Accounting for Land in the United States: Integrating Physical Land Cover, Land Use, and Monetary Valuation

Scott A. Wentland[1*+], Zachary H. Ancona[2], Kenneth J. Bagstad[2], James Boyd[3], Julie L. Hass[1+], Marina Gindelsky[1+], Jeremy G. Moulton[4]. Forthcoming in *Ecosystem Services* 2020.

[1] *U.S. Bureau of Economic Analysis* , [2] *U.S. Geological Survey,*
[3] *Resources for the Future,* [4] *University of North Carolina – Chapel Hill*

Virtual Expert Forum on SEEA Experimental Ecosystem Accounting 2020 – Session 4, Group 4: Accounting for urban areas

November 9, 2020

*__Disclaimer__: The results and opinions are those of the author's and are not necessarily position of the Bureau of Economics Analysis or U.S. Department of Commerce.

Land Accounting & Urban Ecosystems

- **Land** plays a critical role in both economic and environmental accounting.
  - Occupies a unique position at the intersection of:
    - System of National Accounts (SNA)
    - System of Environmental-Economic Accounting Central Framework (SEEA-CF)
    - SEEA Experimental Ecosystem Accounting (SEEA-EEA)
- We developed a pilot set of national and subnational land accounts for the United States
  - Both physical (land cover/use) and monetary accounts
  - Focus for today's short presentation:
    1. Very brief overview of our motivation, methods, and results.
    2. Discussion of challenges for **urban ecosystems**, particularly as it relates to land valuation, and lessons from our research on this.

Land Valuation – Motivation

- Coomes et al. (2018 – *BioScience*) quoted in our introduction:
  - "Global land price data would advance our understanding of the dynamics of **urban sprawl, the functioning of land markets, land speculation and rural land grabbing**, frontier deforestation and the forest transition, and trajectories of land system change. Enhanced land price information would foster research aimed at understanding the dynamics of rising income and asset inequality around the world, the drivers of economic growth, and the impacts of global trade. Furthermore, such data would enable a deeper understanding of the role of landholding in individual wealth accumulation, as well as a social determinant of health, subjective well-being, and mobility. Land price data would also **enable advances in areas at the core of sustainability science, including the valuation of ecosystem services**, the assessment the tradeoffs and synergies in raising agricultural productivity, and the foundations of food security. In conservation science, land price information would helpfully inform research aimed at valuing and protecting critical wildlife habitat, **from urban marshlands to tropical rain forests, and preserving biological diversity**." p. 483 *(emphasis added)*

