

Workshop 2

Ecosystem Services Modeling



Island of Culebra Puerto Rico

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Green Infrastructure Center
May 14, 2024





Canopy Mapping Workshop 2

Final land cover stats

Ecosystem Services

Air Quality & Carbon

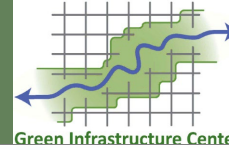
Urban Heat Island

Trees & Stormwater (TSW) Calculator

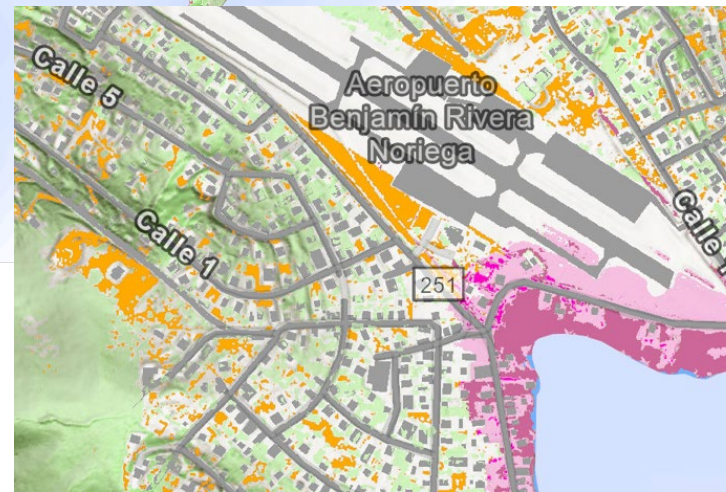
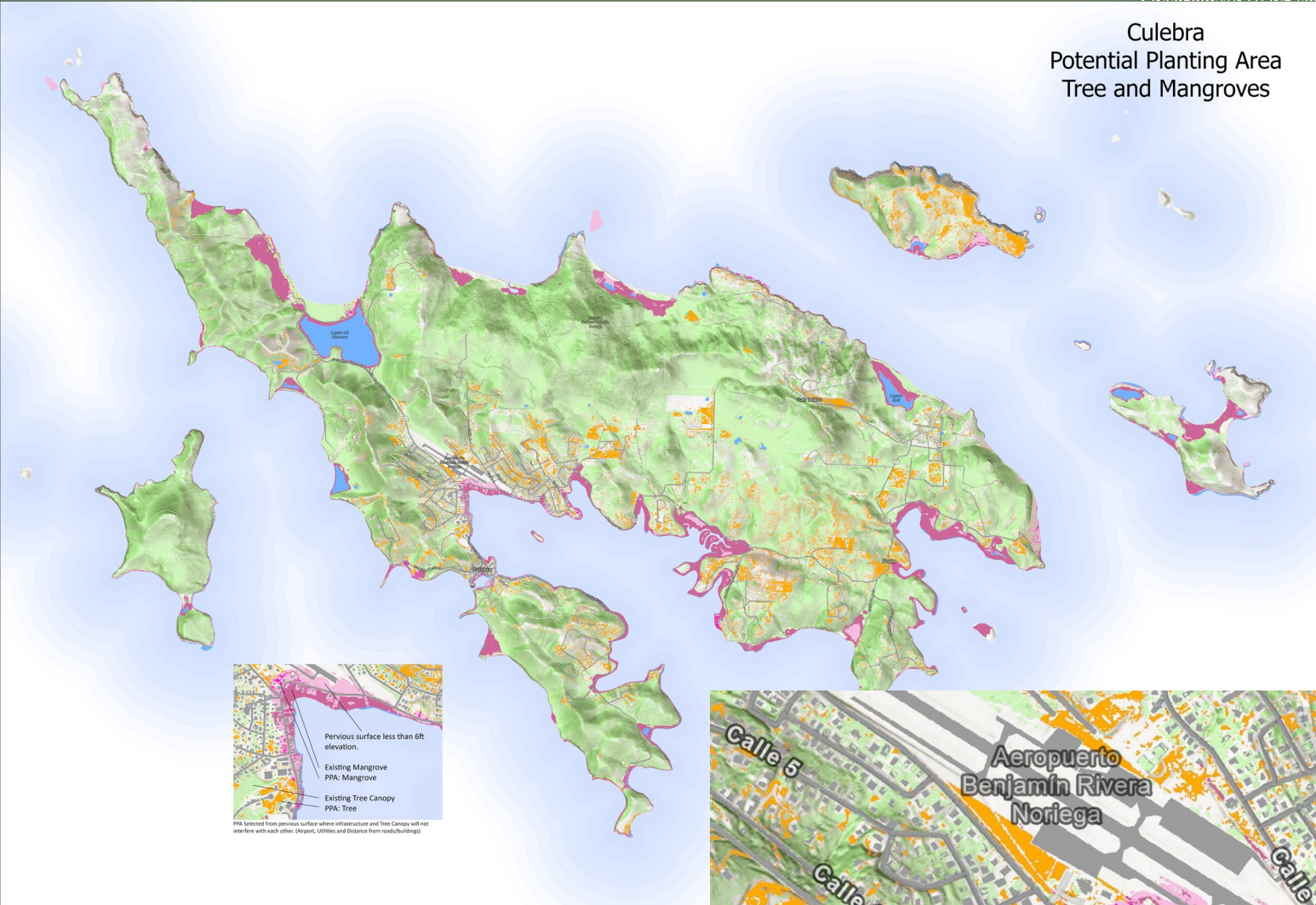
Demo

Next Steps





Culebra
Potential Planting Area
Tree and Mangroves



Culebra Potential Planting Areas (PPA)

