Executive Short Course
March 19 – 23, 2012

Wood Use and the Environment

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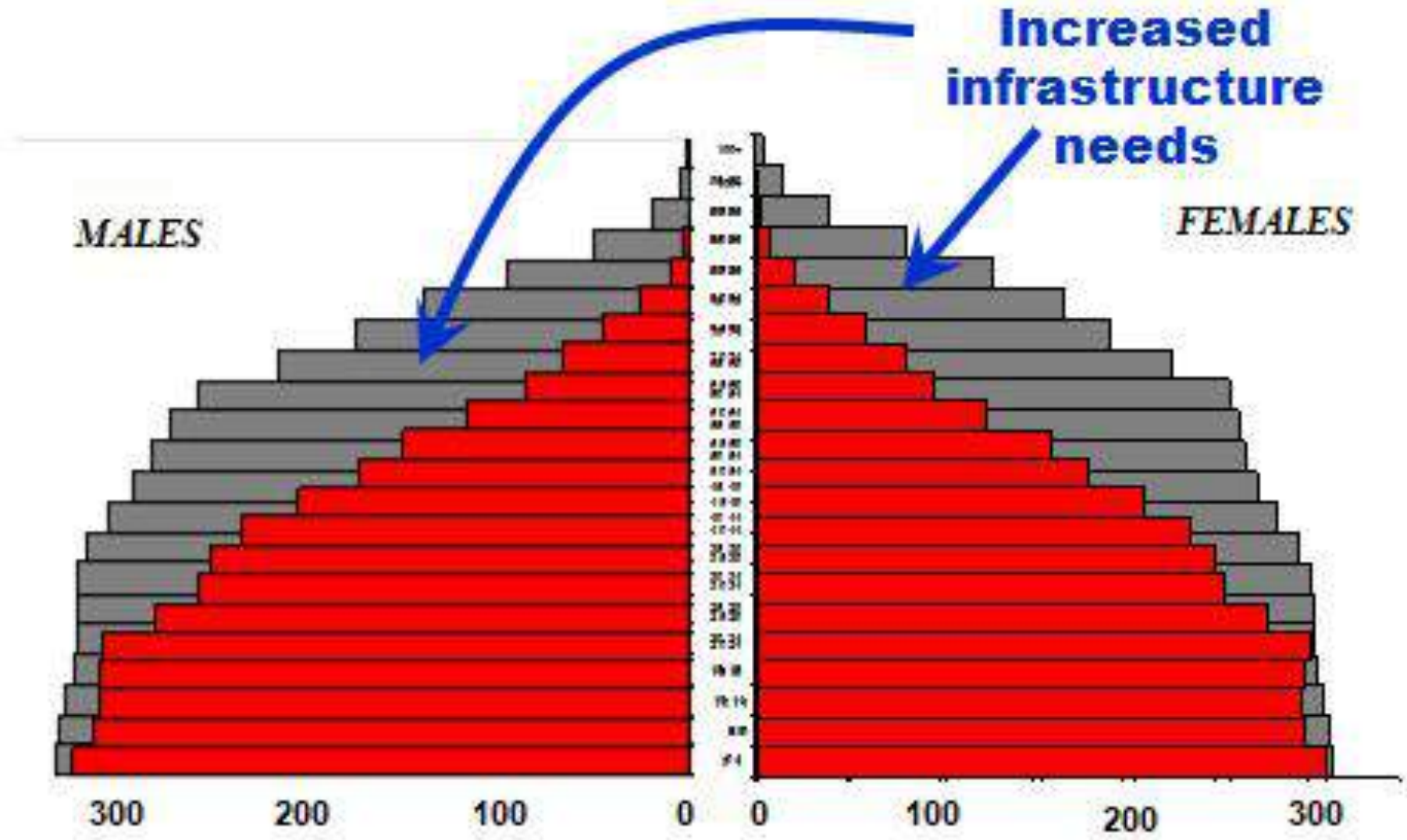
Global Institute of Sustainable Forestry
School of Forestry and Environmental Studies
Yale University

World Population Pyramids, 2010 (red) & 2050 (grey)



Concrete & Steel highrises in Shanghai.

65% of the urban infrastructure in China is yet to be built.

Currently 10% to30% of world's Fossil Fuel consumption and CO2 emissions

Why not wood ?

A

B

C

D

From Bing Images

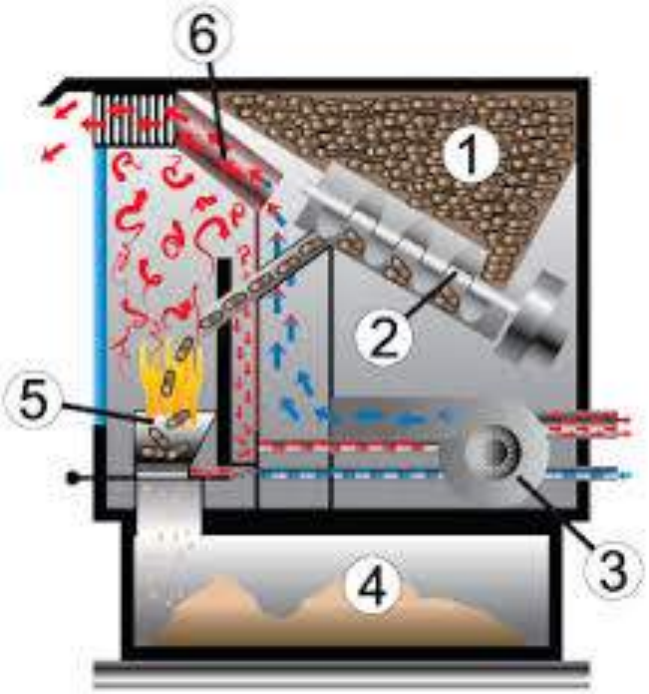
World’s Largest Wood Building

Tojaidi Temple, Nara, Japan

World’s Second Largest Wood Building:

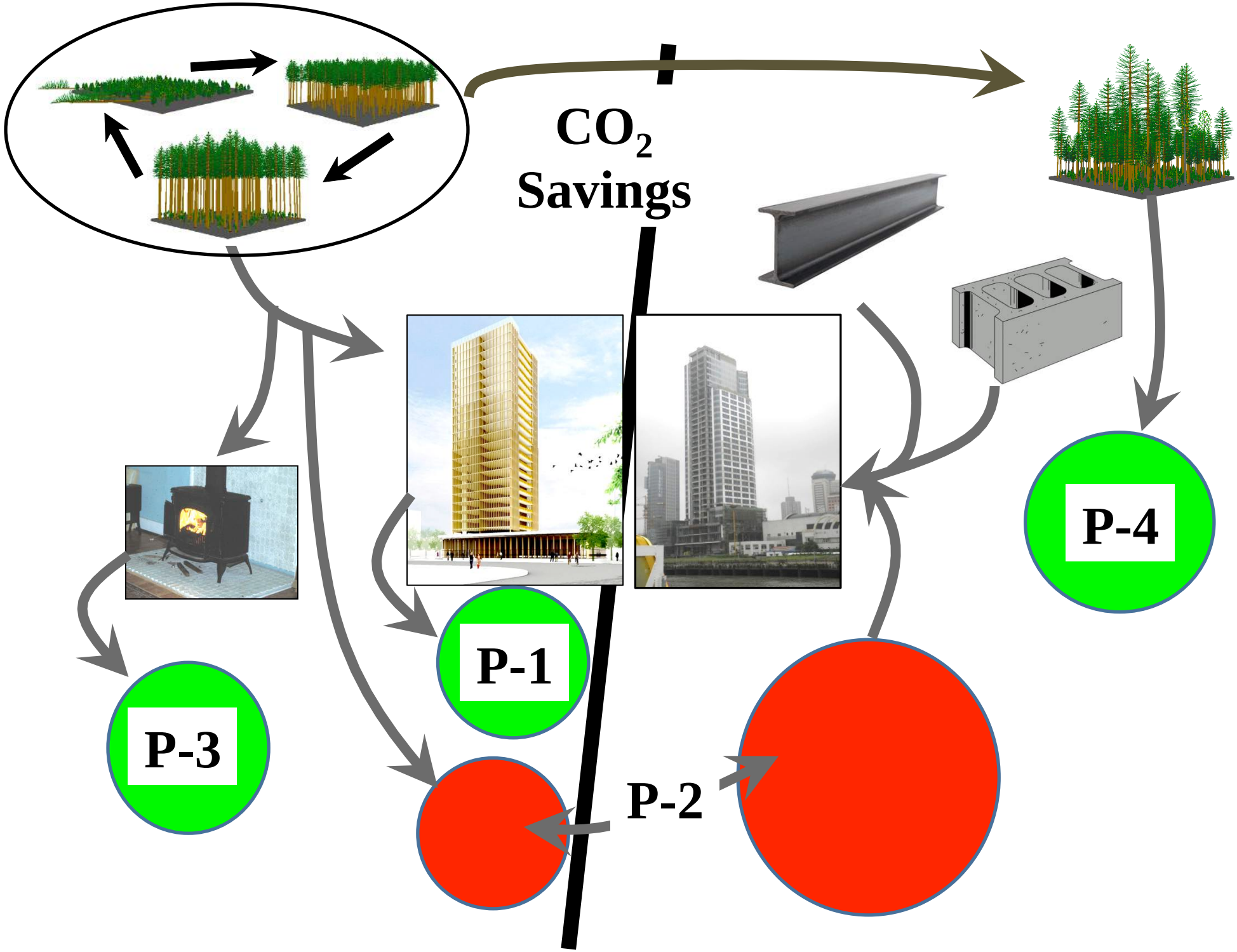
Buyuk Ada, Istanbul, Turkey
(abandoned for past 50 years)

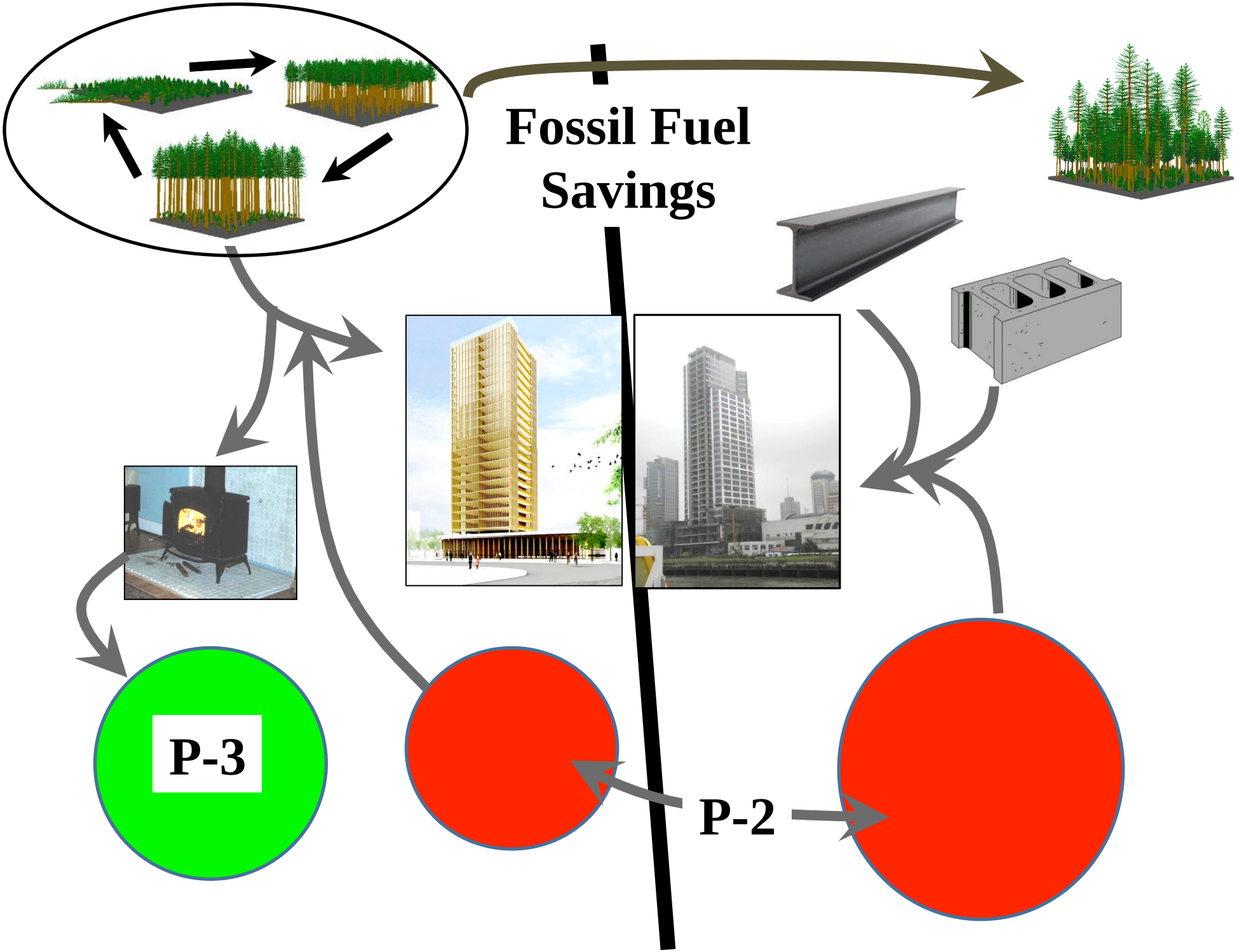
Or, why not wood ?



Potential pathways for Carbon and Fossil Fuel savings

	Carbon Savings	Fossil Fuel Savings
1. Store carbon in wood;	X	
2. Avoid Fossil Fuel (or any) energy use;	X	X
3. Replace Fossil Fuel energy with wood energy;	X	X
4. Store carbon in the forest.	X	


CO_2
Savings
P-1
P-2
P-3
P-4


Fossil Fuel
Savings
P-3
P-2

Questions about Wood Use

1. **Will wood save FF & and CO2?**
2. **Will it save more as wood energy or wood buildings?**
3. **What will forest management & harvest do for wood energy and products?**
4. **What will forest harvest & management do for forest CO2 sequestration?**
5. **Is there enough wood to make wood use worthwhile?**
6. **How will we protect biodiversity?**

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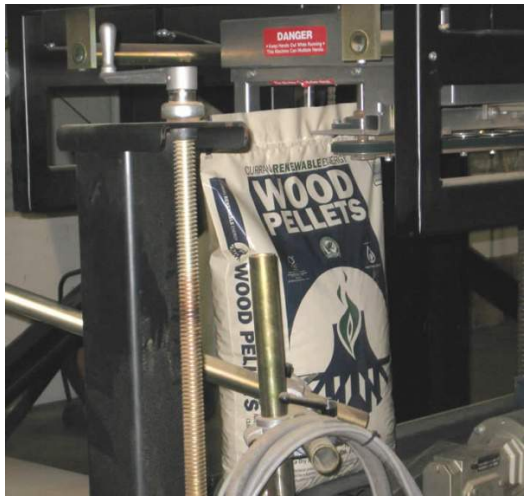

