - the area of land allocated to alternative uses

Biomass Vector - [f^l_1; f^l_2; ...f^l_n]

f^l_s - the biomass content in timber per unit of land with trees of age class s

3.1. The Model

$$v(x^l_{1,0},....x^l_{n,0}) = \underset{\{x^l_{s,t+1},s=1,...n,l=1,...,L,t=0,...\}}{Max} \sum_{t=0}^{\infty} b^t \left[\sum_{l=1}^{L} U^l \left(c^l_t \right) + W \left(y_t \right) \right] \quad (2)$$

subject to

$$c^l_t = \sum_{s=1}^{n-1} f^l_s \left(x^l_{s,t} - x^l_{s+1,t+1} \right) + f^l_n x^l_{n,t},\ l = 1,...,L \quad (3)$$

$$y_t = 1 - \sum_{l=1}^{L} \sum_{s=1}^{n} x^l_{s,t} \quad (4)$$

$$x^l_{s+1,t+1} \leq x^l_{s,t},\ s = 1,.......n-1,\ l = 1,...,L \quad (5)$$

$$\sum_{l=1}^{L} \sum_{s=1}^{n} x^l_{s,t+1} \leq 1 \quad (6)$$

$$\alpha \sum_{l=1}^{L} \sum_{s=1}^{n} x^l_{s,t+1} \leq \sum_{s=1}^{n} x^1_{s,t+1}, \qquad 0 < \alpha < 1 \quad (7)$$

$$x^l_{s,t} \geq 0,\ s = 1,....,n,\ l = 1,...,L \quad (8)$$

4.1 Numerical Simulations

Baseline - The Unconstrained Problem

Species Area

Old Growth

Old Growth and Younger Stands

Numerical Simulations

Salo, S. and O. Tahvonen, 2004, "**Renewable Resources with Endogenous Age Classes and Allocation of Land**", *Amer. J. Agric. Econ*

"When part of the land is allocated to agriculture, forest age-class distribution is smoothed without deviating from Faustmann rotation. After a small age class is harvested, the replanted area can be increased by using part of the existing agricultural land for forestry."

THE UNCONSTRAINED PROBLEM

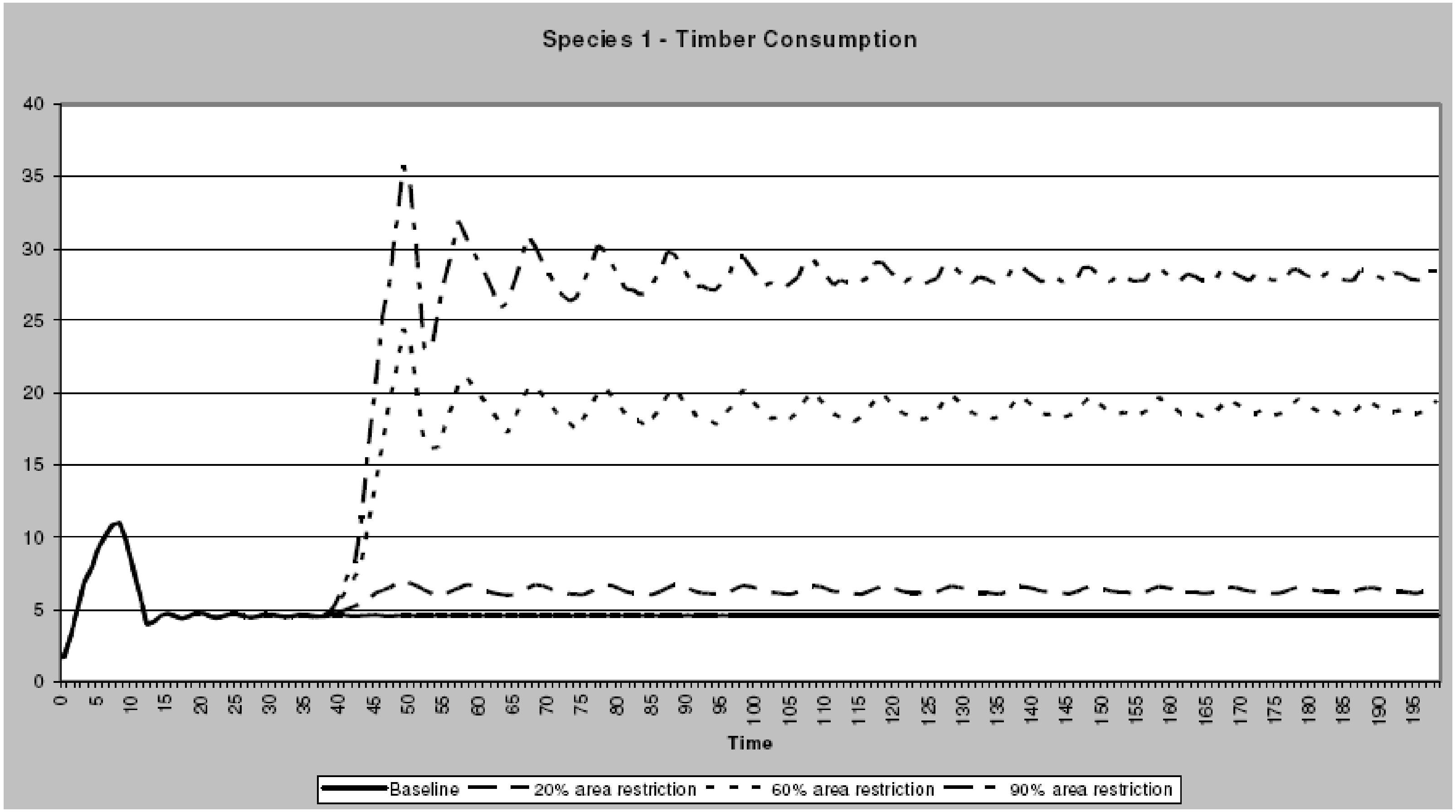
Deviations from Faustmann occur initially.

