



# Constructing an opportunity cost curve

Douglas White



# Objectives

- Discuss an opportunity cost curve
- Examine carbon-profit tradeoffs
- Introduce example
- Generate a REDD+ opportunity cost curve
- Review effect of changes in
  - policy
  - prices
  - technical coefficientson an opportunity cost curve  
(*sensitivity analysis*)

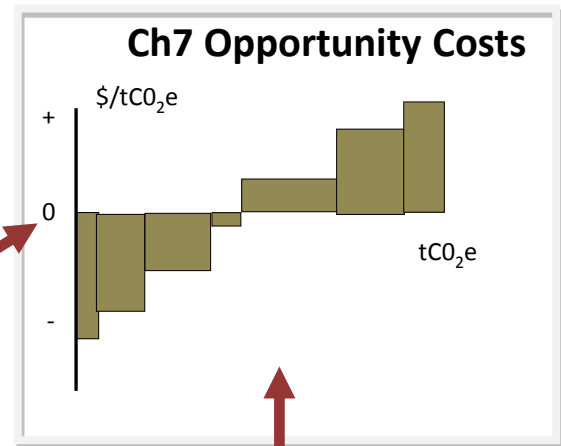
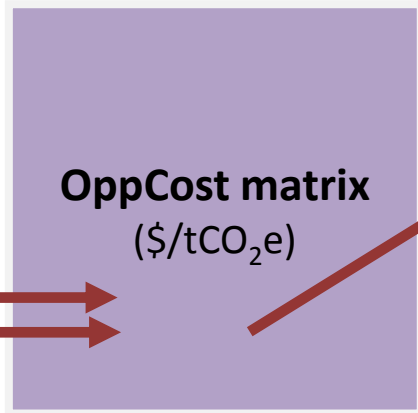
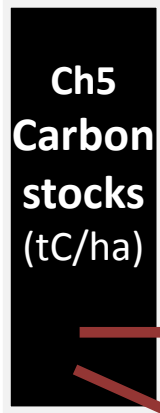


# OppCost curve

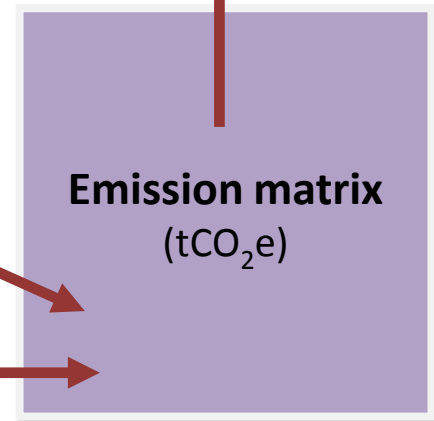
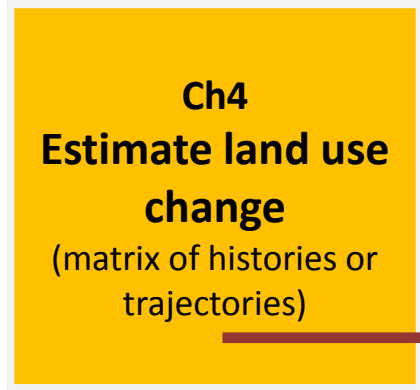
- **Integrates the outputs from previous chapters**
  - **land uses**
  - **land use changes**
  - **carbon stocks**
  - **profits**

