# Carbon Dynamics of the Forest Sector

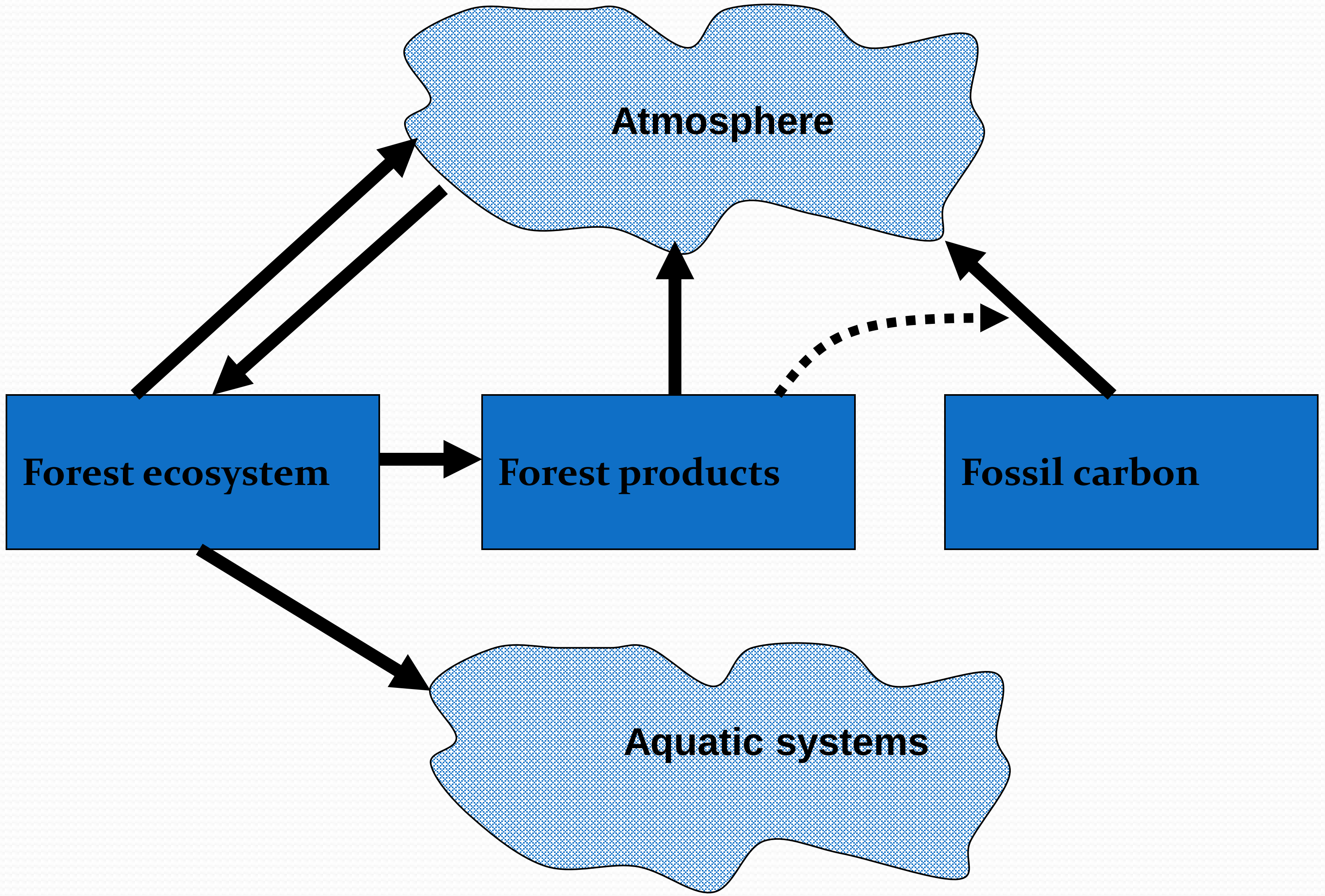
Mark E. Harmon
Richardson Chair & Professor
Forest Ecosystems and Society
Oregon State University
Corvallis, OR

# Main points

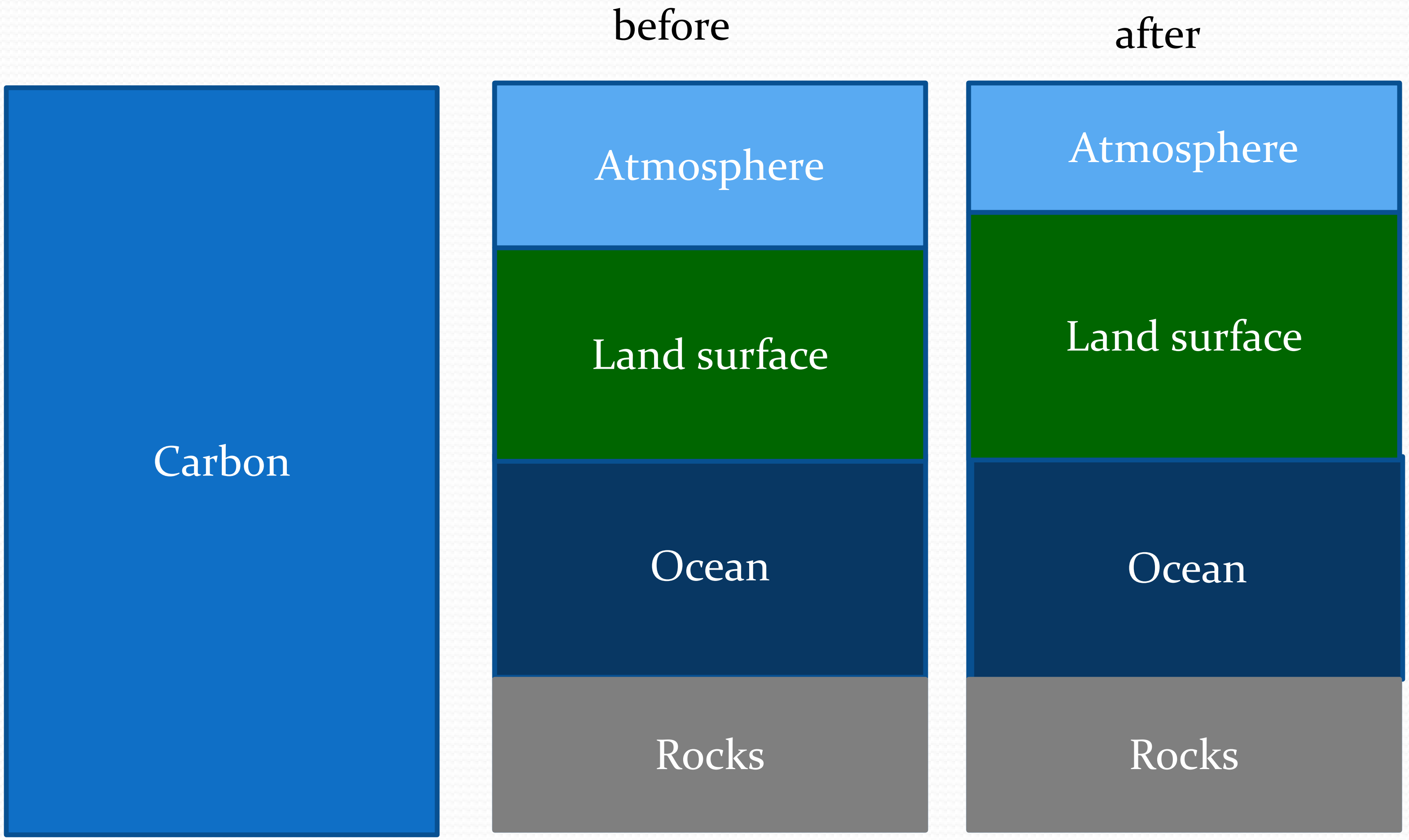
- The basic ecosystem science behind carbon dynamics in forests is relatively straightforward (really!)
- This science doesn't seem to be applied very routinely in the policy arena
- This mismatch is undermining the potential of the forest sector in helping to mitigate greenhouse gases in the atmosphere

