The built environment, land use, and decarbonization
MIT 11.165/477, 11.286J

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Materials for today

- Ray Tomalty. Carbon in the Bank - Ontarios Greenbelt and its role in Mitigating Climate Change. Technical report, David Suzuki Foundation, Vancouver, BC, August 2012. URL.
- Ivan Penn. Putting Green in the Tea Party, She Crusades for Clean Power. The New York Times, February 2018. URL.
- Jonathan Chait. Will Local Politics Cook the Planet? New York Magazine, January 2022. URL.
- Francis Wilkinson. The solar farm that almost destroyed Copake, N.Y. Bloomberg.com, March 2022. URL.
- Andrew Revkin. When Climate Action Meets Energy Friction: Why Permitting Reform is Easier Sought than Done, August 2022. URL.

Three key questions about land use & decarbonization

1. Should cities continue to expand? (or not)
2. What is the role of land use planning in shaping the energy use and climate impact of the built environment?
3. Who and how should land uses be decided? What framing?

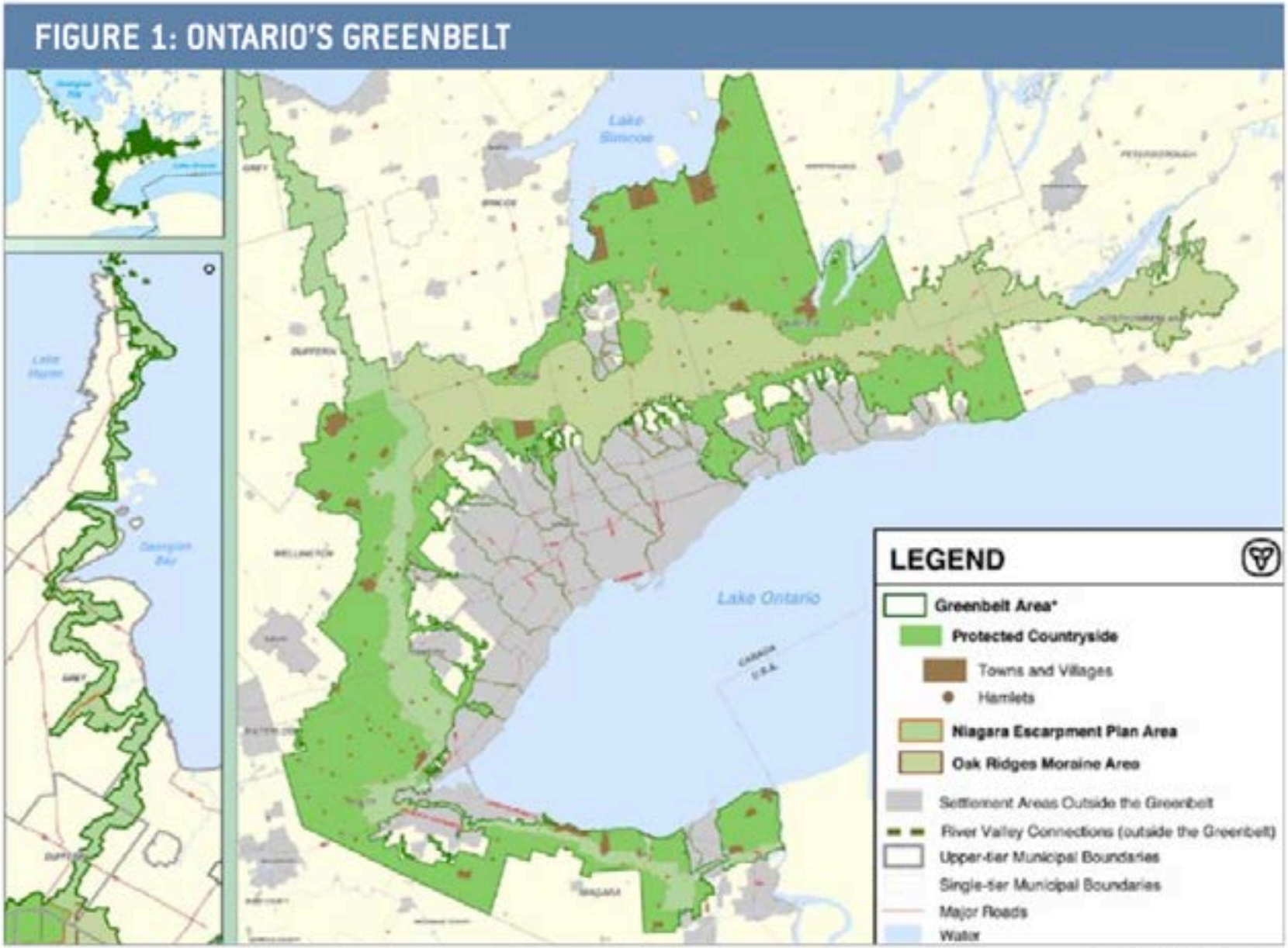

