Technical feasibility
Resource availability and cost
Resource competition
Technology evolution
Summary
Sustainability
GHG emissions
Forest practices

Bioenergy in California

A perspective on feasibility and impacts

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California Energy Commission Staff Integrated Energy Policy Report (IEPR) Workshop

1 Technical feasibility
- Resource availability and cost
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- Technology evolution
- Summary

2 Sustainability
- GHG emissions
- Forest practices

Return on Investment drives markets

Biomass Renewable Obligation Certificate in the UK at \$99 MWh^{-1}

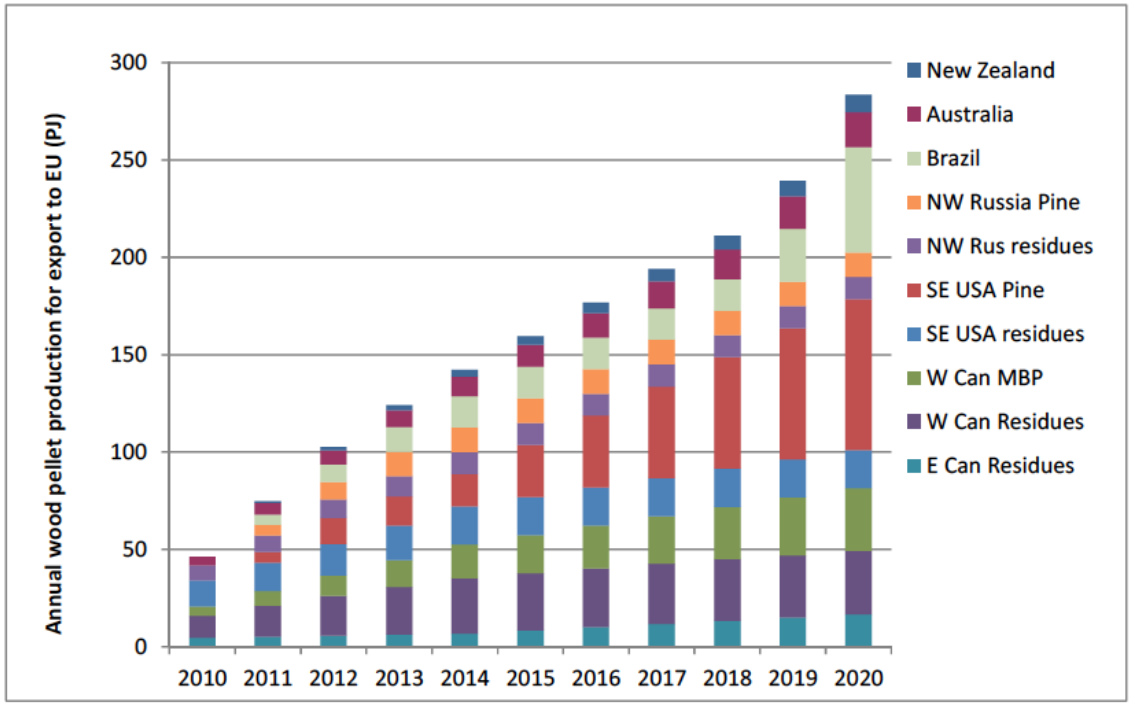


Fig. 1.9 - Anticipated growth in available solid biomass supply from the various sourcing regions. residues = woody industry residues (e.g. sawdust), MPB = Mountain pine beetle affected wood

