High-Resolution Annual Forest Carbon Monitoring Utilizing Remote Sensing

DEPARTMENT OF GEOGRAPHICAL SCIENCES

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March 16, 2021

UNITED STATES CLIMATE ALLIANCE
STATES UNITED FOR CLIMATE ACTION

WORLD RESOURCES INSTITUTE

MARYLAND
DEPARTMENT OF NATURAL RESOURCES

DELAWARE DEPARTMENT OF NATURAL RESOURCES
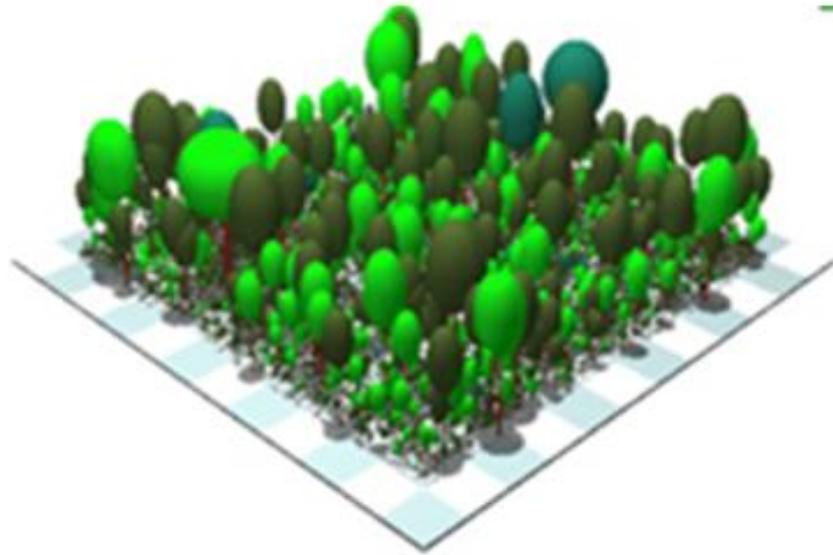AND ENVIRONMENTAL CONTROL
Division of Climate, Coastal and Energy

Overarching Project Goal:

To provide an annual geospatial estimate of forest carbon flux that can be used to evaluate progress under the state's climate action goals.
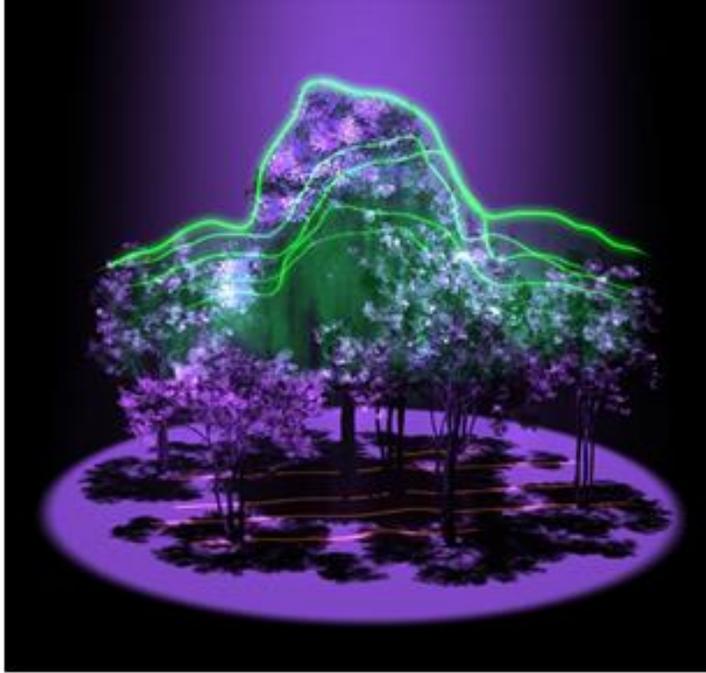
Mapping to Establish Baseline   **Modeling** to Facilitate Planning   **Monitoring** to Provide Assessment

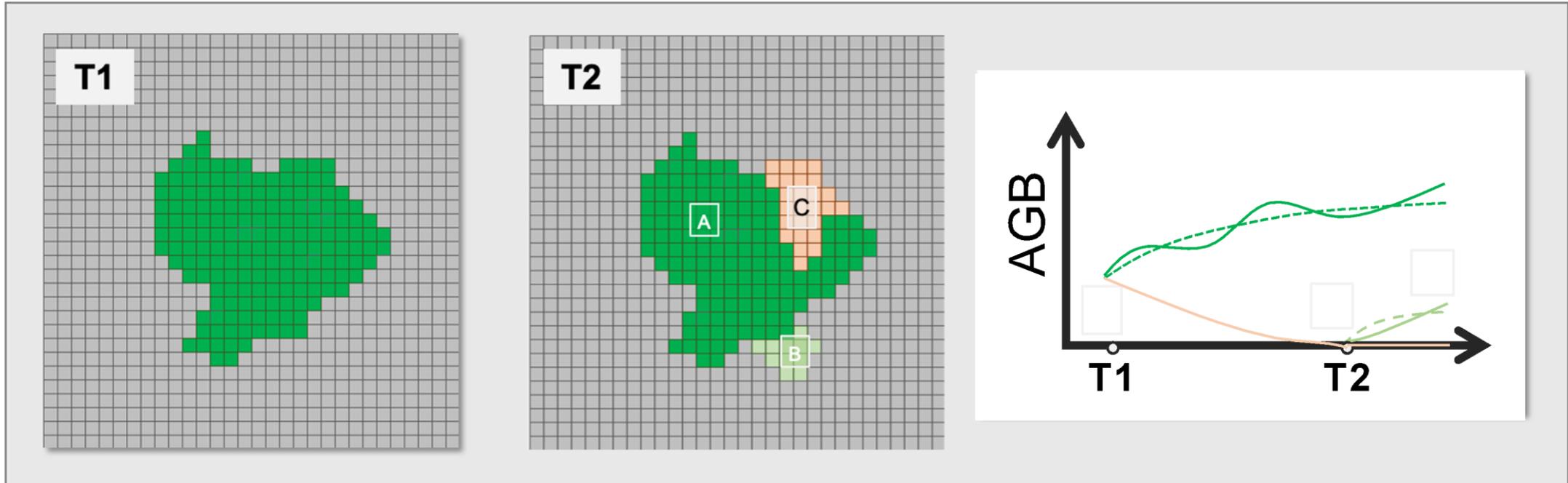*Use of consistent science products across spectrum of applications*

