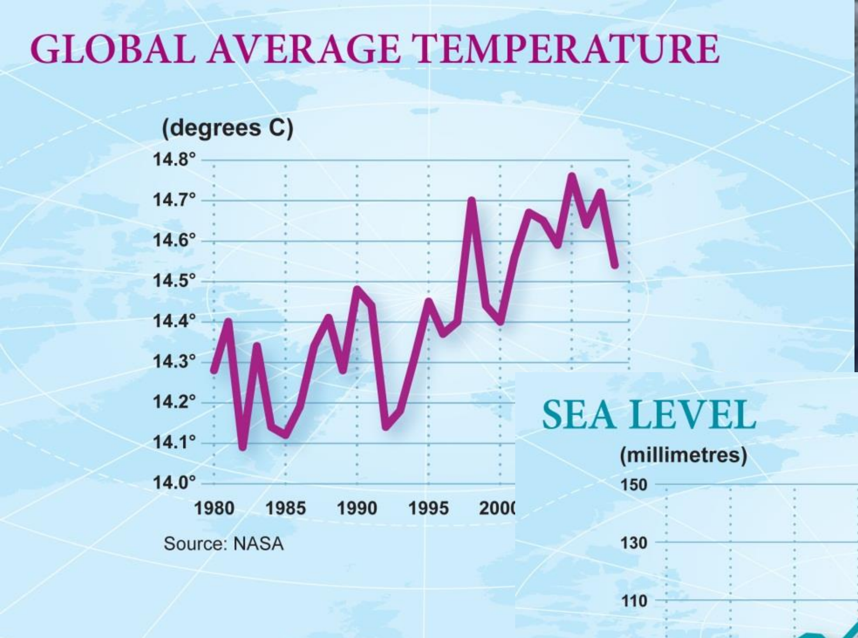
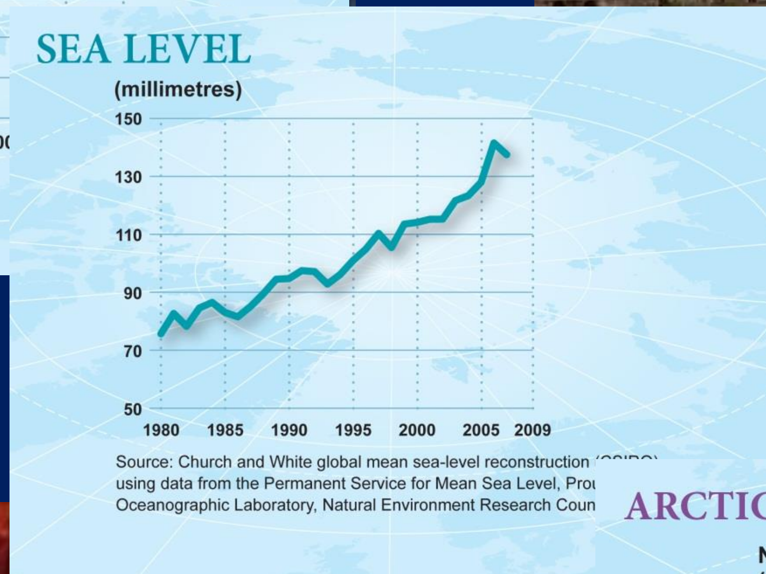
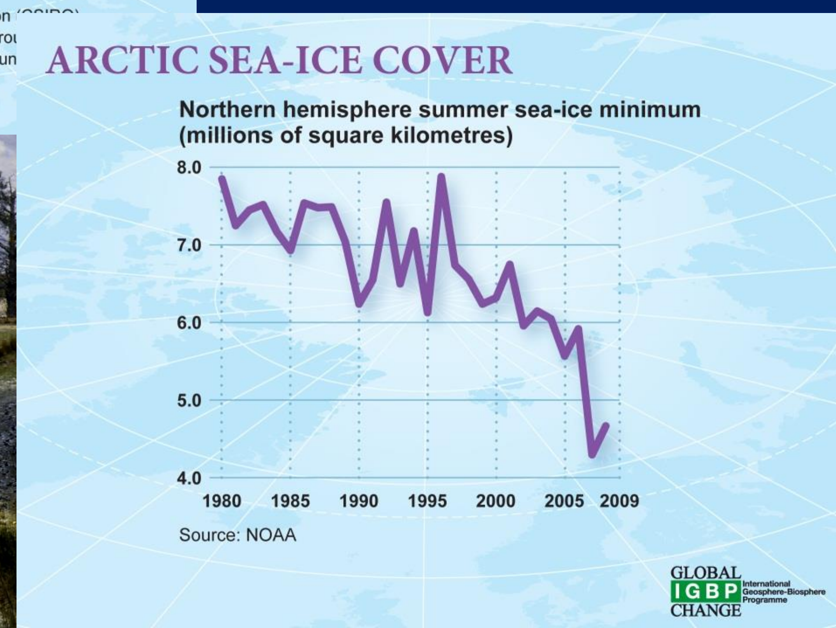
IEA Bioenergy

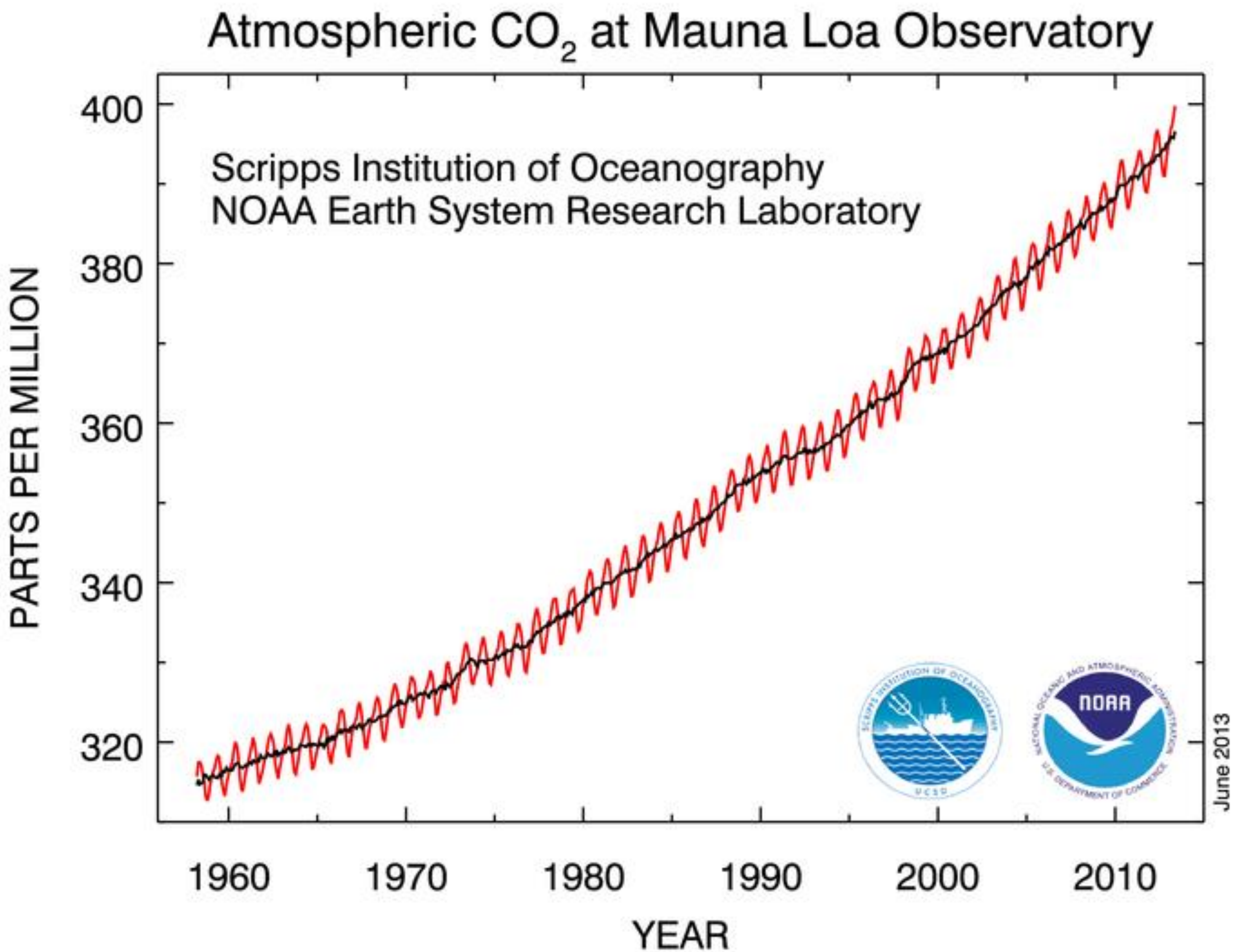
Bioenergy:
Is it good for the climate?

Annette Cowie,
Miguel Brandão and others
IEA Bioenergy Task 38


GLOBAL AVERAGE TEMPERATURE
(degrees C)
14.8°
14.7°
14.6°
14.5°
14.4°
14.3°
14.2°
14.1°
14.0°
1980
1985
1990
1995
Source: NASA


SEA LEVEL
(millimetres)
150
130
110
90
70
50
1980
1985
1990
1995
2000
2005
2009
Source: Church and White global mean sea-level reconstruction
using data from the Permanent Service for Mean Sea Level,
Oceanographic Laboratory, Natural Environment Research


ARCTIC SEA-ICE COVER
Northern hemisphere summer sea-ice minimum
(millions of square kilometres)
8.0
7.0
6.0
5.0
4.0
1980
1985
1990
1995
2000
2005
2009
Source: NOAA


Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
PARTS PER MILLION
400
380
360
340
320
1960
1970
1980
1990
2000
2010
YEAR
June 2013

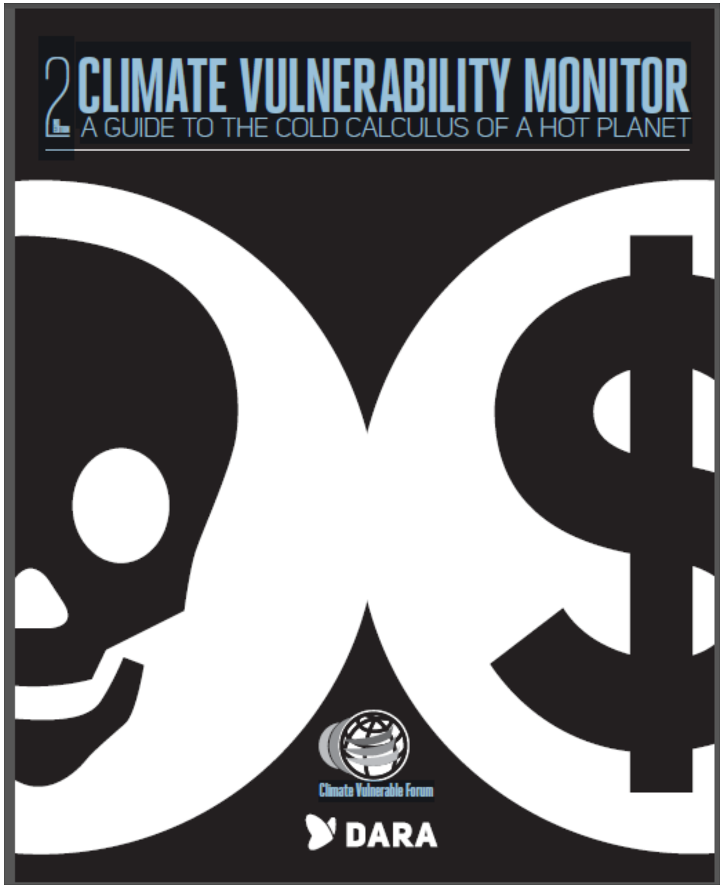
Costs of climate change

In 2010, climate change cost:

- 700 billion USD
    - 0.9% global GDP
- 400,000 deaths per year – 90% children

Climate change + Carbon economy

- costs 1.2 trillion USD
- kills 4.975 million



DARA, 2012

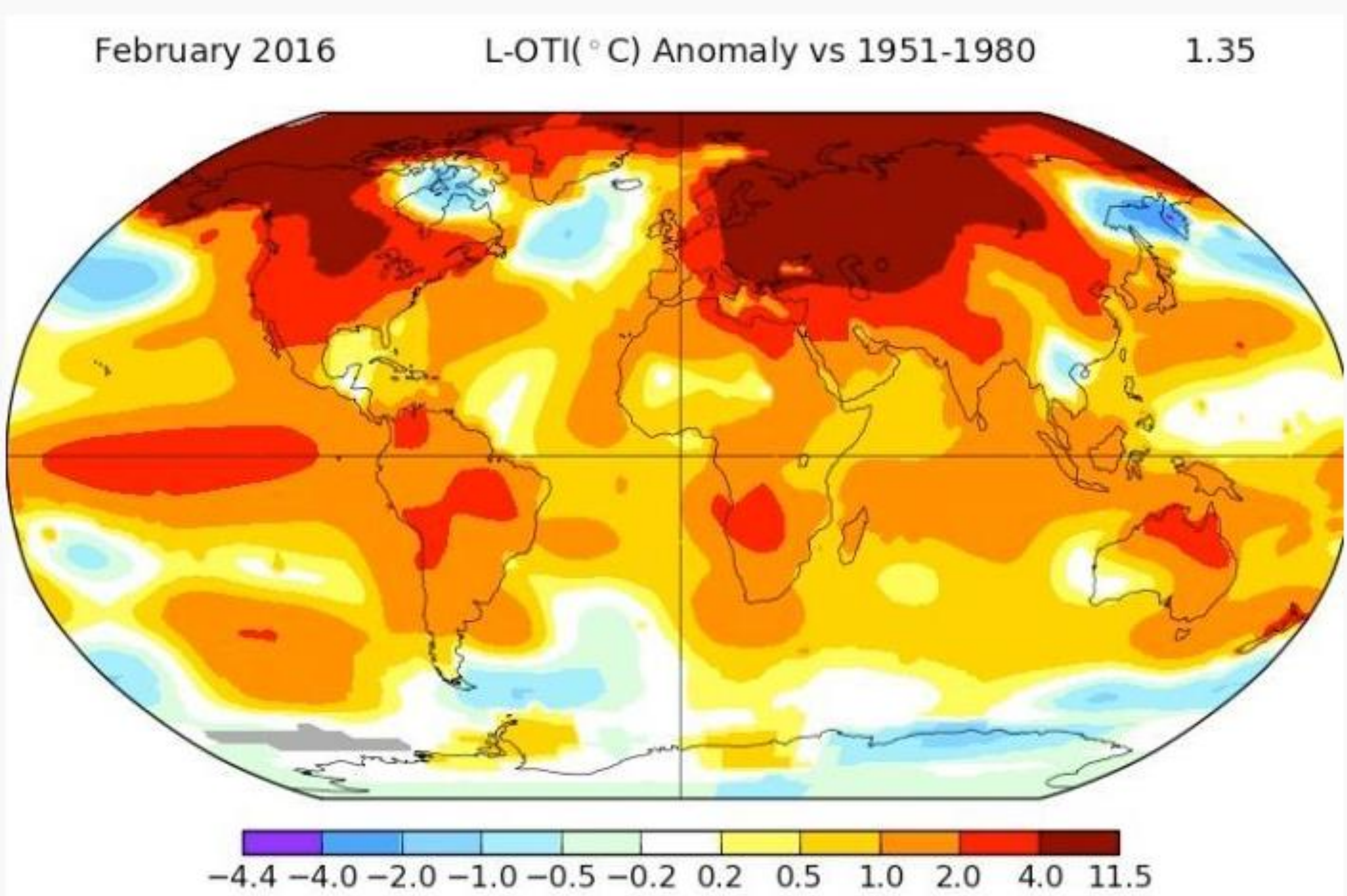
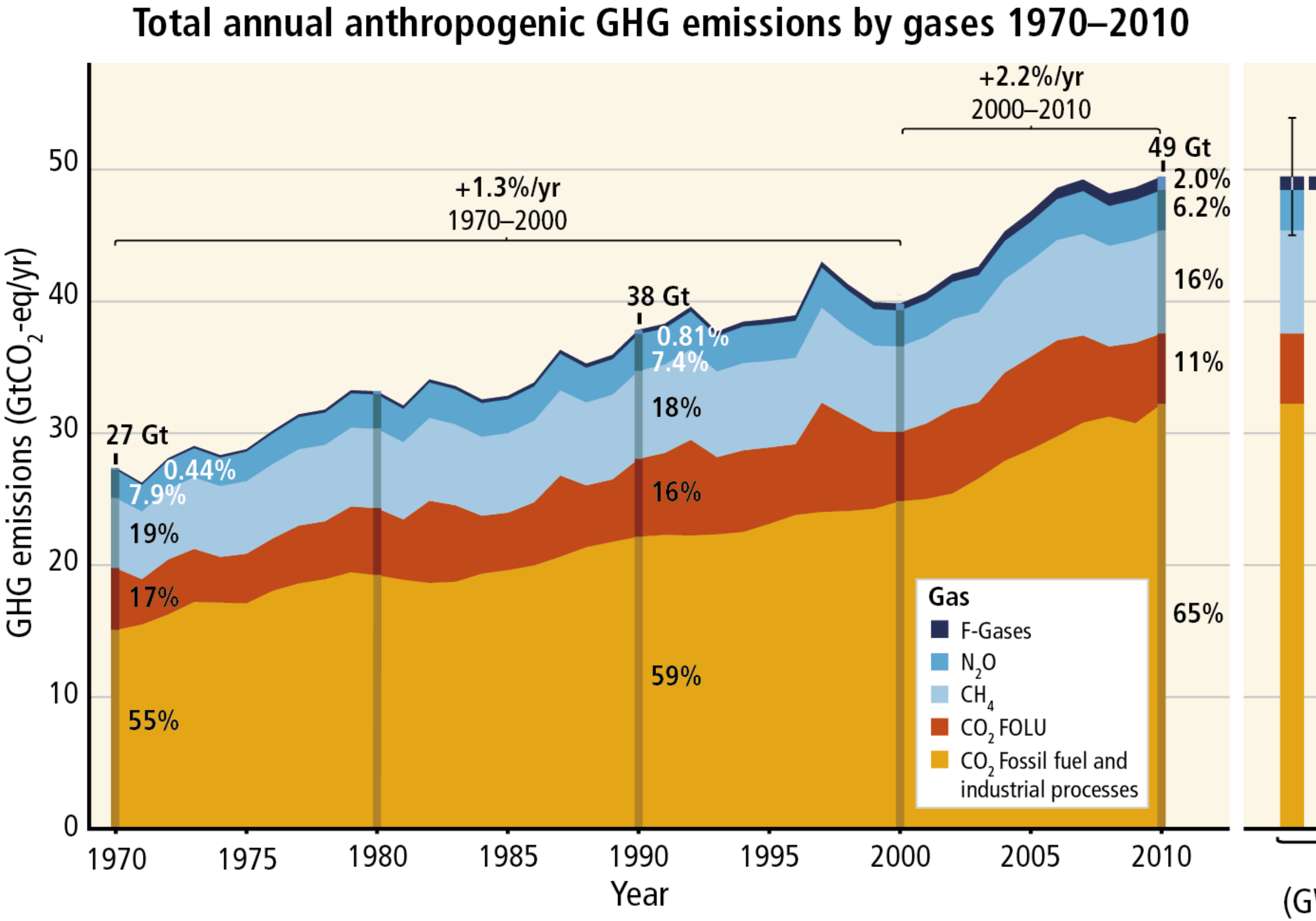
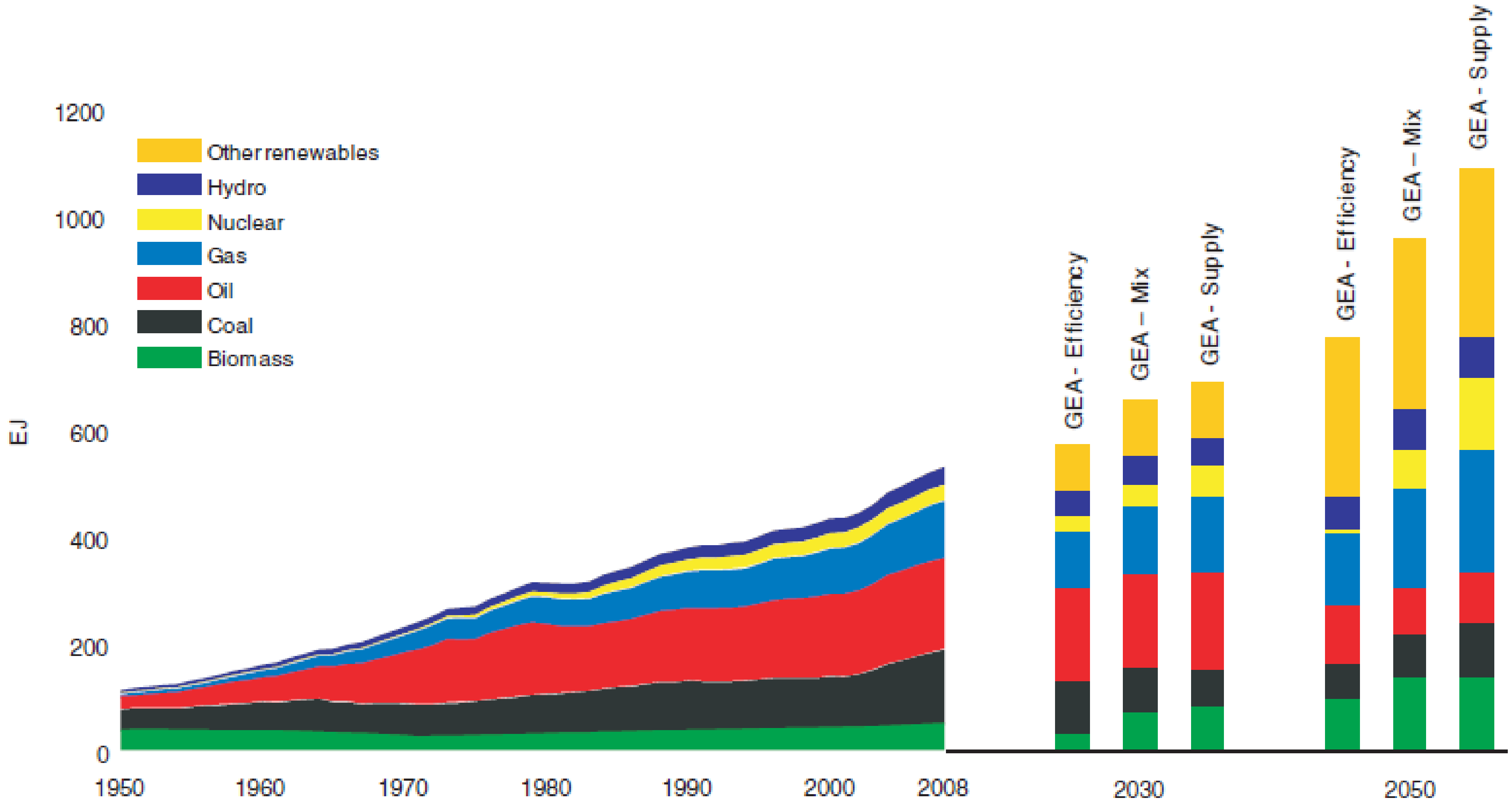


PHOTO: NASA's analysis of satellite data shows extreme hot spots across the Arctic, Russia, and northern North America.



http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf

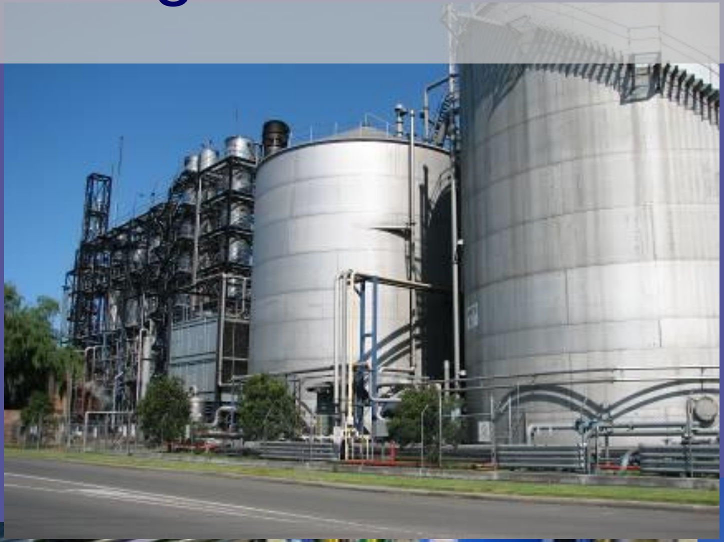


Global Energy Assessment 2012

Also: IPCC AR5: Bioenergy a key technology to meet 2° C target
Technical potential for forest bioenergy in 2050: 50-100 EJ

Bioenergy

- Biomass for heat, electricity
- Sugar, starch for ethanol
- Oilseeds for biodiesel
- 2nd generation biofuels



Forests for Bioenergy

Bioenergy

Feedstocks:

- Urban green waste
- Manure, biosolids
- Food processing residues
- Sawmill residues
- Forest harvest residues?
- Crop stubble?
- Purpose-grown crops?