Figure 1 from Tomalty report

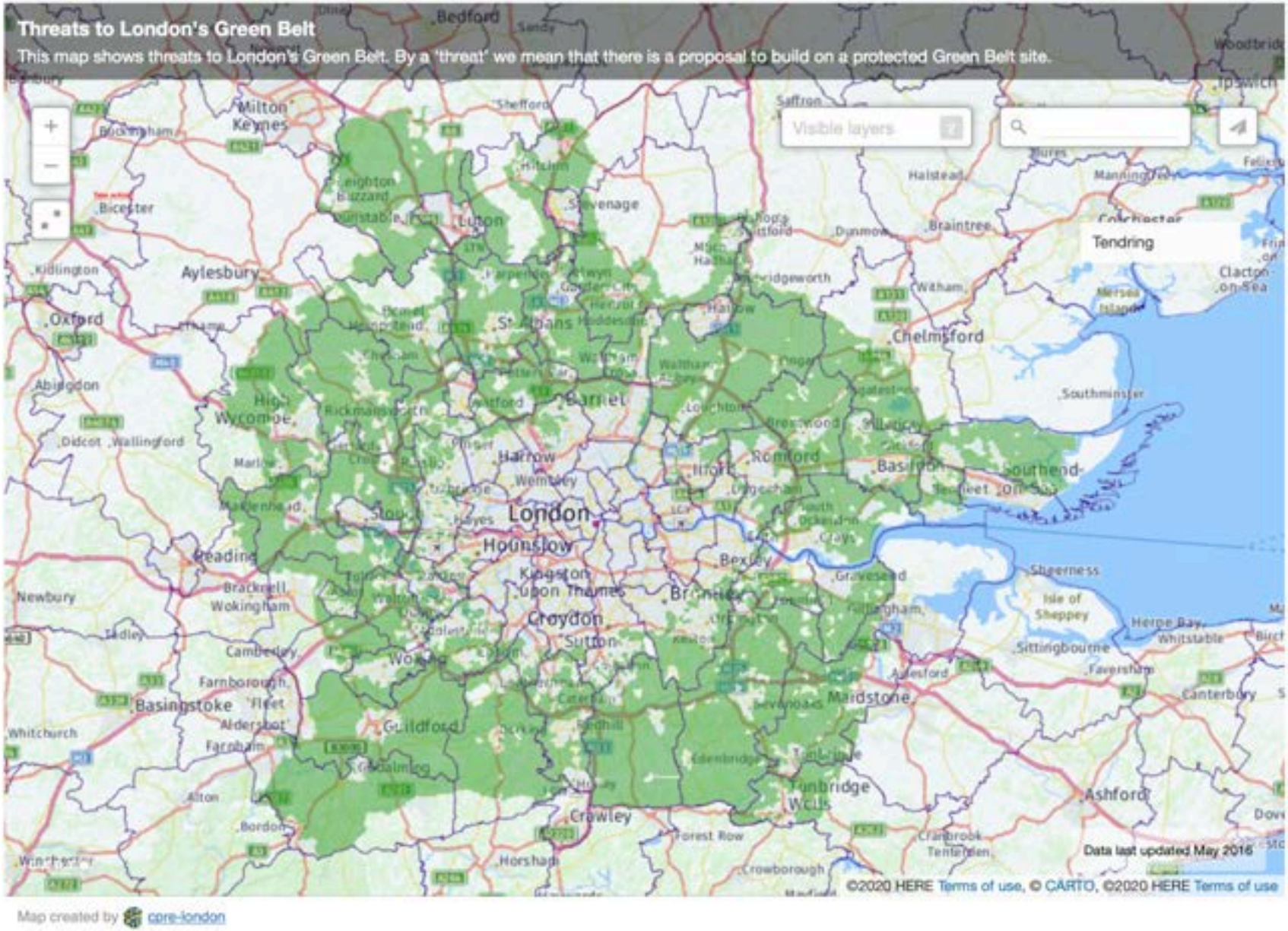

Figure from London Greenbelt Council

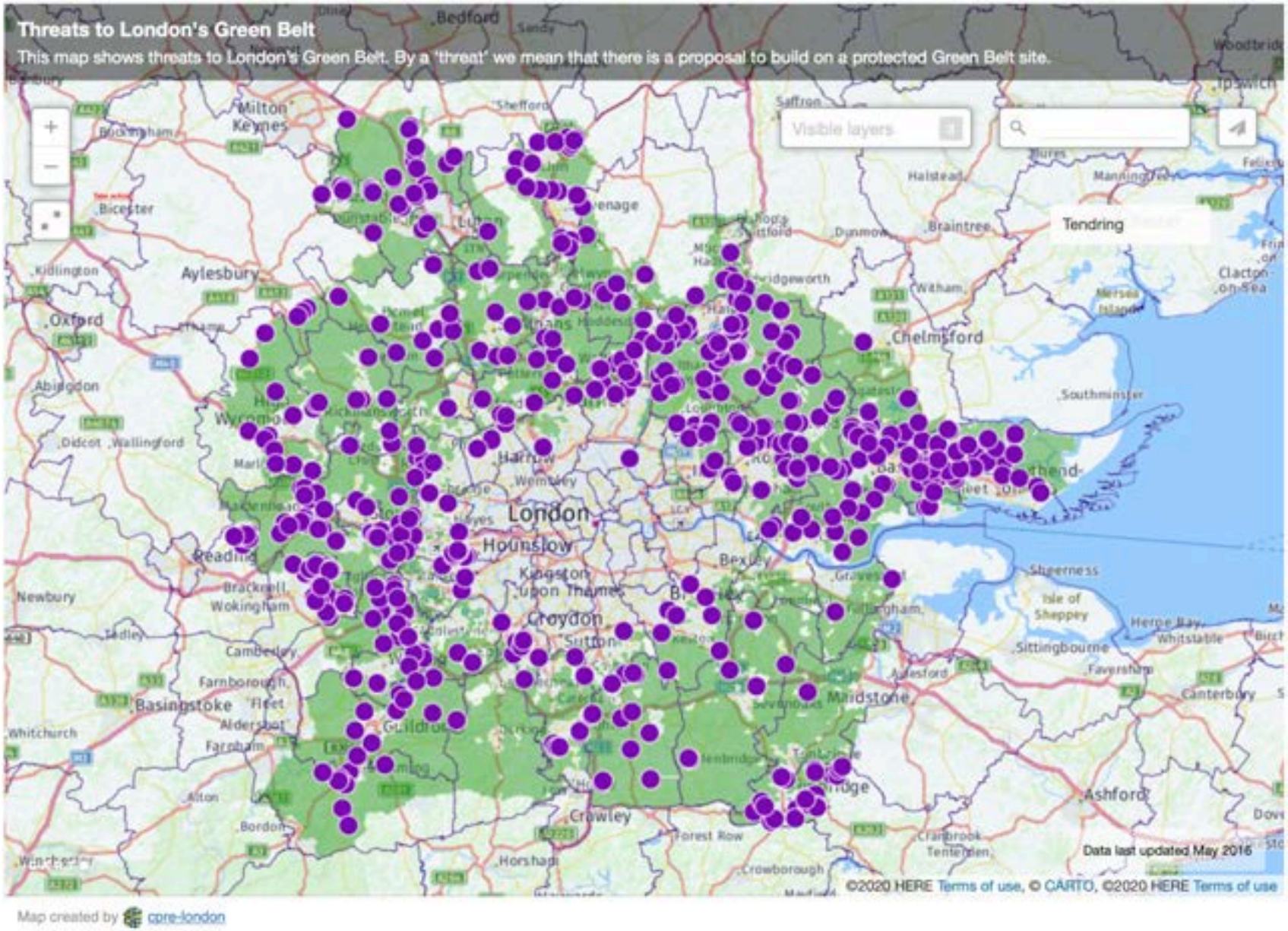

Figure from London Greenbelt Council

Tomalty report on Toronto Greenbelt and mitigation

- Greenbelt facts (page 8):
  - "Close to 750,000 hectares (1.8 million acres) of countryside, the largest greenbelt in the world."
  - "An integrated band of mostly green countryside . . . allows for more complete ecosystem habitats and continuous migration routes than do isolated parks."
  - '217,000 hectares (535,000 acres) of lakes, wetlands, river valleys and forests, providing habitat for over one third of Ontario's species at risk"
  - "Preserves space for locally accessible tourism, recreation, and outdoor activities."
  - "With over 7,000 farms, agriculture is the predominant land use in the Greenbelt, generating over $1.5 billion in total gross farm receipts annually."

- Carbon storage (page 17):
  - 147 million tonnes of carbon dioxide equivalent (CO2e)
  - "To put this quantity of carbon in perspective, this amounts to more than twice the total CO2e released each year in Ontario from transportation, the province's largest source of emissions."

Nature-based climate solutions

Natural climate solutions

Bronson W. Griscom[a,b,1], Justin Adams[a], Peter W. Ellis[a], Richard A. Houghton[c], Guy Lomax[a], Daniela A. Miteva[d], William H. Schlesinger[e,1], David Shoch[f], Juha V. Siikamäki[g], Pete Smith[h], Peter Woodbury[i], Chris Zganjar[a], Allen Blackman[g], João Campari[j], Richard T. Conant[k], Christopher Delgado[l], Patricia Elias[a], Trisha Gopalakrishna[a], Marisa R. Hamsik[a], Mario Herrero[m], Joseph Kiesecker[a], Emily Landis[a], Lars Laestadius[l,n], Sara M. Leavitt[a], Susan Minnemeyer[l], Stephen Polasky[o], Peter Potapov[p], Francis E. Putz[q], Jonathan Sanderman[c], Marcel Silvius[r], Eva Wollenberg[s], and Joseph Fargione[a]

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Contributed by William H. Schlesinger, September 5, 2017 (sent for review June 26, 2017; reviewed by Jason Funk and Will R. Turner)

