Landscape Mapping and Planning Tools for Improving Water Quality

Presented by
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Green Infrastructure Center

Volunteer Monitoring Forum 04.10.2019

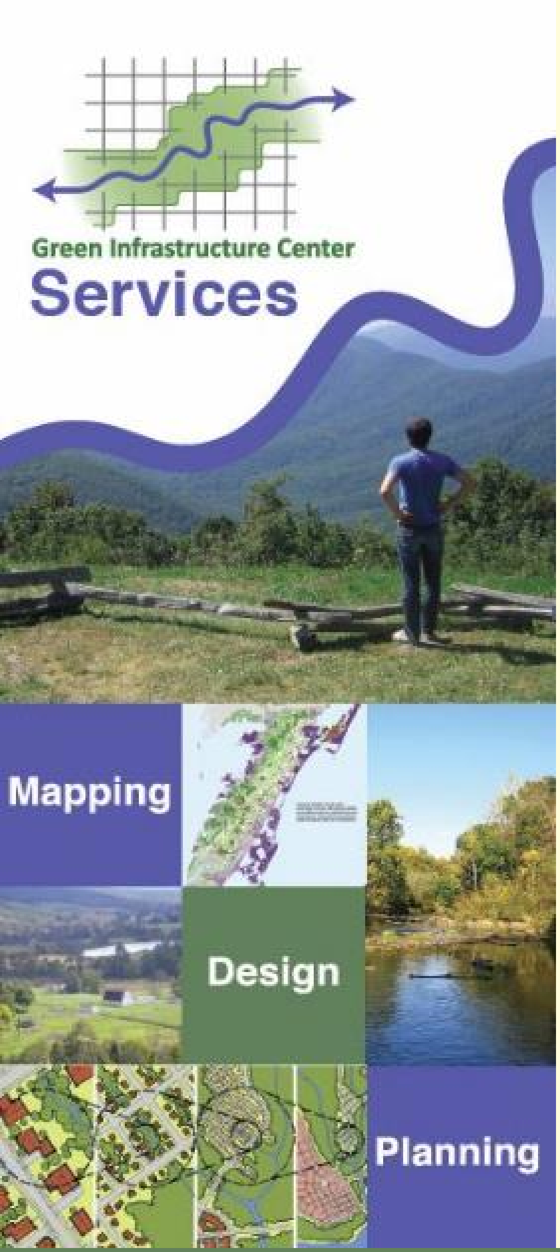
Slide Show Topics

Green 'Stormwater' Infrastructure – using the forest to clean our water

Land Image Analyst Tool

Tree Stormwater Calculator Tool

Policies and Practices Audit Tool



The Green Infrastructure Center helps communities evaluate their green assets to maximize ecological, economic and cultural returns.

We do this by:

Building landscape models

Teaching courses and workshops

Research into new methodologies

Helping communities create strategies

www.gicinc.org

Examples of GIC's work in rural and urban landscapes...

Albemarle County, VA

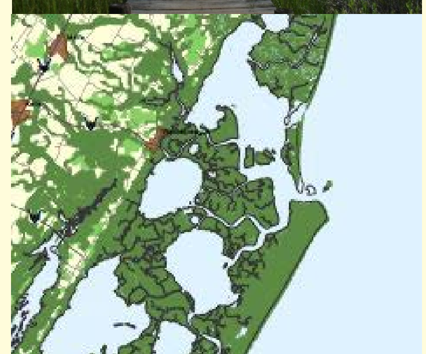
Connecting and conserving intact landscapes to conserve biodiversity, clean water and cultural landscapes.

Richmond, VA

Urban revitalization in a post-industrial city – regreening, regrowing the city, converting empty spaces to green oases.

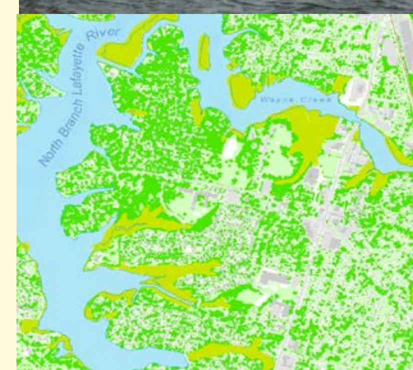
Accomack County, VA

Conserving green infrastructure in the face of rising seas and protecting the fisheries of the Chesapeake Bay.

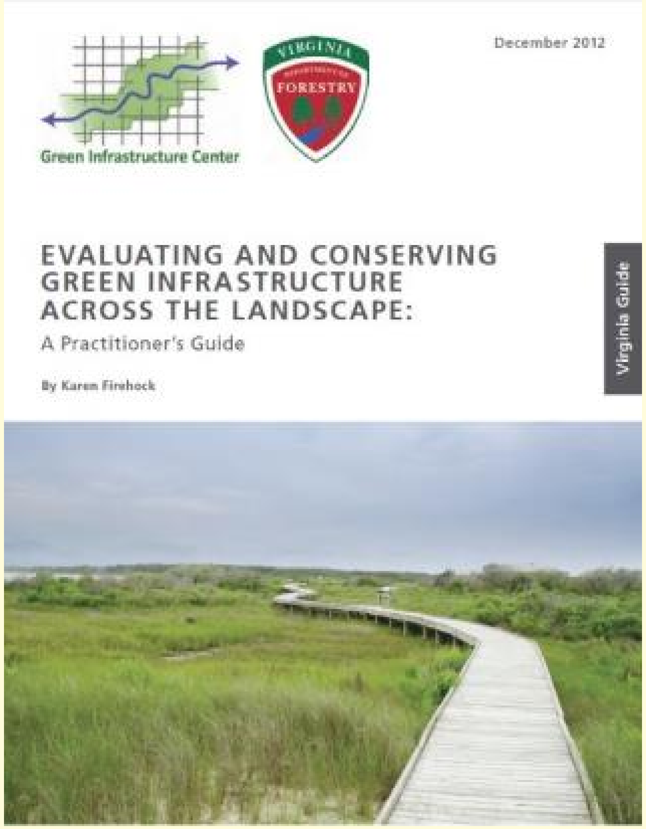


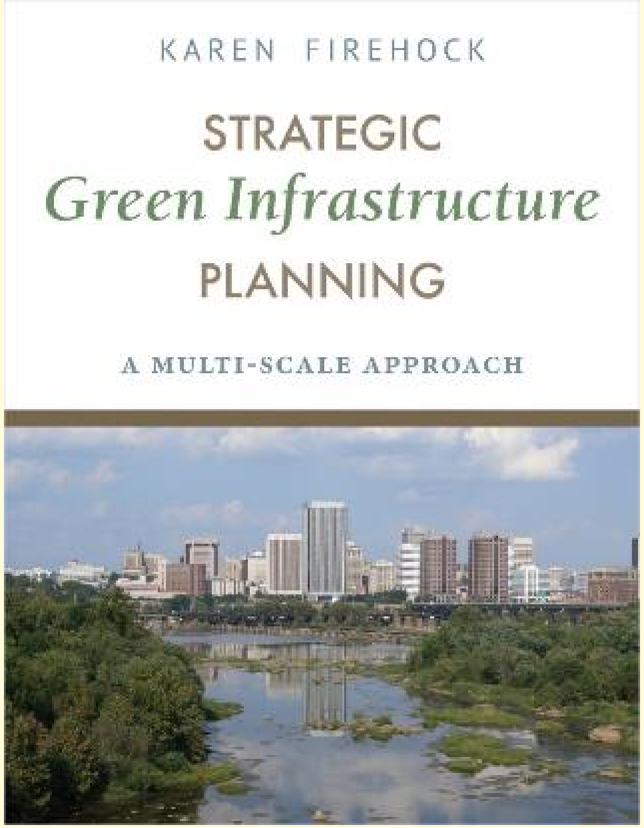
Norfolk, VA

Developing strategies for resilience and restoration in a city challenged by SLR, restoring and conserving.



