The Value of Time-Varying Measures of Natural Capital in Coastal Housing Markets

Oregon State University

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Workshop on Energy & Environmental Research

NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

COPE

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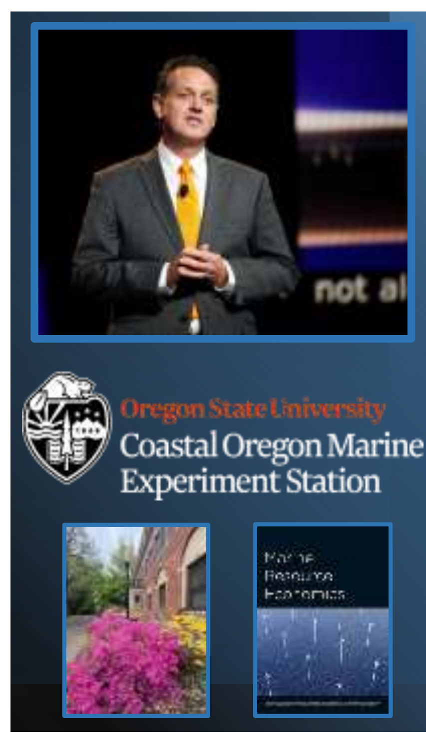
Appointments

- Associate Professor, Oregon State University
  - Department of Applied Economics
  - Coastal Oregon Marine Experiment Station
- Associate Editor, *Marine Resource Economics*

Research Interests

- Non-market valuation
- Environmental policy evaluation
- Economic impacts of climate change & coastal adaptation
- Recreation demand modeling
- Optimal provision of ecosystem services
- Interdisciplinary work on coastal ecosystem services and climate change adaptation



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Funding

NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE
NSF
COPE COASTLINES AND PEOPLE
US Forest Service
NSF
Sea Grant Oregon
Oregon Department of Transportation

Advisory Roles

PUGET SOUND PARTNERSHIP
CALIFORNIA OCEAN SCIENCE TRUST
TILLAMOOK ESTUARIES PARTNERSHIP
OREGON Department of Land Conservation & Development
SHORE FRIENDLY
CIMERS

Coastal Housing & Climate Change

40% of US population lives in coastal areas

Sea-level rise and changes to storm frequency and intensity accelerate erosion concerns

$1 trillion dollars tied up in coastal real estate

Coastal Housing at Risk

Another house collapses into the sea as this N.C. town erodes

The Washington Post : March 13, 2023

After major San Clemente landslide, officials warn next storm could force more evacuations

Los Angeles Times: March 16, 2023

The homeowners struggling to save their homes from plunging off a cliff

The Daily Mail: March 4, 2023

Climate Change & Housing

30% Of Americans Cite Climate Change As A Motivator To Move In 2023

Forbes: May 17, 2023

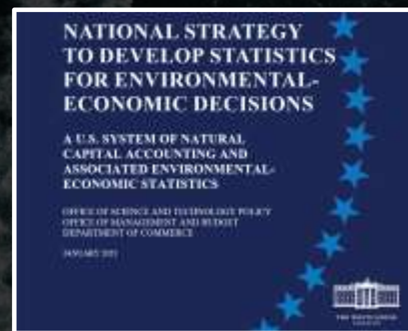
Where U.S. house prices may be most overvalued as climate change worsens

The Washington Post: Feb. 16, 2023

$35 Billion Worth of Real Estate Could Be Underwater by 2050

Scientific American: Sept. 9, 2022

Given projected climate change impacts, how can we approach coastal land-use planning to maximize ecosystem service flows from beaches & dunes?



Research Questions

- How do coastal housing markets capitalize coastal landscape features on a dynamic shoreline?
- Does the type and frequency of measurement of beach width affect valuation efforts?
- What are the spatial extent and temporal stability of these capitalization effects?

Prior Work Valuing Beach Width (10 studies)

Study	State	N	Sample	Beach Width	Measured	Proximity	Marginal Value	$USD Year
Pompe & Rinehart (1995)	SC	385	1983 - 1991	32 Survey markers	Spring 1989	Distance × BW	$1,831/m (OF) $833/m (> ½ mile)	1983
Pompe & Rinehart (1999)	SC	238	1989 - 1994	11 Survey markers	Annual (5 yr avg.)	Distance × BW	$2,087/m (OF) $797/m (non-OF)	1989
Landry et al. (2003)	GA	318	1990 - 1997	Electronic range finder at 32 transects w/ interpolation	Spring 1997	No	$233/m	1996
Landry & Hindsley (2011)	GA	372	1990 - 1999	Electronic range finder at 32 transects w/ interpolation	Spring 1997 (adjusted w/ erosion rates, beach additions & anecdotes)	BW*Bins (100 200, 300 m)	$421 - 487/m (close); $71 - $196/m (all)	1999
Gopalakrishnan et al. (2011)	NC	1,555	2005-2007	GPS & tape measures	n/d	Distance × BW	OF $4,724/m (OLS) (IV: $28,871/m)	n/d

Prior Work Valuing Beach Width (10 studies)

