Carbon sequestration and the optimal forest harvest decision under alternative baseline policies

Patrick Asante

Ministry of Forests Lands and Natural Resources Operations

Government of British Columbia, Canada

Take home message

- Alternative baselines have little or no effect on optimal economic rotation age.

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- Alternative baselines have little or no effect on optimal economic rotation age.

- Although alternative baselines have little effect on optimal decision to harvest, they have a large effect on financial return to the forest landowner.

Life in Ghana

City of Edmonton

West Edmonton Mall

Elevator in the mall

Old lady in a wheelchair

Beautiful Lady

Introduction

- Carbon offset markets have been promoted as a method of allowing entities other than large emitters to contribute to a reduction in GHG emissions;

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- If these other entities are able to sequester more GHGs or to release less as a result of a change in practices, they maybe able to earn carbon offset credits and sell them to large emitters.

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- A number of carbon offset quantification protocols have been developed in Alberta;
- In the recent past, there was considerable discussion about the development of a forest management protocol for the Alberta offset system.

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- However, forest carbon offsets present some unique challenges for technical legitimacy, in particular the issues of additionality;
- Carbon sequestration levels in excess of a baseline level are considered additional and, thus, available for sale as offsets.

Challenges to the Carbon offset Market

- Leakage

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- Permanence

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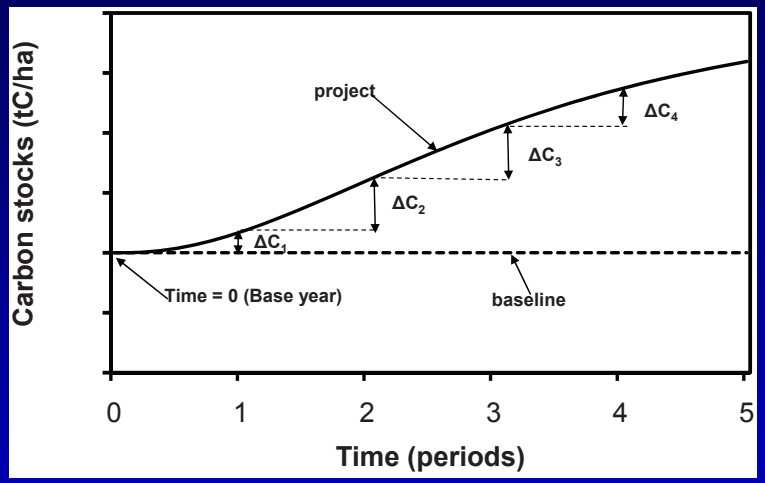
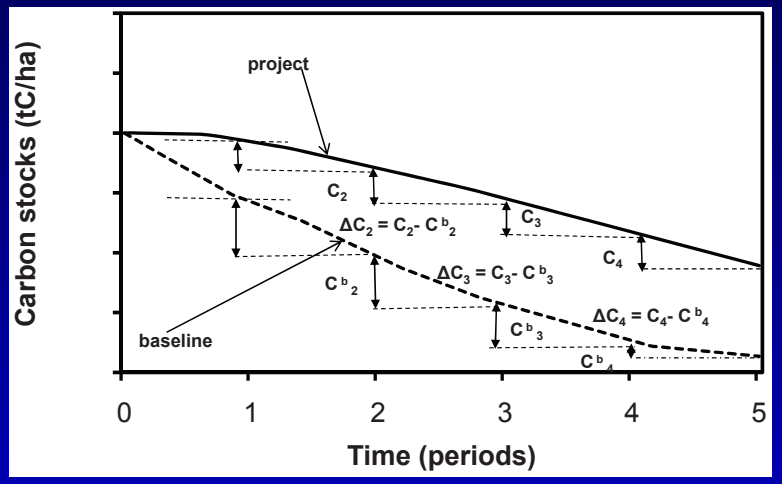
Challenges to the Carbon offset Market

- Leakage
- Permanence
- Additionality
- Baseline



(g) Fixed Baseline



(h) Business-as-usual Baseline

Objective of Study

- To understand if the choice of a baseline can be used as an incentive to increase forest carbon sequestration;

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- To understand if the choice of a baseline can be used as an incentive to increase forest carbon sequestration;
- Rank the alternative baselines in terms of their impact on financial returns; and
- To investigate if the starting conditions of the baseline can affect financial returns to the landowner