Basic Workflow

Annual Net Carbon Flux = Carbon **Gains** - Carbon **Losses** + Carbon **Regrowth**

Gains = ongoing growth over forested fraction of gridcell

Losses = amount of carbon in deforested area

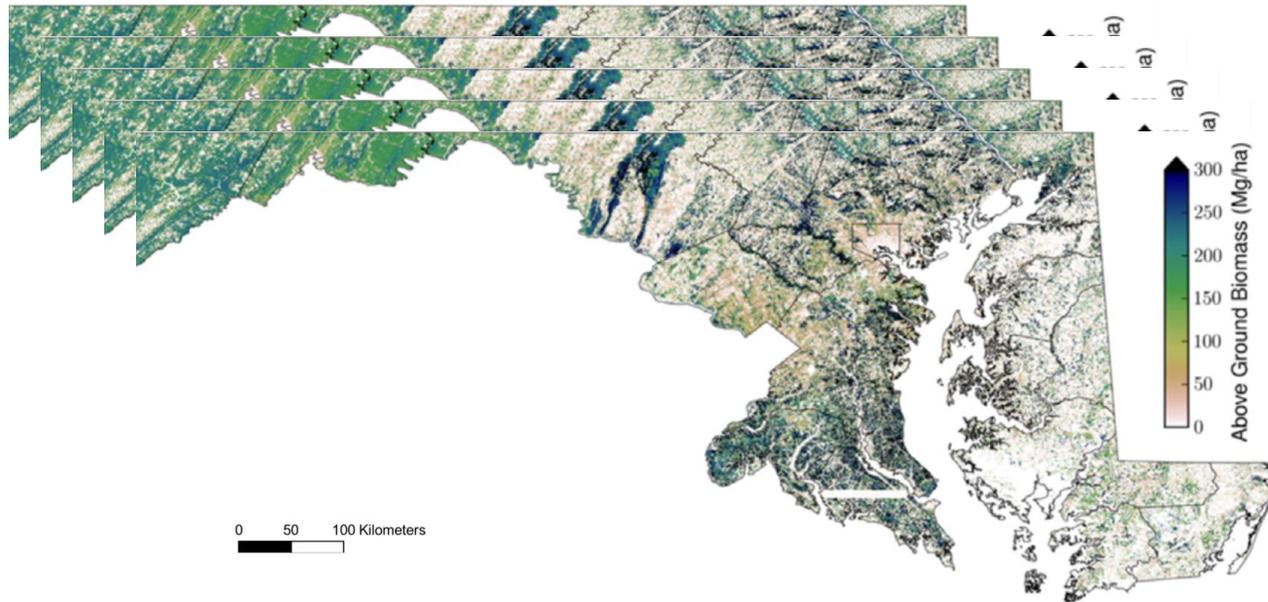**Regrowth** = amount of carbon reaccumulated on gridcells (new/expanded tree cover)

Versioning

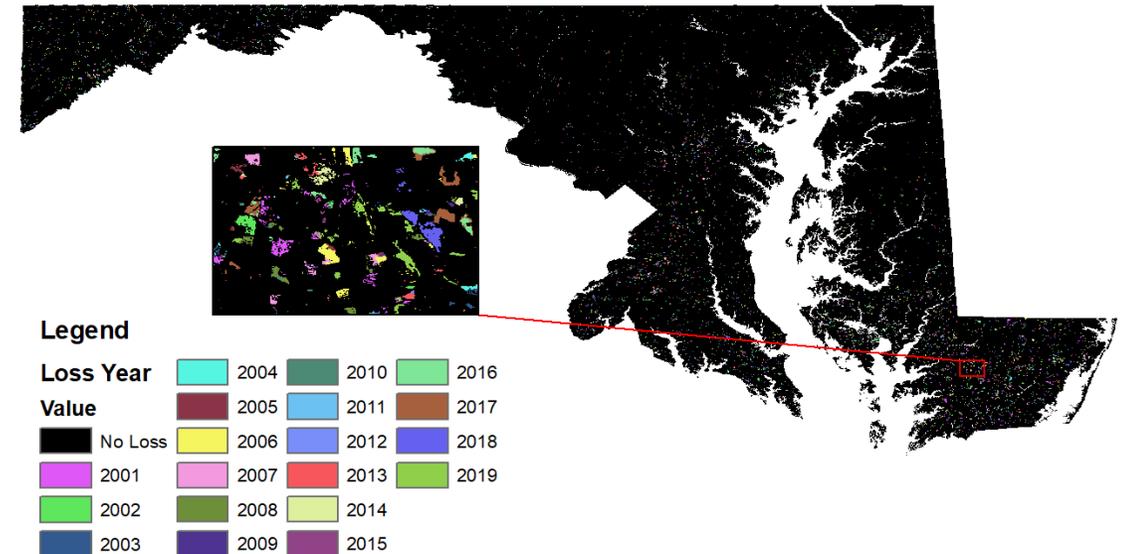| Version	Goal	Period	Forest Area Changes (RS)		AGB Growth Drivers in ED		
			Gain	Loss	Meteorology	CO$_2$	Disturbance
V1	Efficacy of capturing remotely sensed changes in forest area	2011-2019	NLCD	GFW	climatology	constant	constant
V2	Efficacy of using transient drivers (meteorology, CO$_2$ and disturbance) in model	1980-2018	--	--	transient	transient	constant
		1980-2018	--	--	transient	transient	transient