# Basic Principles

# The forest sector



# Conservation of mass law

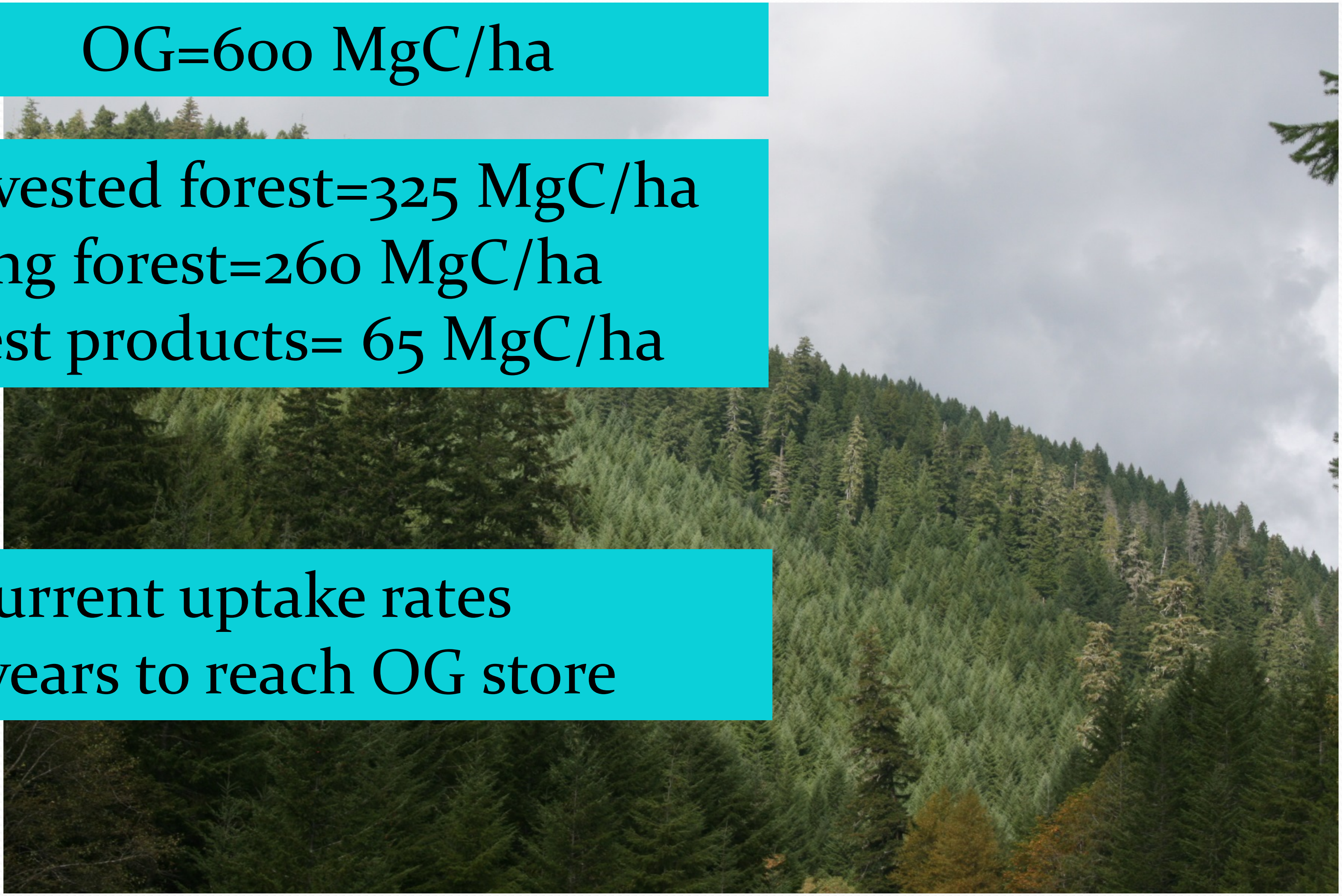


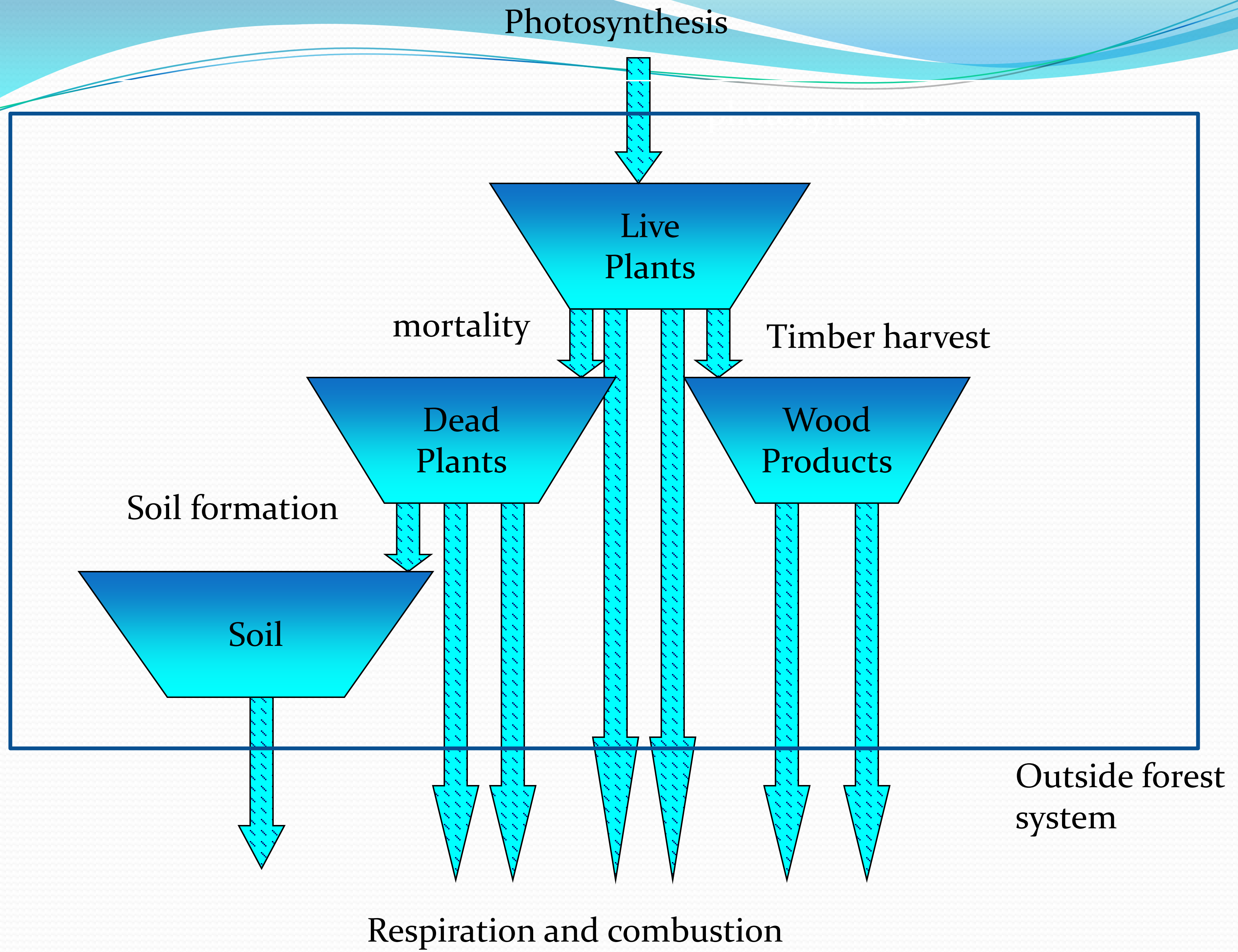
# Which  forest stores more carbon?

OG=600 MgC/ha

Harvested forest=325 MgC/ha
Young forest=260 MgC/ha
Forest products= 65 MgC/ha

At current uptake rates
130 years to reach OG store




Photosynthesis
Live Plants
mortality
Timber harvest
Dead Plants
Wood Products
Soil formation
Soil
Outside forest system
Respiration and combustion