Abstract from PNAS, Griscom et al, 2017

Nature-based climate solutions

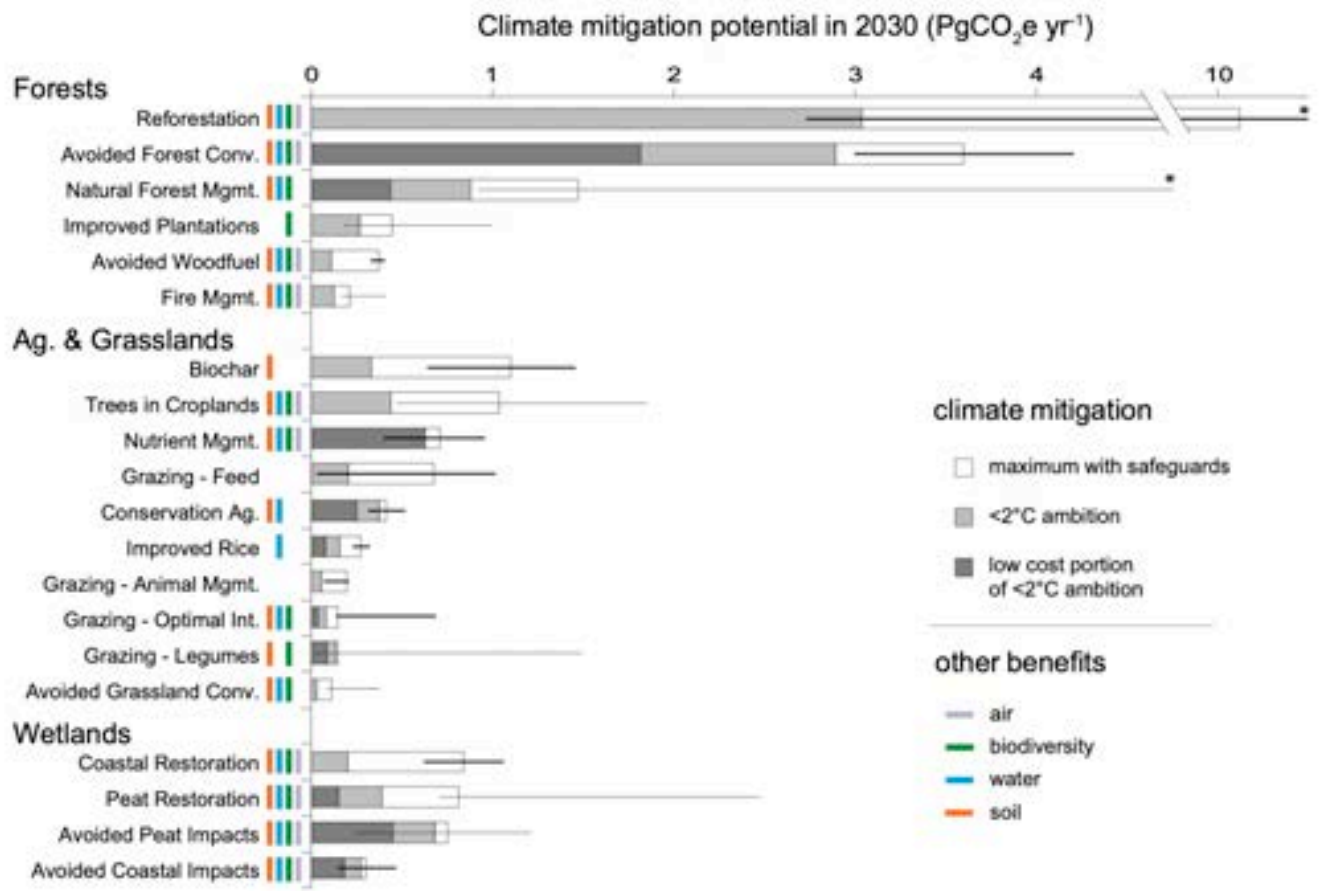

Fig. 1. Climate mitigation potential of 20 natural pathways. We estimate maximum climate mitigation potential with safeguards for reference year 2030. Light gray portions of bars represent cost-effective mitigation levels assuming a global ambition to hold warming to <2 °C (<100 USD $MgCO_2e^{-1}\ y^{-1}$). Dark gray portions of bars indicate low cost (<10 USD $MgCO_2e^{-1}\ y^{-1}$) portions of <2 °C levels. Wider error bars indicate empirical estimates of 95% confidence intervals, while narrower error bars indicate estimates derived from expert elicitation. Ecosystem service benefits linked with each pathway are indicated by colored bars for biodiversity, water (filtration and flood control), soil (enrichment), and air (filtration). Asterisks indicate truncated error bars. See *SI Appendix*, Tables S1, S2, S4, and S5 for detailed findings and sources.

Figure 1 from Griscom et al, 2017

(side note: Powers of Ten)

Famous 1977 film by Charles and Ray Eames.

Mackay appendix (p. 328):

SI stands for Système Internationale. SI units are the ones that all engineers should use, to avoid losing spacecraft.

SI units		
energy	one joule	1 J
power	one watt	1 W
force	one newton	1 N
length	one metre	1 m
time	one second	1 s
temperature	one kelvin	1 K

prefix	kilo	mega	giga	tera	peta	exa
symbol	k	M	G	T	P	E
factor	10^3	10^6	10^9	10^{12}	10^{15}	10^{18}

prefix	centi	milli	micro	nano	pico	femto
symbol	c	m	μ	n	p	f
factor	10^{-2}	10^{-3}	10^{-6}	10^{-9}	10^{-12}	10^{-15}