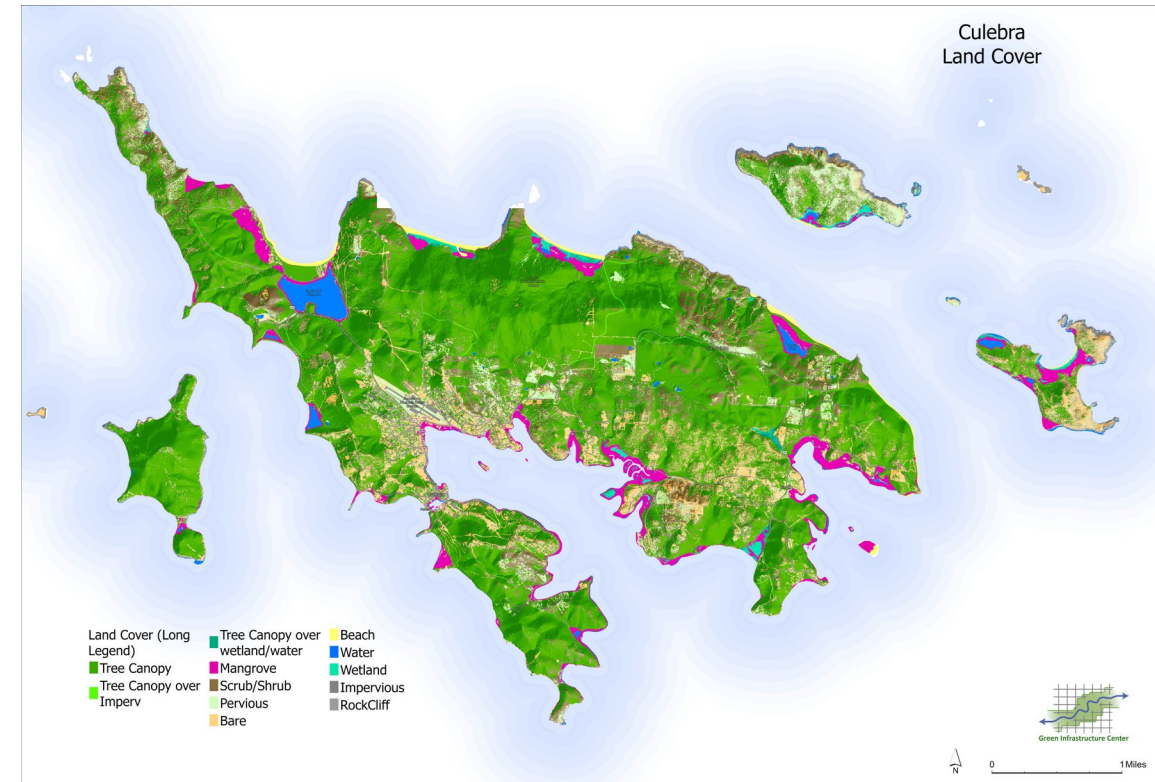
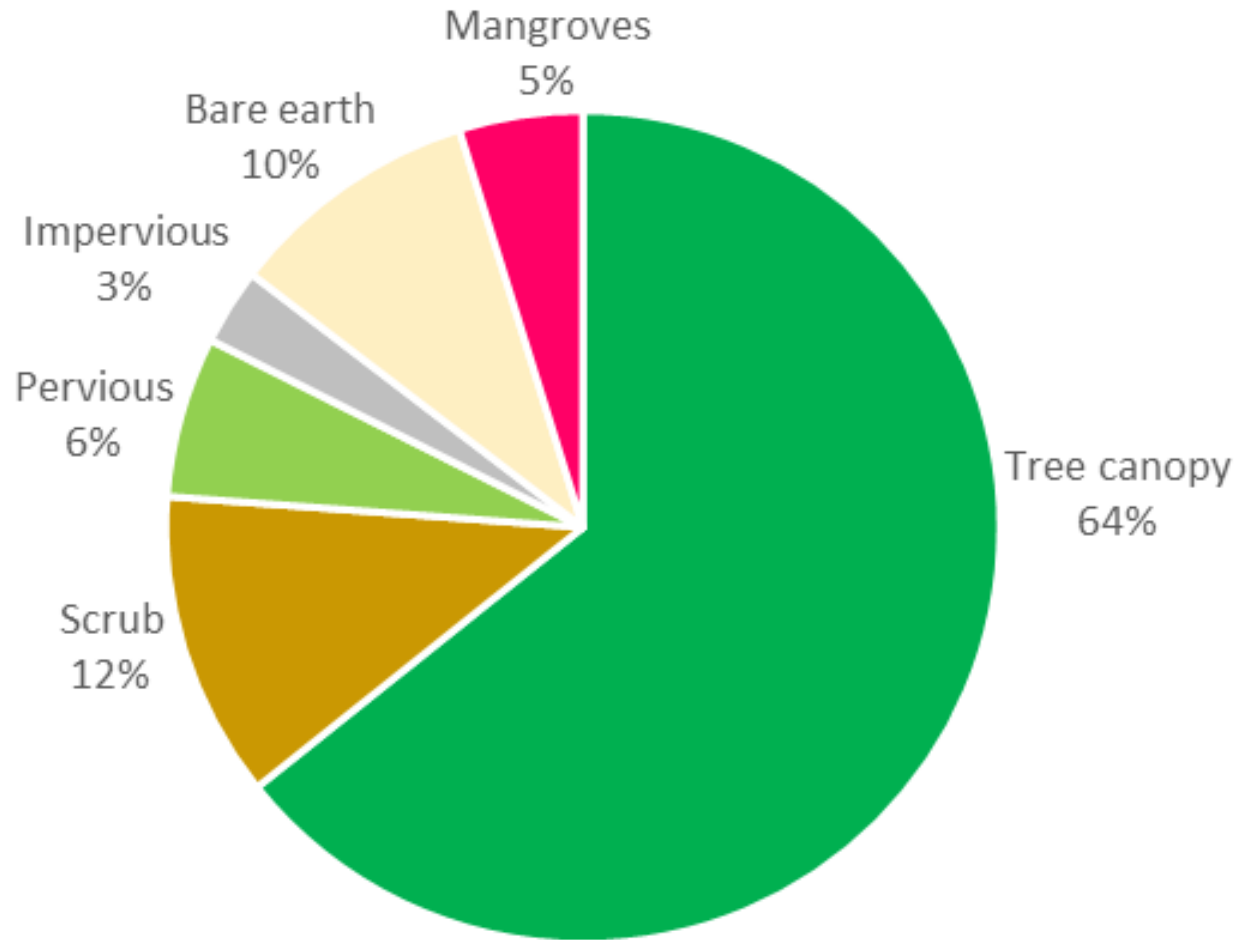
Tree Canopy PPA for
developed areas: 3.9% (Final)
(orange PPA)

297 Acres (Final)
Small trees (20 ft): 21,312
Large trees (40 ft): 8,950
Total trees: 30,262

Mangroves PPA: 7.24 acres
(Final) (magenta PPA)



Culebra Land Cover



Island-wide Canopy* 69% (Final)
Potential Tree Canopy 76% (Final)

*Canopy = Tree Canopy + Tree Canopy over Impervious + Wooded Wetlands + Mangroves



Air Quality Benefits (2023)

Pollutant (Abbrev.)	Benefit Description	Removal rate (lbs/acres/year)	Removal rate (lbs/year)
CO	Carbon monoxide removed annually	0.904	4,708
NO2	Nitrogen dioxide removed annually	1.683	8,765
O3	Ozone removed annually	23.941	124,685
PM10	Particulate matter greater than 2.5 microns and less than 10 microns removed annually	9.222	48,028
PM2.5	Particulate matter less than 2.5 microns removed annually	0.839	4,370
SO2	Sulfur dioxide removed annually	0.002	10

