Bioenergy plus CCS: Constraints and opportunities

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It's critical to understand whether we can scale BECCS the way climate models think we can

- Up to half of U.S. negative emissions by 2050 (0.6 Gt CO_2/yr)
- Median global deployment of 12 Gt CO_2/yr by 2100
- Climate models assume BECCS prices from \$40-100/t CO_2, but this would require market maturation
- Without BECCS and other CO_2 removal tech, carbon prices could exceed \$500/t CO_2 in 2040 and \$7000/t CO_2 by 2100

Smith et al., 2015
Edmonds et al. 2013

Constraints to BECCS

Fresh water

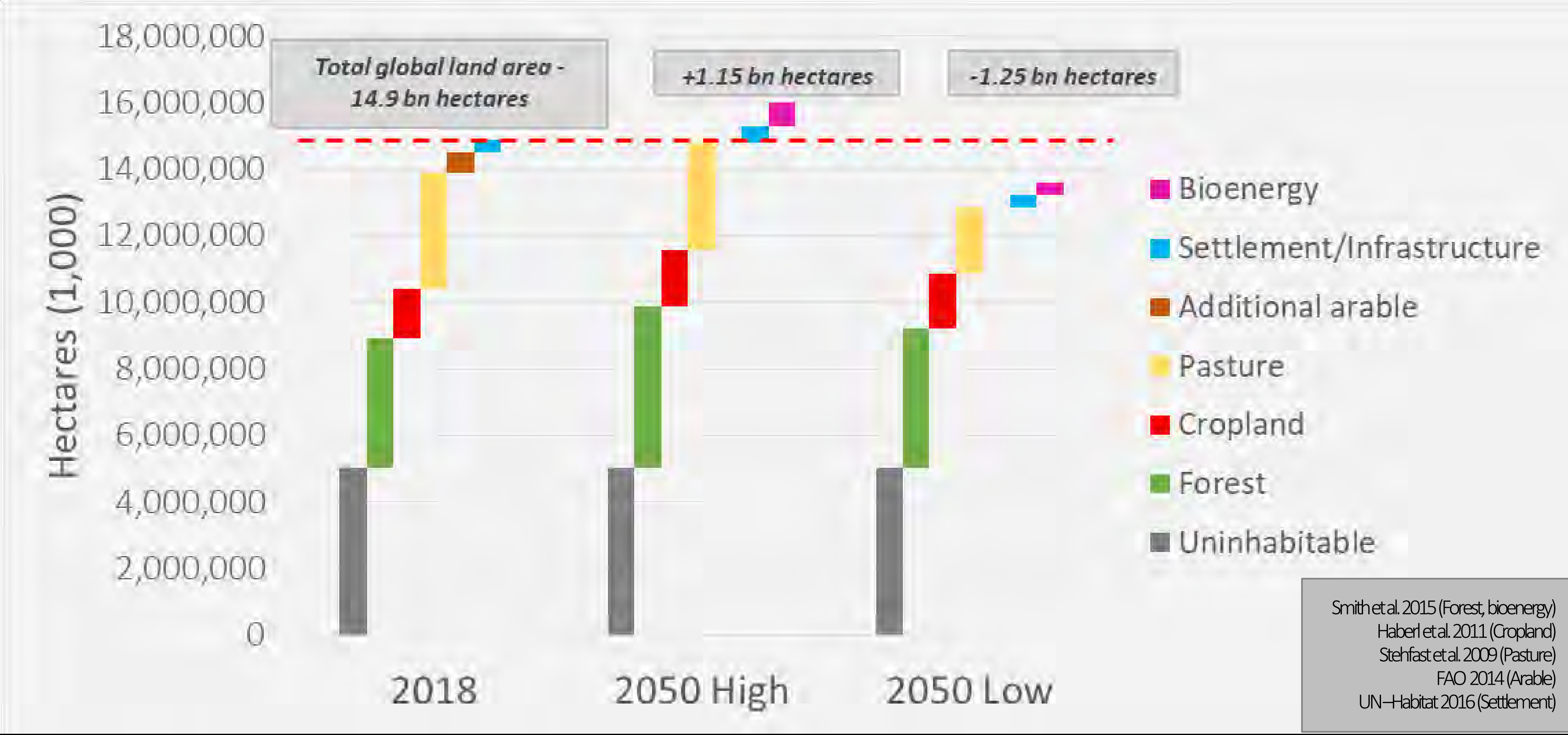
Nutrients

Land use

(Biodiversity)

Albedo

There may be other near-term constraints like seeds, capital, expertise…



Will we run out of land?

No.