GIC created state guides and models for green infrastructure planning at the national, state and county scale. Our state guide (left) discusses Virginia's state green infrastructure model and our national book (right) has a national focus and more urban examples.





Definition: What is green infrastructure?

A map of a city for one of GIC's projects (left) shows a neighborhood's gray infrastructure including buildings and roads. Classified high-resolution satellite imagery (right) adds a green infrastructure data layer (trees and other vegetation) .

Green Infrastructure: You may have heard of this as raingardens, bioswales or green rooftops. This is *constructed green infrastructure* for stormwater management. EPA added this idea in 2006 to the definition.

The key is to
1) Conserve natural green infrastructure (trees, forests, wetlands)
2) Protect and connect the landscape
3) Build in the least impactful manner
4) Then mitigate impacts with best management practices

First conservation, then mitigation.

Rain gardens

Green Rooftops

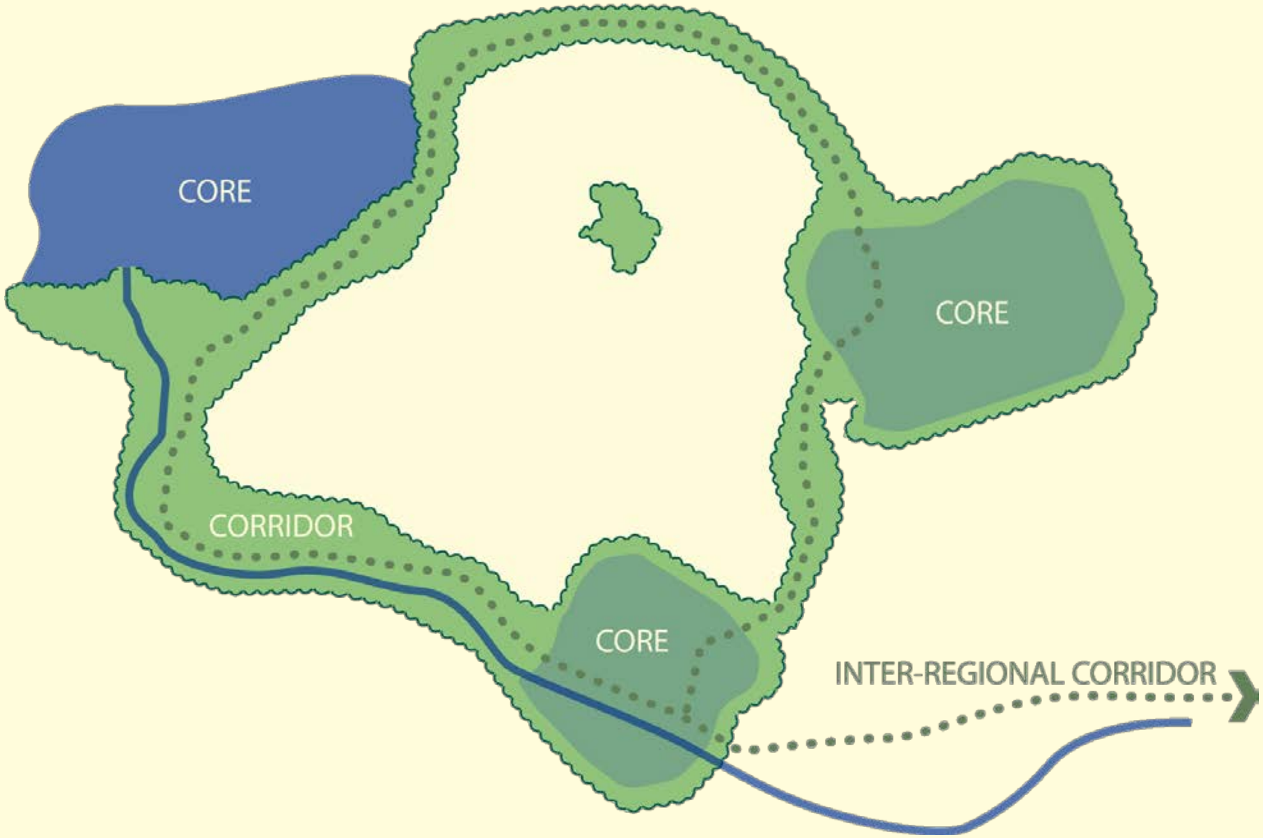
Filterra Boxes

Green Infrastructure Planning Requires Thinking About How to Connect the Landscape

It's about connecting the landscape!

Not just key habitat patches but how we connect them!

The more connected the landscape, the more resilient it is!



The problem of developments that protect green space without thinking about connections beyond parcel boundaries ...

Benefits of Conserving Green Infrastructure

- Preserving biodiversity and wildlife habitat.
- Conserving working lands such as farms and forests, that contribute to the economy.
- Protecting and preserving water quality and supply.
- Providing cost-effective stormwater management and hazard mitigation.
- Improving public health, quality of life and recreation networks.

Protecting Water Supply

Forests also protect surface water sources and aquifer recharge zones and reduce the cost of drinking water treatment.

American Water Works Association found a 10% increase in forest cover reduced treatment costs for drinking water by 20%.
(Ernst et al. 2004)