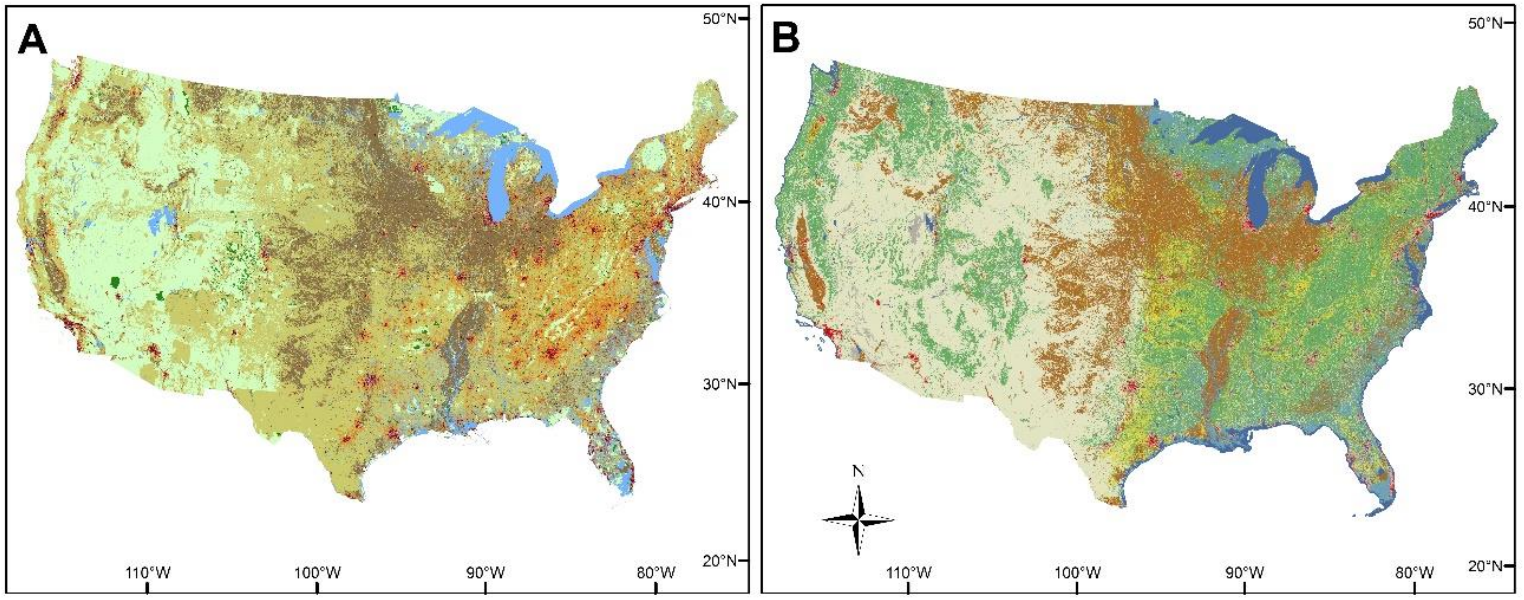
Objectives, Data, and Methods

- **Objectives** *(what we do)*
  - Pilot land use, land cover, land value accounts for the U.S.
- **Data** *(what we use)*
  - National Land Cover Database, National Land Use Database, Zillow "ZTRAX" microdata
    - Zillow is "big data": contains detailed information from hundreds of millions of property transactions and their corresponding physical characteristics (e.g., bedrooms, bathrooms, sqft., acreage, etc.)
- **Methods** *(how we do it)*
  - **Physical**: used ArcGIS tools to condense LULC data into classes most relevant for SEEA accounts and valuation
  - **Monetary**: used iterative hedonic regressions to estimate property-level land value estimates, then we aggregated upward, creating weighted state, regional, & national estimates
    - **Integration**: hedonic regressions separately estimated by land use type and includes property characteristics AND linked land cover composition of the census tract

Results – Highlights

- In total, we estimate private land in the contiguous 48 states to be worth approximately $25.1 trillion
  - An average of $19,838 per acre overall
  - $4,593 per acre for agricultural land in 2016
    - Substantial regional/local variation, as well as variation by land use
- We observe a 28% drop in nominal U.S. land values during the Great Recession with near full recovery by 2016
- Land cover change was less than 4% for 7 of the 11 condensed land-cover categories from 2001-2016
  - A 6.7% gain in developed low-intensity land, 8% loss in pasture/hay, and large (22-24%) increases in the developed medium- and high-intensity classes
- Land use dataset was only available for a single year – no change analysis

Results: LULC Databases



National Land Use Database - 2010

- Farms (NAICS 111)
- Livestock (NAICS 112)
- Forestry and Logging (NAICS 113)
- Fishing, Hunting and related activities for agriculture (NAICS 114-115)
- Mining (NAICS 21)
- Manufacturing (NAICS 31-33)
- Retail (NAICS 44-45)
- Transport warehousing (NAICS 48-49)
- Offices (NAICS 51-56)
- Educational services (NAICS 61)
- Health Care and Social Assistance (NAICS 62)
- Entertainment (NAICS 71)
- Other Services (NAICS 81)
- Government (NAICS 92)
- Households (Dense Urban/Urban)
- Households (Suburban)
- Households (Exurban/Rural)
- No NAICS equivalent

National Land Cover Database - 2016

	Open Water/Ice/Snow	Developed - Open Space	Developed - Low Intensity	Developed - Medium Intensity	Developed - High Intensity	Barren (Rock/Sand/Clay)	Forest (Deciduous/Evergreen/Mixed)	Shrub/Scrub/Grassland/Herbaceous	Pasture/Hay	Cultivated Crops	Wetlands (Woody/Emergent Herbaceous)
01 - 06 - % Change	-1.6%	1.7%	2.8%	10.4%	10.7%	-0.1%	-2.1%	1.4%	-3.7%	0.8%	0.4%
06 - 11 - % Change	4.5%	0.9%	2.0%	6.2%	7.7%	0.0%	-0.8%	0.1%	-2.6%	1.2%	-1.0%
11 - 16 - % Change	-3.7%	0.4%	1.8%	4.3%	4.3%	1.9%	-0.2%	-0.5%	-1.8%	1.8%	0.8%
01 - 16 - % Change	-1.0%	3.0%	6.7%	22.4%	24.3%	1.8%	-3.1%	1.0%	-7.9%	3.8%	0.1%

Results: Land Cover

Table 2. National Land Cover Change – 2001 through 2016 (reported by 1000 ha and % change)