5
Medium
leaks

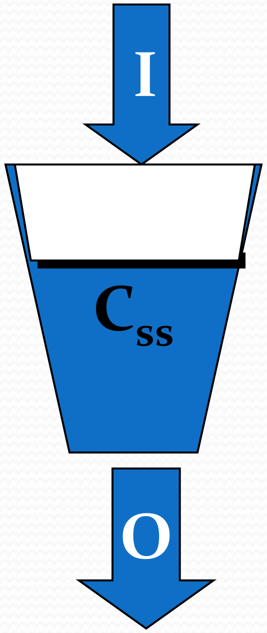

5
Large
leaks


7
Small
leaks


2
Large
leaks

# The Math of Leaky Buckets

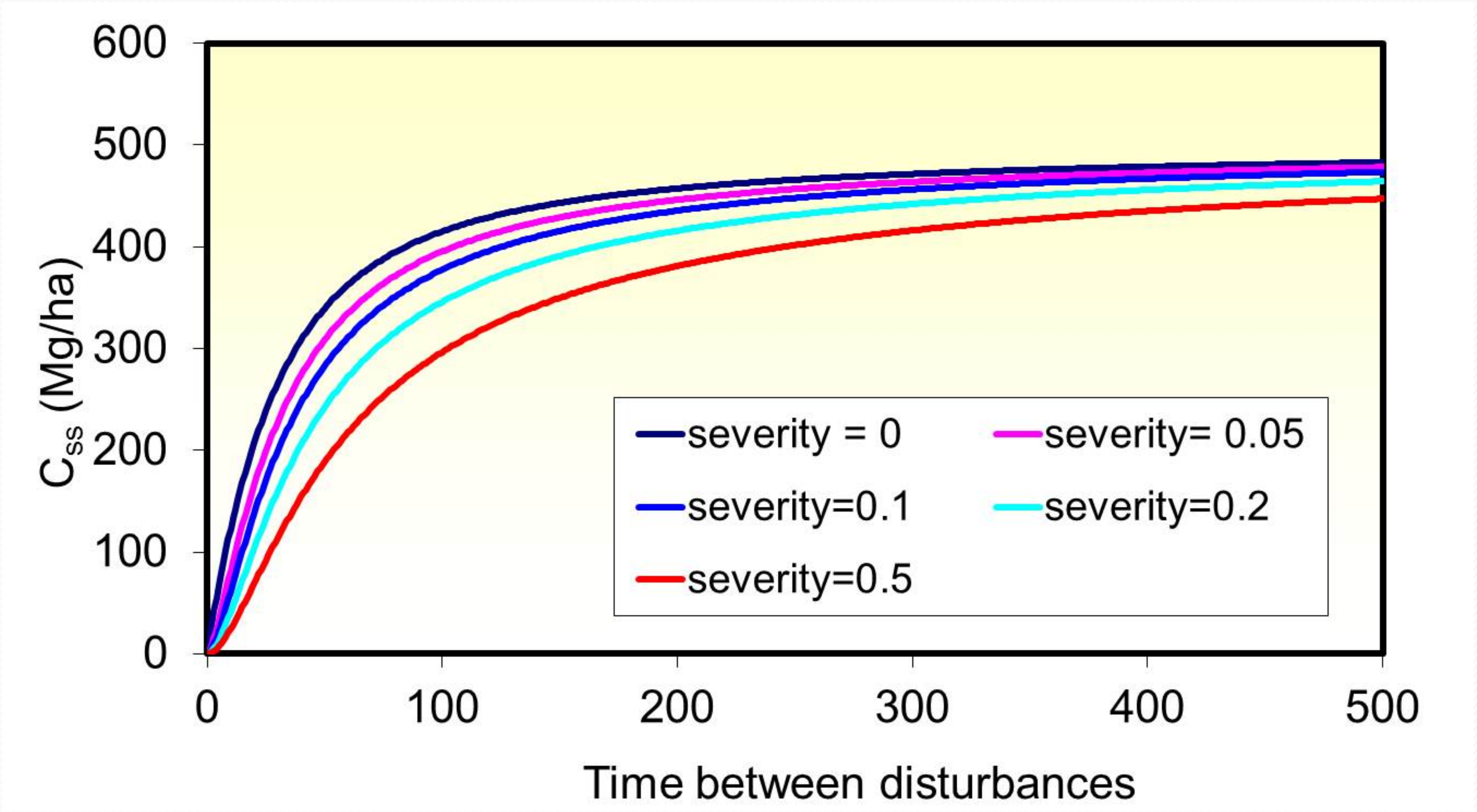
$$C_{ss} = I/k$$




**I is the input rate**

**k is the proportional loss rate**

# The fewer and smaller the holes the more stored




Full input (NPP) returns in 25 years

# Which is more relevant?

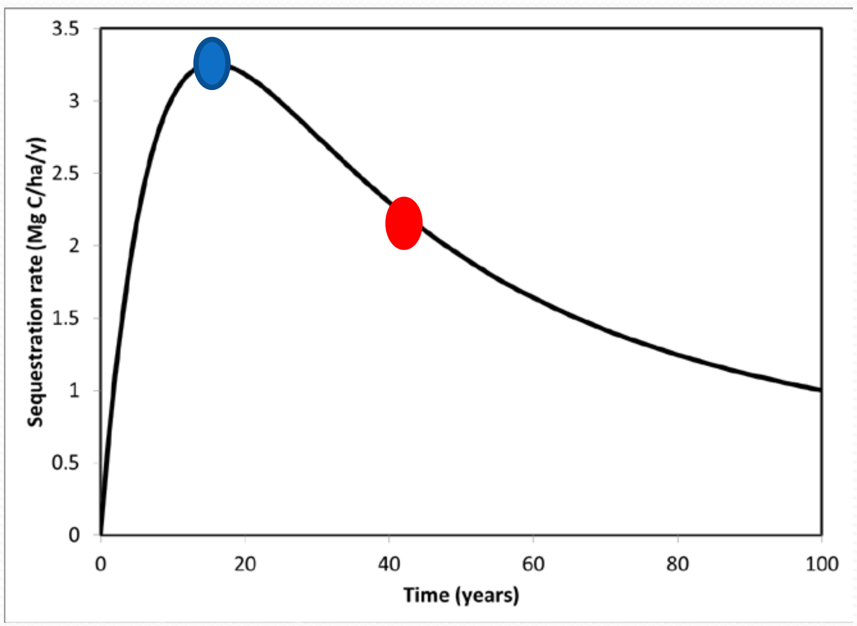
The average rate of uptake (sequestration)

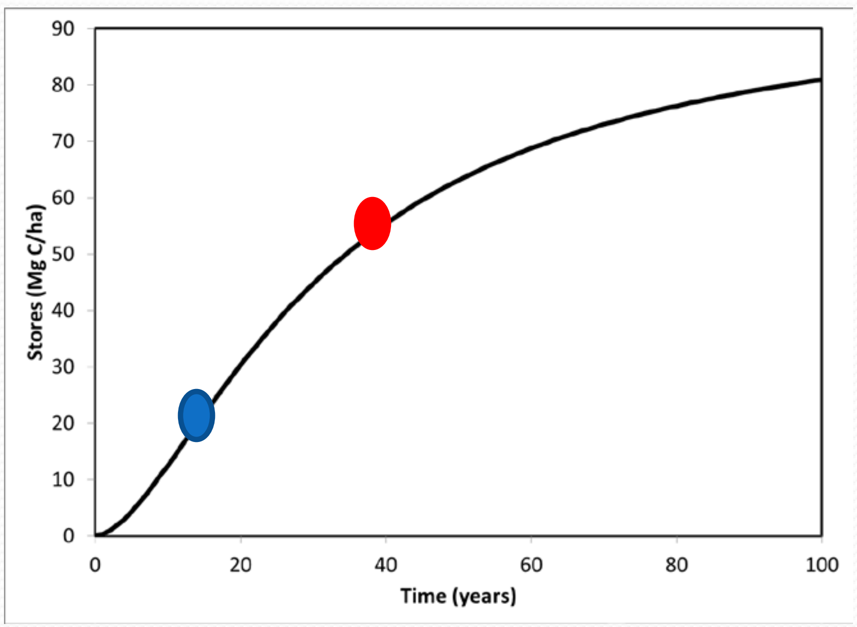
OR

The average amount stored

# System average (all ages)

**Sequestration rate** **Stores**



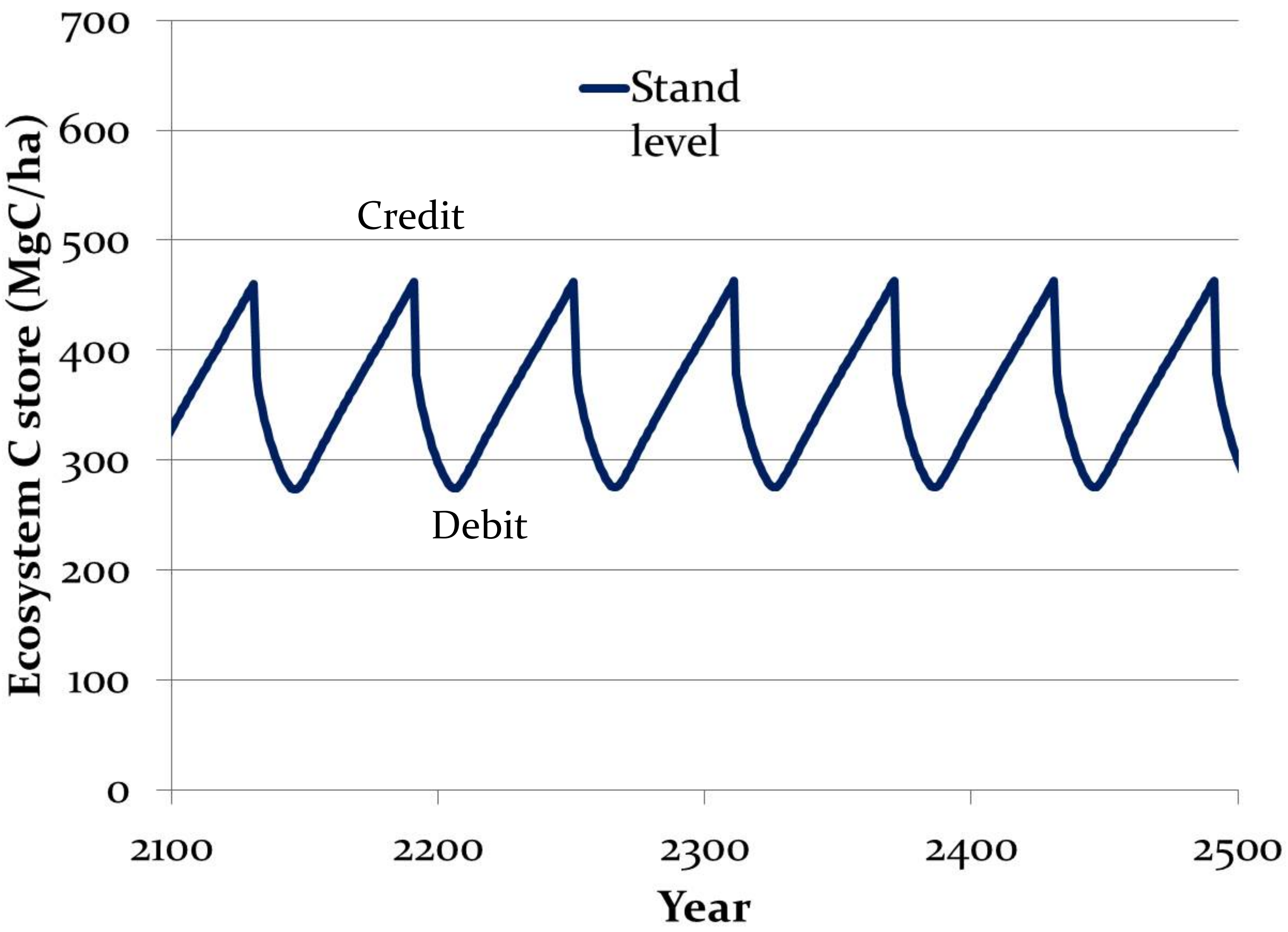

Why the mismatch? They forgot the relative leakiness (I/**k**)