Carbon Pool Dynamics

Total Ecosystem Carbon Stocks is defined as:

$$C_t = B(a) + D_t \tag{1}$$

Carbon Pool Dynamics

Biomass pool

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$$B(a) = b_1 \left(1 - e^{-b_2 a}\right)^{b_3} \tag{2}$$

Carbon Pool Dynamics

With no timber harvest DOM grows according to:

$$C_t = B(a) + D_t \tag{1}$$

$$B(a) = b_1 \left(1 - e^{-b_2 a}\right)^{b_3} \tag{2}$$

$$D_{t+1} = (1 - \alpha) D_t + \beta B(a) \tag{3}$$

Carbon Pool Dynamics

When harvest occurs, DOM grows according to:

$$C_t = B(a) + D_t \tag{1}$$

$$B(a) = b_1 \left(1 - e^{-b_2 a}\right)^{b_3} \tag{2}$$

$$D_{t+1} = (1 - \alpha) D_t + \beta B(a) \tag{3}$$

$$D_{t+1} = (1 - \alpha) D_t + B(a) - \gamma V(a) \tag{4}$$

Carbon Stock Changes

With No Harvest, Change in Biomass

$$\Delta B(a) = B(a+1) - B(a) \tag{5}$$

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$$\Delta D_t = -\alpha D_t + \beta B(a) \tag{7}$$

Carbon Stock Changes

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$$\Delta D_t = -\alpha D_t + \beta B(a) - \gamma V(a) \tag{8}$$