Intact Forests Protect Water Supply and = cheaper water treatment

Totier Creek Reservoir, Albemarle

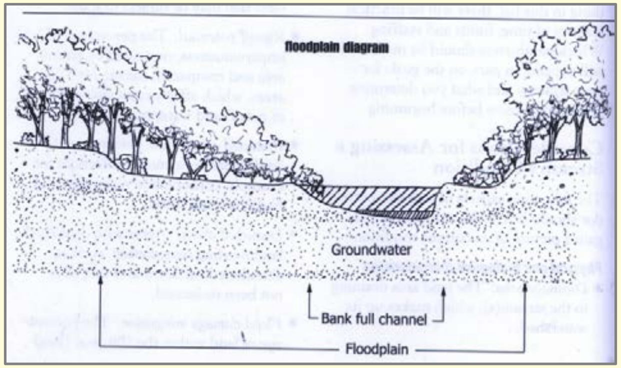
Urban Ecology -- Healthy Streams

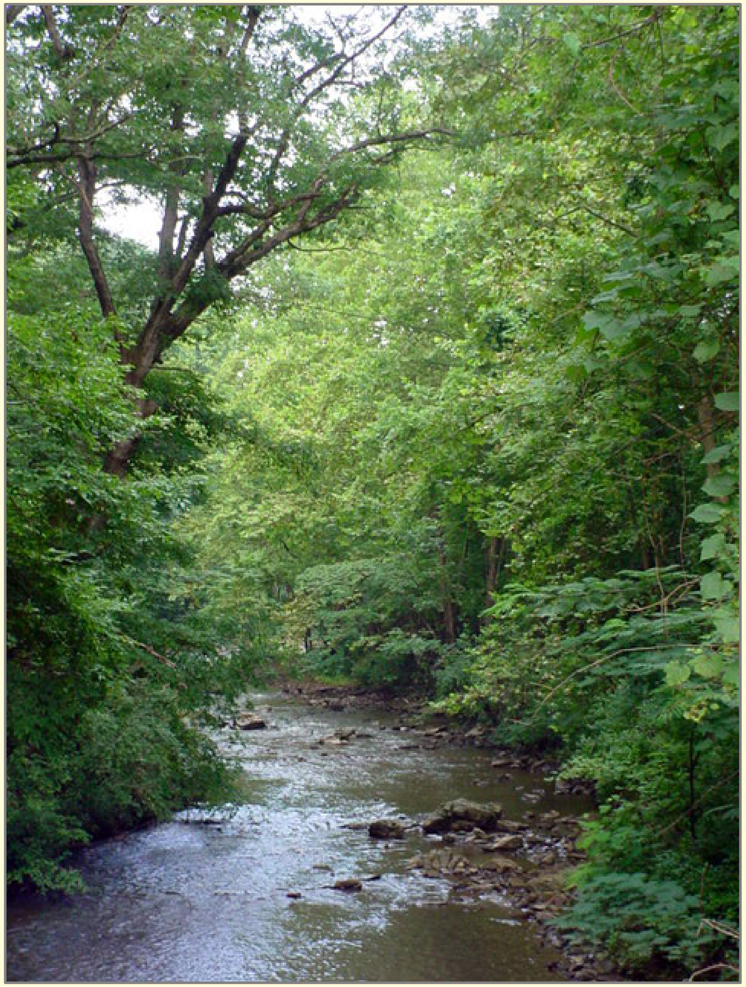
Native, woody vegetation, tree canopy to cool water

Stable vegetated banks, floodplains free of encroachment

Clear water, abundant and diverse, native flora and fauna

Lack of pollutants





Typical Unhealthy Urban Streams

Severely eroding banks

Silt covers stream bottom, unstable bars

Large debris flows and flood debris on banks

Lack of vegetation

Strange odors, colors

Toxics, lack of fish or invertebrates

Debris flows & erosion

Streambank failure

Pavement in the floodplain area, equipment leaks oil & grease

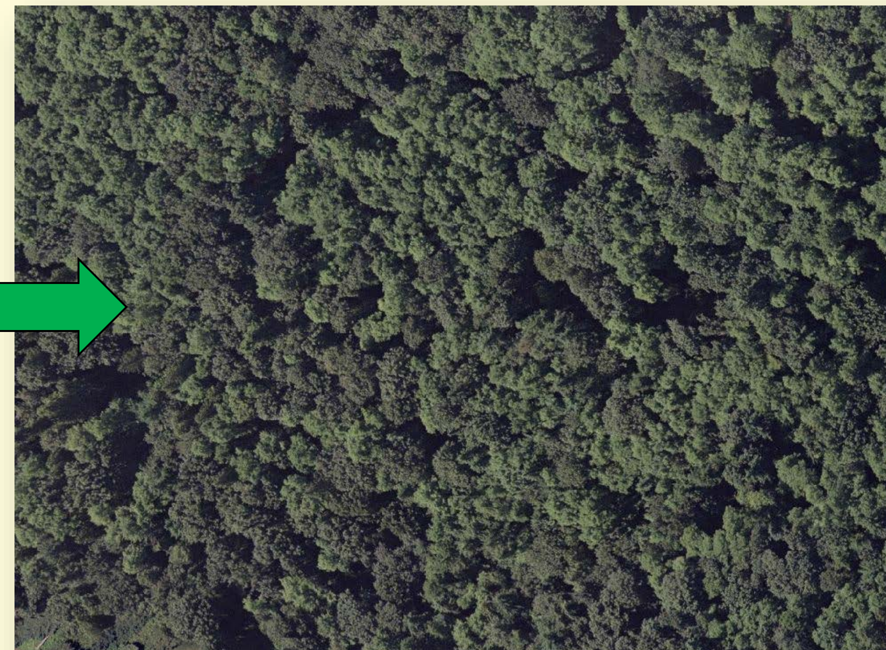
Most stormwater goes directly to streams! When stormwater goes under the buffer, it is not cleansed.

=

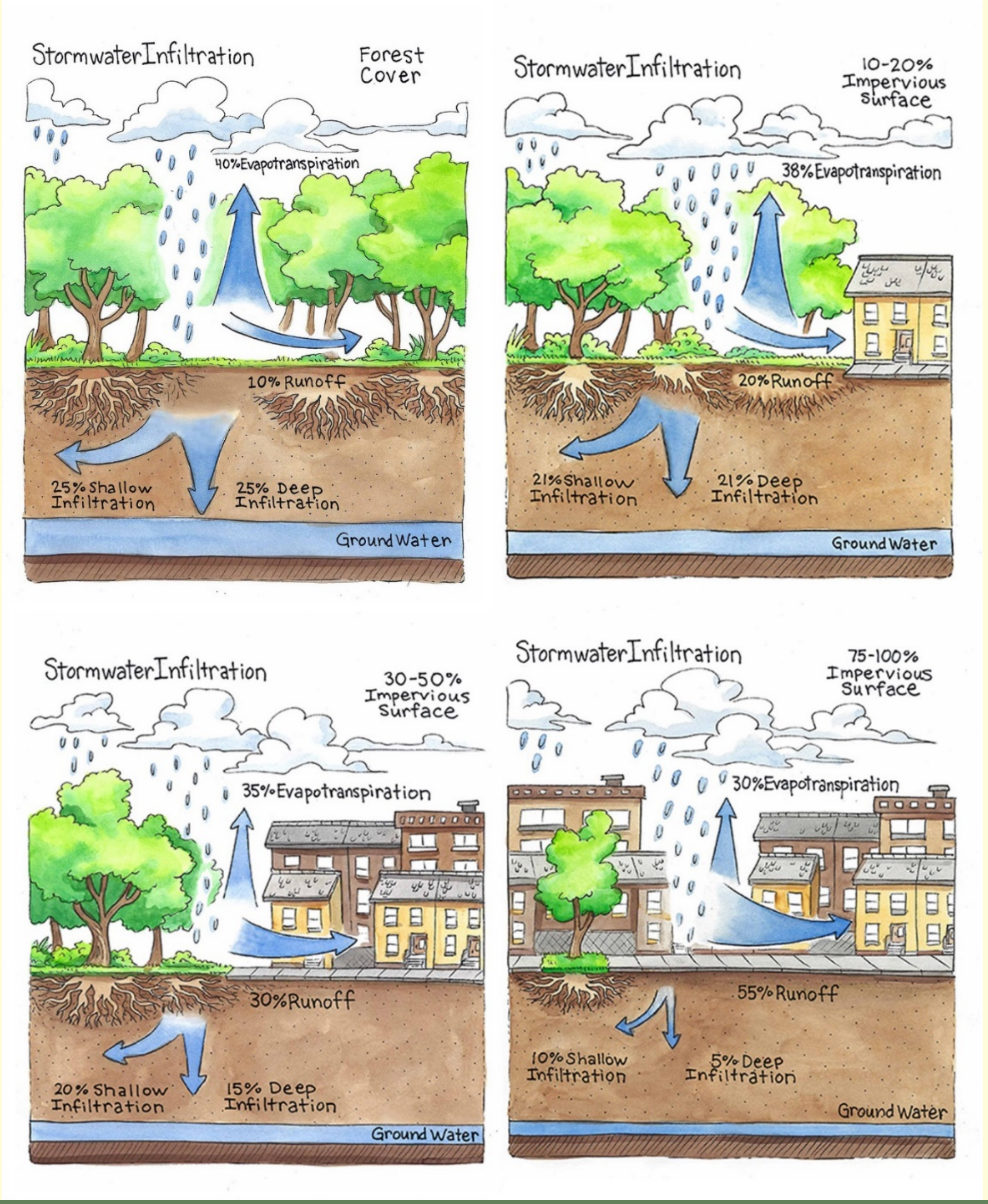
Water flow strategies

How do we make this…

function like this?



