Biomass carbon neutrality in the context of forest-based fuels and products

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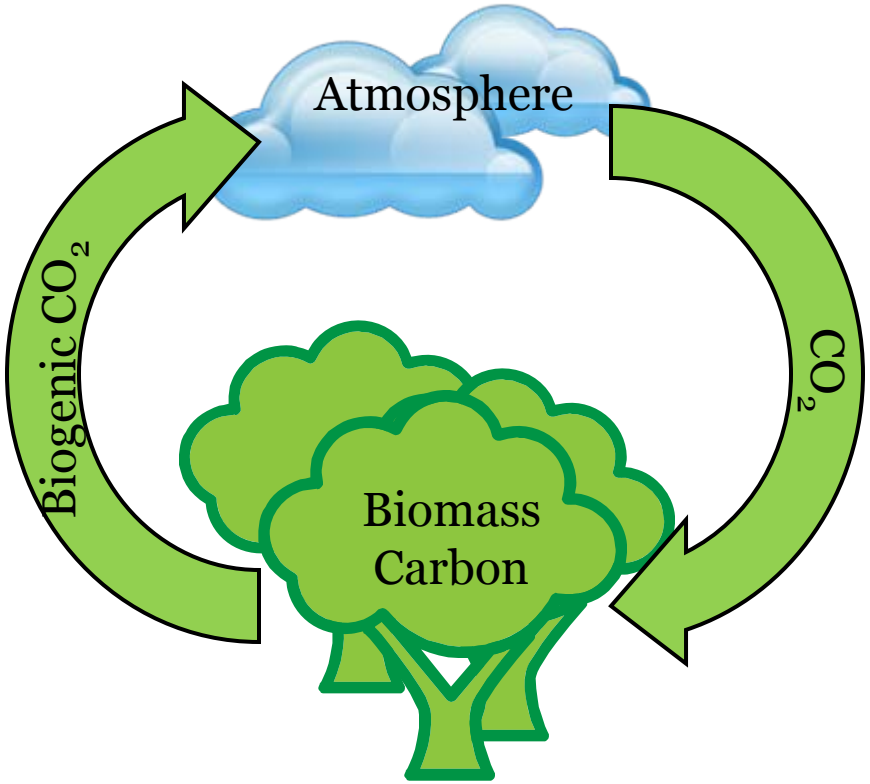
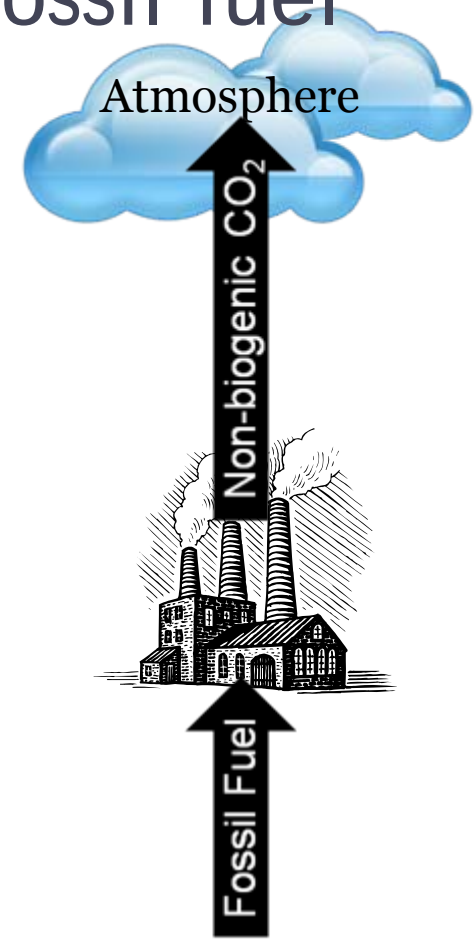
Carbon neutrality: Disagreement or confusion?

- What is “carbon neutrality”, “biomass carbon neutrality”, etc.?
- Are we all speaking the same language?
- Let’s start with the basics

The biomass carbon cycle fundamentally differentiates biomass from fossil fuel



Biogenic carbon is part of a relatively rapid natural cycle that impacts atmospheric CO_2 only if the cycle is out of balance



Fossil fuel combustion transfers geologic carbon into the atmosphere. It is a one-way process

The implications to carbon accounting

- To understand the impacts of fossil fuel-derived emissions, you need only count transfers to the atmosphere
- To understand the impacts of biomass-derived CO2 emissions, you need to know more than the transfers to the atmosphere. You need to know the balance between uptake and transfers to the atmosphere
  - Is the biomass carbon cycle in balance?
- This is why it is important to track fossil-fuel derived emissions separately from biomass-derived CO2.

Unintended consequences

- Some have suggested that the accounting for biomass CO_2 and fossil fuel CO_2 should be the same
- This fails to recognize the important role of the biomass carbon cycle and could result in facilities switching from forest-based fuels to fossil fuels
  - This is because fossil fuels often yield more usable energy per ton of CO_2, primarily due to the higher water content of biomass fuels.

Is the forest carbon cycle in balance?

- At what scales of time and area do we do the forest carbon accounting?
  - National inventory
    - Most US forestland (except areas of AK and HI)
    - One year stock change
  - Studies of biomass products, policies or technologies
    - Areal scale?
    - Temporal scale?

This is what today's discussions are about

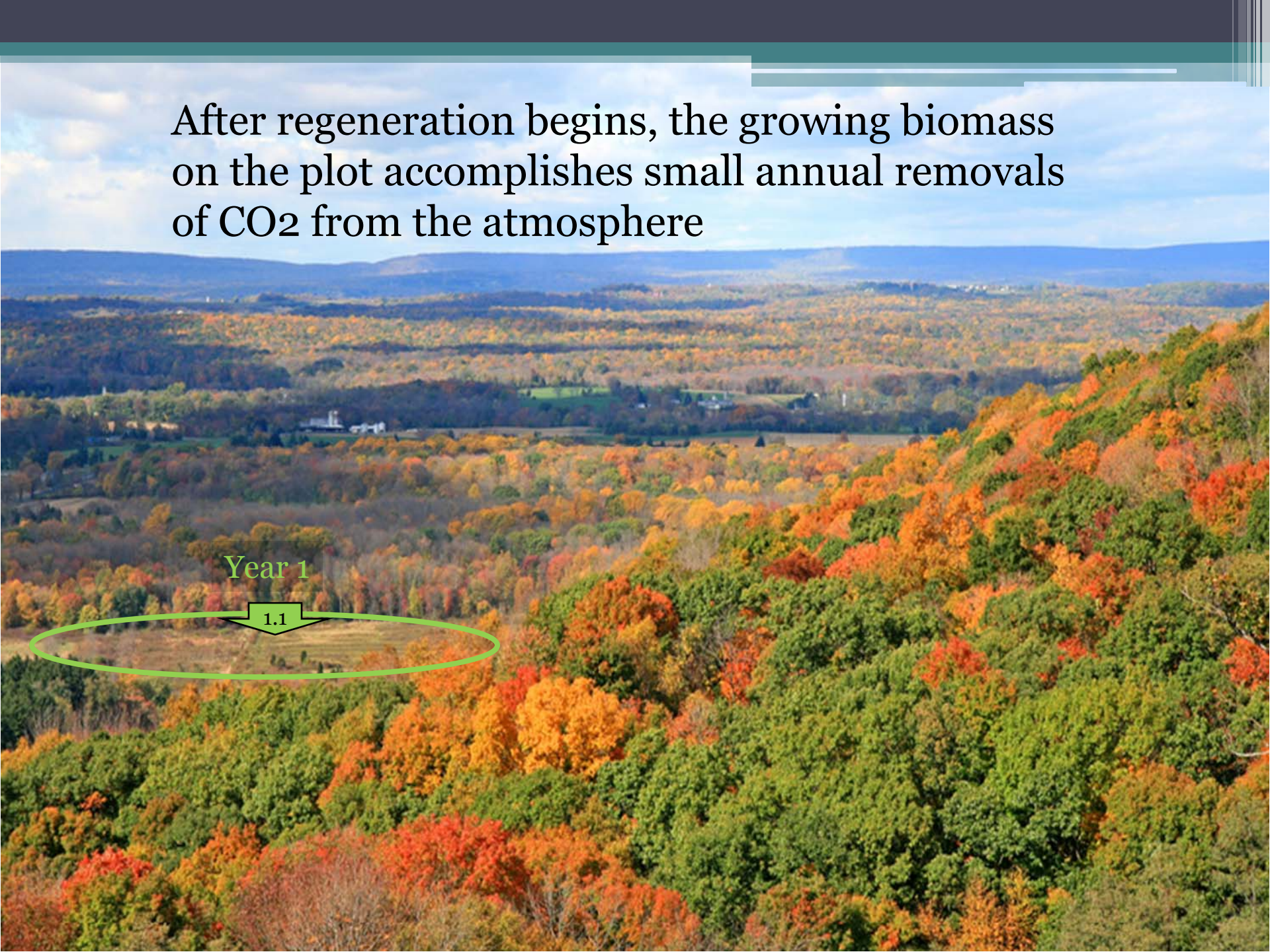
Single plot level analysis

- A common approach for studying biomass energy policies
- Areal scale for biomass carbon accounting = a single plot harvested at time zero

On the landscape, the single-plot approach looks like this

In year zero, the plot is harvested and the wood is burned for energy

After regeneration begins, the growing biomass on the plot accomplishes small annual removals of CO_2 from the atmosphere



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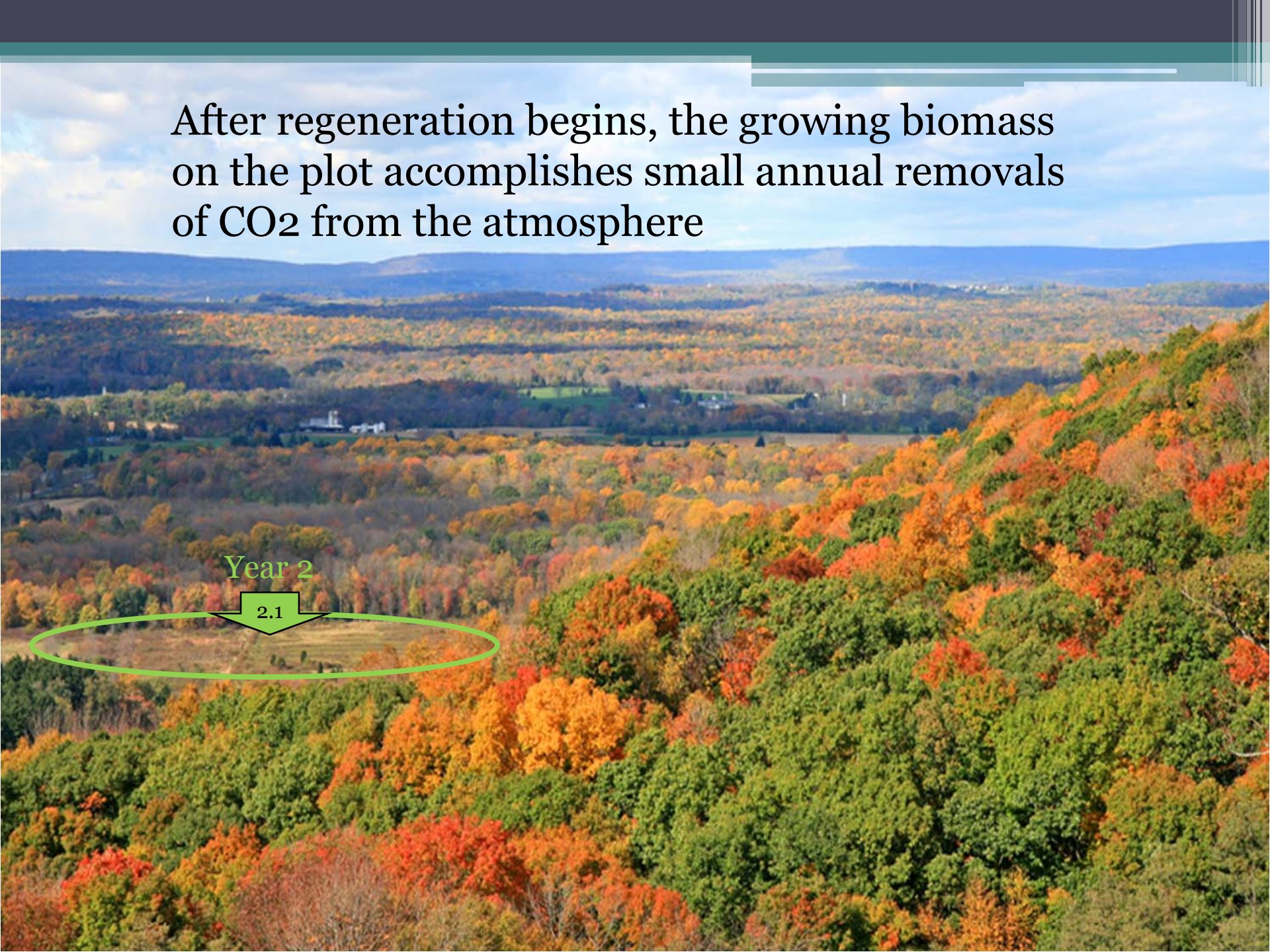