Table I.1. SI units and prefixes

MORE Nature-based climate solutions for the US

SCIENCE ADVANCES | RESEARCH ARTICLE

ENVIRONMENTAL STUDIES

Natural climate solutions for the United States

Joseph E. Fargione[1]*, Steven Bassett[2], Timothy Boucher[3], Scott D. Bridgham[4], Richard T. Conant[5], Susan C. Cook-Patton[3,6], Peter W. Ellis[3], Alessandra Falcucci[7], James W. Fourqurean[8], Trisha Gopalakrishna[3], Huan Gu[9], Benjamin Henderson[10], Matthew D. Hurteau[11], Kevin D. Kroeger[12], Timm Kroeger[3], Tyler J. Lark[13], Sara M. Leavitt[3], Guy Lomax[14], Robert I. McDonald[3], J. Patrick Megonigal[6], Daniela A. Miteva[15], Curtis J. Richardson[16], Jonathan Sanderman[17], David Shoch[18], Seth A. Spawn[13], Joseph W. Veldman[19], Christopher A. Williams[9], Peter B. Woodbury[20], Chris Zganjar[3], Marci Baranski[21], Patricia Elias[3], Richard A. Houghton[17], Emily Landis[3], Emily McGlynn[22], William H. Schlesinger[23], Juha V. Siikamaki[24], Ariana E. Sutton-Grier[25,26], Bronson W. Griscom[3]

Limiting climate warming to <2°C requires increased mitigation efforts, including land stewardship, whose potential in the United States is poorly understood. We quantified the potential of natural climate solutions (NCS)—21 conservation, restoration, and improved land management interventions on natural and agricultural lands—to increase carbon storage and avoid greenhouse gas emissions in the United States. We found a maximum potential of 1.2 (0.9 to 1.6) Pg CO_2e year^{-1}, the equivalent of 21% of current net annual emissions of the United States. At current carbon market prices (USD 10 per Mg CO_2e), 299 Tg CO_2e year^{-1} could be achieved. NCS would also provide air and water filtration, flood control, soil health, wildlife habitat, and climate resilience benefits.

Abstract from Fargione et al, Science Advances, 2018

Image courtesy of Fargione et al. License: CC BY.