Adjustments are made through increases/decreases of replanted area.

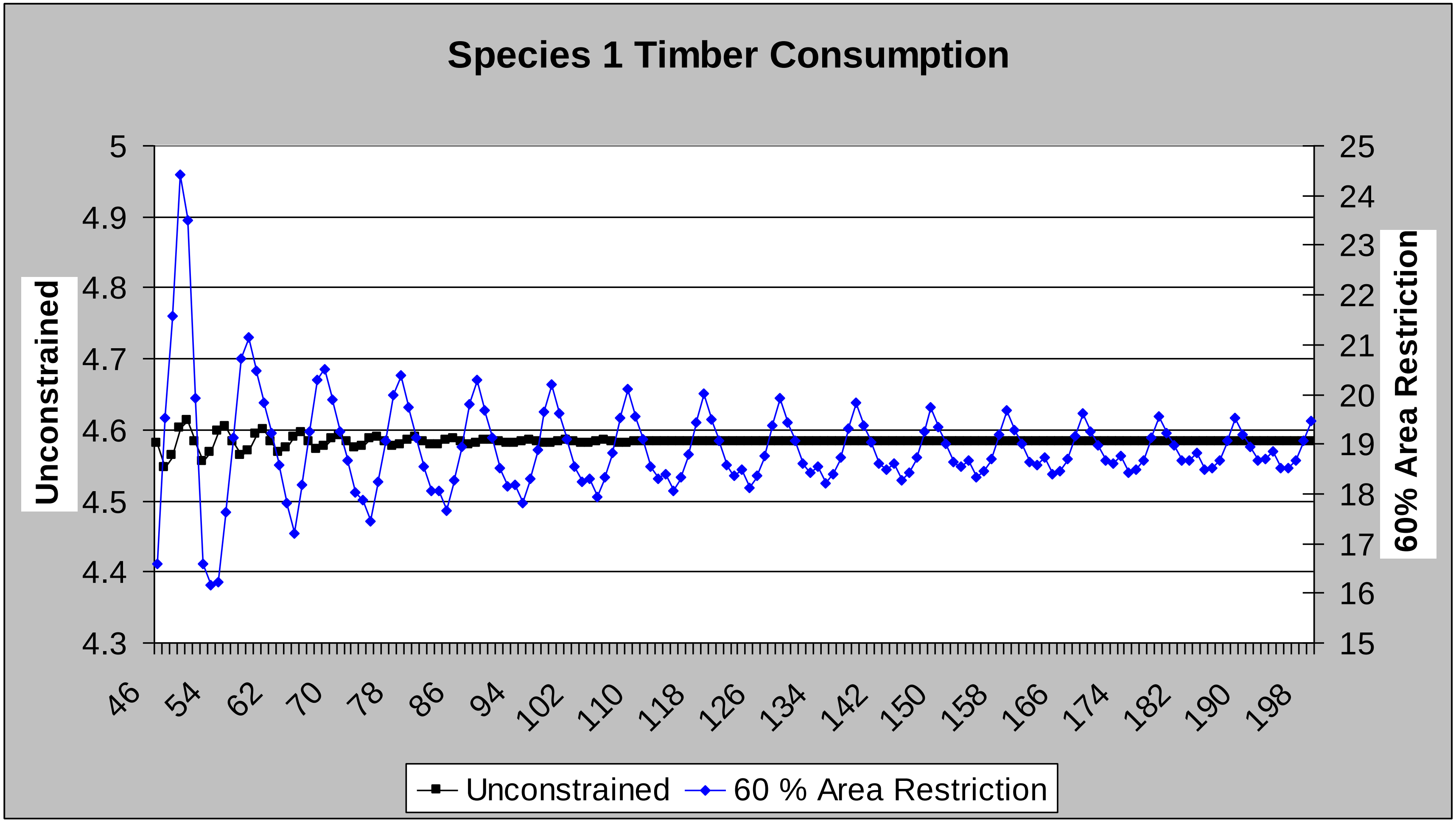
Species Area

$$\alpha \sum_{l=1}^{L} \sum_{s=1}^{n} x_{s,t+1}^{l} \leq \sum_{s=1}^{n} x_{s,t+1}^{1}, \qquad 0 < \alpha < 1$$