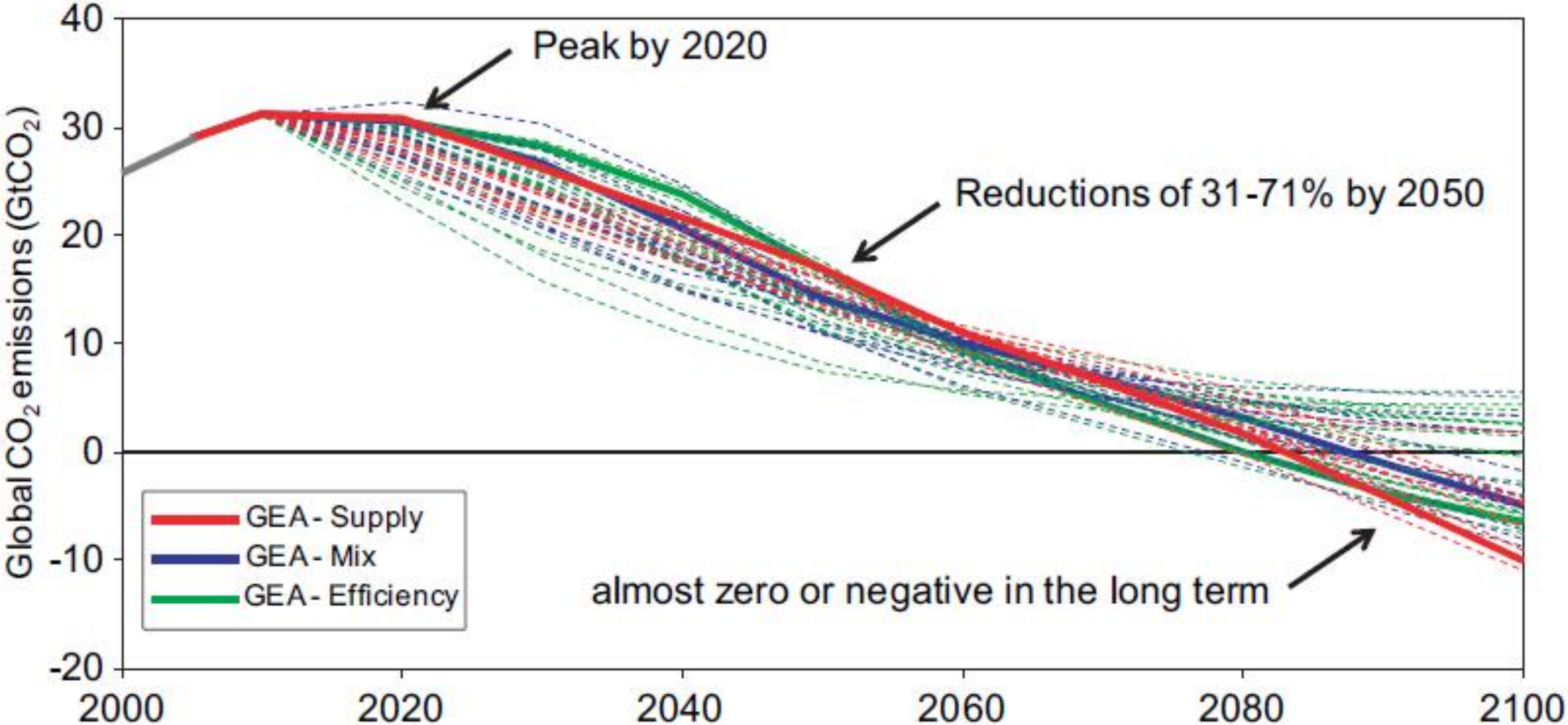



Pyrolysis – bioenergy and biochar

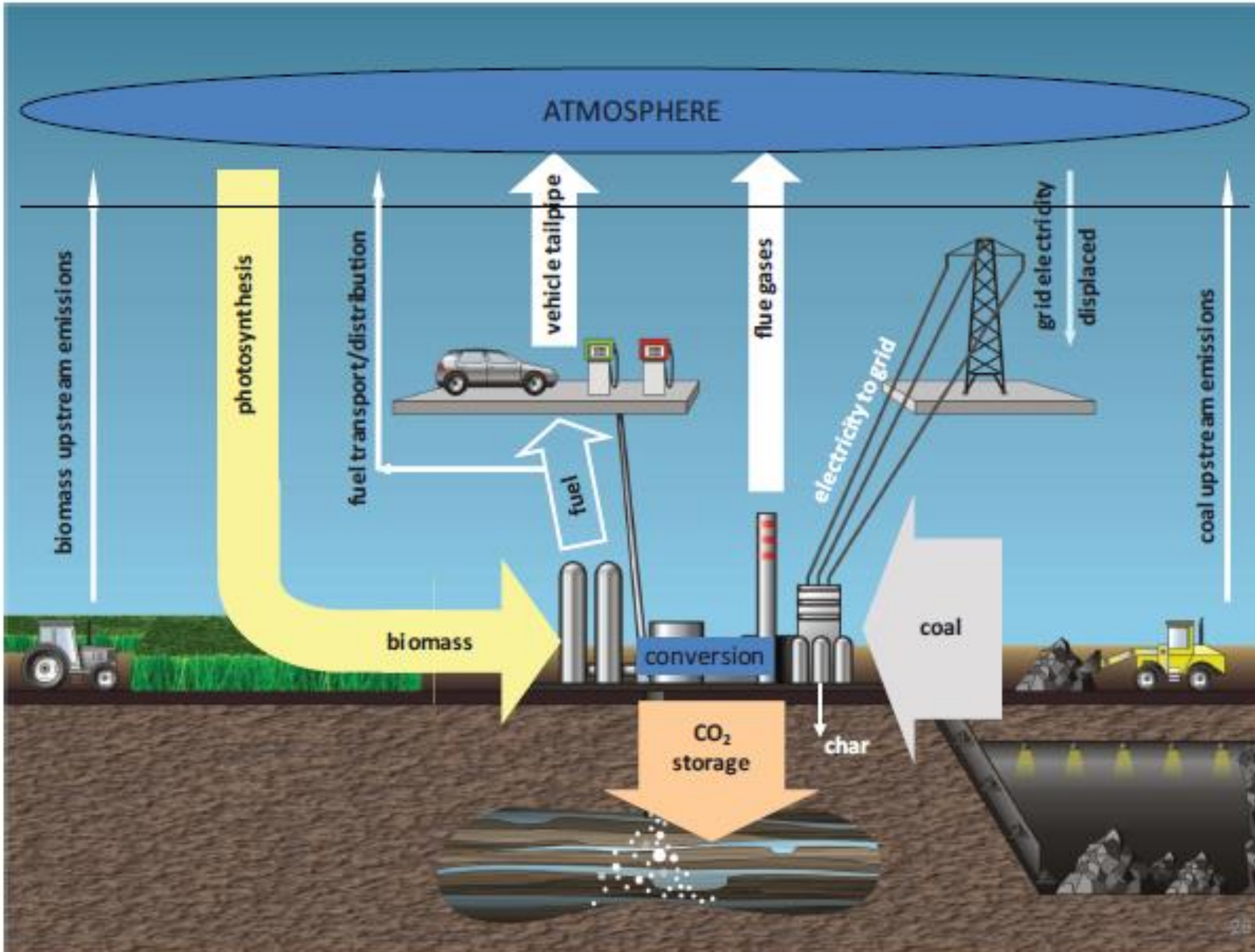
Too late to avoid **2° C ?**

- 2° C: target of the Copenhagen Accord to avoid catastrophic outcomes
- Already increased by 1 degree
- At least 0.5 degree unavoidable
- Without immediate and drastic action we cannot meet the 2° C target

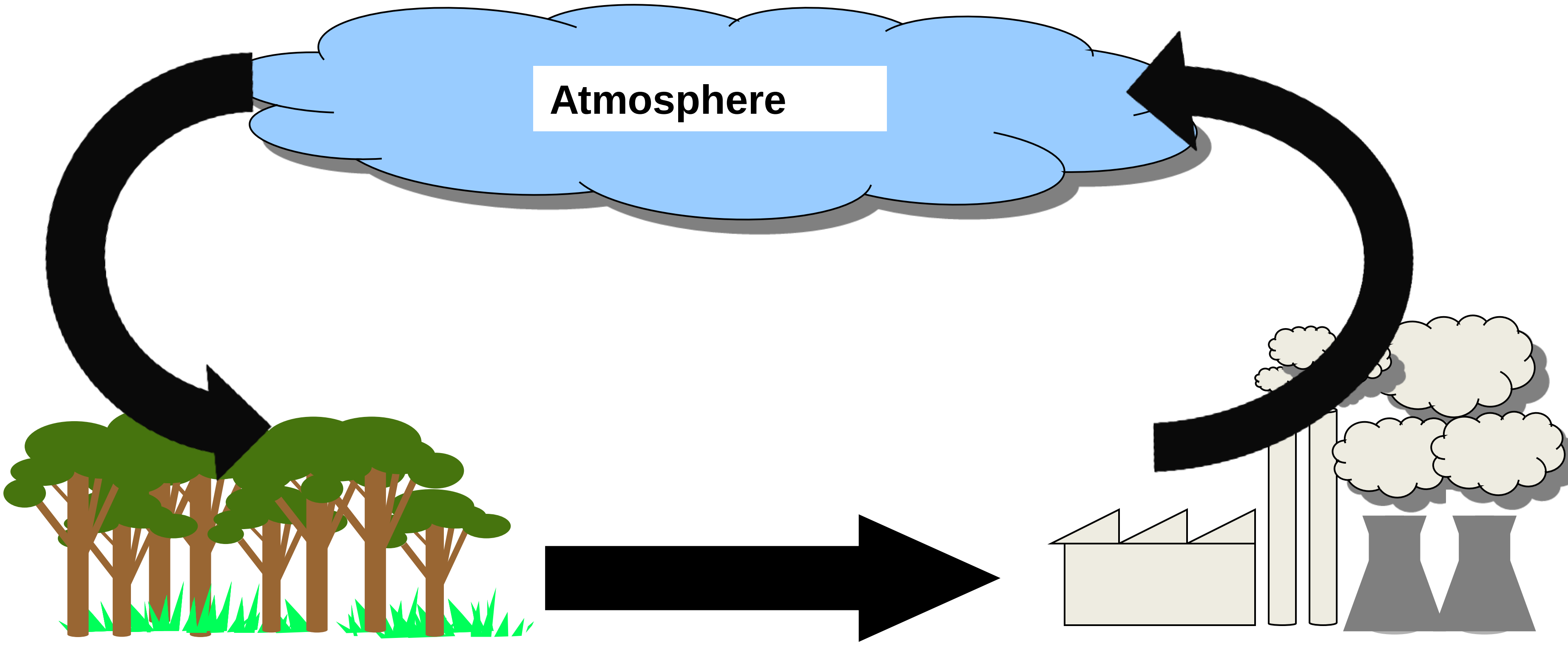
Negative emissions required to meet **2° C target**



Global Energy Assessment 2012



Global Energy Assessment 2012



Bioenergy – "carbon neutral" ?

Manomet Center for Conservation Sciences JUNE 2010 NCI-2010-03

NATURAL CAPITAL INITIATIVE AT MANOMET REPORT

MANOMET Center for Conservation Sciences

BIOMASS SUSTAINABILITY AND CARBON POLICY STUDY

CONTACT IN…

Manomet C…

Bioenergy

a carbon accounting time bomb

BirdLife International · European Environmental Bureau · Transport & Environment

Biomass better than coal? War over carbon accounting erupts

In Washington, the Environment Working Group has released a study that claims the impacts of the American Clean Energy and Security Act (ACESA)—which has already passed the House of Representatives—would require the equivalent of cutting between 18 and 30 million acres by 2025, and up to 50 million acres by 2030.

"From Maine to Washington state, from Ohio to Florida," the EWG report says, "electric utilities have been embracing "biomass power" as a way to reduce dependence on coal and other fossil fuels and to meet ambitious goals for limiting greenhouse ga… th… ar… hu…

CLIMATE CHANGE

Fixing a Critical Climate Accounting Error

Timothy D. Searchinger,[1]* Steven P. Hamburg,[2]* Jerry Melillo,[3] William Chame… Petr Havlik,[5] Daniel M. Kammen,[6] Gene E. Likens,[7] Ruben N. Lubowski,[2] Micha… Michael Oppenheimer,[1] G. Philip Robertson,[8] William H. Schlesinger,[7] G. Davi…

Rules for applying the Kyoto Protocol and national cap-and-trade laws contain a… but fixable, carbon accounting flaw in assessing bioenergy.

The accounting now used for assessing compliance with carbon limits in the … not count changes in emis… use when biomass for energ…

“Carbon debt” some papers:

- Holtsmark, B. (2012). “Harvesting in boreal forests and the biofuel carbon debt.” Climatic Change 112(2): 415-428.
- Hudiburg, T. W., Law B. E., Wirth C. and Luyssaert S. (2011). “Regional carbon dioxide implications of forest bioenergy production.” Nature Clim. Change 1(8): 419-42
- Lamers P., Junginger M., (2013) " The ‘debt’ is in the detail: a synthesis of recent temporal forest carbon analyses on woody biomass for energy." Biofuels, Bioproducts, and Biorefining, in press.
- McKechnie, J., S. Colombo, J. Chen, W. Mabee and H. L. MacLean (2011). “Forest bioenergy or forest carbon? Assessing trade-offs in greenhouse gas mitigation with wood-based fuels.” Environmental Science and Technology 45(2): 789-795.
- Schulze, E.-D., C. Körner, B. E. Law, H. Haberl and S. Luyssaert (2012). “Large-scale bioenergy from additional harvest of forest biomass is neither sustainable nor greenhouse gas neutral.” GCB Bioenergy: 4(6): 611-616.
- Searchinger, T et al (2009). “Fixing a critical climate accounting error.” Science 326(5952): 527-528.
- Walker, T et al (2010). Massachussets Biomass Sustainability and Carbon Policy Study. Manomet Center for Conservation Sciences.
- Zanchi, G., N. Pena and D. N. Bird (2010). The upfront carbon debt of bioenergy. Graz, Austria, Joanneum Research.

Wood worse than coal?

Reference energy system

- Fossil energy reference
- Conversion efficiency
- CO_2/MJ

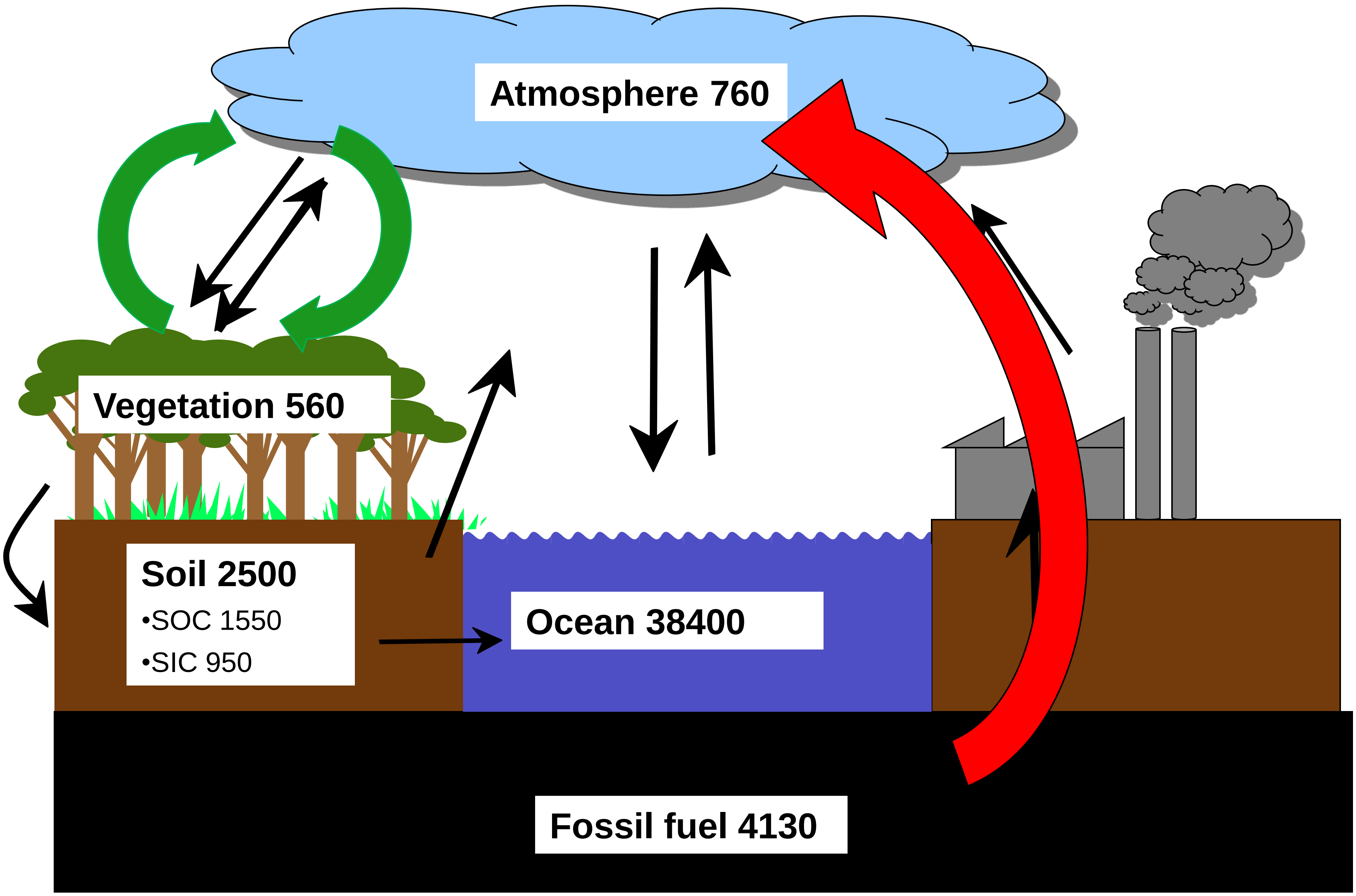
Displacement factor

= $efficiency_{bio}$ /$efficiency_{ref}$ x $CO2_{ref}$/$CO2_{bio}$

- Nearly always <1

Global carbon pools

Units are Pg C (10^{15}g or Gt)



After Carlson et al 2001; data from Lal, 2008

Accounting error in climate treaties could lead to more deforestation

Quick fix could prevent cut forests from being treated like other biomass

'Fixable' error undercuts climate laws

CLIMATE CHANGE

Fixing a Critical Climate Accounting Error

Timothy D. Searchinger,[1]* Steven P. Hamburg,[2]* Jerry Melillo,[3] William Chameides,[4] Petr Havlik,[5] Daniel M. Kammen,[6] Gene E. Likens,[7] Ruben N. Lubowski,[2] Michael Obersteiner,[5] Michael Oppenheimer,[1] G. Philip Robertson,[8] William H. Schlesinger,[7] G. David Tilman[9]

Rules for applying the Kyoto Protocol and national cap-and-trade laws contain a major, but fixable, carbon accounting flaw in assessing bioenergy.

The accounting now used for assessing compliance with carbon limits in the Kyoto Protocol and in climate legislation contains a far-reaching but fixable flaw that will severely undermine greenhouse

not count changes in emissions from land use when biomass for energy is harvested or grown. This accounting erroneously treats all bioenergy as carbon neutral regardless of the source of the biomass, which may cause large

Kyoto context

- Bioenergy treated as CO_2 neutral in energy sector
- Assumes forest C stock changes included in LULUCF
- Assumes fossil energy inputs in energy sector
- Assumes non-CO_2 included in agriculture
- Correct where these assumptions are valid

But

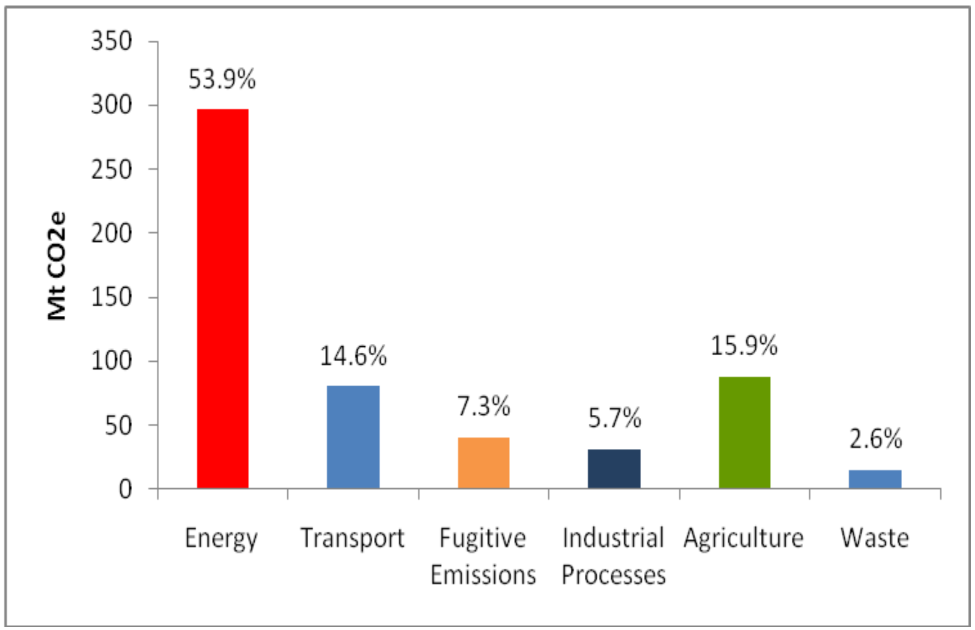
- – Only Annex I countries covered
- – Previously didn't count forest C stock change (KP-1) (but do now KP-2)

Future (Paris Agreement) all countries covered

Inventory context

- Inventory reporting
- UNFCCC
- All parties

- GHG accounting
- Kyoto Protocol
- Annex I parties



Sectoral boundaries
National scale
IPCC Guidelines

Annual emissions / removals

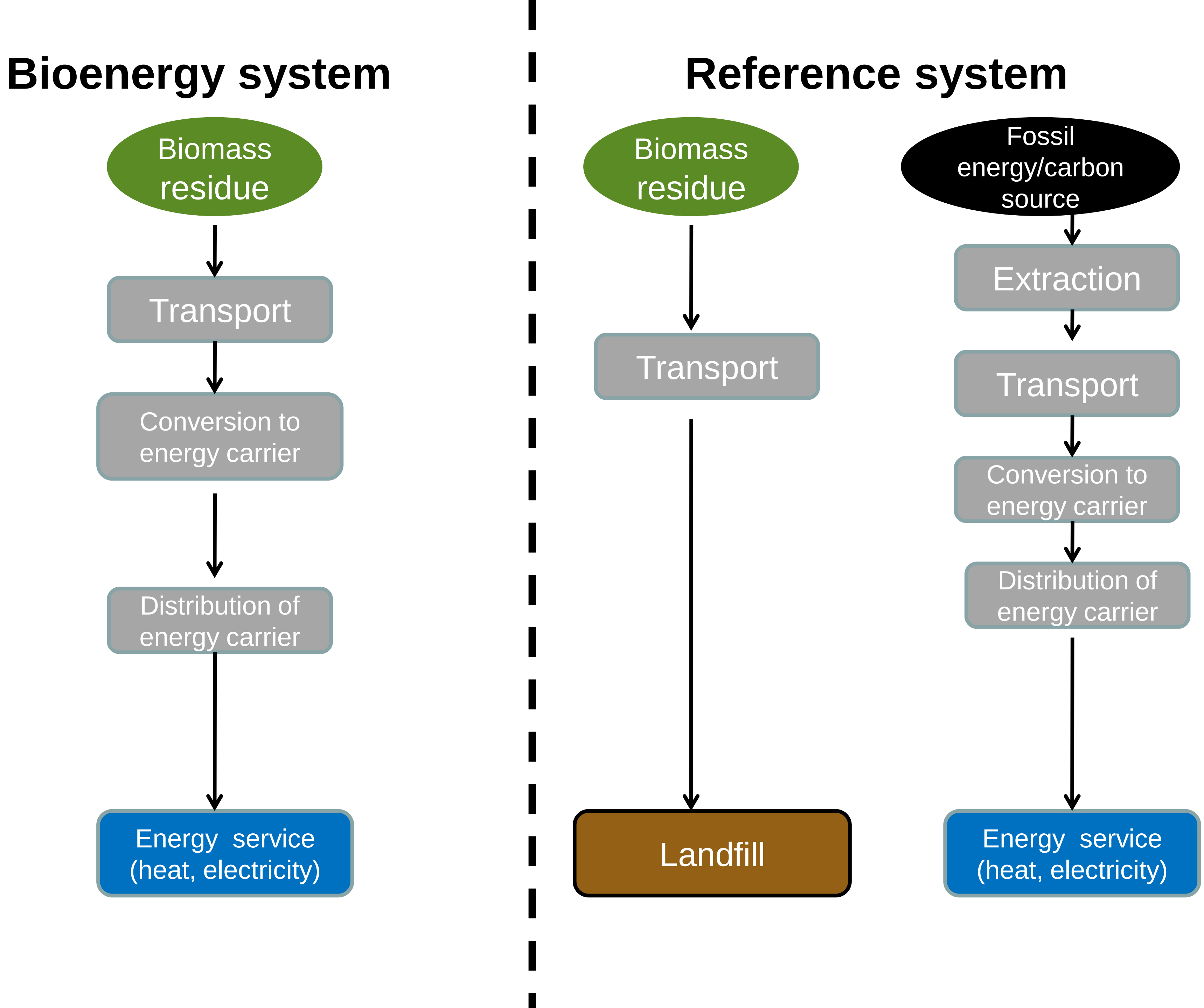
Project context

- Offsets
- Project credits
- Businesses

- LCA
- Carbon labels
- Products or organisations

Cradle to grave boundaries
Farm/forest scale
Schemes, Guidelines, Standards

Emissions reduction, removal enhancement



Bioenergy system
Biomass residue
Transport
Conversion to energy carrier
Distribution of energy carrier
Energy service (heat, electricity)
Reference system
Biomass residue
Transport
Landfill
Fossil energy/carbon source
Extraction
Transport
Conversion to energy carrier
Distribution of energy carrier
Energy service (heat, electricity)

Reference land use

- Timber without residue harvest?
- Conservation forest?