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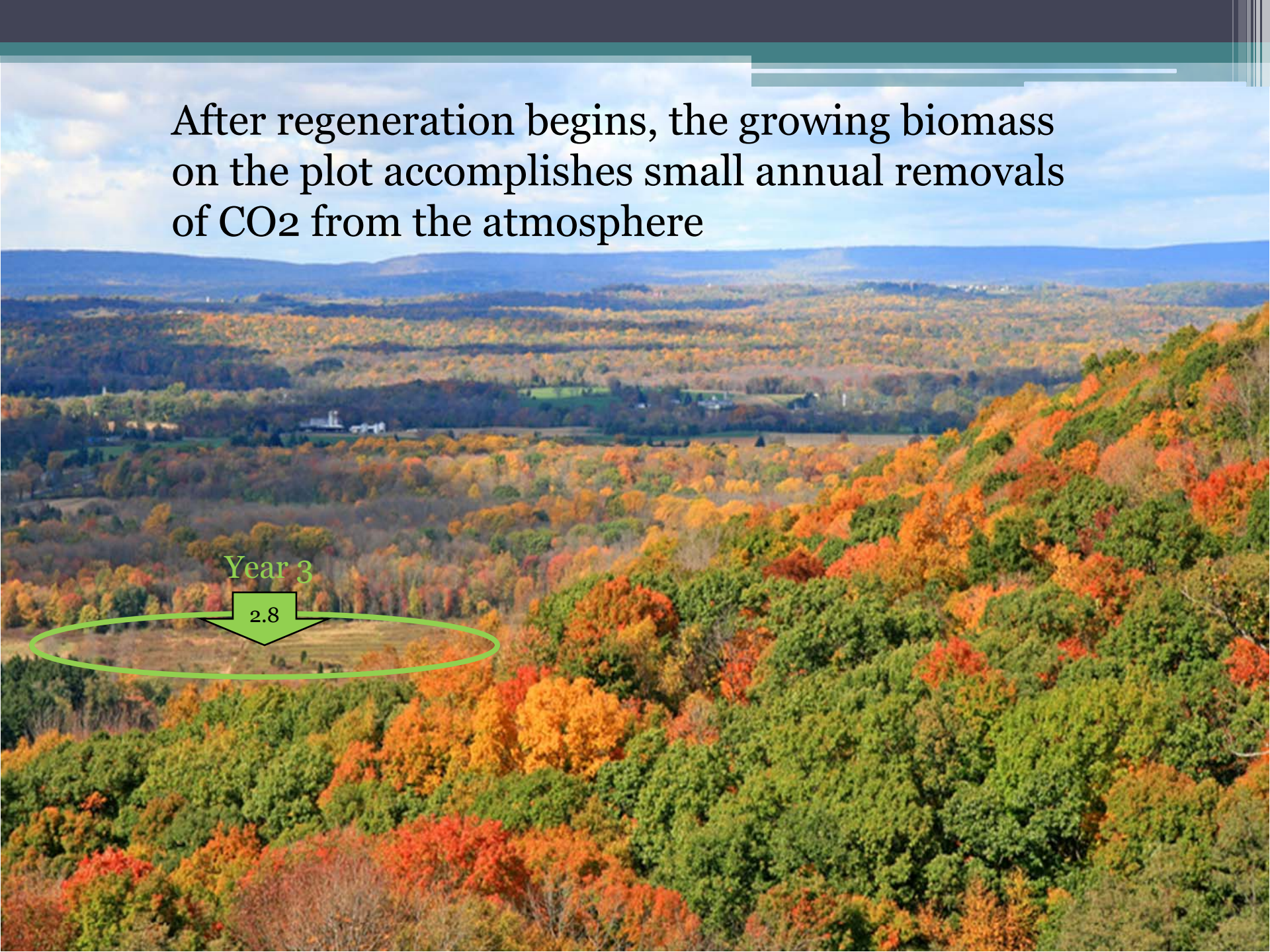
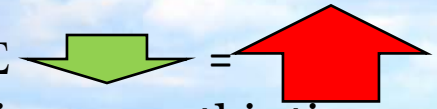


Over time, if carbon stocks are returned to pre-harvest levels…

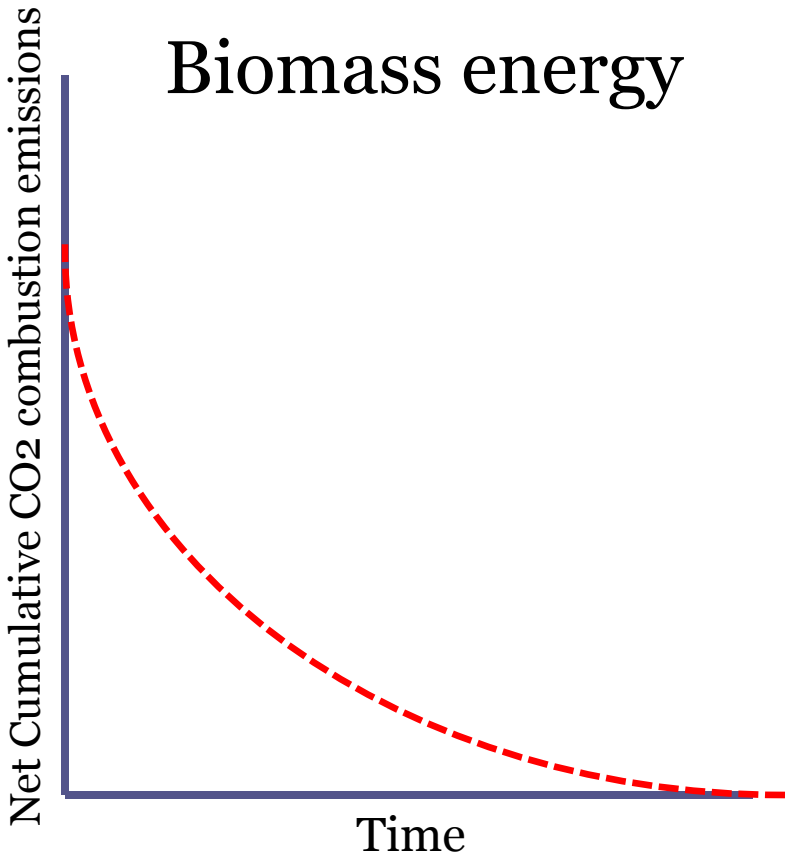


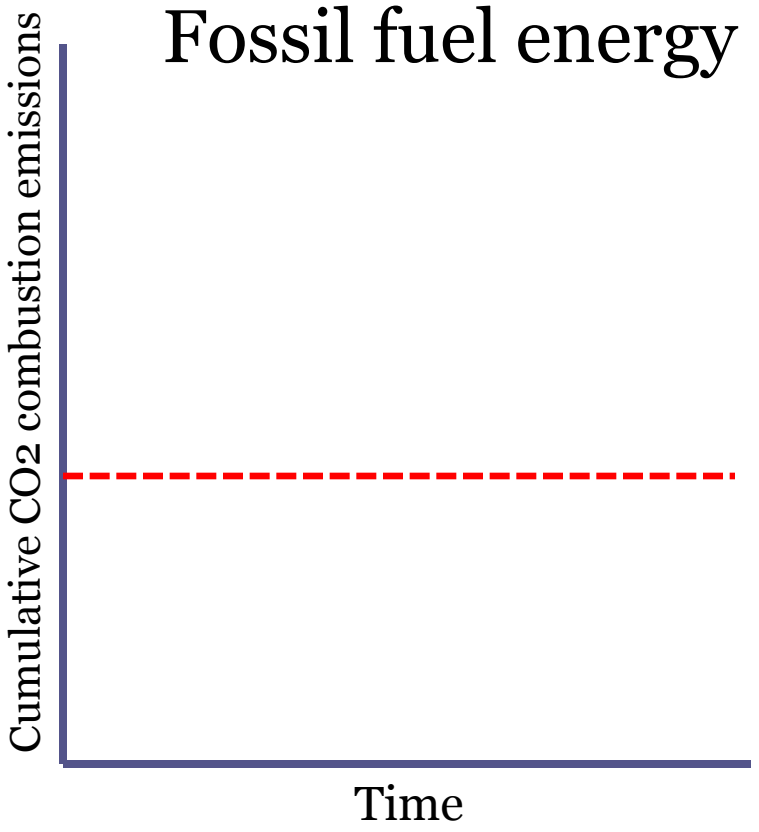
…the net emissions over this time are zero.

Year X, until next harvest

???

Graphically: single plot analysis





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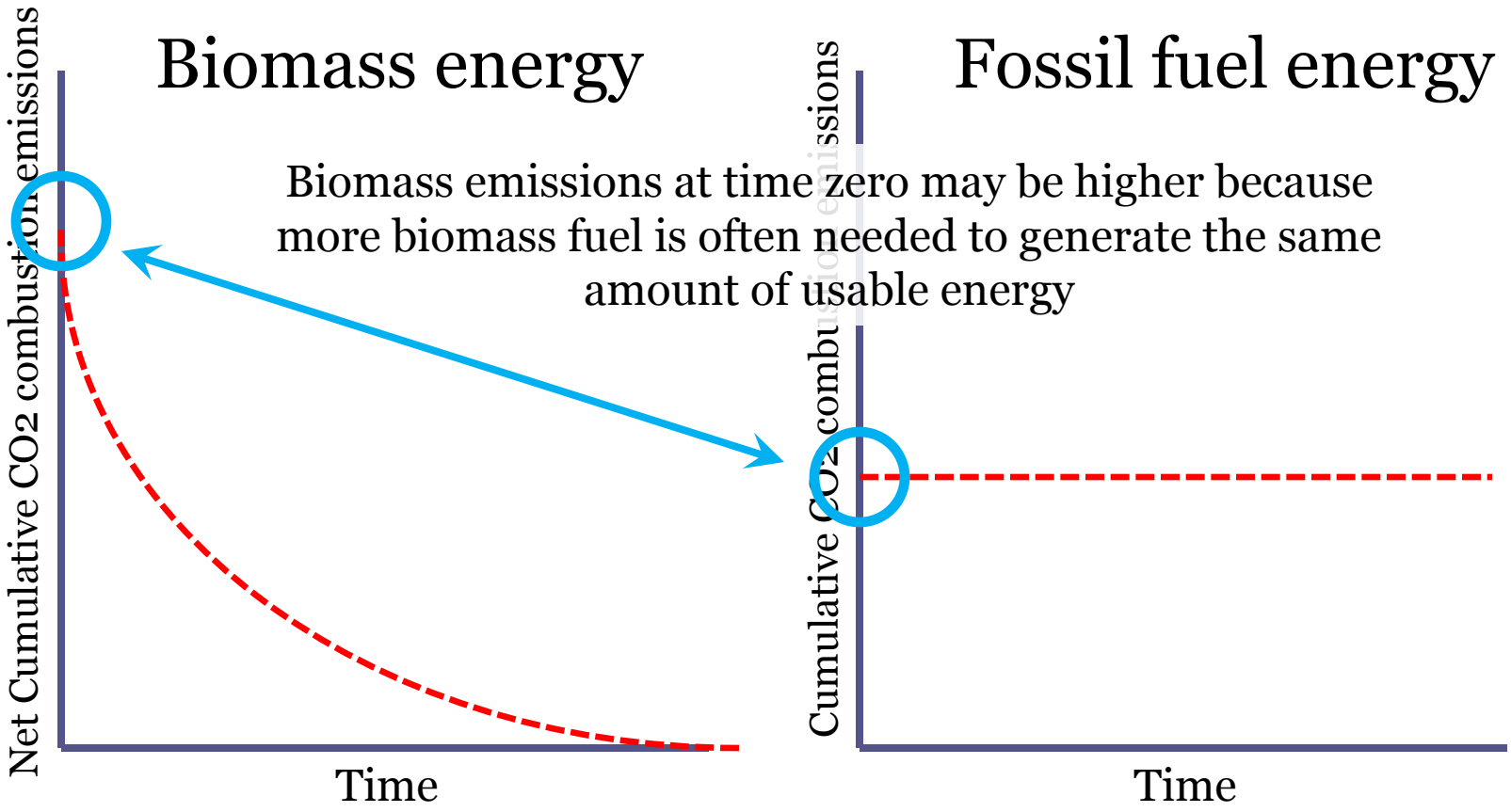