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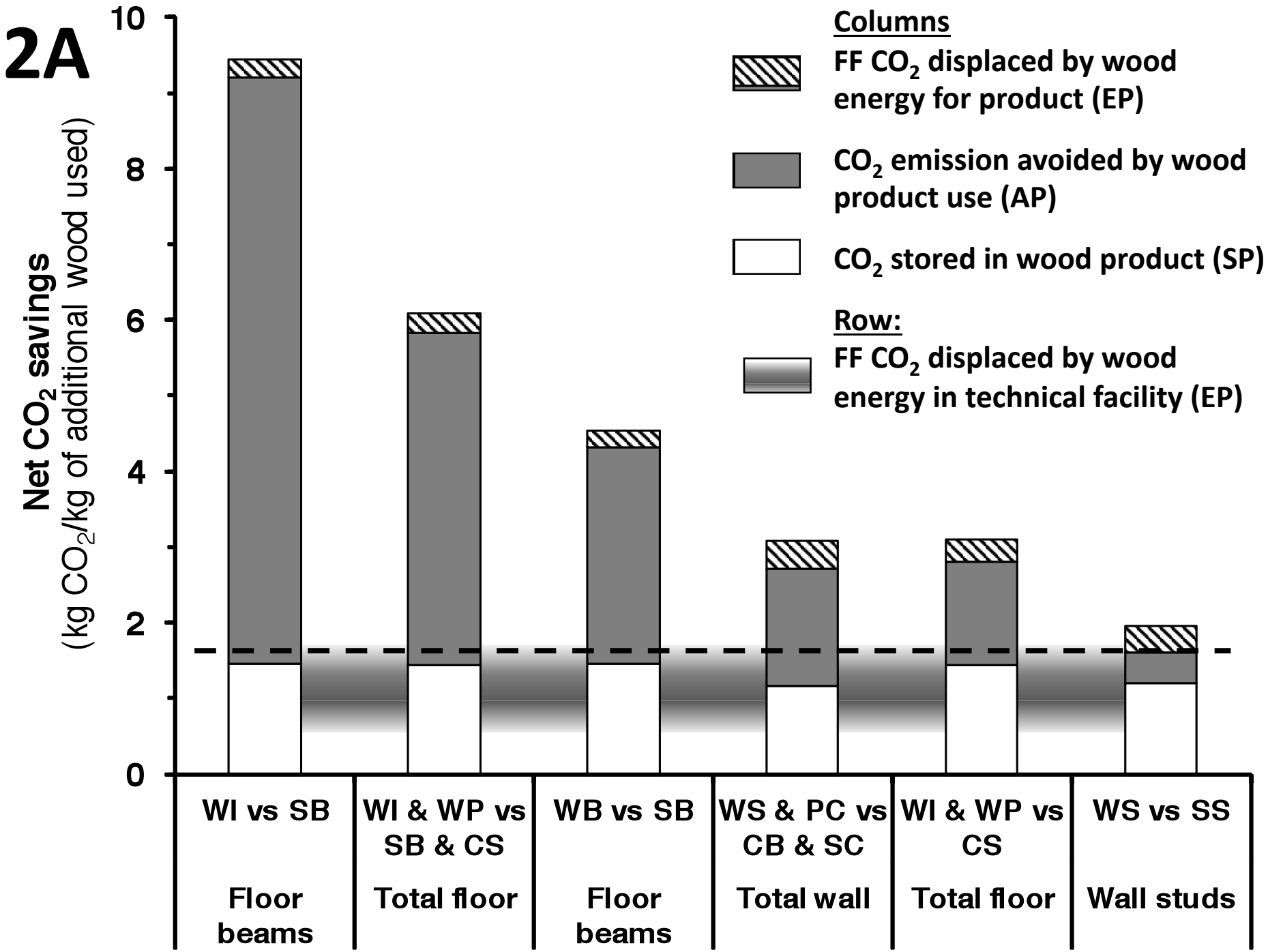
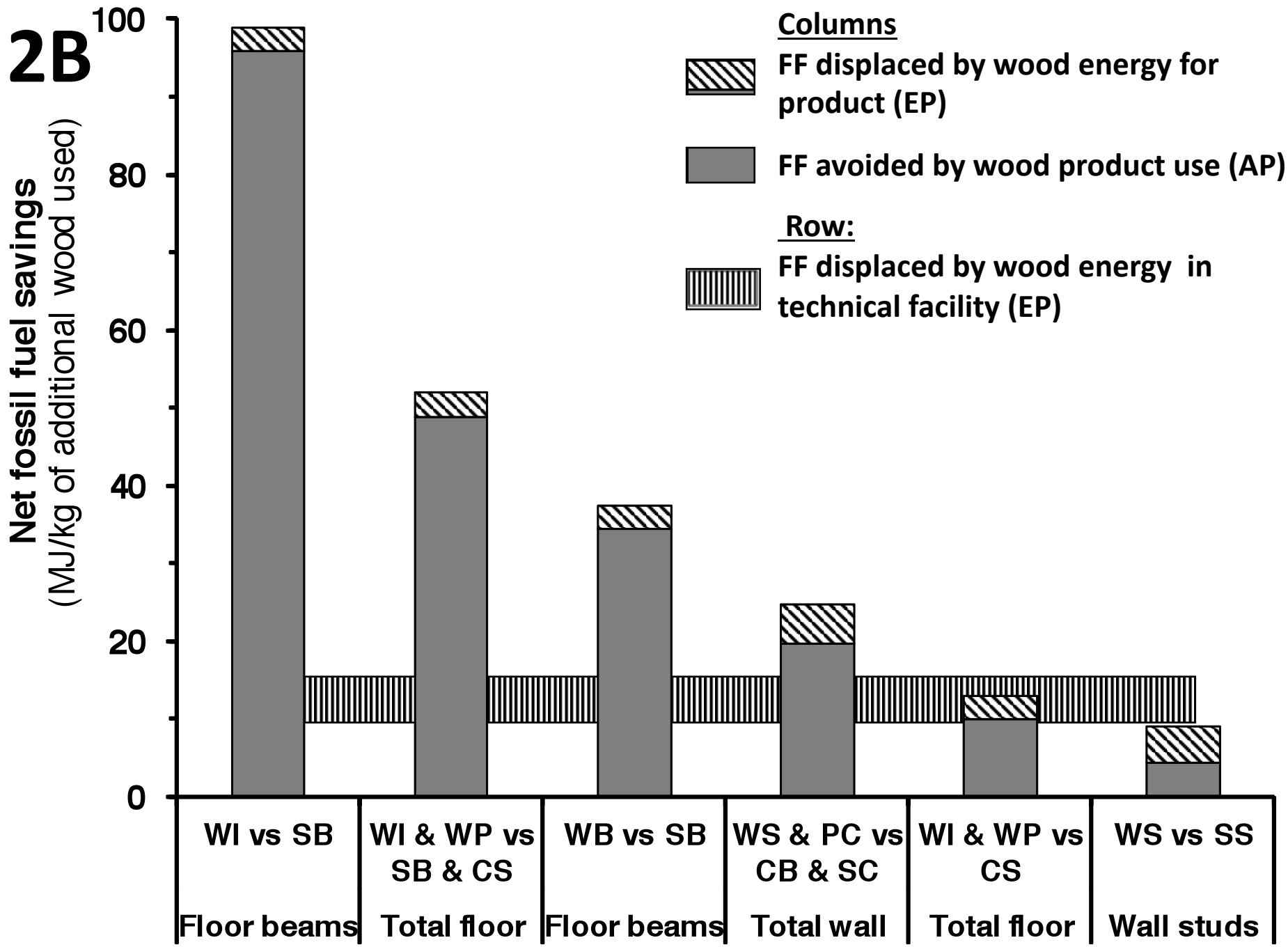
From practicalaction.org

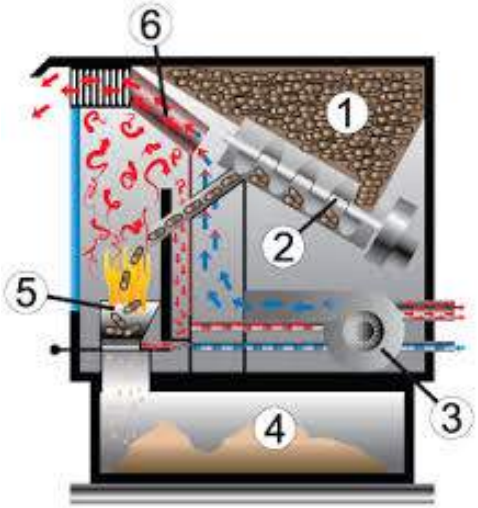

2A
Net CO_2 savings
(kg CO_2/kg of additional wood used)
10
8
6
4
2
0
Columns
FF CO_2 displaced by wood energy for product (EP)
CO_2 emission avoided by wood product use (AP)
CO_2 stored in wood product (SP)
Row:
FF CO_2 displaced by wood energy in technical facility (EP)
WI vs SB
Floor beams
WI & WP vs SB & CS
Total floor
WB vs SB
Floor beams
WS & PC vs CB & SC
Total wall
WI & WP vs CS
Total floor
WS vs SS
Wall studs


2B
Net fossil fuel savings
(MJ/kg of additional wood used)
100
80
60
40
20
0
Columns
FF displaced by wood energy for product (EP)
FF avoided by wood product use (AP)
Row:
FF displaced by wood energy in technical facility (EP)
WI vs SB
Floor beams
WI & WP vs SB & CS
Total floor
WB vs SB
Floor beams
WS & PC vs CB & SC
Total wall
WI & WP vs CS
Total floor
WS vs SS
Wall studs

3 kg CO2/m2 saved
70 MJ FF/m2

40 kg CO2/m2
516 MJ FF/m2

67 kg CO2/m2
806 MJ FF/m2



1.9 kg CO2/kg wood
18 MJ FF/kg wood

1.8 kg CO2/kg wood
0 MJ FF/kg wood

0.9 kg FF CO2/kg wood
11 MJ FF/kg wood

From practicalaction.org

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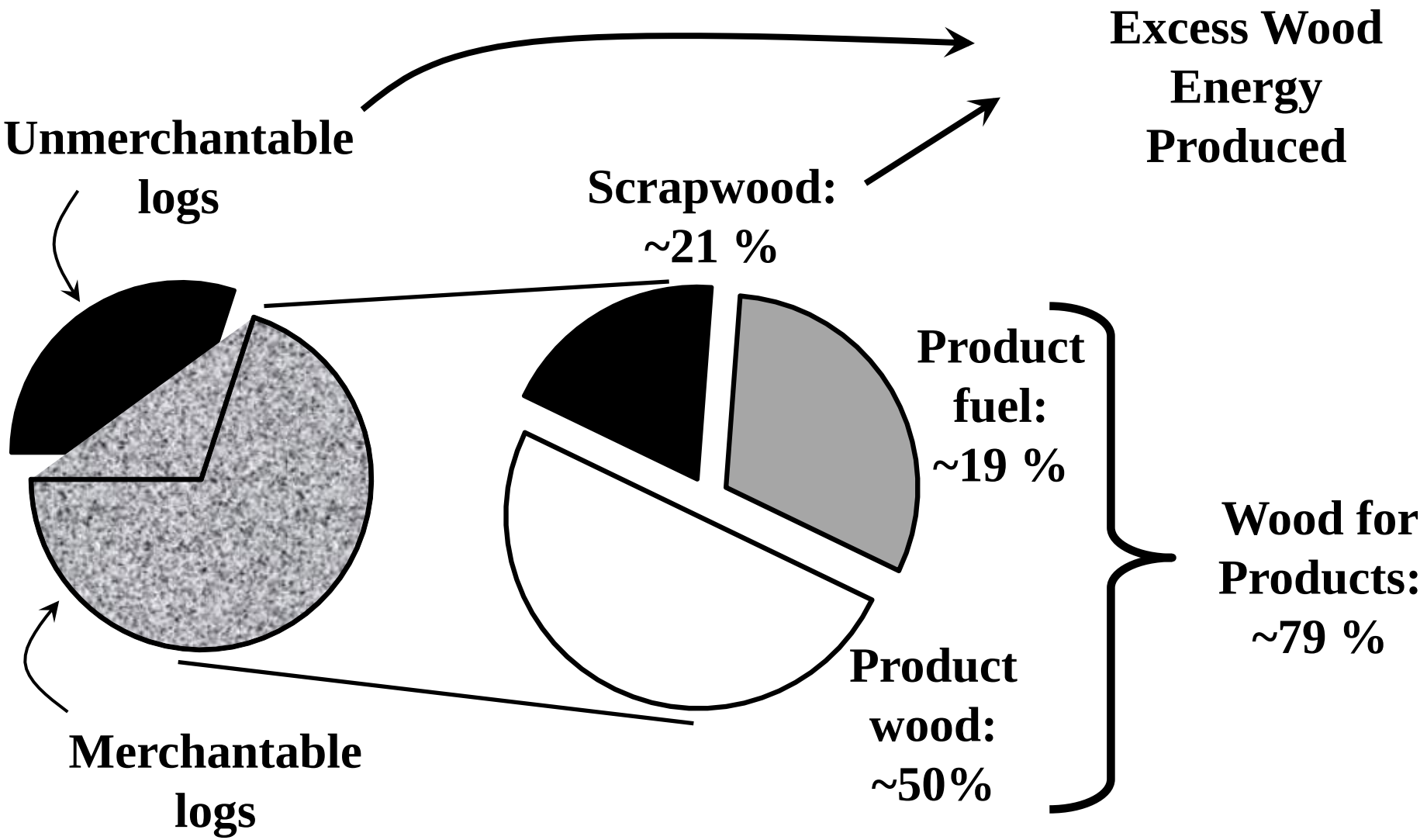

Excess Wood Energy Produced
Unmerchantable logs
Scrapwood: ~21 %
Product fuel: ~19 %
Wood for Products: ~79 %
Product wood: ~50%
Merchantable logs

A. Weight of log and components required per building surface area (kg/m2)

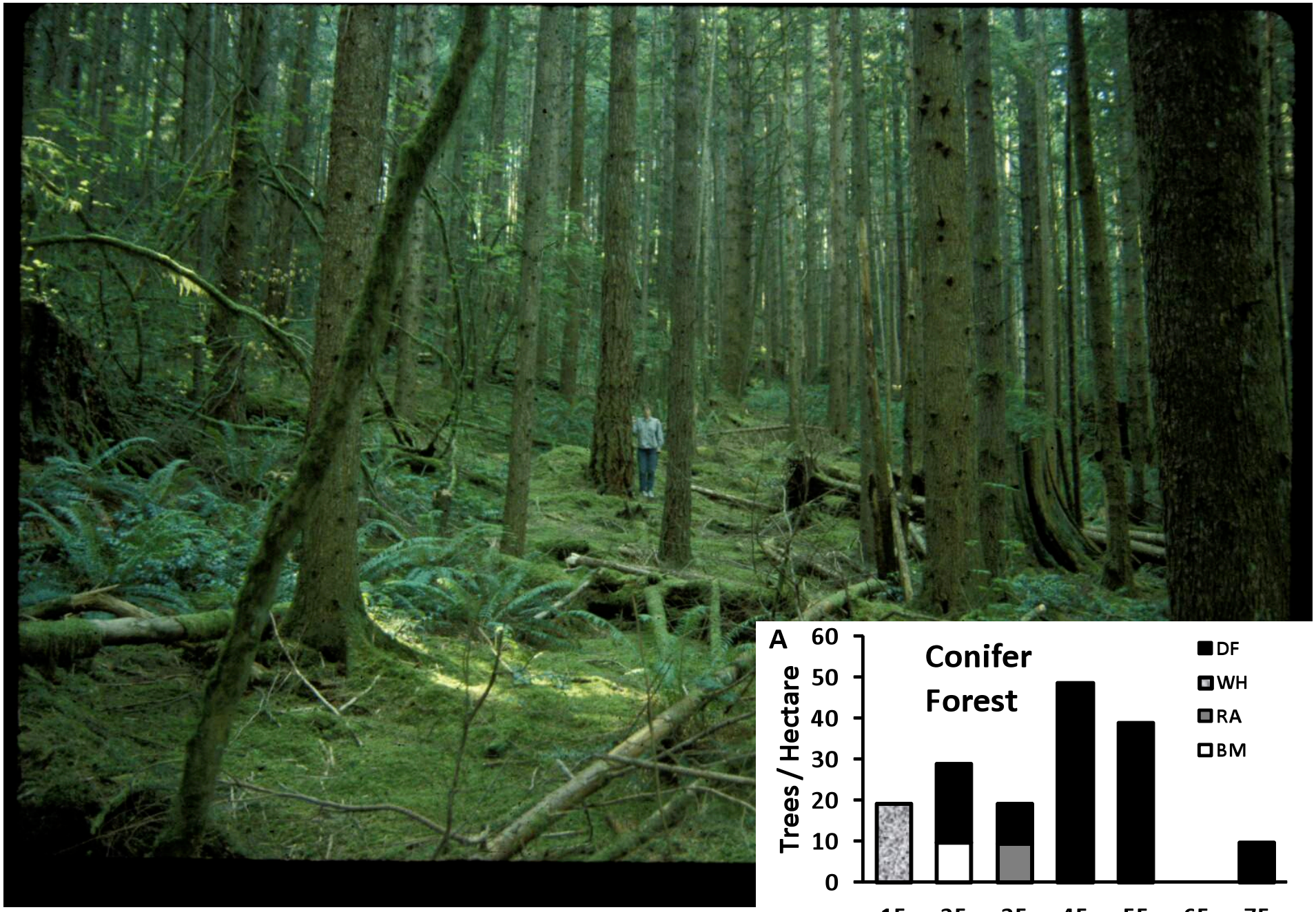
Wood product	Substitute product	Log	Product		Wood Energy needed		Excess wood energy	
		kg	kg	%of log	kg	%of log	kg	%of log
Dimension Joist	Steel Joist	19	9.28	*50%*	2.43	*13%*	6.85	*37%*
EWP I-Joist	Steel Joist	7	3.55	*50%*	0.96	*14%*	2.59	*36%*
EWP/Ply	Concrete Slab	21	10.27	*50%*	2.96	*14%*	7.32	*36%*
EWP/Ply	Steel Joist/Concrete Slab	21	10.27	*50%*	2.96	*14%*	7.32	*36%*
BioDried Stud	Steel Stud	15	7.38	*50%*	3.82	*26%*	3.56	*24%*
BioDryStud/BioDryPly / BioDryPly	Concrete Block/Stucco	42	20.91	*50%*	11.81	*28%*	9.10	*22%*