With natural disturbance?

- Purpose-grown crop?
- Grown on marginal or degraded land?
- When to start the clock?

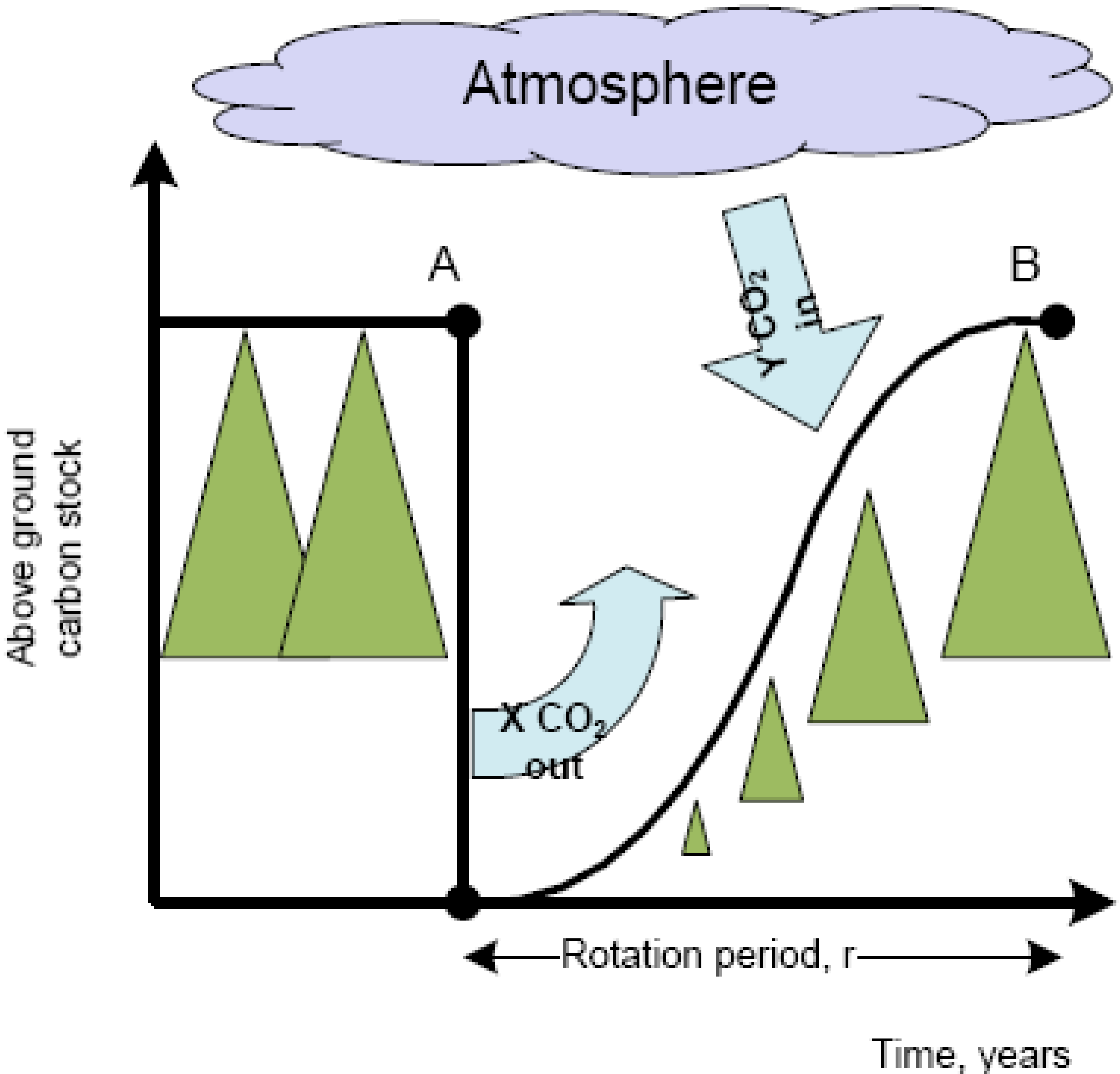
Reference land use

- Timber without residue harvest?
- Conservation forest?

With natural disturbance?

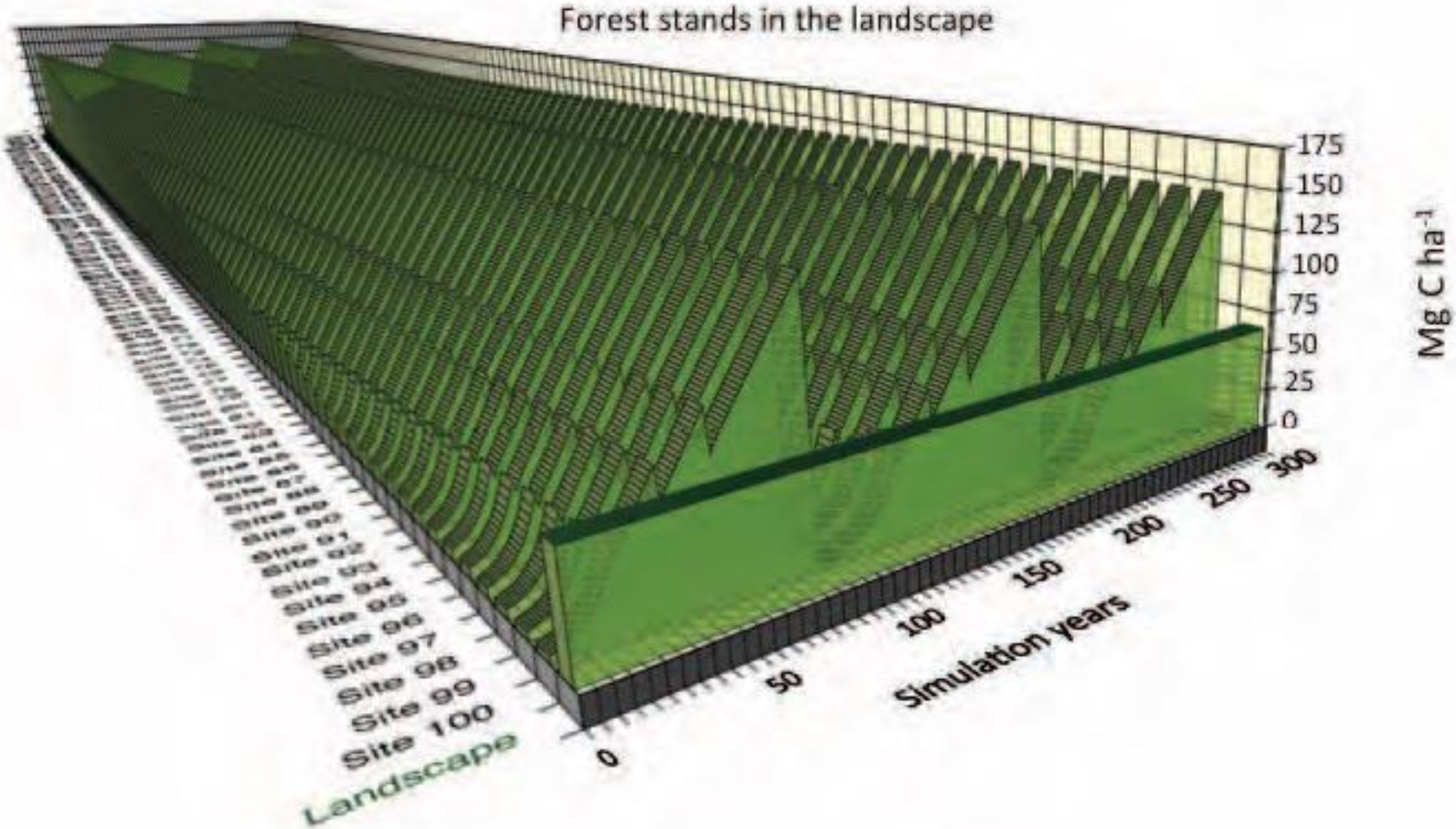
- Purpose-grown crop?
- Grown on marginal or degraded land?
- When to start the clock?

Carbon neutral ≠ Climate neutral?



F Cherubini NTNU

Spatial scale?



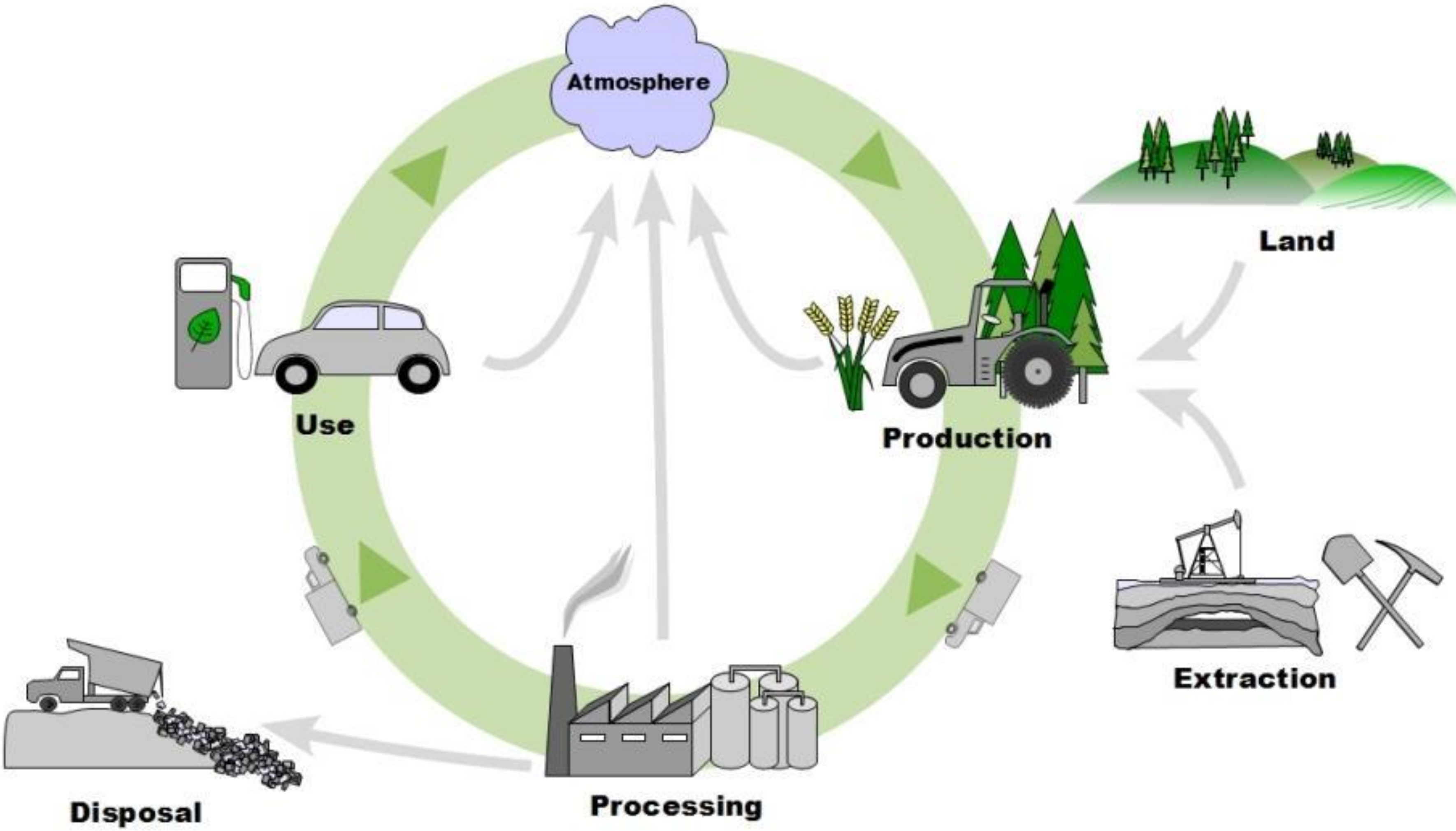
Berndes et al 2011

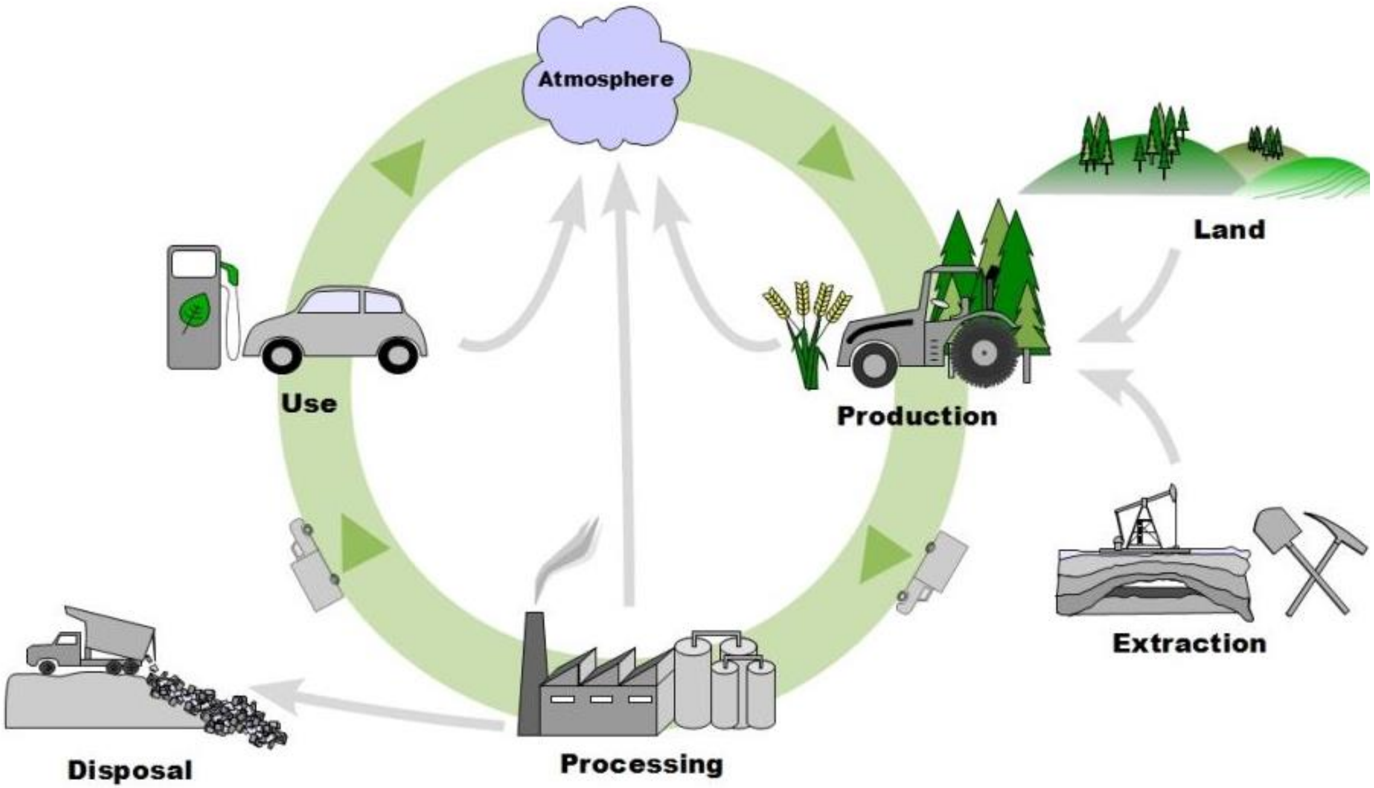
Different perspectives

- Individual operator / forest company / national government / researcher
- Policy development or implementation

- Stand vs landscape scale
- Reference land use: Natural system vs managed system
- Reference energy system: Average vs marginal
- Start clock at planting vs at harvest
- Short term vs long term
- Specific stage vs whole life cycle
- Biomass only vs integrated forest product system

Task 38 focus: Life cycle climate change effects of bioenergy

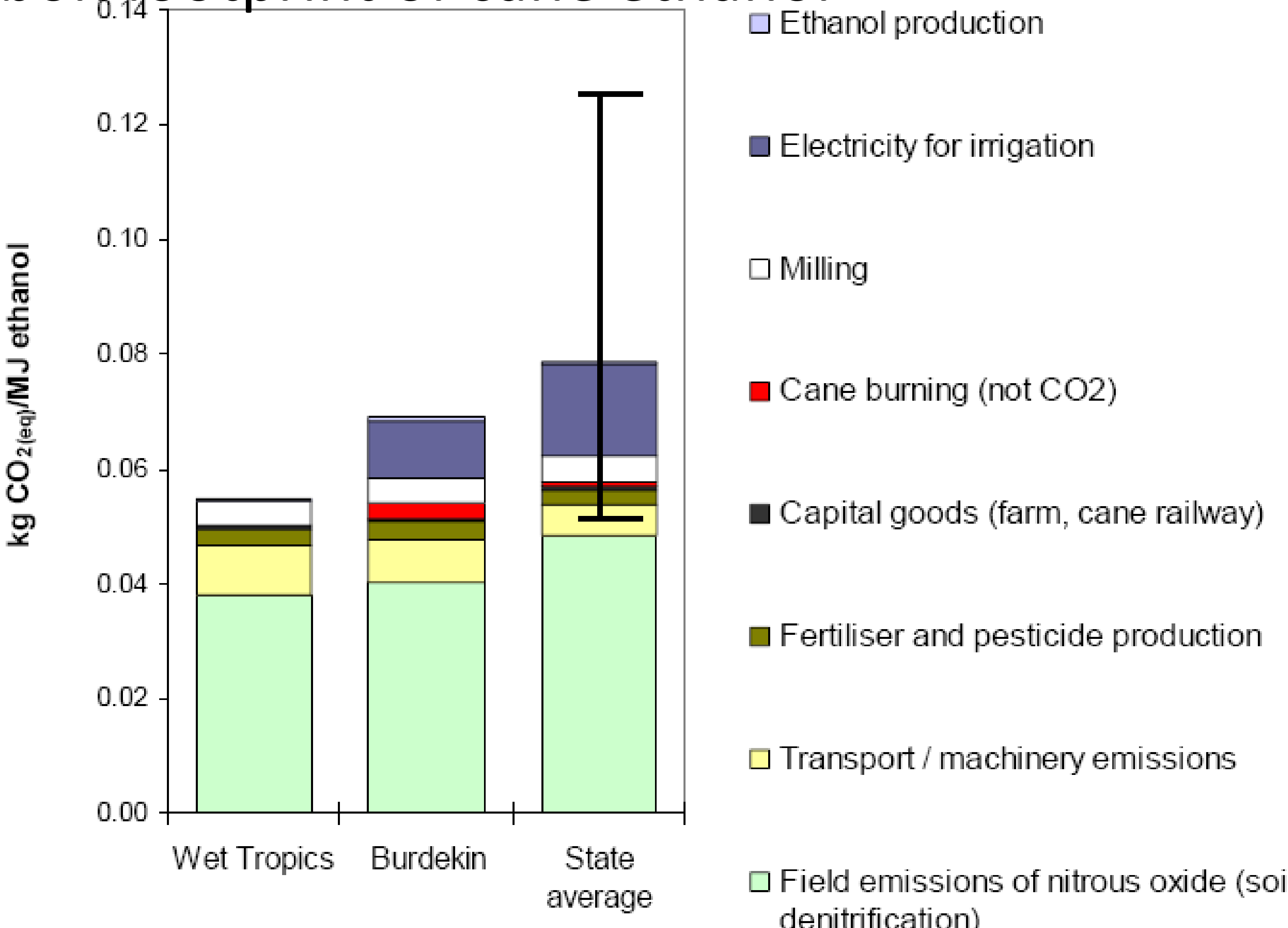




- Production chain emissions
- Non-CO_2 GHGs
- C stock change in biomass, soil (direct effect)
- C stock change in biomass or soil thru ILUC
- Albedo and other biophysical effects on climate