Annual Datasets

AGB GAIN

AGB trajectories from ED model (2011 – 2311, 90 m resolution)
(Hurtt et al. 2019, Ma et al. 2020 *in review*)

G Hurtt[1], M Zhao[1], R Sahajpal[1], A Armstrong[1,2], R Birdsey[3,4], E Campbell[5], K Dolan[1,2,6],
R Dubayah[1], J P Fisk[1,7], S Flanagan[1,8], C Huang[1], W Huang[1,9], K Johnson[3,10], R Lamb[1], L Ma[1],
R Marks[5], D O'Leary[1], J O'Neil-Dunne[11], A Swatantran[1] and H Tang[1]

AGB LOSS

Observed forest loss by year (2000 – 2019, 30 m resolution)
(Hansen et al. 2013) version 1.7 2000-2019

Legend

Loss Year Value					
	2004		2010		2016
	2005		2011		2017
No Loss	2006		2012		2018
2001	2007		2013		2019
2002	2008		2014		
2003	2009		2015		

Decadal Dataset - GFW

AGB REGROWTH (New Tree Cover)

Detected gains per ~decade (30 m resolution, Hansen et al. 2013)

- Binary classification over time period

- No attribution by year

- No attribution by cause (*under development*)

- Sensitive to "forest" algorithm

- 2000-2012 data published now

- Will incorporate when available

Legend

■ No Gain

■ Gain

Legend
■ No Gain
■ Gain

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**Global Forest Change 2000–2019
Data Download**