4.1 Numerical Simulations – Species Area



4.1 # Numerical Simulations – Species Area



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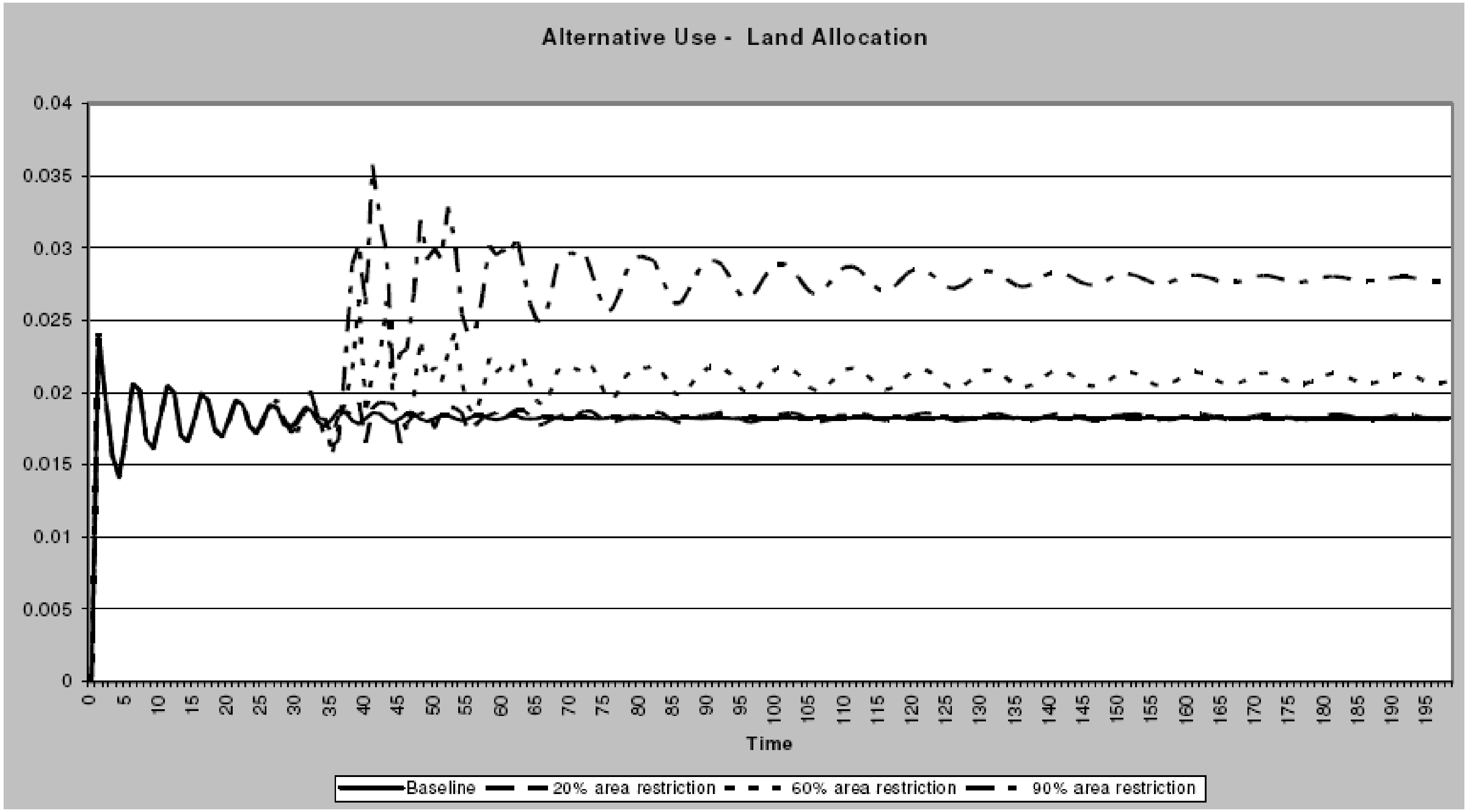

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Numerical Simulations - Species Area

Market Effects

Higher disturbance on timber prices

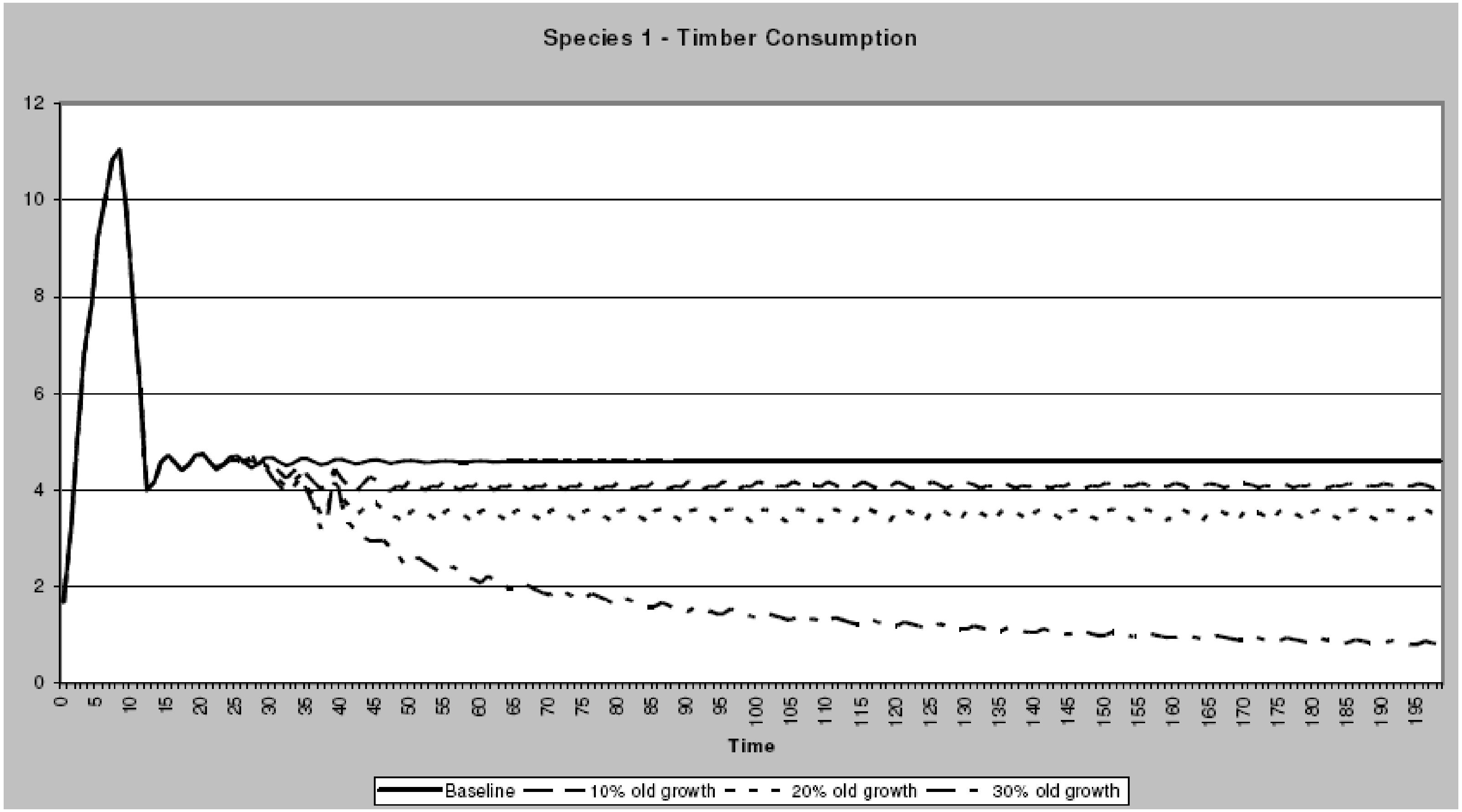
Higher disturbance on land markets.