MORE Nature-based climate solutions for the US

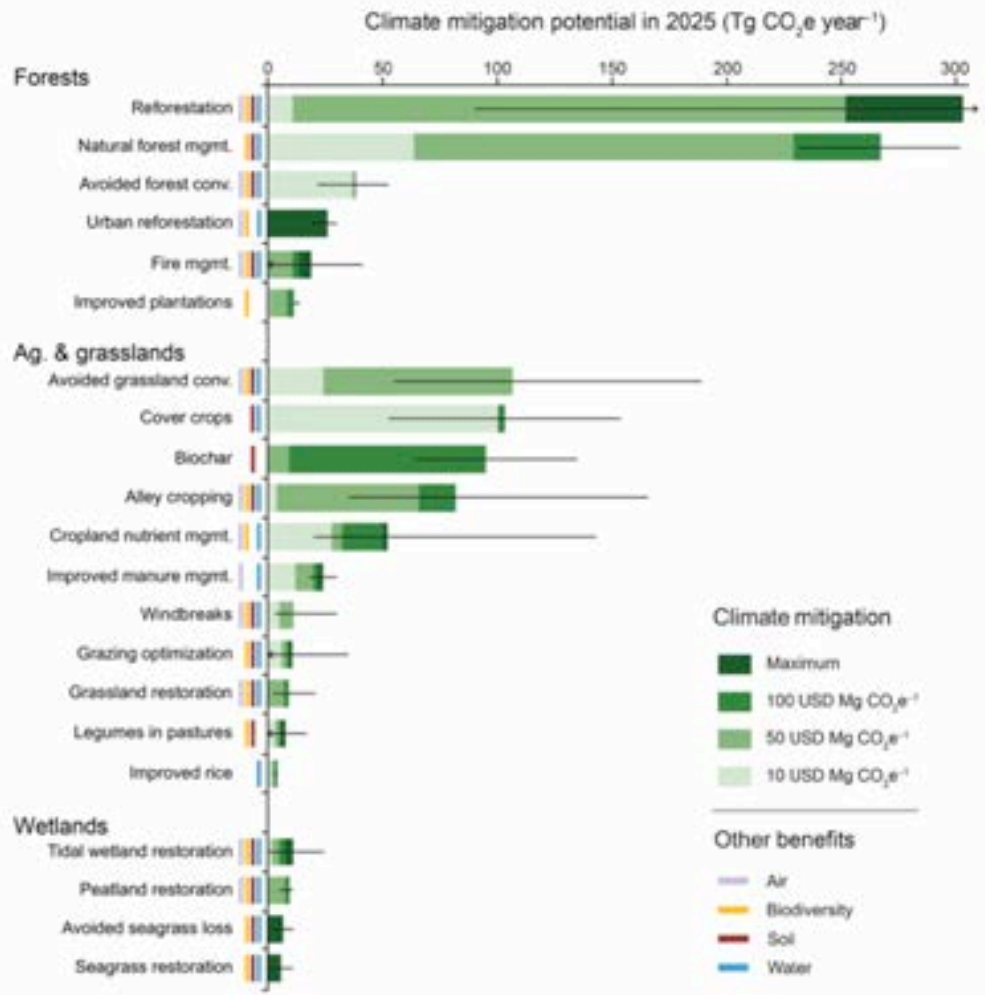

Fig. 1. Climate mitigation potential of 21 NCS in the United States. Black lines indicate the 95% CI or reported range (see table S1). Ecosystem service benefits linked with each NCS are indicated by colored bars for air (filtration), biodiversity (habitat protection or restoration), soil (enrichment), and water (filtration and flood control). See the Supplementary Materials for detailed findings and sources.

Fig. 1 from Fargione et al, Science Advances, 2018

Importance of land uses and land cover

Summary from ecological literature, conversations:

1. the total sequestration potential is currently uncertain
   - dynamics of sequestration are also uncertain
2. 'natural' or existing ecosystems are more efficient than restored ones
3. policy mechanisms may be wildly different for different ecosystems
   - farm preservation versus biodiversity protections
   - carbon storage may fit into different regimes

Q: What does this all imply for urban planning of cities? (So what?)

A: Controlling the spatial expansion of cities is crucial.