As land cover changes, so does stormwater infiltration …



Trees: the original –best – green infrastructure!

Trees give us cleaner air, shade, beauty and stormwater benefits at a cost that is far cheaper than engineered systems!

A typical tree can intercept water, ranging from 760 gallons to 4000 gallons per tree per year, depending on age and species.

*GIC is studying the role of trees for stormwater management in **6 states and 12 cities.** In VA they are Harrisonburg, Lynchburg and Norfolk.*
VA DOF and USFS fund this work!

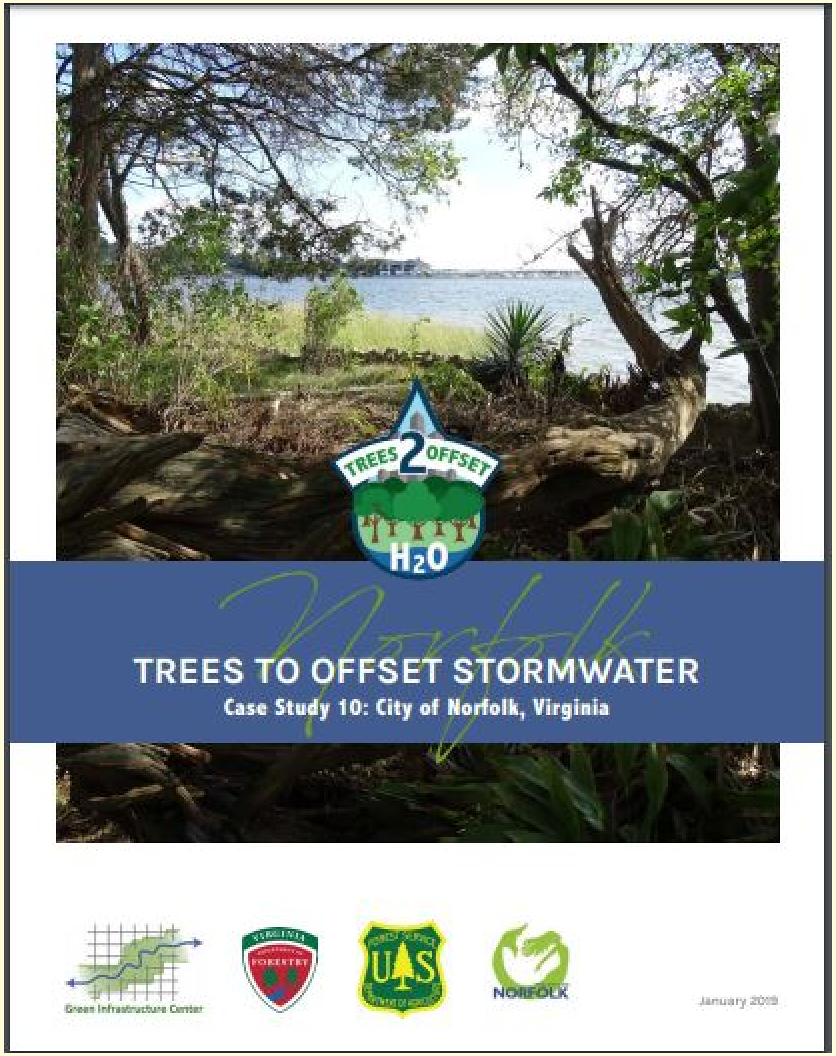
Project Goals

This project is helping communities map, evaluate, protect and restore urban forests for improved stormwater management and clean water.

Urban forests are a vital tool in managing and reducing runoff.

Project Outcomes

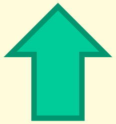
- ✓ Map of the city's urban forest and possible planting areas.
- ✓ Method for linking urban forest systems to urban stormwater management.
- ✓ Calculating stormwater uptake by trees
- ✓ Recommendations for how the city can adopt new programs, codes, processes to better integrate the city's trees as part of stormwater management
- ✓ Sharing the work – a case booklet and presentation detailing methodology, lessons learned, best practices

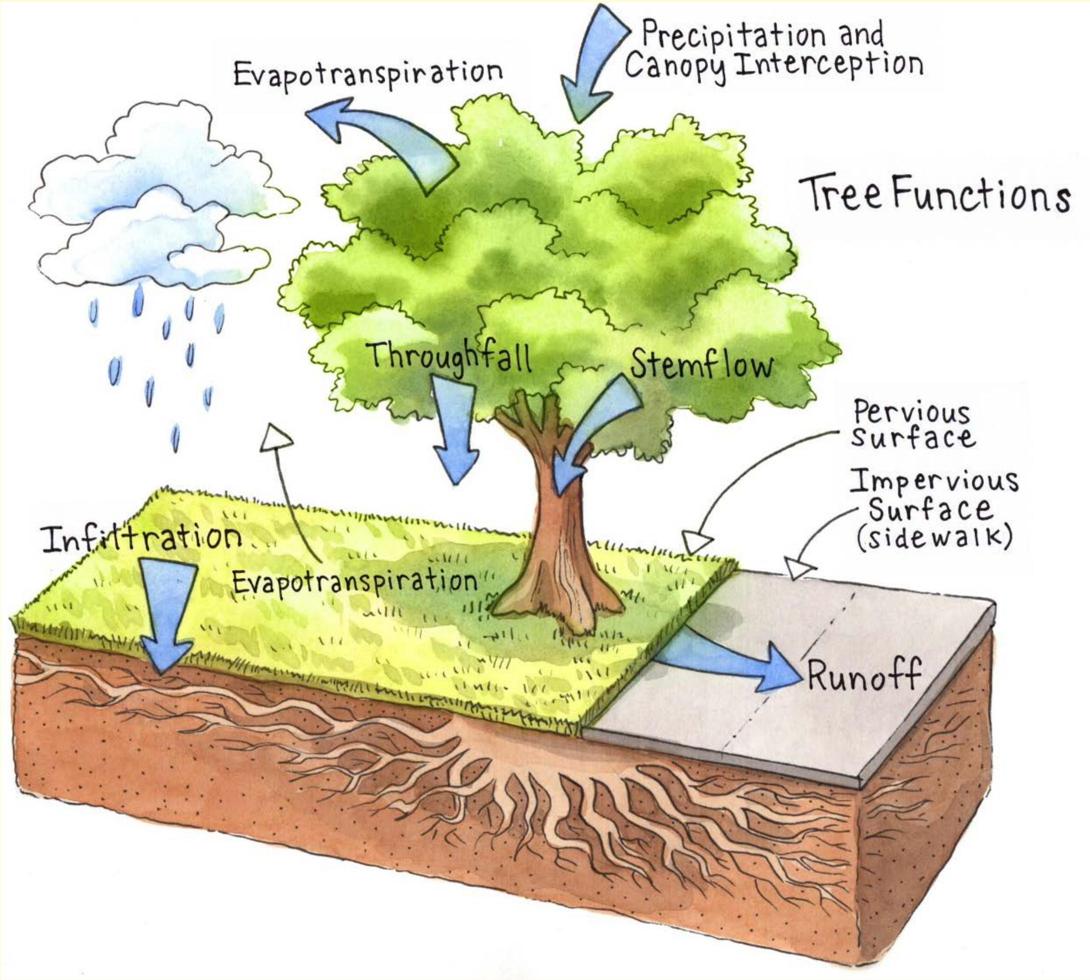


Urban Tree Canopy

20% of annual rainfall or > retained in crown
(Xiao et al., 2000)