# Questions of scale

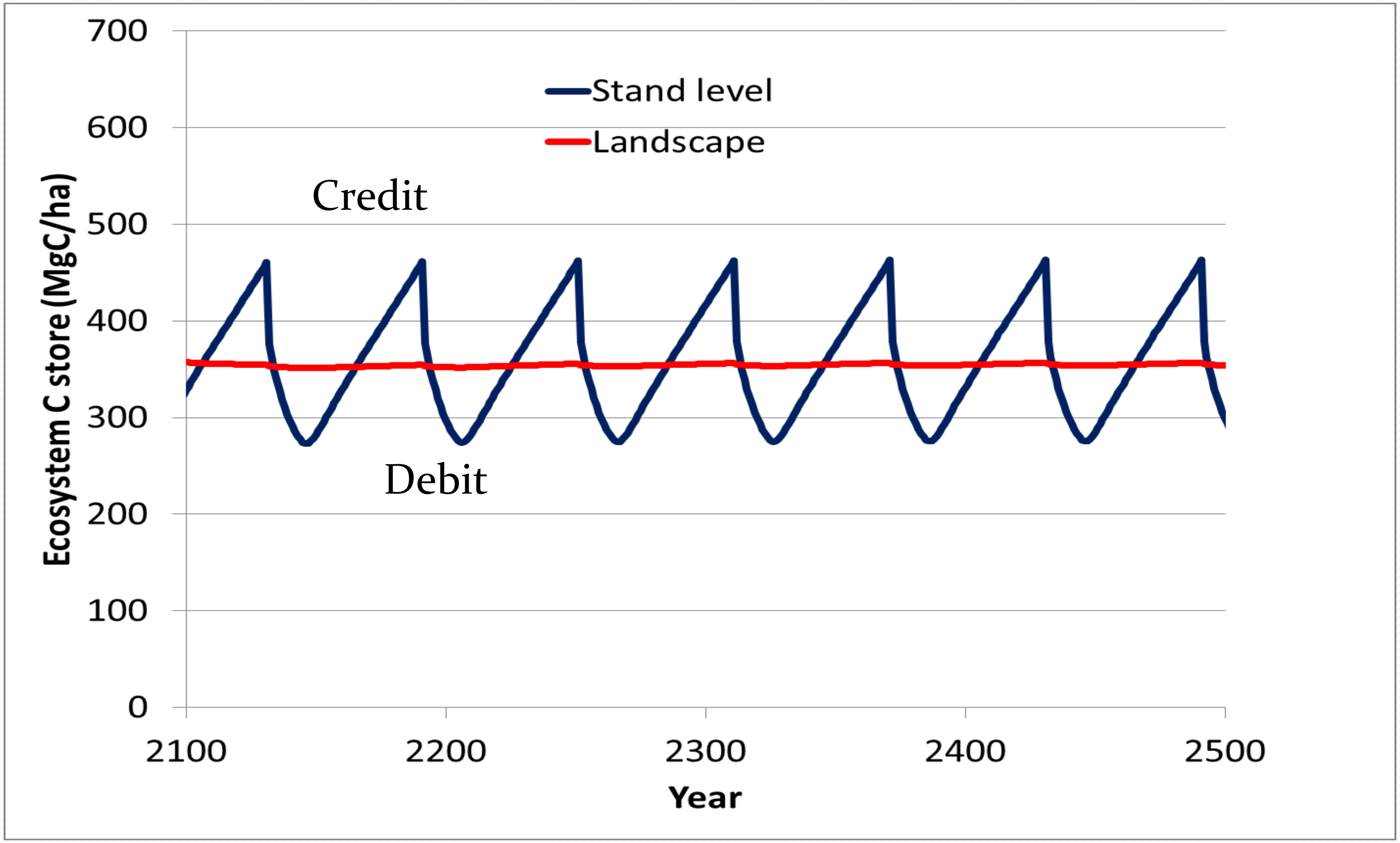
The answer depends on scale

Some scales are more relevant than others for policy

# Can a steady-state have a carbon debt or credit?

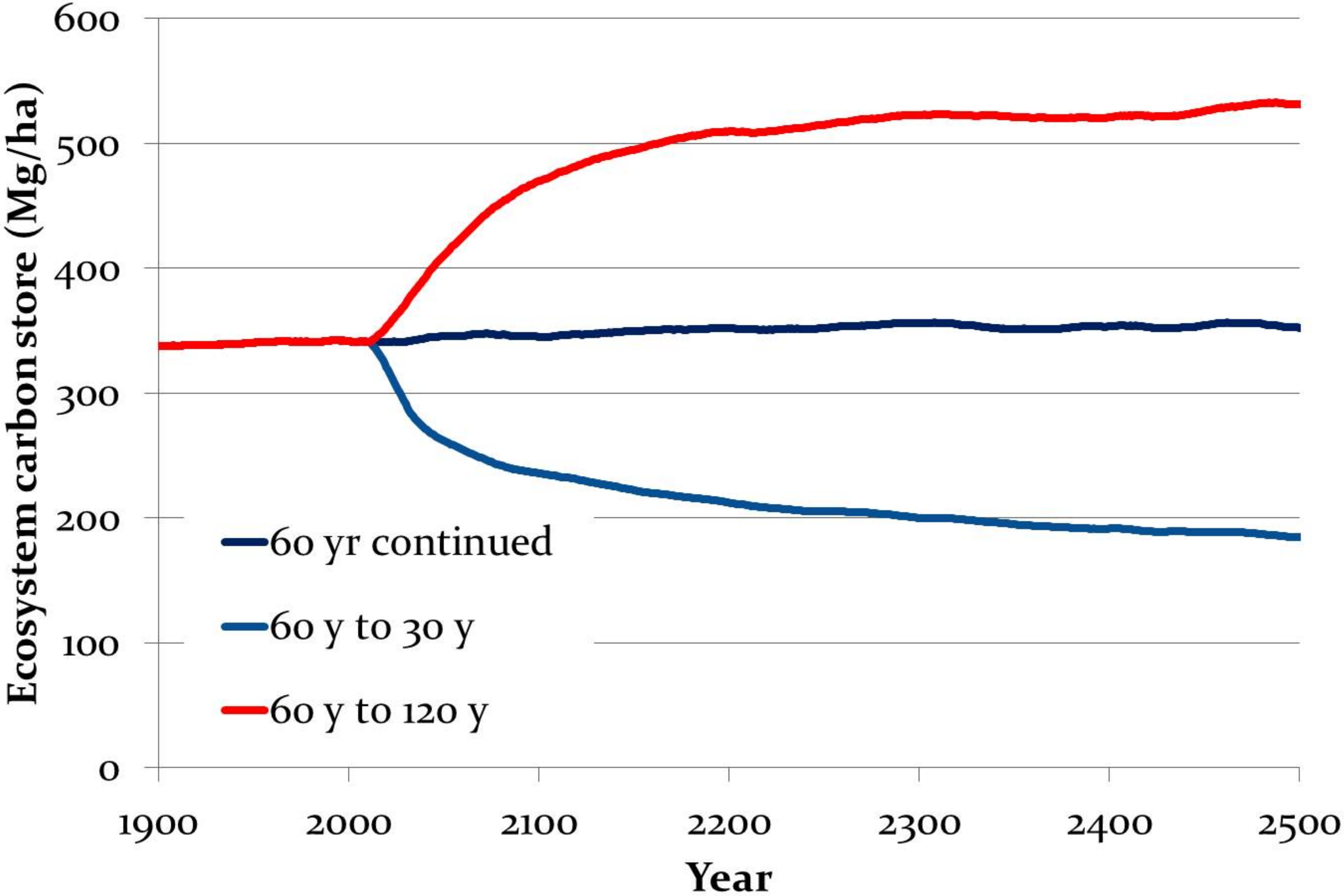


# Can a steady-state have a carbon debt or credit? Not really, as it makes no sense



# Going from one steady-state to another can create either a carbon debt or credit!

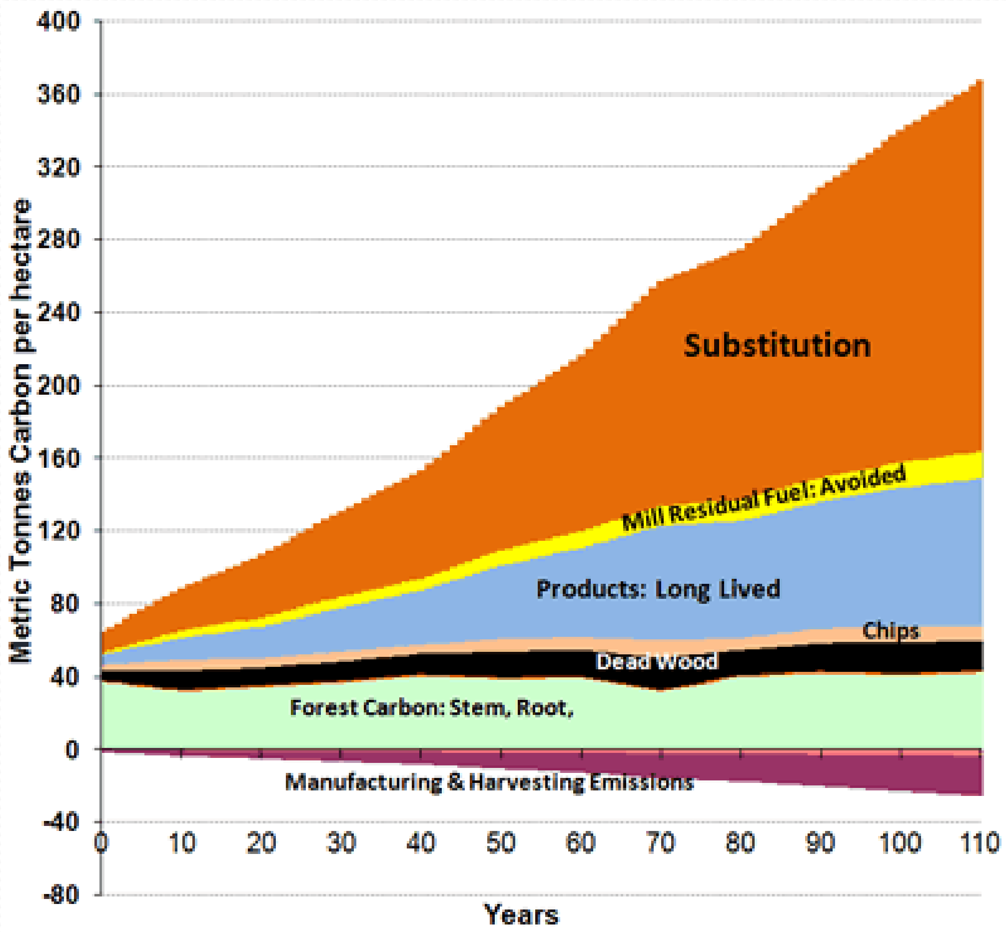
**This is the real issue we need to evaluate**