Numerical Simulations – Old Growth

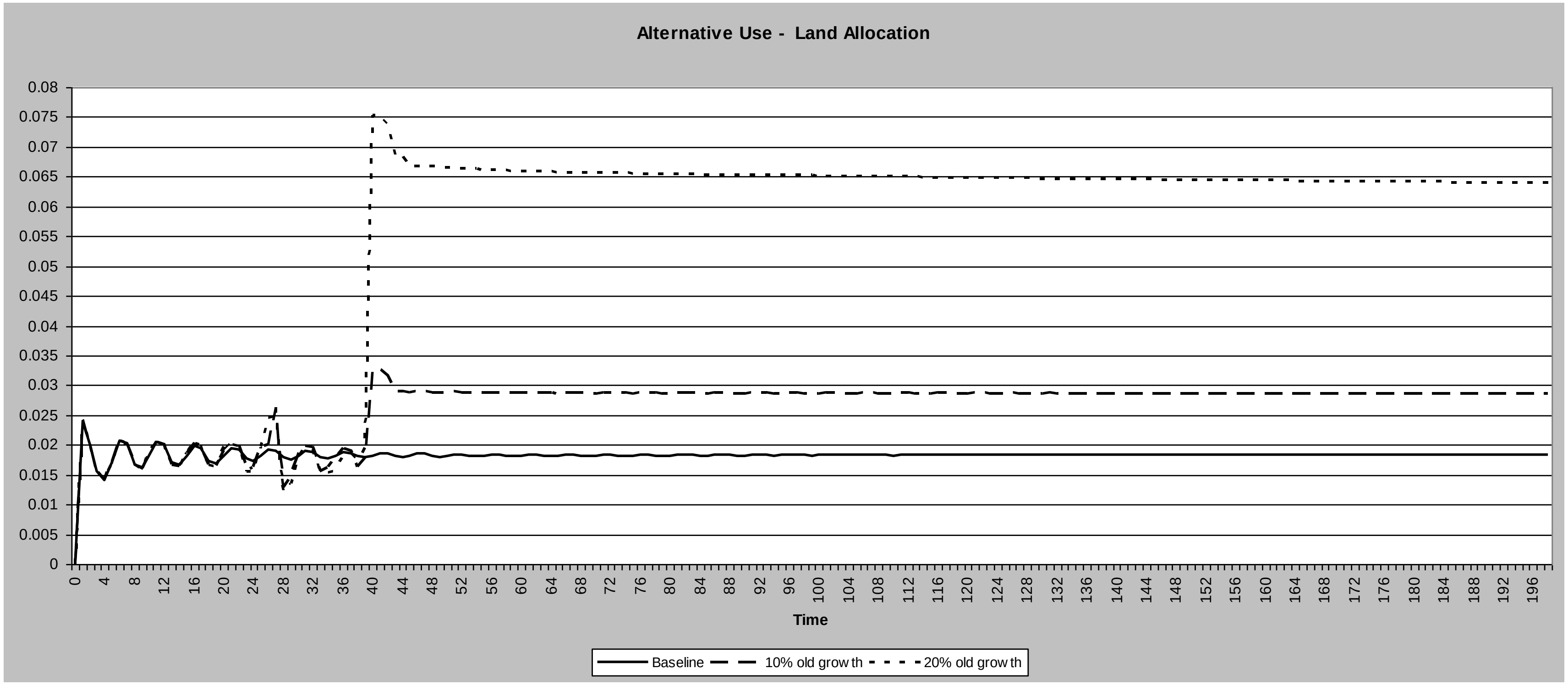
Old Growth

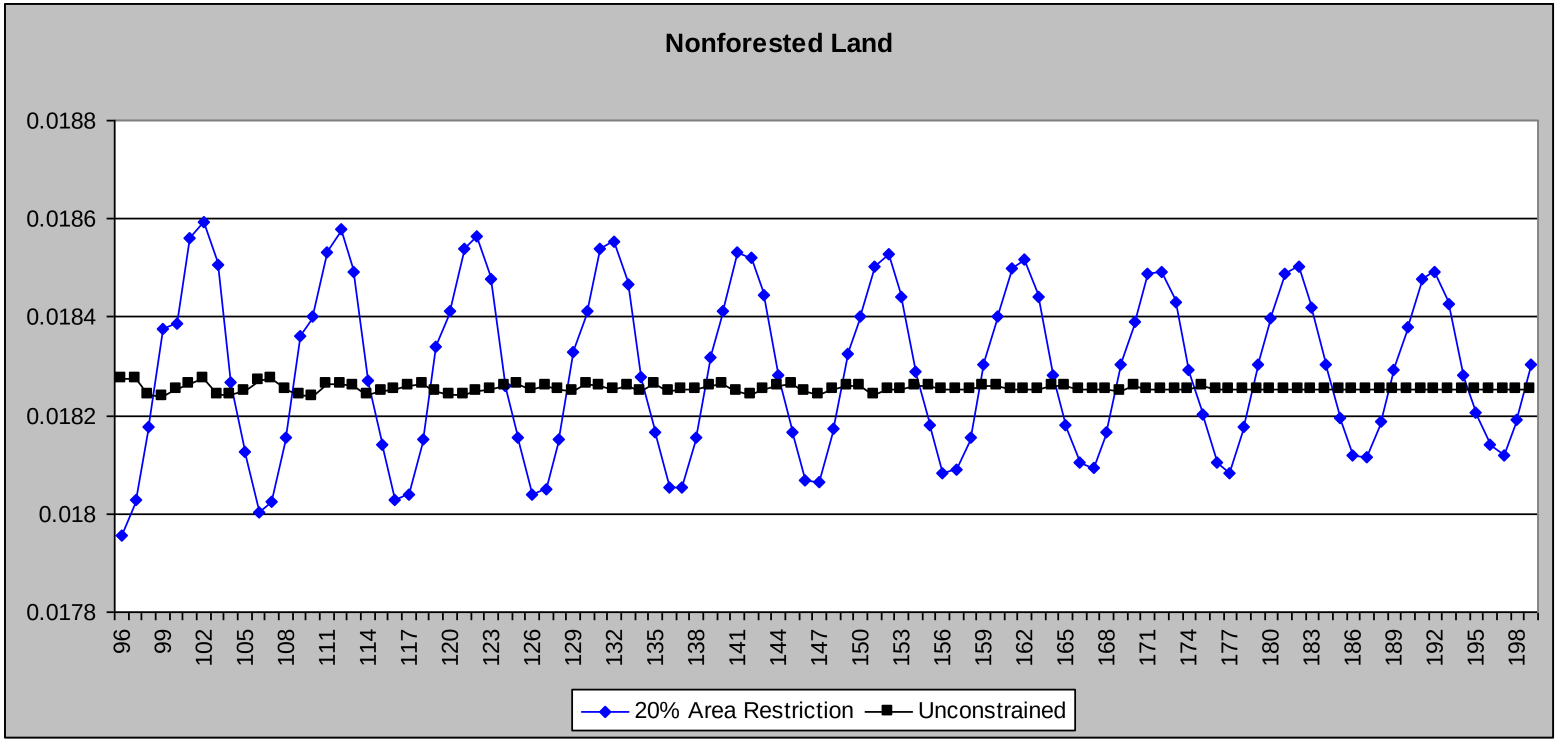
$$\alpha \sum_{l=1}^{L} \sum_{s=1}^{n+1} x^{l}_{s,t+1} = x^{1}_{n+1,t+1},$$

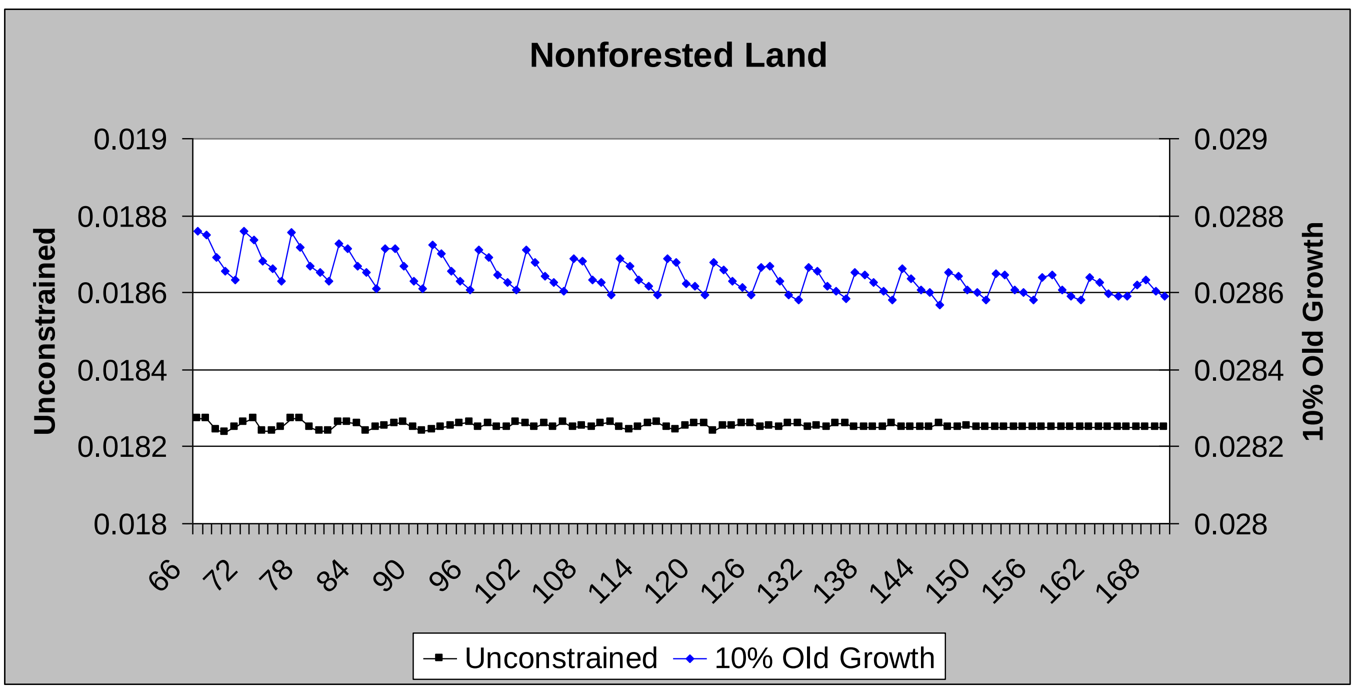
4.1 Numerical Simulations – Old Growth



4.1 Numerical Simulations – Old Growth




Nonforested Land
0.0188
0.0186
0.0184
0.0182
0.018
0.0178
96 99 102 105 108 111 114 117 120 123 126 129 132 135 138 141 144 147 150 153 156 159 162 165 168 171 174 177 180 183 186 189 192 195 198
20% Area Restriction
Unconstrained