Study	State	N	Sample	Beach Width	Measured	Proximity	Marginal Value	$USD Year
Dundas (2017)	NJ	4,912	2001 - 2012	Difference from public access points to USGS shoreline	2002, 2007, 2012	No	$925/m (all) - $2,162/m (post-nourishment policy)	2012
Catma (2020)	SC	332	2011 - 2016	Local Monitoring Report	2007, 2016	Distance × BW	$9,882/m for close; $5,387/m for 300ft	2016
Landry et al. (2022)	NC	1,986	1997-1998	Digitizing rectified aerial photographs	Spring 1997, 1998	Multiple	$7,789/m (OF); $3,363/m (< 500ft); $433/m (<2500ft)	1999
Addicott (2022)	NC	3,155	2008 - 2017	USGS Coastal LiDAR	n/d, one-time measure	No	$1,283/m (OLS) $18,675/m (IV)	2016
Addicott (2024)*	CT; FL	197,940; 3,249	2004 - 2022	USGS Coastal LiDAR	n/d, one-time measure	No	$876/m (CT) $29,446/m (FL)	2017

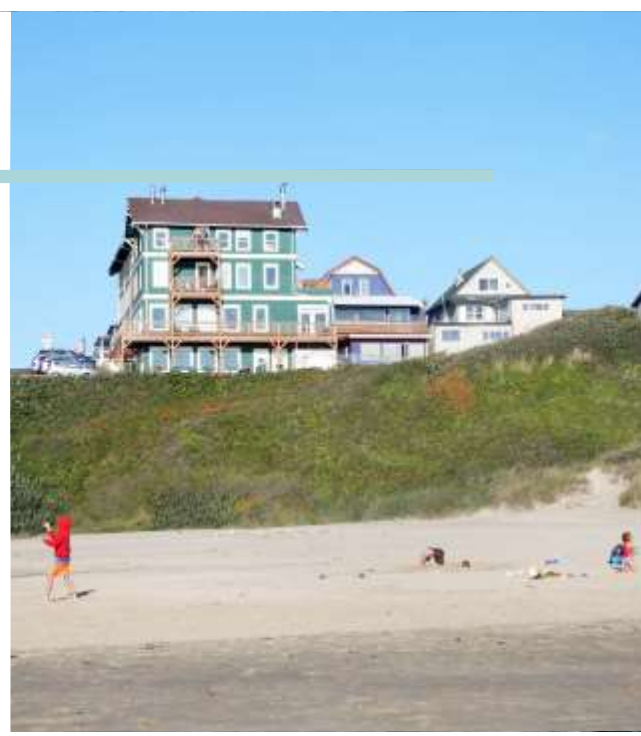
Prior Results

- Beach width estimates btw $200/m to $30,000/m
  - 10 Studies, mostly in Southeast (2 exceptions NJ & CT)
- Dunes even less prior work
  - Landry & Hindsley (2011): GA dune width btw $212/m & $383/m
  - Dundas (2017): federal policy in NJ to construct dunes produced annual average benefit of $3,229/home
  - Addicott (2022) values dune height in NC ranging from -$47,635/m to $23,632/m.

Study Area

Sales Data

- ~13,100 sales on sandy beaches within 2.5km of shoreline sold between Jan. 2005 & Feb. 2020
- CoreLogic data for single-family homes determined to be arms-length transactions



Linked Data

- Oceanfront, dune-backed, armoring eligibility indicators
- Bedrooms, bathrooms, square footage, lot size, age of home, garage indicator
- Parcel elevation & distance to UGB
- Distances from building footprint to shoreline, beach access, shoreline armoring structures
- Density of neighboring structures
- Flood & Tsunami risk zones
- Long-term erosion rates

Housing Summary Statistics

	Mean	S.D.	Min	Max
Sale price ($2018)	399,474.74	221,019.33	65,597.07	1,907,631.62
Footprint to USGS shoreline (m)	730.28	583.91	21.90	2,497.14
Bldg sq. ft.	2,049.46	865.85	147.00	8,673.00
Lot sq. ft.	10,976.76	15,360.30	648.00	217,800.00
Ocean front	0.07	0.25	0.00	1.00
G18 eligibility	0.05	0.21	0.00	1.00
Bedrooms	2.85	0.84	1.00	10.00
Baths	1.99	0.74	1.00	21.00
Age sold	28.60	22.85	0.00	206.00
Mean footprint elevation	95.51	62.85	13.53	540.83
Garage	0.55	0.50	0.00	1.00
Dist. to beach access (m)	447.86	366.93	0.00	2,275.13
Intersects Tsunami XXL	0.58	0.49	0.00	1.00
Dist. to armoring (m)	1,682.12	3,372.25	0.00	22,182.07
Dune-backed	0.45	0.50	0.00	1.00
Neighbors in radius (100m)	33.43	16.38	1.00	90.00
Obs.	13,140			

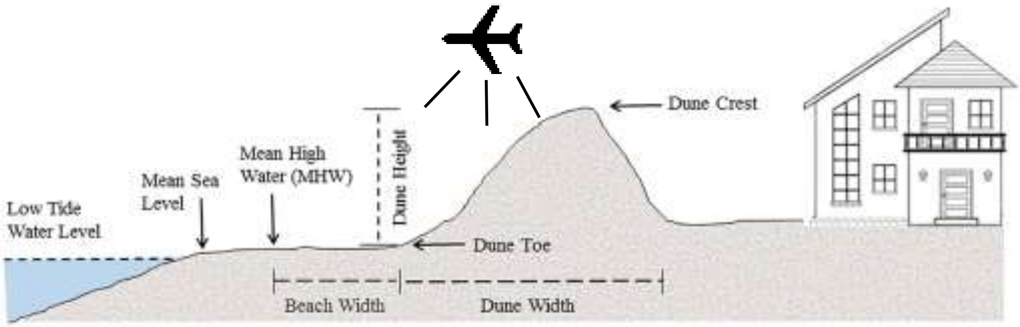
Beach Width

- One time exact measure: LiDAR flight of Oregon Coast in May 2016
- Many measurements: Probabilistic Climate Emulator (TESLA) produces hourly estimates across entire sample frame 2005 – 2020
- Spatial resolution along shoreline for both ~ 50m

Gopalakrishnan et al. 2011 (p. 298) “Researchers may measure the beach width without error at a point in time, but it is the expected path of beach width over the life of the property that influences the sale price. The hedonic price function more appropriately would associate the value of coastal property with a measure of the average beach width at the location where the property is situated, but this average is unavailable with fine spatial detail.”