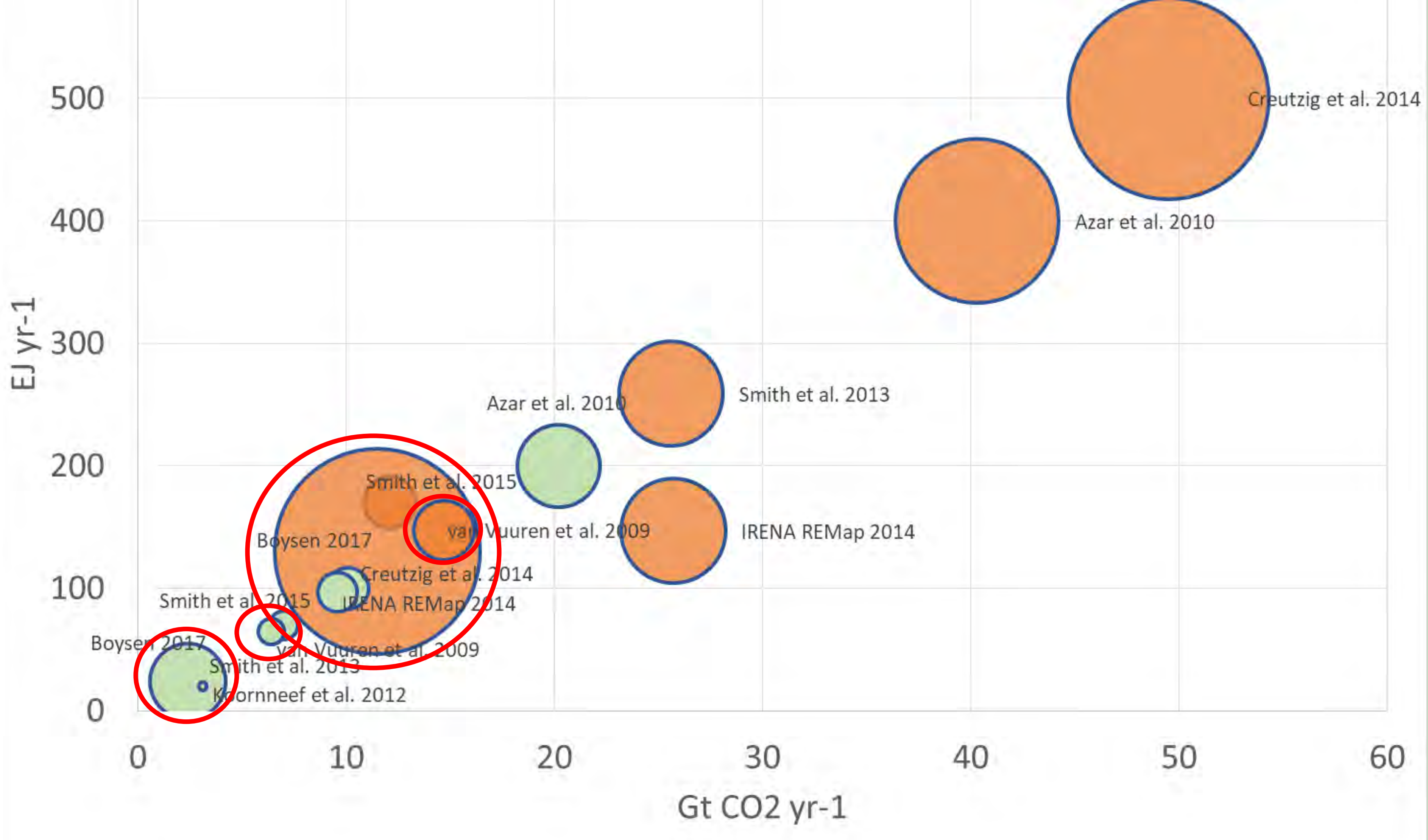
But land and other inputs could get much more expensive

The question

How much can BECCS contribute to the ~12 Gt CO2 annual need for CDR, considering all environmental and economic constraints?

Estimate "especially conservative" global biomass availability by 2050, 2100 for BECCS

		Land use constraints				Environmental constraints	
	Scenario(s)	Food production	Forest expansion	Conservation	Urban	Water	Nutrients
Boysen et al. 2017	LPJmL: 10-25% conversion of ag, natural lands; abandoned crop/pasture	3,000 kcal/cap/day, 7 billion population	Steffen et al. 2015 (no forest expansion)	N/A	N/A	Rain-fed vs. unlimited irrigation	Double planetary boundary
Smith et al. 2015	BECCS deliver all CDR required for 450	380-700Mha				2-2.5 m^3 per t Ceq (evaporative)	10-20 kg N per t Ceq
Van Vuuren et al. 2009	IMAGE: abandoned ag land and natural grasslands	FAO medium economic growth, 9.4 billion	N/A	Bio-reserves expanded 12-25%	N/A	WaterGap analysis	IMAGE prices N2O
Smith et al. 2013	Biomass and afforestation on “spare land”	FAO medium case	6.1 – 16.5 gT CO2/yr	N/A	N/A	N/A	N/A
IRENA REMap 2014	Assumes only current cropland/pasture available	FAO projections?	N/A	N/A	N/A	N/A	N/A
Azar et al. 2010	IMAGE/GET/MESSAGE: MAC for BECCS vs. no CCS tech	N/A	N/A	N/A	N/A	N/A	N/A
Popp et al. 2014	GCAM/IMAGE/REMIND: Scenarios for	N/A	GCAM has highest forest	N/A	N/A	IMAGE assumes	All models price N2O



How does this compare to 12 Gt median need?

High and low global BECCS potential estimates across 8 studies

Bubbles represent area of land use for biomass , ranges from 140 million to 2.7 billion hectares

Innovative biomass options

	Assumptions	Hectares (1000)	Low yield (6 mt/ha)	High yield (12 mt/ha)
			BECCS sequestration ($Gt\ CO_2/yr$)	
Cultivated pasture rotation	30% of cultivated pasture (1.6% of total global pasture)	55,226	0.6	1.2
Economically marginal cropland	10% of total cropland	16,2908	0.2	0.4
Temporary fallow	100% of temp fallow	82,999	0.9	1.8
Early planted forest rotation	7% of planted forest (first 7 years of 100 yr. rotation)	19,858	0.2	0.4
Invasive brush removal	All encroached grassland in U.S. southwest	8,090	0.1	0.2
Salt-affected soils restoration	All soils impacted by salt	12,000	0.1	0.3
Mined land restoration	Low-end extrapolation of all U.S. post-mined land	1,000	0.01	0.02
Total		195,463	2.2	4.3

Global land areas derived from FAO, 2017 except invasive brush removal from NRCS 2010 and mined land BLM 2014, EPA 2015

But most importantly…
we need to get started


USDA Pine-Switchgrass Pilot, 2017
Thank you!
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