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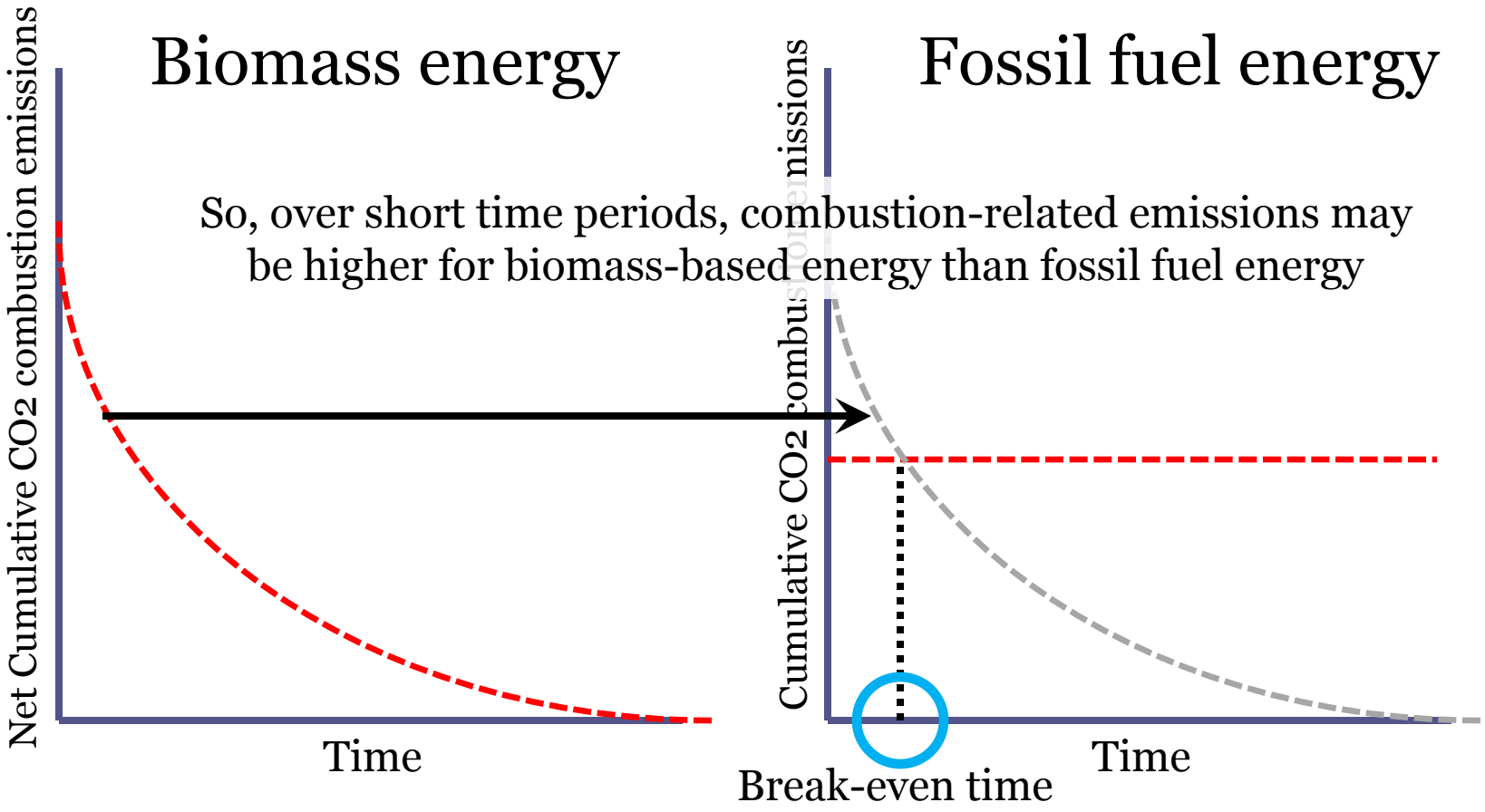

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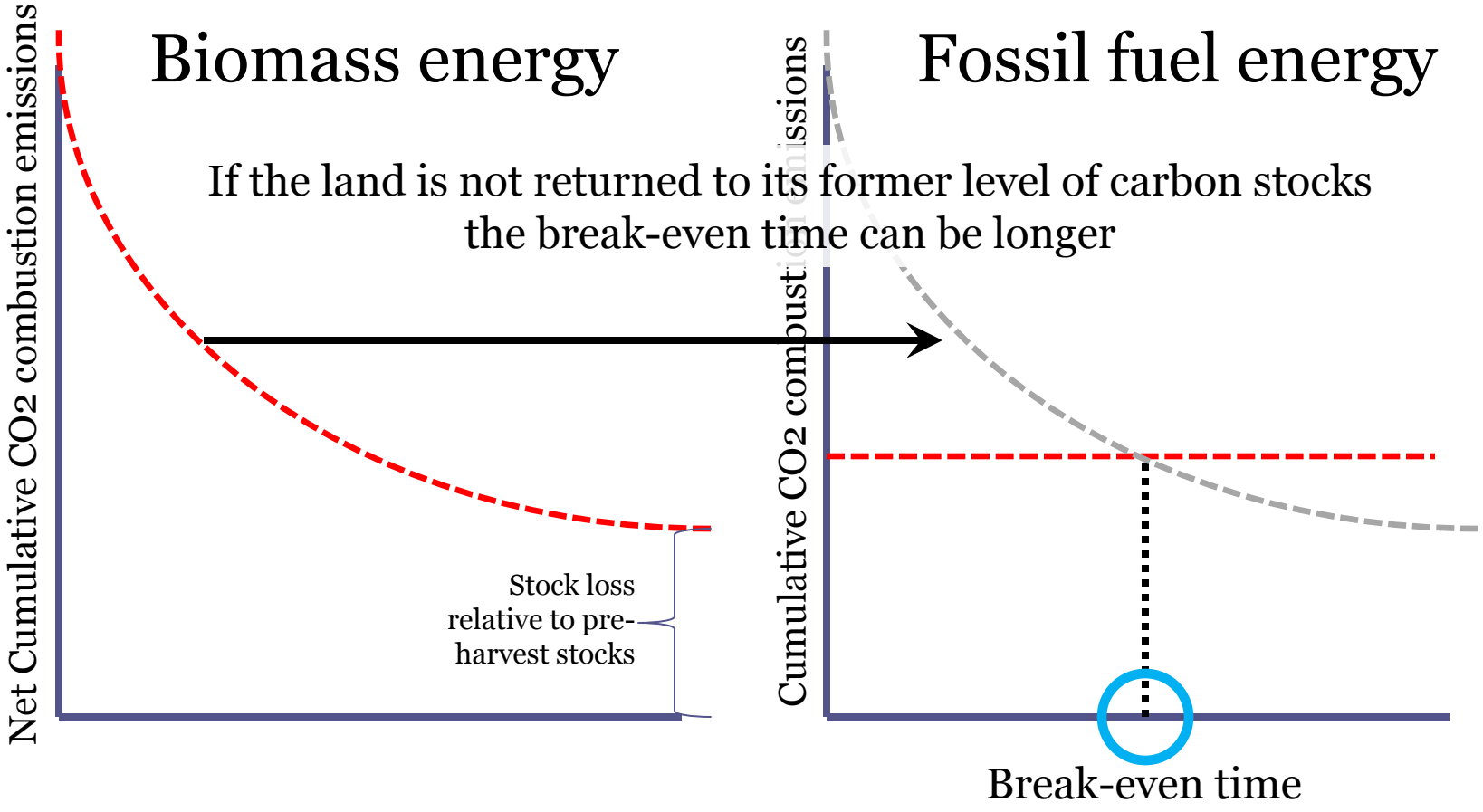
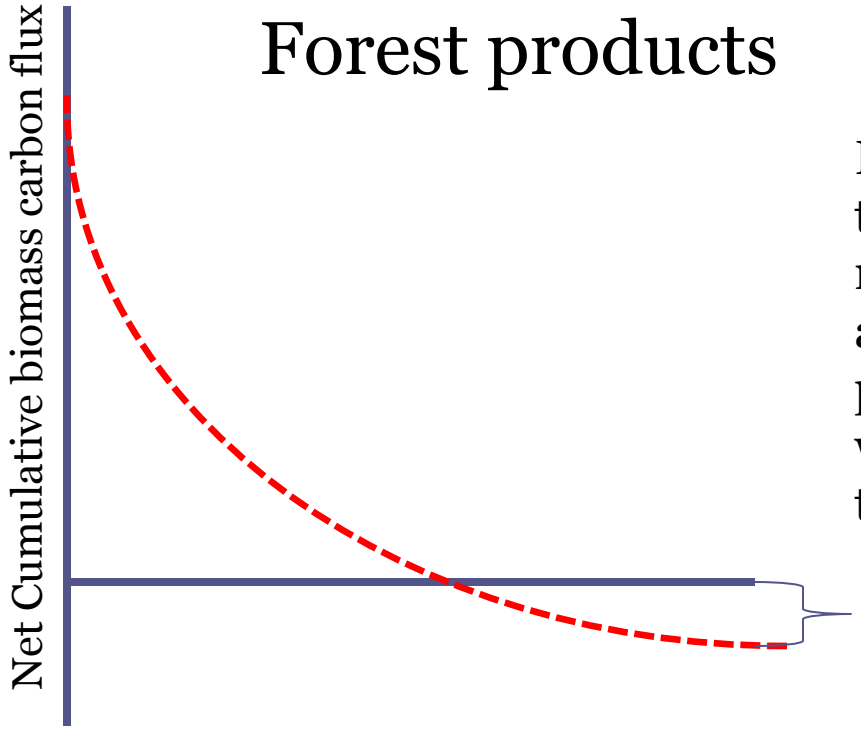


The same concepts apply to forest products but carbon stored in products must also be included



Forest products

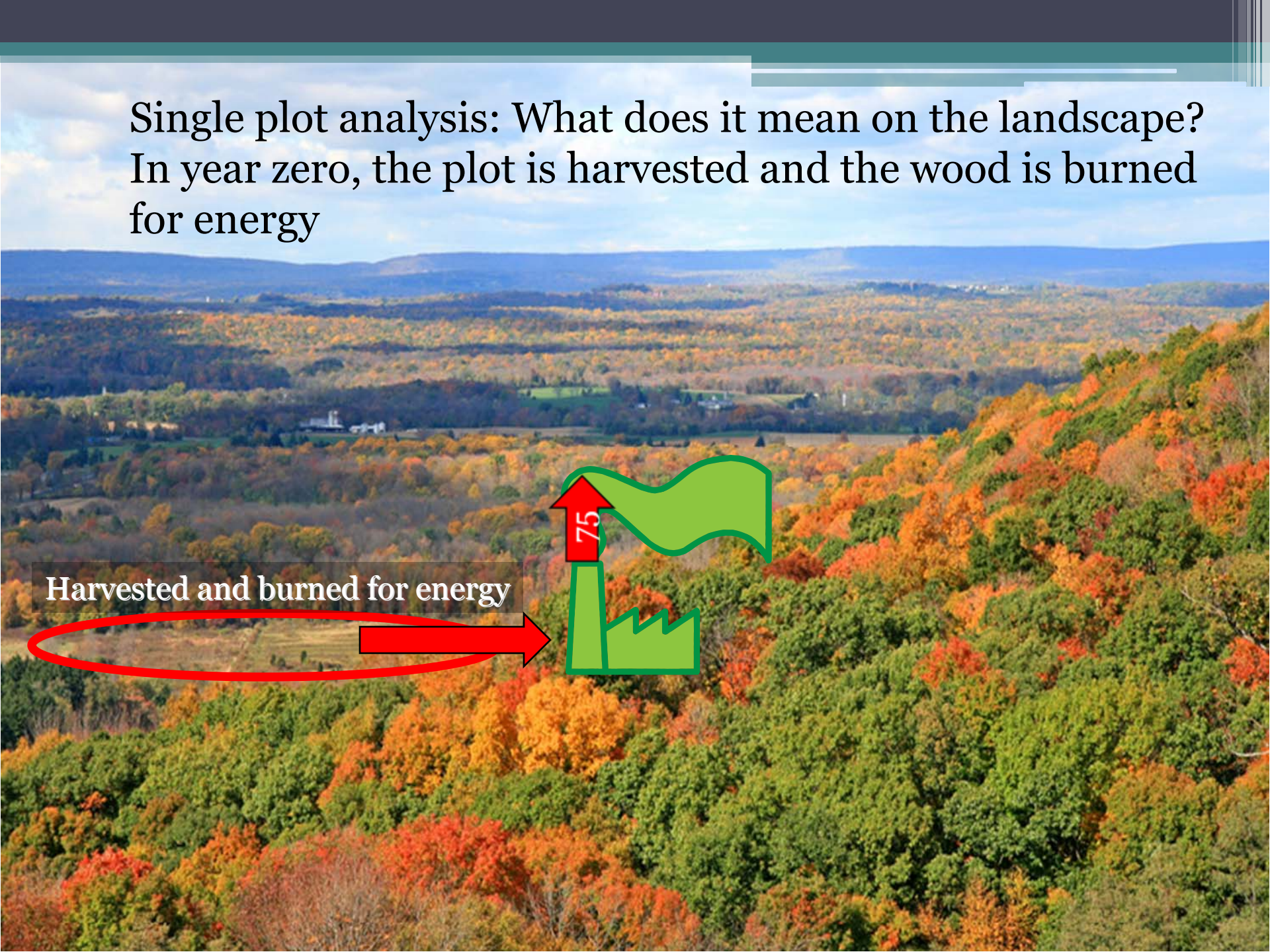
Returning forest carbon stocks to pre-harvest levels brings the net emissions to zero. If additional carbon is stored in products made from harvested wood, the net emissions are less than zero.