Non-CO_2 GHGs

Carbon footprint of cane ethanol

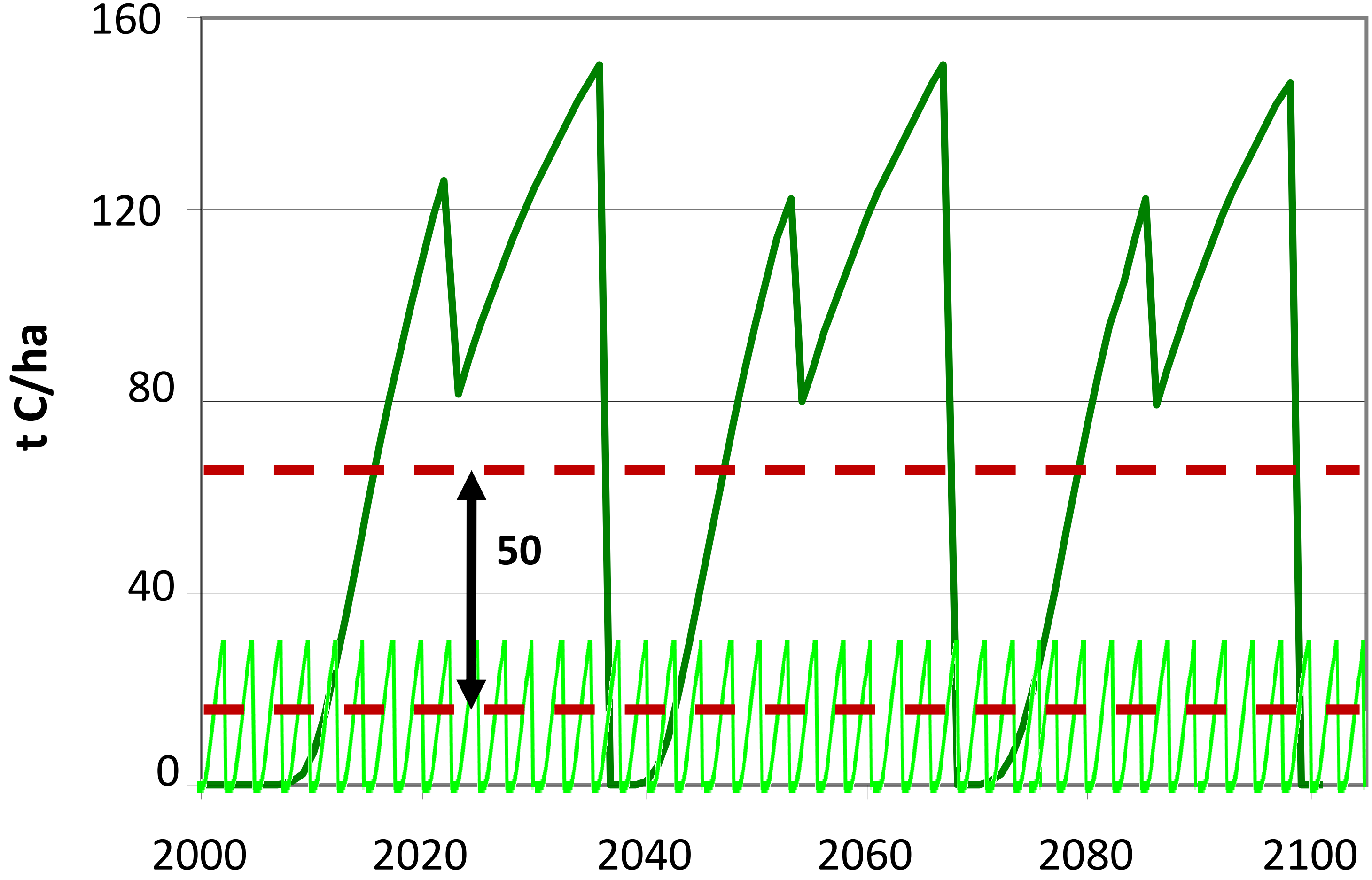


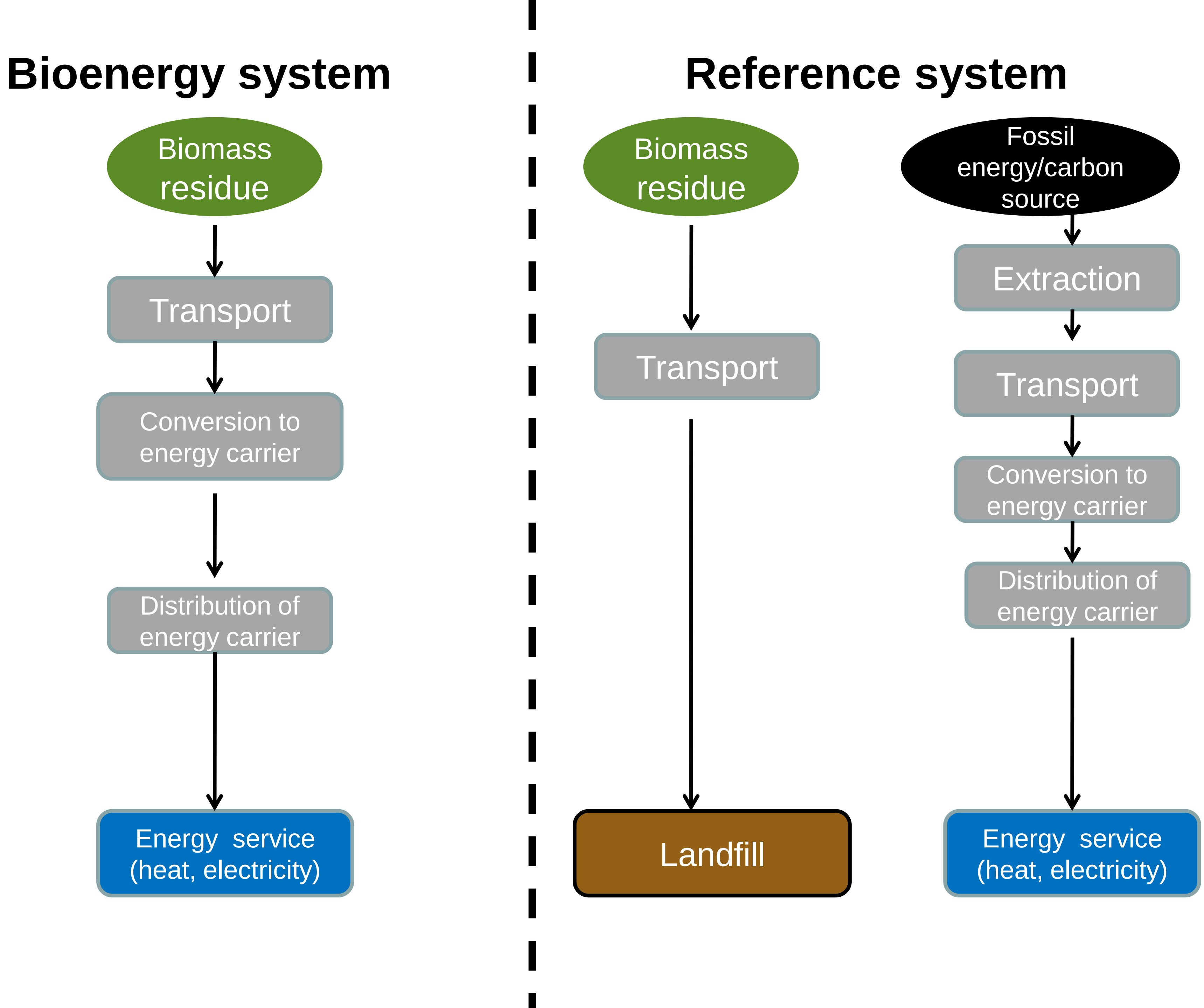
M. Renouf 2007

Consider carbon stock change

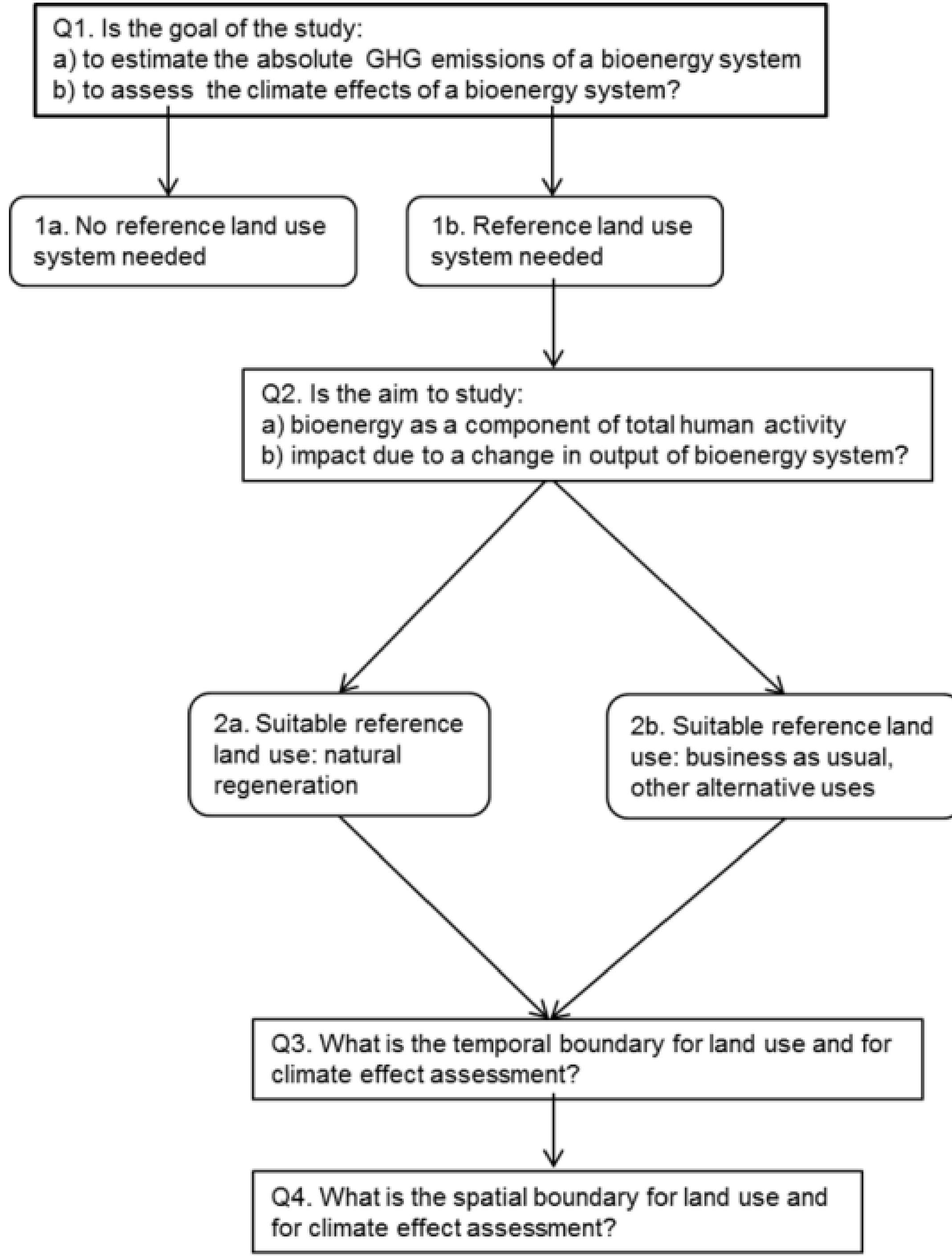
- Include C stock change in biomass or soil
- "direct land use change - dLUC"
- change in management practice
- Δ long term average C stock
  – Biomass
  – Soil carbon

Biomass C stock change




Bioenergy system
Reference system
Biomass residue
Transport
Conversion to energy carrier
Distribution of energy carrier
Energy service (heat, electricity)
Biomass residue
Transport
Landfill
Fossil energy/carbon source
Extraction
Transport
Conversion to energy carrier
Distribution of energy carrier
Energy service (heat, electricity)

Choosing the land use reference system



Koponen et al, in prep

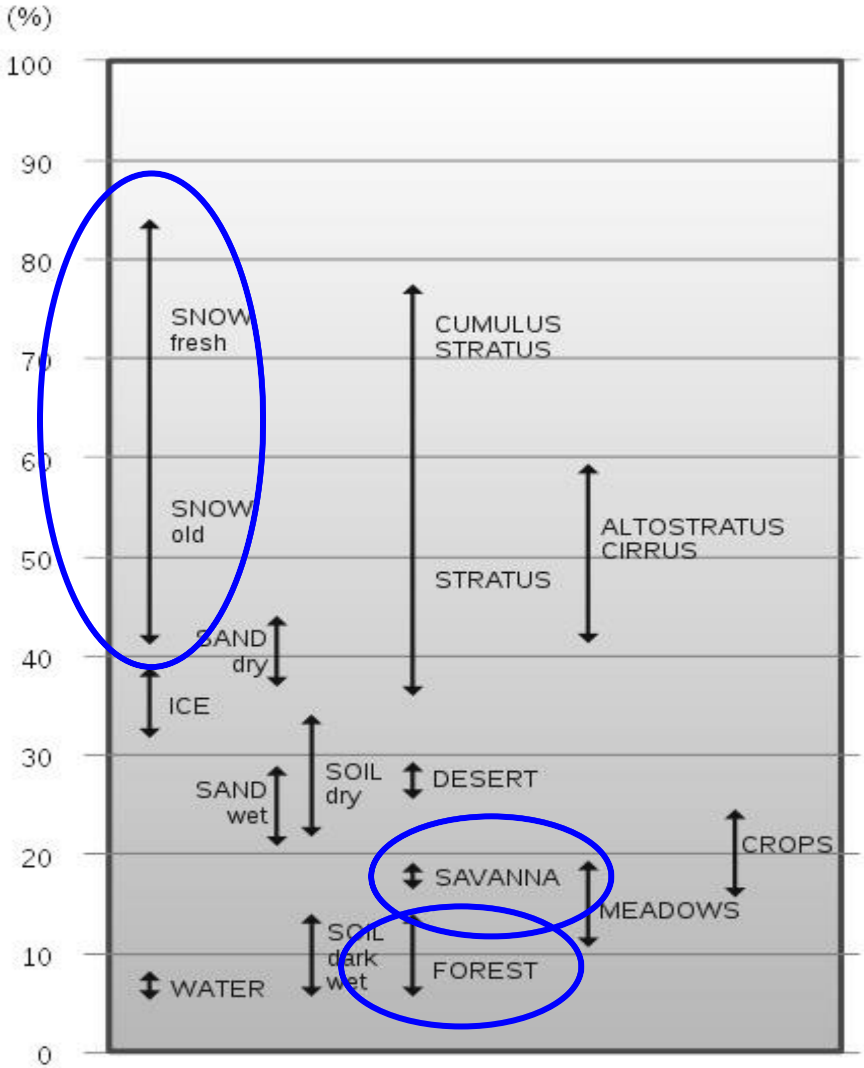
Reference biomass use

(For biomass residues)

- Crop residues, forest slash, thinnings:
Leave in paddock/forest floor?
- Sawmill, Demolition: Landfill?


NIGHTLY AT 8
COLE PORTER'S
MUSICAL
EMPIRE-NICHOLSONS
"FATHER
"INTIMATE

Impact of albedo



Coniferous forest and snow
High latitudes (Austria)

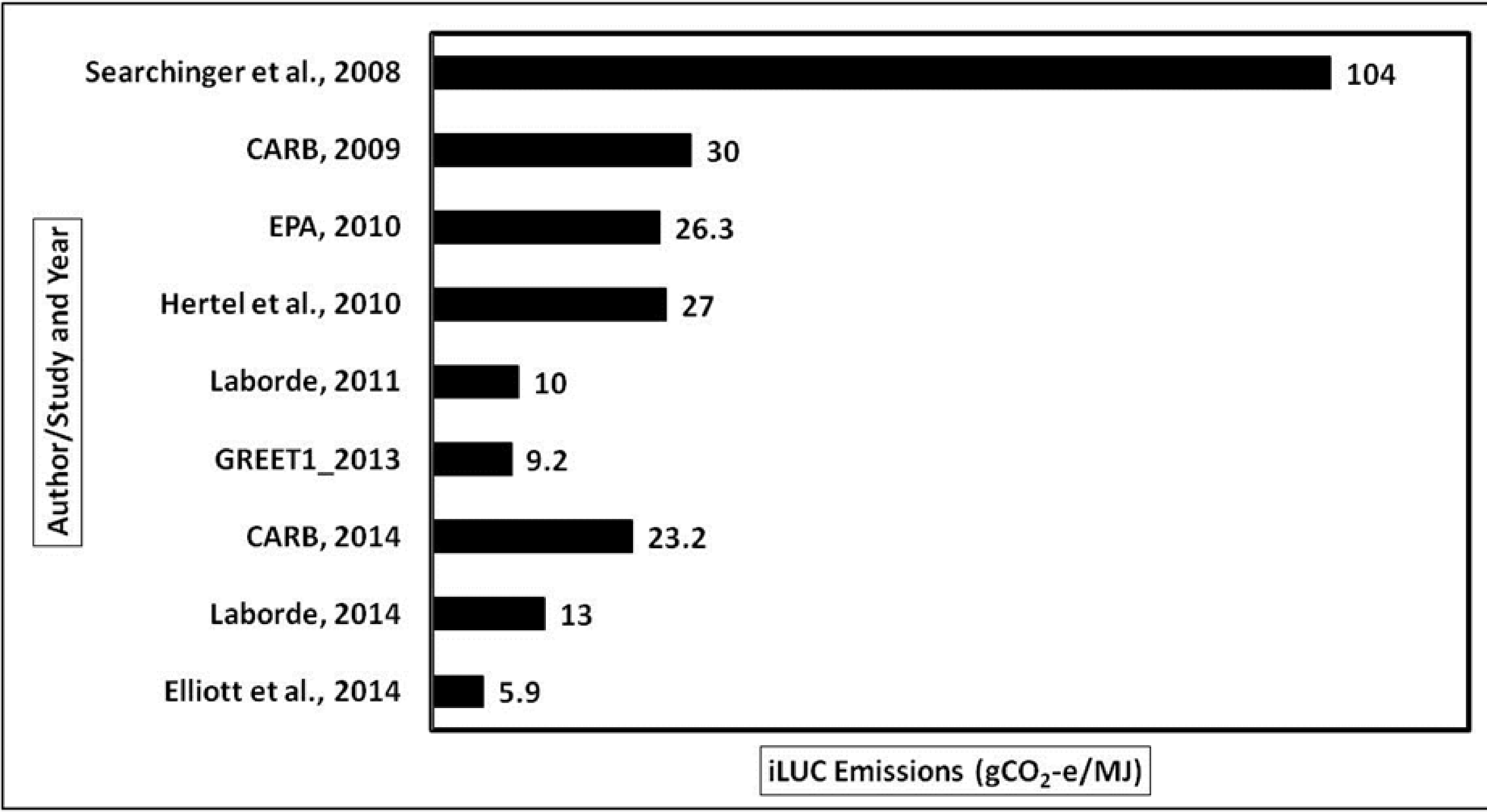
Pine plantations and savanna
Low latitudes (South Africa)

Neil Bird, 2009

Indirect landuse change

- Outside system boundary
- Form of “leakage”
- Off-site carbon stock change, methane, nitrous oxide emissions
  - logging
  - fire
  - drainage of peatlands

Indirect land use change from corn-based ethanol



Units

- Emissions CO_2-e per MJ?
- Biomass and land are limited resources

- Emission reduction per unit biomass
- Emissions reduction per unit land area

Co-products

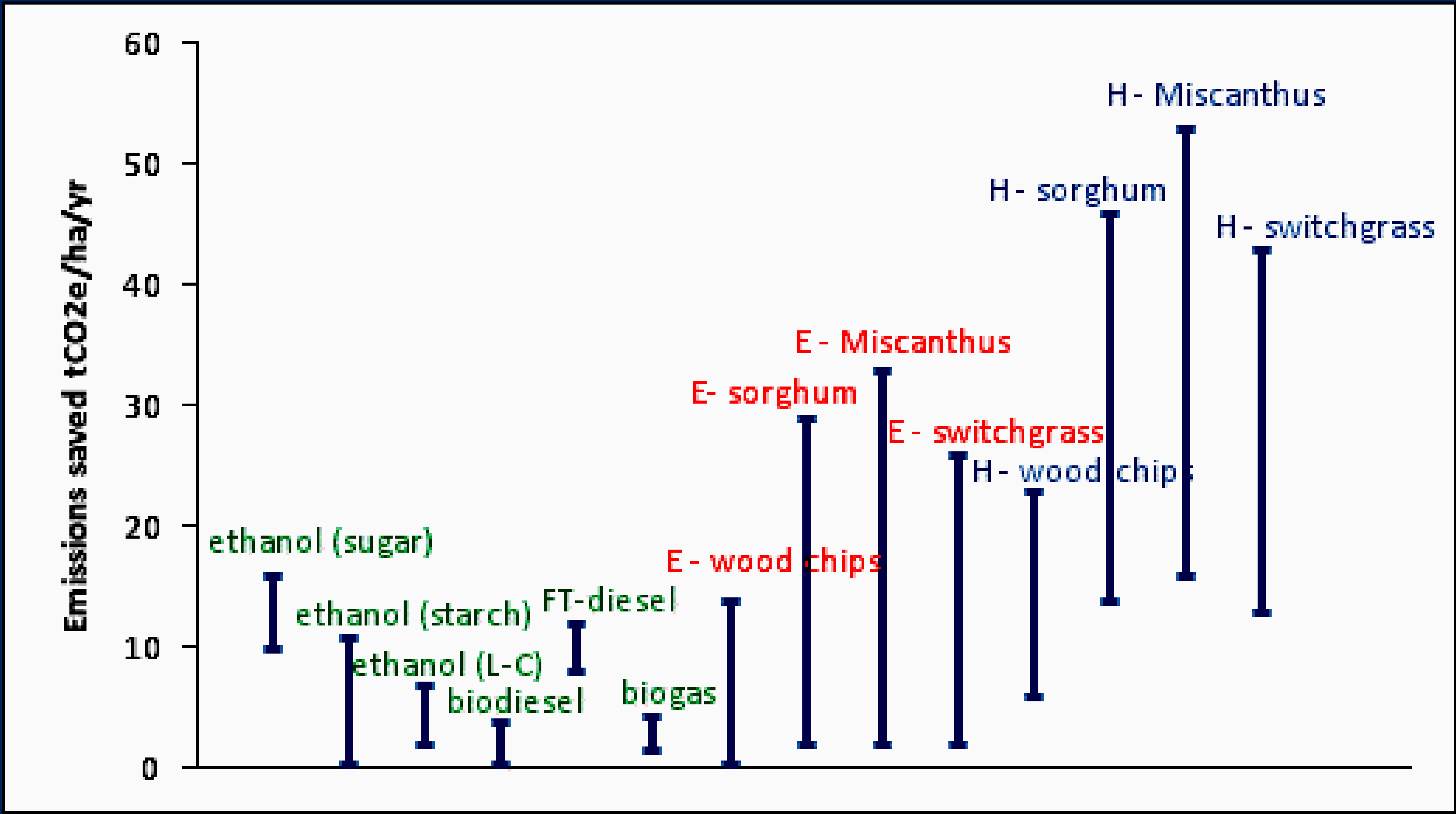
Product Substitution

For each t C in wood products:

GHG emission reduction 1 - 3 t C

Task 38 Standard Methodology

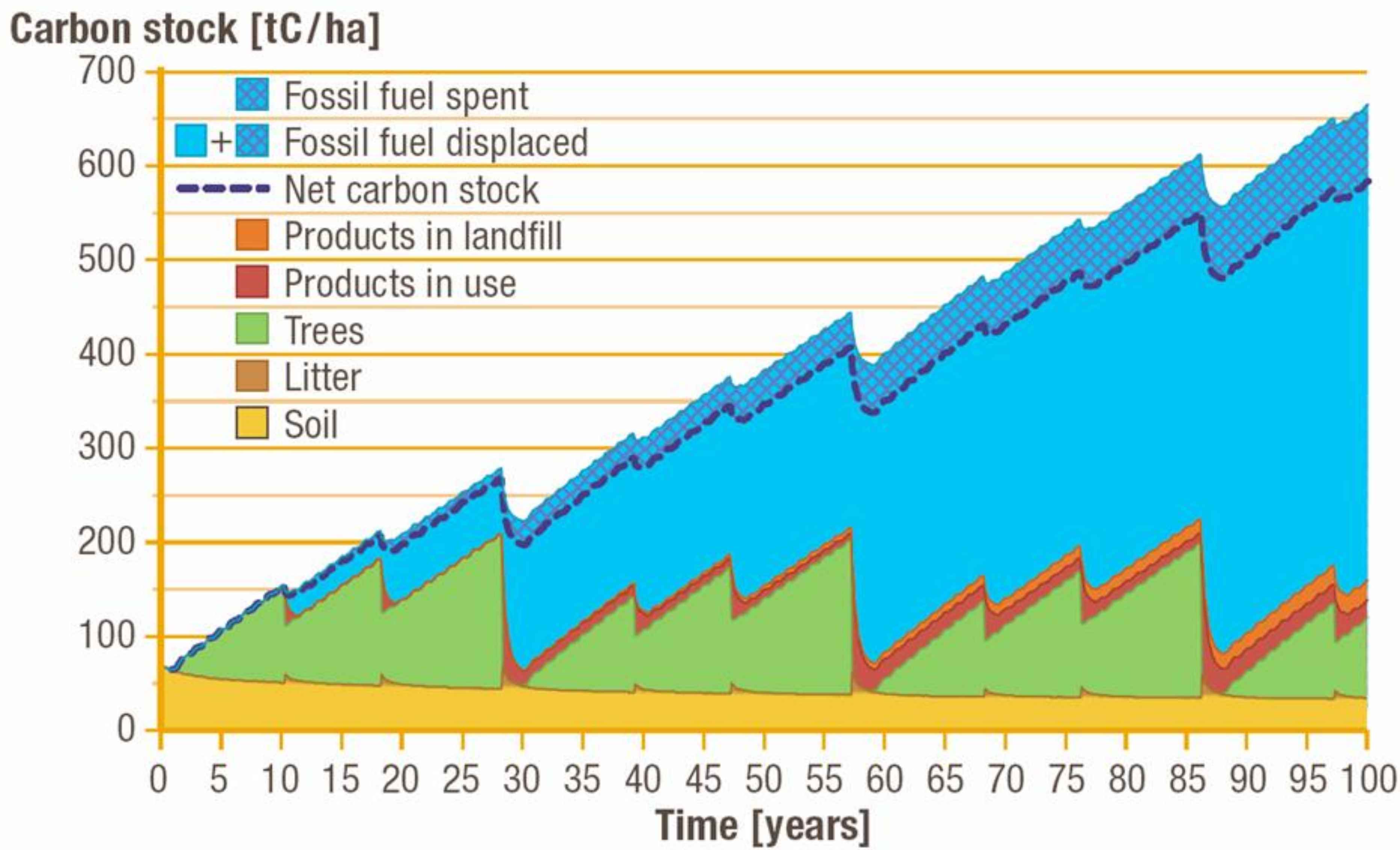
- Compare project with reference
- Consider whole system life cycle
  - Production chain, end of life, co-products
- System boundary
  - Deliver equivalent service
- Scope:
  - All greenhouse gases CO_2 and non-CO_2
  - C stock change in biomass+soil, albedo, ILUC
- Emissions reduction per unit biomass/land
- Result is specific to each situation



Excludes indirect land use change

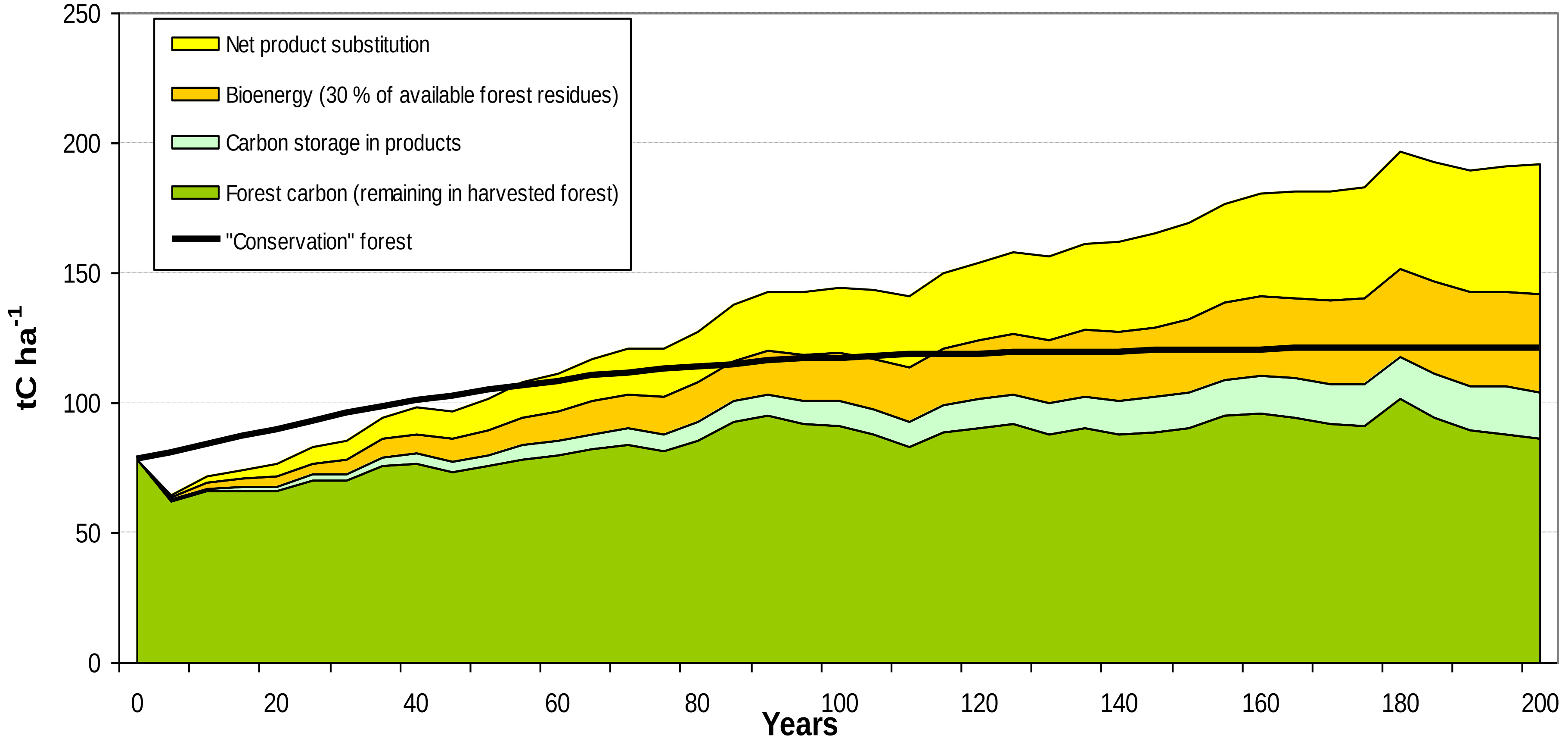
Data from Cherubini et al 2009

Case study Northern NSW: Using logging residues for bioenergy



Cowie, 2005

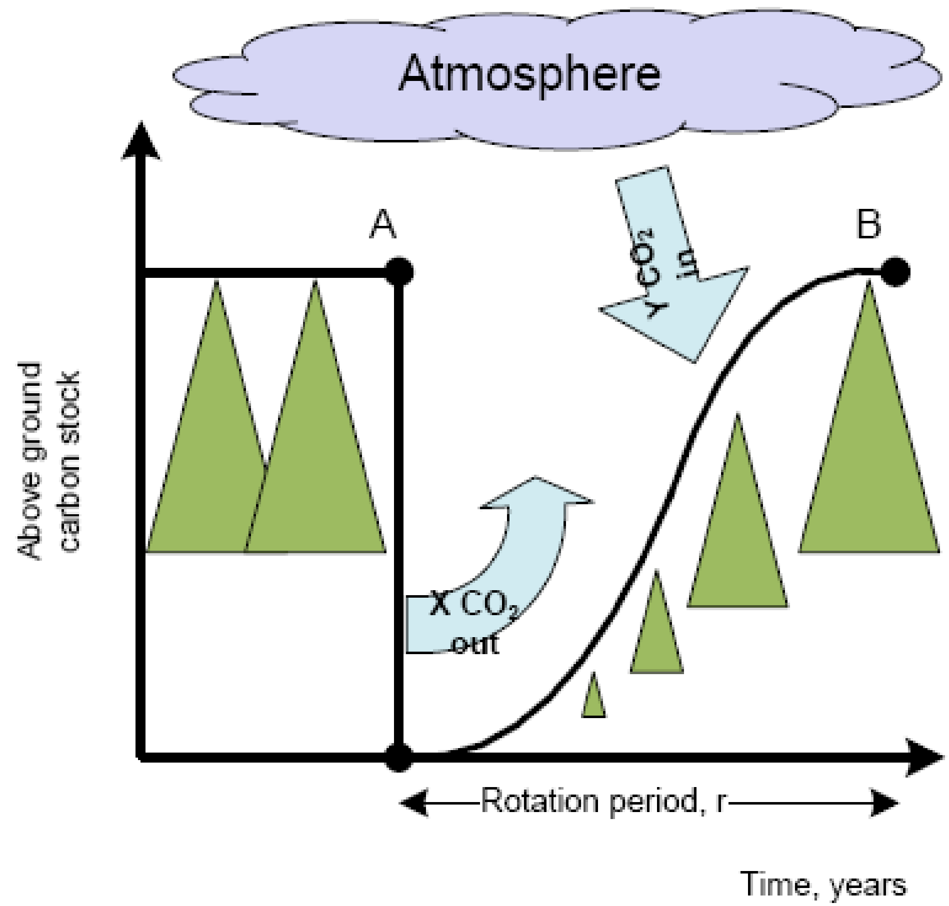
South Coast NSW
Conservation vs managed forest



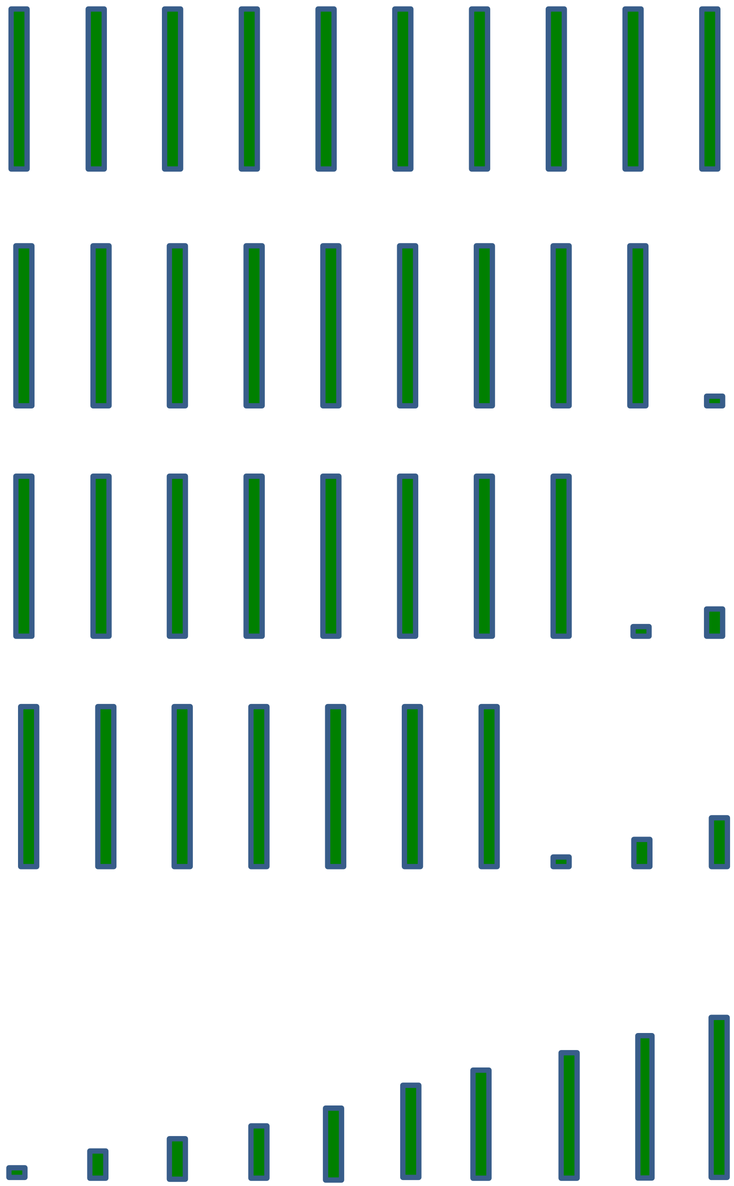
Ximenes et al, 2012

Bioenergy

- Carbon neutral?
  - Maybe nearly
- Climate neutral?
  - Not if you start with existing forest



F Cherubini NTNU



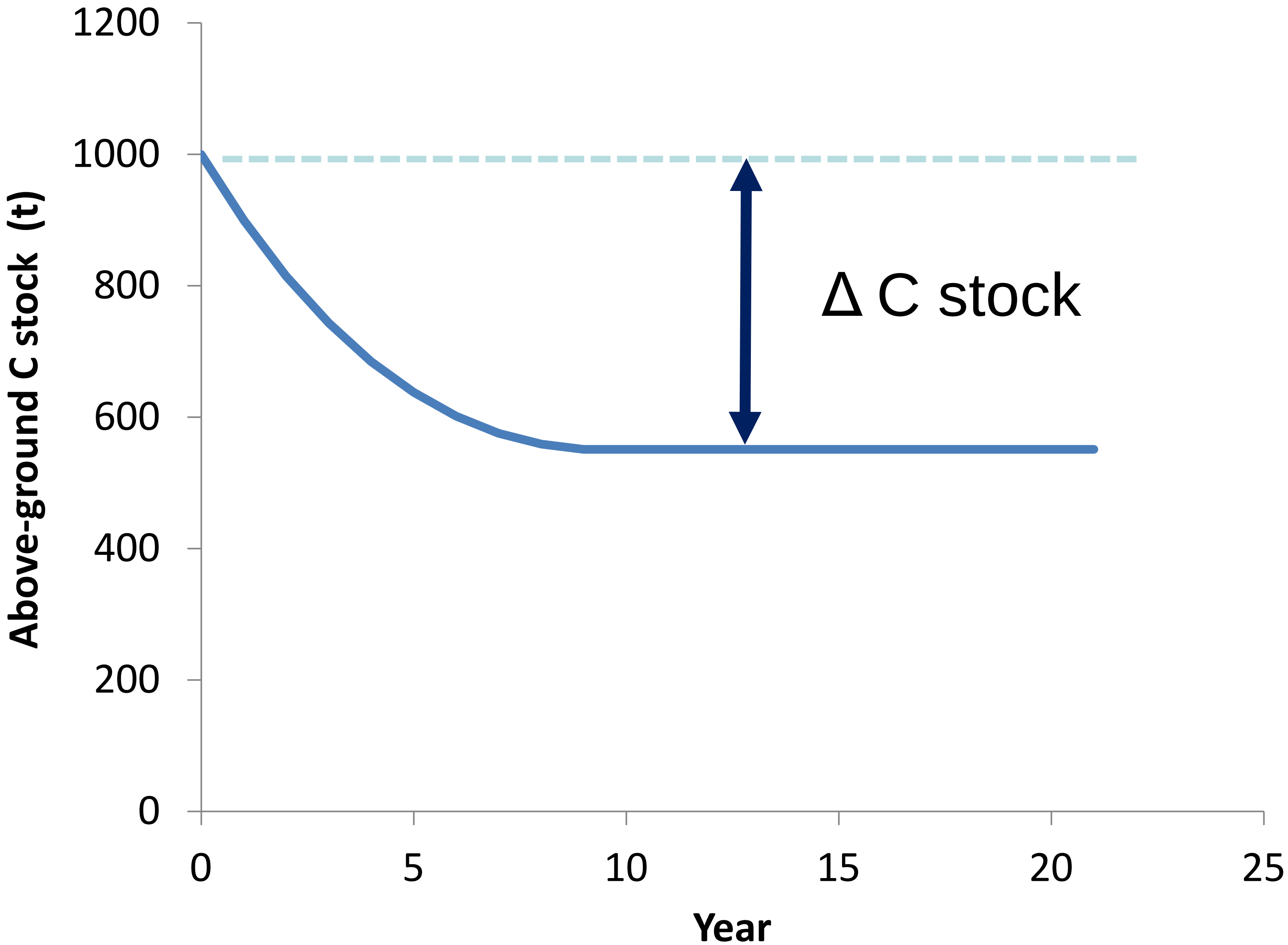
Forest estate, all stands mature, stable C stocks

Year 1: One stand harvested

Year 2: Second stand harvested, first beginning to regrow.

And so on each year for remaining stands

Year 10 – 10th stand harvested. 1st stand regrown, will be harvested in 11th year

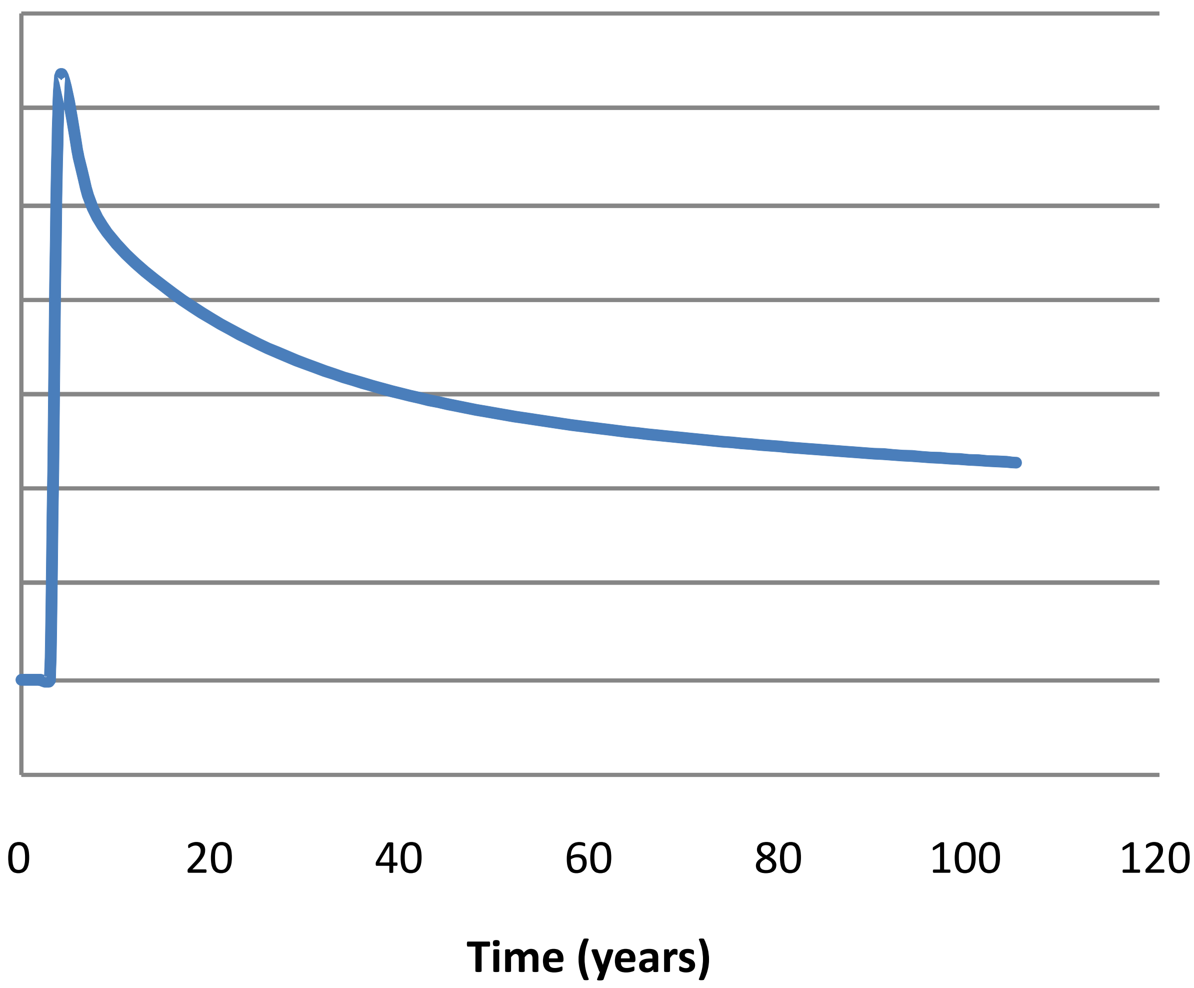


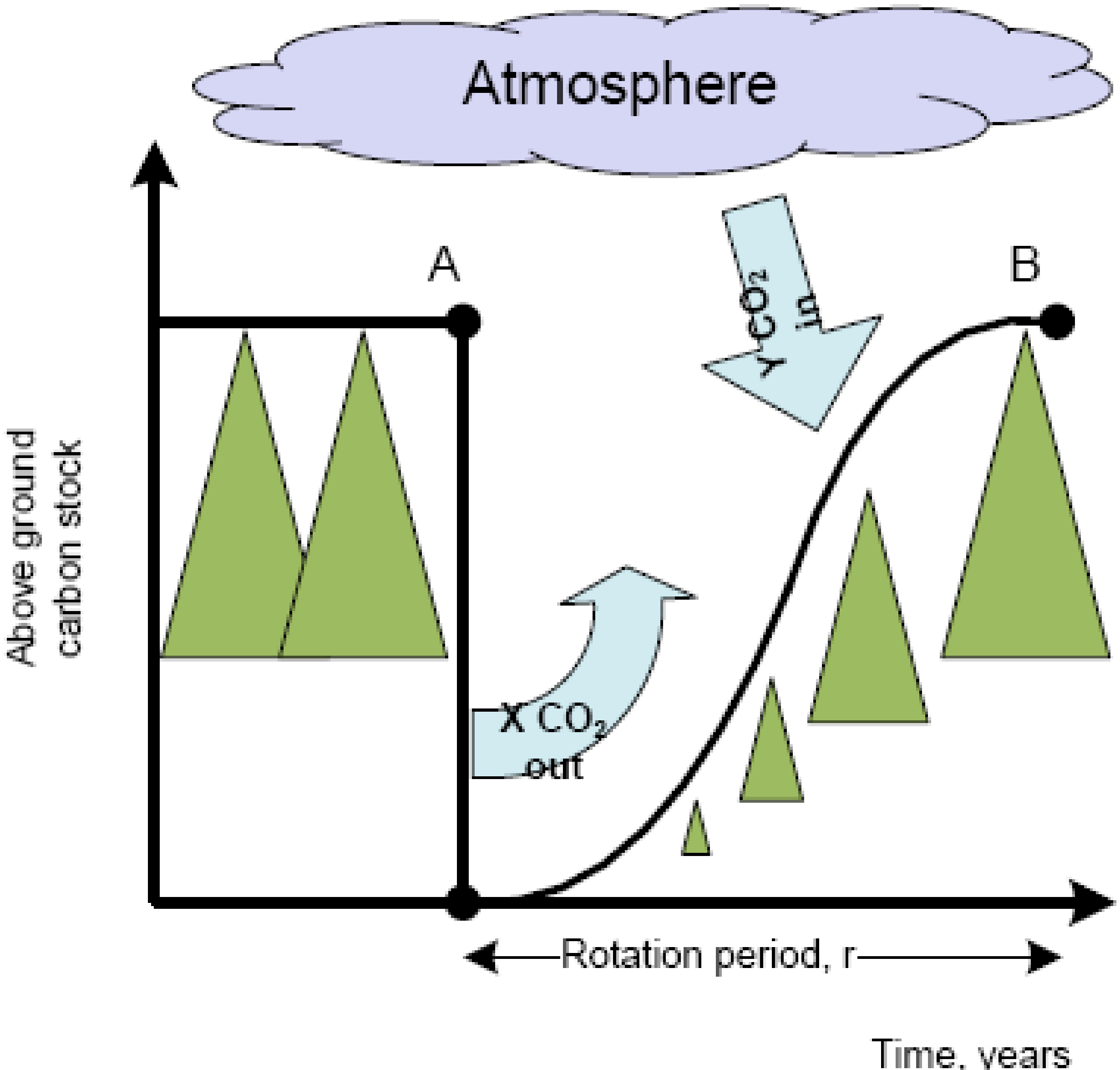
1200
1000
800
600
400
200
0
Above-ground C stock (t)
0
5
10
15
20
25
Year
Δ C stock