Closest approximate location used was Monroe County, Florida. (Florida Keys)

Source: Hirabayashi, 2014, "i-Tree Canopy Air Pollutant Removal and Monetary Value Model Descriptions"



Carbon Sequestration & Storage (2023)

Tree Canopy 4,914 Acres

Mangroves 366 Acres

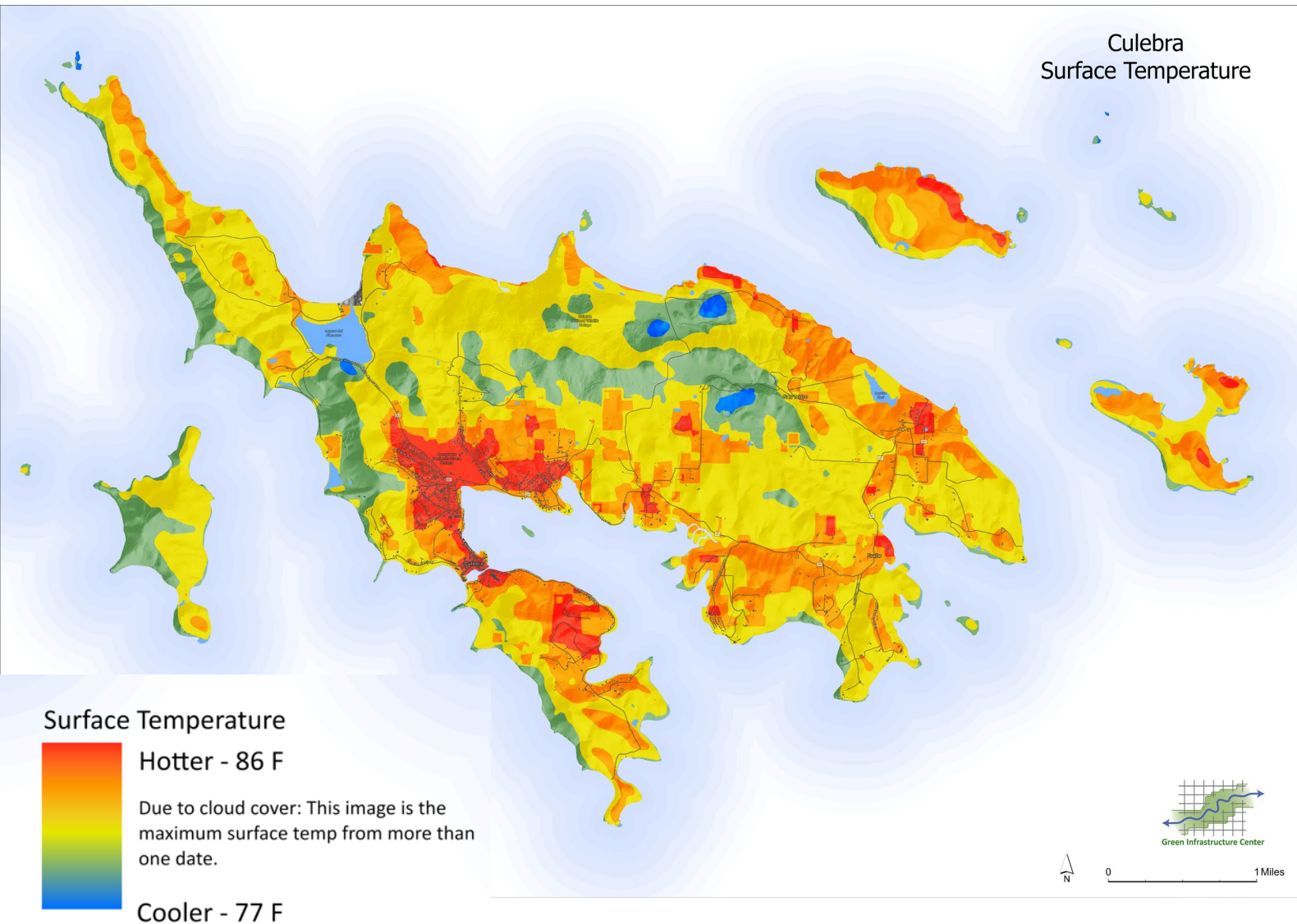
Pollutant (Abbrev.)	Benefit Description	Removal rate (mT/acres/year)	Removal rate (mT/year)	Removal rate (mT/acres/year)	Removal rate (mT/year)
C seq	Carbon sequestered annually in trees	0.87	4,275	4.71	1,724
C stor	Carbon stored in trees (note: this benefit is not an annual rate)	5.81	24,838	23.24	8,506

Closest approximate location used was Monroe County, Florida. (Florida Keys)

Source: Nowak, D. et al., 2013, "Carbon storage and sequestration by trees in urban and community areas of the United States"

Mangrove sequestration average source: Blue Carbon Initiative [LINK](#)

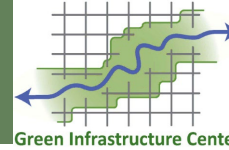
Mangrove average storage source: NOAA [LINK](#)



Surface Heat and Shade

Average temperature island-wide on July 29 2013 and December 29 2022— **79** deg F

This data is an input layer used to help prioritize areas of the island for tree planting for shade.