Carbon stored in products

The problems with single plot assessments

- If the biomass is produced via annual crops, then including all of the production area as a single plot can be reasonable.
  - This “plot” produces all of the feedstock needed by the “facility” or industry
- But what if a source of biomass (e.g. trees) requires more than one year to grow?

Single plot analysis: What does it mean on the landscape? In year zero, the plot is harvested and the wood is burned for energy



Year 1:
The plot is regrowing. The facility sits idle.

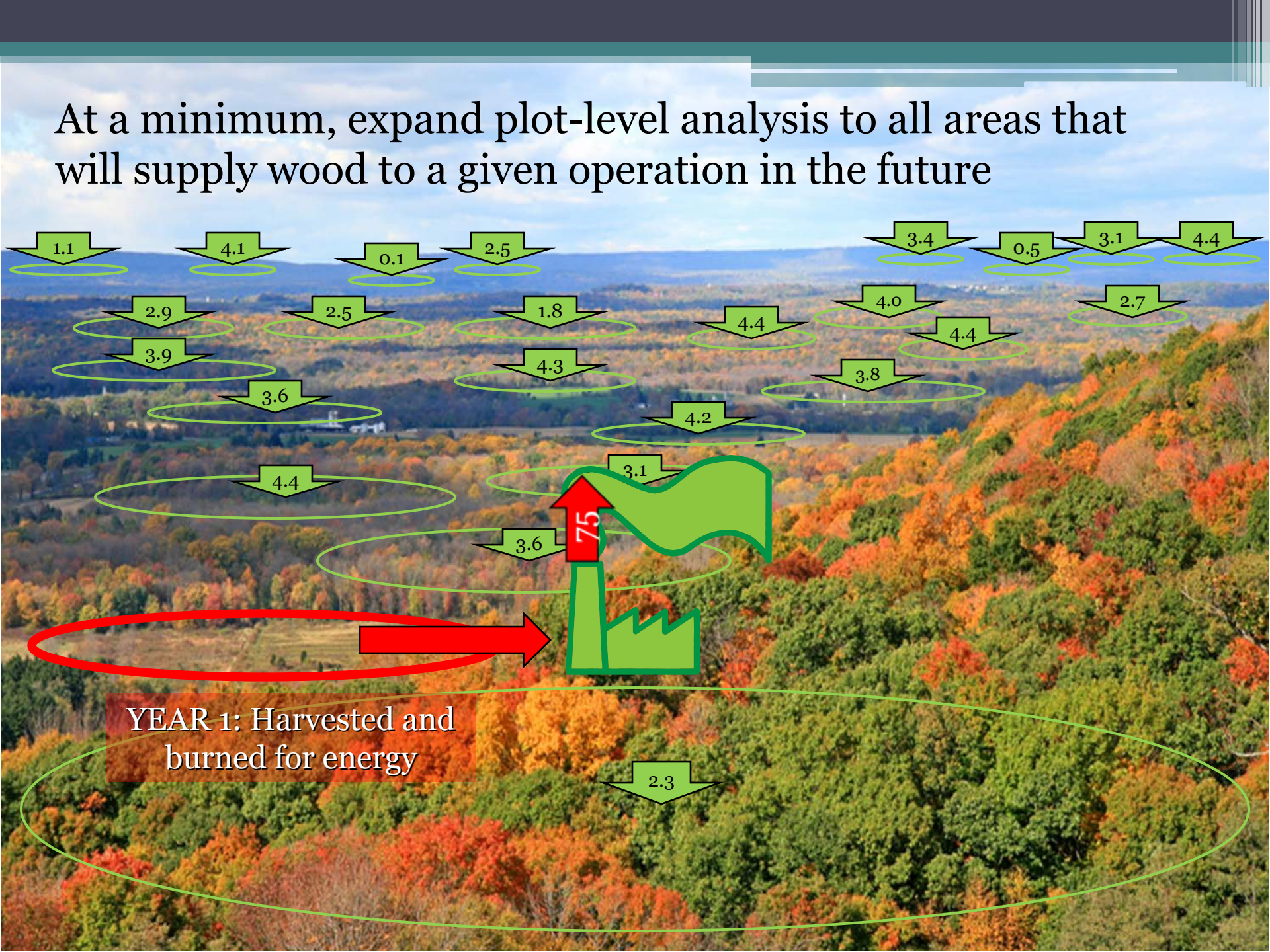
Year X:
The plot is still regrowing. The facility sits idle.

Finally the plot is ready to harvest.
The plot is harvested, and the plant is restarted for one year to use the harvested wood.

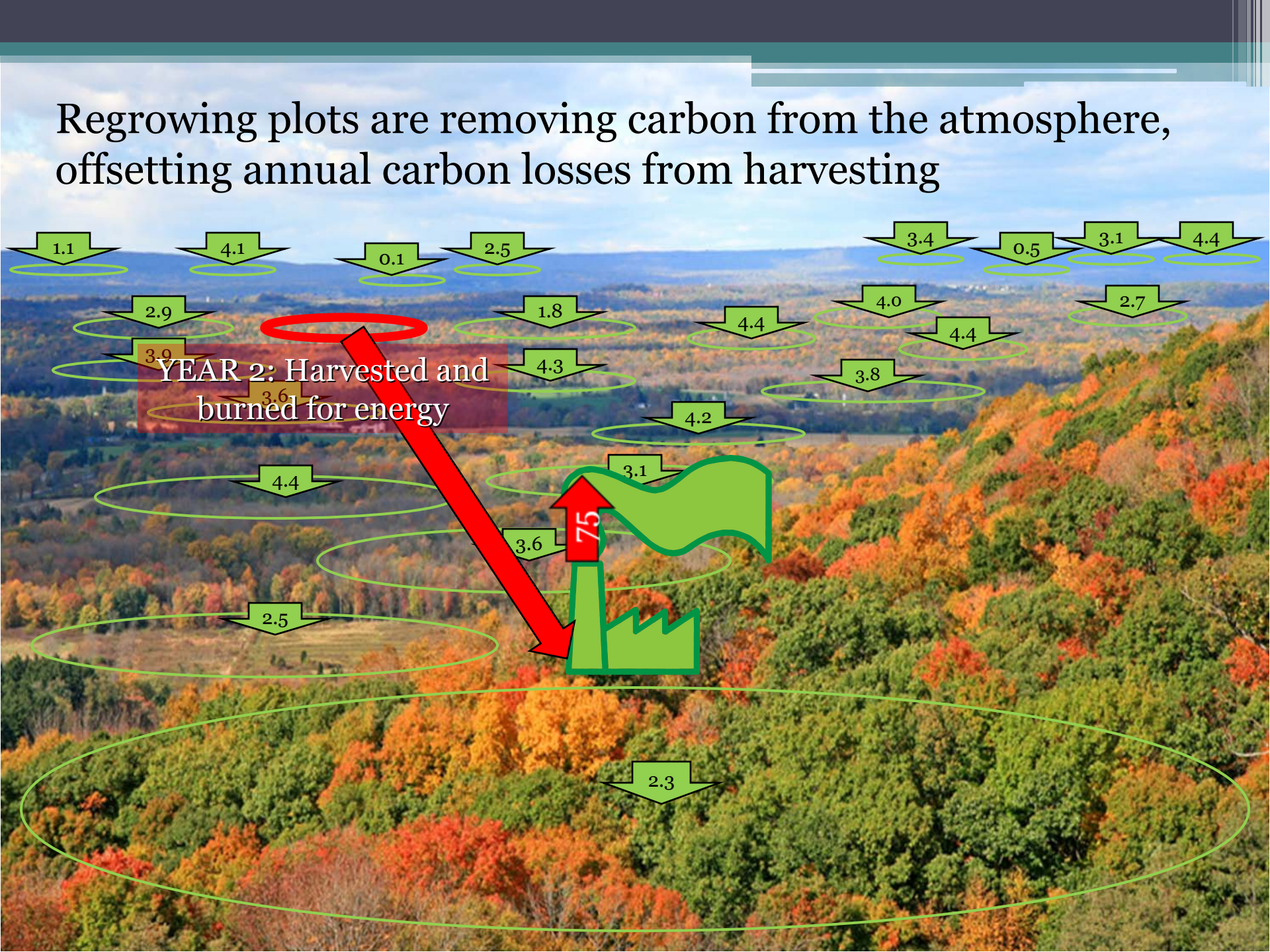
For crops that require more than one year to mature

- The assessment should encompass the entire area needed to supply the facility or industry

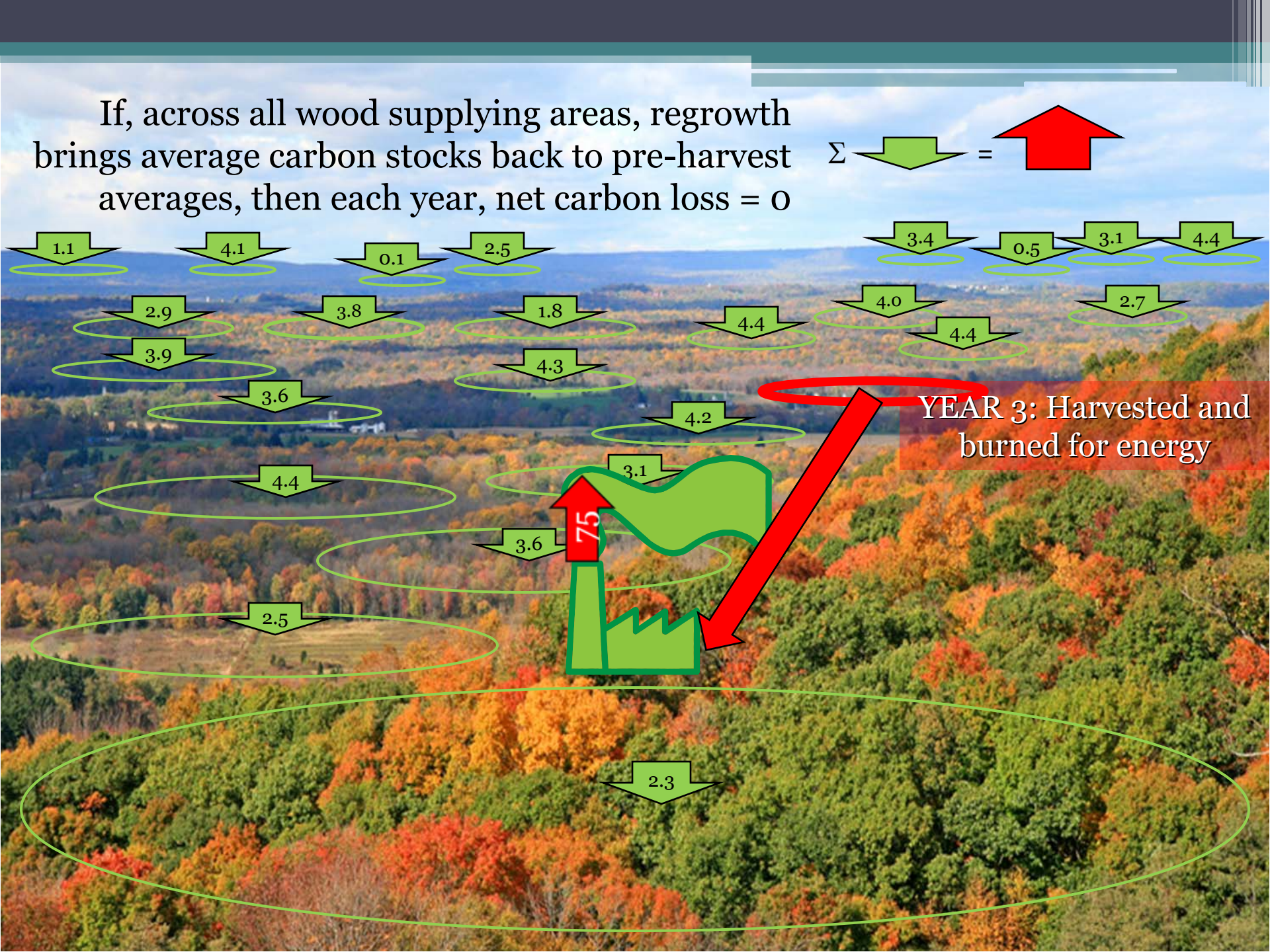
At a minimum, expand plot-level analysis to all areas that will supply wood to a given operation in the future