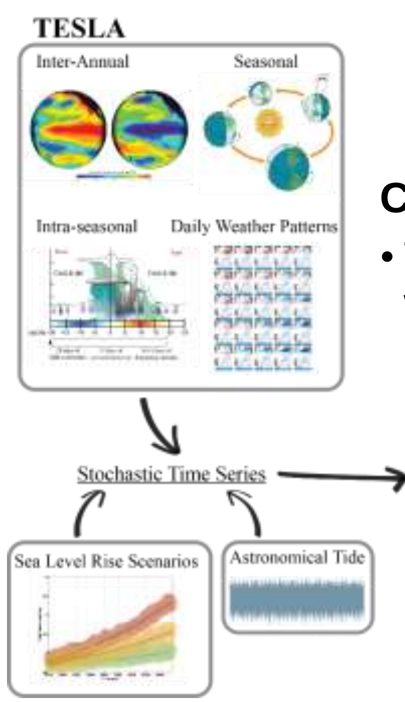
Landry et al. (2003, p. 108) “To the extent that beach conditions in previous years ('90 to '96) were significantly different from the spring of '97, the hedonic price of beach width could be biased.”

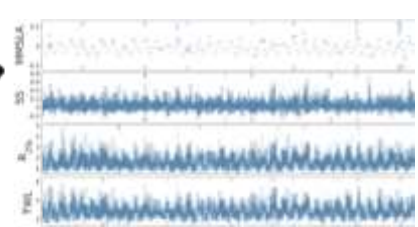
Landry and Hindsley (2011, p. 94) “… note the potential for mismeasurement of the beach width effect given the limited information on beach quality and relatively longer period of sales data.”



Probabilistic Climate Emulator

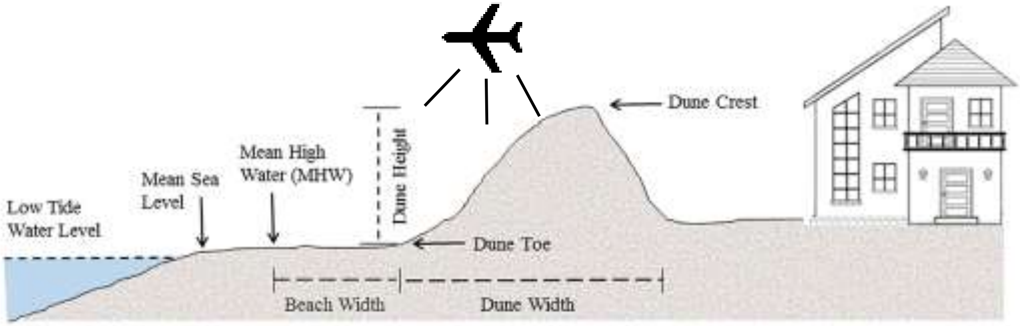
- Time-varying Emulator for Short and Long-Term Analysis (TESLA; Anderson et al. 2019)
- Generates historical time series for entire Oregon coastline and able to generate future hourly max total water level (TWL) time series