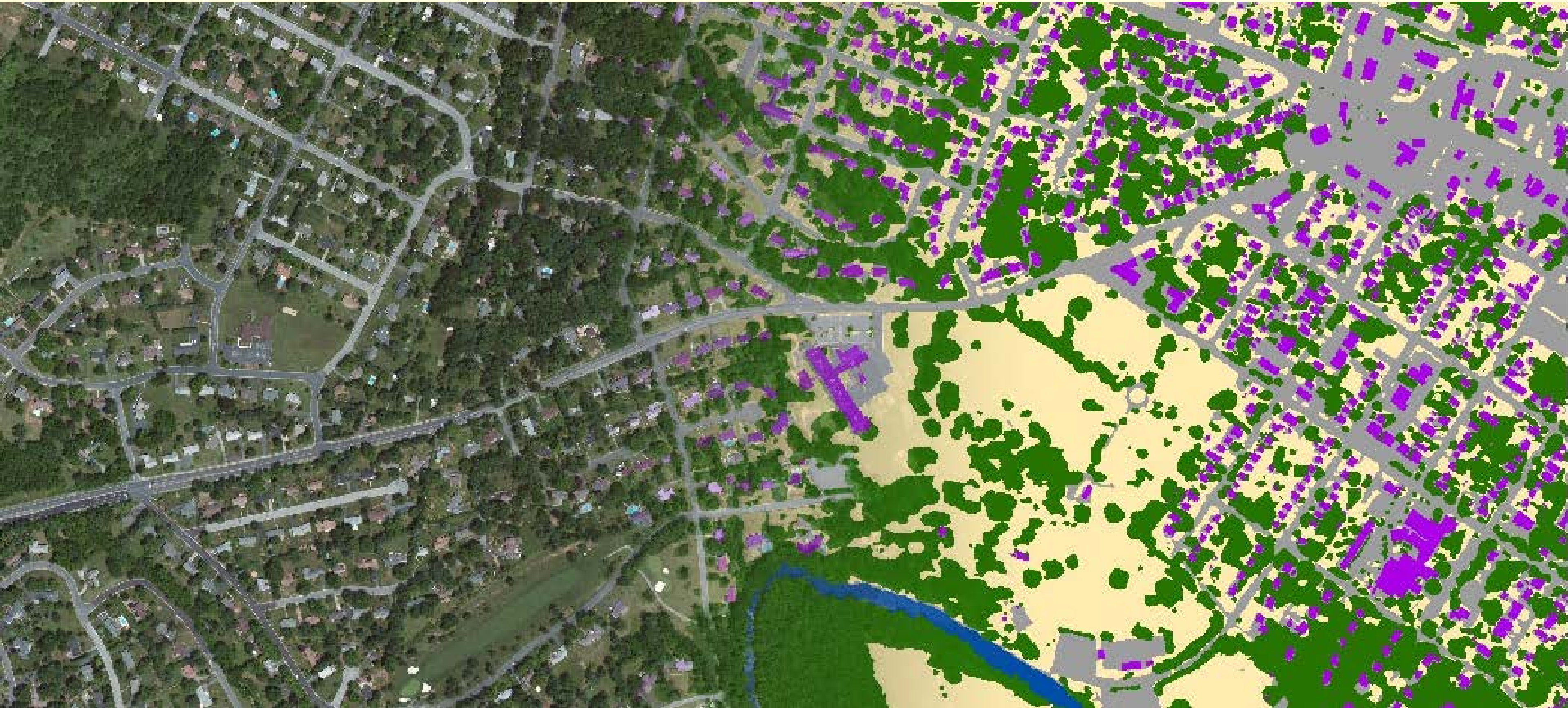
Delays runoff up to 3.7 hours


infiltration capacity of soils

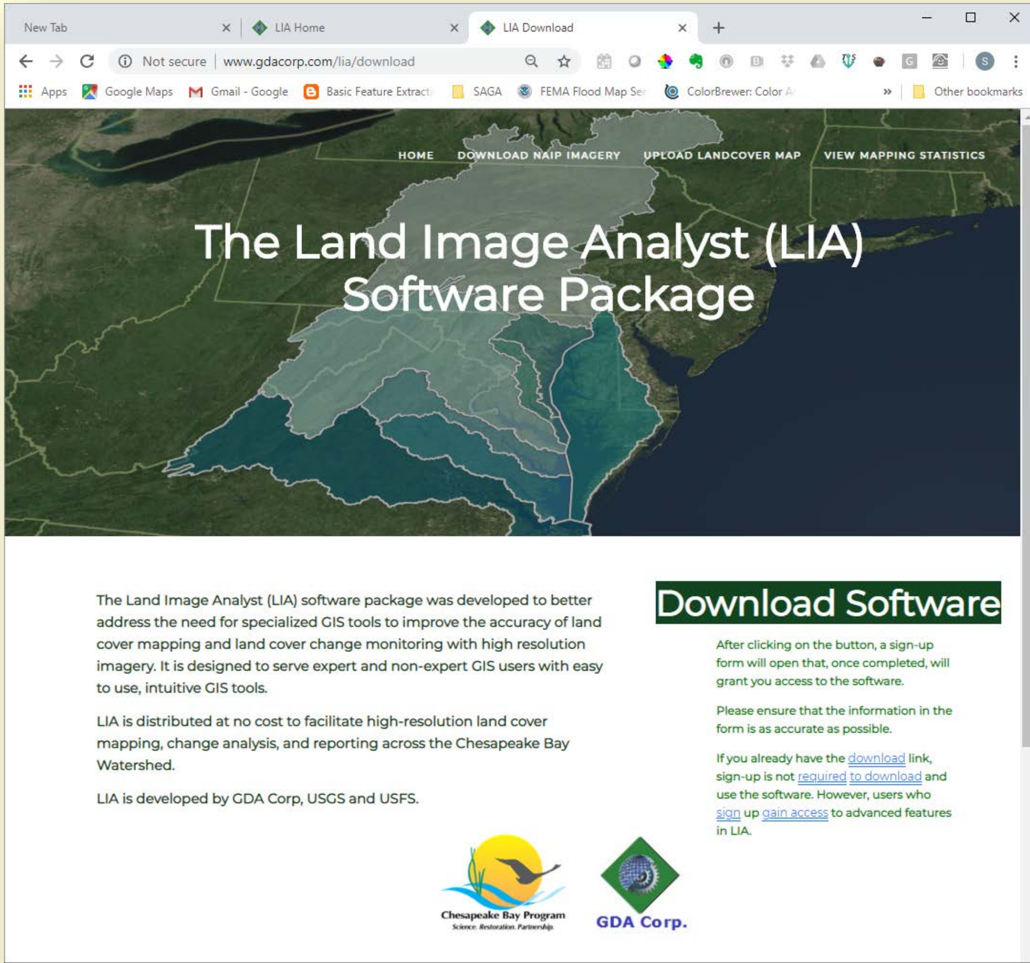


Mapping Land Cover – Using Image Classification

Image classification is the process of breaking an image into discrete 'classes', with one of the most common applications being to identify land use classes (urban, agriculture, forest, etc.) How impervious or infiltrative is your watershed? Where is your treed land?