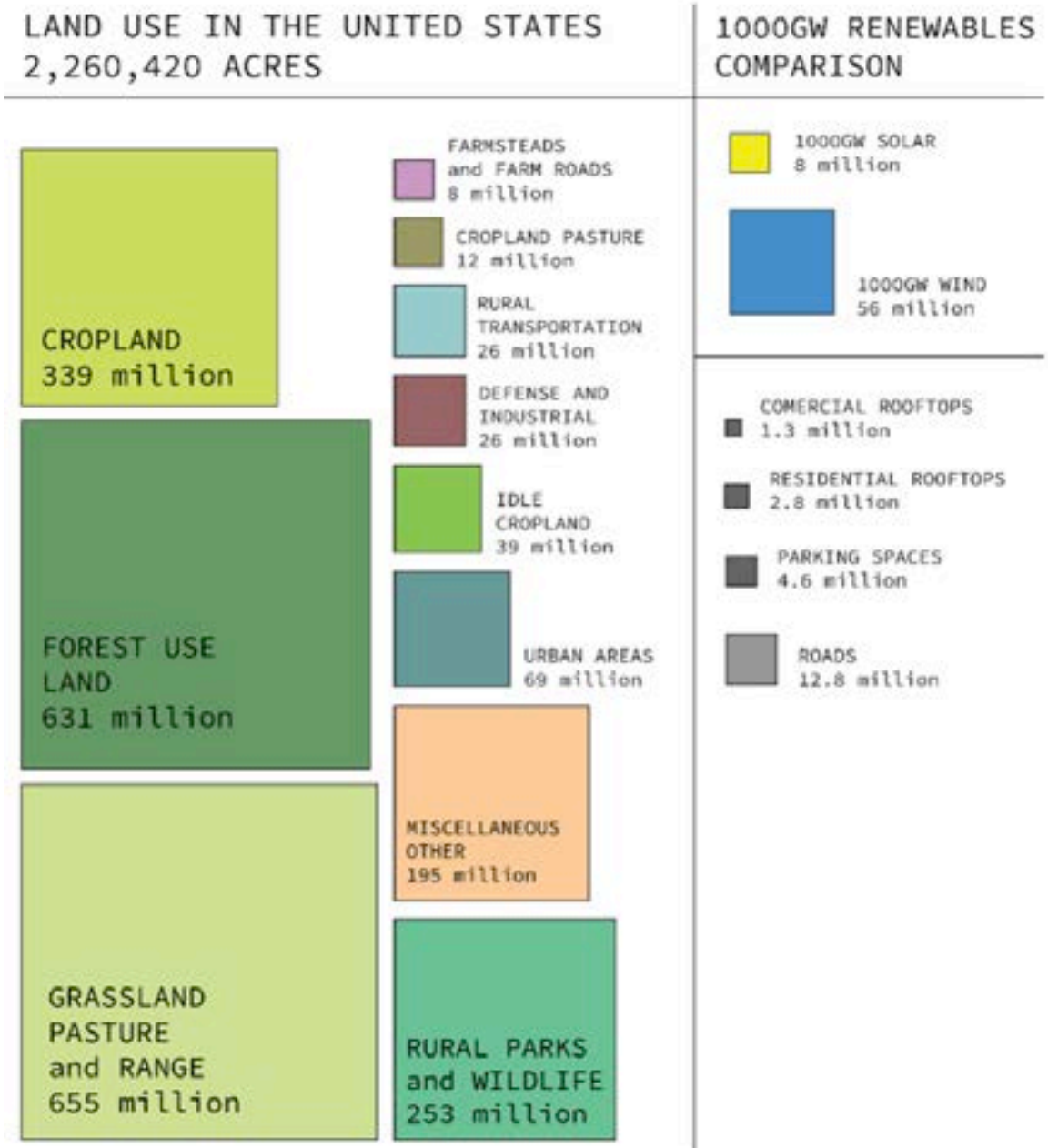

Figure from Rewiring America report

Many aspects of decarbonization depend on land use

- electricity
  - solar, wind, nuclear, hydropower
  - transmission lines
- buildings
  - heating, cooling systems + pipes and wires
  - locations!
  - uses, value, historic preservation, occupancy
- transportation
  - roads, bridges, charging stations
  - locations!
  - transit, freight, air, shipping
- industry
  - factories
  - energy sources
  - supply chains
  - jobs!

Jurisdictions over land use and energy

In the US, most decisions about land use are made at the local level!

Local:

- land & property taxes
- zoning
- building codes
- urban planning
- infrastructure financing

Federal:

- National Environmental Policy Act of 1970
- federal land protections
  - ownership
  - restricted uses (recreation, conservation, biodiversity, etc.)

State:

- "little NEPAs"
- (some) regional growth plans
- utility commissions
- state legislation, constitutions (pre-emption)

Local fragmentation

Mancur Olson, *The Logic of Collective Action*, 1965

- really about the difficulty of collective action
- 'free-rider' problem:
  - things that would broadly benefit many may be opposed by a concentrated minority
  - if the many are not sufficiently motivated, then the few win

Elinor Ostrom, *Governing the Commons*, 1990

- common pool resources can be preserved by collective action & goals
  - institutions
  - norms
  - enforcement mechanisms (formal and informal)
- "governance"

OUR CLIMATE | JAN. 25, 2022

Will Local Politics Cook the Planet?

By Jonathan Chait

Photo: George Rose/Getty Images

One of the more depressing lead sentences I have ever read in a news story was published on January 11. "A temporary moratorium on developing large-scale, ground-mounted solar projects, defined as ones that generate at least 250 kilowatts of power, is winning support from residents," begins the article. From there, the report only gets worse. The