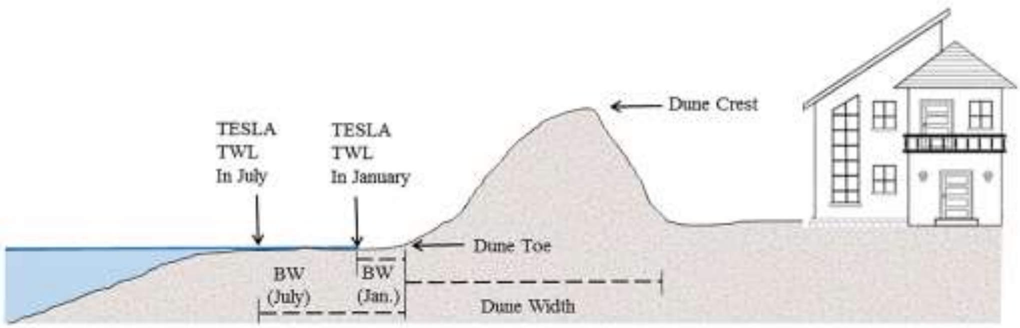




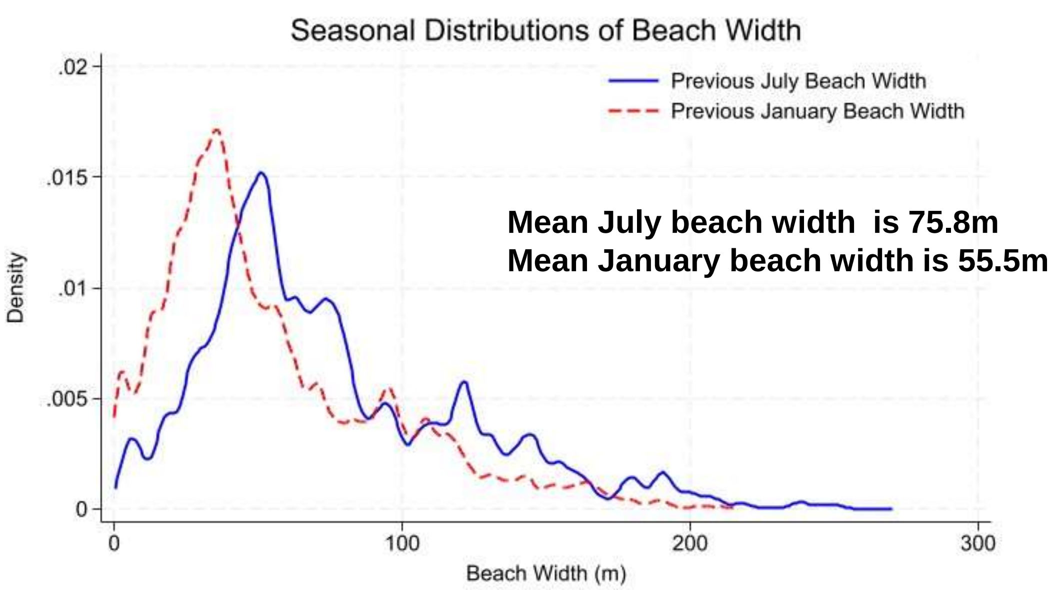
Calculate Metrics

- Time-varying beach width





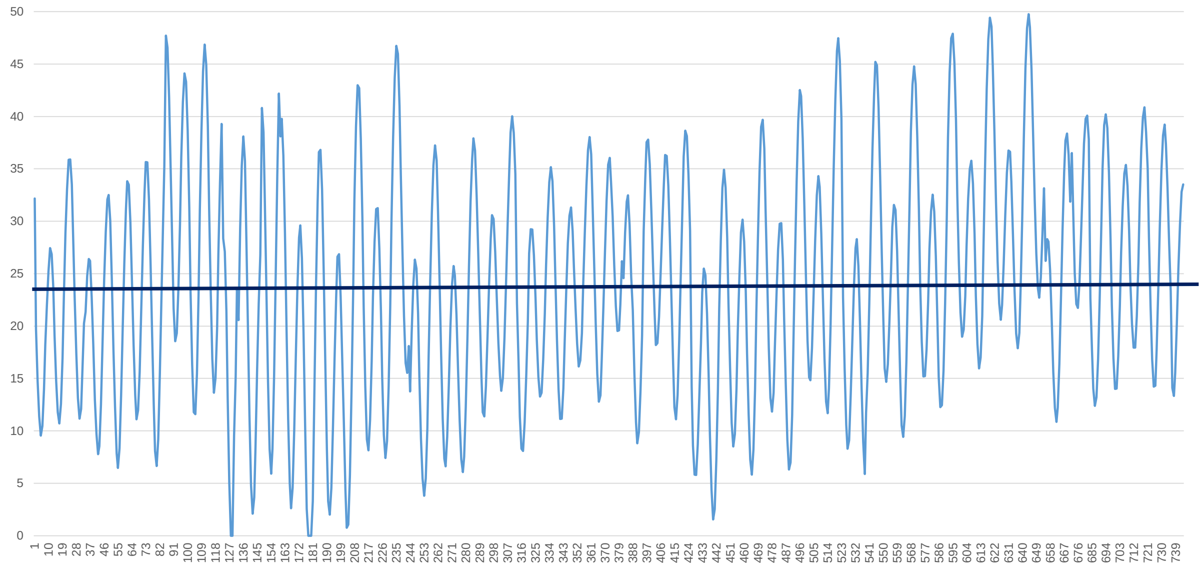
TESLA Beach Width: Seasonal



Mean July beach width is 75.8m
Mean January beach width is 55.5m

TESLA Beach Width: May 2016

744 hourly measurements
Range: 0m to ~50m within 1 month

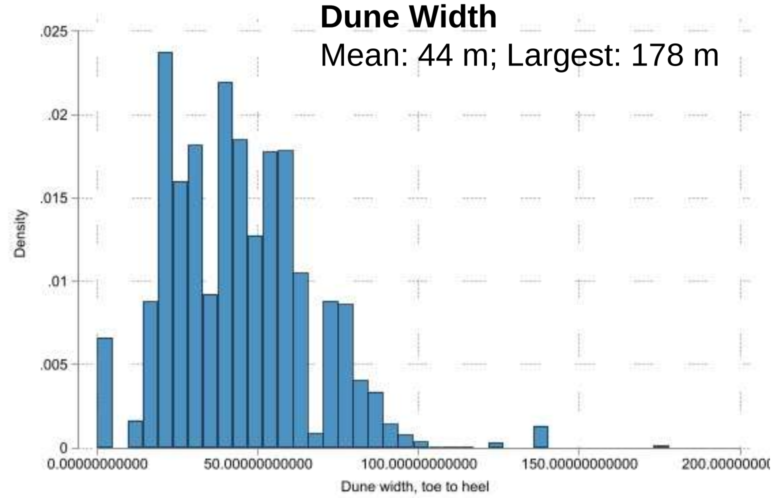


Beach Width

- Primary specification: Match each transaction to monthly average TESLA BW, 2 month prior to closing date
  - Oregon average from bid acceptance to closing date ~6 weeks
- Alternative specifications: Compare with capitalization effects found when using single LiDAR measurement or single TESLA monthly average. Estimate single-year models to test temporally stability of estimates