Time in Life Cycle Assessment

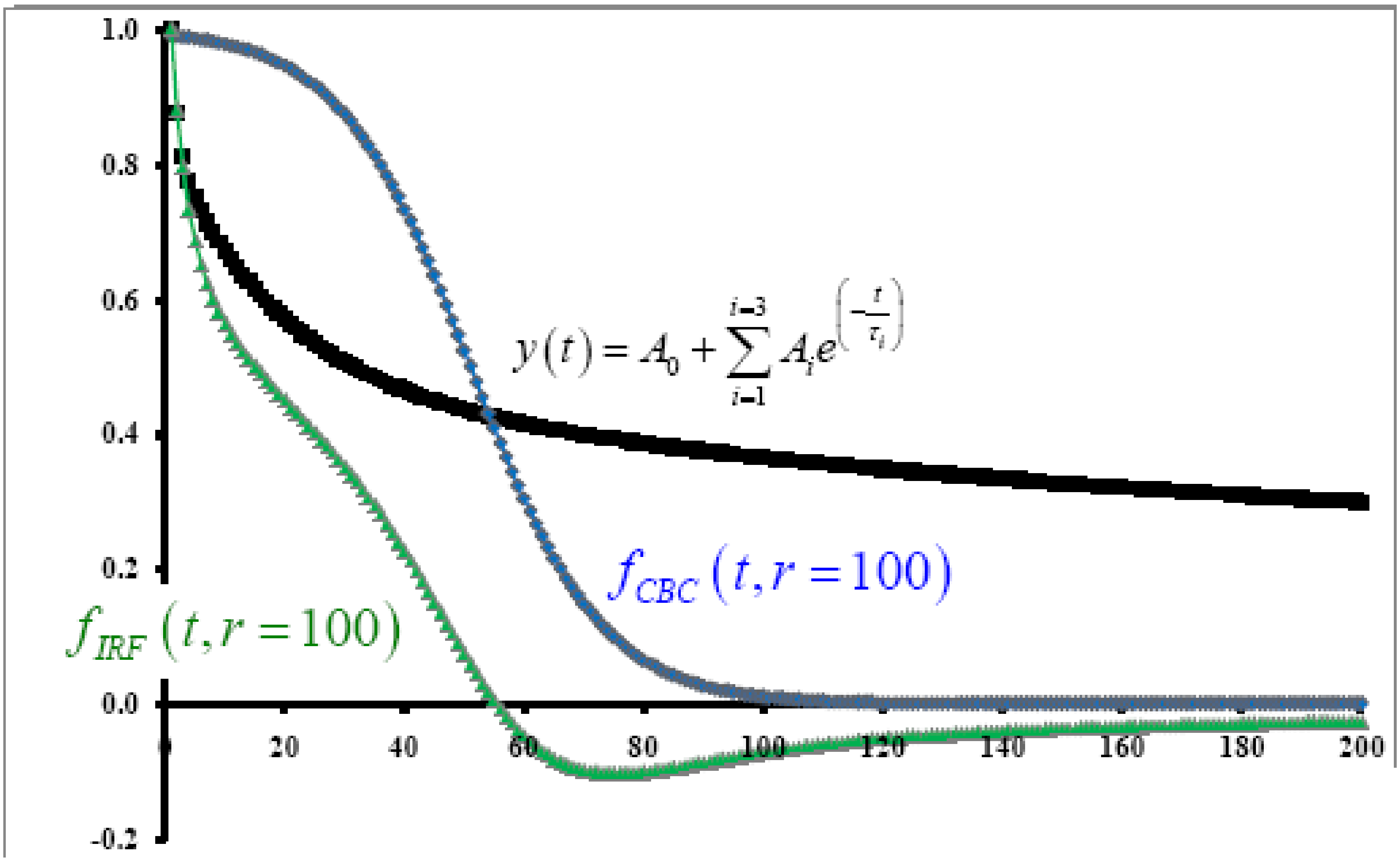
- Environmental flows summed across life cycle
- Timing of flows ignored ISO 14040, 14044
- ISO TS14067 allows for timing in supplementary value
- Does time matter?
  - Credit for temporary storage?
  - Is there a value in delaying emissions?
  - Buys time for technology development
  - Avoids tipping points?
  - Includes value judgment
    - Assumes next generation better able to cope

Atmospheric [CO2] - pulse emission





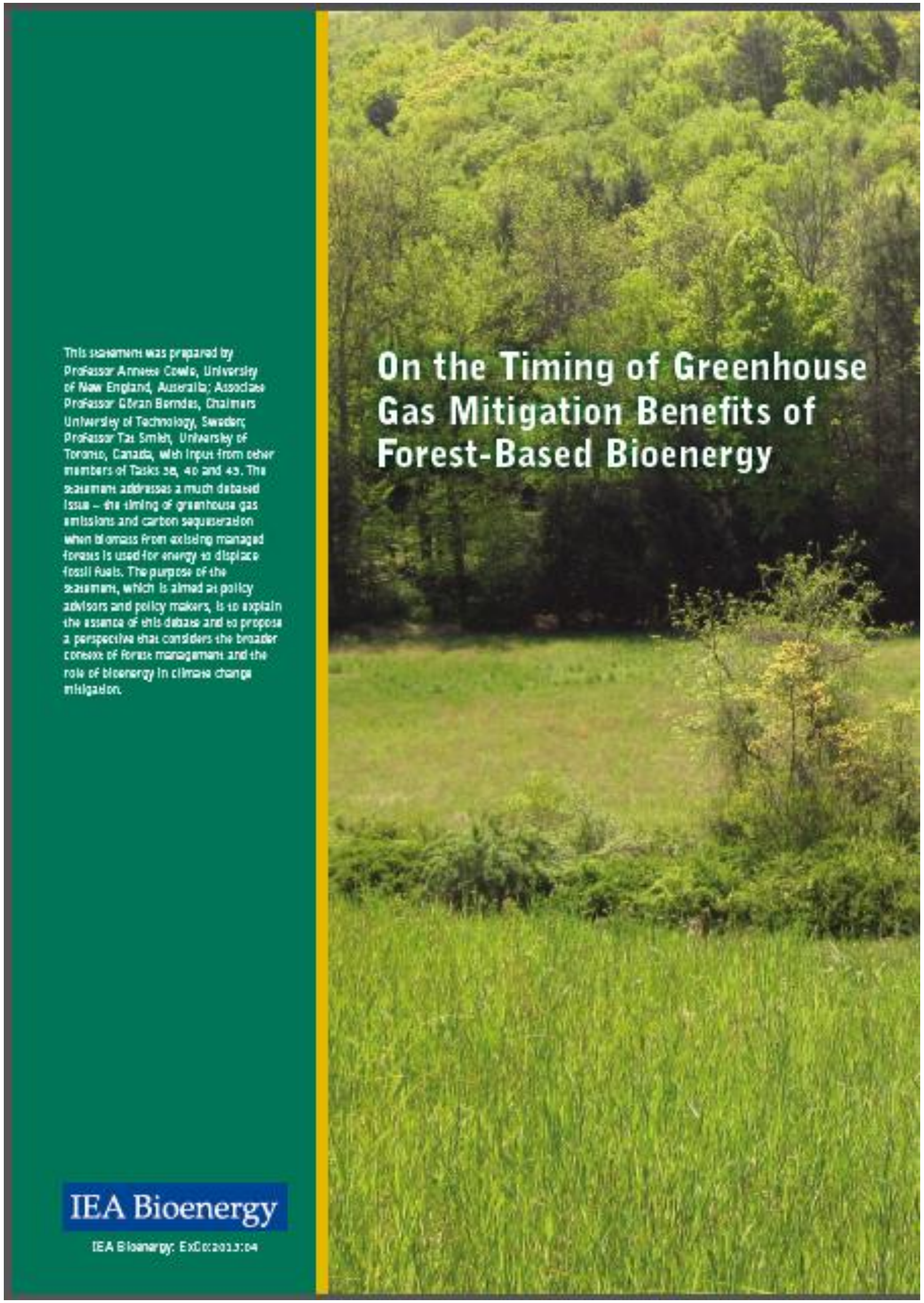
F Cherubini NTNU



F Cherubini NTNU

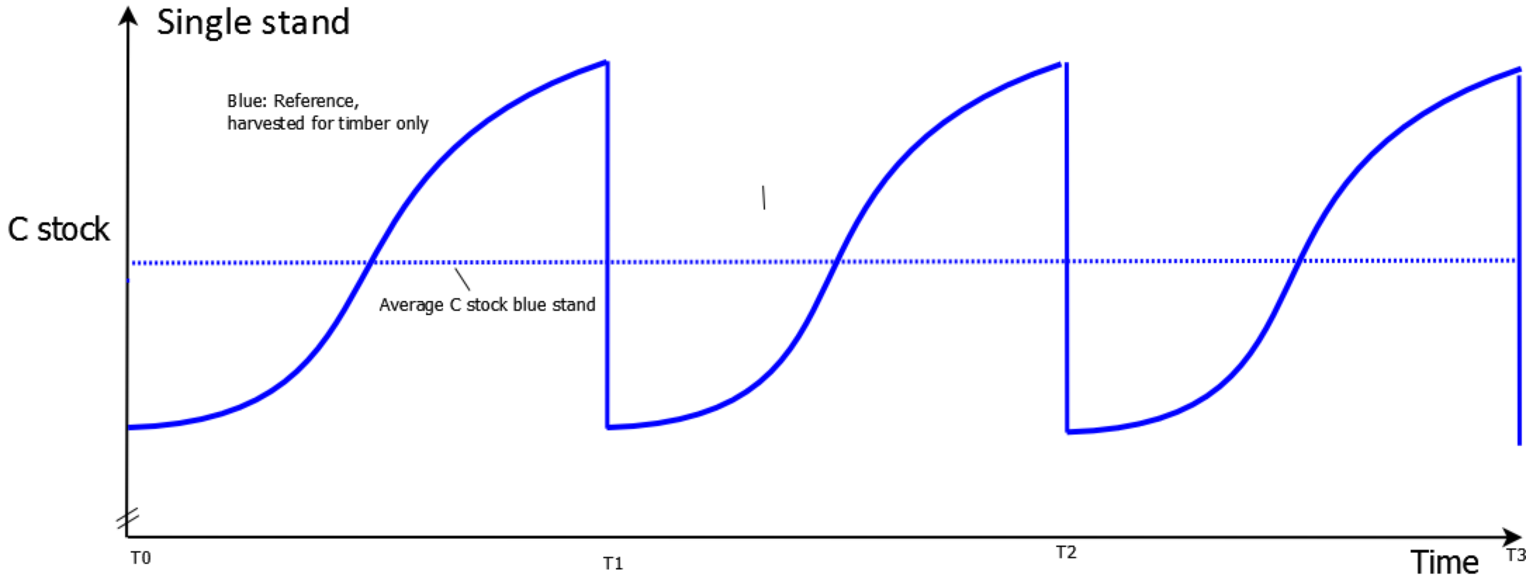
	r	GWP_{bio} TH = 100	GWP_{bio} TH = 500
Annual crops	1	0.004	0.002
Fast growing biomass	2	0.01	0.003
	8	0.03	0.01
	10	0.04	0.01
	20	0.08	0.02
	30	0.12	0.02
Tropical forest	40	0.16	0.03
	50	0.21	0.04
	60	0.25	0.05
Temperate forest	70	0.30	0.05
	80	0.34	0.06
Boreal forest	90	0.39	0.07
	100	0.43	0.08

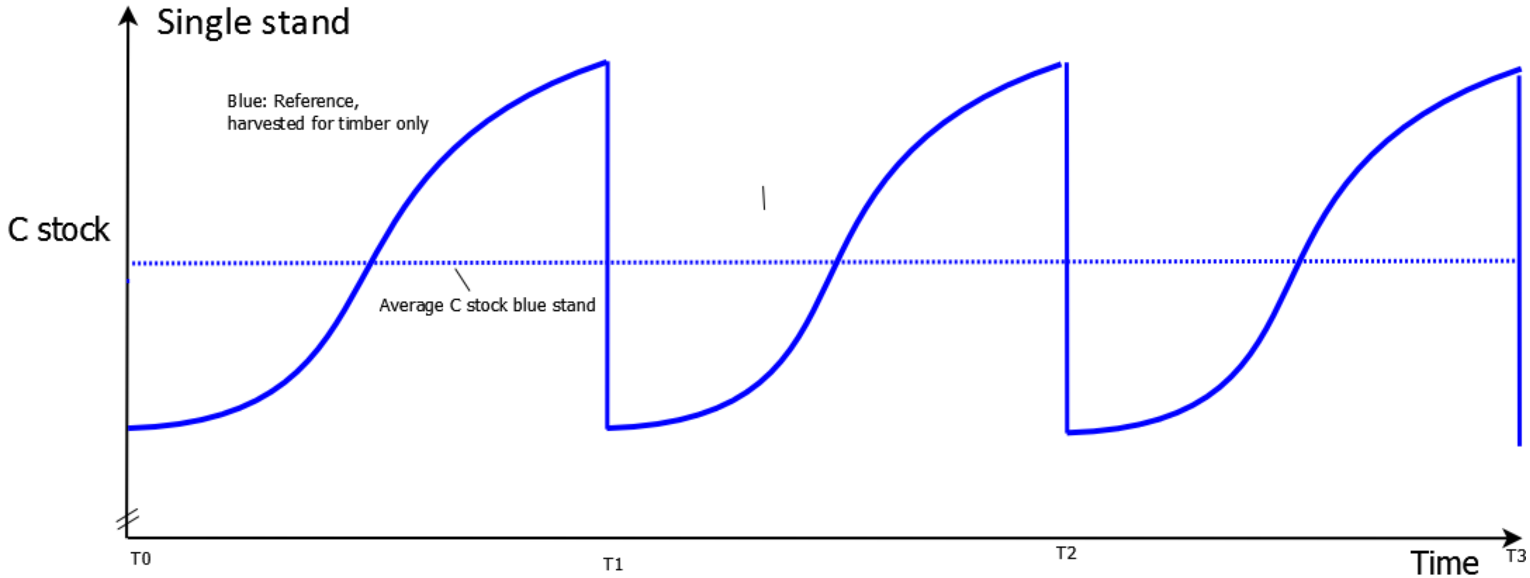
F Cherubini NTNU



Timing statement published July 2013
ieabioenergy.com/iea-publications/

Annette Cowie,
Göran Berndes,
Tat Smith
and others from Tasks 38, 40 and 43


Single stand
Blue: Reference,
harvested for timber only
C stock
Average C stock blue stand
T0
T1
T2
Time
T3


Single stand
Blue: Reference,
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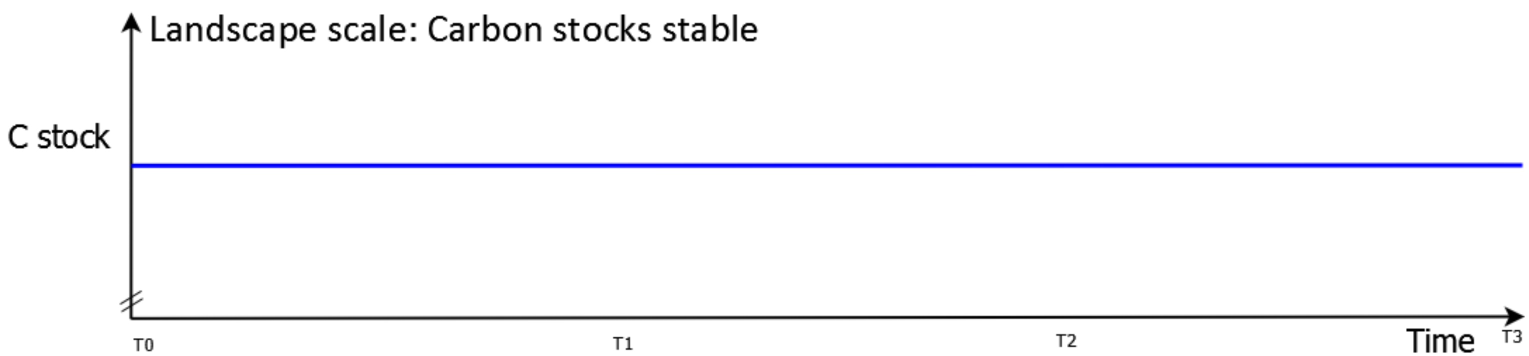
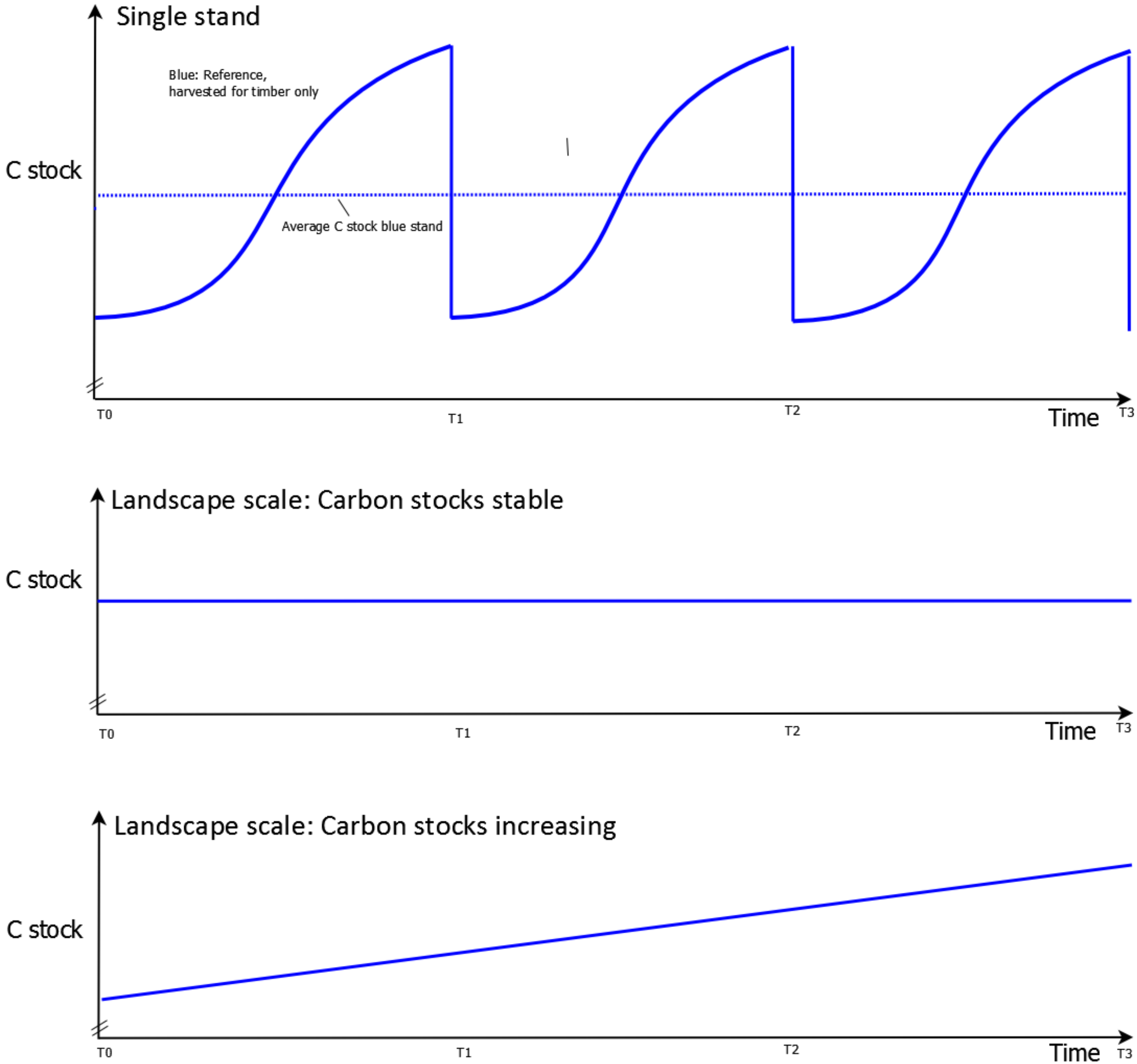
C stock
Average C stock blue stand
T0
T1
T2
Time
T3


Landscape scale: Carbon stocks stable
C stock
T0
T1
T2
Time
T3



Single stand
Blue: Reference,
harvested for timber only
C stock
Average C stock blue stand
T0
T1
T2
Time
T3
Landscape scale: Carbon stocks stable
C stock
T0
T1
T2
Time
T3
Landscape scale: Carbon stocks increasing
C stock
T0
T1
T2
Time
T3

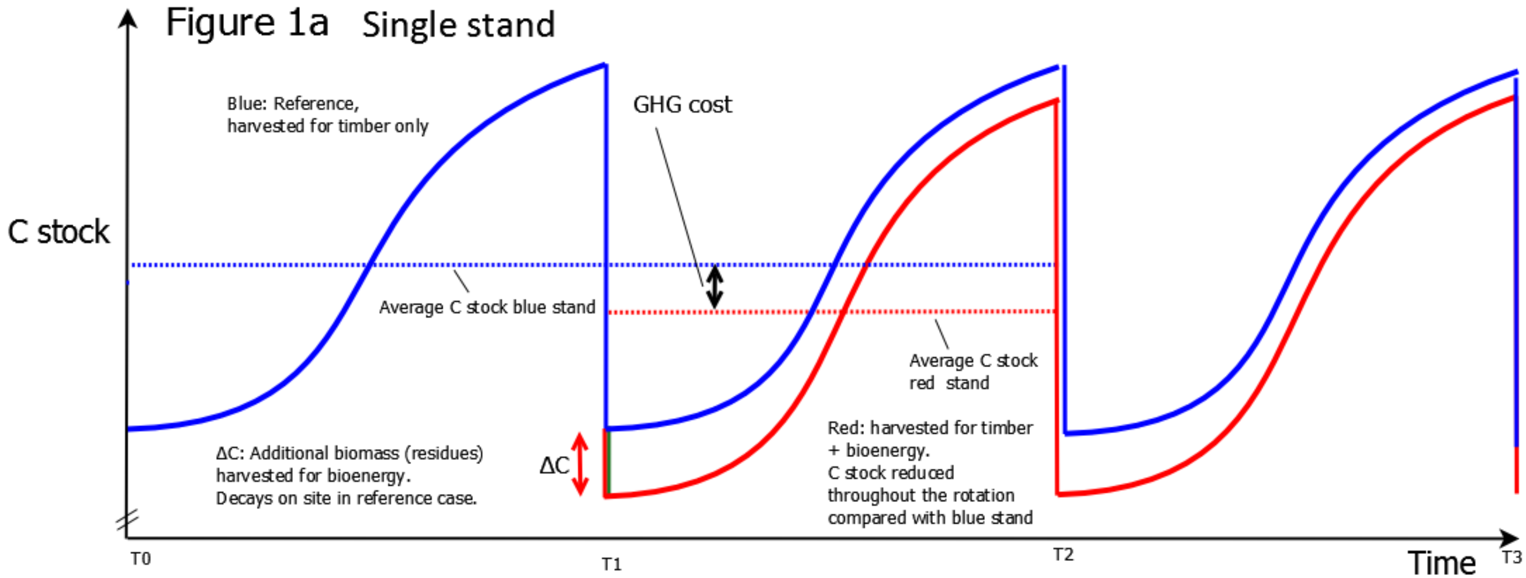
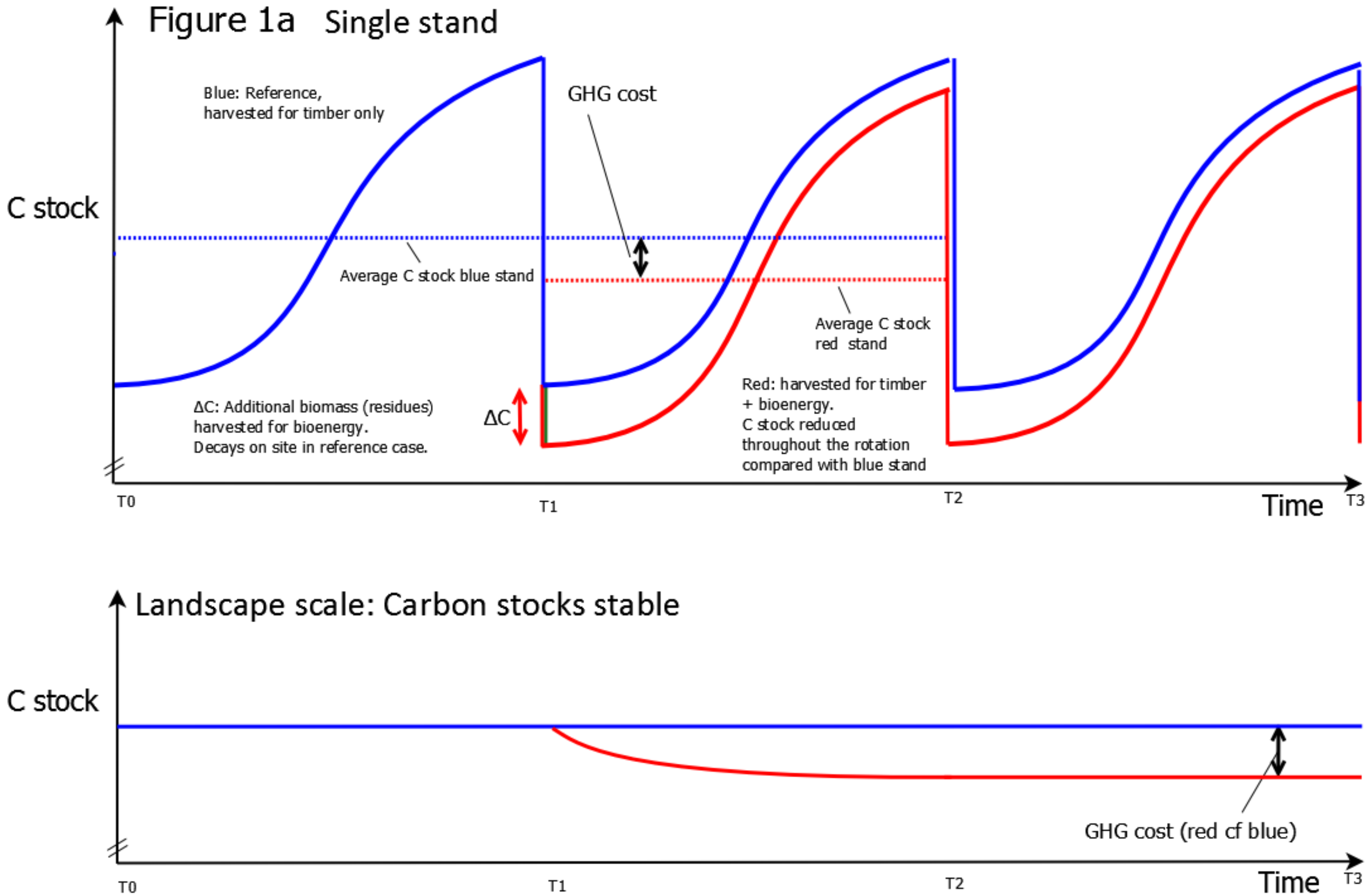