Jonathan Chait article in New York magazine

The Solar Farm That Almost Destroyed Copake, N.Y.

Residents of a small upstate town were bitterly divided over a planned development — until they weren't.

The Sutter Greenworks Solar Site in Calverton, New York. *Photographer: Bruce Bennett/Getty Images North America*

By Francis Wilkinson
March 20, 2022 at 8:00 AM EDT

Bloomberg

Debbie Dooley article

On a different area – solar subsidies and connections to the grid – but questions about the relationship between individuals, government, and technology.

Many positive articles from national publications about her effectiveness as a conservative activist for solar power, with fundamentally different motivations.

"Permitting reform"

Key questions to ask:

1. are we talking about specific legislative language?
2. will this change the speed of current permitting?
   - is there sufficient administrative capacity?
   - will this result in more or less litigation?
3. will this change the amount of public participation?
4. is this leading to the desired outcomes?
   - is this necessary to build renewable resources? (affordable housing?)
   - is this necessary to build or block fossil fuel resources?
5. could this get the necessary votes in the House and Senate?

Class discussion

Be prepared to discuss your p-set answers at length:

1. what city are you interested in learning more about its energy system?
2. what aspects of the built environment and land use affect your city's energy system?
3. what did you read?
4. what areas do you feel that you don't have enough information about your city or these aspects yet?
5. what additional questions do you have about the built environment, land use, and decarbonization after the readings, p-set, and video lecture?

Thank you!