A new tool to map your land cover... Land Image Analyst

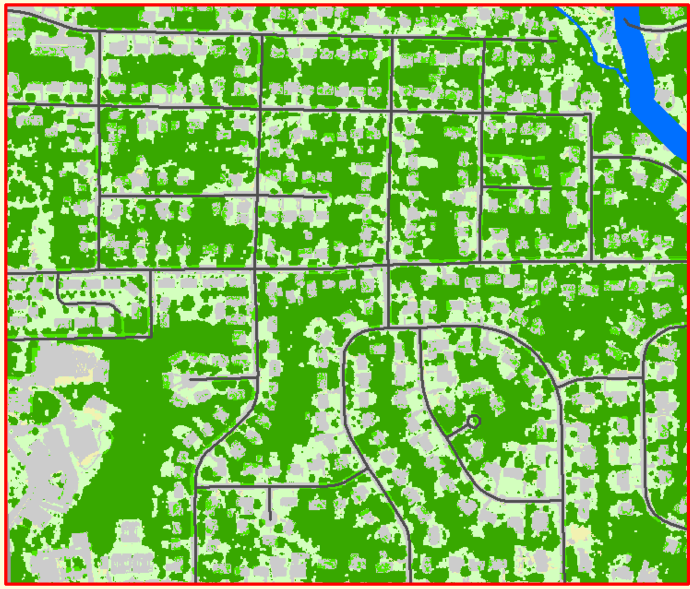


The Land Image Analyst (LIA) software package was developed by the USDA Forest Service Chesapeake Bay Program with technical support from GDA Corp to better address the need for specialized GIS tools, and to improve the accuracy of land cover mapping and land cover change monitoring.

- FREE
- Can be used stand-alone, OR
- Easily compatible formats to use with ArcGIS or QGIS.
- Best applied to smaller areas or cities.

What it is and what it used for.

- Land cover recognition tool that uses digital aerial imagery (Satellite and Aircraft) to create land cover data layer and calculate basic statistics for spatial planning purposes.
- Can be integrated with more advanced GIS software and be used as a primary remote sensing tool..



Supervised Classification

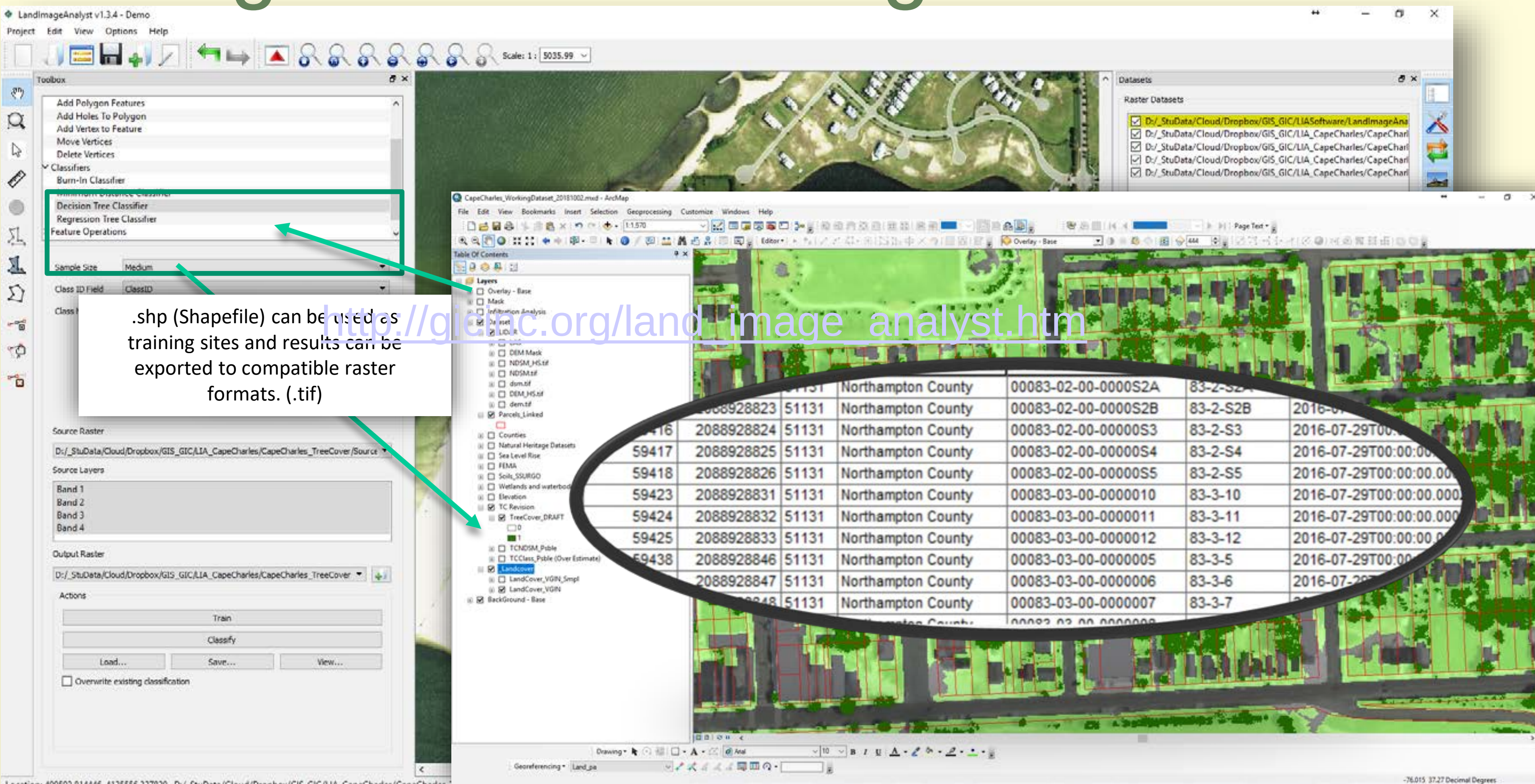
Involves carefully selecting ‘training samples’ from the imagery.

Each training sample contributes to building a ‘spectral signature’ for each land cover class.

The spectral signatures are used in the classification algorithms to predict the probability that a pixel is part a class (e.g. how well does a pixel match up with the spectral signature for the ‘tree’ class?)

Therefore, a number of techniques should be used to increase the probability that a pixel is put in the correct class, including field verifying the training samples, as well as the output classification

Quickly create tree canopy and integrate with existing datasets.