Dune Metrics

Dune Width
Mean: 44 m; Largest: 178 m



Dune Height
Mean: 4.3 m; Largest: 12.9 m

Beach & Dune Summary Statistics

	Mean	S.D.	Min	Max
Beach width (TESLA 2mo prior, m)	66.95	44.10	0.00	254.25
Beach width (TESLA 12mo prior, m)	67.42	43.98	0.02	258.67
Beach width (TESLA avg. 6mo prior, m)	66.07	43.28	0.02	242.42
Beach width (TESLA prev. July, m)	75.84	46.03	0.21	270.27
Beach width (TESLA prev. Jan, m)	55.51	39.68	0.00	217.06
Beach width (TESLA May 2016, m)	73.16	45.28	0.39	264.40
Beach width (Lidar May 2016, m)	107.38	49.18	9.16	323.87
Dune width, toe to heel	43.75	23.17	0.00	177.75
Dune height (m)	4.28	2.77	0.00	12.89
Dune volume (small)	137.76	150.95	0.00	793.14
Shoreline change rate 2002-2016	-0.61	2.00	-6.37	6.17
Min bldg elev. to dune crest (m)	70.13	62.25	-8.95	524.74
Obs.	13,140			

Empirical Estimation

$$lnP_{it} = \beta_0 + \beta_1 BW_{it} + \beta_2 BW_{it} \times Prox_i + \beta_3 D_i^h + \beta_4 \left(D_i^h\right)^2 + \beta_5 D_i^w + \beta_6 (D_i^w)^2 + \mathbf{X}_{it}\sigma + \rho_{it} + \tau_t + \epsilon_{it}$$

- BW modeled as function of proximity to shoreline
- Dune features modeled with squared term
- County-by-year & storm quarter FEs
- SEs clustered by city

Average Sales Price (2018USD): **$399,475**

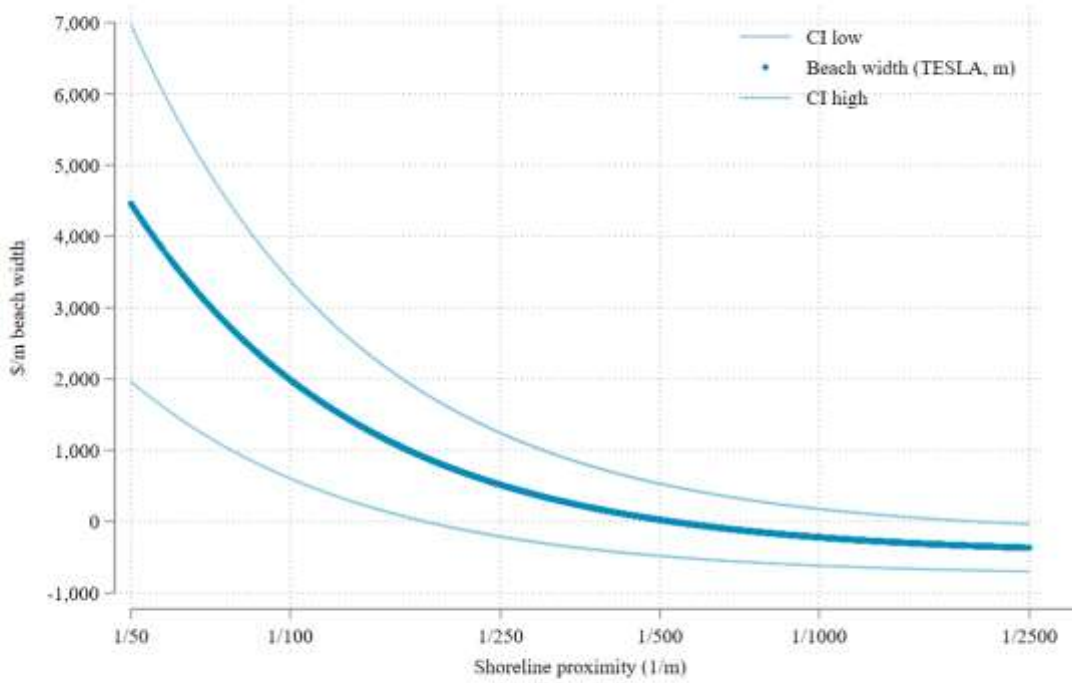
Capitalization Effect:
$1,198/m BW

Capitalization Effects:
$293/m BW ***
$14,179/m DH
-$1,197/m DW

BW capitalization:
$4,531/m within 50 m
~$2,000/m @ 100 m
~$500/m @ 250 m
$0 @ > 600 m

Primary Results

	(1)	(2)	(3)
Beach width (m)	0.003** (0.001)	0.003** (0.001)	-0.001*** (0.000)
Beach width (m) × Beach width (m)	-0.000*** (0.000)	-0.000*** (0.000)	
Dune height (m)		0.054** (0.025)	0.052** (0.022)
Dune height sq.		-0.004** (0.002)	-0.004** (0.002)
Dune width (m)		-0.003** (0.001)	-0.003** (0.001)
Dune width sq.		0.000 (0.000)	0.000* (0.000)
Shoreline proximity (1/m) × Beach width (m)			0.614*** (0.135)



Dune Estimates

Dune Height

- At very small dune heights, an extra meter is valued @ $21,322.
- At the mean, dune height is valued @ 14,179$/m
- With tall dunes, dune height is valued @ 176$/m.