Carbon Stock Changes

Total Ecosystem Stock Change

$$\Delta B(a) = B(a+1) - B(a) \tag{5}$$

$$\Delta B(a) = B(1) - B(a) \tag{6}$$

$$\Delta D_t = -\alpha D_t + \beta B(a) \tag{7}$$

$$\Delta D_t = -\alpha D_t + \beta B(a) - \gamma V(a) \tag{8}$$

$$\Delta C_t = \Delta B(a) + \Delta D_t \tag{9}$$

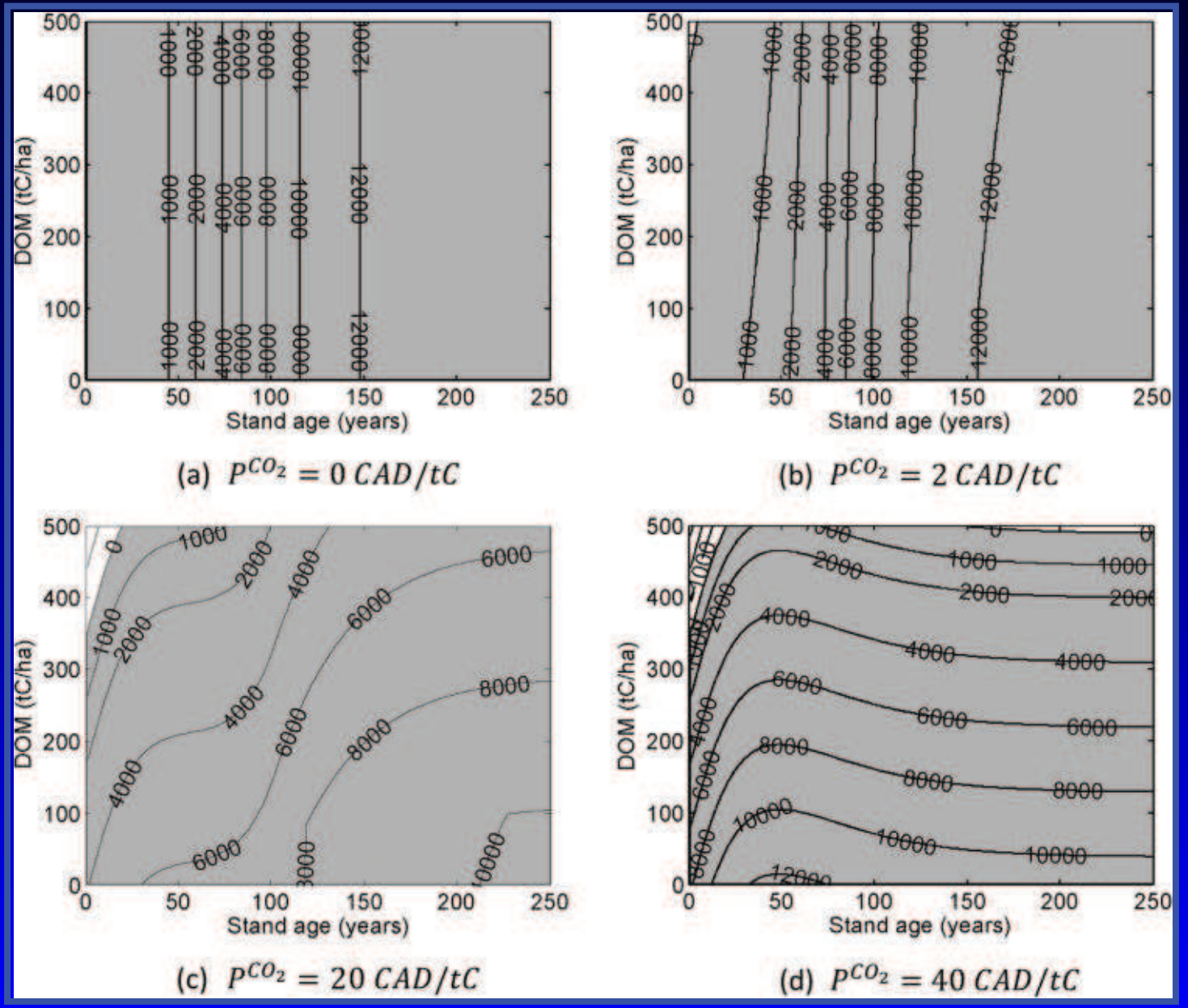
Variables in DP Model

Type	Variable	Description
Stage	Time	One year time steps $(1, \ldots, 500)$
State	1. Age	251 discrete one-year age classes $a_j = j,\ j = 0, 1, \ldots, 250$ years
	2. DOM	501 discrete DOM classes $d_i = i,\ i = 0, 1, \ldots, 500$ tC/ha
Decision	Harvest Policy	1. No Harvest (growth) 2. Harvest

Comparing Optimal Harvest Ages

P^{CO_2} (CAD/tCO_2)	Harvest age (Base year baseline) (years)	Harvest age (Faustmann baseline) (years)	Harvest age (MSY baseline) (years)
0	73	73	73
1	74	75	76
2	75	76	77
5	78	79	79
10	84	84	85
20	101	101	102
30	139	139	139
35	>250	>250	>250