# OppCost analysis process

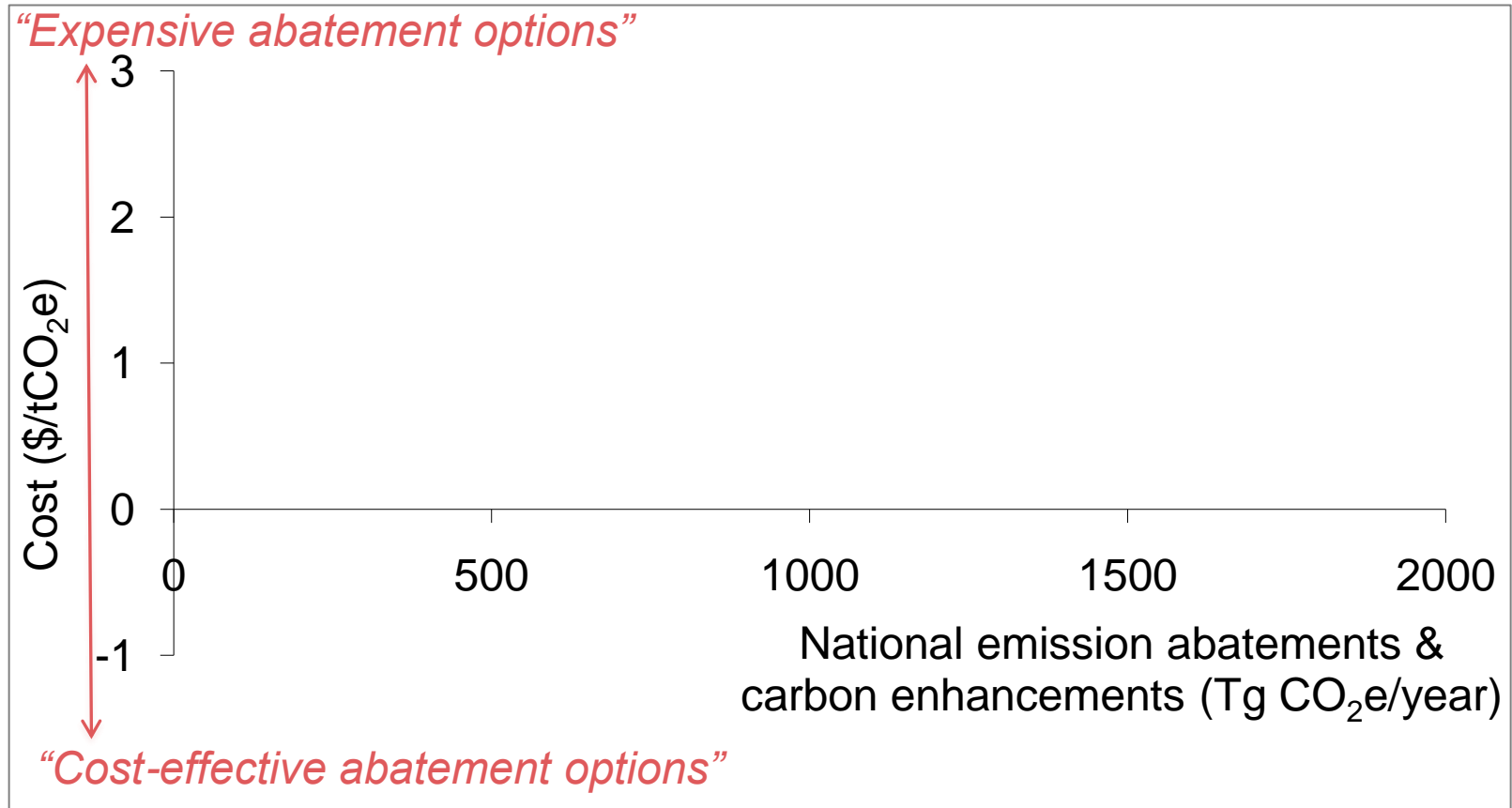
*For the vertical axis:*



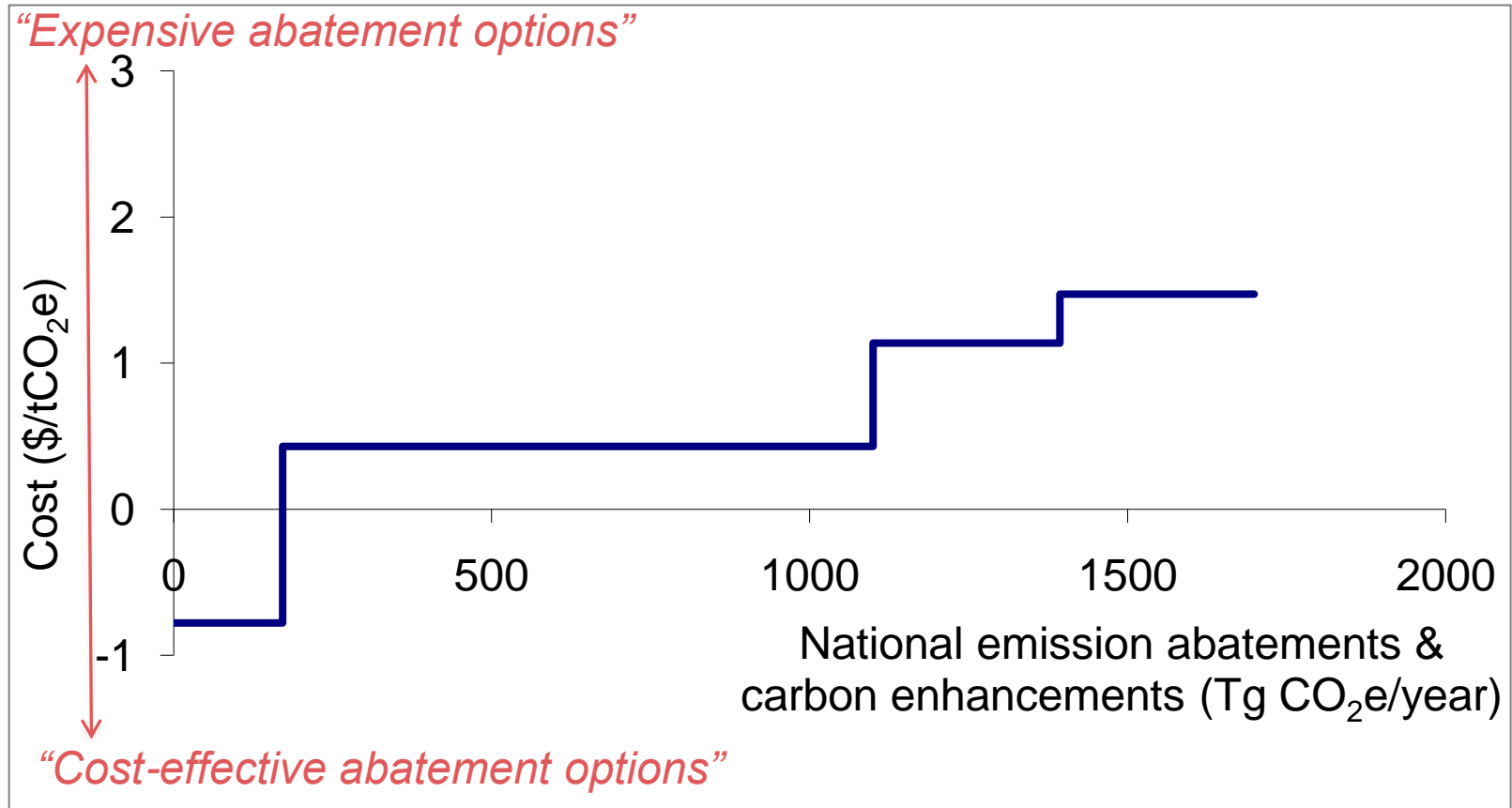