# An example of dubious carbon science:

Product substitution will result in a large carbon sink

# The Classic Products Substitution Story



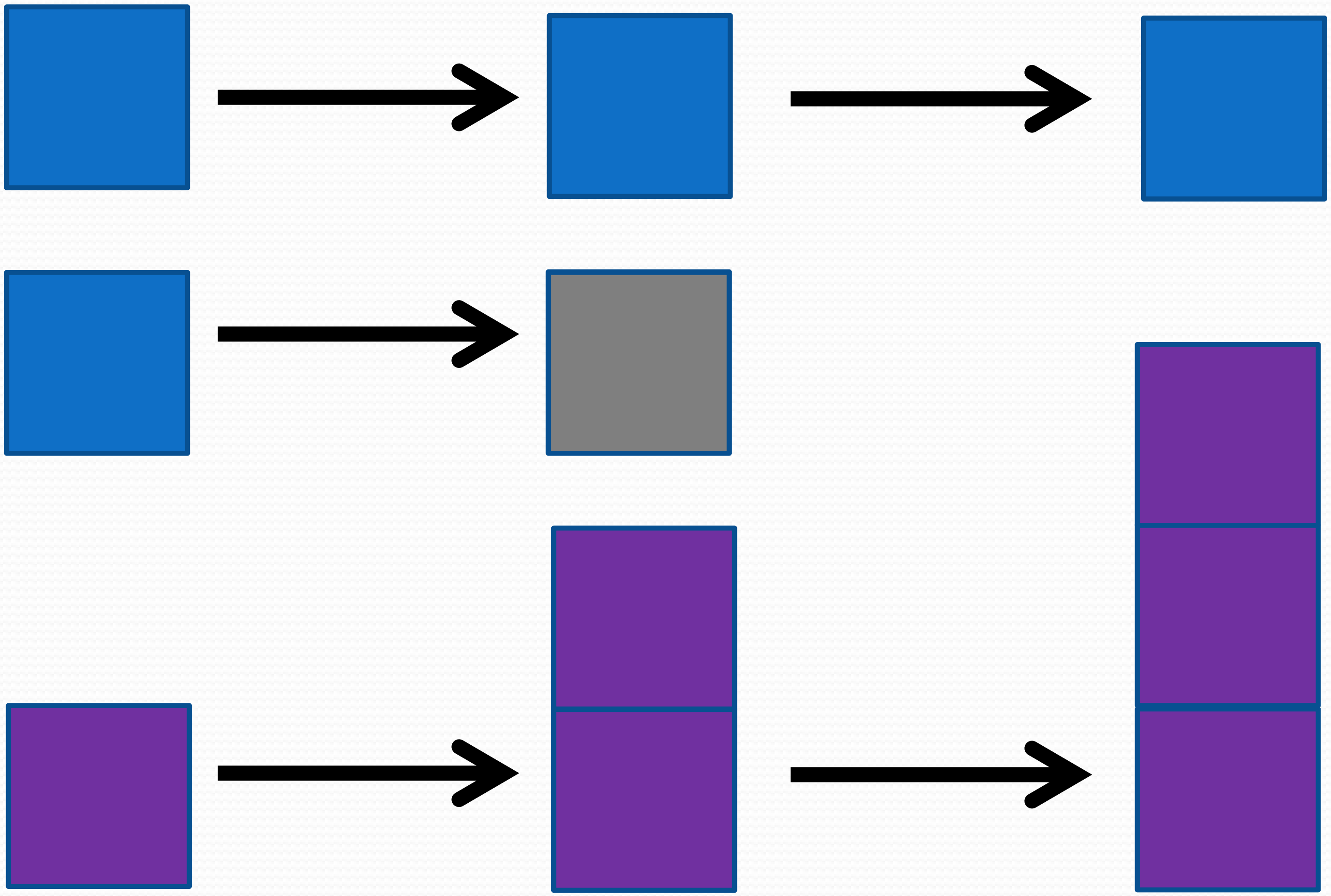

Long lived products store
About 1/3 of sector C

Substitution (a virtual store) increases to infinity because the substitution is infinite

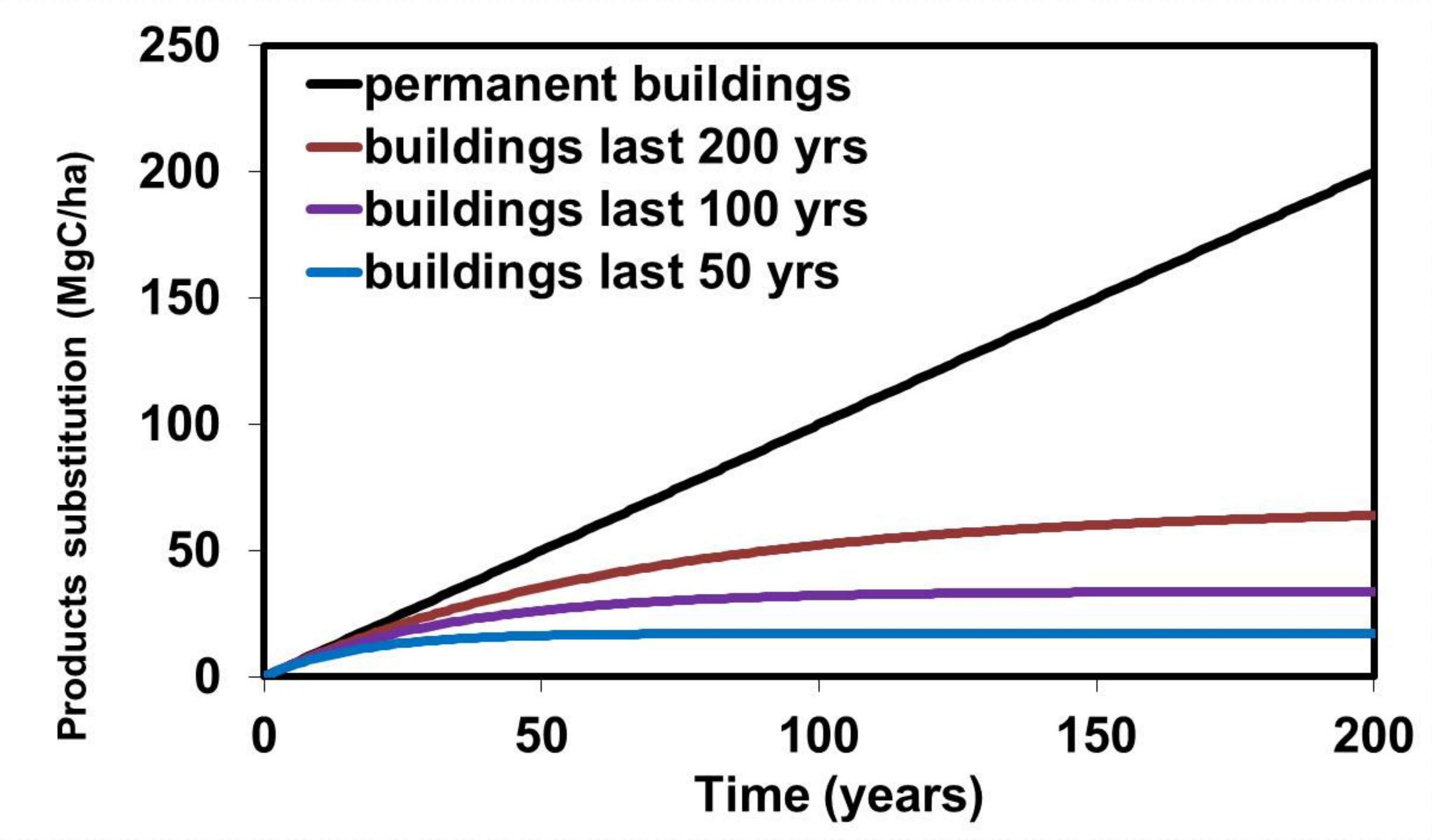
Note that adding an additional leak via harvest did not decrease the forest carbon-curious

http://www.washington.edu/news/articles/wood-products-part-of-winning-carbon-emissions-equation-researchers-say

# The true nature of product substitutions: they are finite



# The fact buildings don't last forever has consequences



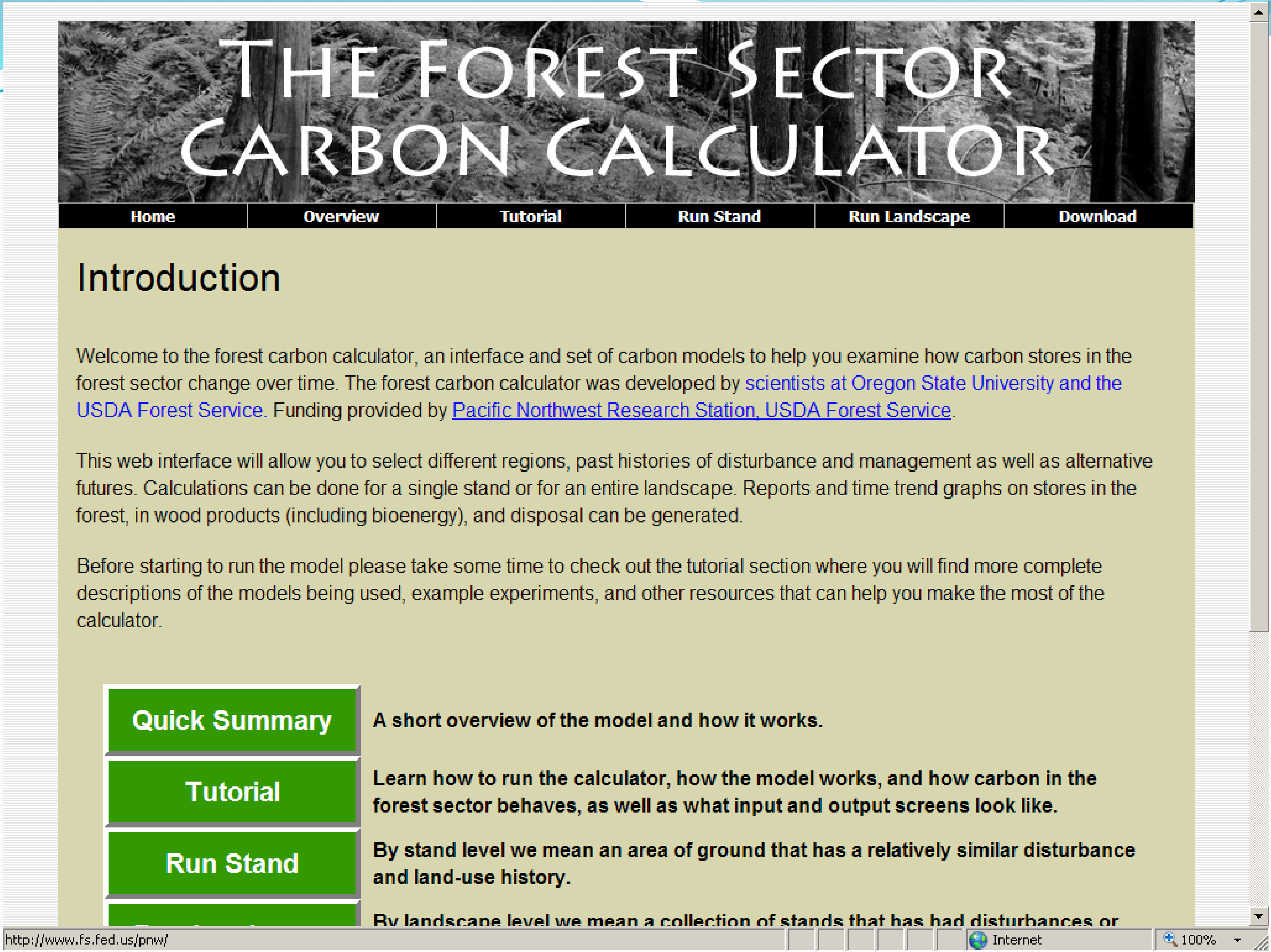
# Other issues needing to be addressed ASAP