GWF definition : global forest cover (gain)
Defined as the inverse of loss, or a non-forest to forest change entirely within the study period. Encoded as either 1 (gain) or 0 (no gain)
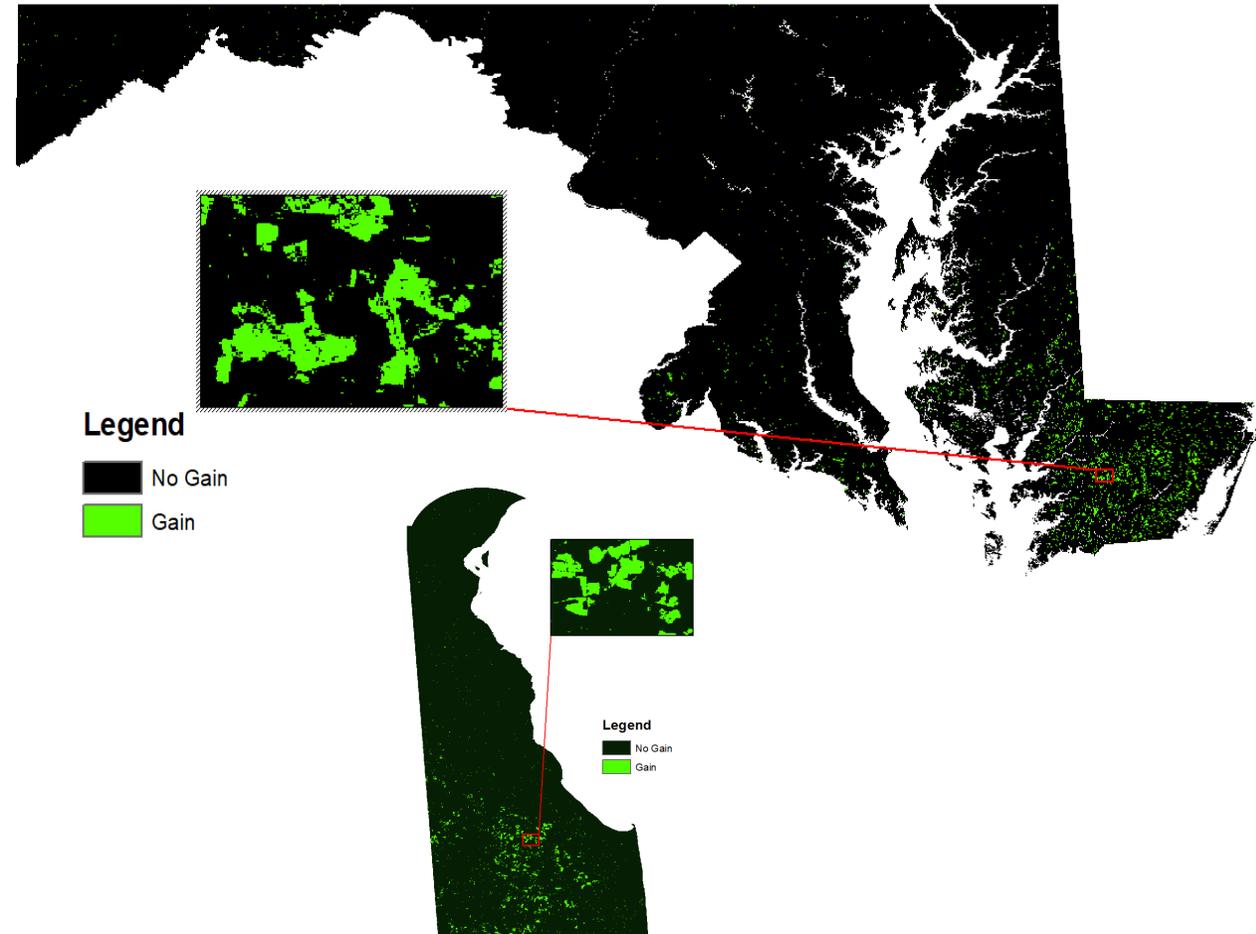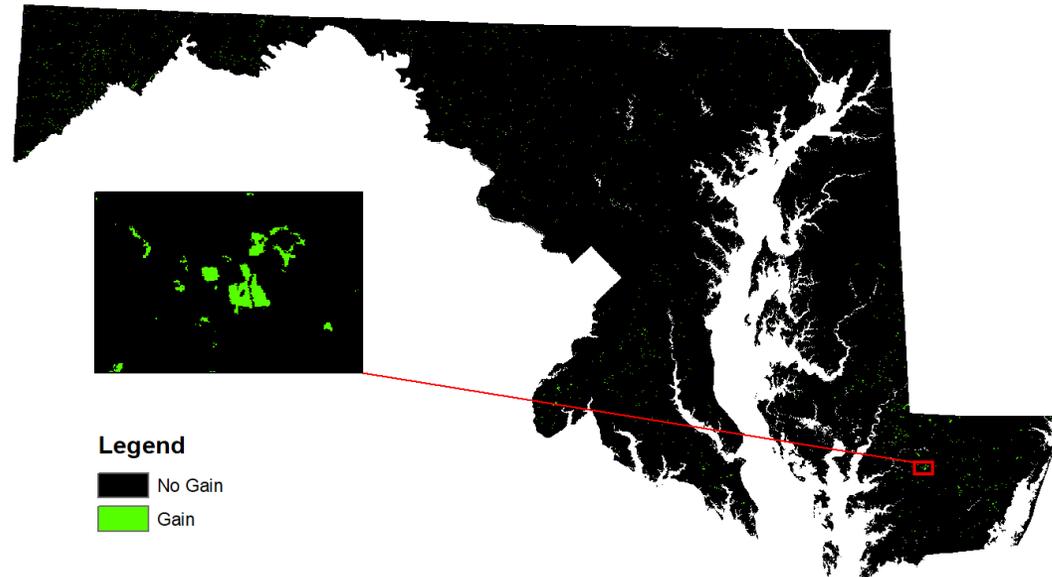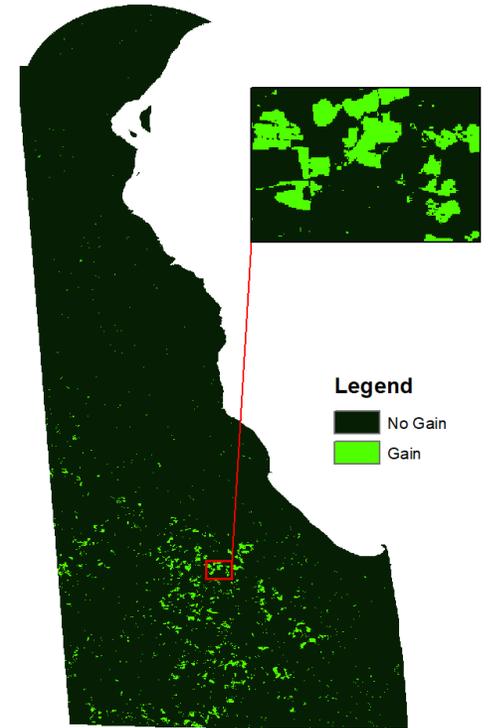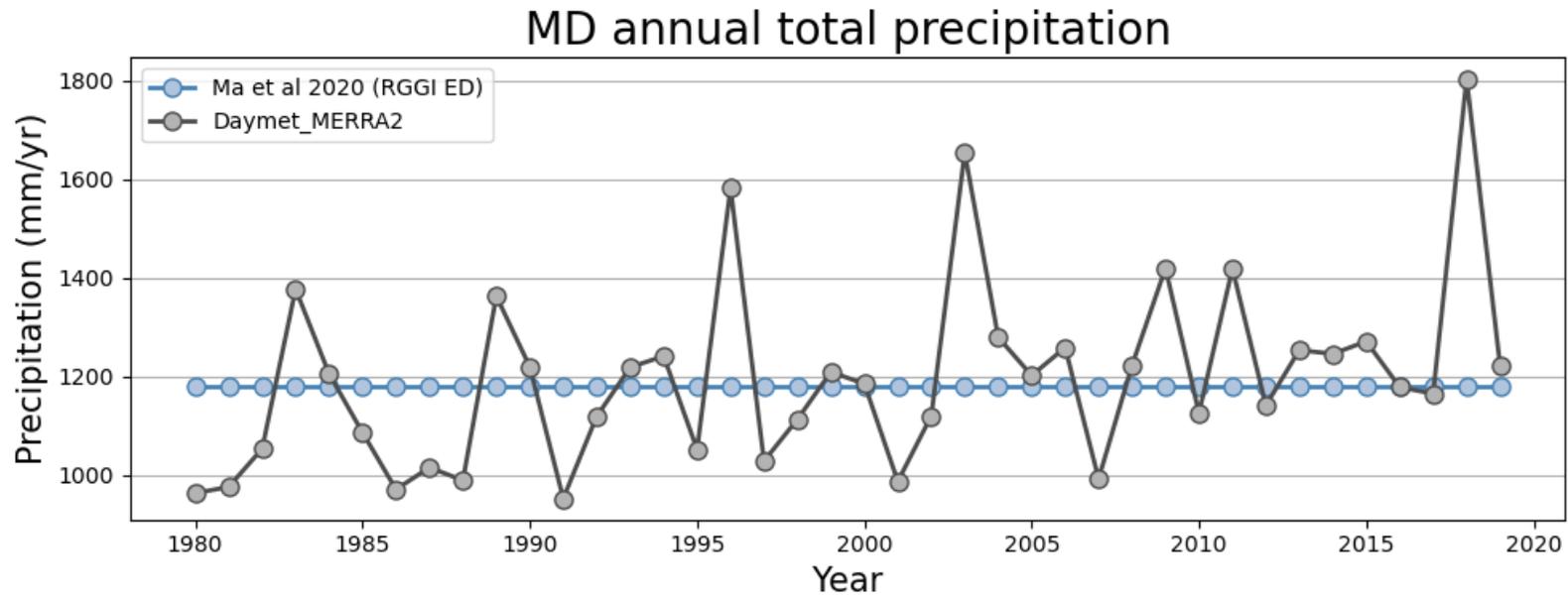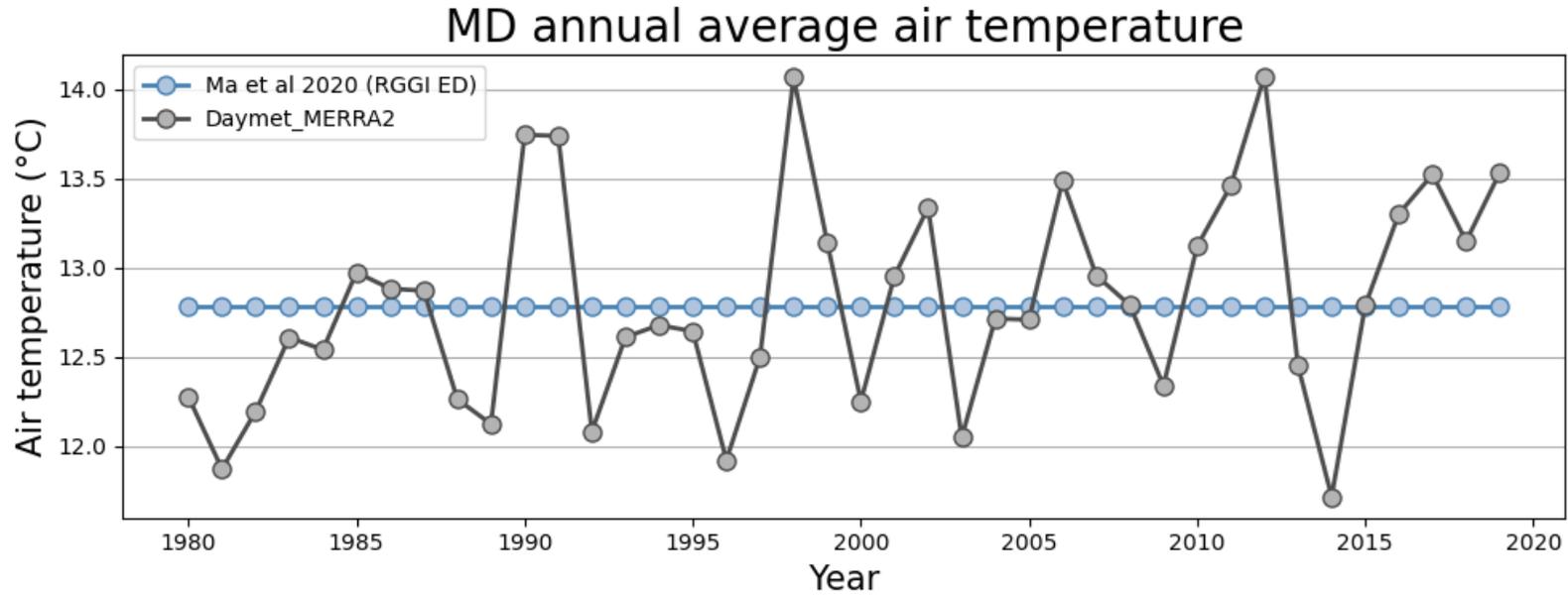
Triennial Dataset - NLCD