B. Fossil Fuel energy avoided use (MJ/kg wood)

Wood product	Substitute product	<< Merchantable Log >>					Unmerchantable Log	
		Total		Avoided FF consumption	FF avoided by excess wood energy			
		Maximum efficiency MJ/kg of logs	Minimum efficiency MJ/kg of logs	MJ/kg of logs	Maximum efficiency MJ/kg of logs	Minimum efficiency MJ/kg of logs	Maximum efficiency MJ/kg of logs	Minimum efficiency MJ/kg of logs
Dimension Joist	Steel Joist	33.9	25.4	23.5	10.4	1.9	28.2	5.1
EWP I-Joist	Steel Joist	73.0	64.6	62.8	10.3	1.9	28.2	5.1
EWP/Ply	Concrete Slab	18.4	10.1	8.3	10.0	1.8	28.2	5.1
EWP/Ply	Steel Joist/Concrete Slab	43.5	35.2	33.4	10.0	1.8	28.2	5.1
BioDried Stud	Steel Stud	13.6	8.1	6.9	6.8	1.2	28.2	5.1
BioDryStud/BioDryPly / BioDryPly	Concrete Block/Stucco	25.3	20.3	19.2	6.1	1.1	28.2	5.1

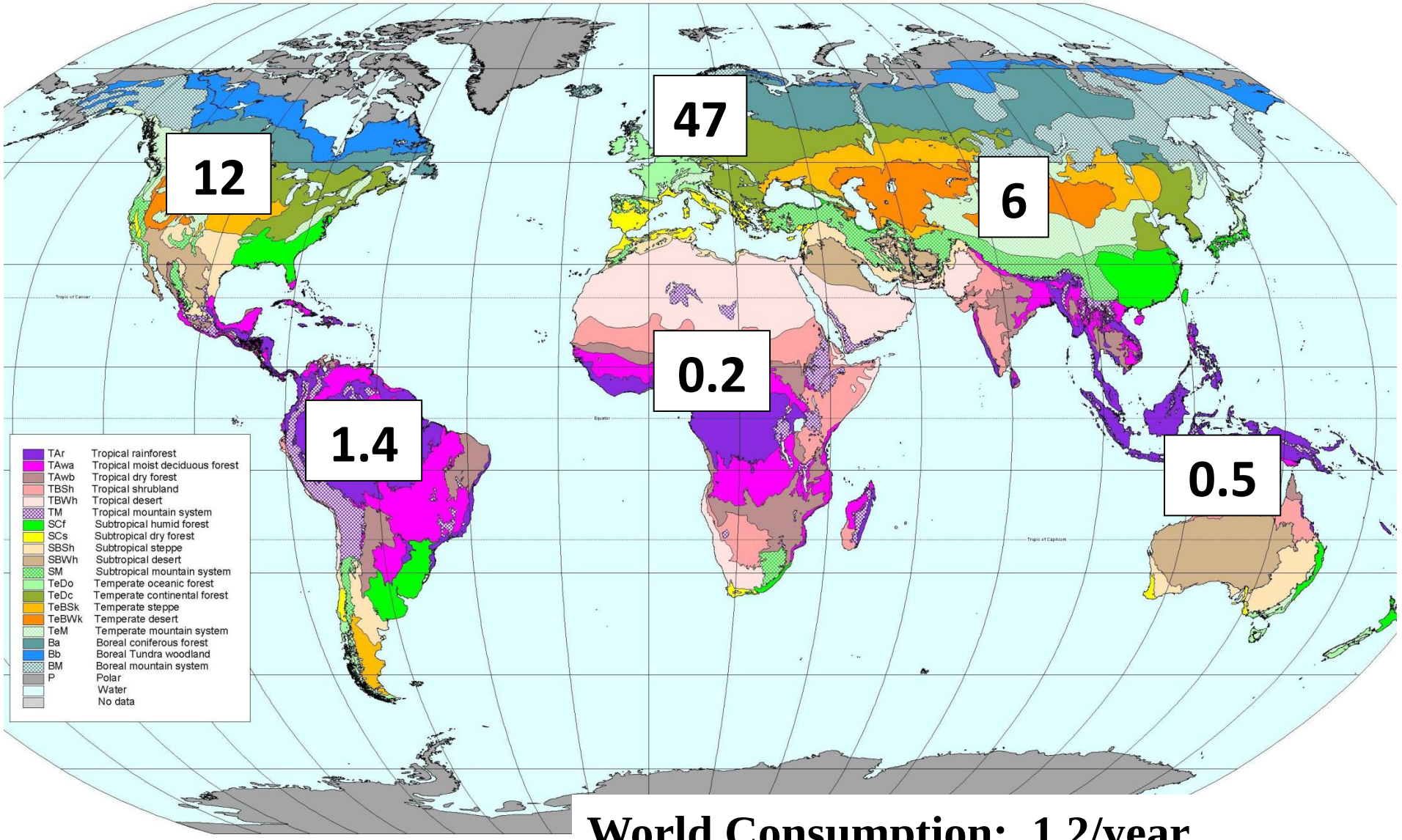
C. CO2 avoided emissions (kg CO2/kg of logs)

		<< Merchantable Log >>						Unmerchantable Log	
Wood product	Substitute product	Total		Product CO2 storage	Avoided CO2 emissions	CO2 avoided by excess wood energy		CO2 avoided by direct burning entire log for energy	
		Maximum efficiency kg	Minimum efficiency kg	kg	kg	Maximum efficiency kg	Minimum efficiency kg	Maximum efficiency kg	Minimum efficiency kg
Dimension Joist	Steel Joist	4.1	3.0	0.9	1.9	1.2	0.1	3.3	0.3
EWP I-Joist	Steel Joist	10.6	8.5	1.4	5.0	1.2	0.1	3.3	0.3
EWP/Ply	Concrete Slab	4.3	3.2	1.4	1.7	1.2	0.1	3.3	0.3
EWP/Ply	Steel Joist/Concrete Slab	7.3	6.2	1.4	4.7	1.2	0.1	3.3	0.3
BioDried Stud	Steel Stud	2.8	2.0	1.2	0.8	0.8	0.1	3.3	0.3
BioDryStud/BioDryPly /BioDryPly	Concrete Block/Stucco	3.8	3.1	1.2	1.9	0.7	0.1	3.3	0.3

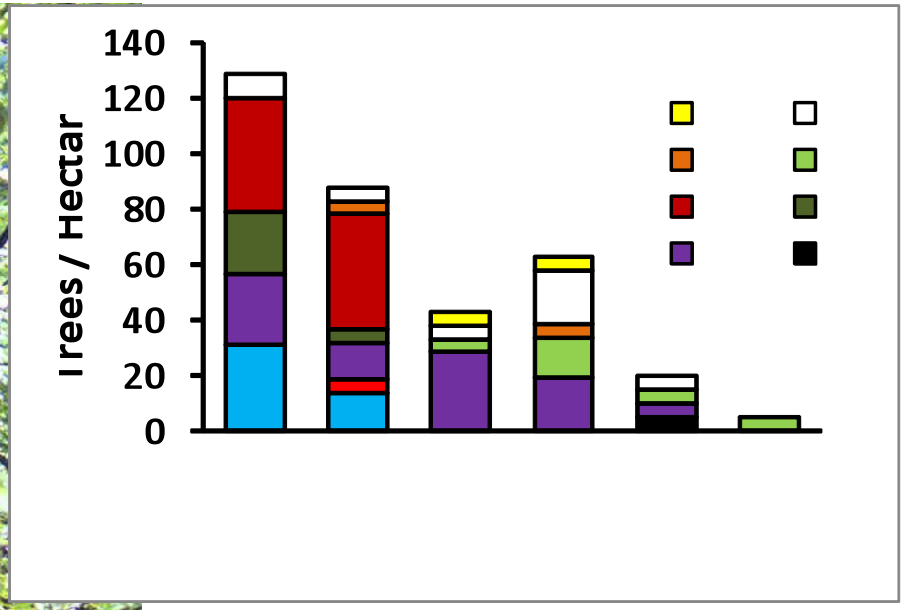

A
Conifer
Forest
DF
WH
RA
BM
Trees / Hectare
60
50
40
30
20
10
0
15
25
35
45
55
65
75
DBH Classes, 10 cm midpoints

Global Ecological Zones

Accessible Conifer Timber (Billion M3)