*For the horizontal axis:*



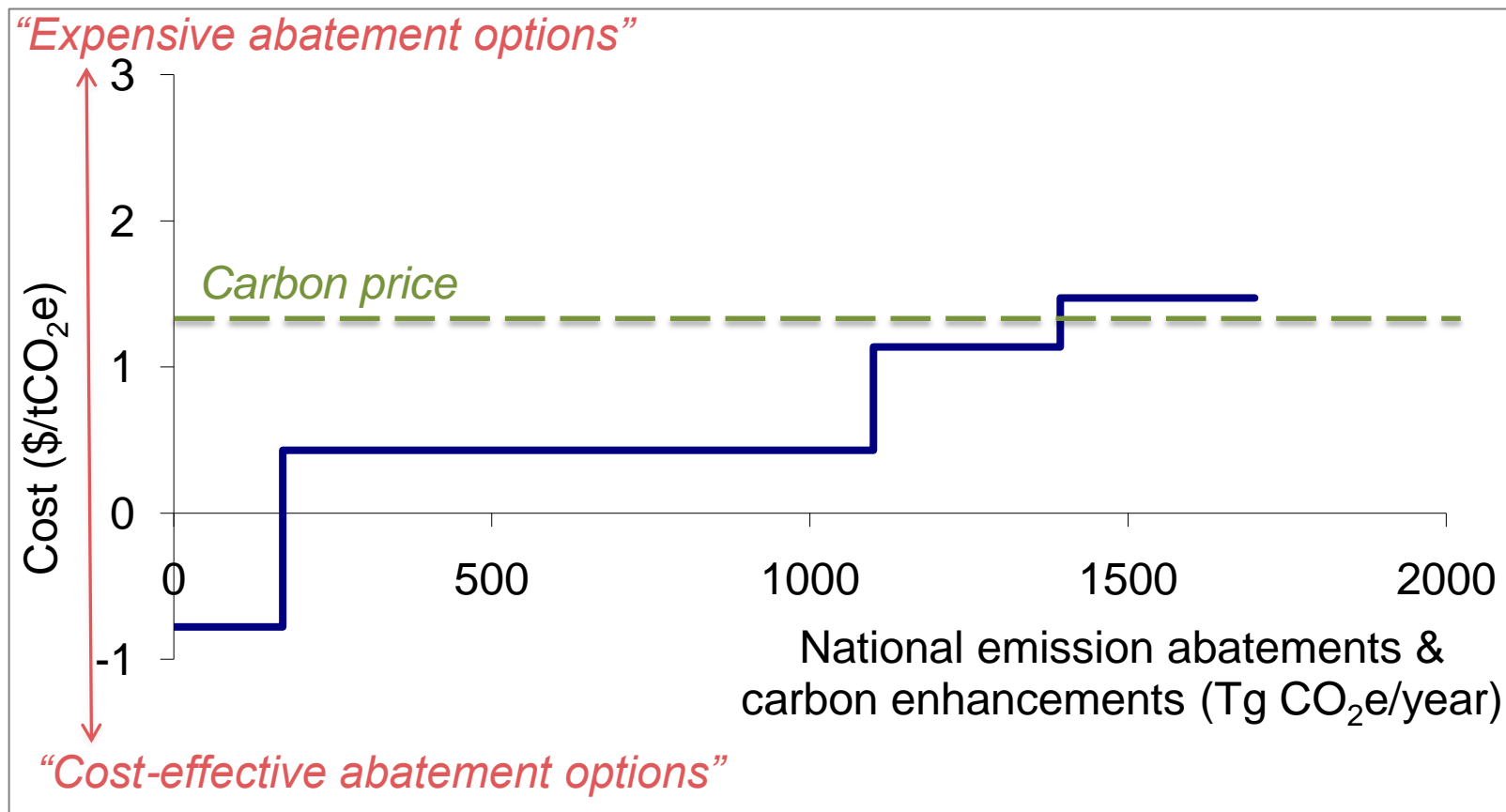
# What is an opportunity cost curve?