	Water (1)	**Developed Open Space** (2)	**Developed Low Intensity** (3)	**Developed Medium Intensity** (4)	**Developed High Intensity** (5)	**Barren** (6)
Percent Change (2001-2016)	-1.02%	3.04%	6.71%	22.38%	24.32%	1.80%
Total Acreage Change (2001-2016)	-383	1,691	1,860	2,542	978	360
Opening Stock (2001)	37,579	55,702	27,726	11,358	4,023	20,015
Closing Stock (2001)/Opening Stock (2006)	36,965	56,659	28,515	12,544	4,453	19,985
Closing Stock (2006)/Opening Stock (2011)	38,637	57,184	29,075	13,324	4,794	19,993
Closing Stock (2011)/Opening Stock (2016)	37,196	57,393	29,586	13,900	5,002	20,375

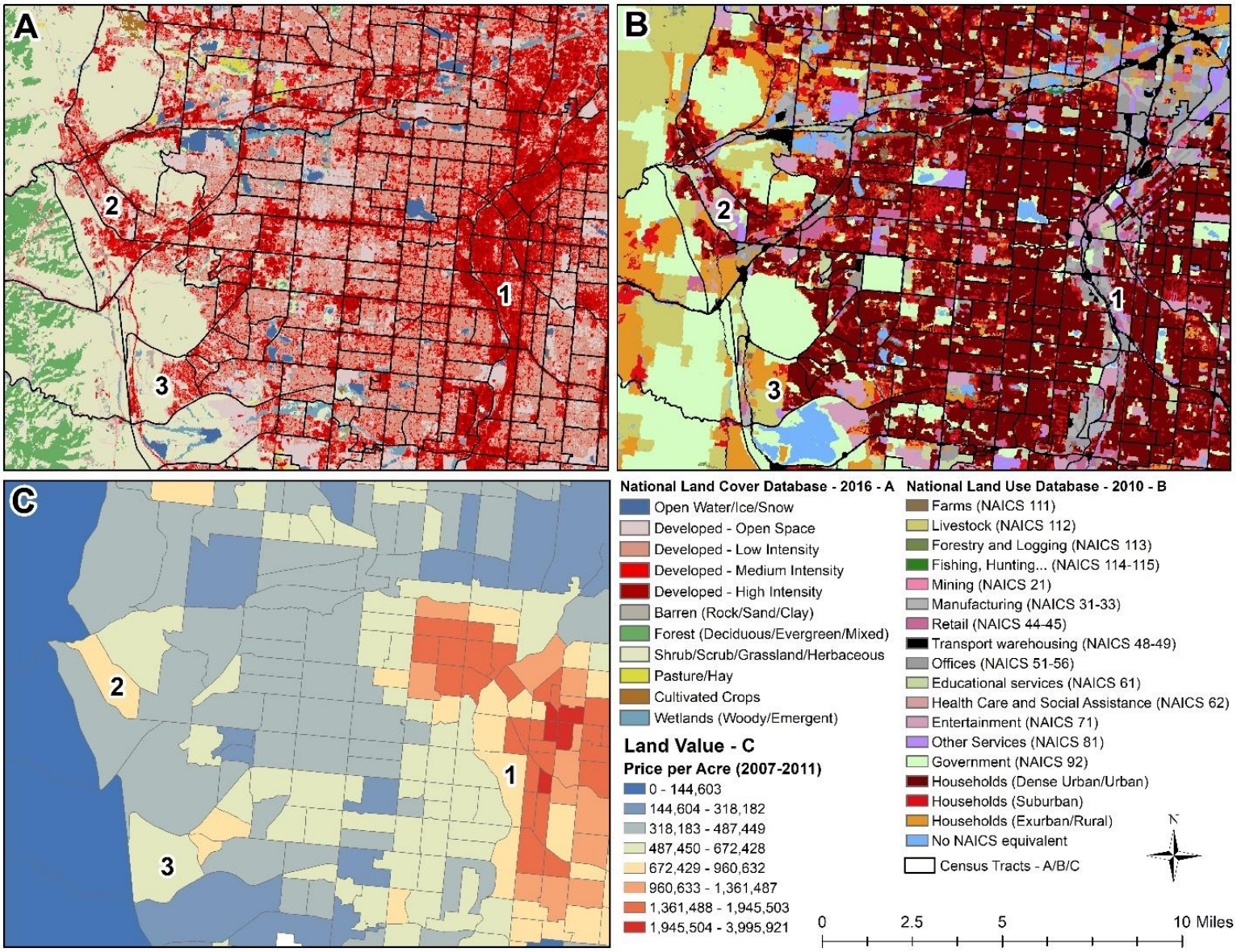
	Forest (7)	**Shrub/Scrub** (8)	**Pasture/Hay** (9)	**Cultivated Crops** (10)	**Wetlands** (11)
Percent Change (2001-2016)	-3.12%	1.05%	-7.94%	3.84%	0.08%
Total Acreage Change (2001-2016)	-15,700	7,383	-10,817	11,998	88
Opening Stock (2001)	503,420	703,895	136,240	312,478	116,177
Closing Stock (2001)/Opening Stock (2006)	492,800	713,797	131,189	315,095	116,609
Closing Stock (2006)/Opening Stock (2011)	488,751	714,830	127,776	318,853	115,395
Closing Stock (2011)/Opening Stock (2016)	487,720	711,278	125,422	324,476	116,265