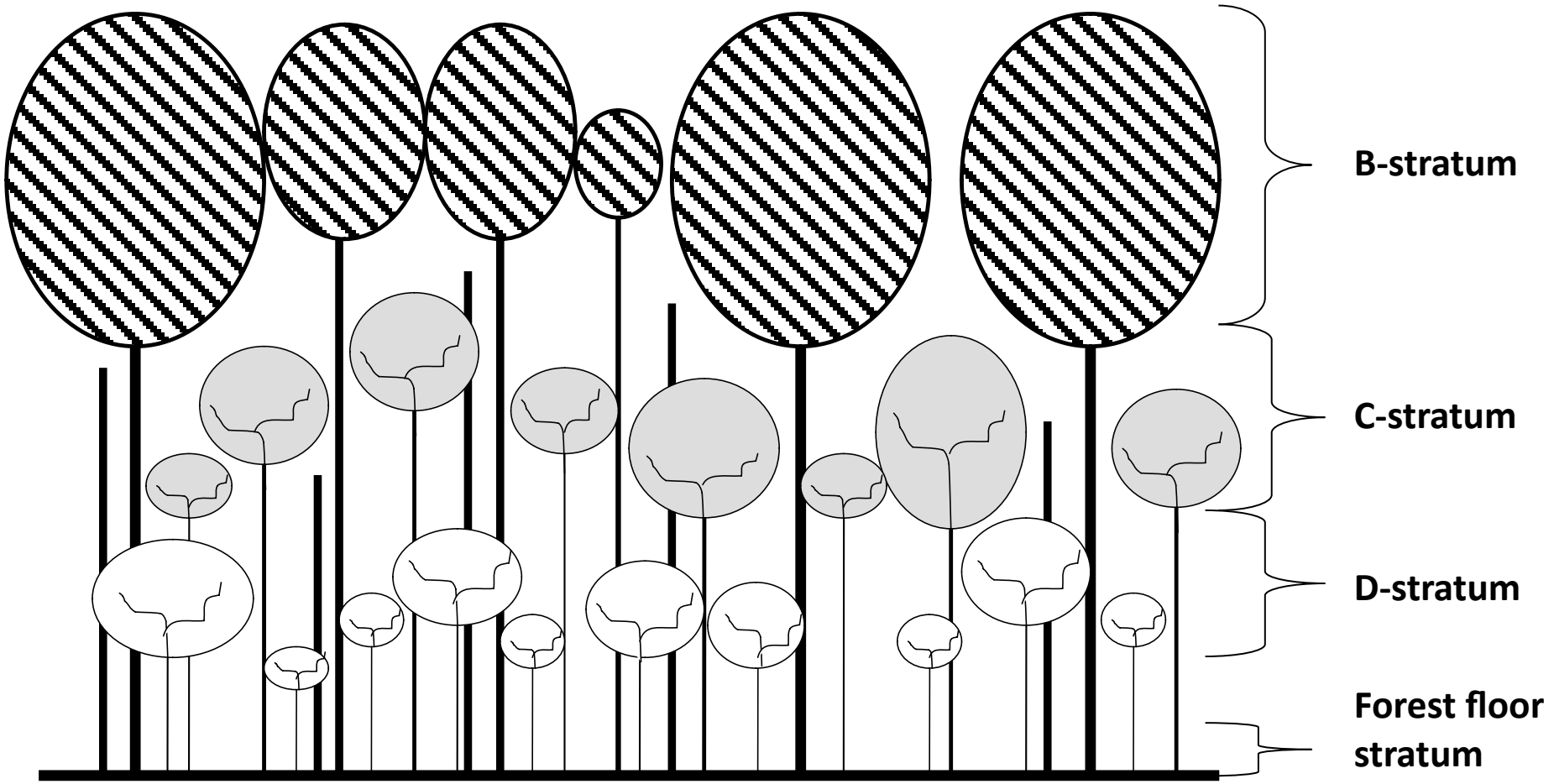


World Consumption: 1.2/year

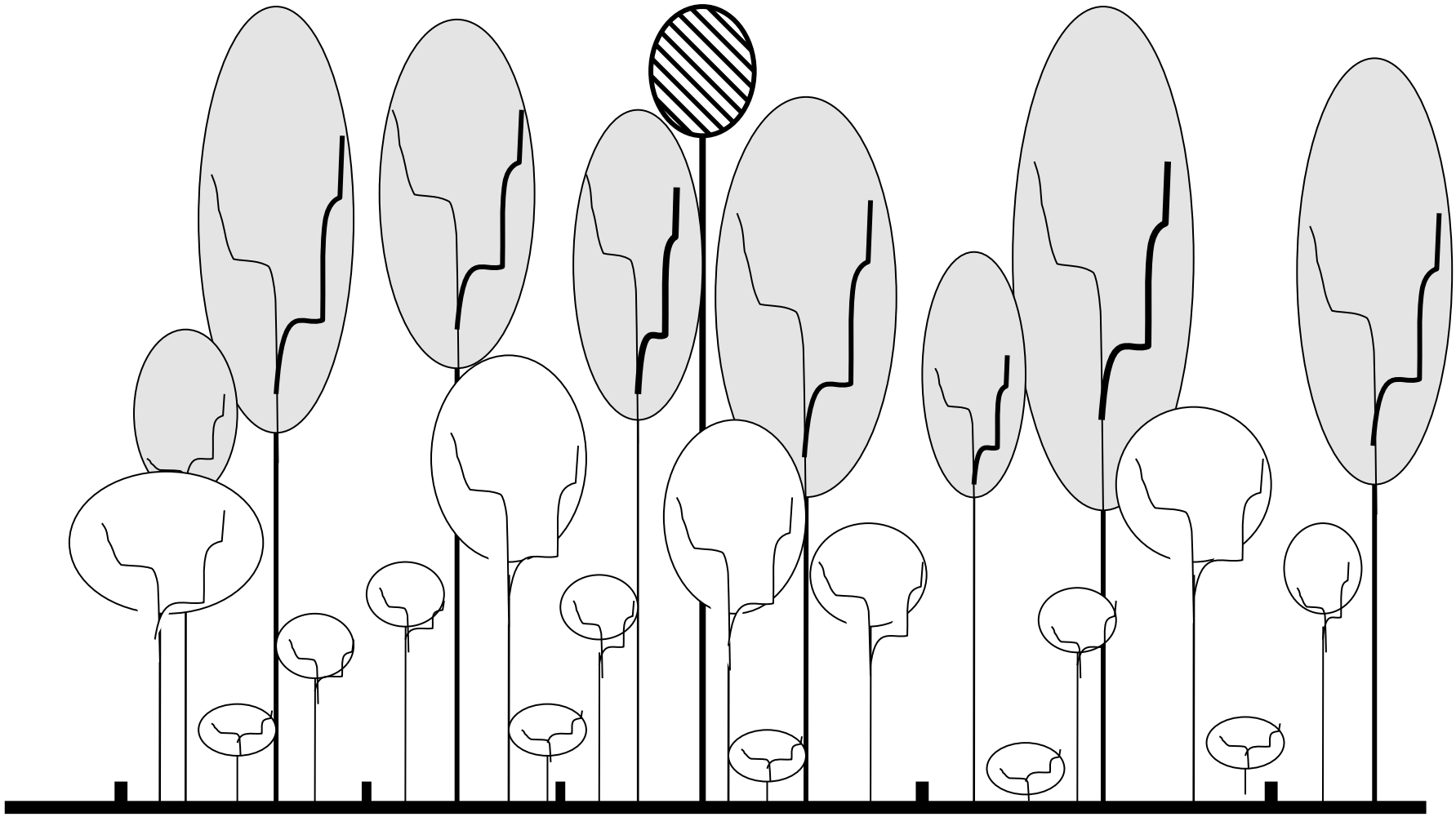


Slide from C. Oliver, Yale University

2 C.

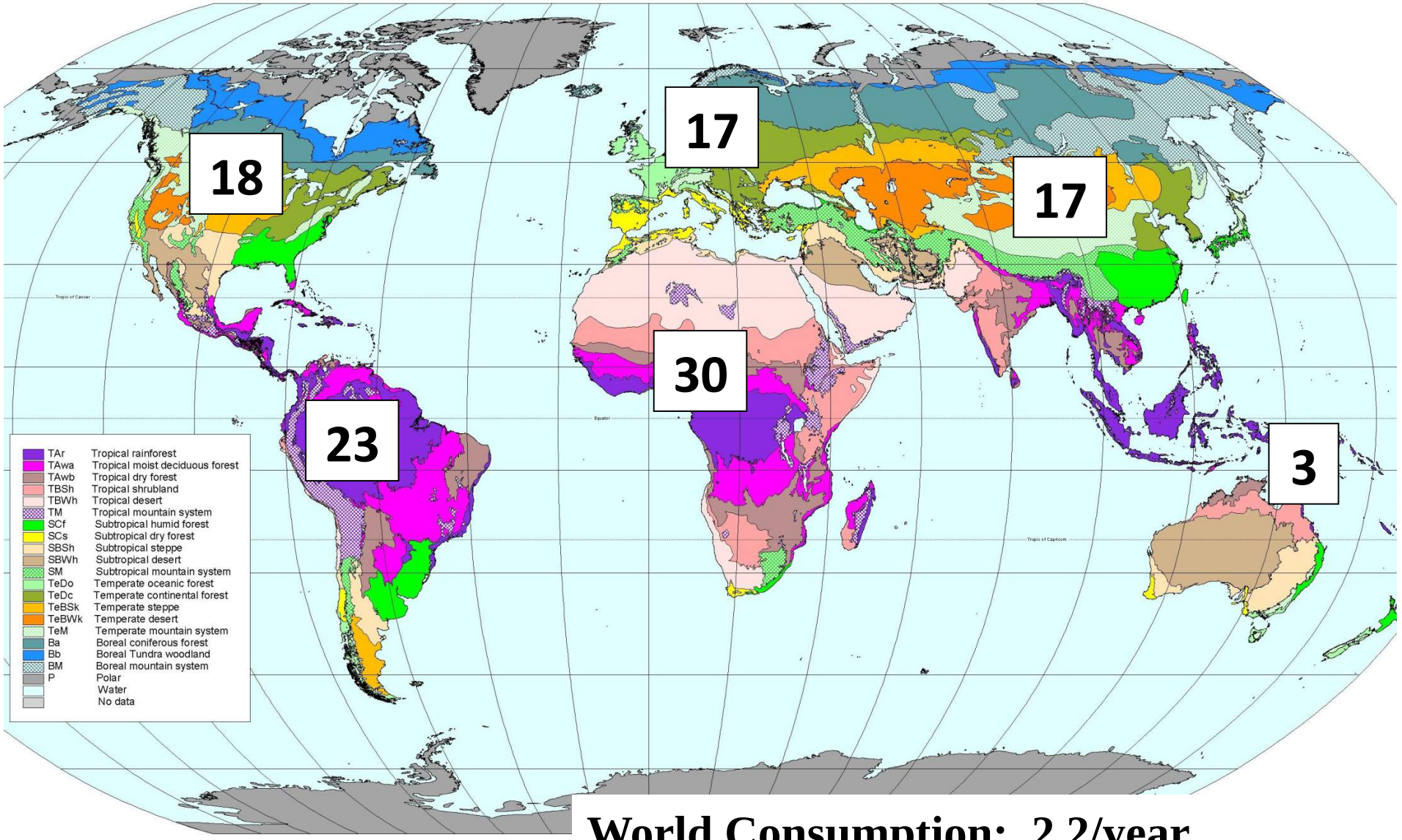


3.



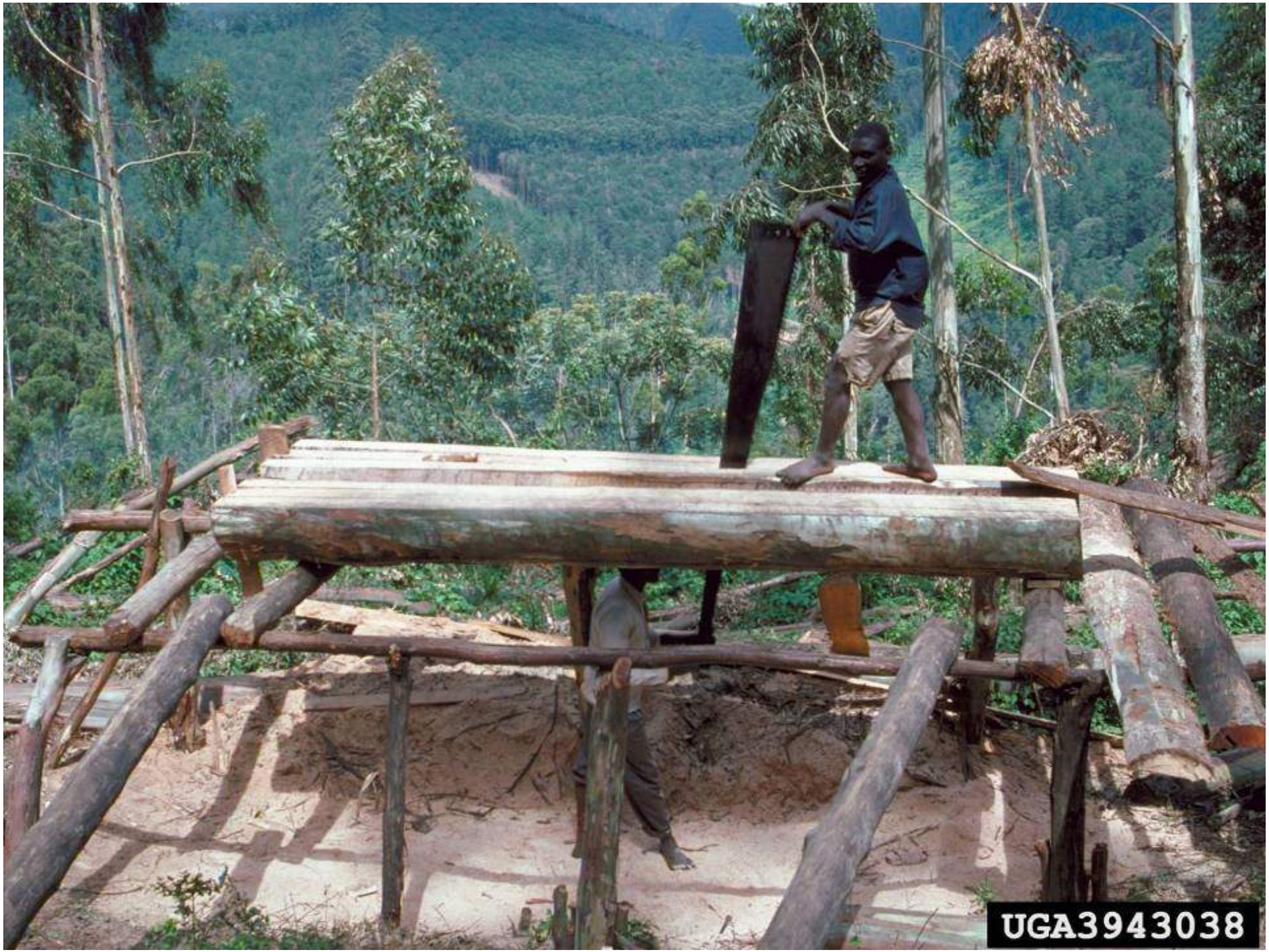
Global Ecological Zones

Accessible Tropical & Temperate Hardwoods (Billion M3)



World Consumption: 2.2/year

High graded forest in Russian Far East


UGA3943038

LUCAS Mill

X REMOVE

puma

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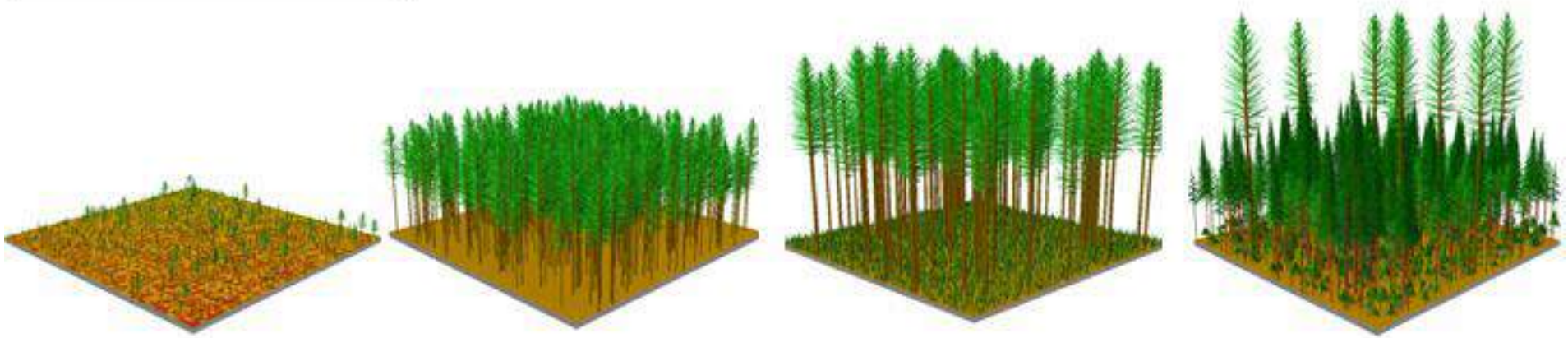
Stand Initiation

Stem Exclusion

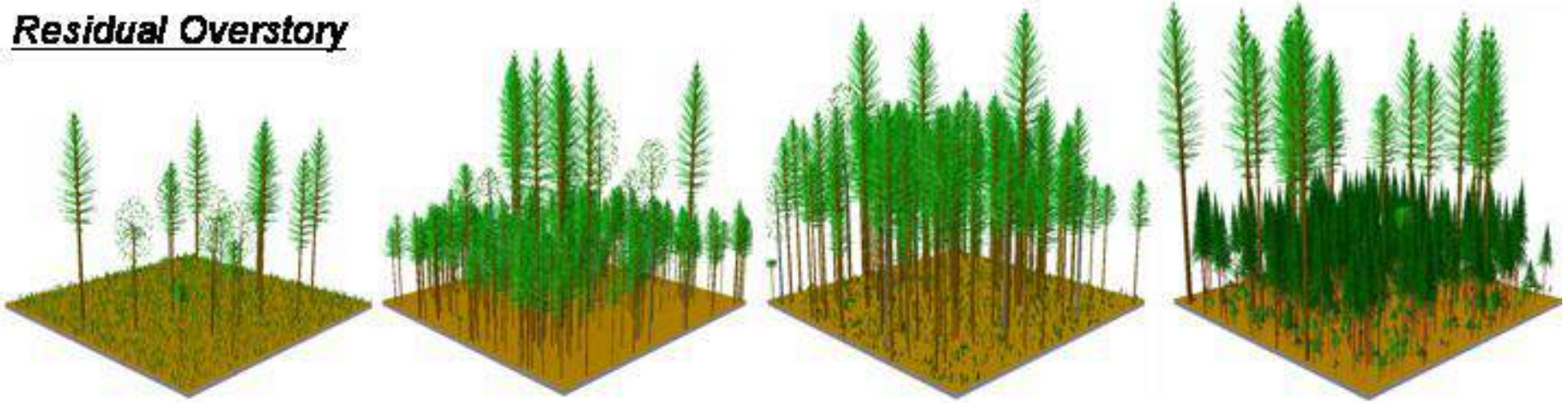
Understory Reinitiation

"Old Growth"