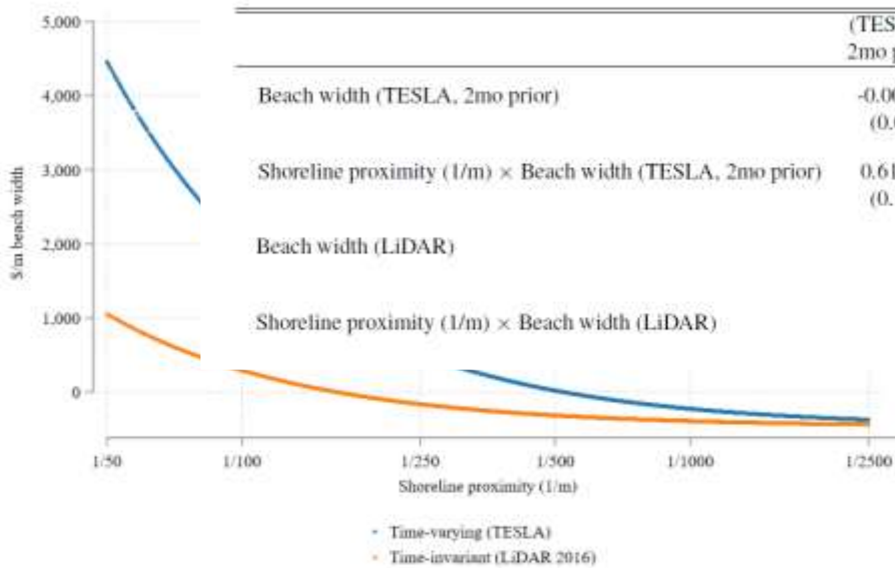
Dune Width

- Disamenity -$1,197/m
- Doesn't vary with proximity or non-linearly

Alternative BW Measurements

	(TESLA) 2mo prior	(TESLA) 12mo prior	(TESLA) Avg. 6mo prior
Beach width (TESLA, 2mo prior)	-0.001*** (0.000)		
Shoreline proximity (1/m) × Beach width (TESLA, 2mo prior)	0.614*** (0.135)		
Beach width (TESLA, 12mo prior)		-0.001*** (0.000)	
Shoreline proximity (1/m) × Beach width (TESLA, 12mo prior)		0.630*** (0.130)	
Beach width (TESLA, 6mo avg)			-0.001*** (0.000)
Shoreline proximity (1/m) × Beach width (TESLA, 6mo avg)			0.640*** (0.137)

Alternative BW Measurement



	(TESLA) 2mo prior	(LiDAR) May 2016
Beach width (TESLA, 2mo prior)	-0.001*** (0.000)	
Shoreline proximity (1/m) × Beach width (TESLA, 2mo prior)	0.614*** (0.135)	
Beach width (LiDAR)		-0.001*** (0.000)
Shoreline proximity (1/m) × Beach width (LiDAR)		0.190** (0.087)

Alternative BW Measurement

There are two potential reasons for this difference:

1) Differences in estimates between the use of LiDAR compared to TESLA data is driven the nature of the data (i.e., panel v. cross-sectional)

2) TESLA captures the observed beach width "better" than LiDAR because even single monthly measure captures average beach width (744 hourly measurements are used to calculated the average value for May 2016) compared to a single measurement with LiDAR.

1) Differences in estimates between the use of LiDAR compared to TESLA data is driven the nature of the data (i.e., panel v. cross-sectional)

Alternative BW Measurement

	TESLA Time-var.	TESLA May 2016	LiDAR May 2016
Beach width (TESLA, 2mo prior)	-0.001***		
	(0.000)		
Shoreline proximity (1/m) × Beach width (TESLA, 2mo prior)	0.614***		
	(0.135)		
Beach width (TESLA, May 2016)		-0.001***	
		(0.000)	
Shoreline proximity (1/m) × Beach width (TESLA, May 2016)		0.621***	
		(0.129)	
Beach width (LiDAR)			-0.001***
			(0.000)
Shoreline proximity (1/m) × Beach width (LiDAR)			0.190**
			(0.087)

Alternative BW Measurement

2) TESLA captures the observed beach width “better” than LiDAR because cross-sectional monthly measure captures average beach width, compared to a single measurement with LiDAR which can be sensitive to time of day/day of measurement.