Figure: Projected imports of wood pellets to europe at \$180 ton^{-1}

Biomass availability

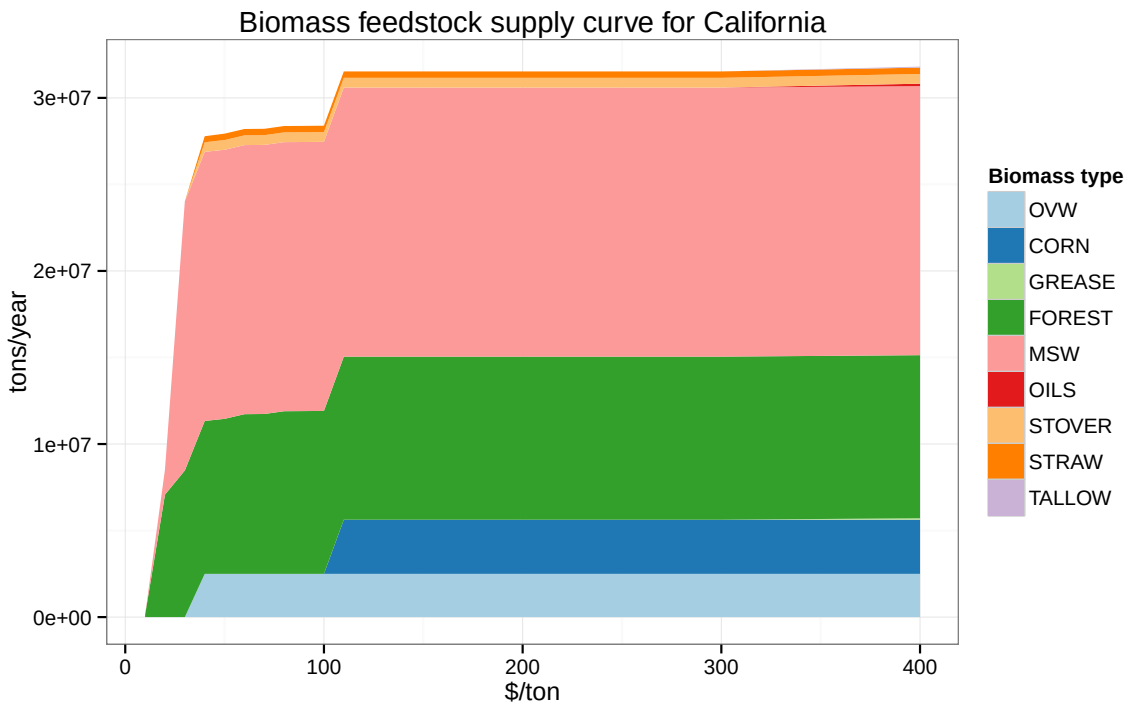


Figure: California biomass supply curve. Source: CBC

Does not include:

- Manures
- Biosolids
- Wastewater
- Landfilled waste

At full utilization solid fuels could generate $\approx$ 4000 MWe

Forest biomass resources in California

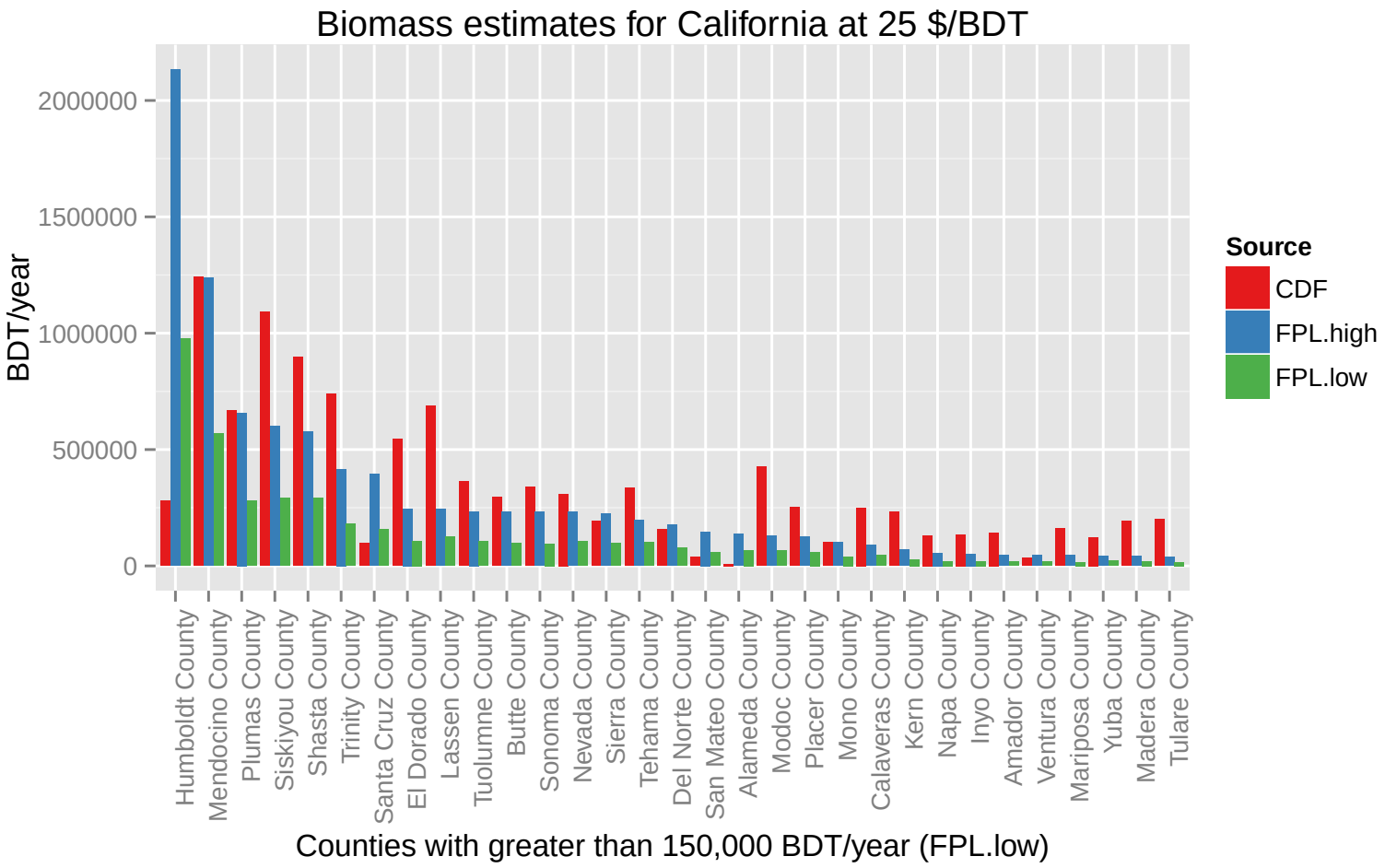


Figure: California Biomass Collaborative, does not include transportation costs

Procurement costs

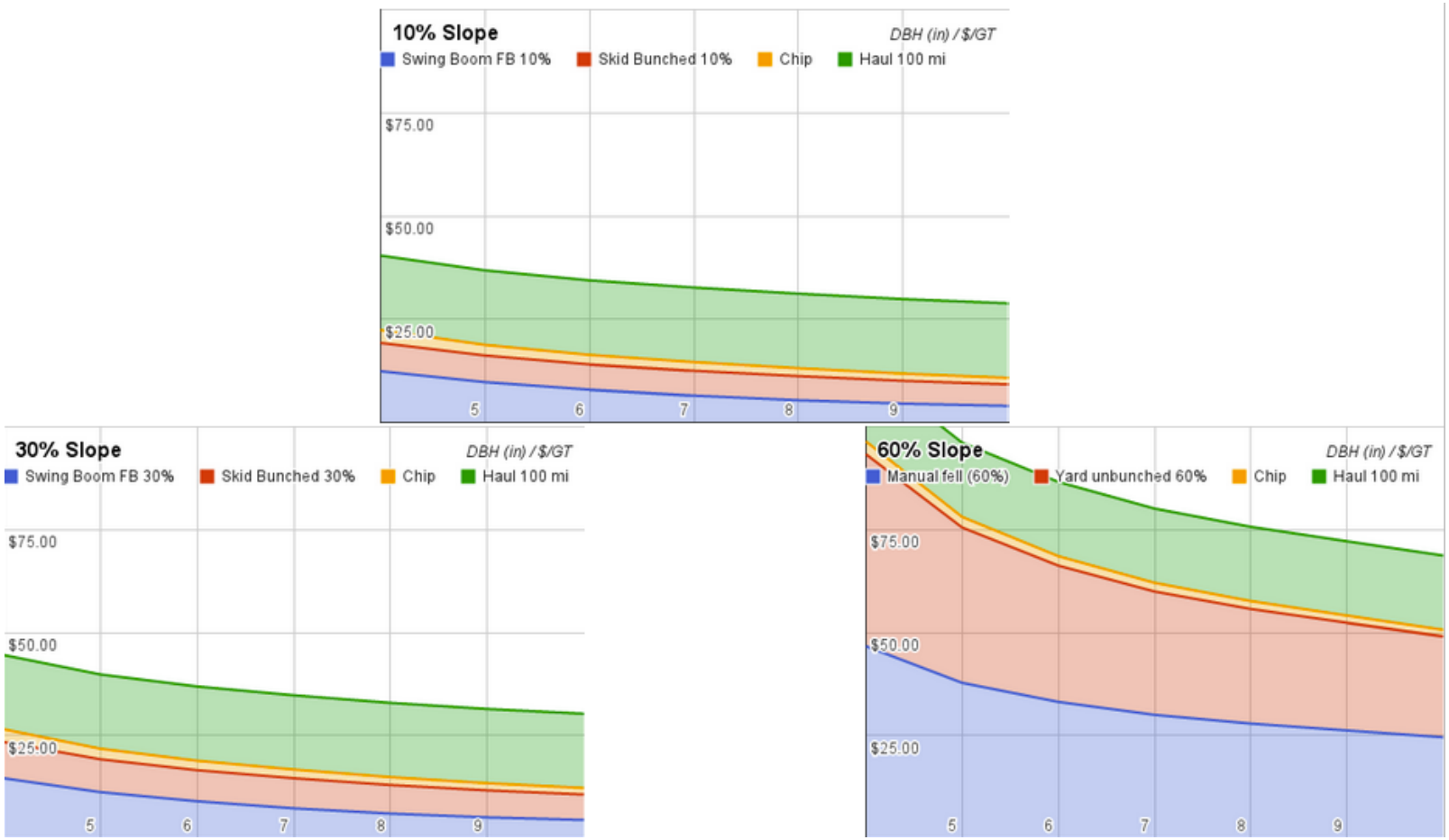


Figure: Feedstock procurement from forests.

RPS bioenergy pricing undervalues biomass electricity

Uncompensated (Ancillary) Benefits of Biomass Energy Production
(from 1999 NREL Report)

US Biomass Fuel Mix

	thousand bdt/yr
Mill Residues	6,400
Forest Residues	1,800
Agricultural Residues	2,300
Urban Wood Residues	1,400
Total	11,900

Value of the Benefits

	¢ /kWh
Criteria Pollutants	4.3
Greenhouse Gases	5.9
Avoided Landfill	1.1
Timber Stand Improvement	0.1
Total Benefits, US Biomass fuel mix	11.4

Figure: Estimated value of biomass electricity

Does not include:

- Wildfire suppression costs
- Impacts to utility infrastructure
- Water impacts
- Market price of electricity.