Figure 1a Single stand
C stock
Blue: Reference,
harvested for timber only
GHG cost
Average C stock blue stand
Average C stock
red stand
ΔC
ΔC: Additional biomass (residues)
harvested for bioenergy.
Decays on site in reference case.
Red: harvested for timber
+ bioenergy.
C stock reduced
throughout the rotation
compared with blue stand
T0
T1
T2
Time
T3



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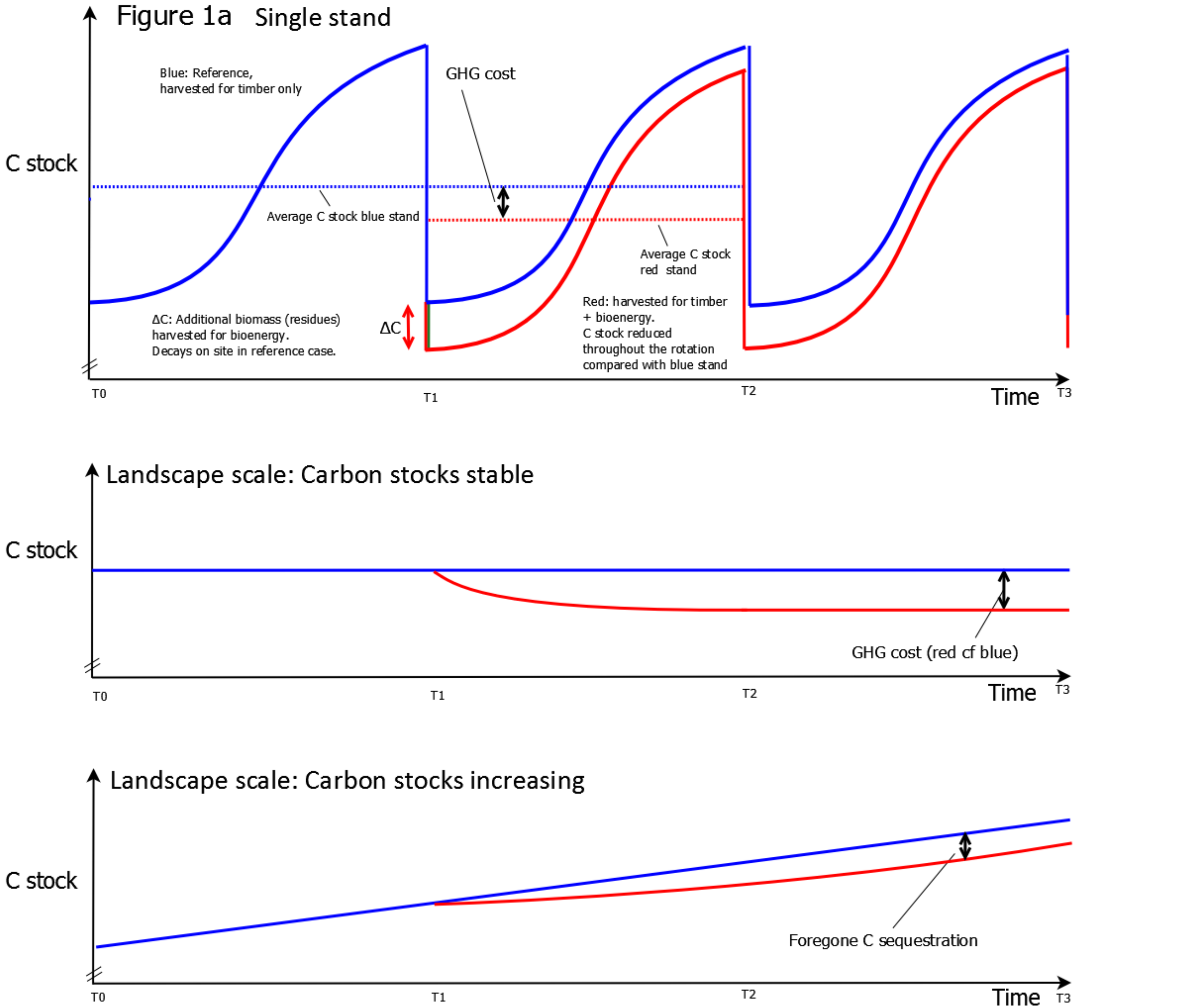
T0
T1
T2
Time
T3
Landscape scale: Carbon stocks stable
C stock
GHG cost (red cf blue)
T0
T1
T2
Time
T3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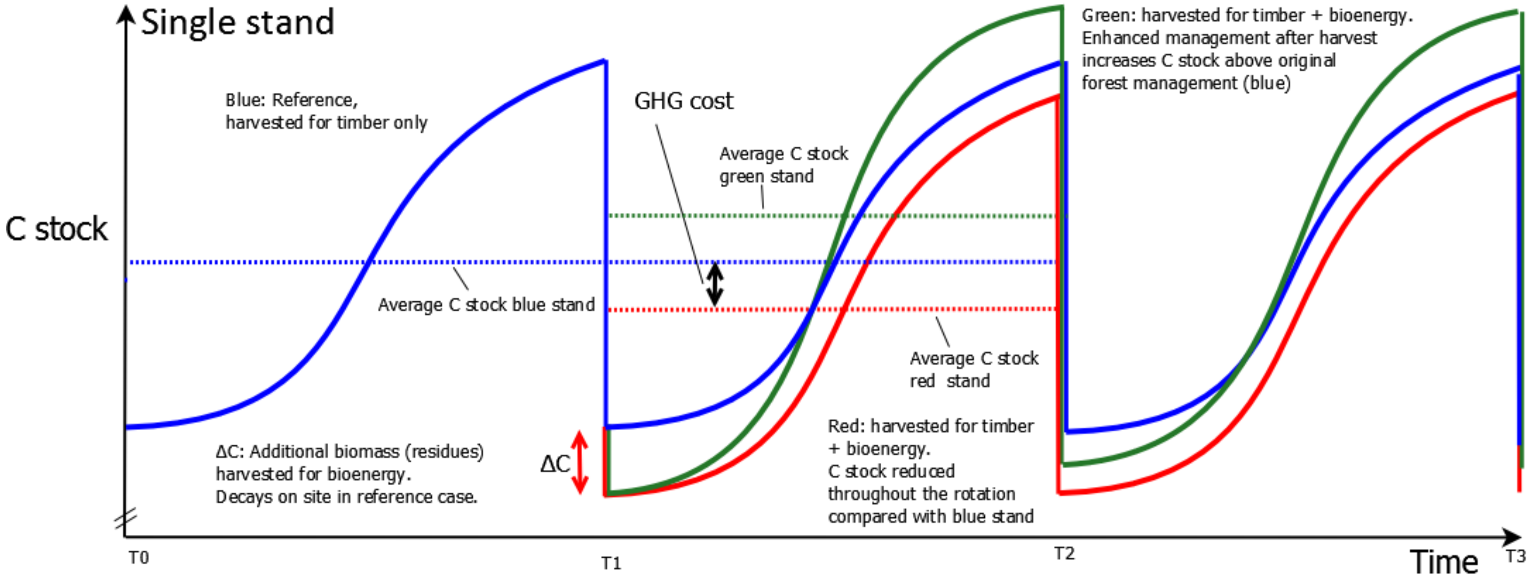
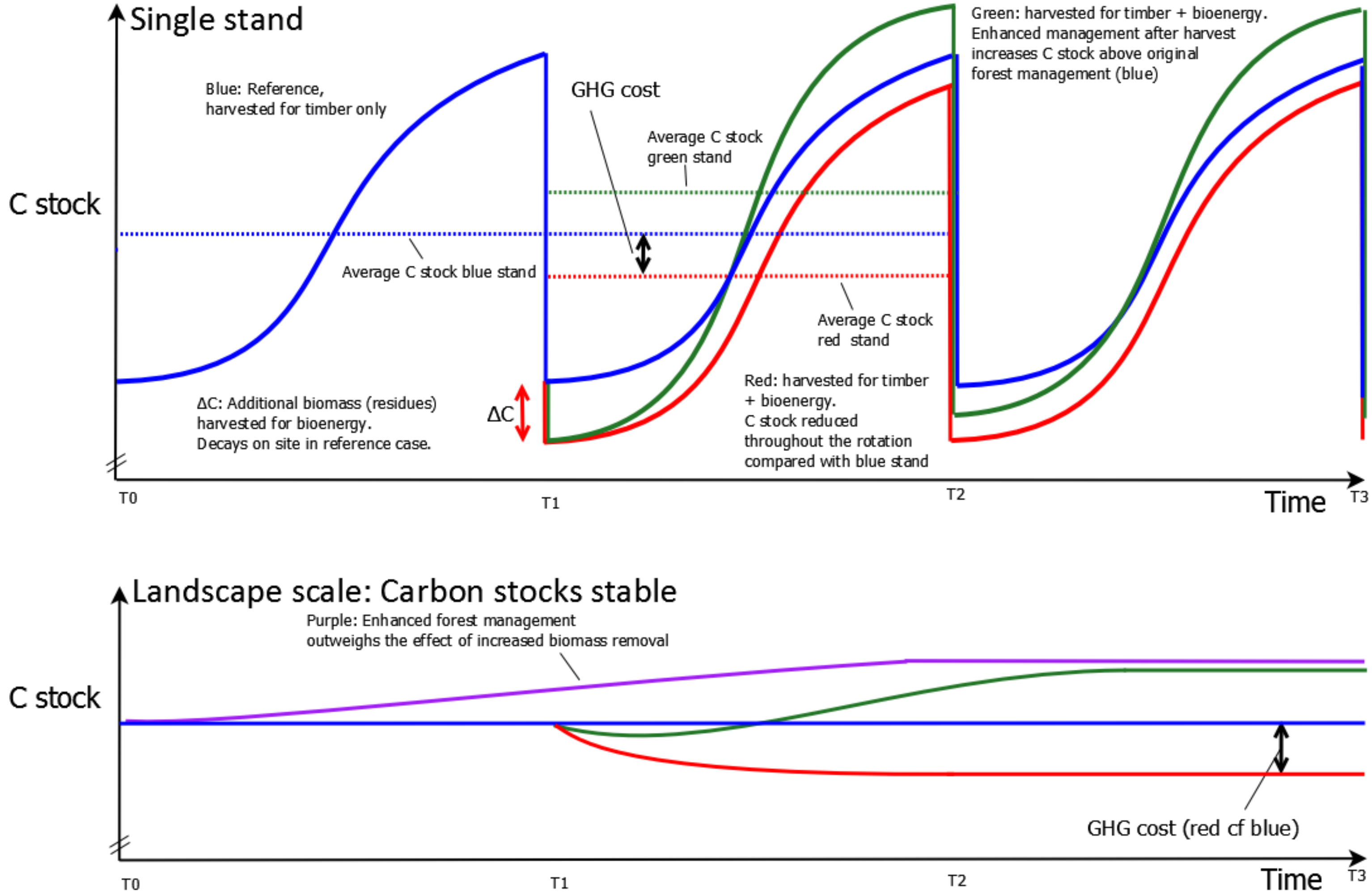
T0
T1
T2
Time
T3
Landscape scale: Carbon stocks stable
C stock
GHG cost (red cf blue)
T0
T1
T2
Time
T3
Landscape scale: Carbon stocks increasing
C stock
Foregone C sequestration
T0
T1
T2
Time
T3


Single stand
C stock
Blue: Reference,
harvested for timber only
GHG cost
Average C stock
green stand
Green: harvested for timber + bioenergy.
Enhanced management after harvest
increases C stock above original
forest management (blue)
Average C stock blue stand
Average C stock
red stand
ΔC: Additional biomass (residues)
harvested for bioenergy.
Decays on site in reference case.
ΔC
Red: harvested for timber
+ bioenergy.
C stock reduced
throughout the rotation
compared with blue stand
T0
T1
T2
Time
T3



Single stand
C stock
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GHG cost
Average C stock
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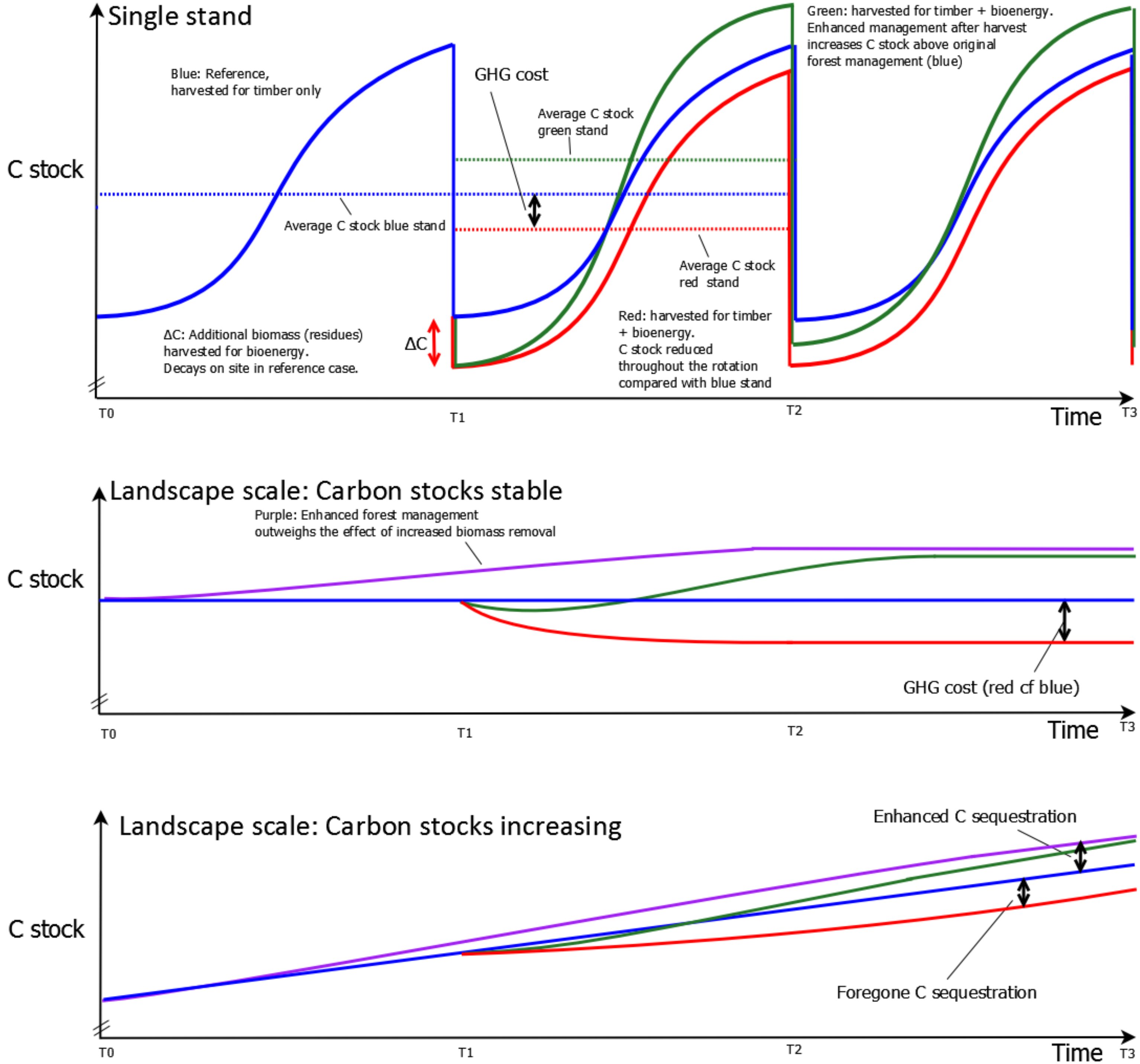
C stock reduced
throughout the rotation
compared with blue stand
T0
T1
T2
Time
T3
Landscape scale: Carbon stocks stable
Purple: Enhanced forest management
outweighs the effect of increased biomass removal
C stock
GHG cost (red cf blue)
T0
T1
T2
Time
T3



Single stand
C stock
Blue: Reference, harvested for timber only
GHG cost
Average C stock green stand
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Average C stock blue stand
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ΔC: Additional biomass (residues) harvested for bioenergy. Decays on site in reference case.
ΔC
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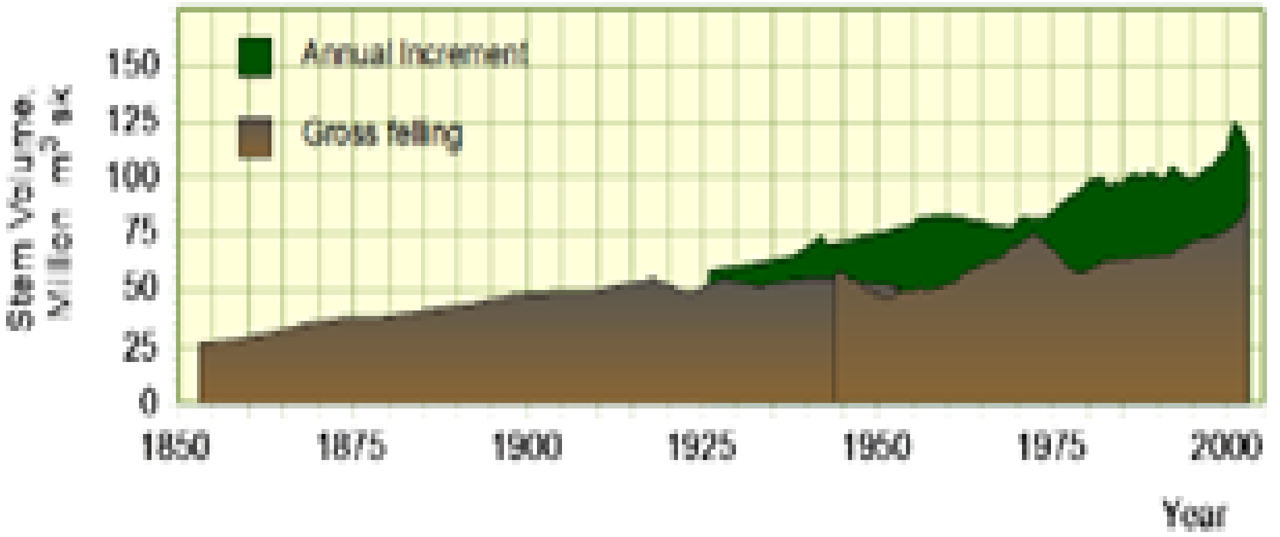
T0
T1
T2
Time
T3
Landscape scale: Carbon stocks stable
Purple: Enhanced forest management outweighs the effect of increased biomass removal
C stock
GHG cost (red cf blue)
T0
T1
T2
Time
T3
Landscape scale: Carbon stocks increasing
Enhanced C sequestration
C stock
Foregone C sequestration
T0
T1
T2
Time
T3