- Attribution over 3-5 yr period
- Sensitive to "forest" detection
- 2011, 2013, 2016 cover transitions
- Can incorporate 2019 data once released

AGB REGROWTH (New Tree Cover)

Detected gains per ~decade
(30 m resolution, NLCD 2011, 2013, 2016)
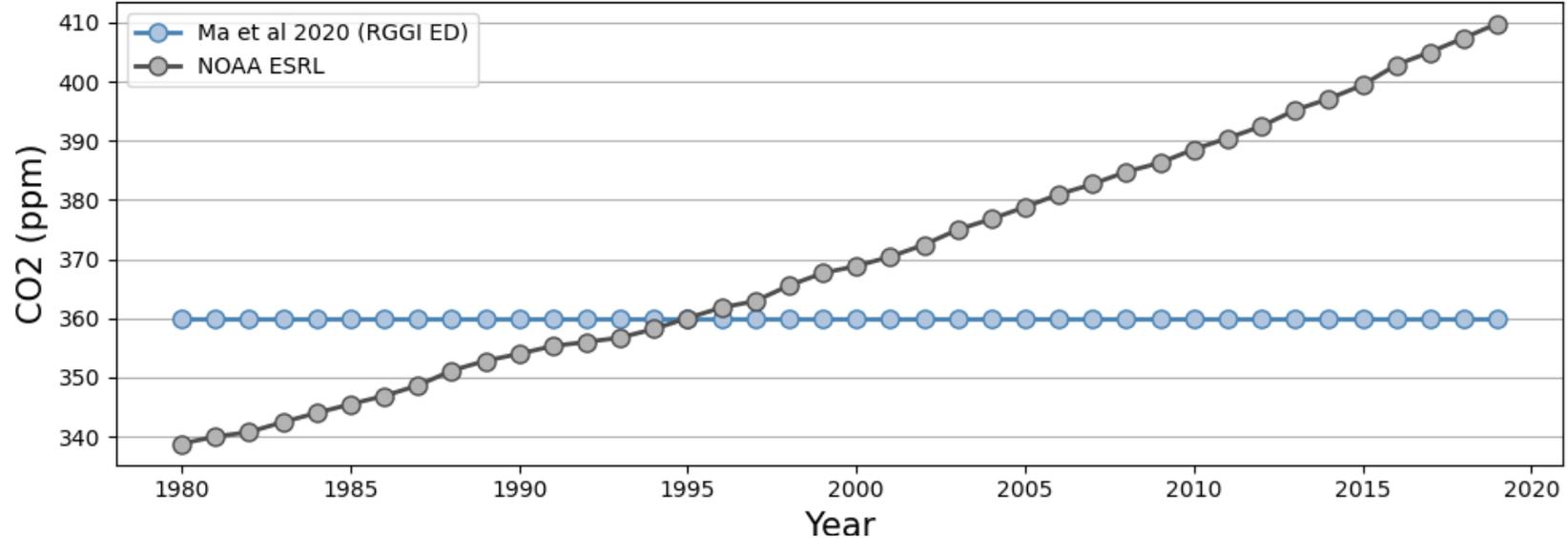
Legend

No Gain

Gain

Legend

No Gain

Gain

Exploration of ED Drivers- Air Temperature & Precipitation

MD annual average air temperature

MD annual total precipitation

Exploration of ED Drivers- CO_2 & Disturbance
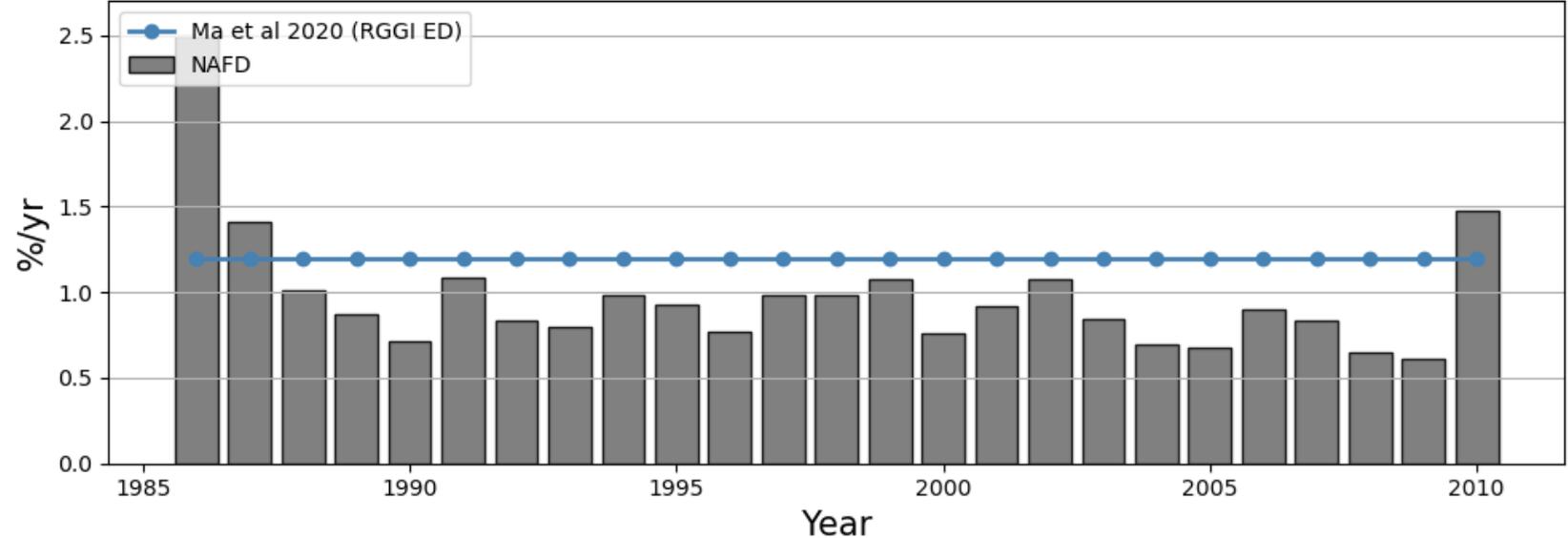
NPP of transient runs