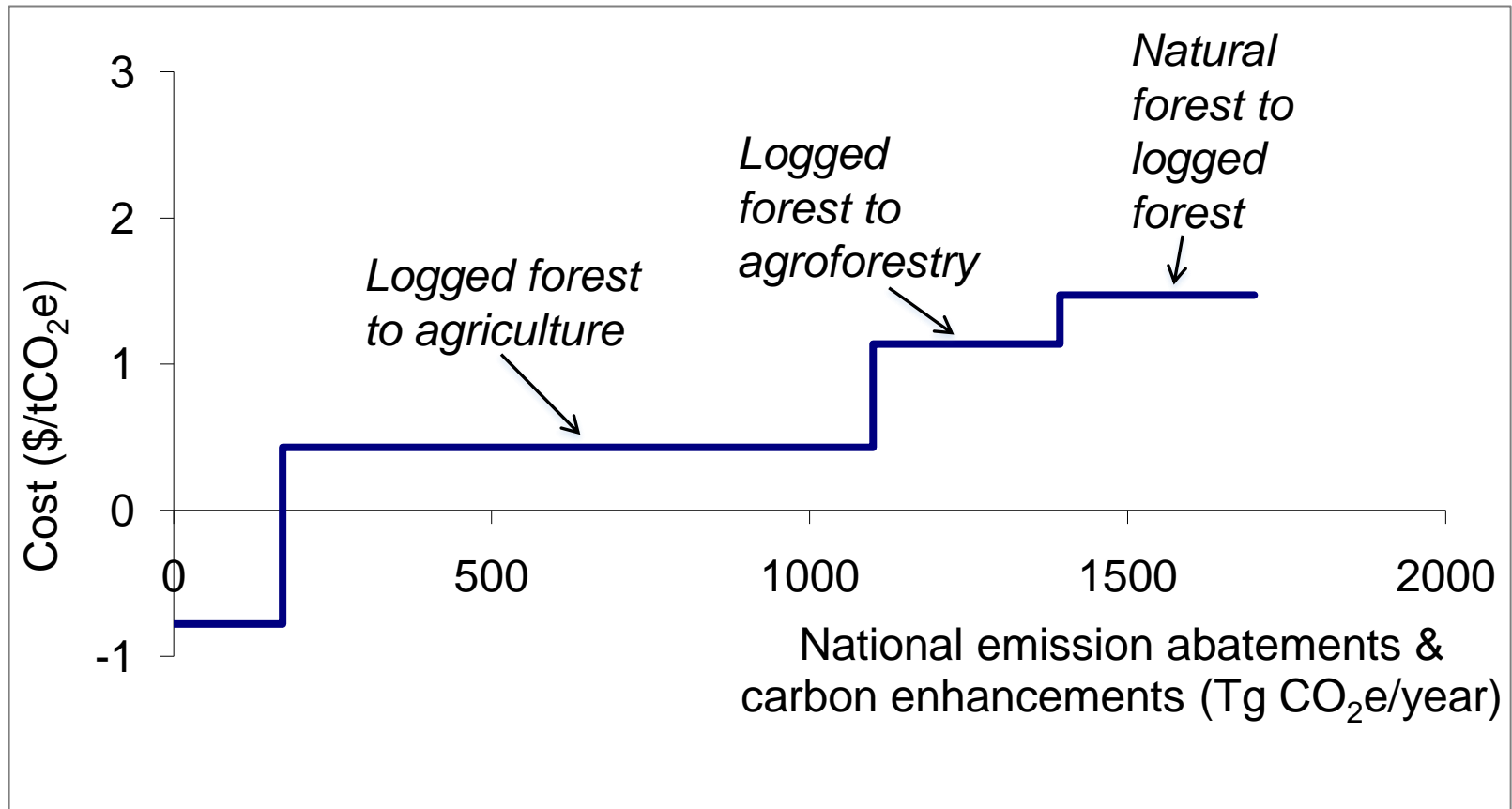
# What is an opportunity cost curve?