Nonforested Land
Unconstrained
0.019
0.0188
0.0186
0.0184
0.0182
0.018
10% Old Growth
0.029
0.0288
0.0286
0.0284
0.0282
0.028
66 72 78 84 90 96 102 108 114 120 126 132 138 144 150 156 162 168
Unconstrained
10% Old Growth

Market Effects

High disturbance on timber prices

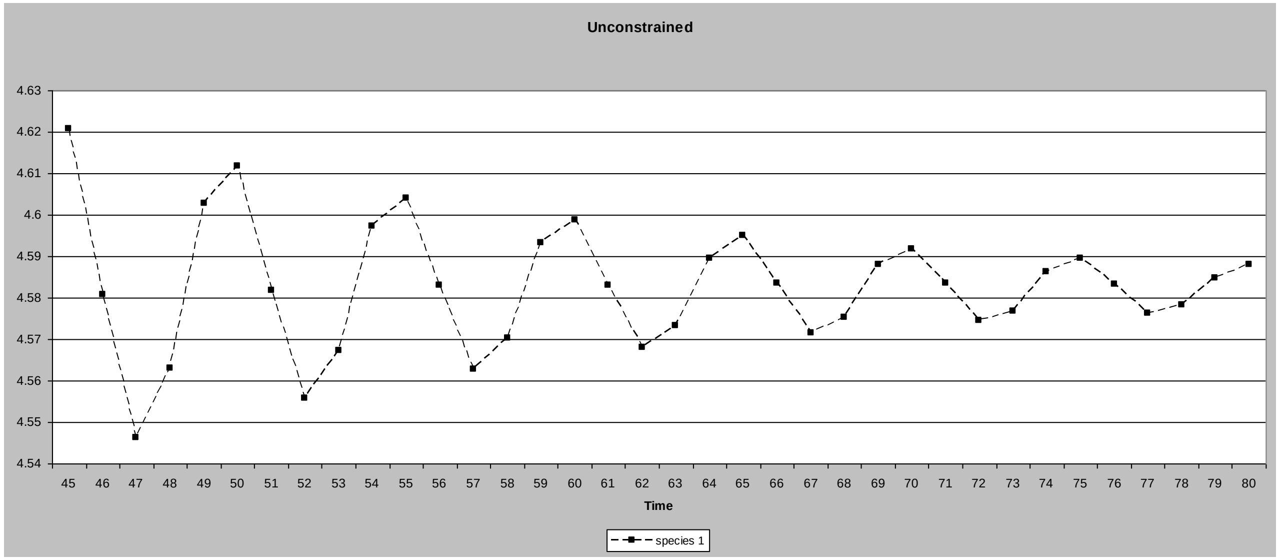
Low disturbance on land markets.

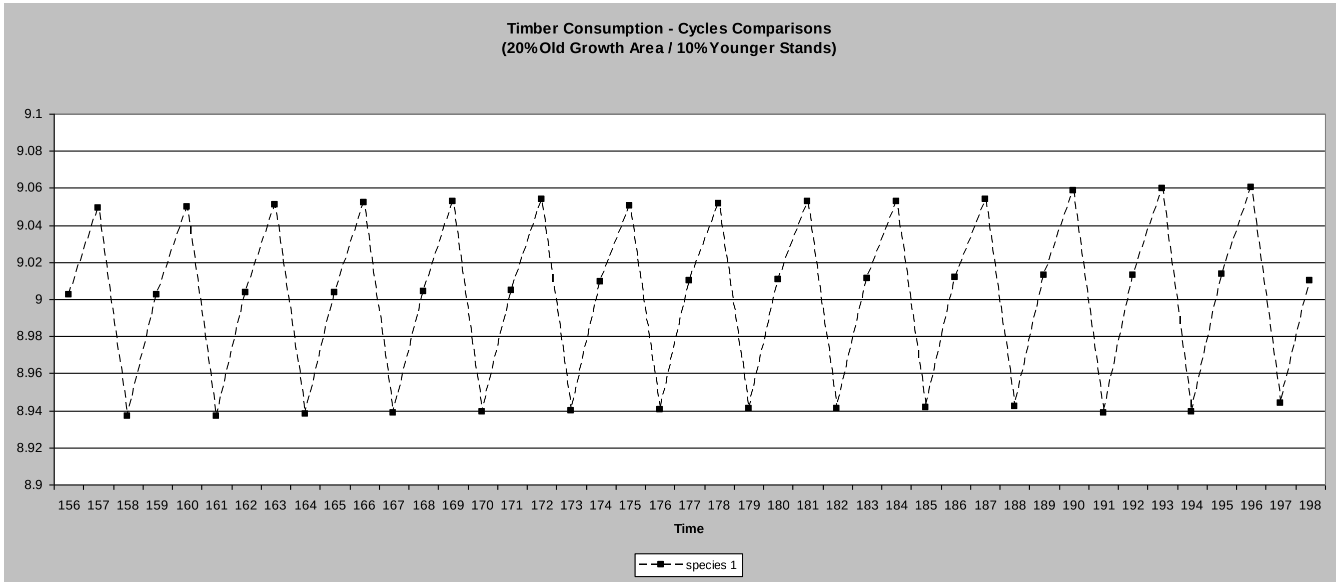
Old Growth and Younger Stands

$$\alpha_1 \sum_{l=1}^{L} \sum_{s=1}^{n+1} x_{s,t+1}^{l} = \sum_{s=1}^{3} x_{s,t+1}^{1}, \qquad 0 < \alpha_1 < 1$$