Urban Heat Island and Equity

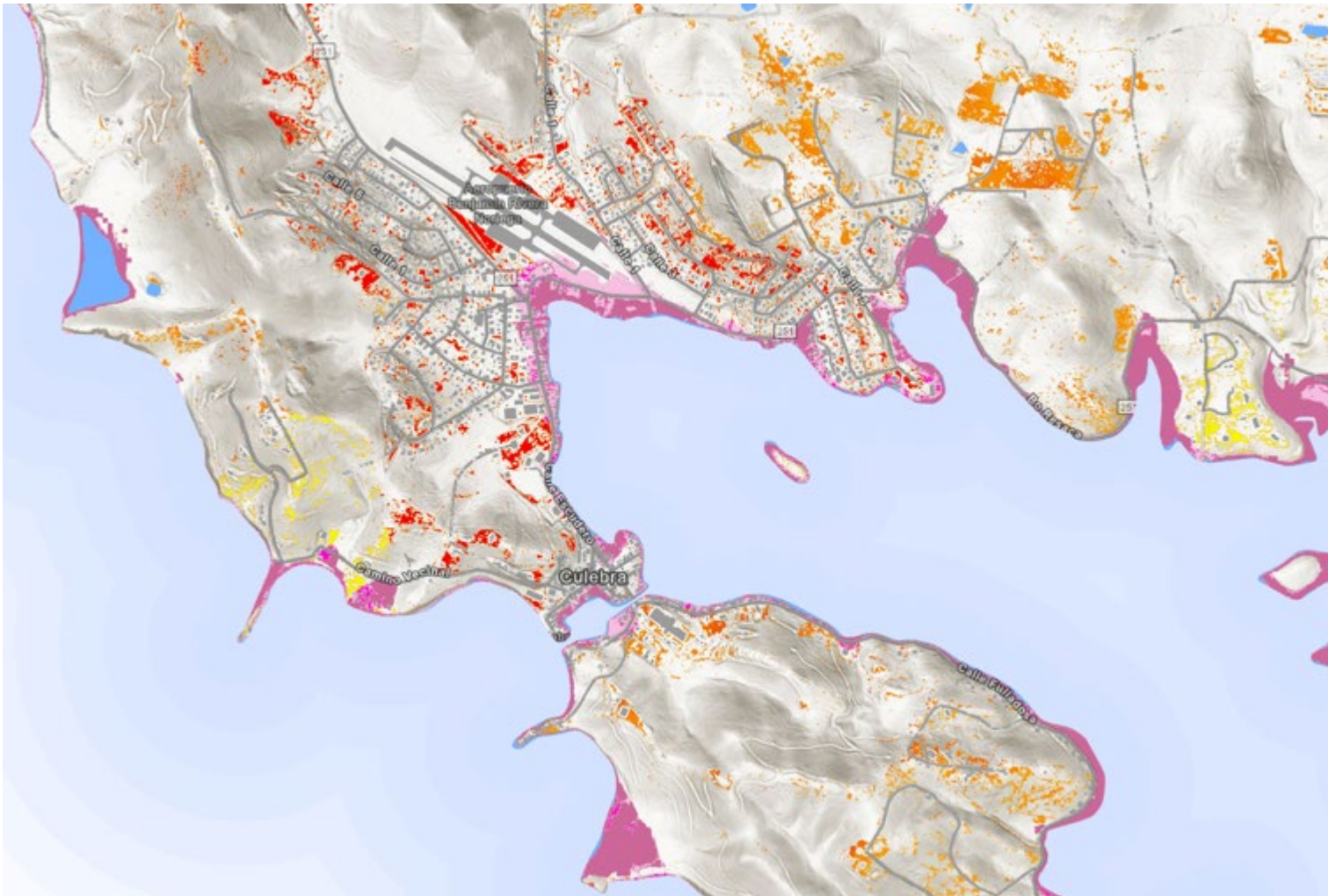
One way to prioritize the data and Potential Planting Areas (PPA) is analyze it through demographics and environmental impacts.

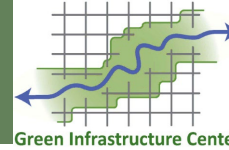
This map example prioritizes the hottest areas on the island that also have the highest concentration of owner-occupied housing.

High priority – 38 acres

Moderate priority – 98 acres

Low priority – 160 acres





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Funded by USFS
Southern Region

The GIC partnered with 6 states to demonstrate the role of trees as green infrastructure. The goal is to reduce flooding and to clean the water!

SC, NC, GA, FL, AL, VA = 12 cities large to small, from mountains to coast!

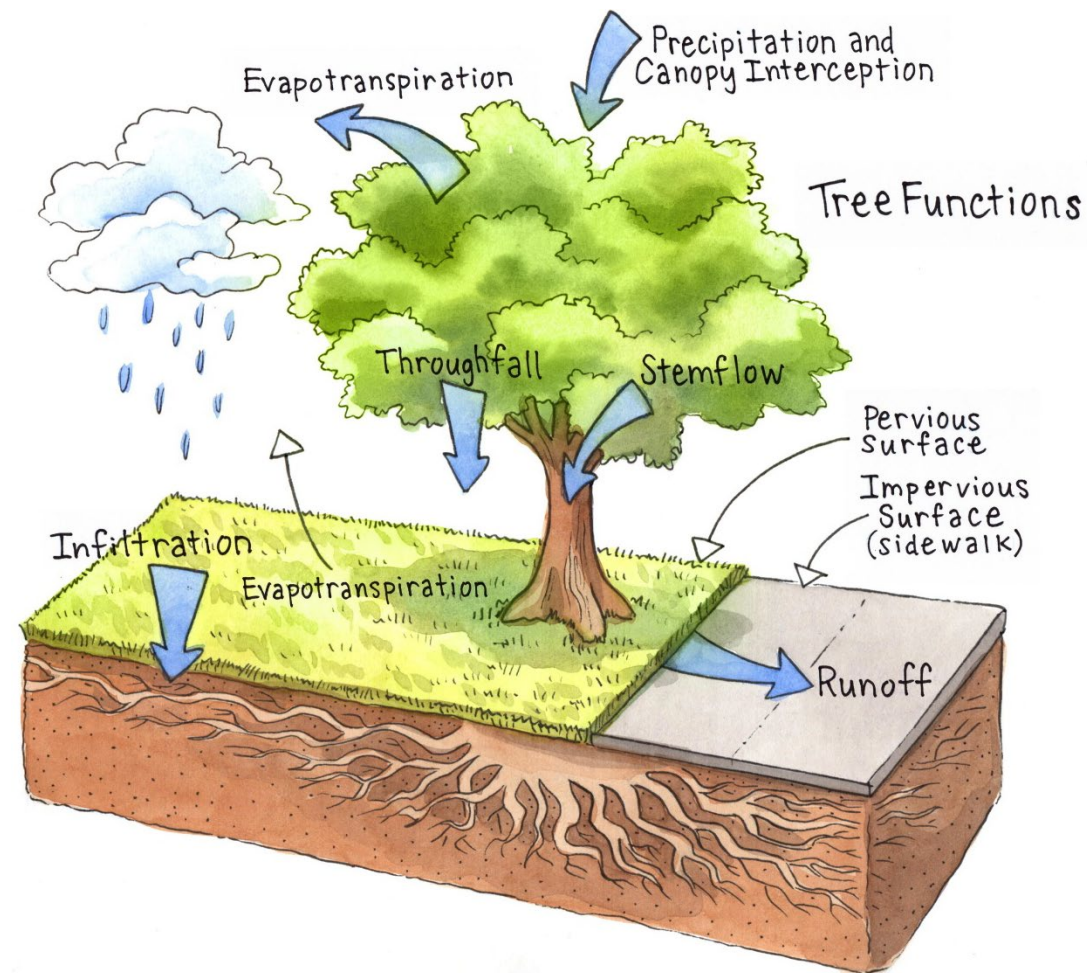
Summary report for the project or to find individual reports on each city visit: http://www.gicinc.org/trees_stormwater.htm