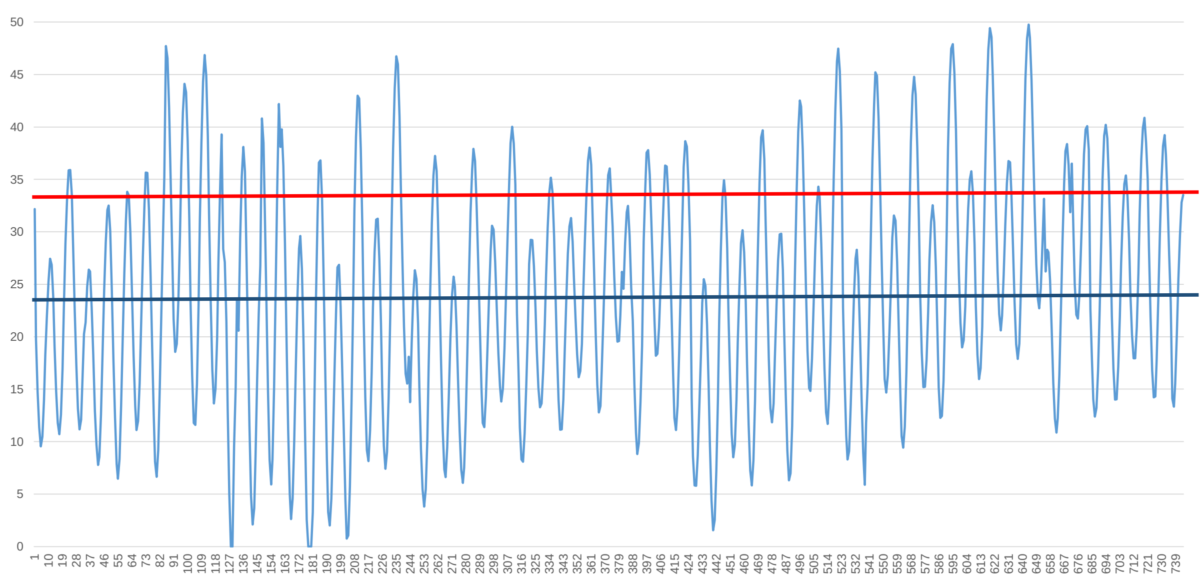
	Mean	S.D.	Min	Max
Beach width (TESLA May 2016, m)	73.16	45.28	0.39	264.40
Beach width (Lidar May 2016, m)	107.38	49.18	9.16	323.87

RECALL:

Gopalakrishnan et al. 2011 (p. 298) “The hedonic price function more appropriately would associate the value of coastal property with a measure of the average beach width at the location where the property is situated.”