MD Net Primary Productivity (NPP)

Legend:
- NTSG Landsat 30m
- Ma et al 2020 (RGGI ED)
- Transient run (CC, CO2)
- Transient run (CC, CO2, DIS)
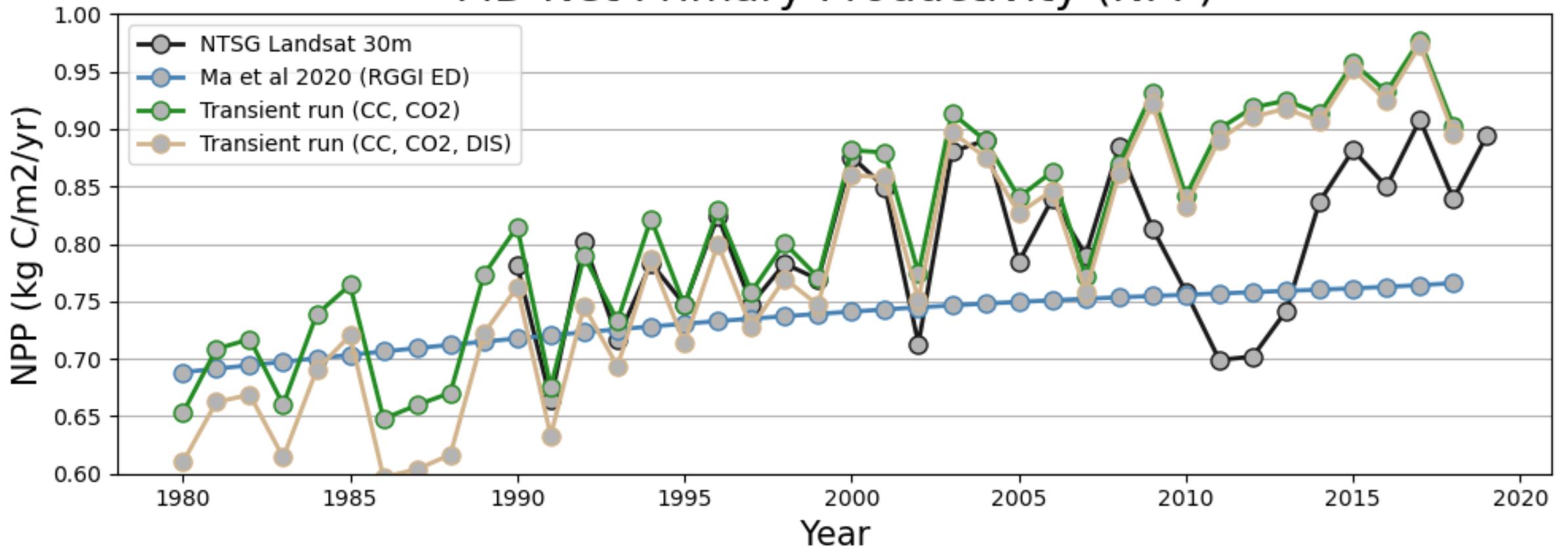
AGB growth rate of transient runs
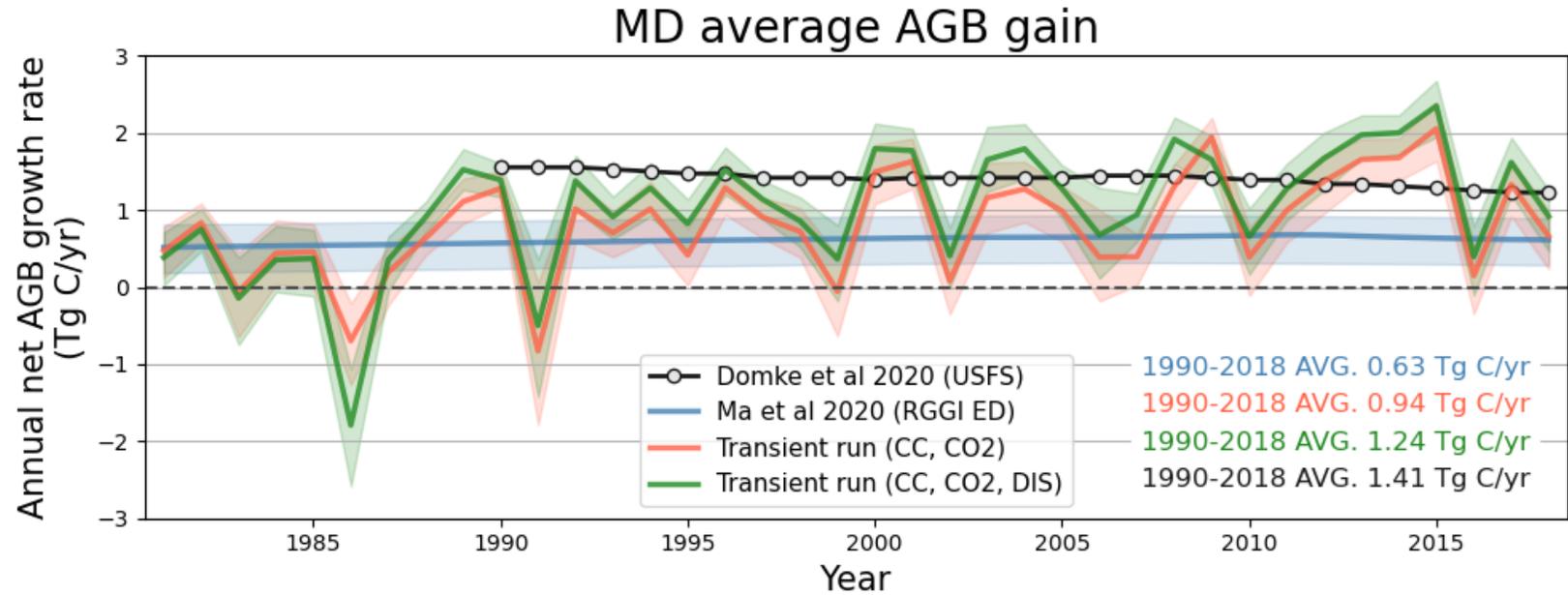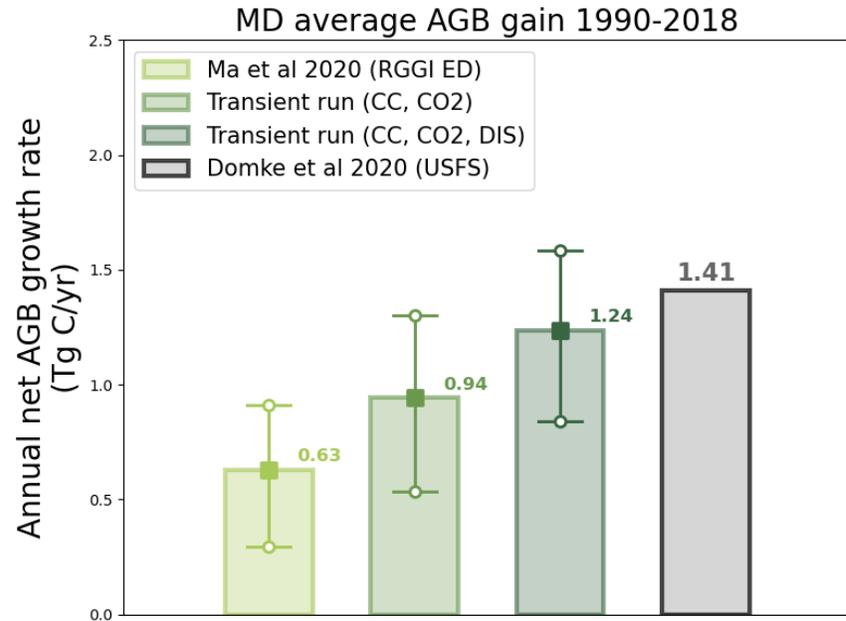
Key Takeaways