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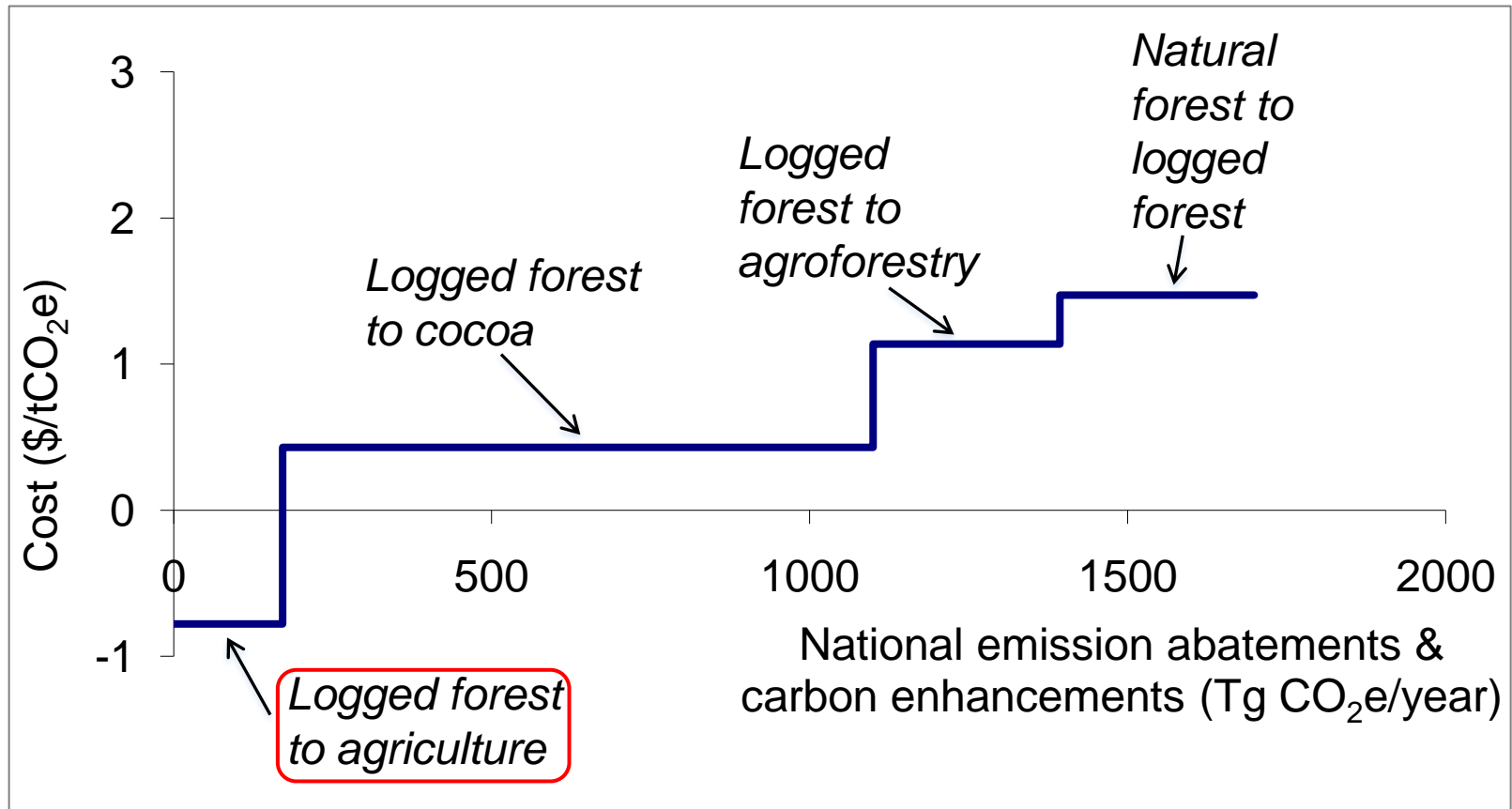


# What is an opportunity cost curve?





# What is an opportunity cost curve?





# Land use categories

- **A mix of national, IPCC and other criteria are used to determine categories**
- **To enable systematic and rigorous analysis of REDD+ opportunity costs, land use systems need to be:**
  - **Unambiguous (pertain to only one land use category),**
  - **A basis from which to integrate multiple types of data,**
  - **Carbon-relevant (homogenous in C stock),**
  - **Profit-relevant (homogeneous in profits),**
  - **Consistent for reporting at multiple scales: global, national, local**