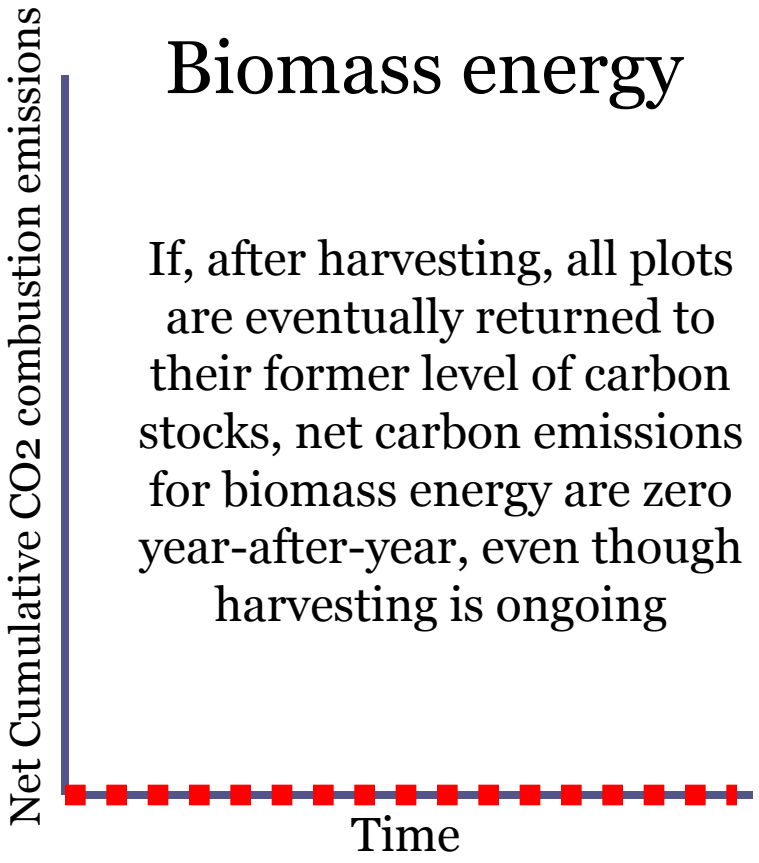
Regrowing plots are removing carbon from the atmosphere, offsetting annual carbon losses from harvesting



If, across all wood supplying areas, regrowth brings average carbon stocks back to pre-harvest averages, then each year, net carbon loss = 0



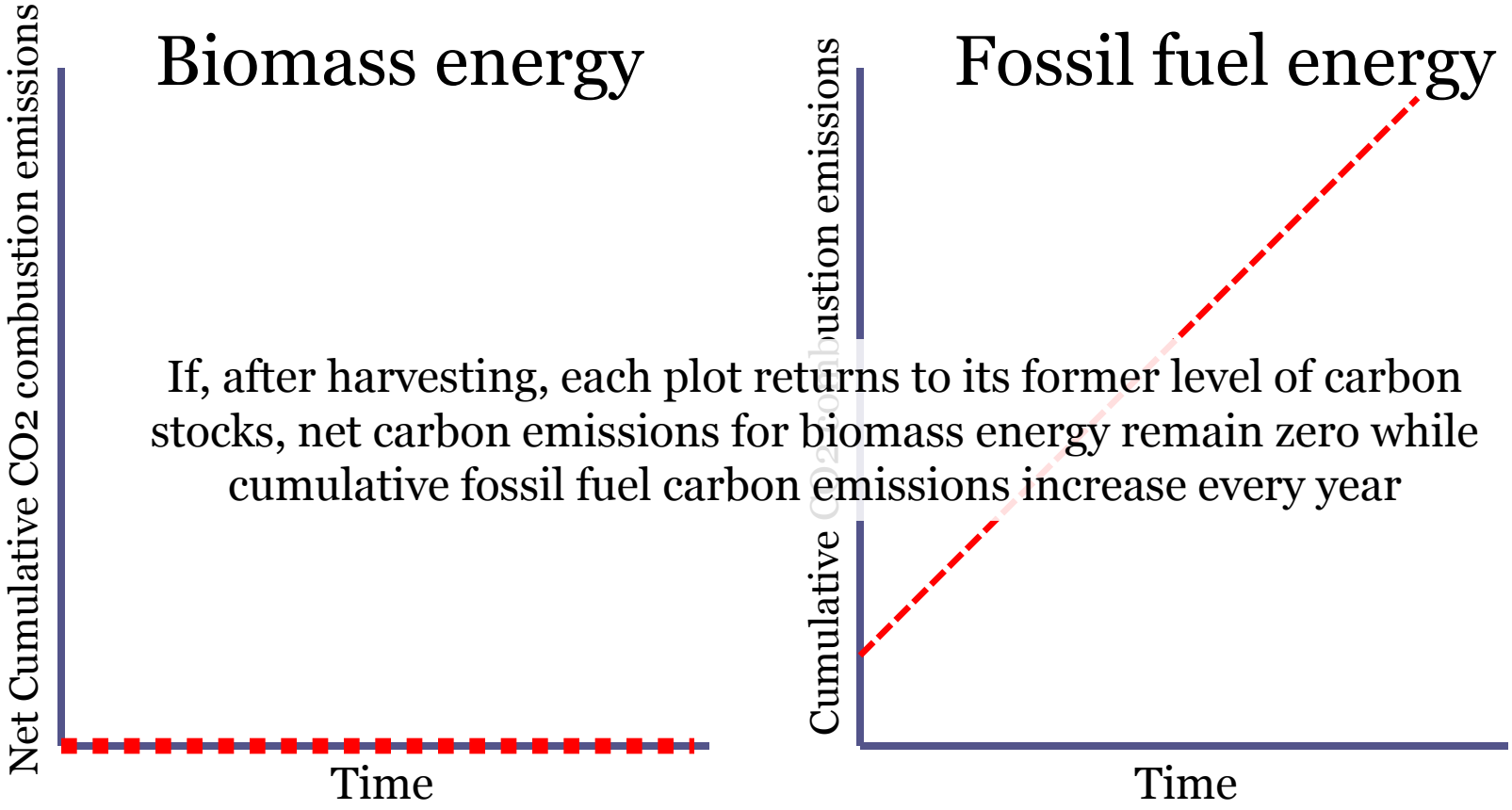
Graphically:
Extending the analysis to all plots that will supply wood in the future



Graphically:

Extending the analysis to all plots that will supply wood in the future

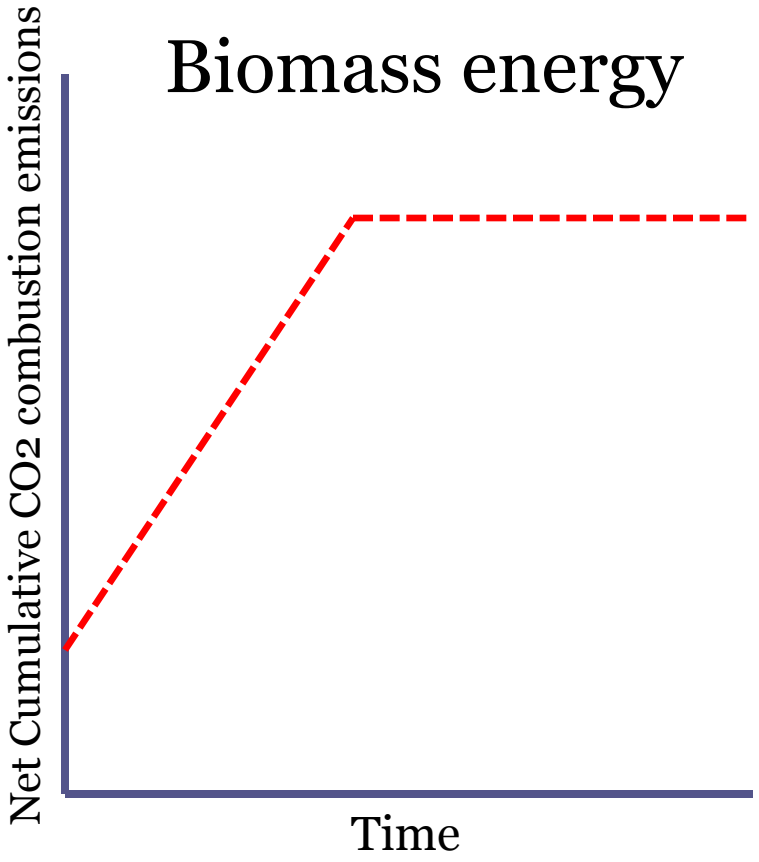
AND considering the ongoing supply of biomass energy provided by these plots

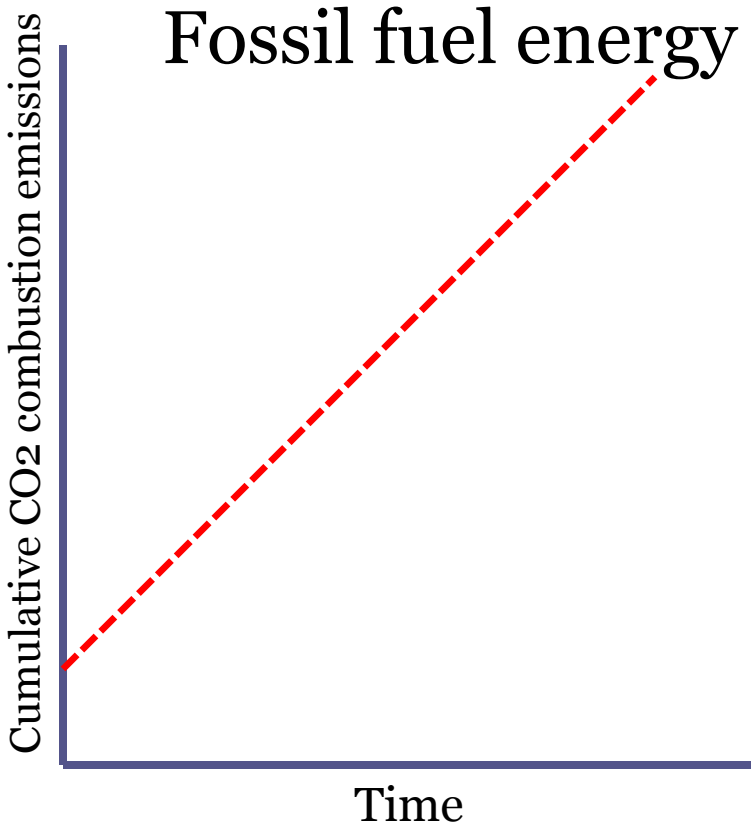


If, after harvesting, each plot returns to its former level of carbon stocks, net carbon emissions for biomass energy remain zero while cumulative fossil fuel carbon emissions increase every year