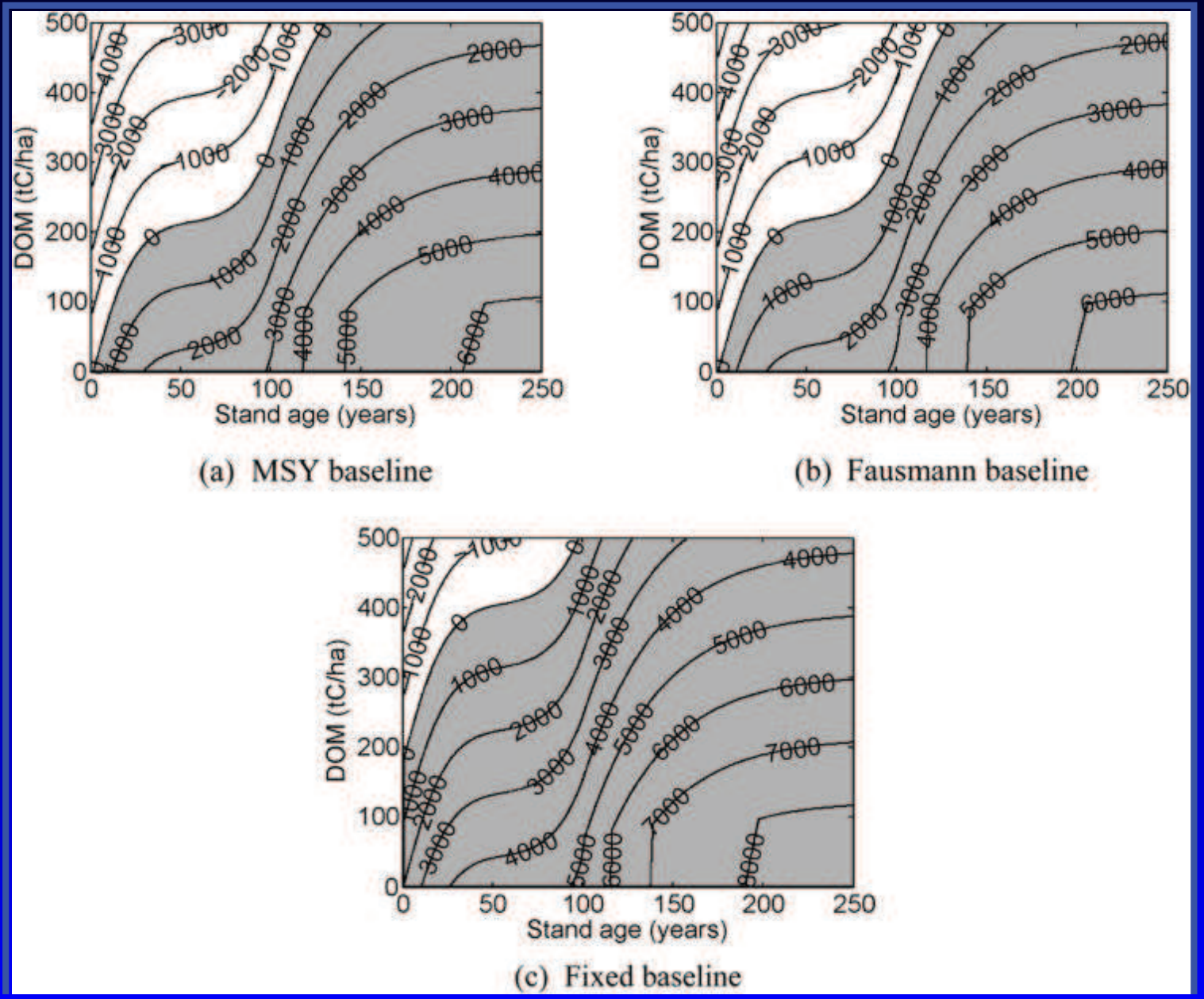
Economic Returns Based on Different Carbon Prices



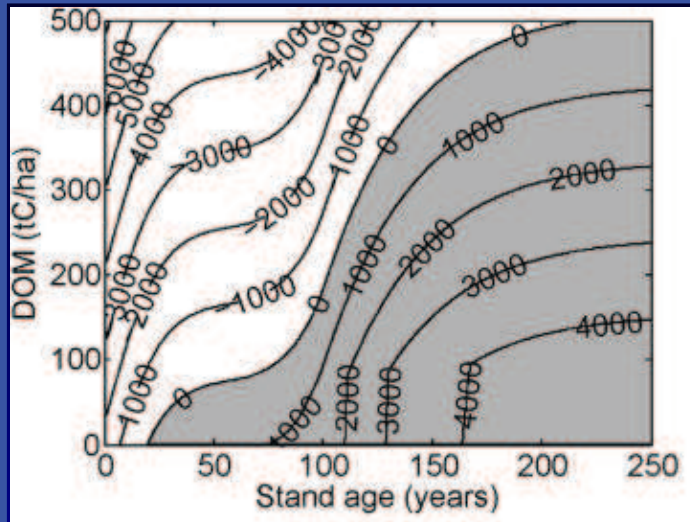
Comparing Economic Returns

Starting Age (years)	MSY Baseline	Faustmann Baseline	Fixed Baseline
Initial DOM = 100 tC/ha			
50	1 100	1 200	3 300
100	2 200	2 500	4 800
200	4 900	5 100	7 100
Initial DOM = 200 tC/ha			
50	0	100	2 100
100	1 500	2 000	3 500
200	3 500	4 000	6 000