# Land use categories

- **Levels of homogeneity to be determined according to impact on results.**
- **In some instances, 5-10% difference may not greatly affect opportunity cost estimates**
- **Precision and rigor is a matter of discussion, increases cost of analysis**
- **The costs of data collection and analysis are weighed against the benefits of better estimates**



# A national opportunity cost curve

## Recall that

- **Such a national analysis is a useful step in understanding the costs of carbon abatement**
- **The results, however, are a simplification of a diverse reality**
- **A broad range of sub-national contexts typically reveals big differences from generalized results**



# Sensitivity analysis (1)

- **Why**
  - **To check the robustness of a quantitative analytical model**
  - **To identify the variables that account for more variation in the model results**



# Sensitivity analysis (2)

- **Key steps:**
  - **Prioritize a subset of variables for sensitivity analysis (e.g. inputs, yields, prices, discount rate)**
  - **Determine the realistic range of variation of the variable**
  - **Examine the results of low and high estimates of each variable**
  - **Document, compare and discuss the results**
  - **Identify priority scenarios to consider in policy discussions**
  - **Consider additional land use classifications to improve precision**
  - **Identify priority areas of research to clarify the range of specific parameters (e.g. inputs, yields, prices)**



# Hands-on Exercise with Abacus

## Context: Sumatra, Indonesia

- **Different carbon stocks and profit levels from**
  - **land uses**
  - **sub-regions**

# Site context

- Batang Toru, North Sumatra

248,250 ha  
or  
2,483 km<sup>2</sup>





# Asia example

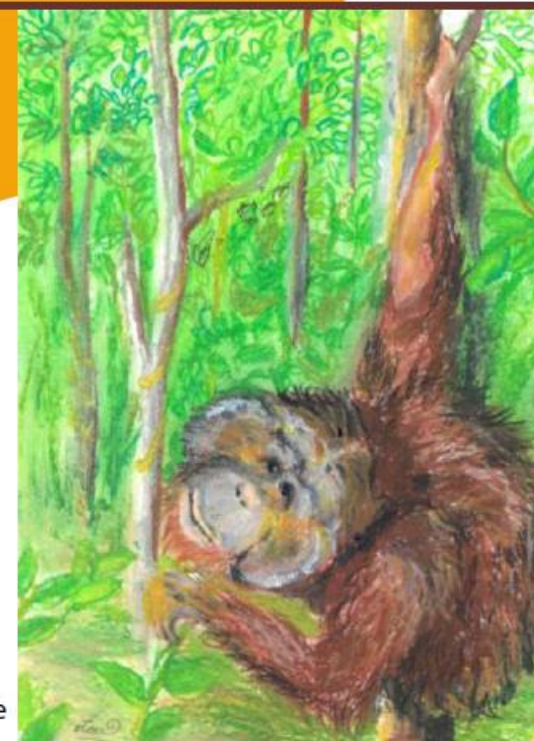
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Subekti Rahayu  
Atiek Widayati  
Rachmat Mulia

Human livelihoods, ecosystem services  
and the habitat of the  
Sumatran orangutan

Project  
Report

*"Sumatran orangutan habitat ecosystem services  
assessment and opportunity cost analysis"*