Urban Tree Canopy

- 20% of annual rainfall or > retained in crown (Xiao et al., 2000)
- Delays runoff up to 3.7 hours
- infiltration capacity of soils

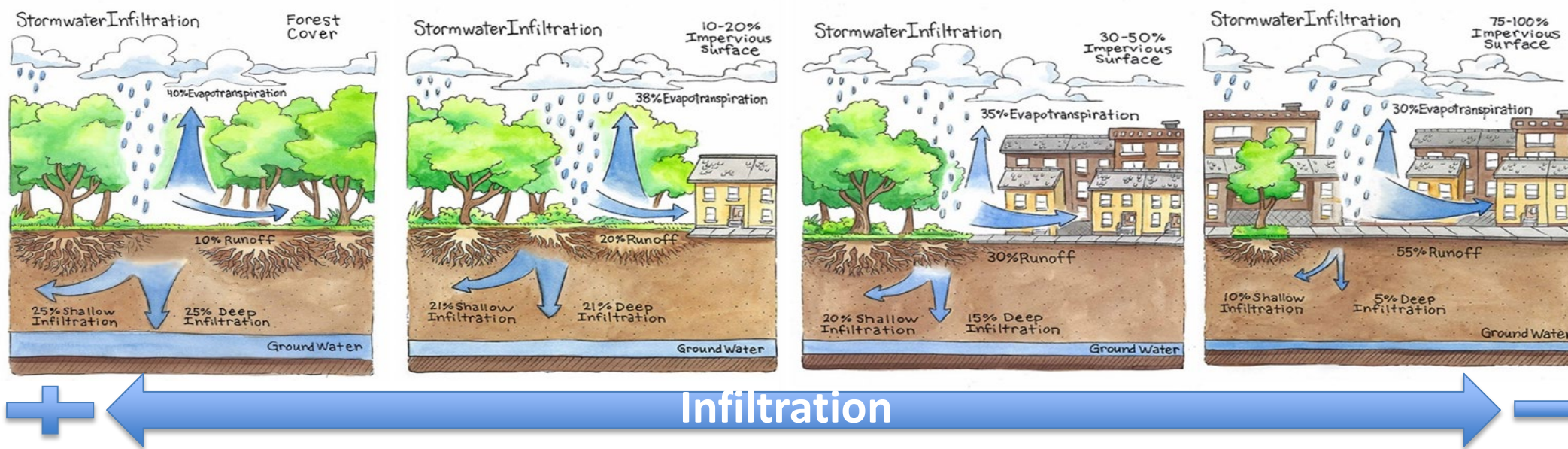




How much stormwater do the trees take up?

Benefits are typically modeled on a tree-by-tree basis. We need to be able to apply benefits on a per unit area basis...

We need to analyze trees based on the conditions of the setting and soils by watershed.





Forestry Work Group Study

Tree canopy reduces the proportion of precipitation that becomes stream and surface flow, also known as *water yield*. The Hynicka and Divers study (2016) modified the water yield equation of the NRCS model by adding a canopy interception term (C_i), resulting in:

$$R = \frac{(P - C_i - I_a)^2}{(P - C_i - I_a) + S}$$

Where R is runoff

P is precipitation

I_a is the initial abstraction,

S is the potential maximum retention after runoff begins for the subject land cover.

($S = 1000/CN - 10$)

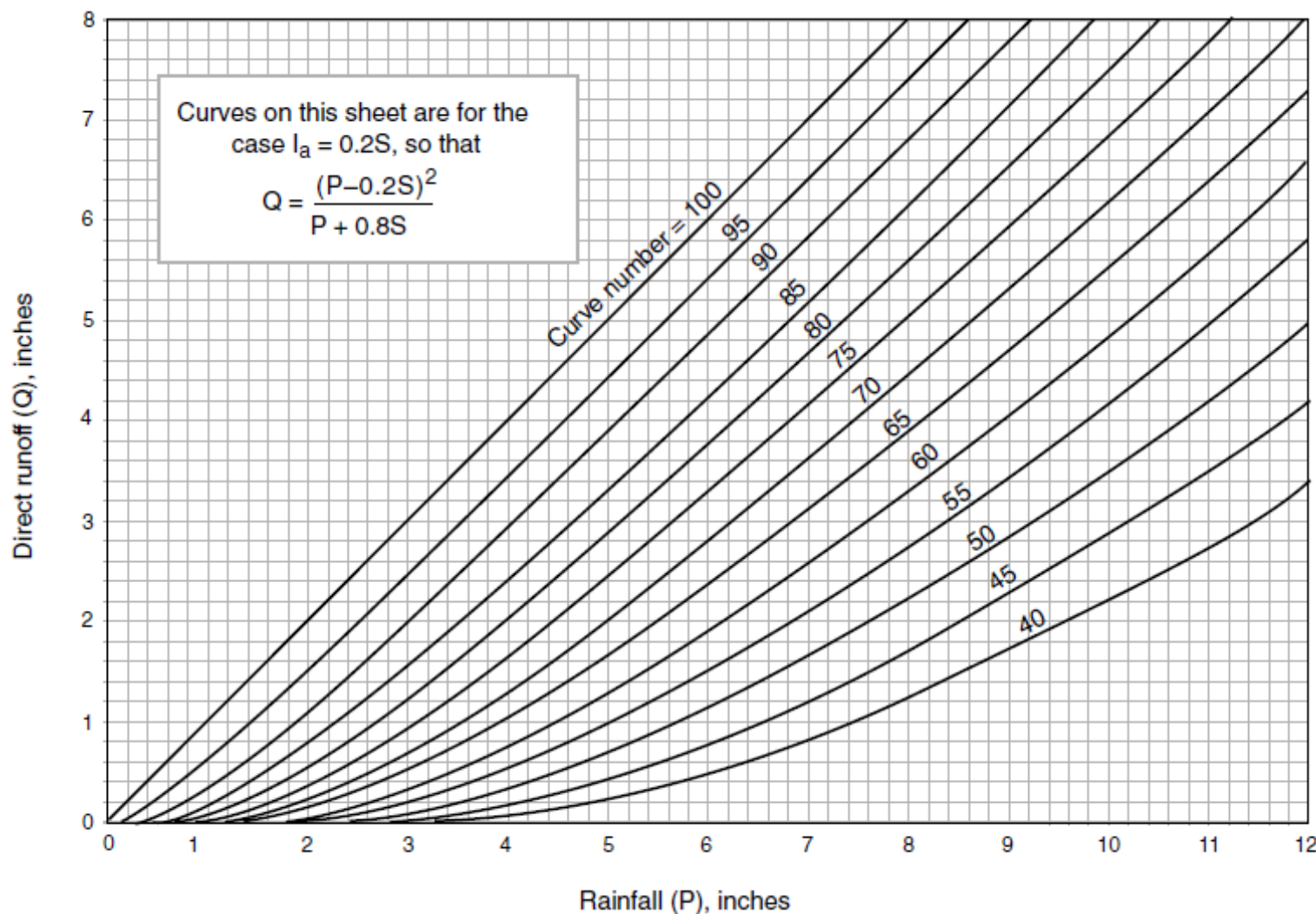
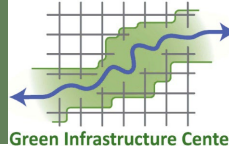
Recommendations of the Expert Panel to Define BMP Effectiveness for Urban Tree Canopy Expansion