- Instantaneous uptake/release versus long-term stores
- Failure to observe conservation of mass
- Exclusion of pools, processes, or key factors
- Irrelevant processes (hiding real relationships)
- Failing to give initial conditions or BAU
- Improper or inconsistent scaling in space & time
- Inconsistent frameworks
- Logical incongruities

# Conclusions

- To be credible carbon policy must be based on science (real world) otherwise it will not deliver the goal

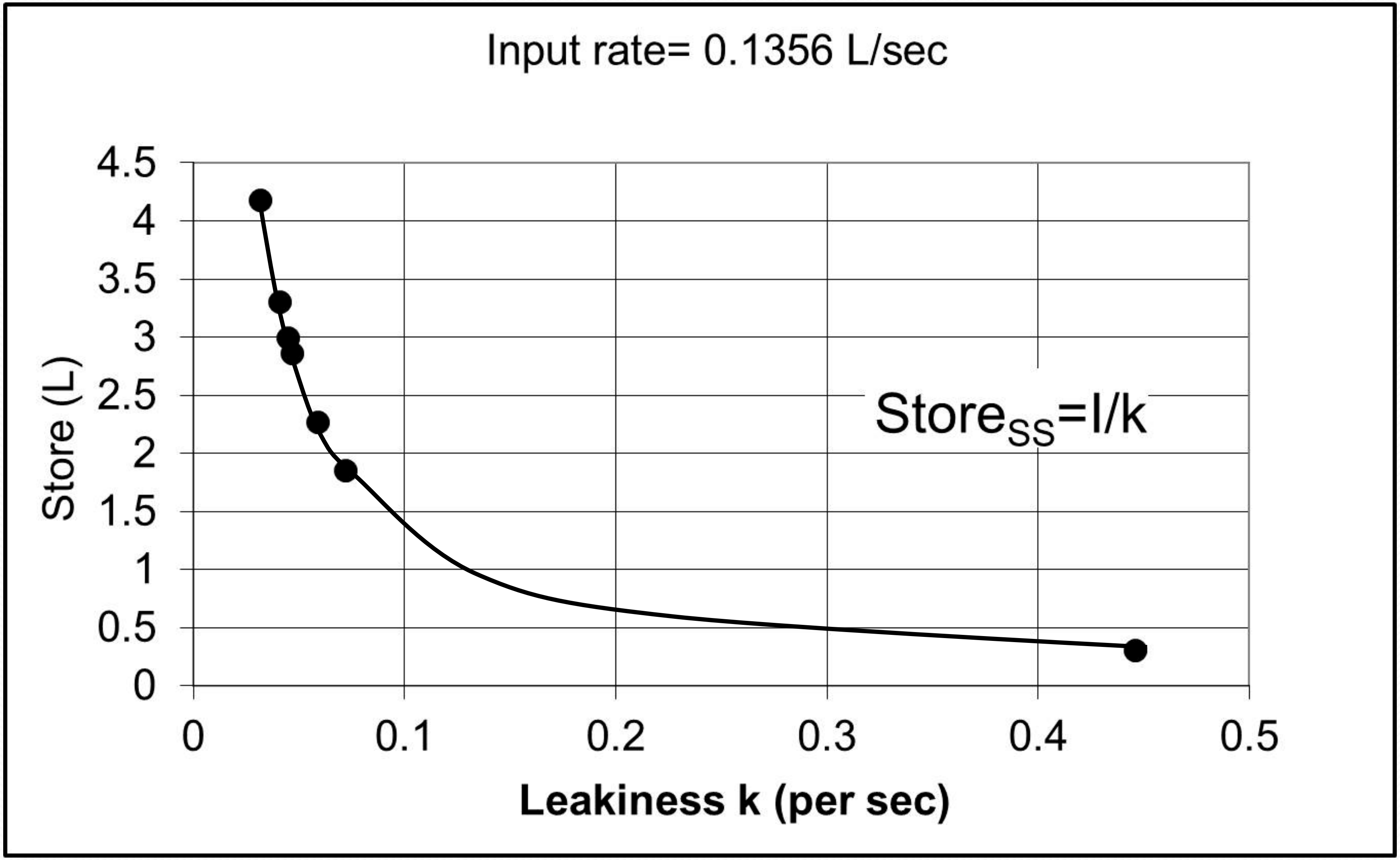
- There are many objectives of forest management
- Some will have carbon costs
- If these costs are not recognized then policies to counter or reduce these costs can not be developed



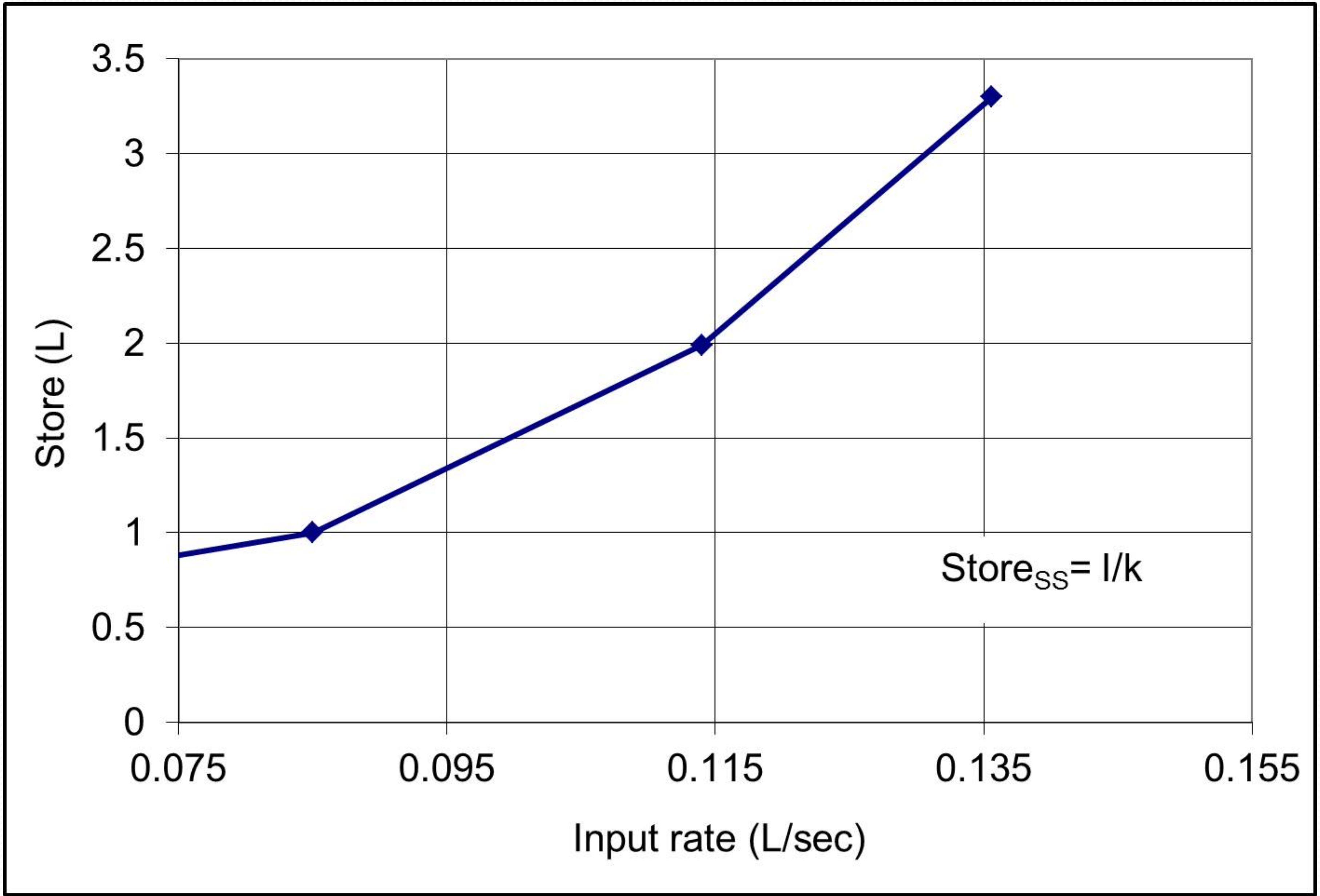

http://landcarb.forestry.oregonstate.edu/

# Thanks!!

**As the leakiness increases, the amount stores decreases (hyperbolically)**



## As the input increases, the amount stored increases (linearly)



# Another example of dubious carbon science:

Thinning adds more carbon to forests than not thinning

# Forest Thinning

- Increases the health and growth of trees
- Faster growing trees means more carbon can be stored
- Before After
- **1 ‹ 1.1**