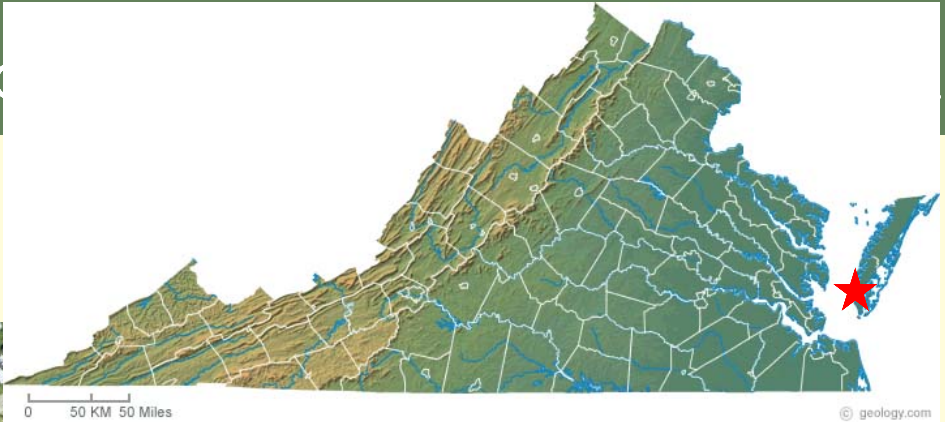


.shp (Shapefile) can be used as training sites and results can be exported to compatible raster formats. (.tif)

http://gicinc.org/land_image_analyst.htm

Cape Charles VA

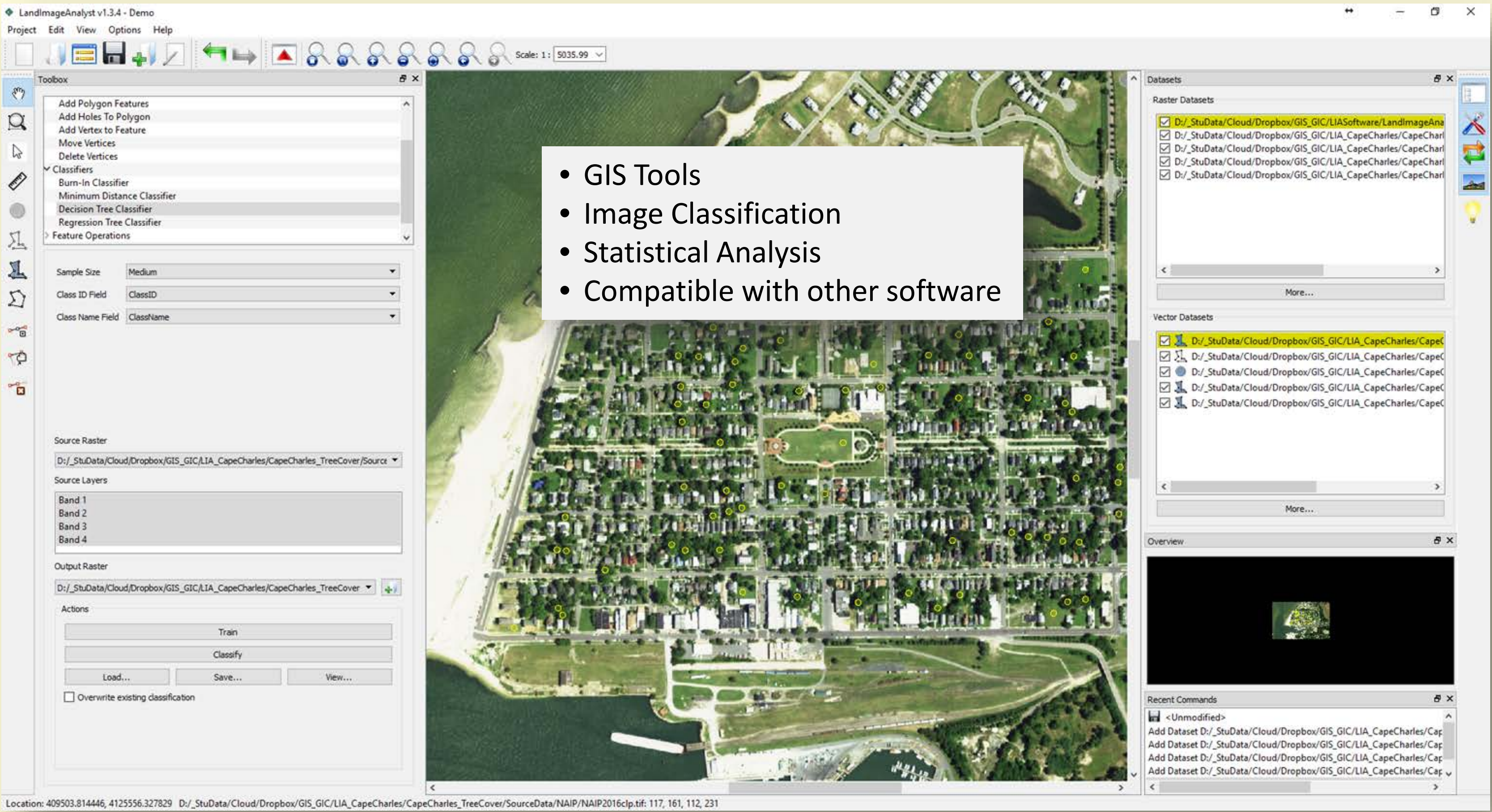
NAIP Imagery



Available Land Cover Dataset (VGIN)

Urban Tree Canopy Added using LIA

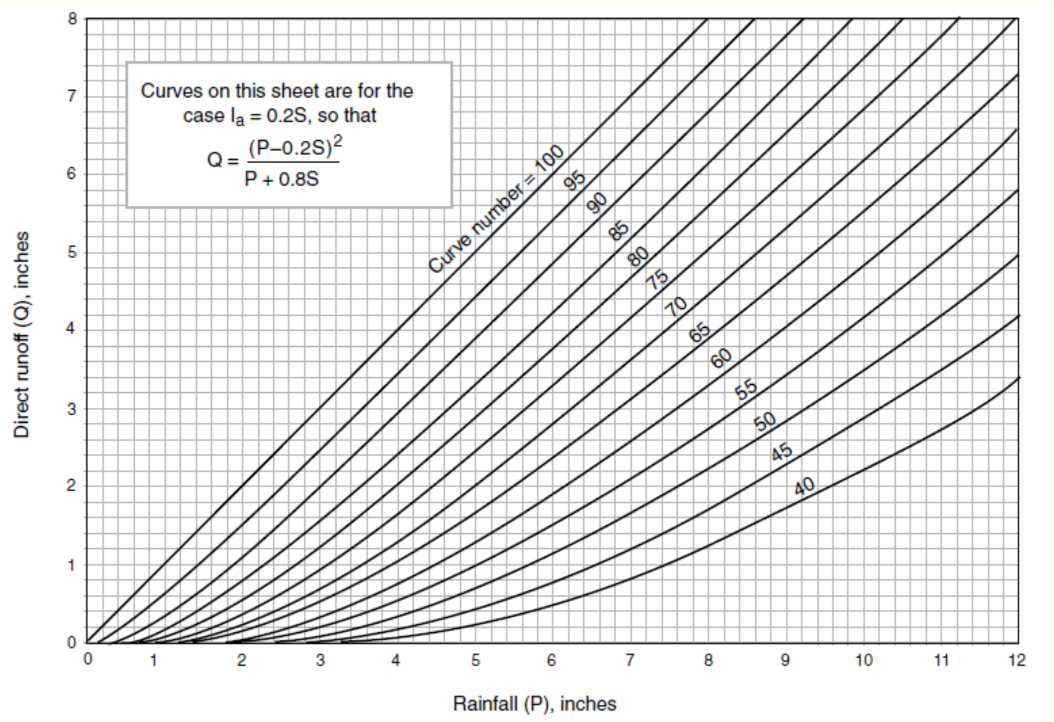
We have tested the LIA tool from the Chesapeake Bay Program and can train you to use it!