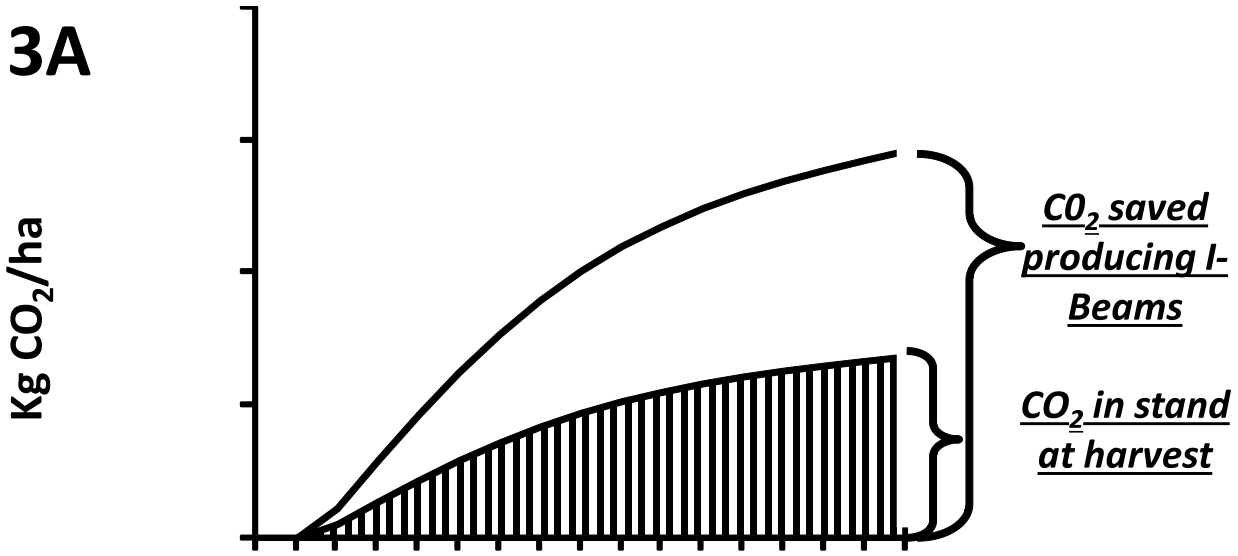
No Residual Overstory



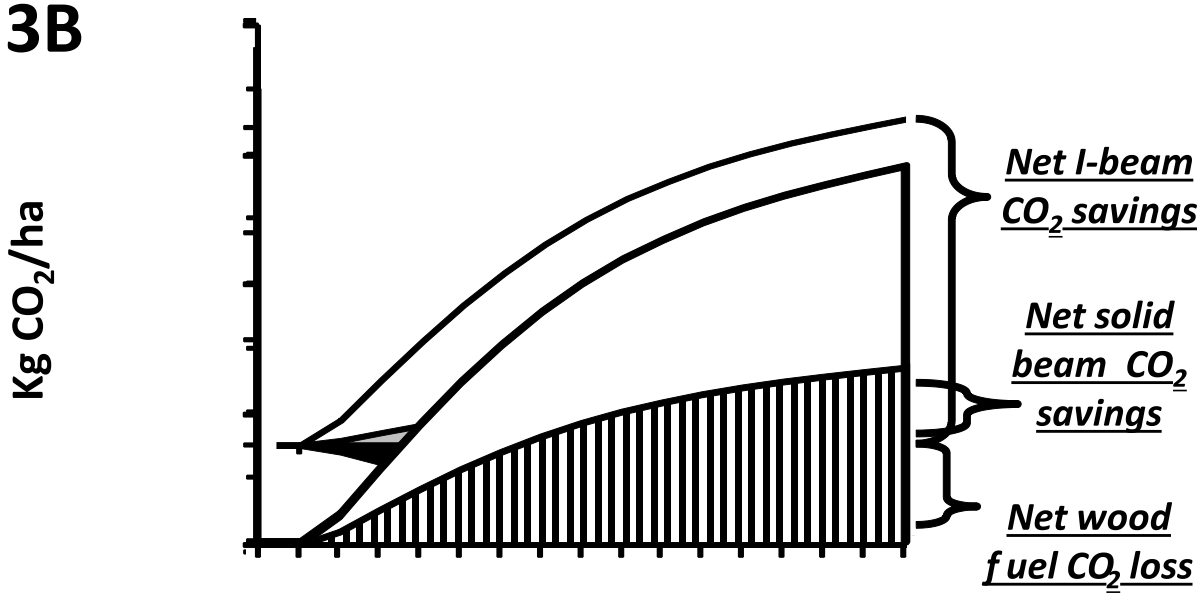
Residual Overstory

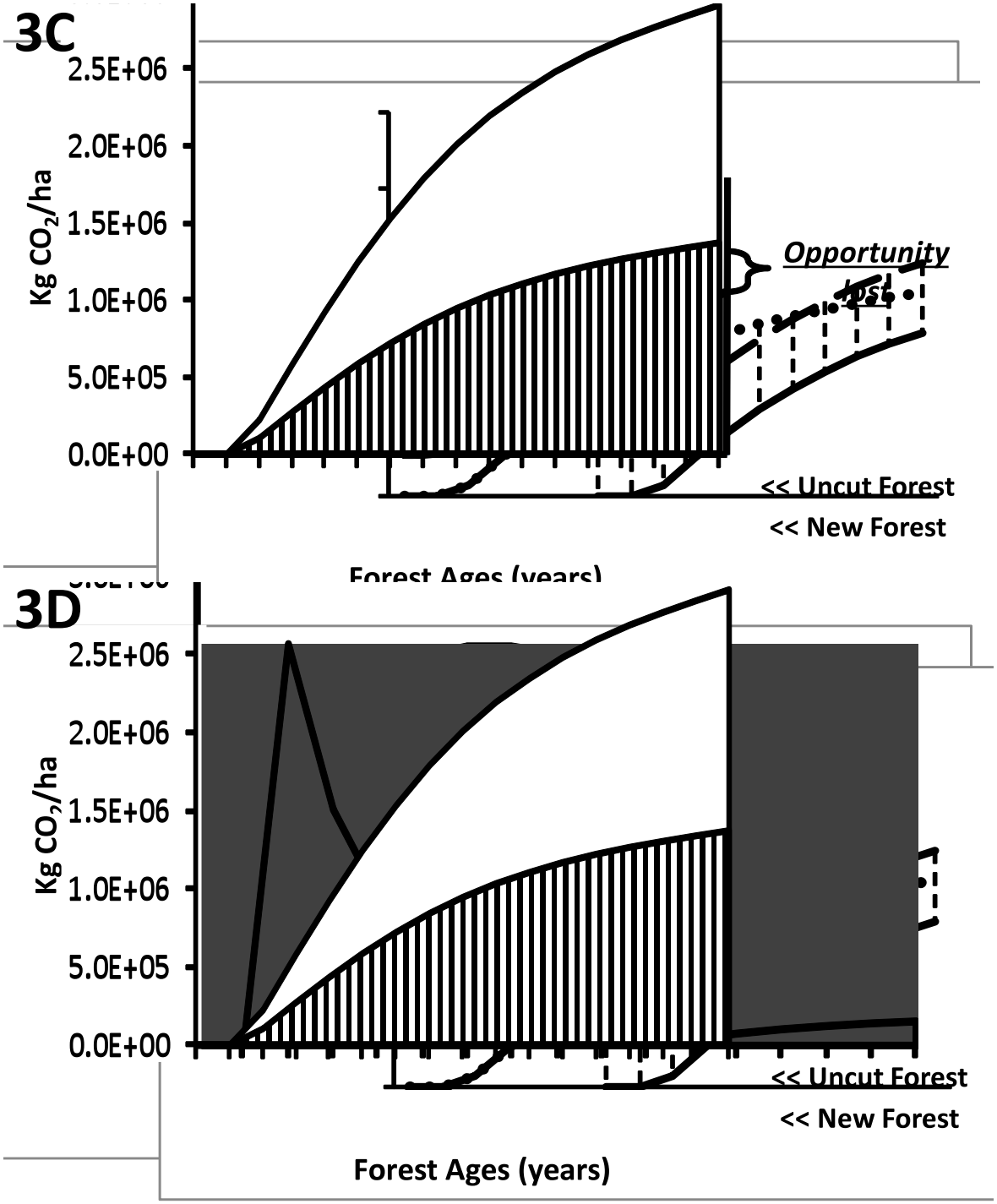


3A


Kg CO_2/ha
$C0_2$ saved producing I-Beams
CO_2 in stand at harvest

3B


Kg CO_2/ha
Net I-beam CO_2 savings
Net solid beam CO_2 savings
Net wood fuel CO_2 loss


3C
2.5E+06
2.0E+06
1.5E+06
1.0E+06
5.0E+05
0.0E+00
Kg CO_2/ha
Opportunity
Cost
<< Uncut Forest
<< New Forest
Forest Ages (years)
3D
2.5E+06
2.0E+06
1.5E+06
1.0E+06
5.0E+05
0.0E+00
Kg CO_2/ha
<< Uncut Forest
<< New Forest
Forest Ages (years)

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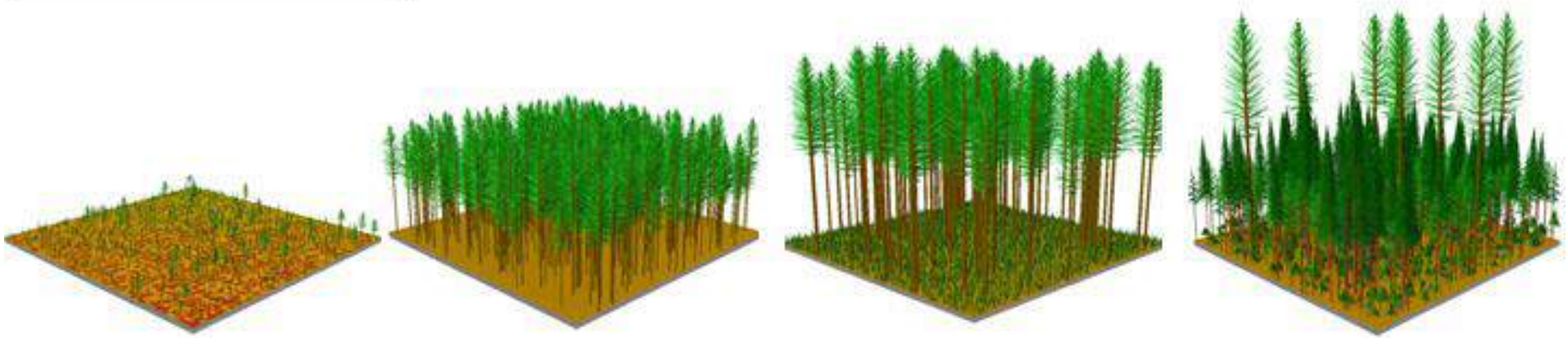
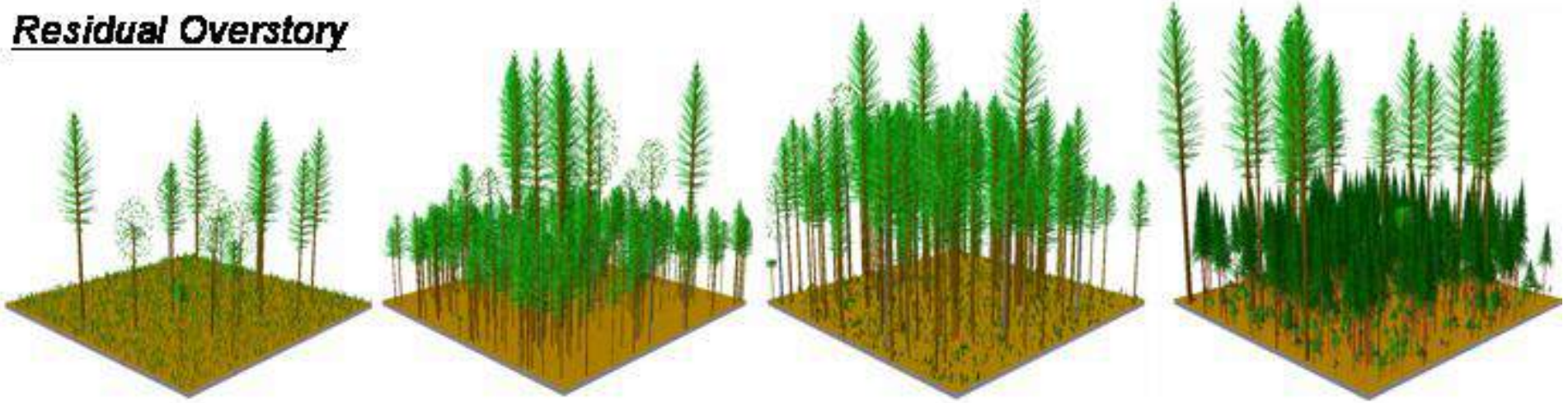
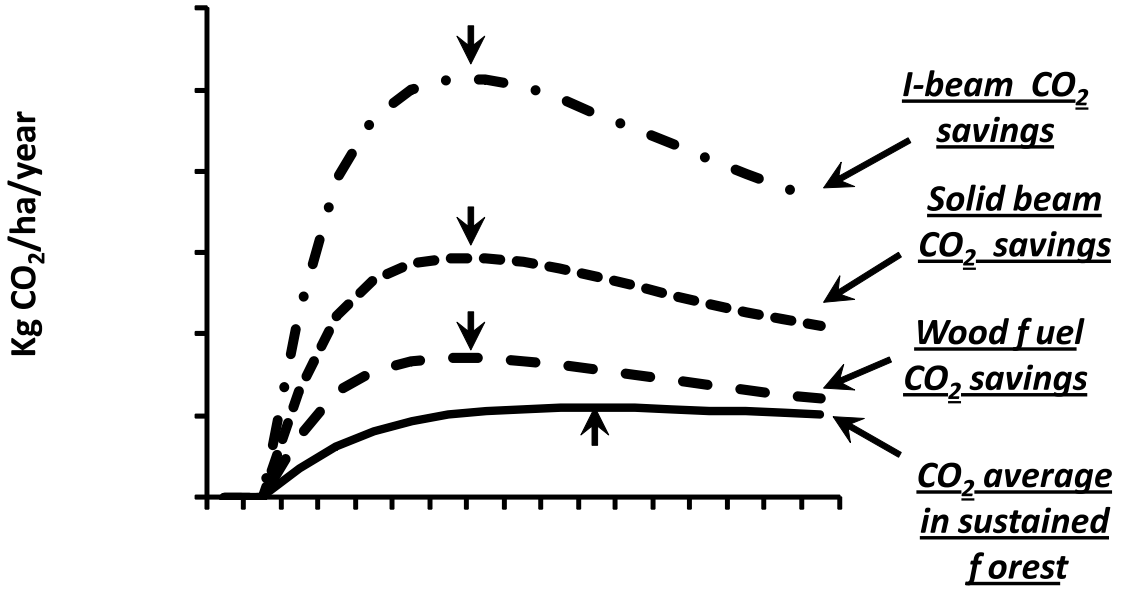


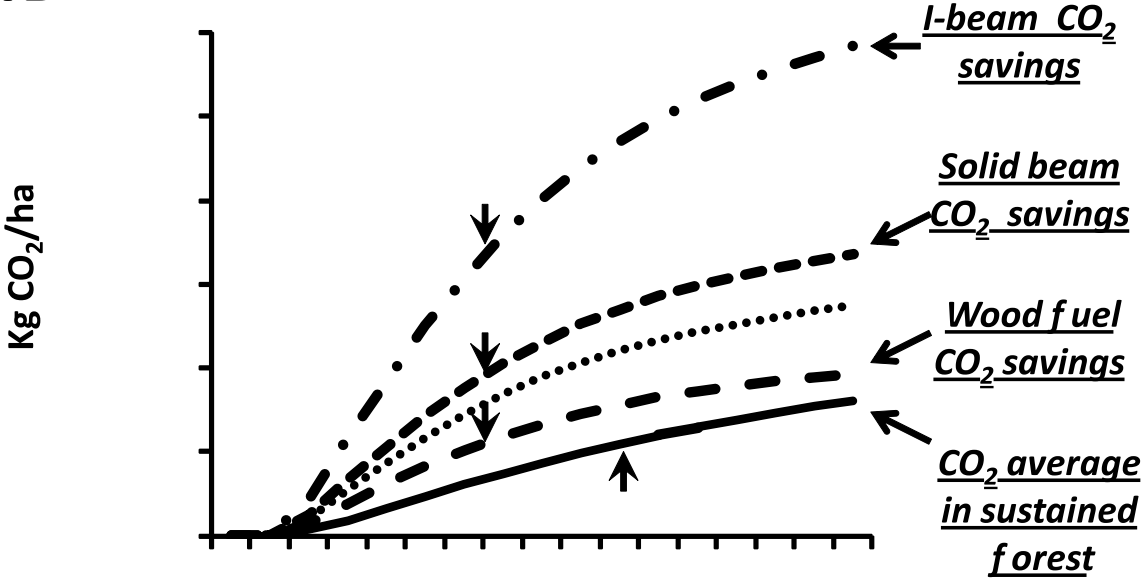
Residual Overstory



4A


Kg CO_2/ha/year
I-beam CO_2 savings
Solid beam CO_2 savings
Wood fuel CO_2 savings
CO_2 average in sustained forest