Table 4: Acreage (National Land Use Database), Total Value, and Average (Nominal) Price Per Acre by Census Division

		NLUD 2010 Total Acreage (000s)	2002 – 2006 Total Value ($Billions)	2002 – 2006 Average Price Per Acre ($)	2007 - 2011 Total Value ($Billions)	2007 - 2011 Average Price Per Acre ($)	2012 – 2016 Total Value ($Billions)	2012 – 2016 Average Price Per Acre ($)
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
West Region	**Pacific**							
	Dense Urban Residential	237	1,098	4,637,323	642	2,713,550	1,032	4,359,191
	Urban Residential	2,415	2,284	945,988	1,360	563,433	2,182	903,476
	Suburban Residential	1,629	1,870	1,147,403	1,116	684,984	1,799	1,103,923
	Rural Residential	9,893	310	31,356	186	18,789	248	25,045
	Commercial	611	376	615,376	295	483,490	495	810,437
	Industrial	261	107	408,685	84	319,963	163	624,334
	Agricultural	78,480	485	6,183	404	5,145	578	7,370
	Mountain							
	Dense Urban Residential	81	214	2,635,320	110	1,353,508	176	2,161,364
	Urban Residential	1,383	786	568,303	675	487,965	792	572,334
	Suburban Residential	1,263	837	662,197	444	351,817	728	576,506
	Rural Residential	7,587	353	46,481	188	24,744	250	32,937
	Commercial	521	379	727,706	256	491,118	343	658,781
	Industrial	212	69	324,449	45	212,820	67	317,188
	Agricultural	218,751	1,605	7,336	934	4,270	1,386	6,335
Northeast Region	**Middle Atlantic**							
	Dense Urban Residential	232	999	4,312,964	889	3,837,826	1,046	4,518,215
	Urban Residential	1,462	1,342	917,921	1,324	906,084	1,408	963,542
	Suburban Residential	2,171	859	395,603	688	317,066	726	334,150
	Rural Residential	19,415	208	10,735	170	8,773	183	9,435
	Commercial	311	133	426,483	118	379,014	143	459,362
	Industrial	151	27	176,781	25	164,142	31	208,065
	Agricultural	21,632	52	2,417	58	2,695	62	2,884
	New England							
	Dense Urban Residential	61	277	4,510,260	261	4,251,129	308	5,016,572
	Urban Residential	669	522	780,697	336	502,186	454	678,871
	Suburban Residential	1,176	360	306,002	268	227,625	315	267,880
	Rural Residential	10,836	211	19,430	155	14,316	184	16,990
	Commercial	196	64	328,157	48	242,726	62	315,970
	Industrial	90	18	201,702	12	138,261	18	199,450
	Agricultural	15,761	155	9,848	114	7,202	157	9,960
	U.S. National Totals	***1,264,975***	***26,592***	***21,022***	***19,333***	***15,283***	***25,095***	***19,838***

**Abbreviated version of Table 4 (for space)*

An Application Integrating All Three: The Case of Denver, Colorado



Urban Land – Challenges & Lessons

- **Data issues** in dense urban areas
  - How do municipalities assign portions of land plots to condos/apartments (or other dense urban property) where many units share a building or grounds?
    - **Arbitrary**? 100 condos on a 1 acre portion of land = 0.01 acre per unit? Should larger units have a higher share of land?
    - Or, might a municipality say all condos are 0.01 (regardless of the fraction of underlying land)?
    - Dense urban land value estimates → a healthy "grain of salt"
- **Other challenges** in urban areas
  - Methodological challenge: **externalities**
    - Not all value is captured in transaction prices
      - Some ecosystem services are presumably captured in transaction prices, but only to the extent that buyers value them individually (e.g., properties near water, parks, or other natural amenities tend to have higher value)

Thank You!

Additional questions/comments?

Scott Wentland

Scott.Wentland@bea.gov