$$\alpha_2 \sum_{l=1}^{L} \sum_{s=1}^{n+1} x_{s,t+1}^{l} = x_{n+1,t+1}^{1}, \qquad 0 < \alpha_2 < 1$$

4.1 Numerical Simulations - Old Growth and Younger Stands





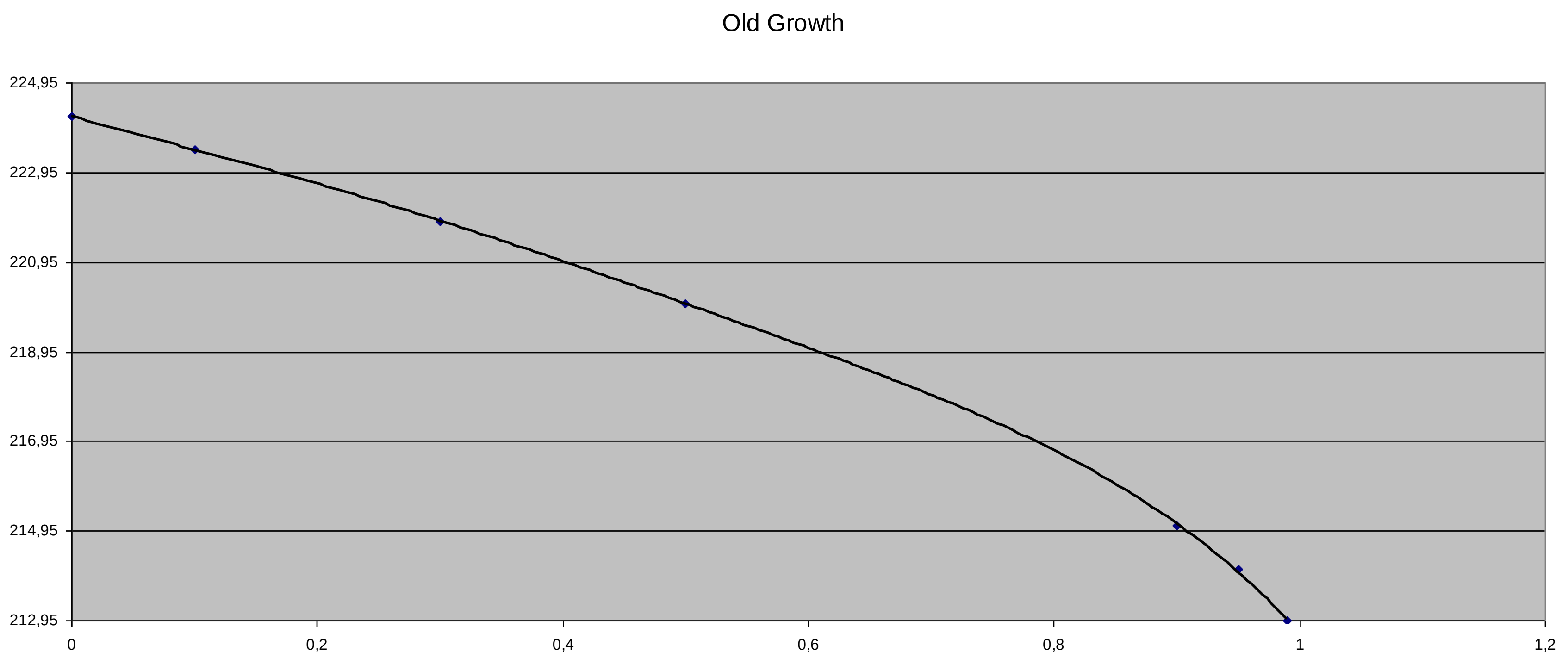
6 Conclusions

- Major differences in timber prices
- Major differences in timber management
- Major differences in land markets