World Agroforestry Centre

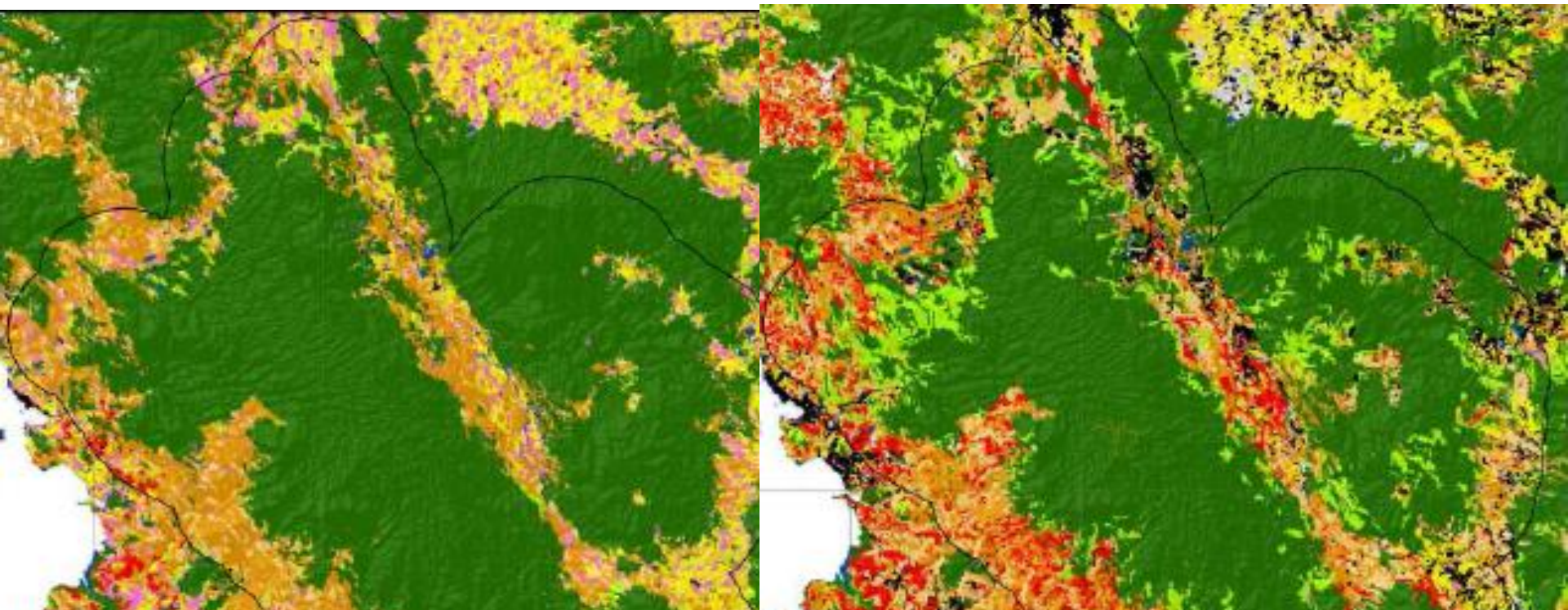
# Land: covers/uses



# Land covers/uses

<i>Area (ha)</i>	<b>1994</b>	<b>2009</b>
Undisturbed forest	159470	133563
Logged forest	3312	15513
Rubber agroforest	38651	30201
Mixed gardens	15425	27808
Coffee agroforest	15506	11576
Pine plantation	1462	13470
Rice paddy	11557	11700
Oil palm	873	2425

# Land cover maps 1994, 2009



## Legend

-  Batangtoru Study Area Boundary
-  Cleared land
-  Coffee Agroforest
-  Crops
-  Disturbed/degraded forest
-  Estate/Plantation

-  Mixed Garden
-  Rubber Agroforest
-  Settlement
-  Shrub/Grass
-  Undisturbed Forest
-  Water body