Karen Capiella, Sally Claggett, Keith Cline, Susan Day, Michael Galvin, Peter MacDonagh,
Jessica Sanders, Thomas Whitlow, Qingfu Xiao



Accepted conditionally by Forestry Work Group, June 23, 2016
Approved by Watershed Technical Work Group, DATE TBD
Final Approval by Water Quality Goal Implementation Team, DATE TBD

Prepared by
Neely L. Law, PhD, Center for Watershed Protection, Expert Panel Chair
Jeremy Hanson, Virginia Tech, Expert Panel Coordinator





Curve Number Selection

Major factors determining CN are

- ☐ The hydrologic soil group (defined by surface infiltration rates and transmission rates of water through the soil profile, when thoroughly wetted)
- ☐ Land cover types
- ☐ Hydrologic condition – density of vegetative cover, surface texture, seasonal variations
- ☐ Treatment – design or management practices that affect runoff



The parking lot curve # is about 98 while below it's 40. Higher curve #s = more runoff.





Tree Over Parking Lot



Tree Over Street



Tree Over Lawn



Tree Over Natural Forest Cover

Trees take up more or less water depending on their settings so our high resolution 1 meter x 1 meter maps account for conditions of the urban forest.



The GIC's stormwater calculator uses land cover and soils to model the benefit of maintaining or increasing urban canopy.

CULEBRA ISLAND

Urban Tree Canopy Stormwater Model

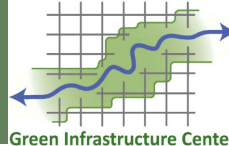
version May 4, 2022



The Green Infrastructure Urban Tree Canopy Stormwater Model estimates stormwater runoff yields for current and potential land cover. The methodology is based upon the NRCS TR-55 method for small urban watersheds. It is used to provide better estimates using GIC's high-resolution land cover and modeling of potential canopy area.

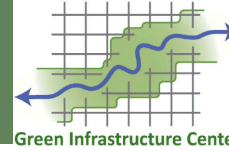


H2O				million gallons										
TOTALS		67.8%	2.9%	23.6	0.5	0.1	66.7%							
Statistics by Drainage Basin (current settings)							Variable							Variable
Area	Current Tree Cover	Current Impervious Cover	Tree H2O Capture	Increased H2O w/xx% tree loss	Added H2O Capture w/xx% PCA	Adjusted Tree Cover from loss and gain scenarios	Pick an Event	Pick a loss scenario		Converted Land			Canopy Added	Enter % canopy to add
	%		million gallons			%	Event	% UTC loss	% FOS Loss	% Imperv	Max TC Possible	Maximum Potential Added Canopy Area	% Canop Added	% of PCA achieved
1 Zone1	70.9%	1.8%	2.6	0.04	0.01	66%	1 yr / 24 hour	15%	0%	0%	72.9%	2.0%	0.4%	20%
2 Zone2	31.0%	0.0%	0.6	0.03	0.06	35%	1 yr / 24 hour	0%	10%	10%	57.4%	26.4%	5.3%	20%
3 Zone3	88.8%	0.1%	3.0	0.42	-	82%	1 yr / 24 hour	0%	15%	0%	89.5%	0.8%	0.0%	0%
4 Zone4	43.3%	0.0%	0.6	-	-	43%	1 yr / 24 hour	0%	0%	0%	43.4%	0.1%	0.0%	0%
5 Zone5	89.6%	0.0%	1.3	-	-	90%	1 yr / 24 hour	0%	0%	0%	89.8%	0.2%	0.0%	0%



The GIC's stormwater calculator uses land cover and soils to model the benefit of maintaining or increasing urban canopy.

40900	48	3345	47	1950	17	0	0	0	0	0	0
Statistics by Drainage Basin (current settings)											
Non-Point Pollution Captured by Existing Trees (% = percent of total load without trees)						Change in Pollution Load from Landuse Variables (% = percent increase or decrease of total load)					
N lbs/yr	N (%)	P lbs/yr	P (%)	SED t/yr	SED (%)	N lbs/yr	N (%)	P lbs/yr	P (%)	SED t/yr	SED (%)
4,669	56	382	55	217	20	0	0	0	0	0	0
471	14	38	12	33	4	0	0	0	0	0	0
5,938	73	487	75	254	35	0	0	0	0	0	0



Water Quality and Quantity

The Island's current tree canopy captures:

32,513 lbs/year of Nitrogen

2,703 lbs/year of Phosphorus

1,709 tons/year of sediment

23.6 million gallons of stormwater runoff during a 1-year/24 hour rainfall event (2.72 inches)