Competition between fuels and electricity

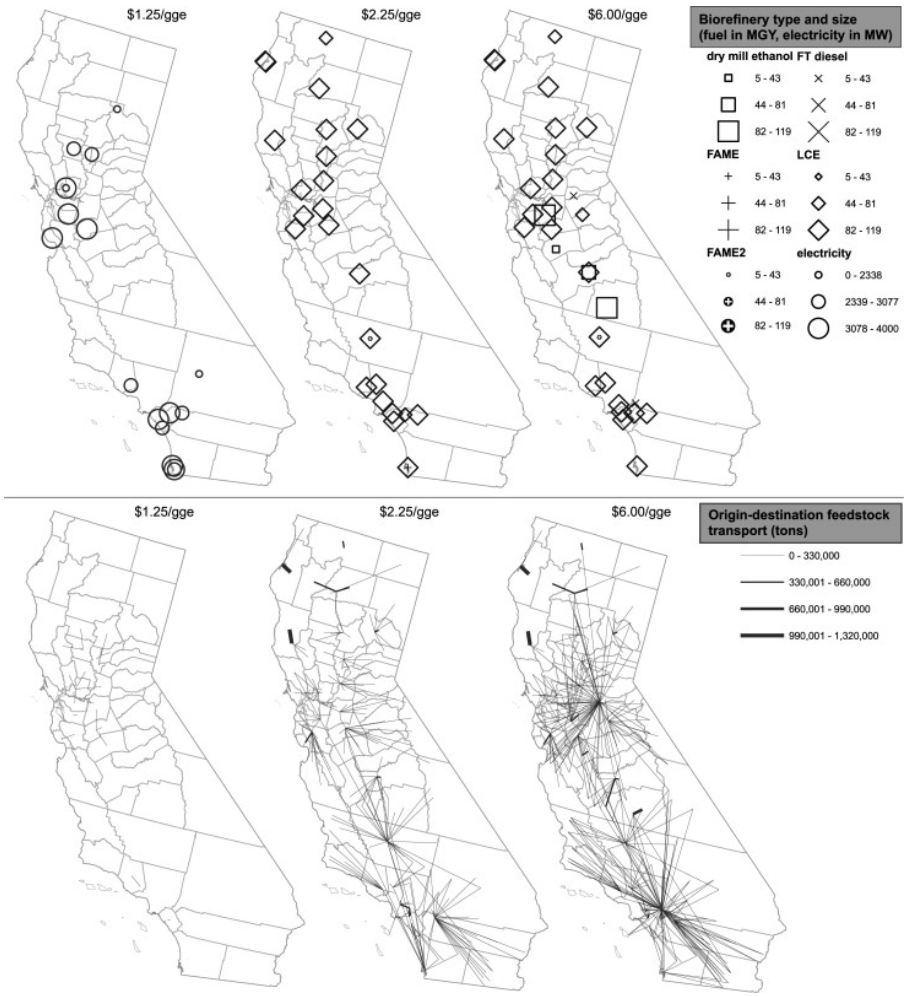
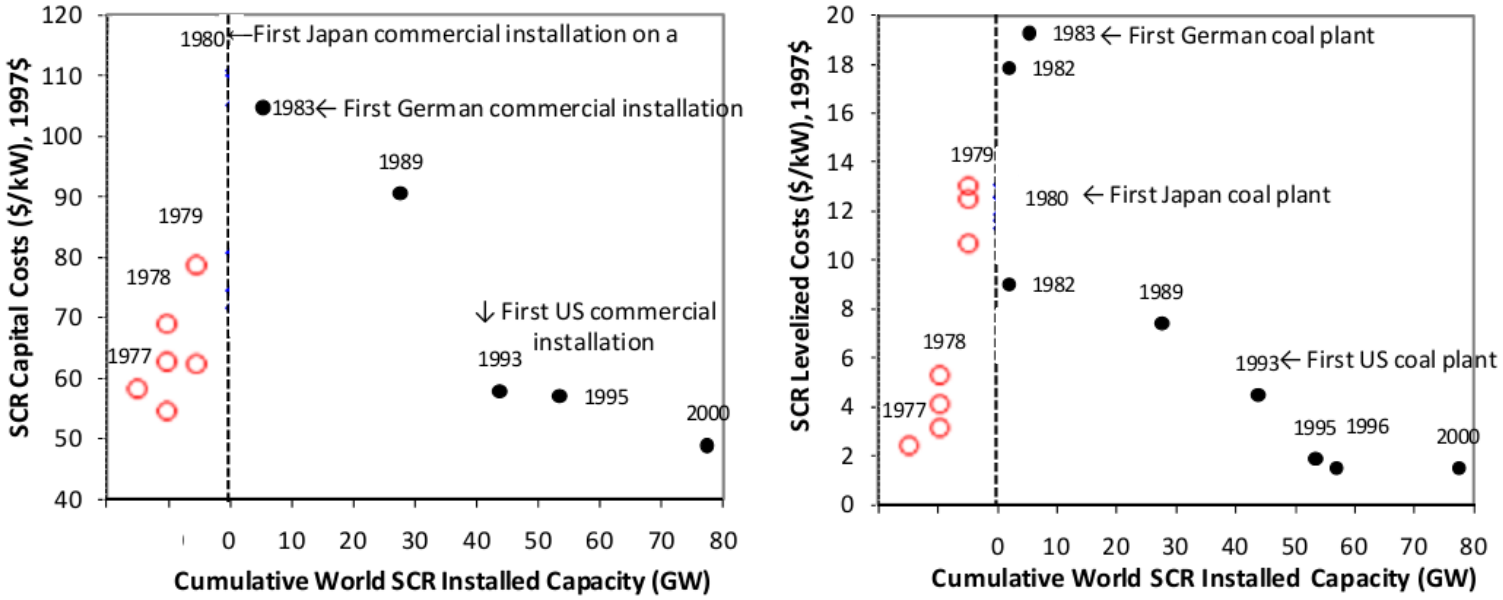


Figure: Feedstock utilization under a range of fuel prices.