4B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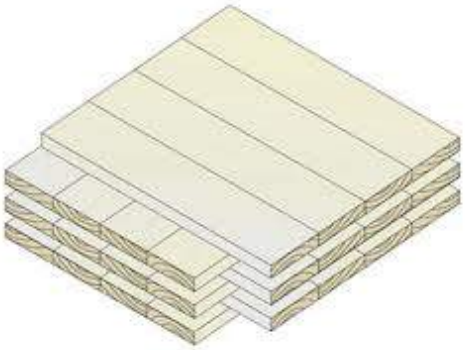
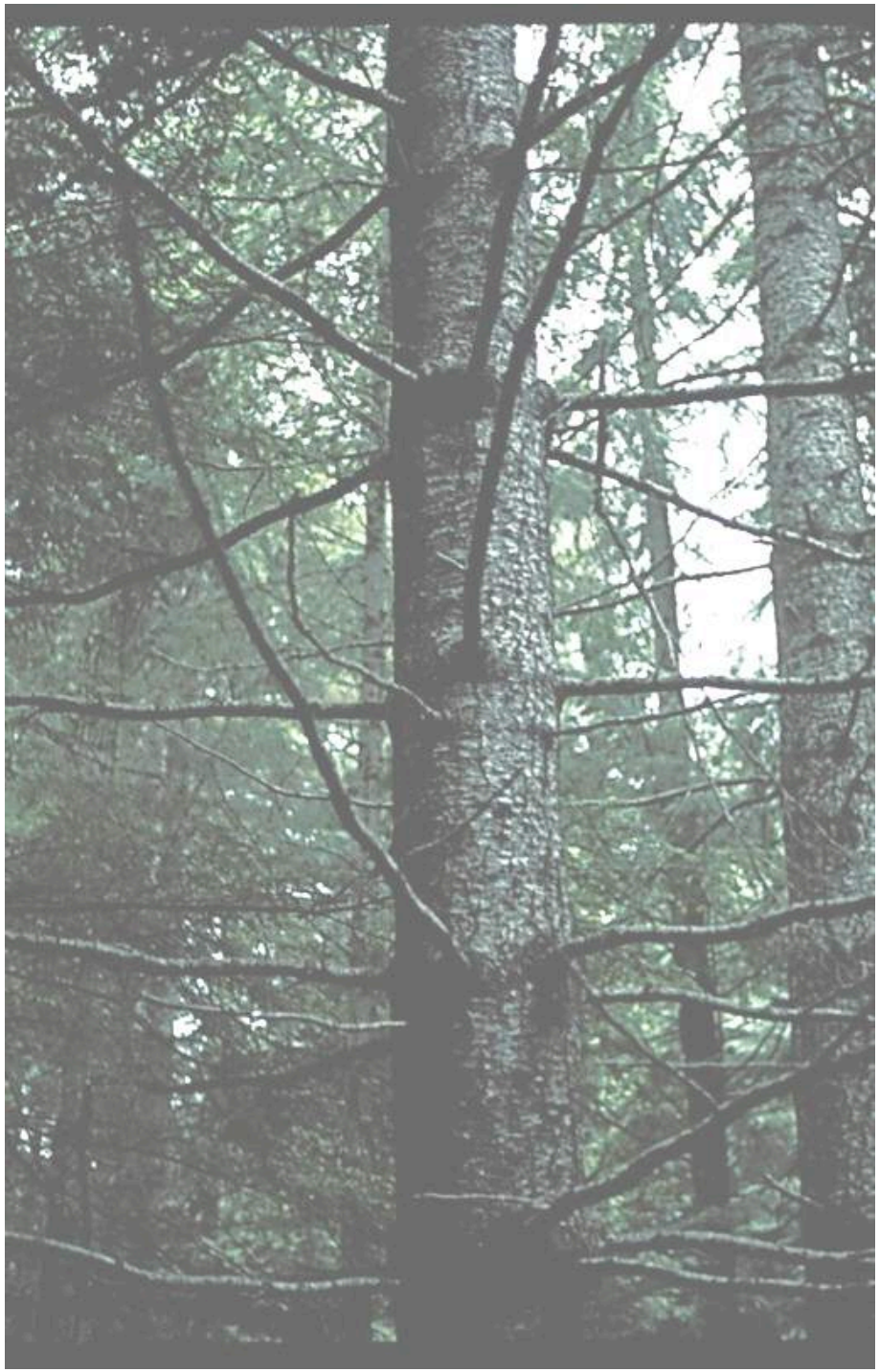
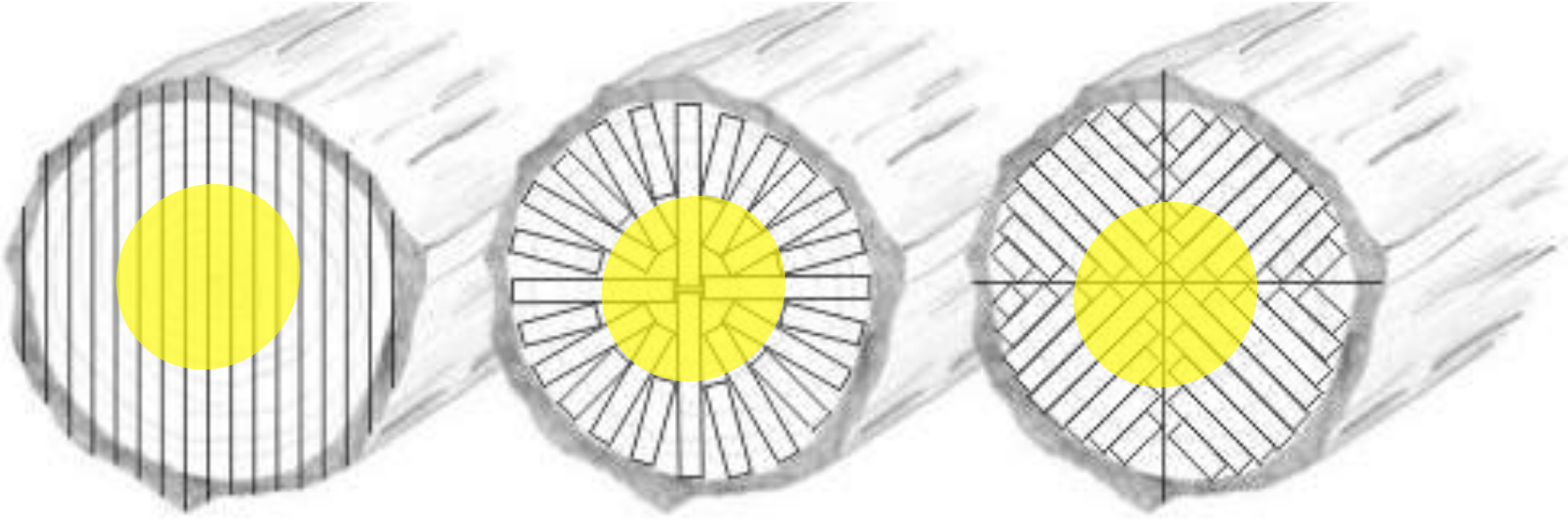
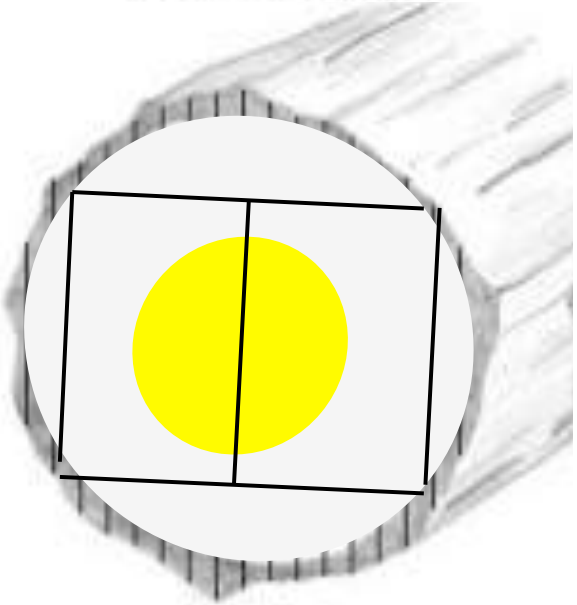


The Wood Quality Issue

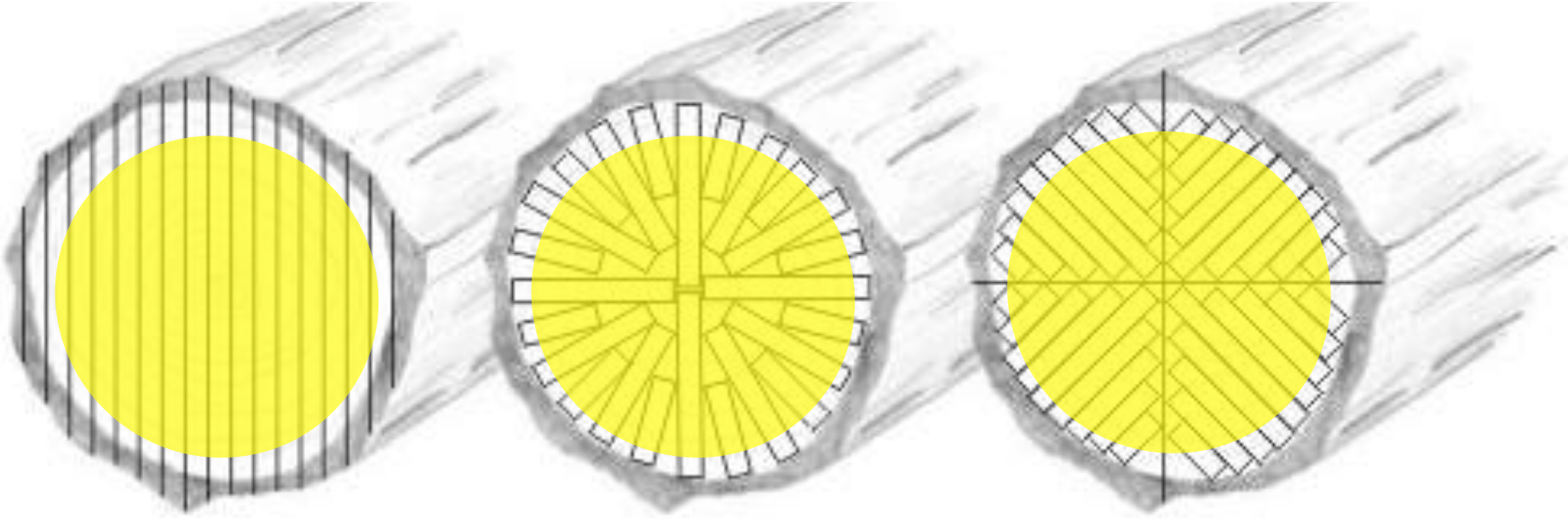


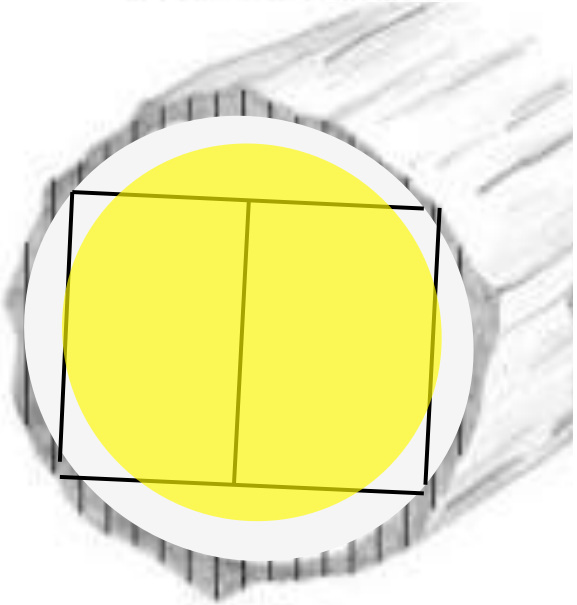


Plainsawn Riftsawn Quartersawn



Chip & Saw





Chip & Saw

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1	2	3	4	5
United Nations Food and Agriculture Global Ecoregions	Estimated average potential timber growth	Forest area	Potential global forest growth	
	(m^3/ha/year)	(10^6 ha)	Volume (10^6 m^3)	Mass (10^9 kg)
Tropical rainforest	8	1,004	7,929	3,048
Tropical moist deciduous forest	7	355	2,485	955
Temperate oceanic	6	46	282	109
Tropical dry	6	430	2,367	910
Subtropical mountain	5	112	562	216
Subtropical humid	4	156	610	234
Tropical shrub	3	71	219	84
Temperate continental	3	248	719	276
Subtropical dry	3	55	148	57
Temperate mountain	3	195	487	187
Boreal coniferous	2	580	870	334
Boreal mountain	1	329	165	63
Tropical mountain	1	111	56	21
Boreal tundra	1	96	48	18
Subtropical steppe	1	48	24	9
Temperate steppe	1	31	15	6
Subtropical desert	1	12	6	2
Temperate desert	1	8	4	2
Tropical desert	1	2	1	0
Polar	0	16	0	0
Total		3,906	16,996	6,534

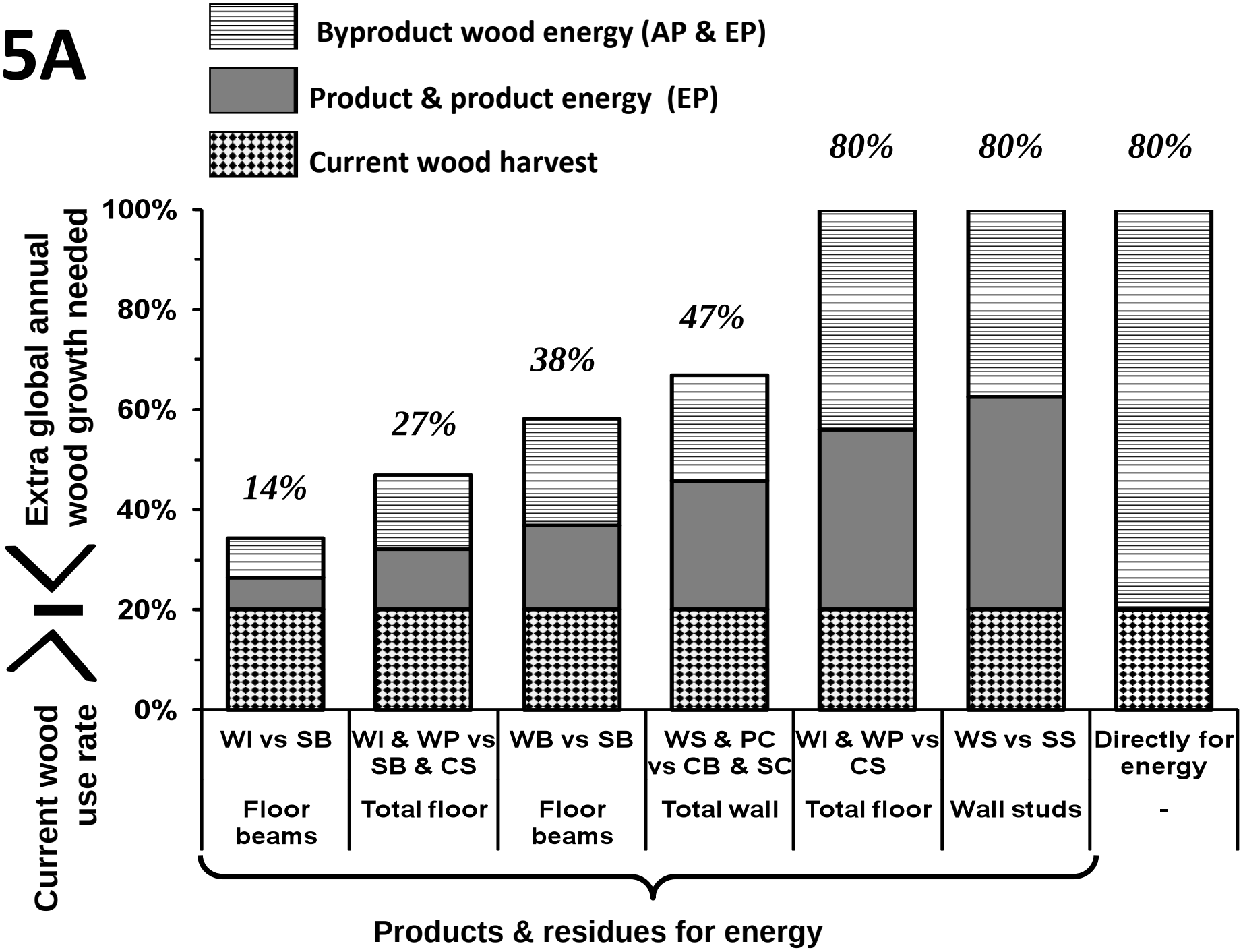
	Global Value	Year	Amount
1	Global FF annual use (MJ/yr)	2010	4.11E+14
2	Global annual CO_2 emissions (kg/yr)	2010	3.27E+13
3	Global potential wood growth (kg/yr)	(2000 - 2011)	6.53E+12
4	Current global annual harvest (kg/yr)	2010	1.31E+12
5	Current global forest area (ha)		3.91E+09
6	Current global crop area (ha)		1.55E+09
7	Forest area in reserves (ha)		4.88E+08