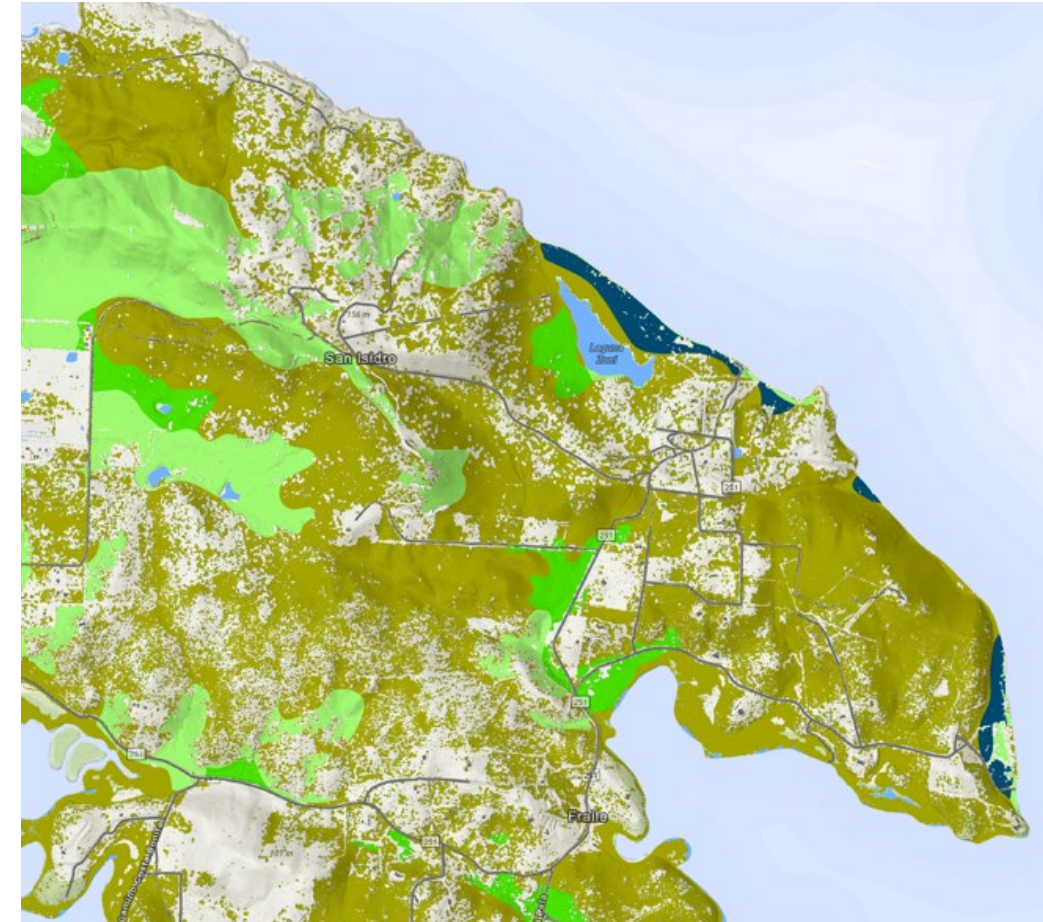
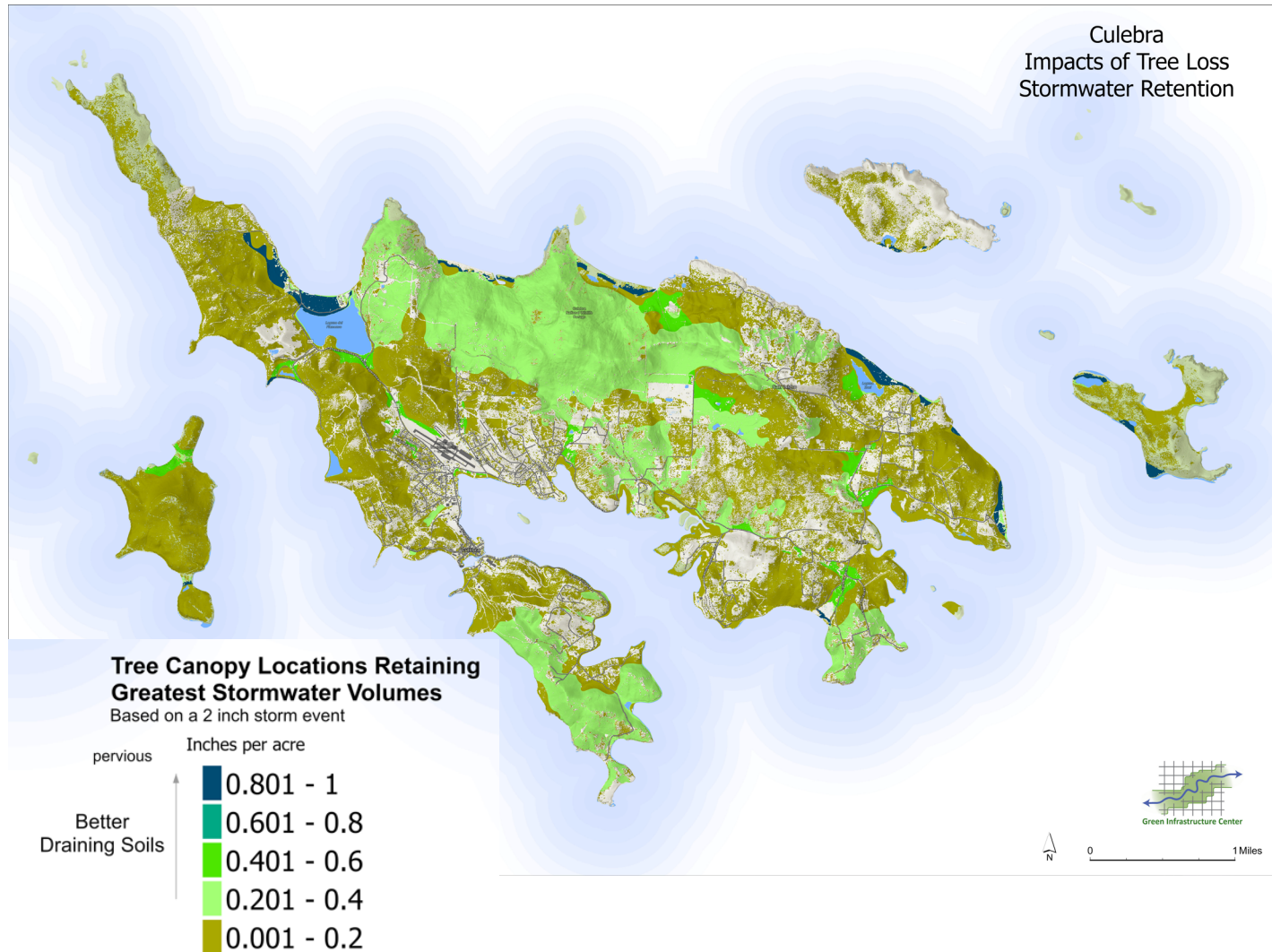
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Trees and Stormwater Calculator Demo