# Wait a minute!

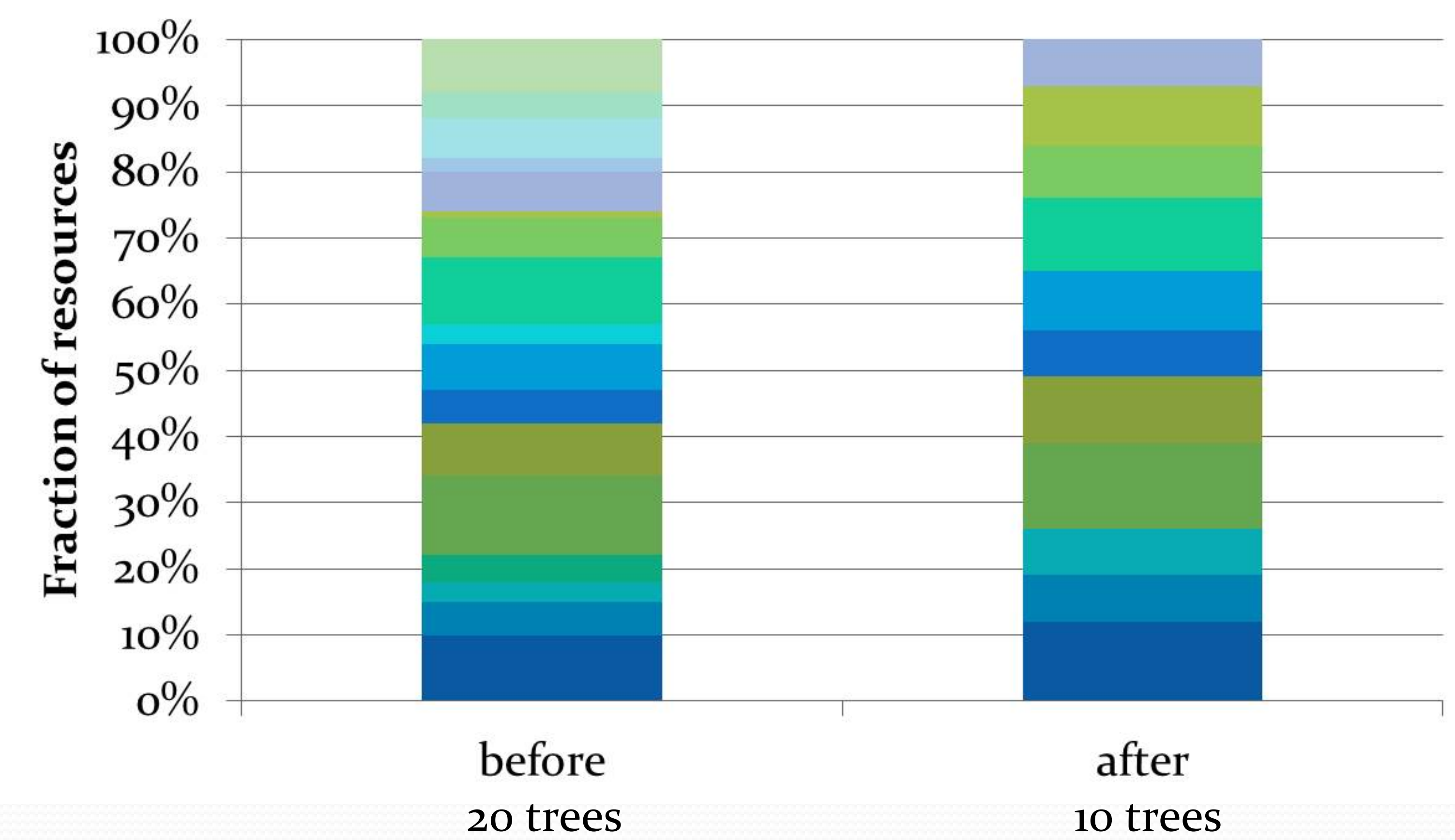
- Aren't there fewer trees after thinning?
- Before After
- 1 < 1.1 incomplete comparison
- 1 X 100 ≈ 1.1 X 90 complete comparison
- To store more total growth must increase, not stay the same

# For total growth to increase the following must be true

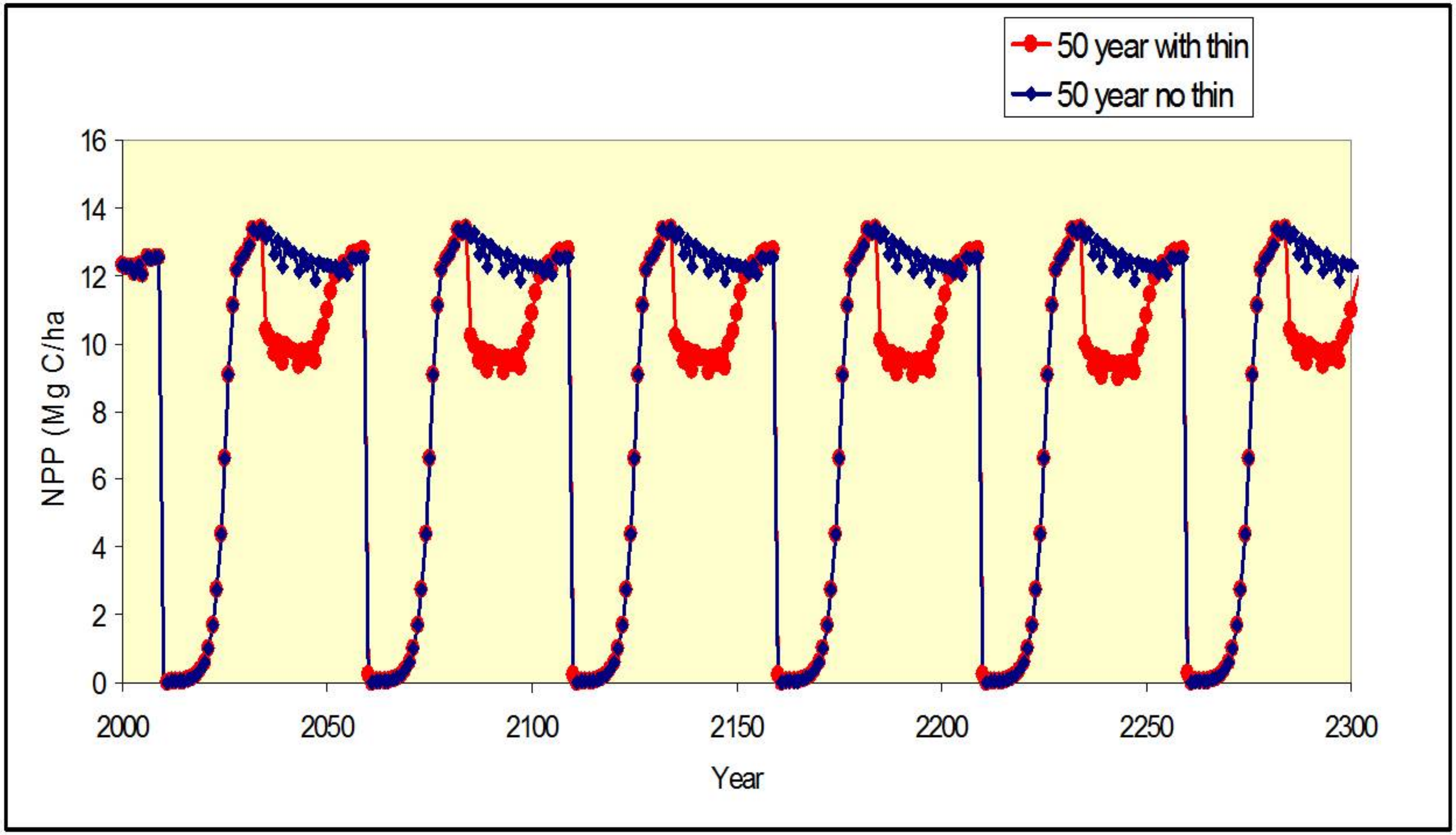
- The recovery of tree production after thinning must be instantaneous (BUT IT IS NOT)

- Thinning must increase the total amount of resources available to trees so that total production of thinned trees can increase (HOW?)