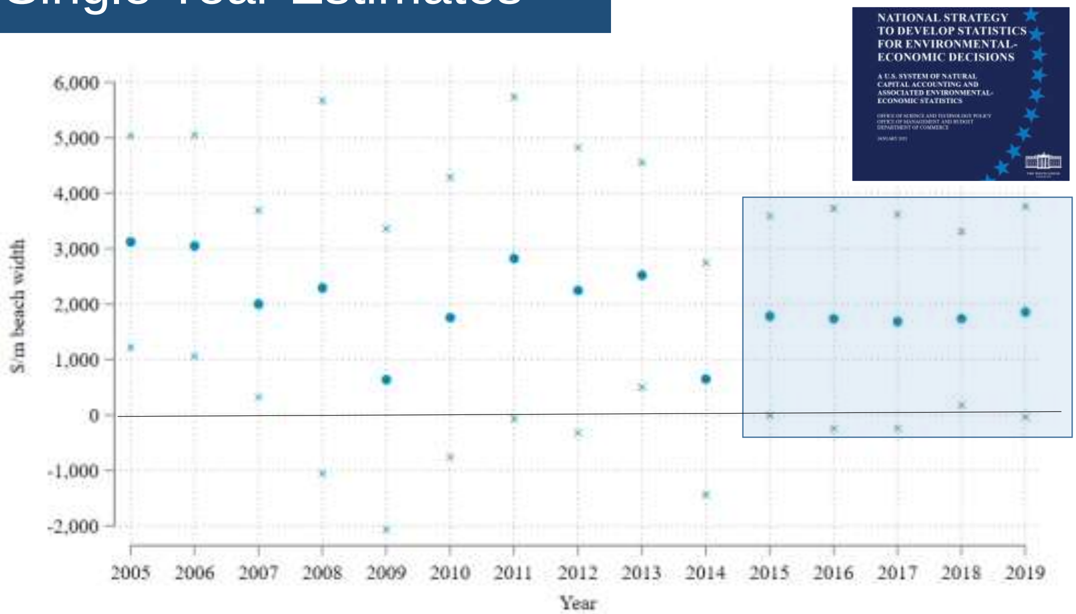
TESLA Beach Width May 2016

Location in Clatsop County



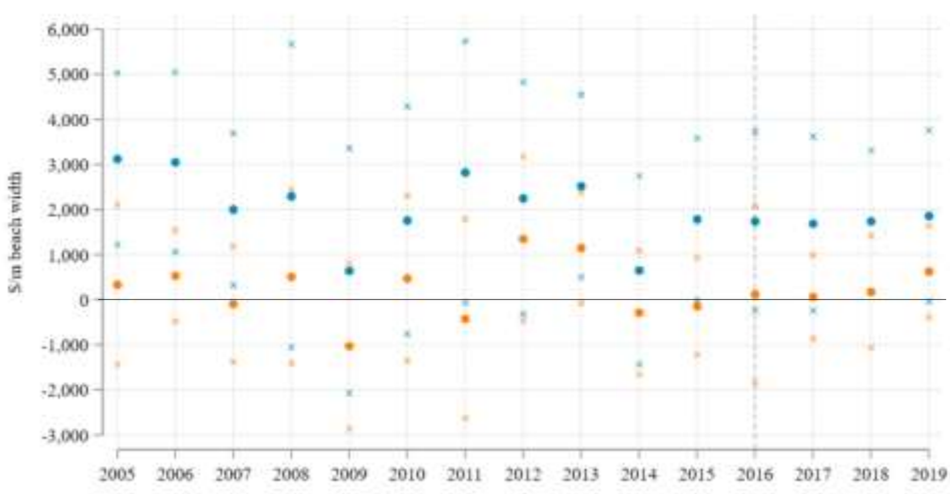
Single Year Estimates

Proximity: 100 m from shoreline



Testing for Direction of Bias

Proximity: 100 m from shoreline



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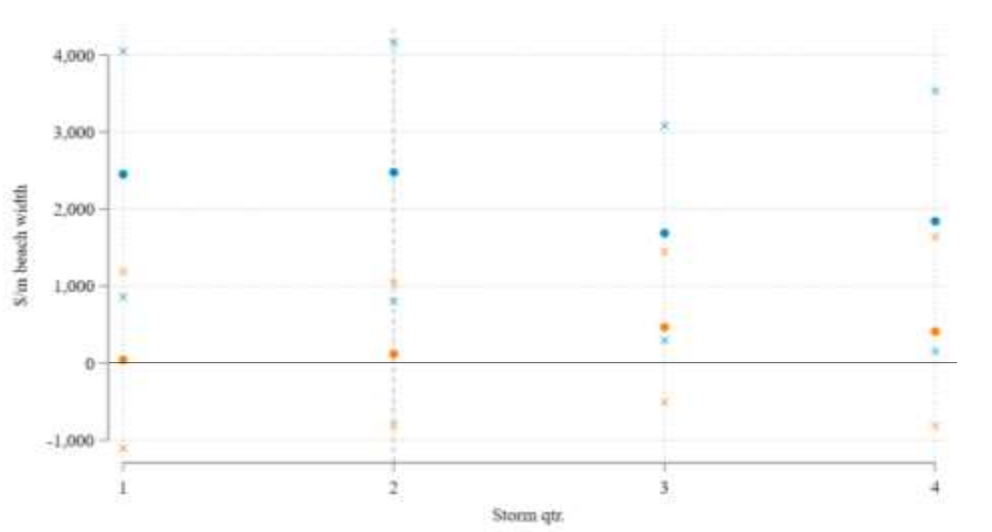
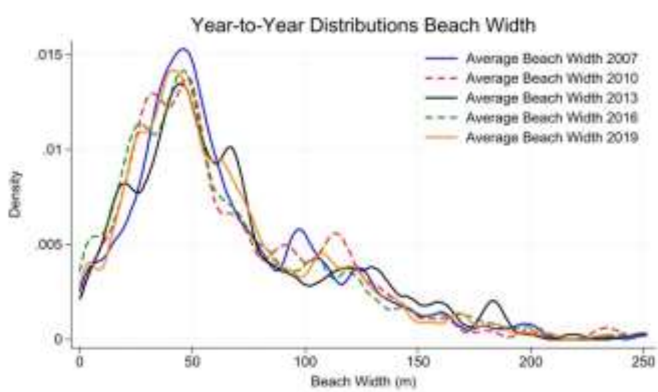
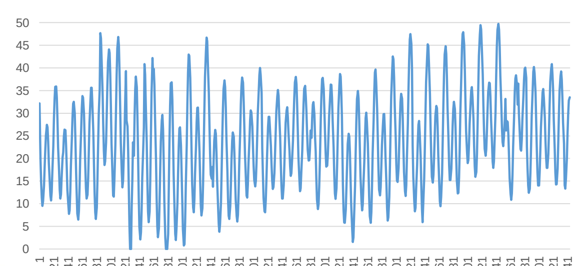


Conclusion?



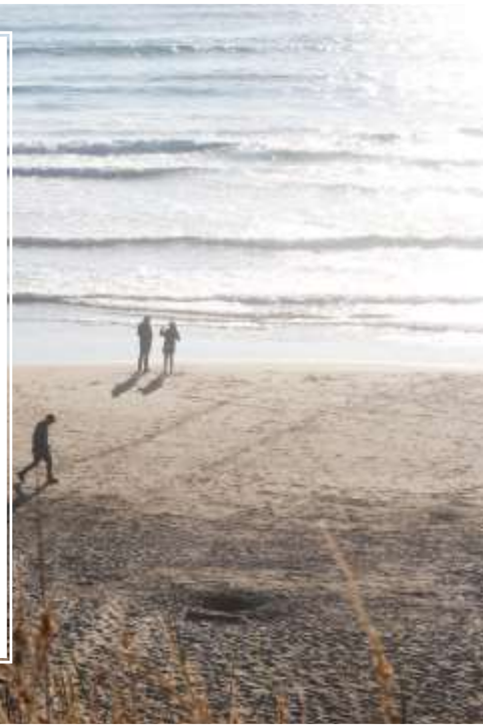


For Oregon: Capturing within-month variation with any average BW measure is more important than matching that measure temporally to sale date. This is likely true due to small amount of inter-annual variation in BW at any given location.

	Mean	S.D.	Min	Max
Shoreline change rate 2002-2016	-0.61	2.00	-6.37	6.17

Summary

- Value for beach width varies with proximity to shoreline
  - ~$4,500/m for oceanfront homes
  - Value drops to $0 for homes > 600/m away from the beach
- Dune height is valuable to all homes within 2.5 km
- Dune width is viewed as a disamenity



Summary

- Value for beach width fluctuates w/ volatility in housing market
  - BW not valued 2008 – 2010 (Great Recession housing crash)
  - Very stable 2015 - 2019
- Multiple measurements to represent average conditions yields higher capitalization effects
- Combining hedonics with models like TESLA enable annual estimates to contribute to natural capital accounting efforts.

Use of Estimates

- Estimates combined with another hedonic study, 2 stated preferences surveys, & dune blue carbon field measurements to estimate protection, recreation, habitat, and carbon storage values for the landscape
- Evolve coastal landscape over time with TESLA & other models with and w/o land-use policies (e.g., beach mgmt., retreat, armoring, etc.)
- Reassess ES flows, estimate tradeoffs, & make policy recs.

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Thank You!

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