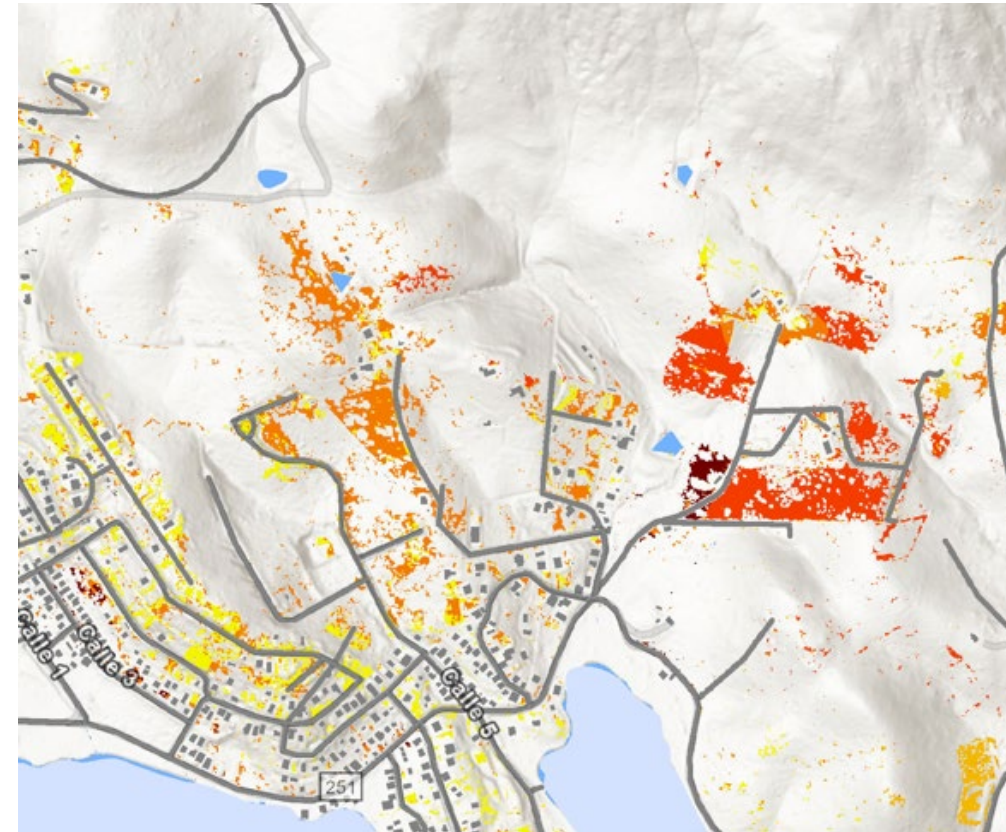
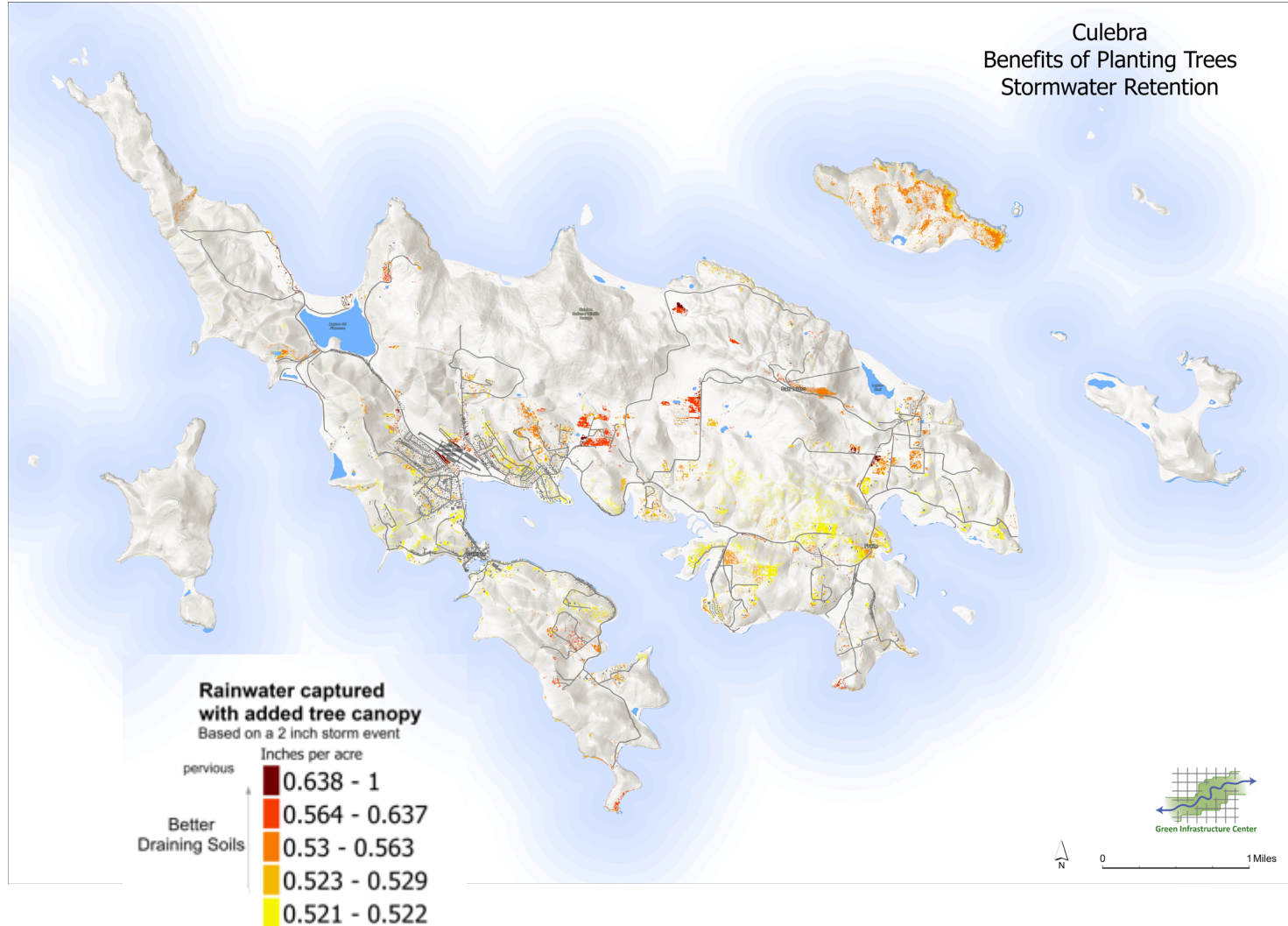


Existing canopy that is best at retaining and infiltrating stormwater on site.





There are many planting spaces within developed areas of the island are well-suited for infiltration and planting trees for stormwater.





Project Next Steps

- ✓ GIC will print maps and ship to Culebra municipal staff to share with the community.
- ✓ GIC will transfer all GIS data and maps to any interested stakeholders and the USFW. USFW will store data on behalf of local partners.
- ✓ Local stakeholders will continue to conduct research, monitoring and evaluation of mapping data and mangroves.



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Comments,
Questions?

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