# Thinning redistributes the same resources among few individuals



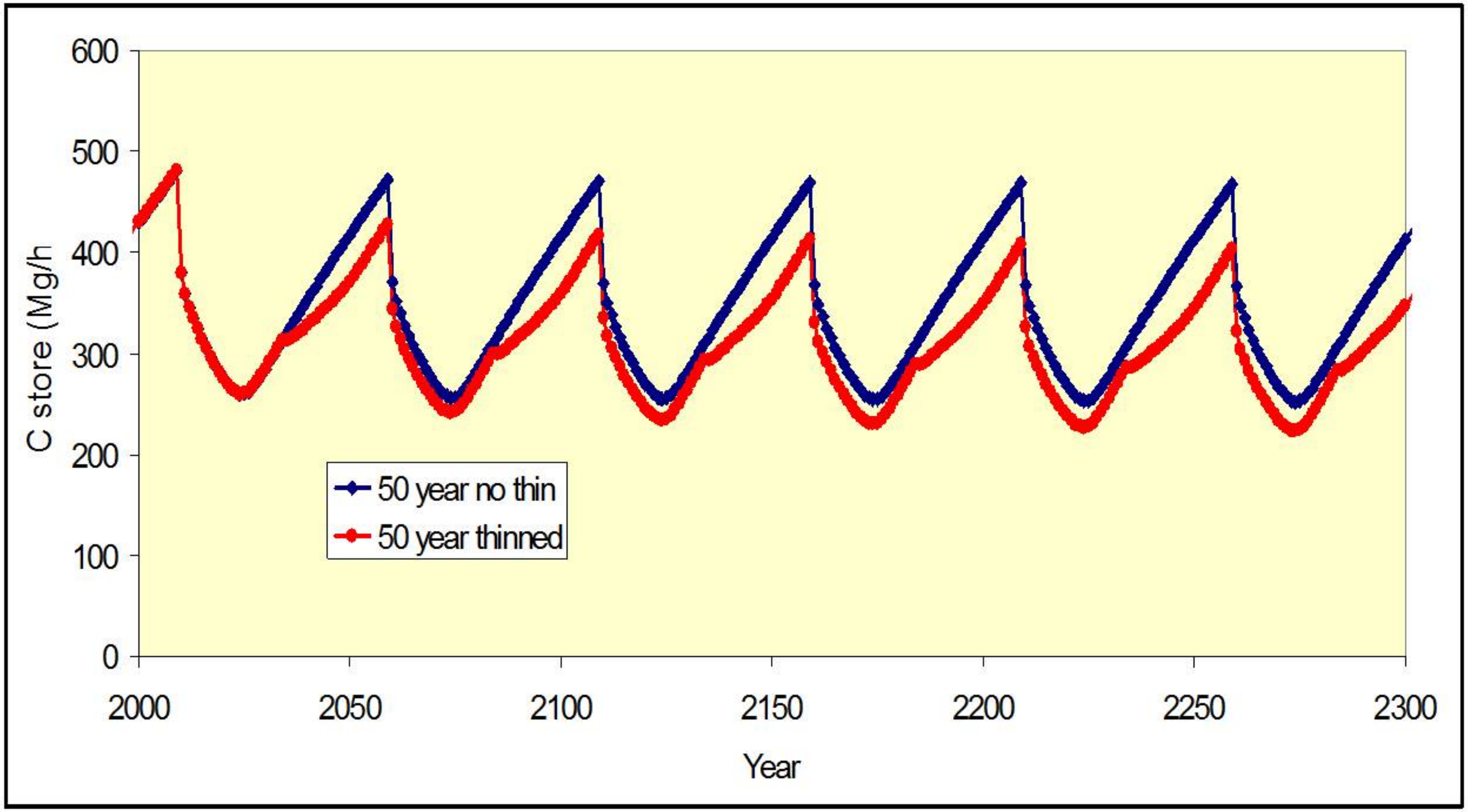
# Thinning does not increase the input to the forest!




| | Thinned | Not thinned | |
|---|---|---|---|
| NPP | 7.93 | 8.83 | 11% less |

Mg C/ha/y

# Thinning decreases forest carbon stores



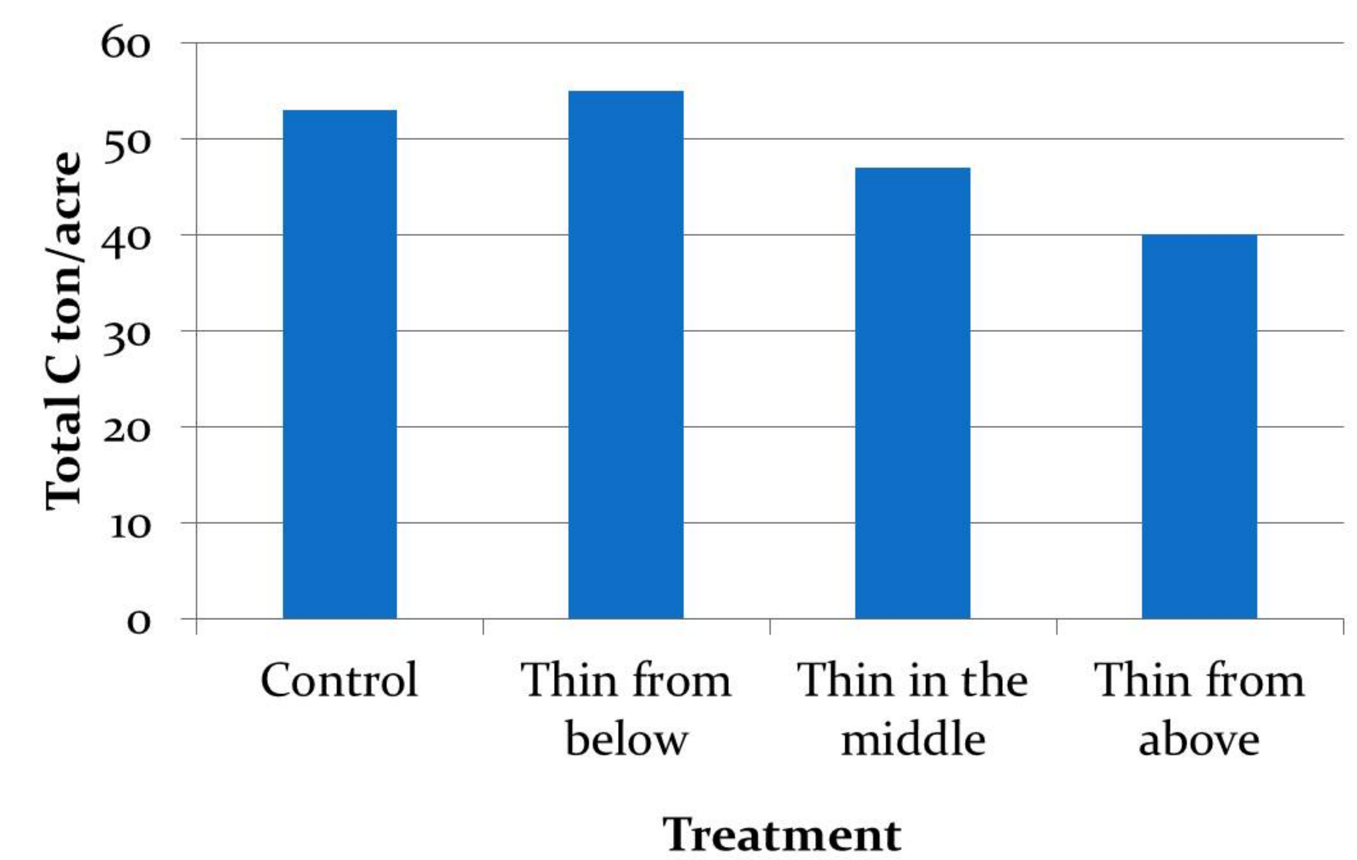

| | Thinned | Not thinned | |
|---|---|---|---|
| Store | 298 | 341 | 13% less |

Mg C/ha

Table 1. Ca

| Carbon Pool | Control |
|---|---|
| Live biomass | 43 (40) |
| Deadwood | 10 |
| Slash | 0 |
| Products | 0 |
| Total | 53 |

Data are metric t … on stocks at the beginning of the

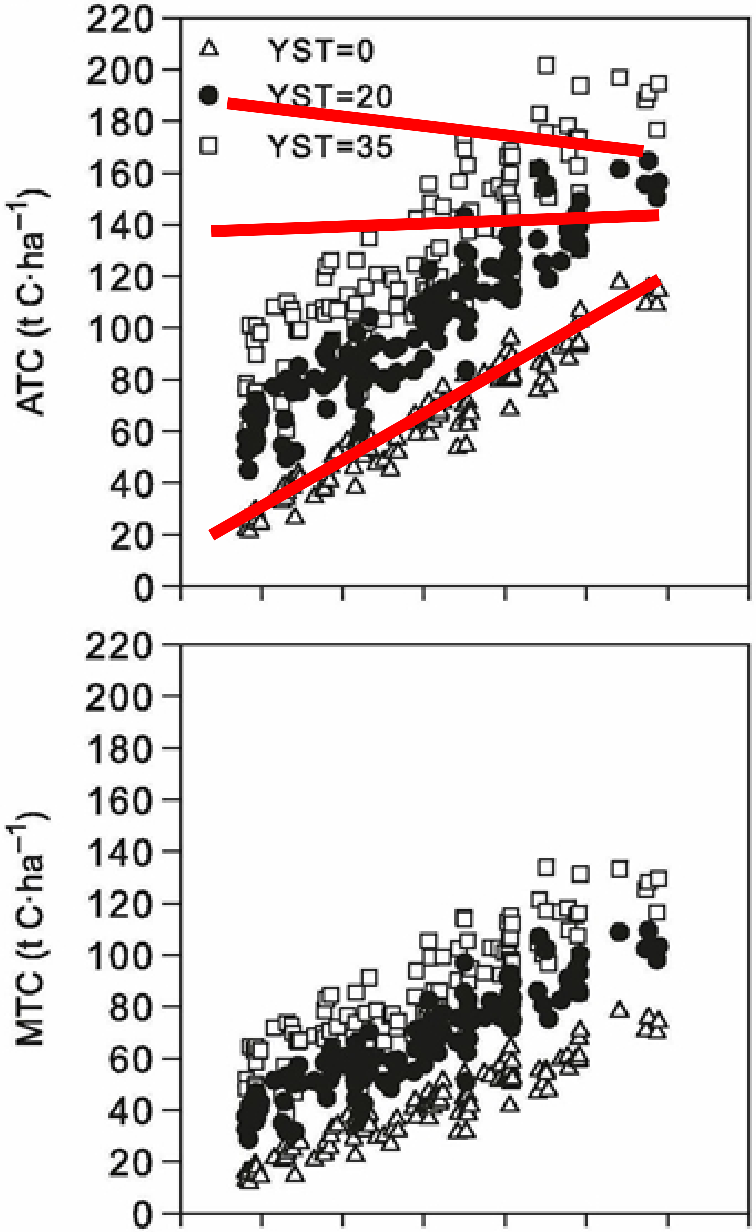



The larger the trees removed, the less the carbon forest sector stores

Larger leaks means less carbon stored in the forest sector

Hoover and Stout 2007 Journal of Forestry Black cherry/sugar maple

**Fig. 1.** Observed C storage in the ATC, MTC, and ATMSC biomass pools over 0, 20, and 35 years since thinning (YST) (0 = 1966).




Keyser 2010
Canadian Journal of Forest Research
Yellow poplar