Sustained market effects on production costs.



From Yeh, S. and E. Rubin. (2010) Uncertainties in Technology Experience Curves for Energy-Economics Models.

- Sustained competitive markets result in innovation and increases in production efficiency.

Feasibility summary

- Feasibility of bioenergy policy objectives limited by markets ($ J^{-1}).
- Resource potential is a constraint but:
  - difficult to quantify
  - unlikely to be a limiting factor on balance with procurement cost.
- A sustained market will exert downward pressure on production costs.
  - Initial costs will be high compared with legacy technologies.
- Monetizing ancillary benefits can offset early stage technology costs but cannot be achieved w/o political will.

The difficulty with sustainability

I dont like the word very much. The reason is that no one, as far as I know, is in favor of un-sustainability, and so therefore sustainability tends to mean almost anything you want it to mean, and I think we should be rather **more specific** *than that. The other problem is that sustainability sometimes sounds a bit* **too passive and static**, *and I think throughout history we have transformed our relationship to nature sometimes in good ways sometimes in bad ways. And I think the question for us is* **how we are going to transform our relationship to nature in the future**.

- David Harvey on the term "Sustainability"

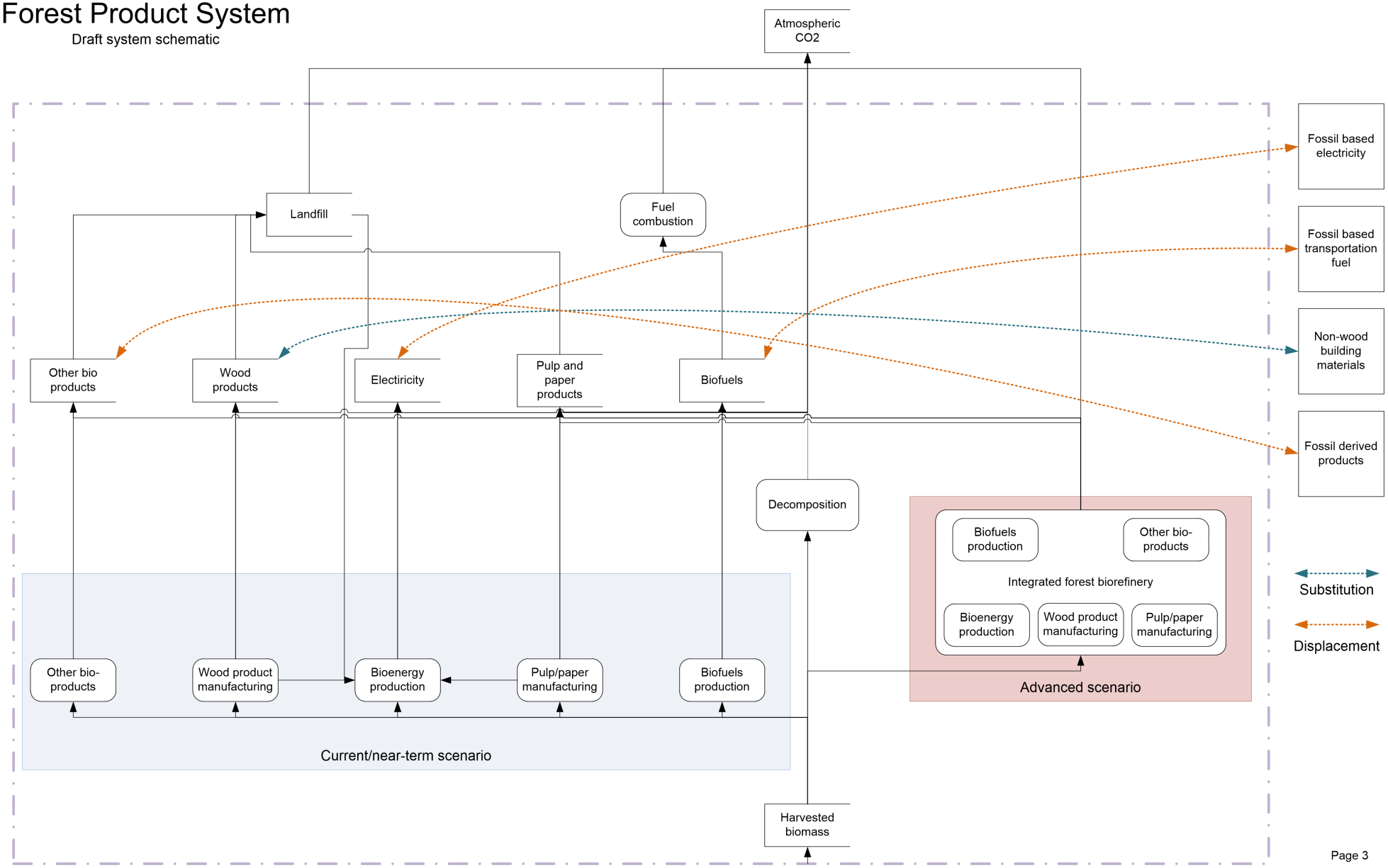
What we talk about when we talk about sustainability of bioenergy