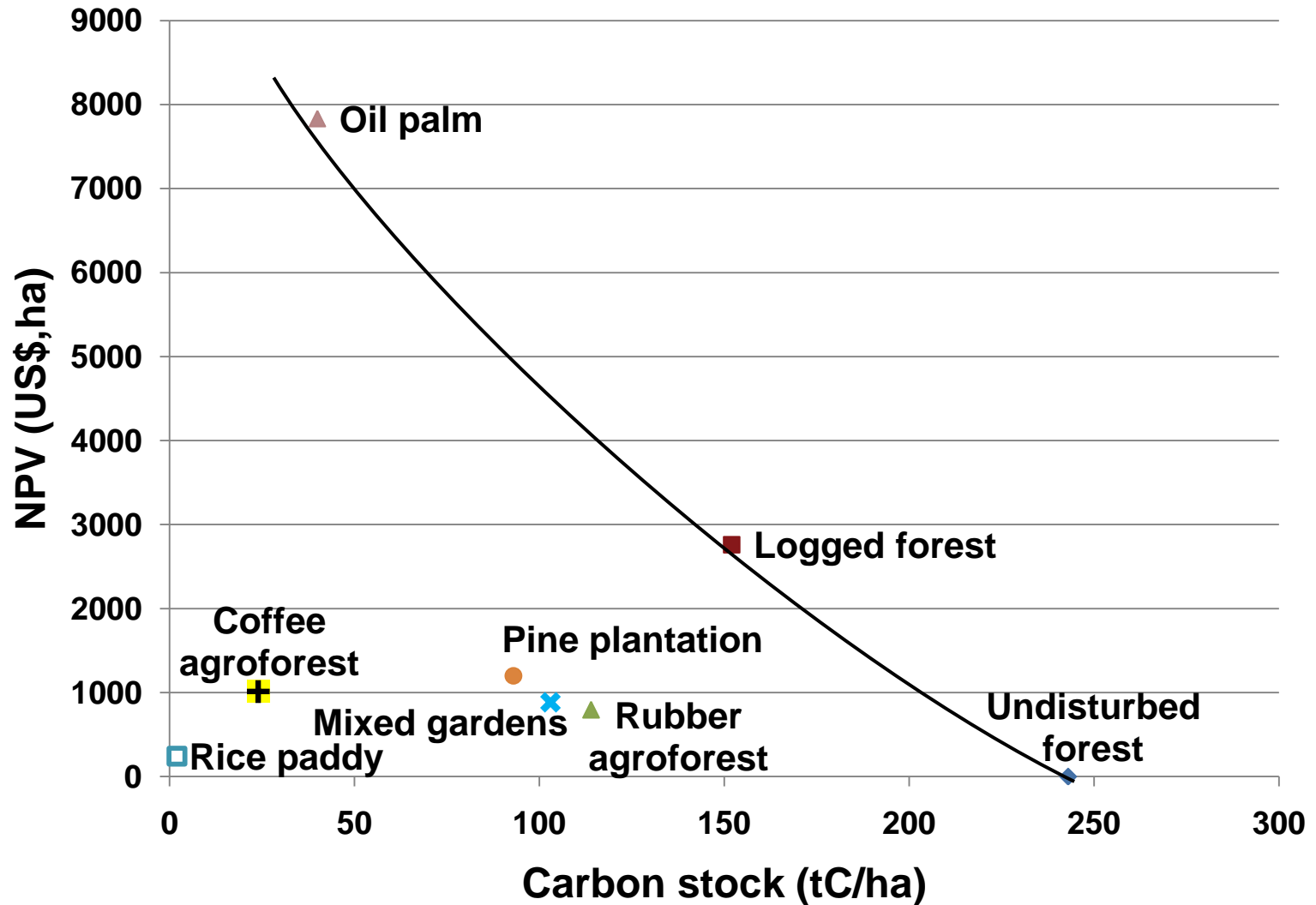
# Land use change matrix

Batang Toru, Sumatra		1994		Rubber		Coffee		Rice	Oil palm
		2009	Undisturb ed forest	Logged forest	agrofore st	Mixed gardens	agrofore st		
hectares		<b>133563</b>	<b>15513</b>	<b>30201</b>	<b>27808</b>	<b>11576</b>	<b>13470</b>	<b>11700</b>	<b>2425</b>
Undisturbed forest	<b>159470</b>	<b>133563</b>	<b>12383</b>	<b>8</b>	<b>6245</b>	<b>1369</b>	<b>4580</b>		<b>1322</b>
Logged forest	<b>3312</b>	<b>0</b>	<b>3130</b>	<b>0</b>	<b>12</b>	<b>0</b>	<b>114</b>	<b>32</b>	<b>24</b>
Rubber agroforest	<b>38651</b>	<b>0</b>	<b>0</b>	<b>30193</b>	<b>4283</b>	<b>573</b>	<b>3525</b>	<b>0</b>	<b>77</b>
Mixed gardens	<b>15425</b>	<b>0</b>	<b>0</b>		<b>11925</b>		<b>3284</b>	<b>87</b>	<b>129</b>
Coffee agroforest	<b>15506</b>	<b>0</b>	<b>0</b>		<b>5343</b>	<b>9634</b>	<b>505</b>	<b>24</b>	
Pine plantation	<b>1462</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1462</b>	<b>0</b>	<b>0</b>
Rice paddy	<b>11557</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>11557</b>	
Oil palm	<b>873</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>873</b>

# Carbon and profit levels

Land use	Region 1	
	<u>Carbon</u>	<u>NPV</u>
Undisturbed forest	243	0
Logged forest	152	2760
Rubber agroforest	114	796
Mixed gardens	103	885
Coffee agroforest	24	1012
Pine plantation	93	1199
Rice paddy	2	242
Oil palm	40	7832

# Carbon-Profit Tradeoff



# Hands-on Exercise with Abacus

Land use	Region 1		Region 2	
	<u>Carbon</u>	<u>NPV</u>	<u>Carbon 2</u>	<u>NPV2</u>
Undisturbed forest	243	0	243	0
Logged forest	152	2760	152	3450
Rubber agroforest	114	796	85.5	995
Mixed gardens	103	885	77.25	1106.25
Coffee agroforest	24	1012	18	1265
Pine plantation	93	1199	93	1199
Rice paddy	2	242	2	302.5
Oil palm	40	7832	30	9790
		<i>Carbon2</i>	<i>gray cells have 75% of original carbon estimate</i>	
		<i>NPV2</i>	<i>gray cells have 125% of original NPV estimate</i>	



# Batang Toru

<i>Districts</i>	<i>South Tapanuli</i>	<i>Central Tapanuli</i>
<b>Main plantation commodities</b>	Rubber, oil palm, snakefruit, tobacco, cinnamon, coffee, clove	Rubber, coconut, oil palm and cocoa
<b>Main crops</b>	Paddy rice, maize, soybeans	Paddy rice, maize, animals
<b>Land holdings</b>	Paddy 0.5 ha, Mixed garden (rubber, sugar palm) 1-4 ha Snakefruit 0.5-2 ha	Paddy rice 0.5 ha Upland rice 0.5 ha Mixed garden (rubber, sugar palm, etc) 1- 4 ha Rubber agroforest 1-2 ha