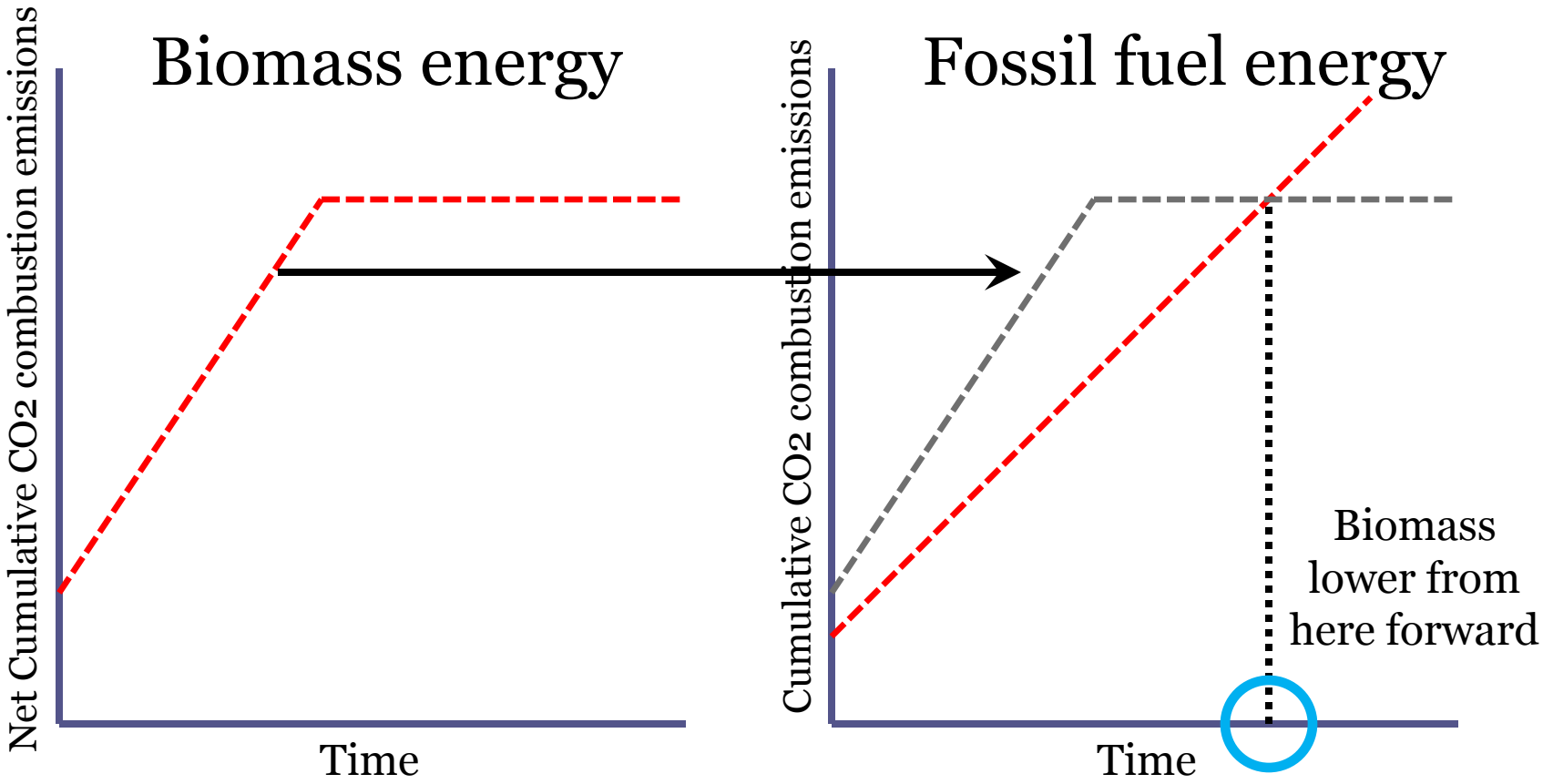
What if a new biomass production system is gradually replacing forest that has higher carbon stocks?

Net cumulative carbon emissions increase to reflect stock losses , but stop increasing after all plots have been converted to production forest.

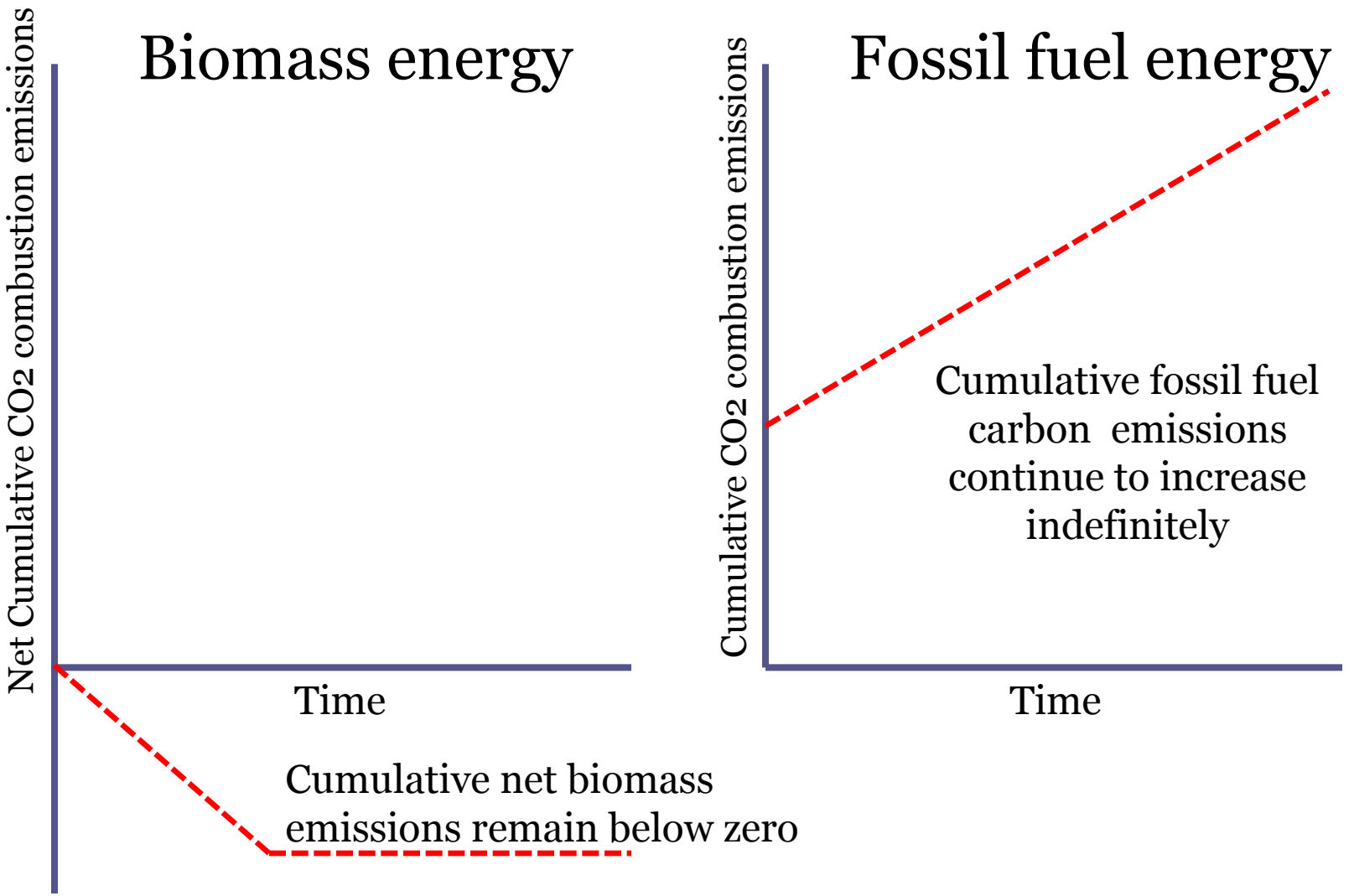




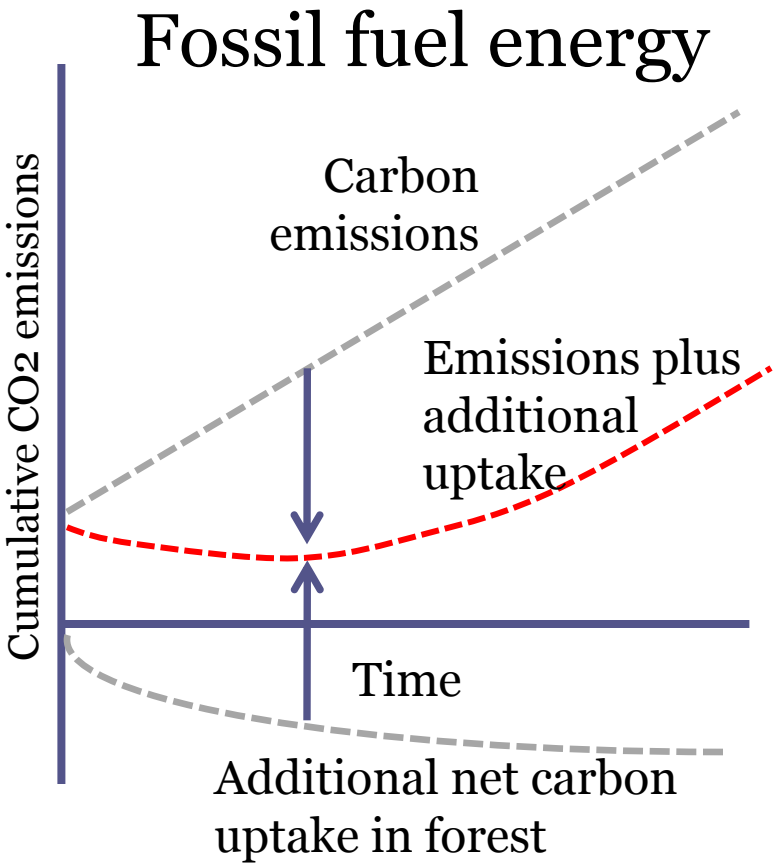
This increases the time required for biomass to show net benefits, but after the "break even point" the benefits of biomass continue to accrue



Of course, the opposite can happen. Land can be converted to higher carbon stocks to provide biomass energy (e.g. afforestation)



If we don't harvest, don't we get more sequestration by the forest?



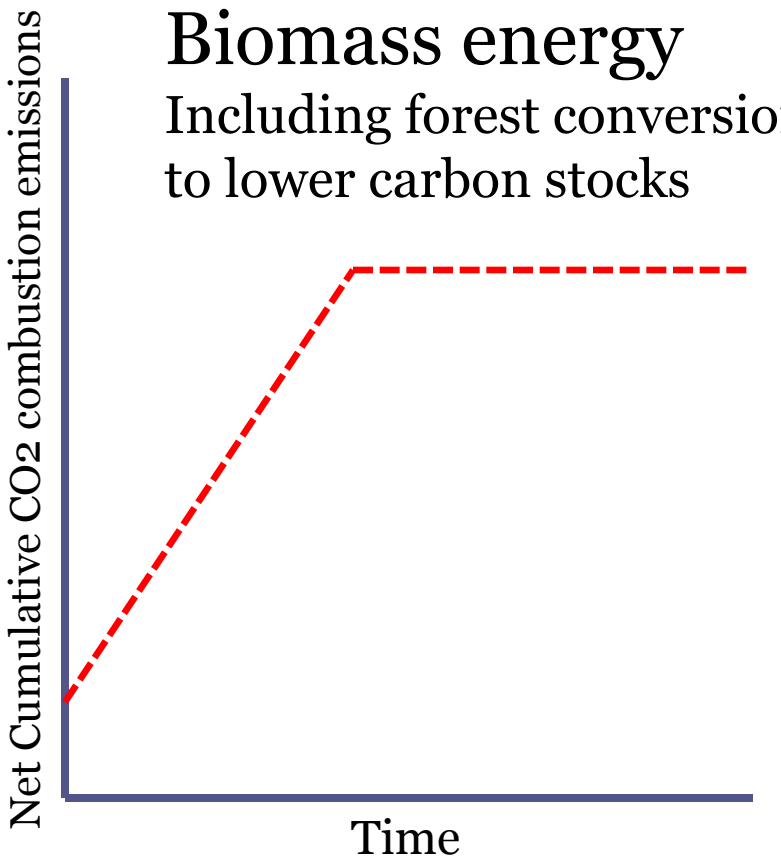
When forest carbon benefits saturate (in simplistic terms, the trees "stop growing"), the benefits of "no harvest" stop.