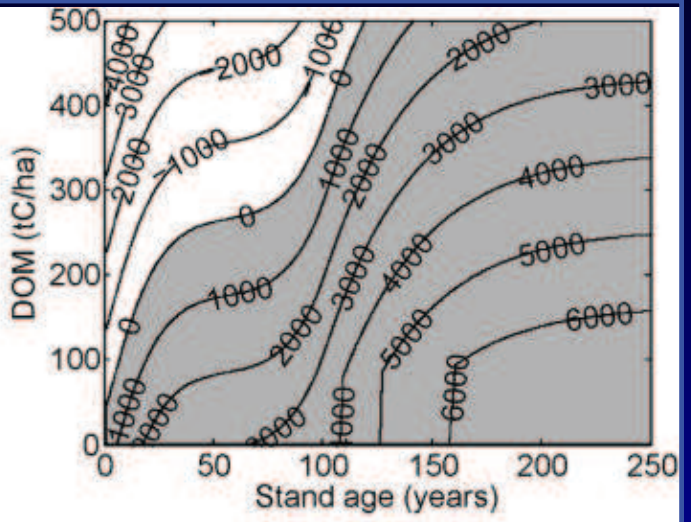
Economic Returns Based on Different Baselines



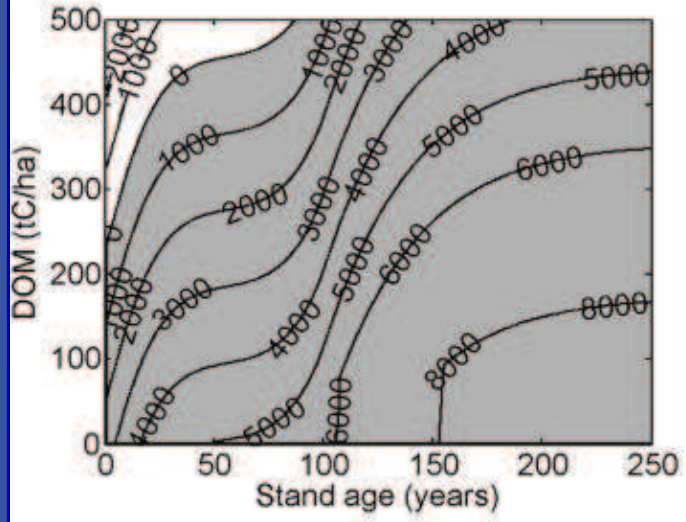
Economic Returns Based on diff. Staring Conditions



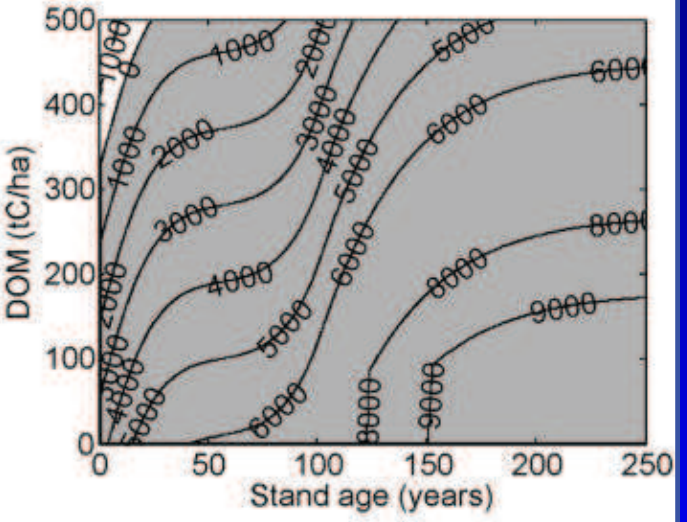
(a) MSY baseline with initial DOM stock of 0 tC/ha and initial age of 50 years.



(b) MSY baseline with initial DOM stock of 200 tC/ha and initial age of 50 years.



(c) MSY baseline with initial DOM stock of 400 tC/ha and initial age of 50 years.



(d) MSY baseline with initial DOM stock of 500 tC/ha and initial age of 50 years.

Concluding Remarks

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- The fixed baselines approach produced the highest financial return to the landowner. This was followed by the Faustmann baseline and then the MSY baseline.

Concluding Remarks

- Alternative baselines have little effect on optimal decision but can have a large effect on financial return to landowner.
- The fixed baselines approach produced the highest financial return to the landowner. This was followed by the Faustmann baseline and then the MSY baseline.
- The starting conditions of the baseline policy have a significant impact on the financial return to the landowner.

Thanks for Listening!