1. Created monitoring prototype that is consistent with our existing suite of mapping and modeling products, based on high-resolution remote sensing and prognostic ecosystem modeling in concert with USFS data.

2. We found that we can get consistent monitoring results with the USFS, but with added wall-wall coverage, increased temporal resolution, and added process detail.

3. We seek to operationalize these products within Maryland and Delaware, expand to other states and via USCA.

4. For MD, we are planning on v3, updated for use in MD 2020 inventory, summer 2021.

5. Through NASA CMS we have recently been selected to continue this work, and expand the coverage nationally/globally (harnessing GEDI, ICESat-2, Landsat).

References

Hurtt, G. C., M. Zhao, R. Sahajpal, A. Armstrong, R. Birdsey, E. Campbell, K. Dolan, R. Dubayah, J. P. Fisk, S. Flanagan, C. Huang, W. Huang, K. Johnson, R. Lamb, L. Ma, R. Marks, D. O'Leary III, J. O'Neil-Dunne, A. Swatantran, H. Tang. (2019) Beyond MRV: High-resolution forest carbon modelling for climate mitigation planning over MD, USA. *Environmental Research Letters.* https://doi.org/10.1088/1748-9326/ab0bbe

Hurtt, G. C., Q. Shen, C. E. Silva, L. Ma, R. L. Lamb. (2020) High-resolution monitoring of forest carbon sequestration to meet climate goals AGU Fall Meeting. Poster. *Earth and Space Science Open Archive*. https://doi.org/10.1002/essoar.10505479.1

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Ma, L., G. Hurtt, H. Tang, R. Lamb, E. Campbell, R. Dubayah, M. Guy, W. Huang, A. Lister, J. Lu, J. O'Neill Dunne, A. Rudee, Q. Shen, C. Silva. (2021-in press) High-resolution forest carbon modeling for climate mitigation planning over the RGGI region, USA. *Environmental Research Letters.* https://doi.org/10.1088/1748-9326/abe4f4