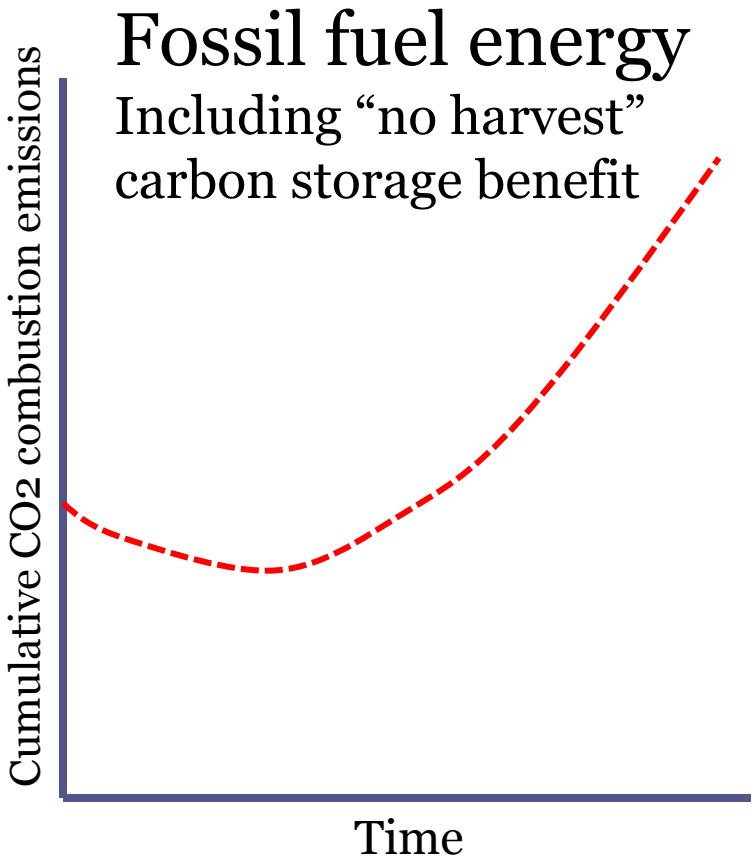
The time to saturation and carbon uptake curves are very site specific.

The "no harvest" scenario should consider the potential increased risks of

- land conversion
- natural disturbances (e.g. fires)
- other changes that impact carbon

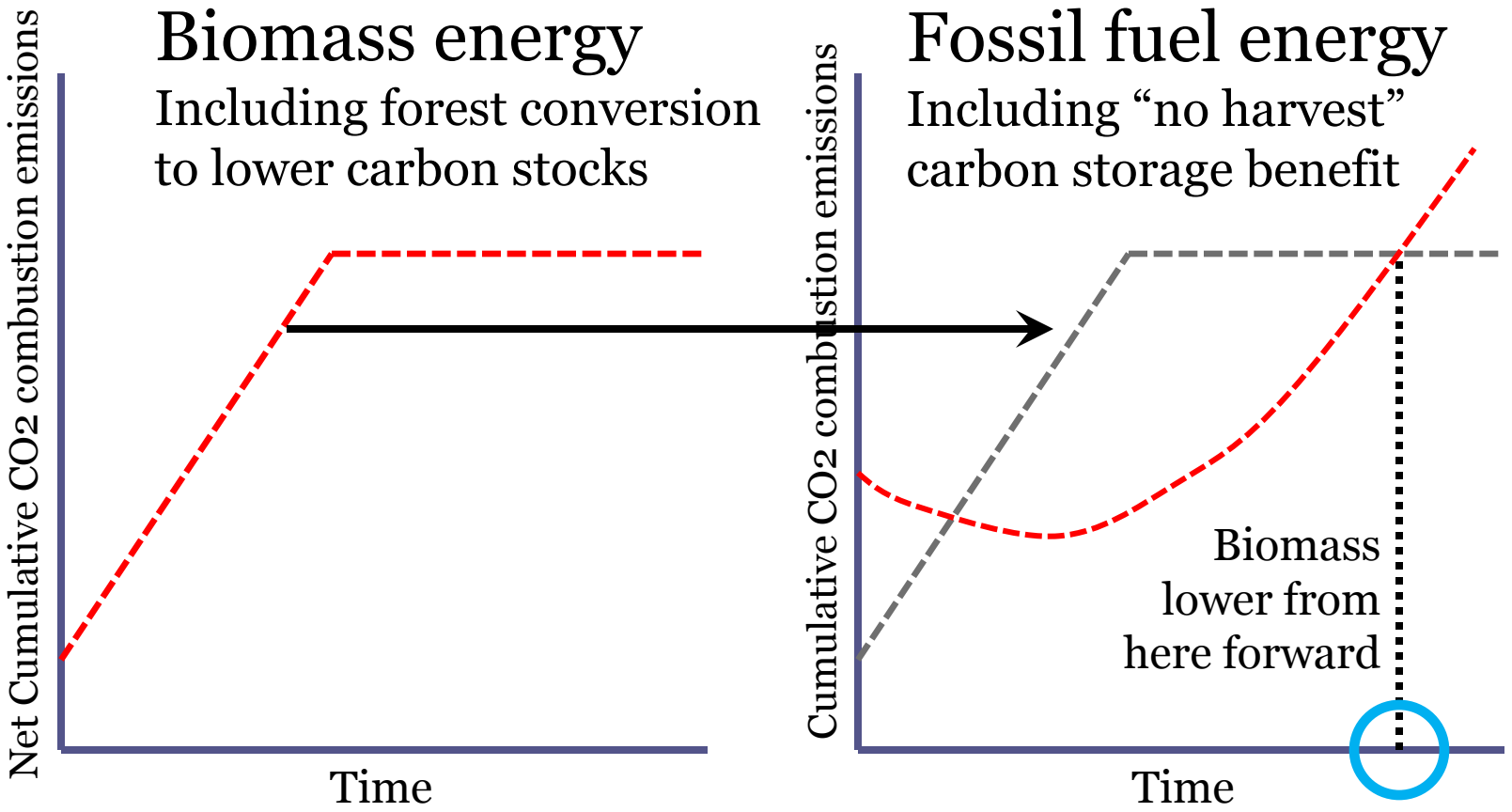
Worst case scenario – Biomass system is gradually replacing forest that has higher carbon stocks and fossil fuel is given credit for foregone sequestration.





Worst case scenario – Biomass system is gradually replacing forest that has higher carbon stocks and fossil fuel is given credit for foregone sequestration. Is the break-even time so long that biomass energy is not a good choice?

- Must consider (a) other life cycle emissions (addressed in later slides) and (b) the balance between short-term and long-term benefits

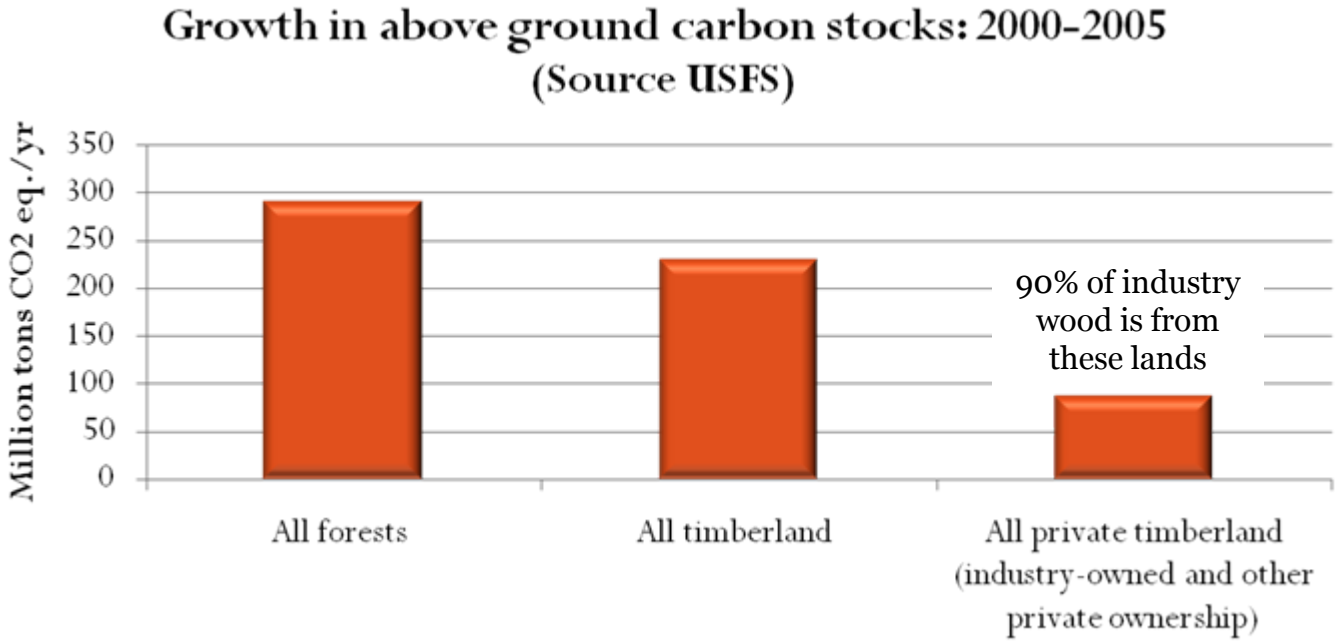


The appropriate scale for forest biomass carbon cycle accounting

- We have seen…
  - Single plot assessments give a very misleading picture
  - The scale of the analysis should be expanded to cover all areas that will supply biomass to the facility or industry in future years.
- For many purposes, analysis on a regional scale or national scale may be most appropriate
  - Better reflects the impacts on the atmosphere
  - Avoids over-reacting to small-scale impacts that are compensated for elsewhere

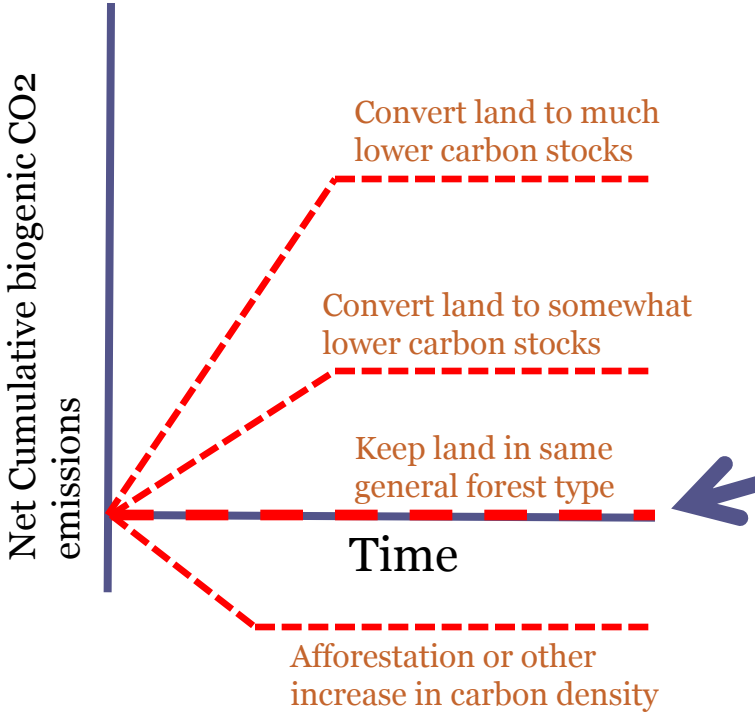
Forest carbon stocks at the national level

- In the U.S., there is a net uptake of carbon in the forests that supply wood to the industry
  - Carbon stocks are increasing on non-industrial private timberland and are stable on industry-owned timberland



Impacts of different carbon scenarios for producing biomass energy

So, we have seen that the net cumulative emissions of biogenic carbon vary depending on whether the overall carbon stocks on the land are changing



In the United States, carbon stocks on wood-producing land are stable or increasing, so the national situation is best represented by this line.