Carbon stock and harvest in Swedish forests have both grown over last century



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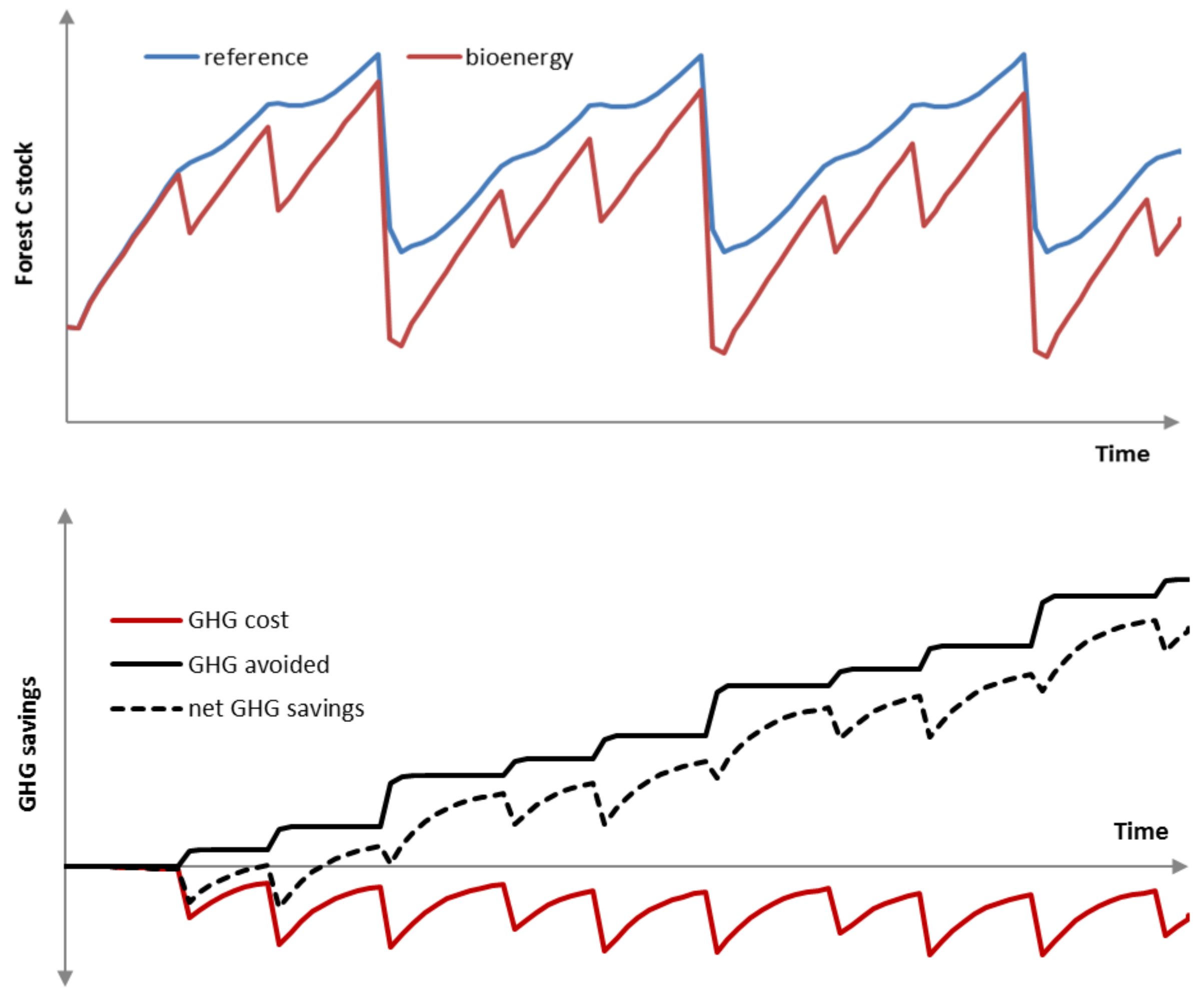
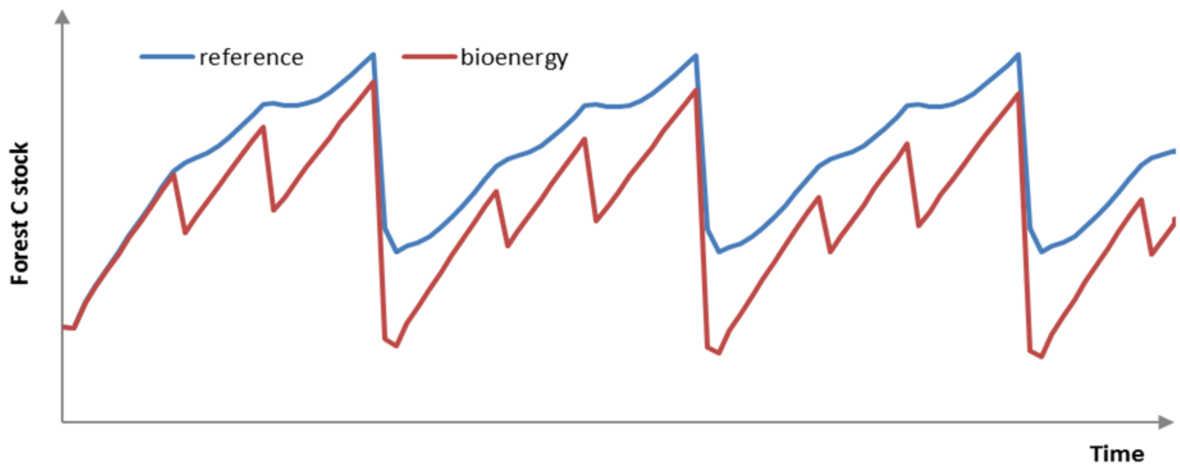
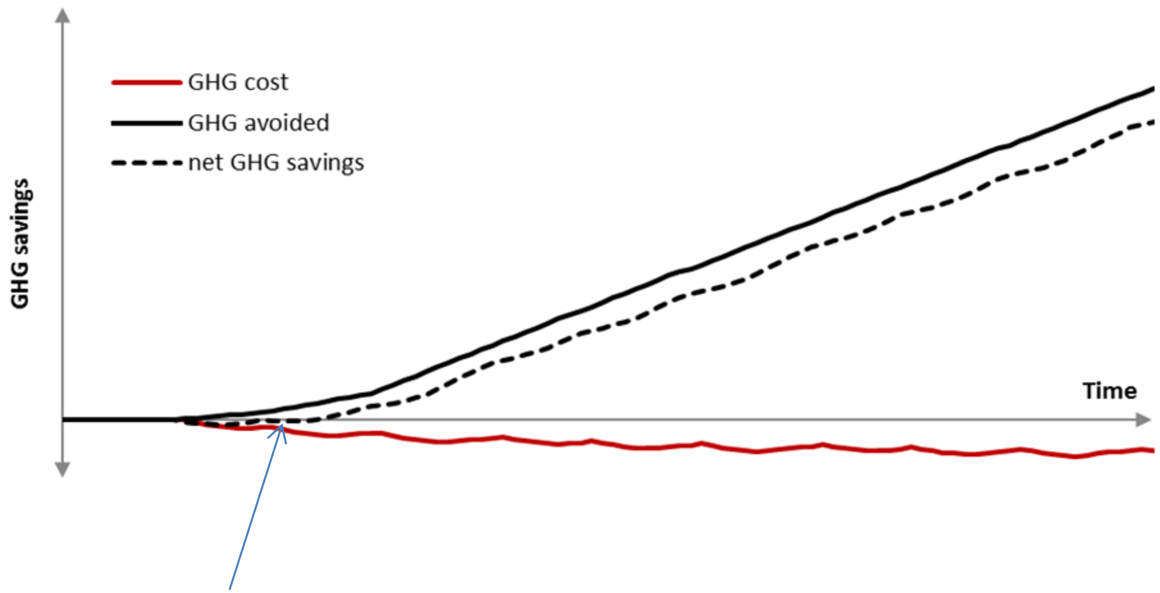


reference
bioenergy
Forest C stock
Time
GHG cost
GHG avoided
net GHG savings
GHG savings
Time





Compensation point: zero net emissions

IEA Bioenergy

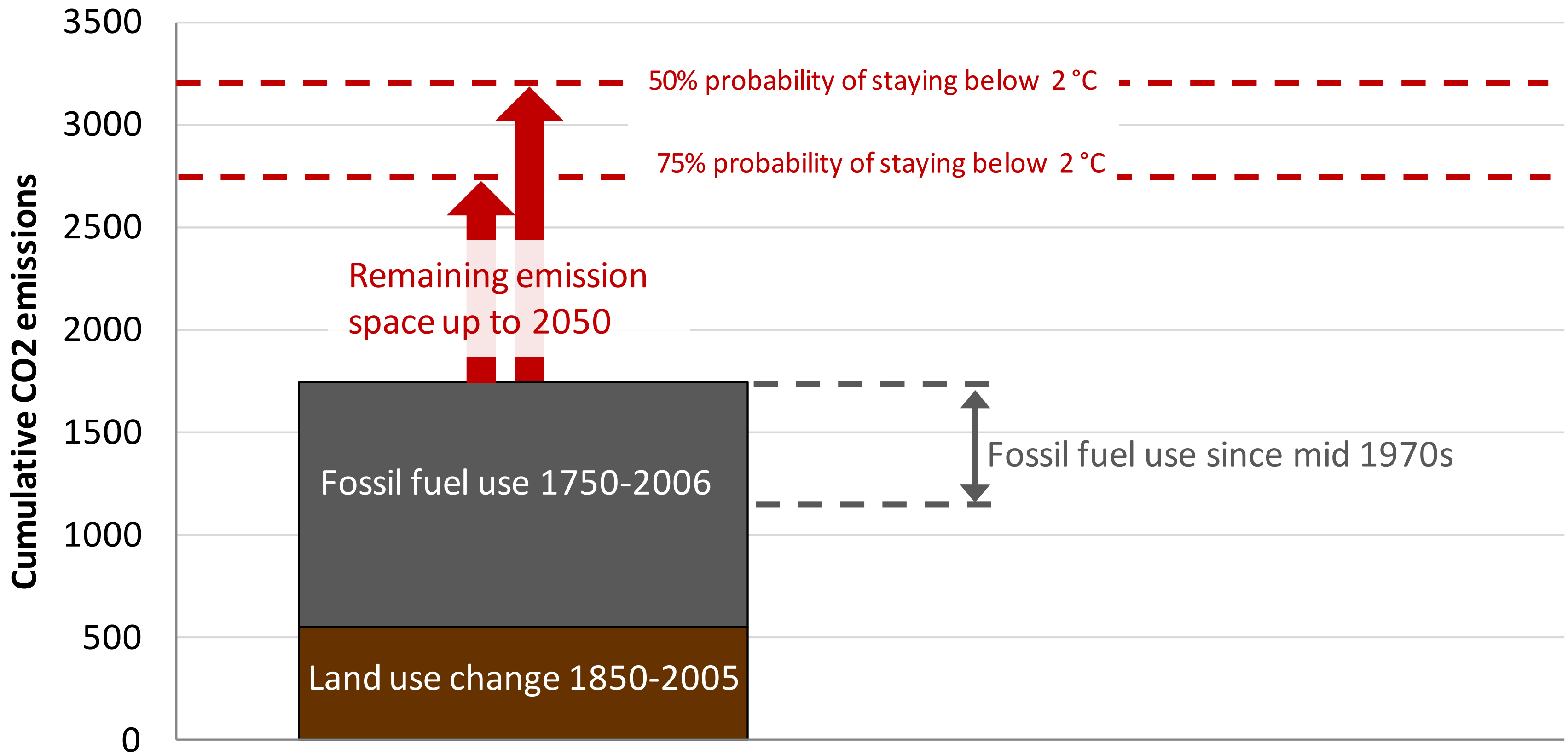
Summary:

- Consider the big picture - the whole life cycle, the long term, human influences
- Biomass for energy is usually one of several products from a managed forest
- Forest C stock should be considered across the landscape; declines are emissions that must be offset

IEA Bioenergy

Summary:

- Loss in C stock can be minimised by investment in intensive forest management
- Bioenergy benefits increase over time
- GHG cost of forest bioenergy is an investment in establishing renewable energy system



- To meet global temperature targets, scientists have estimated a concentration of atmospheric GHGs that should not be exceeded.
- The difference between current concentrations and this threshold represents the atmospheric capacity for GHG emissions – the “emissions space”

- Critical strategic question: how should society use the remaining emissions space?

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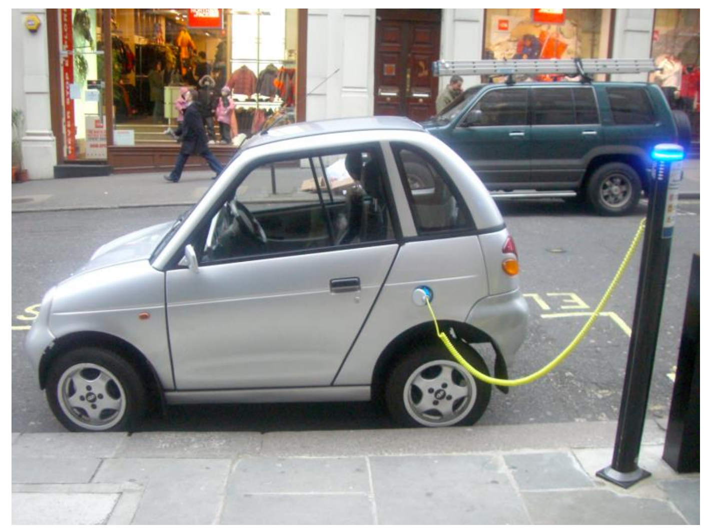
Development of new energy and transport systems will take time, and will create GHG emissions



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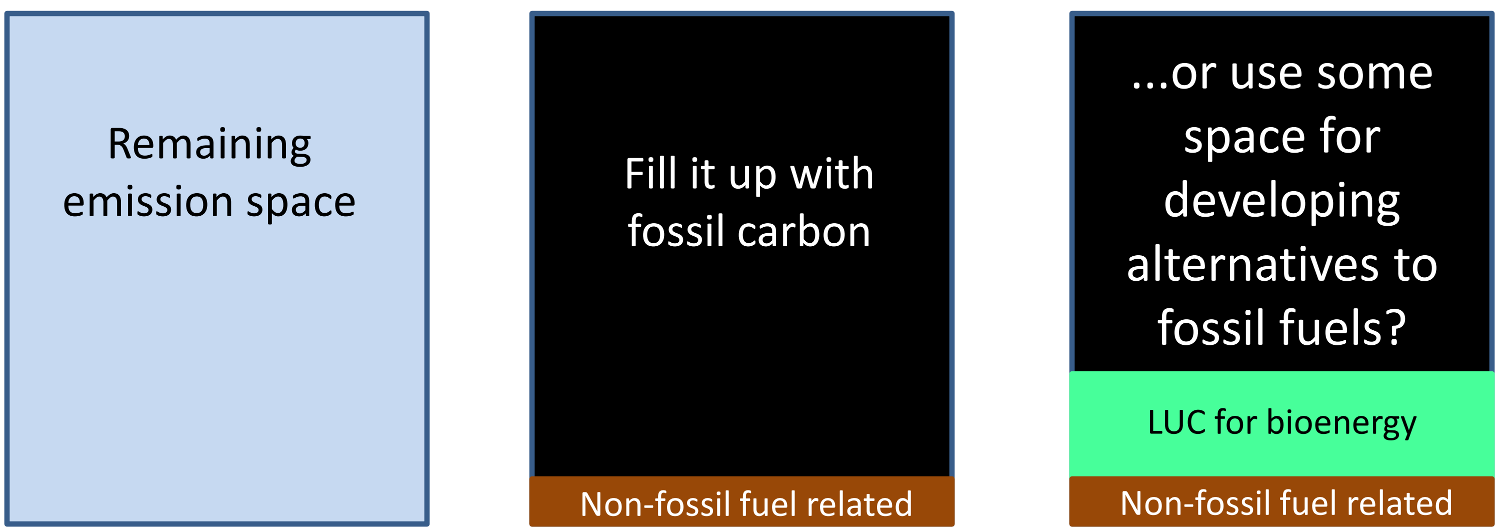
Some of the emission space could be used to develop a bioenergy industry to provide renewable and climate friendly energy services for the world



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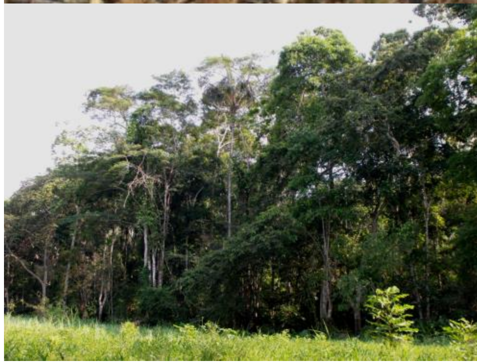
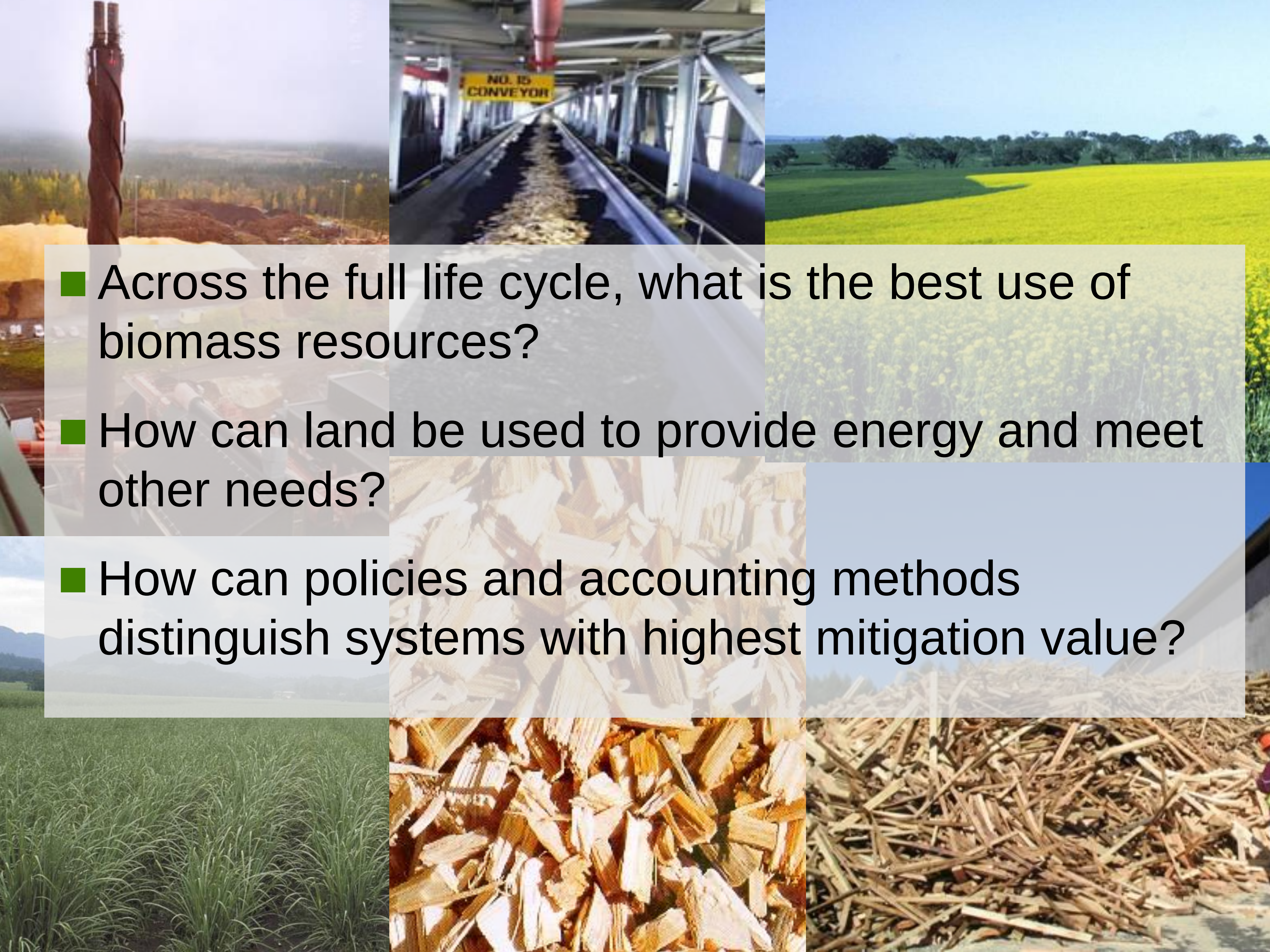
Sustainability issues for bioenergy

- Residues:
  - Soil erosion, compaction
  - Nutrient depletion
  - Organic matter decline

- Purpose grown
  (direct and indirect effects):
  - Water yield
  - Biomass and/or soil carbon stocks
  - CH_4, N_2O emissions
  - Biodiversity
  - Social – displacement, food security





- Across the full life cycle, what is the best use of biomass resources?
- How can land be used to provide energy and meet other needs?
- How can policies and accounting methods distinguish systems with highest mitigation value?

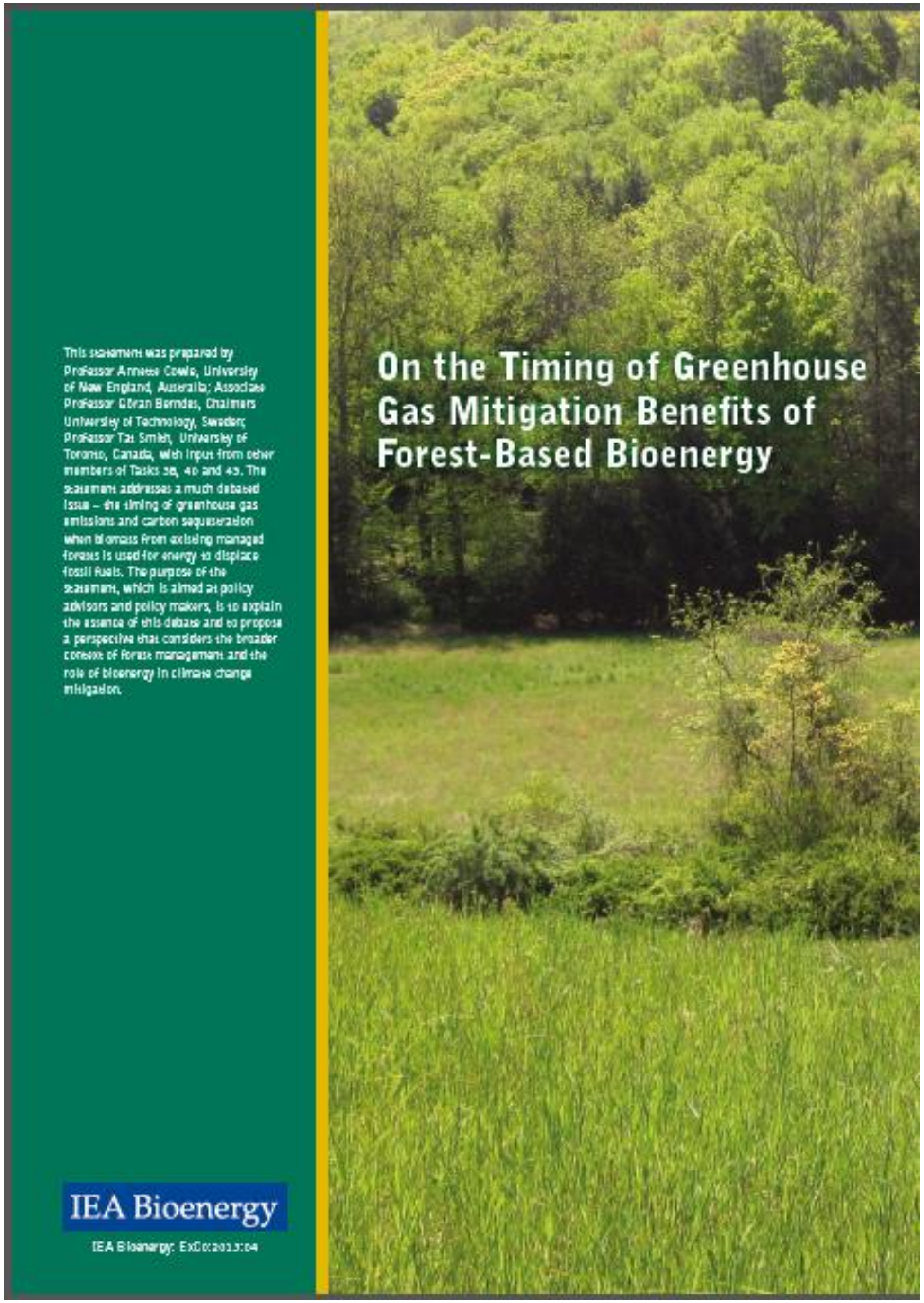
Integrated biomass production




The bioenergy – climate debate: Conclusions

- Significant contribution required from bioenergy to meet 2° C target
- Not all bioenergy systems are beneficial for climate
- Promote the good systems
  - Sustainable biomass harvest
  - Efficient energy conversion
  - Displace GHG-intensive fuels
  - Integrate biomass with other land use
- Bioenergy has a key role in low carbon energy systems of the future system

It is urgent to reduce GHG emissions: we should quickly implement bioenergy systems that provide long term GHG savings



This statement was prepared by Professor Annette Cowie, University of New England, Australia; Associate Professor Göran Berndes, Chalmers University of Technology, Sweden; Professor Tat Smith, University of Toronto, Canada, with input from other members of Tasks 38, 40 and 43. The statement addresses a much debated issue – the timing of greenhouse gas emissions and carbon sequestration when biomass from existing managed forests is used for energy to displace fossil fuels. The purpose of the statement, which is aimed at policy advisors and policy makers, is to explain the essence of this debate and to propose a perspective that considers the broader context of forest management and the role of bioenergy in climate change mitigation.

On the Timing of Greenhouse Gas Mitigation Benefits of Forest-Based Bioenergy

IEA Bioenergy

IEA Bioenergy: ExCo:2013:04

Timing statement published July 2013

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Annette Cowie,
Göran Berndes,
Tat Smith
and others from
Tasks 38, 40 and 43

IEA Bioenergy Task 38

Climate Change Effects of
Biomass and Bioenergy Systems

www.ieabioenergy-task38.org

annette.cowie@dpi.nsw.gov.au

Timing statement:
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