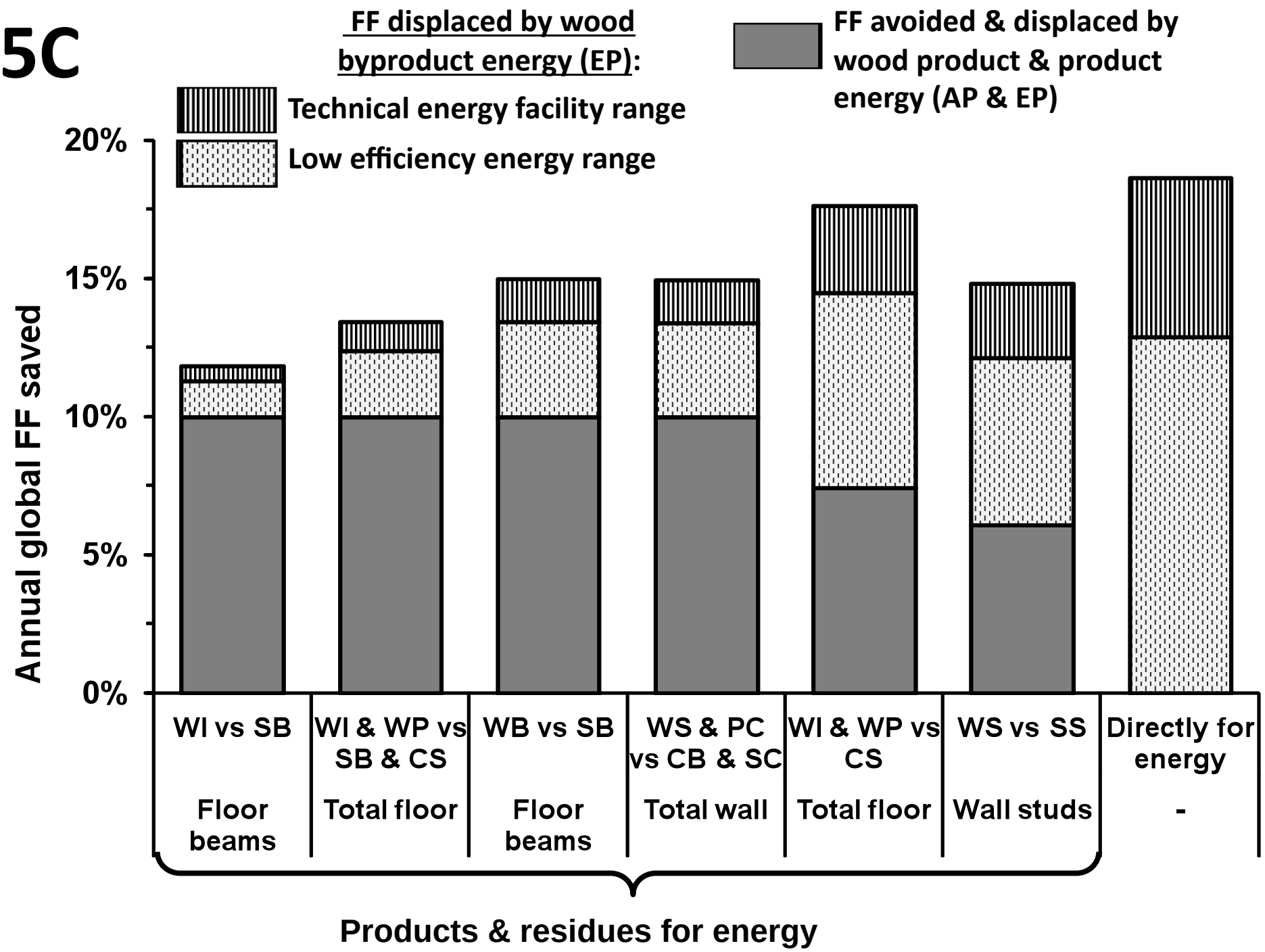
2010 Global Wood Use		
	Cubic meters (billions)	**% of use**
Fuelwood	**1.87**	**55%**
Pulp for paper	**0.53**	**16%**
Construction wood	**1.00**	**30%**

	a	b	c	d	e
1	**Construction Material**	**2010 global production (kg)**	**Embedded energy estimate (MJ/kg)**	**Total FF energy consumed (MJ)**	**Percent of Global FF consumed**
2	**Steel**	1.42E+12	25	3.55E+13	**9%**
3	**Concrete**	2.21E+13	1	2.21E+13	**5%**
4	**Brick**	2.00E+12	5	1.00E+13	**2%**
5	**Aluminum**	4.08E+10	100	4.08E+12	**1%**
			Total	**7.16E+13**	**17%**

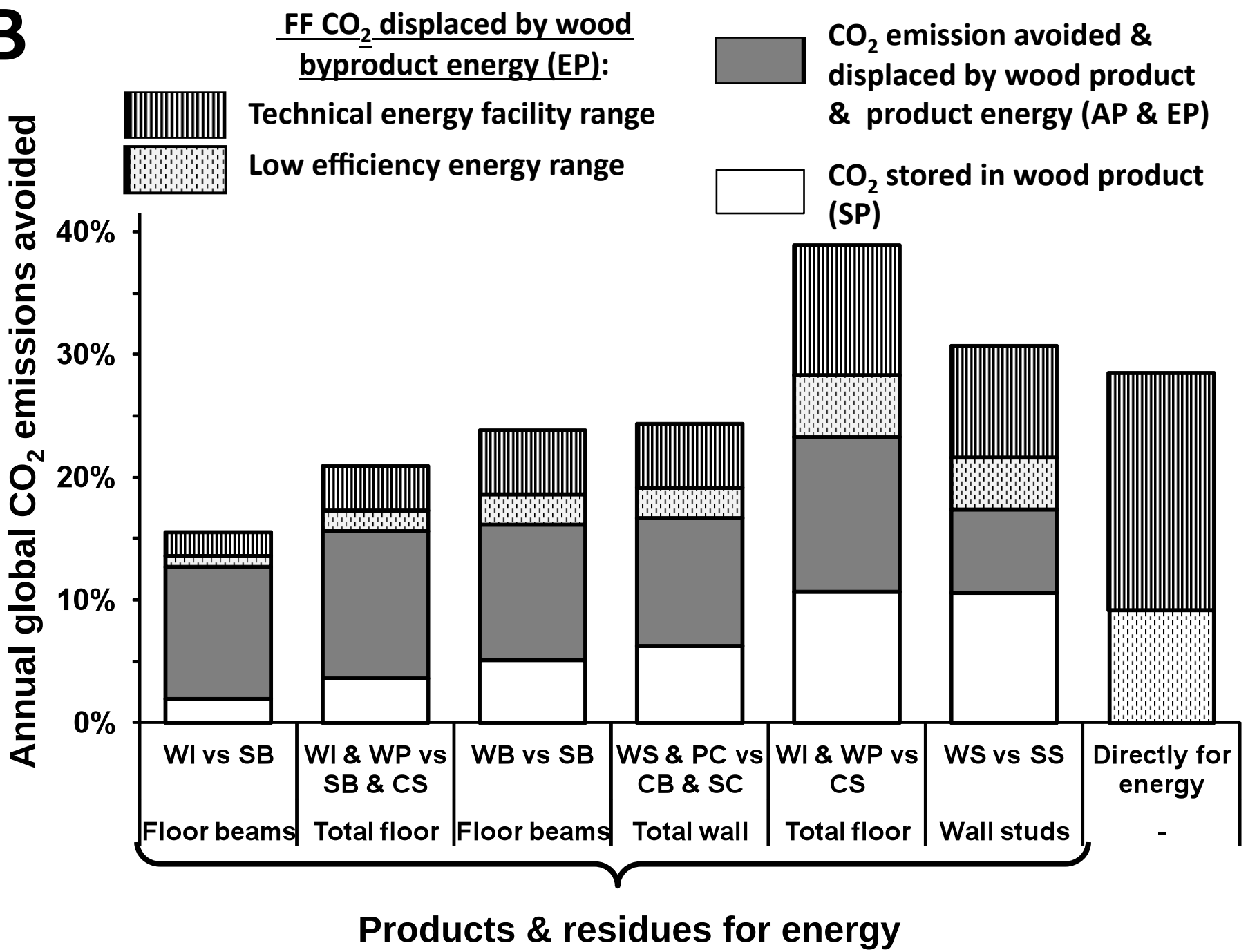
	Scenario 1: Wood use to save 10% global FF use through wood use in construction			Scenario 2: All wood growth used, first to save 10% global FF use through wood use in construction, remaining for energy.		
Wood product & substitute	Wood growth used	CO_2 saved	FF saved	Wood growth used	CO_2 saved	FF saved
Wood i-beam ~ Steel joist	**14%**	**15%**	**12%**	**80%**	**32%**	**22%**
Wood i-beam & plywood ~ Steel joist & concrete slab	**27%**	**20%**	**13%**	**80%**	**34%**	**22%**
Wood dimension beam ~ Steel joist	**38%**	**23%**	**15%**	**80%**	**34%**	**22%**
BioDryStud/BioDryPly/BioDryPly ~ Concrete block/stucco	**47%**	**23%**	**15%**	**80%**	**32%**	**20%**
Wood i-beam & plywood ~ Concrete slab	**80%**	**37%**	**18%**	**80%**	**37%**	**18%**
BiodDry/stud ~ Steel stud	**80%**	**29%**	**15%**	**80%**	**29%**	**15%**
Wood only for energy	**80%**	**27%**	**19%**	**80%**	**27%**	**19%**

5A


Byproduct wood energy (AP & EP)
Product & product energy (EP)
Current wood harvest
Extra global annual wood growth needed
Current wood use rate
100%
80%
60%
40%
20%
0%
14%
27%
38%
47%
80%
80%
80%
WI vs SB
Floor beams
WI & WP vs SB & CS
Total floor
WB vs SB
Floor beams
WS & PC vs CB & SC
Total wall
WI & WP vs CS
Total floor
WS vs SS
Wall studs
Directly for energy
-
Products & residues for energy


5C
FF displaced by wood byproduct energy (EP):
Technical energy facility range
Low efficiency energy range
FF avoided & displaced by wood product & product energy (AP & EP)
Annual global FF saved
20%
15%
10%
5%
0%
WI vs SB
WI & WP vs SB & CS
WB vs SB
WS & PC vs CB & SC
WI & WP vs CS
WS vs SS
Directly for energy
Floor beams
Total floor
Floor beams
Total wall
Total floor
Wall studs
-
Products & residues for energy

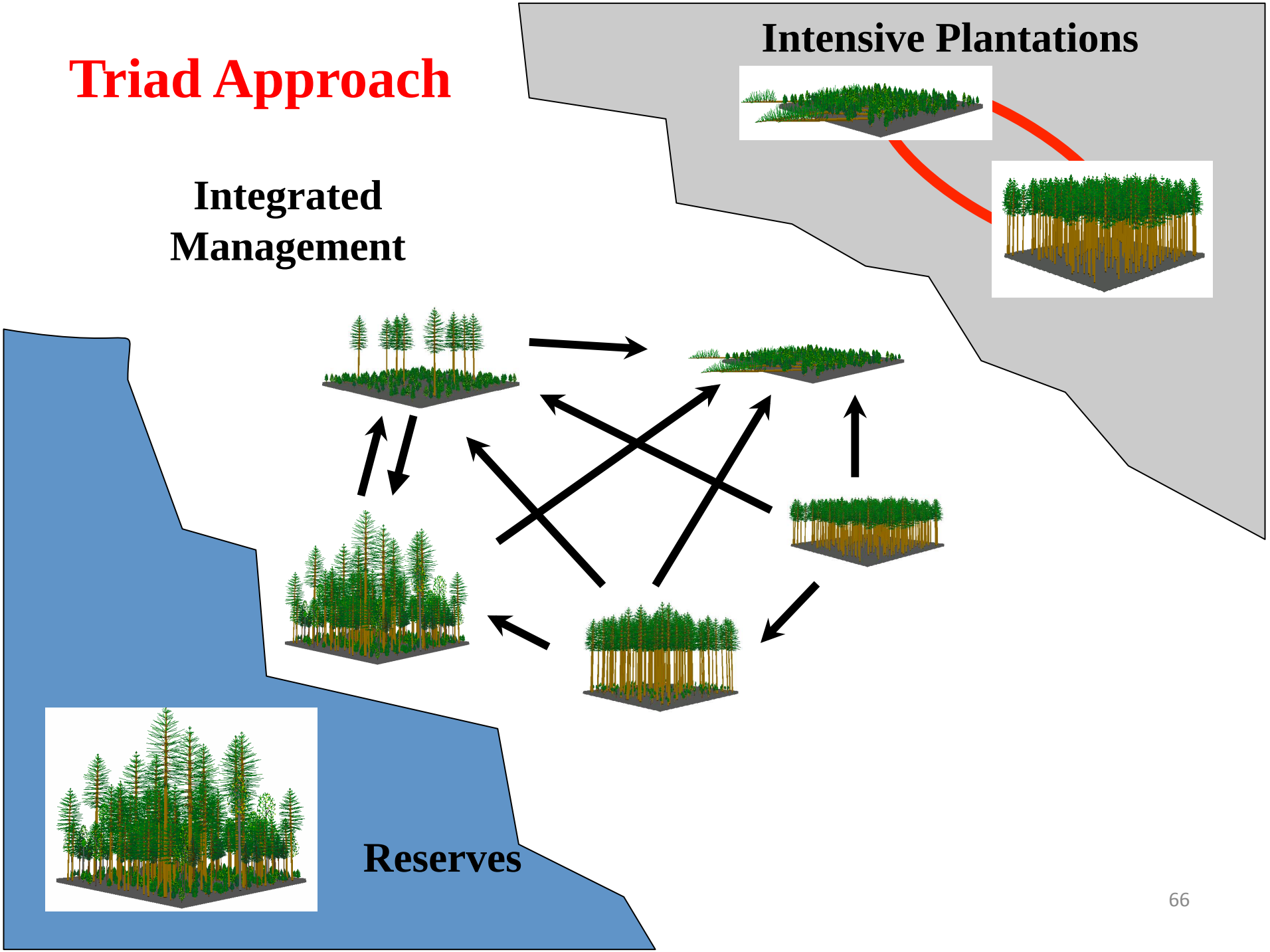
5B


FF CO2 displaced by wood byproduct energy (EP):
Technical energy facility range
Low efficiency energy range
CO2 emission avoided & displaced by wood product & product energy (AP & EP)
CO2 stored in wood product (SP)
Annual global CO2 emissions avoided
40%
30%
20%
10%
0%
WI vs SB
Floor beams
WI & WP vs SB & CS
Total floor
WB vs SB
Floor beams
WS & PC vs CB & SC
Total wall
WI & WP vs CS
Total floor
WS vs SS
Wall studs
Directly for energy
-
Products & residues for energy