This means that the forest biomass carbon placed in the atmosphere is offset by new forest growth on wood-producing land

Three things determine the benefits of forest-derived energy/products

1. The impacts on net transfers of biomass carbon to/from the atmosphere
   - i.e. impacts on the biomass carbon cycle
   - Biogenic CO_2 accounted for here
2. The emissions of other greenhouse gases during "use" relative to those associated with the displaced fossil fuel or products
3. The other life cycle emissions of greenhouse gases relative to those associated with the displaced fossil fuels or products

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Biomass carbon cycle accounting

Life cycle greenhouse gas accounting

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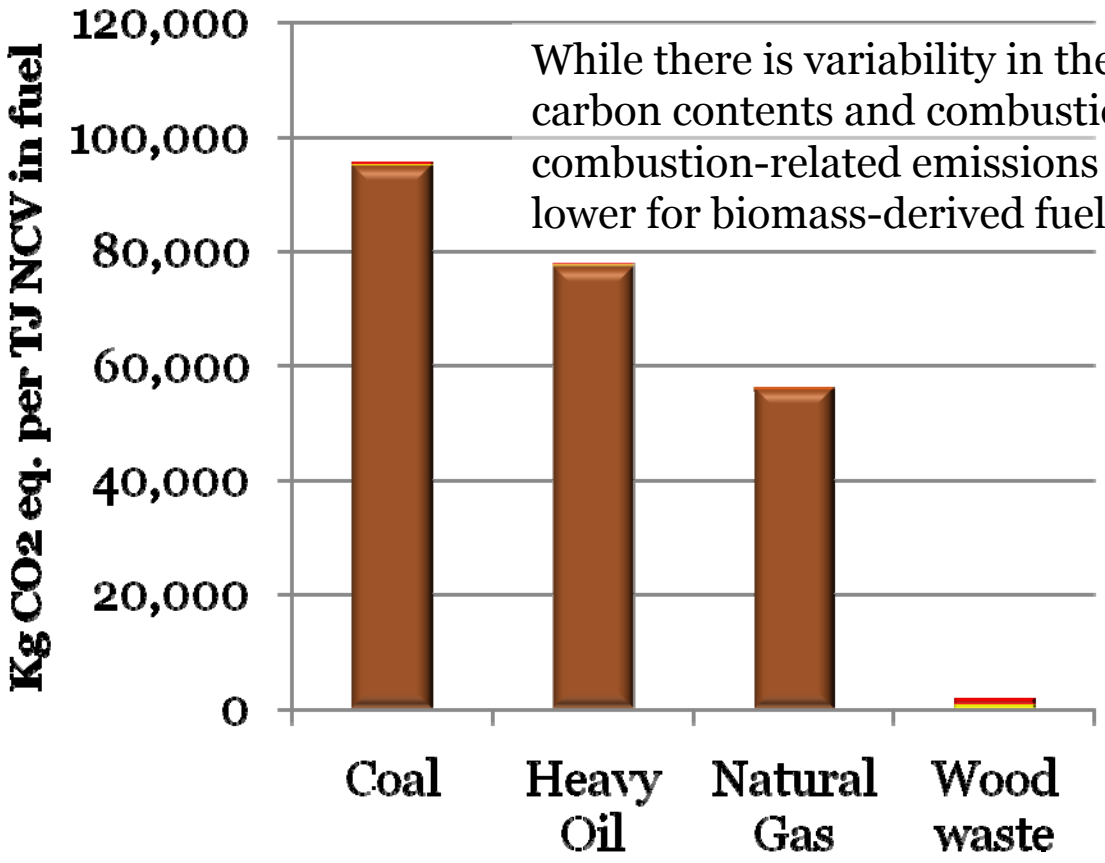
Biomass carbon cycle accounting

Life cycle greenhouse gas accounting

For wood-derived energy, emissions during “use” are from combustion



While there is variability in these values due to differing carbon contents and combustion conditions, total combustion-related emissions of these gases are always lower for biomass-derived fuels than for fossil fuels

- Nitrous Oxide, CO_2 eq.
- Methane, CO_2 eq.
- Non-biogenic CO_2

Biogenic CO_2 from combustion is addressed in the biomass carbon cycle accounting

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Biomass carbon cycle accounting

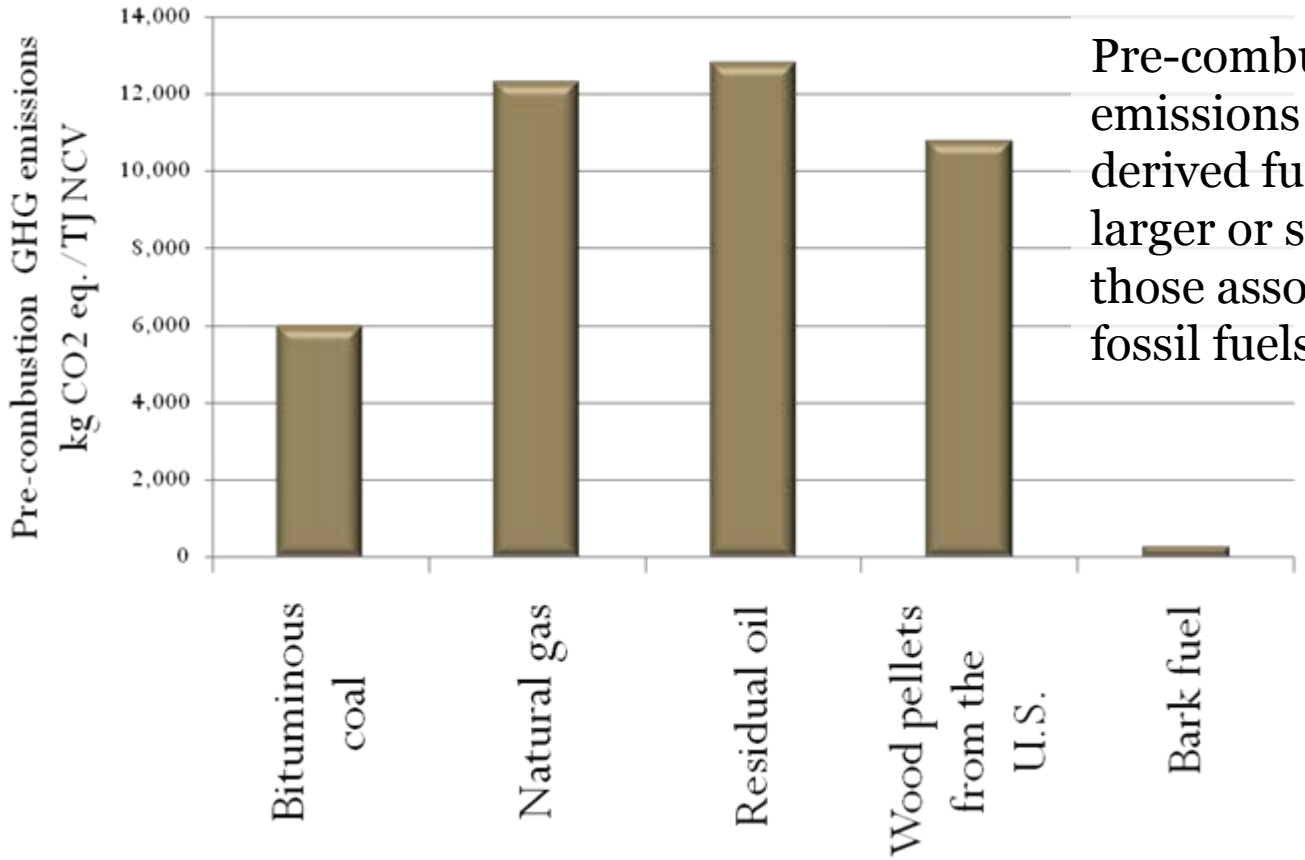
Life cycle greenhouse gas accounting

For energy systems, these other emissions are "pre-combustion" emissions

- Pre-combustion emissions are highly variable
- Fossil fuels
  - Extraction-related emissions
  - Processing-related emissions
  - Transport-related emissions (including CH_4 losses)
- Wood-derived fuels
  - Chemicals used in wood production
    - e.g. emissions associated with the production and use of fertilizers
  - Fossil fuels used in forestry
    - e.g. in harvesting and regeneration
  - Processing (highly variable)
  - Transport

Pre-combustion emissions:

Not including transport



Pre-combustion emissions for wood-derived fuels can be larger or smaller than those associated with fossil fuels

Data sources: IPCC, USLCI Database, other public life cycle databases

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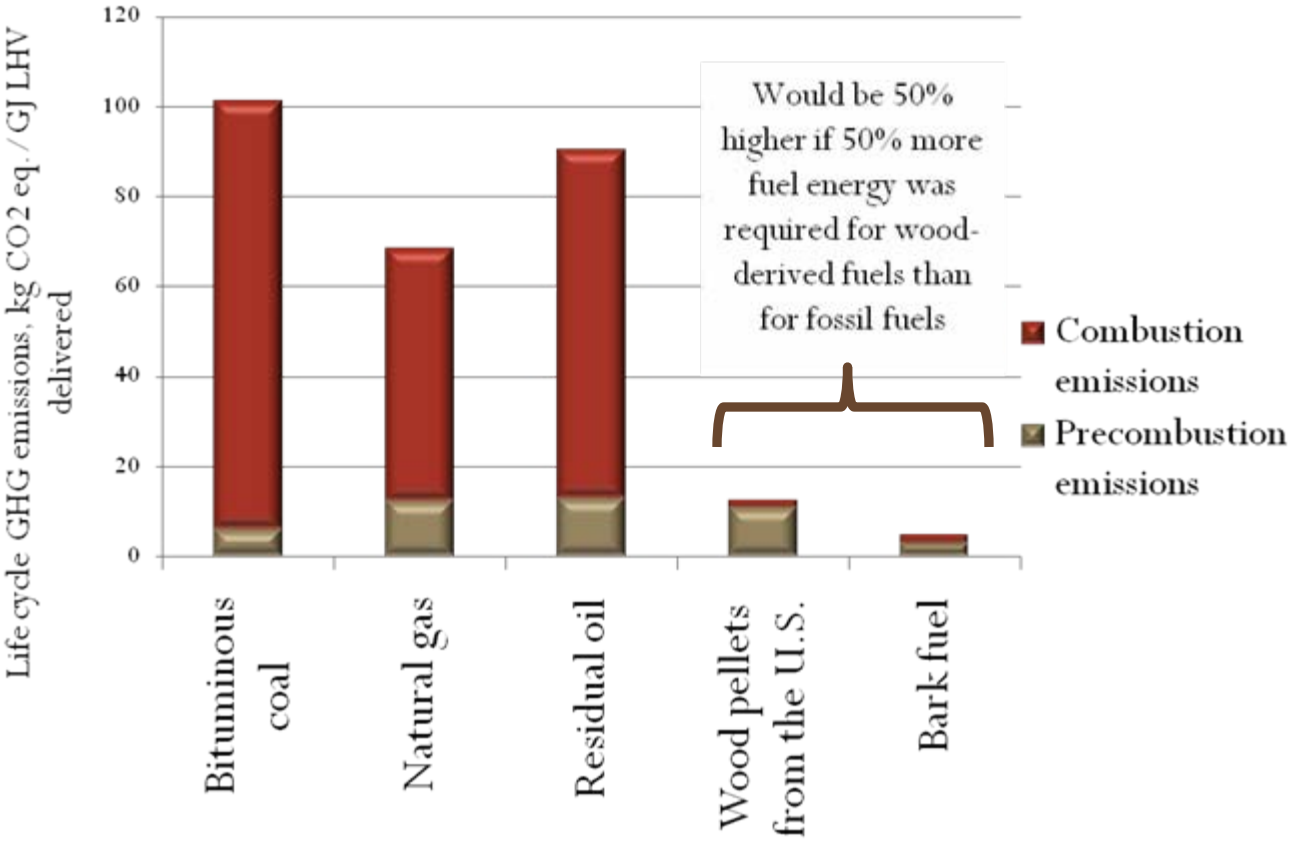
Biomass carbon cycle accounting

Life cycle greenhouse gas accounting

Life cycle GHG emissions for wood-derived energy:

Assuming constant forest carbon stocks over the area supplying forest biomass, as is true for wood-producing land in the U.S.

- Even if 50% more fuel energy is required, fuels derived from forest biomass still have far lower life cycle emissions than fossil fuels



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What about biomass carbon neutrality?

- Emissions associated with biomass energy consist of…
  - Net gains/losses of carbon in the biomass carbon cycle
  - Many other combustion and pre-combustion emissions
- Different definitions of biomass carbon neutrality encompass different aspects of these factors
  - If "carbon neutral" means that transfers of forest carbon to the atmosphere are being offset by new growth, then in the context of wood-producing land in the US, forest biomass can be characterized as "carbon neutral".
- Regardless of your definition, it is critical to use an accounting framework that examines biomass carbon emissions…
  a) in the context of the biomass carbon cycle examined over appropriate scales of area and time,
  b) separately from fossil fuel to avoid unintended consequences, and
  c) without requiring complex and costly monitoring of forest carbon