With apologies to Raymond Carver

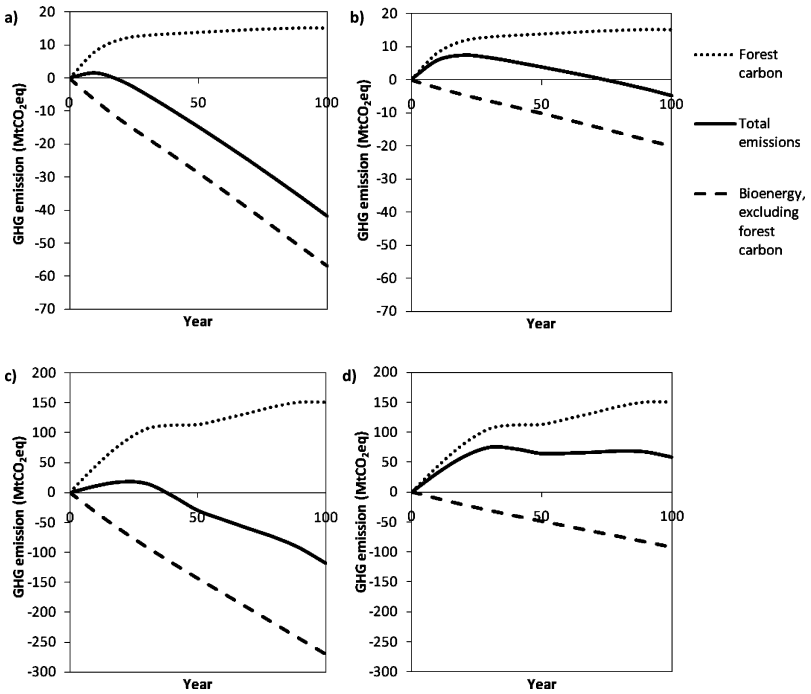
- Forest productivity
- **Forest resistance/resilience**
- Habitat
- **GHG emissions**
- Water quality/quantity
- Ecosystem services (broadly)
- Jobs
- Environmental equity
- ...

Forest Product System

Draft system schematic



Impacts of wood biomass utilization for energy



Cumulative GHG emissions from continuous biomass harvest for bioenergy production: (a) pellets produced from residues, displacing coal (20% cofiring), (b) ethanol produced from residues, displacing gasoline (E85 fuel), (c) pellets produced from standing trees, displacing coal (20% cofiring), and (d) ethanol produced from standing trees, displacing gasoline (E85 fuel). Positive values indicate an increase in GHG emissions to the atmosphere.

- Important time-scale difference between GHG from biomass and GHG from fossil resources.

Forest bioenergy impact on forest practices

- Unlikely that markets for biomass will incentivise additional adverse impacts from forestry operations.
- Restricting restricting the use of residuals in energy production:
  - likely won't impact industrial timber operations (driven by timber value)
  - misses low-hanging fruit for low-carbon energy source
  - misses an opportunity to enable restorative forest management on public and private lands that generate no or little timber value.

University of California Woody Biomass Utilization Program

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