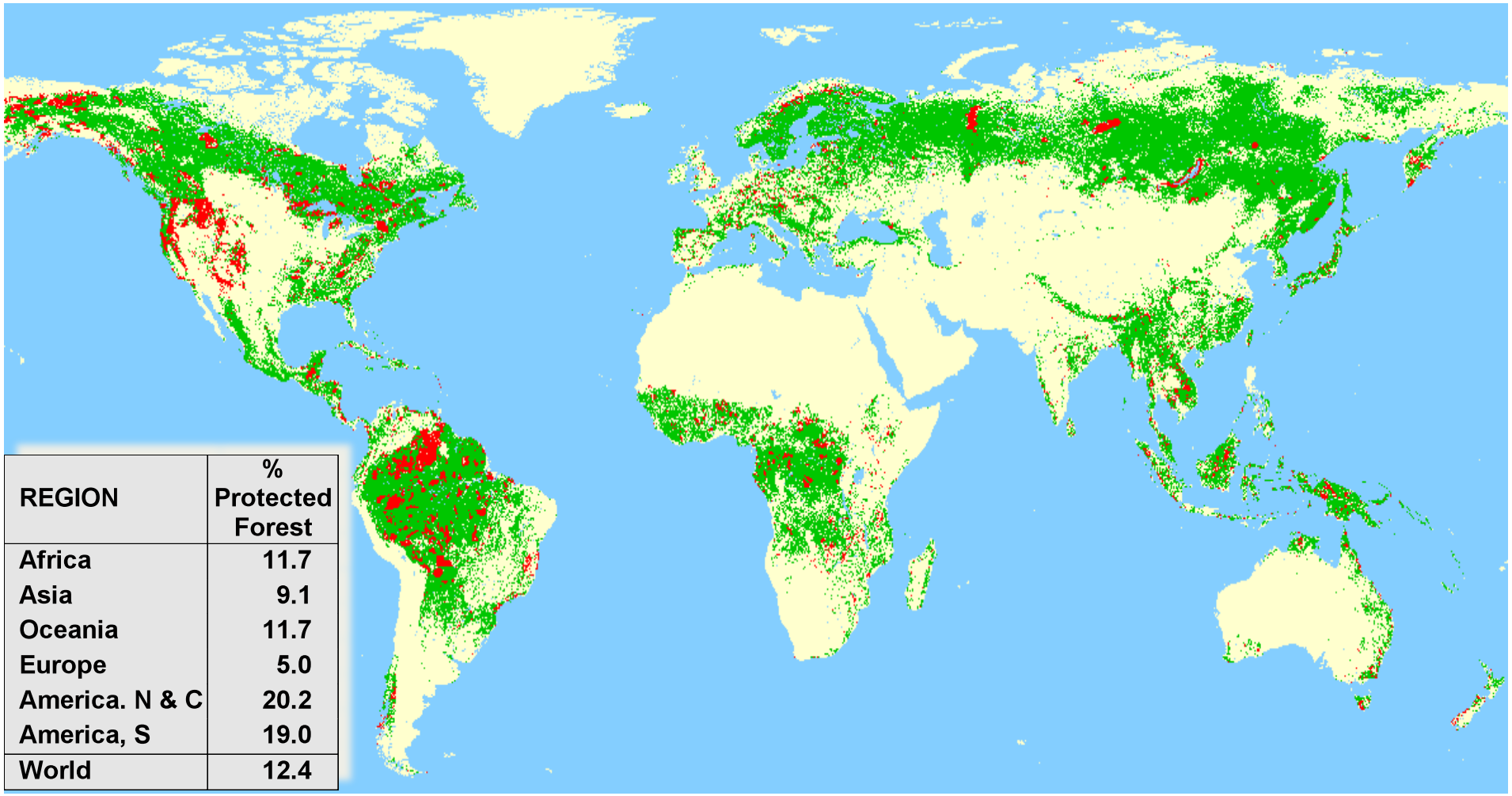
Questions about Wood Use

1. **Will wood save FF & and CO2?**
2. **Will it save more as wood energy or wood buildings?**
3. **What will forest management & harvest do for wood energy and products?**
4. **What will forest harvest & management do for forest CO2 sequestration?**
5. **Is there enough wood to make wood use worthwhile?**
6. **How will we protect biodiversity?**

Triad Approach



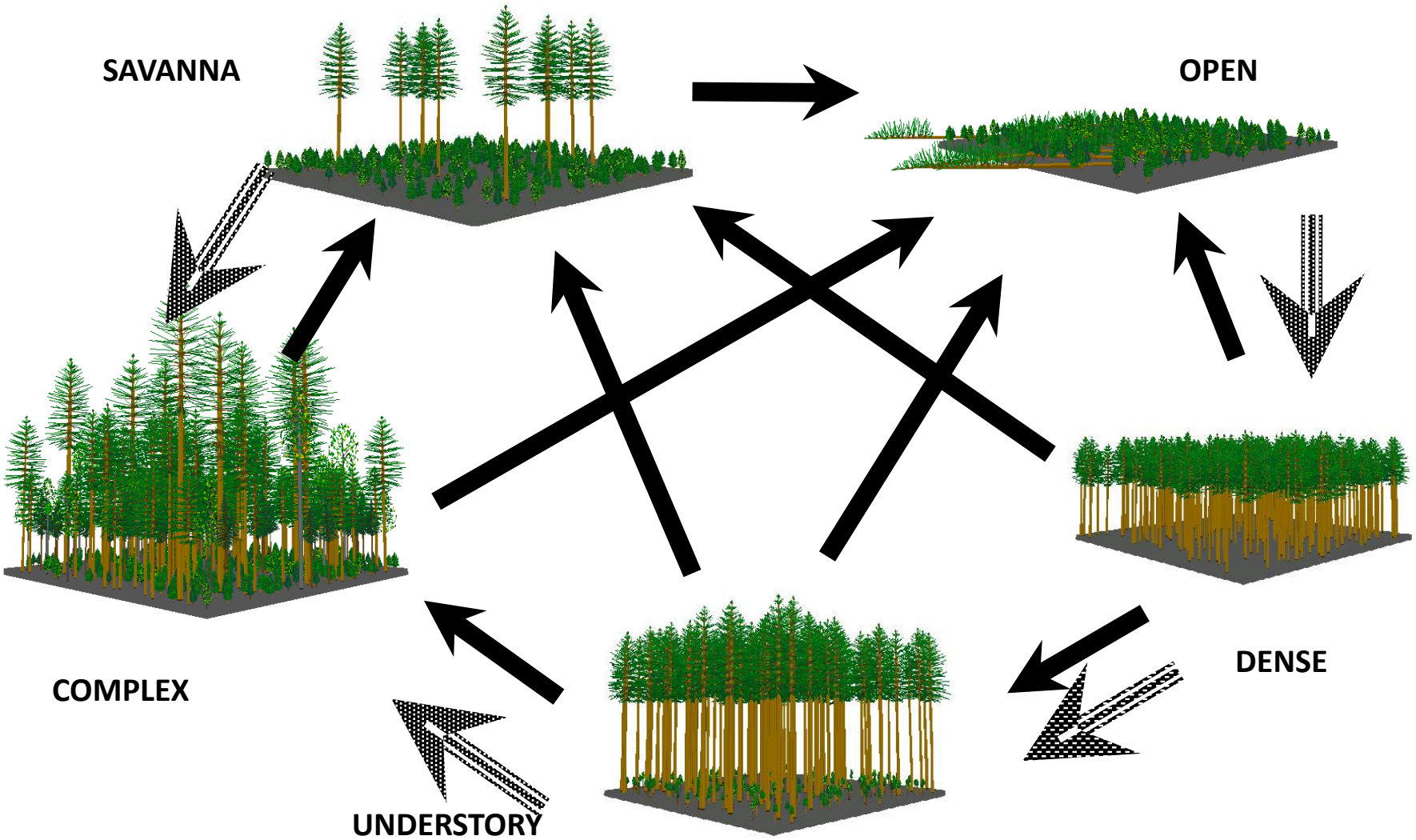
FOREST RESERVES: (12.4 %, WORLD AVERAGE)



REGION	% Protected Forest
Africa	11.7
Asia	9.1
Oceania	11.7
Europe	5.0
America. N & C	20.2
America, S	19.0
World	12.4

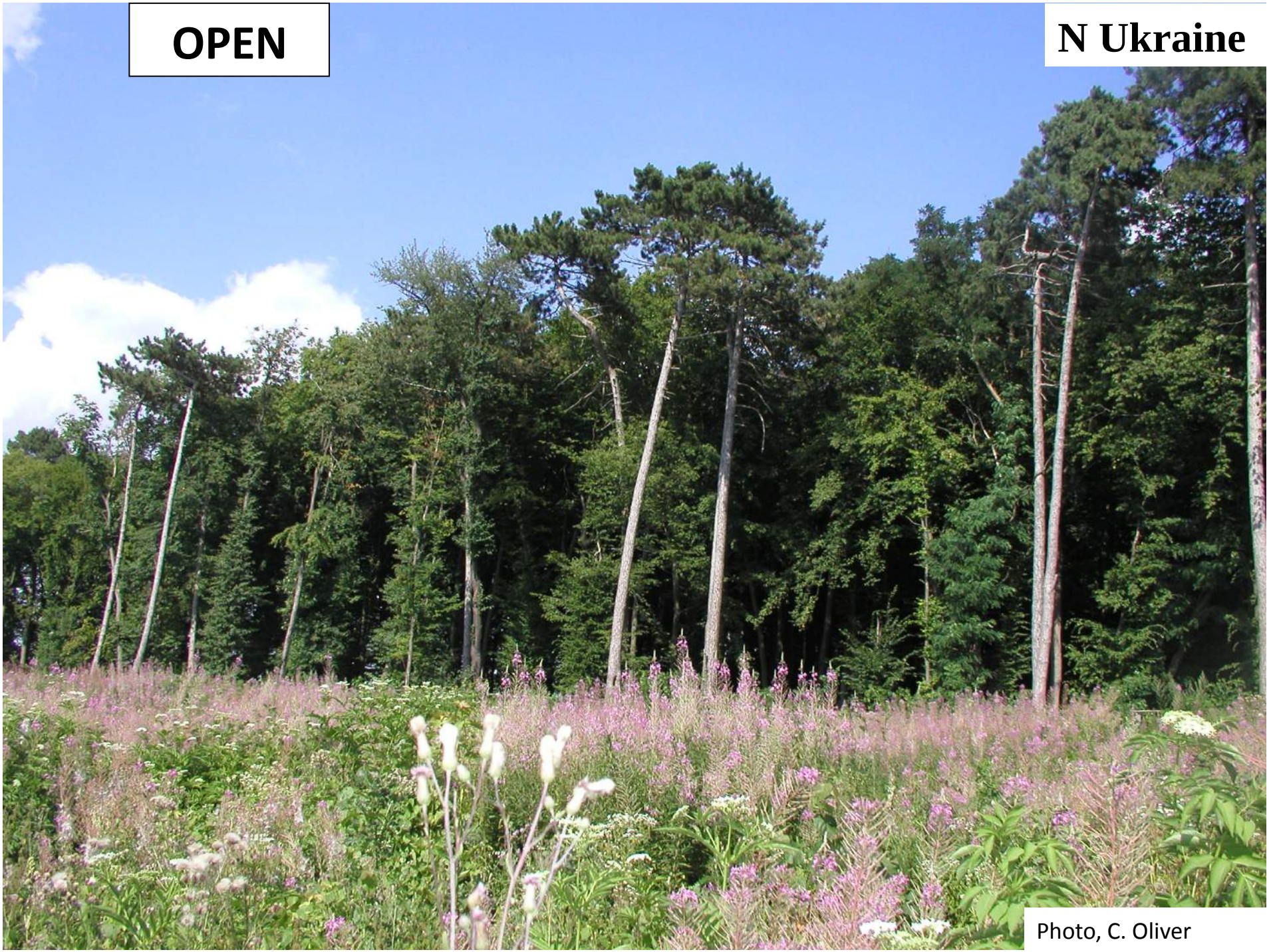
NEW SCIENTIFIC PARADIGM:

Forests are dynamic. They change with growth and disturbances.
They contain many structures.



Oak-hardwood savanna, Russian Far East

Slide from Photo, C. Oliver



Photo, C. Oliver

DENSE

UNDERSTORY

COMPLEX

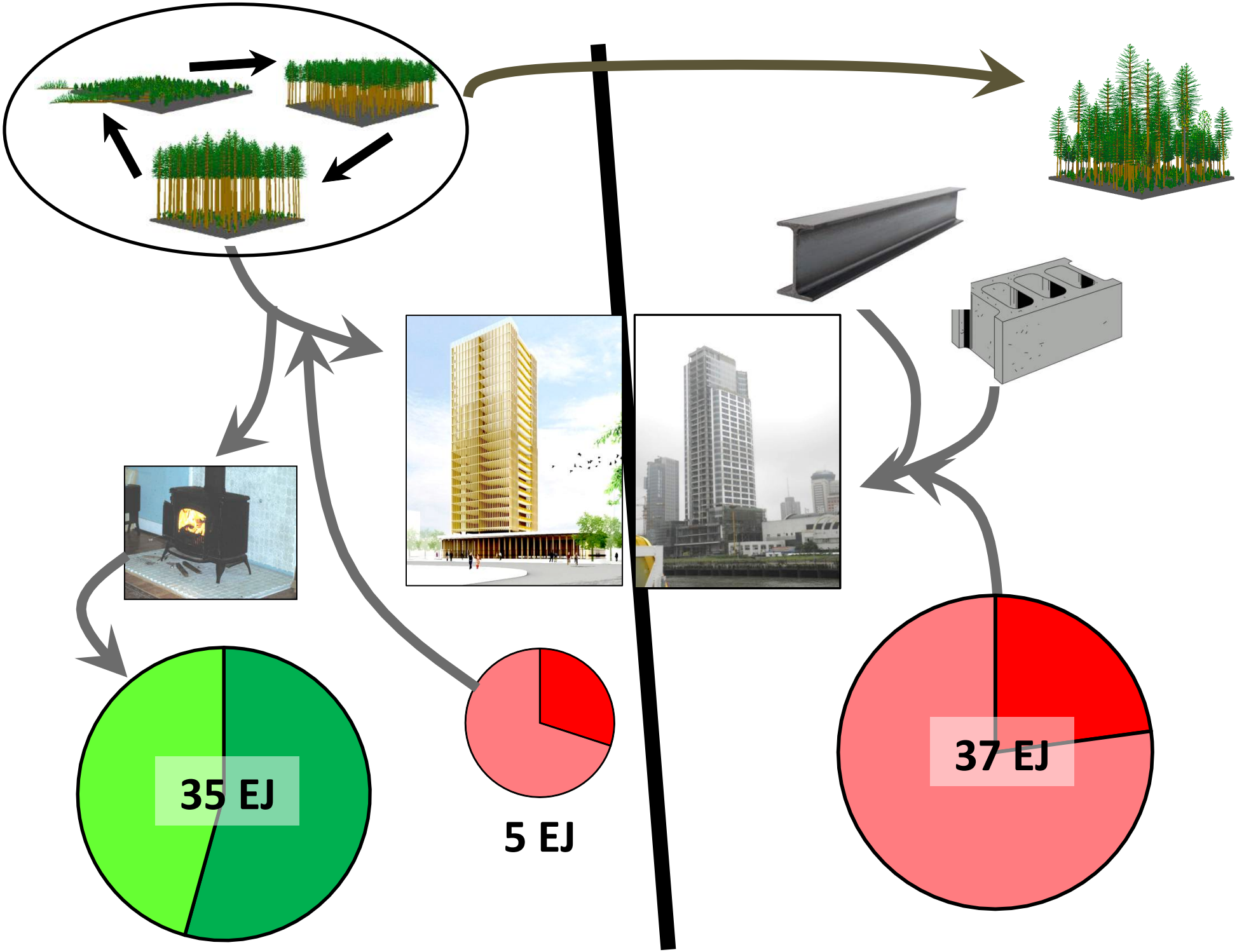
Slide from C. Oliver, Yale University

From Fotosearch.com

From Bing Images

Courtesy of Bing Images

Courtesy of Bing Images


35 EJ
5 EJ
37 EJ