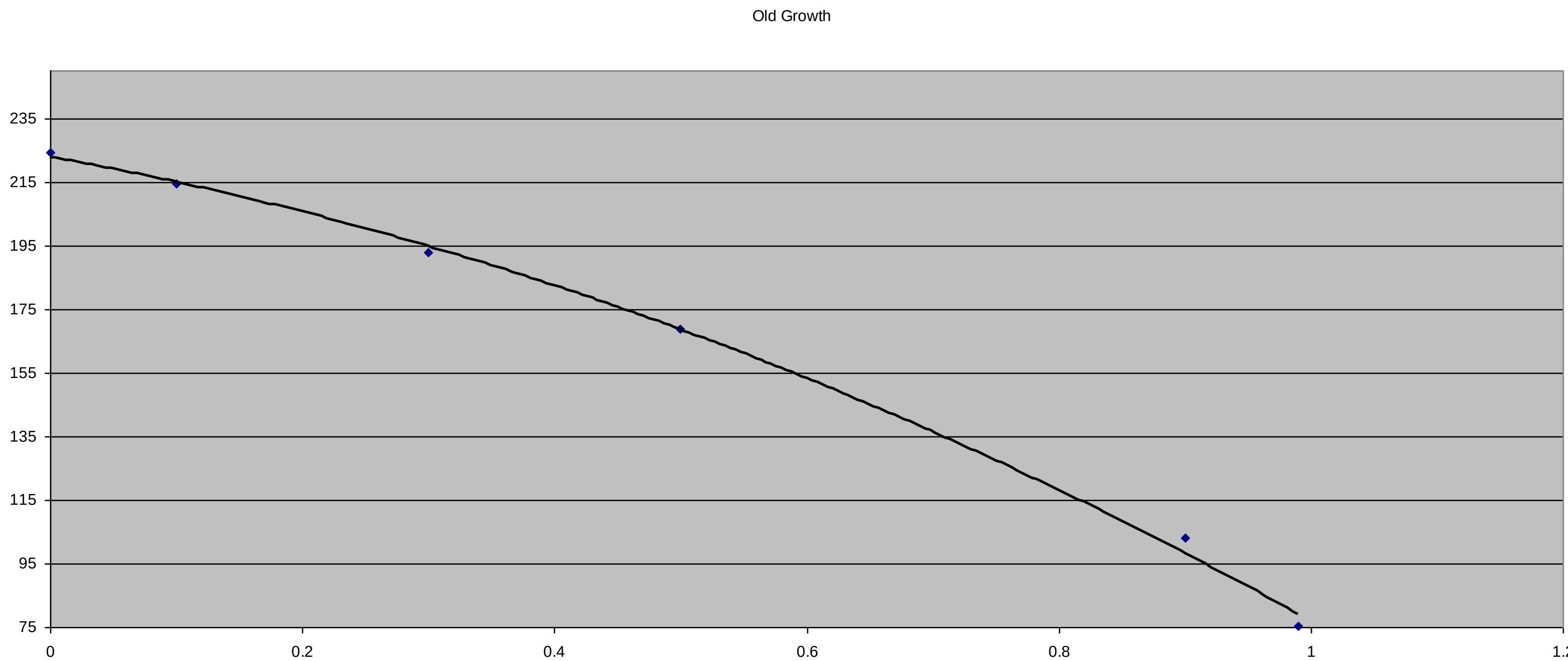
- PPF Analysis

- Not possible with usual stand level analyses

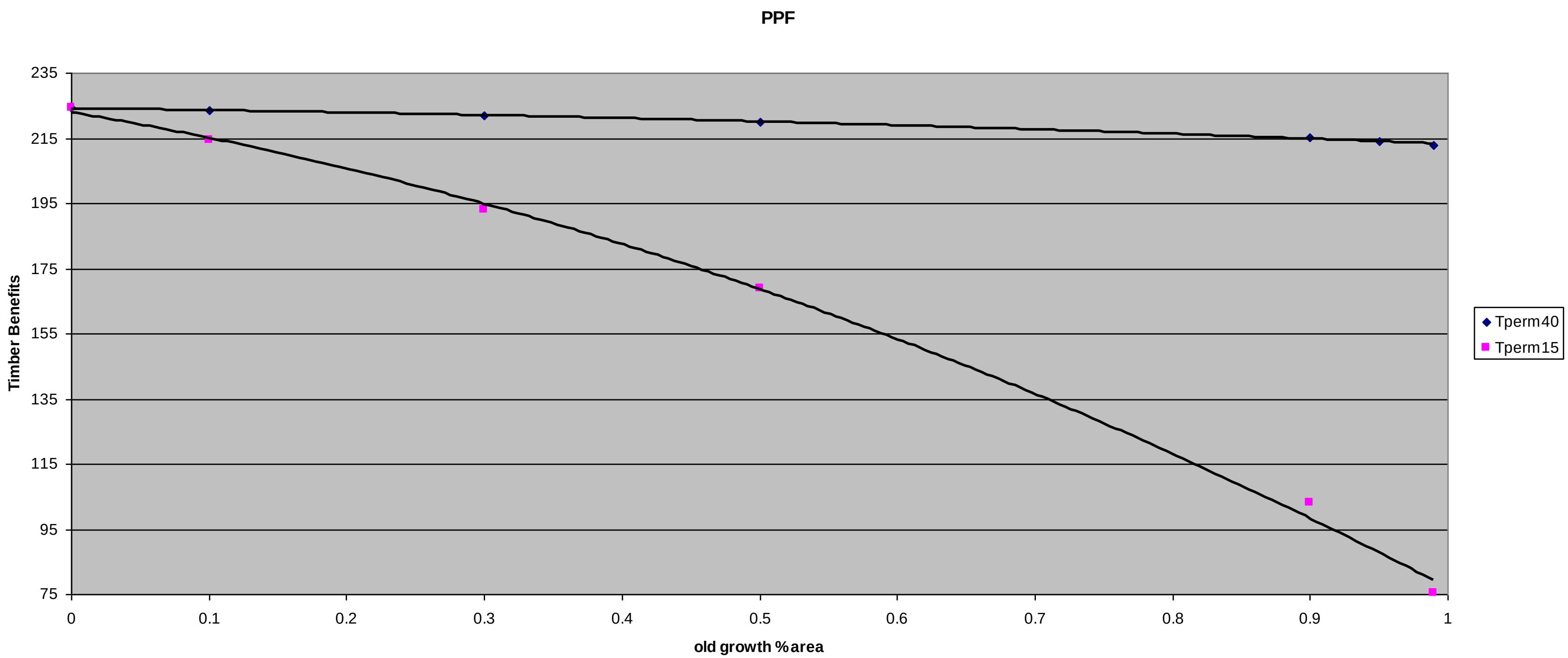
5.1 Work in Progress



Work in Progress



Work in Progress



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- Comments are most welcome!