http://gicinc.org/land_image_analyst.htm

Determining how trees take up water. The NRCS Runoff Curve Number (CN)

- ✓ A coefficient used to estimate runoff from precipitation, accounting for losses due to canopy interception, surface storage, evaporation, transpiration and infiltration
- ✓ Curve numbers have been developed for a variety of land covers and soil conditions



CN by land cover and HSG

Cover	HSG – Hydrologic Soil Group			
	A	B	C	D
Forest open space	30	55	70	77
Urban tree canopy	37	59	72	78
Urban pervious	39	61	74	80
Impervious	98	98	98	98
Bare earth	72	82	87	89

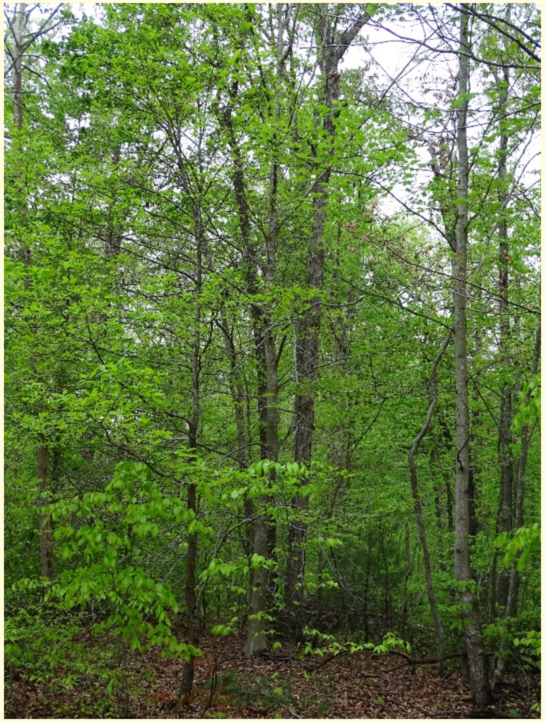
Hydrologic Soil Groups

A low runoff potential - high rates of infiltration & water transmission

B moderate runoff potential - moderate rates of infiltration & water transmission

C moderately high runoff potential - low rates of infiltration & water transmission

D very high runoff potential – very low rates of infiltration & water transmission, due to high water tables, high clay levels, clay pans, or shallow soils



Forested open space has understory vegetation, leaf litter and more porous soils = lower runoff

Forestry Work Group Study

Tree canopy works to reduce the proportion of precipitation that becomes stream and surface flow, also known as *water yield*.

The Hynicka and Divers study (1996) modified the water yield equation of the SCS model by adding a canopy interception term (C_i), resulting in:

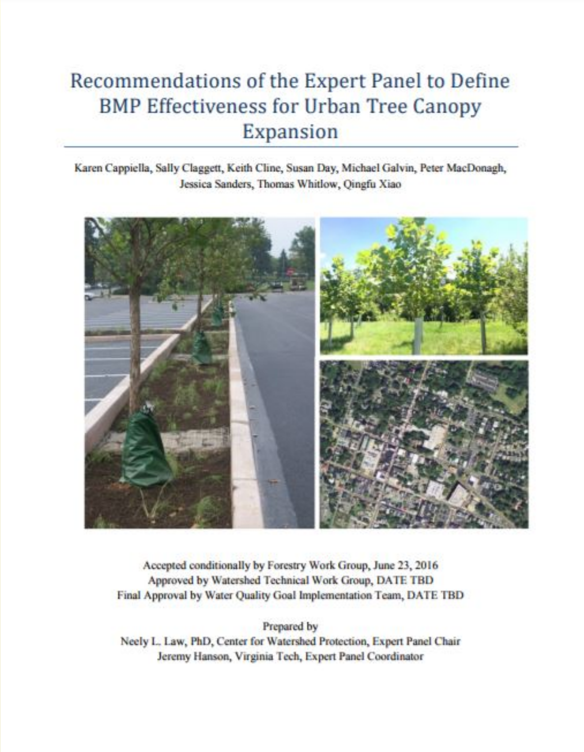
$$R = \frac{(P - C_i - I_a)^2}{(P - C_i - I_a) + S}$$

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 Cappiella, 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

How much stormwater do the trees uptake?

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.

Types of tree canopy cover

Tree Over Parking Lot

Tree Over Natural Forest Cover

Tree Over Lawn

Tree Over Street

The GIC stormwater calculator tool models the benefit of maintaining or increasing tree canopy.

Harrisonburg, VA | **Urban Tree Canopy Stormwater Model** | **version July 15, 2018**

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.

Green Infrastructure Center

TREES 2 OFFSET H2O

TOTALS	26.5%	38.4%	12.4	7.5	7.5	32%

Statistics by Drainage Basin (current settings)

	Area	Tree Cover	Impervious Cover	Tree H20 Capture	Increased H2O w/xx% tree loss	Added H2O Capture w/xx% PPA	Tree Cover Goal	Pick an Event	Pick a loss scenario				Enter Canopy % Increase		
		%		million gallons			%	Event	% UTC loss	%FOS Loss	PCA	PPA	Add Canopy	% of PPA	Acres
1	Blacks Run	24.9%	41.6%	9.73	5.99	5.99	30%	5 yr / 24 hour	20%	20%	40.9%	15.9%	5%	31.4%	9,066
2	Cooks Creek	33.4%	23.3%	1.70	1.00	1.00	38%	5 yr / 24 hour	20%	20%	53.2%	19.8%	5%	25.2%	1,348
3	Dry Fork	37.1%	23.4%	0.76	0.35	0.35	42%	5 yr / 24 hour	20%	20%	53.7%	16.6%	5%	30.1%	493
4	Linville Creek	21.1%	44.4%	0.11	0.08	0.08	26%	5 yr / 24 hour	20%	20%	36.4%	15.3%	5%	32.8%	118
5	Mill Creek-North River	36.5%	34.2%	0.09	0.04	0.04	41%	5 yr / 24 hour	20%	20%	53.5%	17.0%	5%	29.5%	87
6	Town of Keezletown-Cub Run	61.0%	0.7%	0.06	0.03	0.03	66%	5 yr / 24 hour	20%	20%	93.9%	32.9%	5%	15.2%	15
7															

The calculator tool shows how much runoff will occur if new trees are planted or existing trees are preserved.

- Build the use of the tool into the development process.
- Understand which landscapes and parcels take up the more stormwater. Protect those parcels.

Stormwater Uptake Calculations: Scenarios

Modeling Increased Development in the Incorporated Area

				1-inch storm
What if? -Loss of Canopy			**P**	1.00
Change % below		**Land Cover Class**	**Q (in)**	**Runoff (gals)**
20%	**urban**	Tree over pervious	0.02	16,841,474
30%	**woodland**	Woodlands A	0.00	-
Increase in Runoff Yield		Woodlands B	0.00	-
29%		Woodlands C	0.04	2,317,008
for 1-inch storm		Woodlands D	0.11	830,488
Impervious Ratio*		Tree over impervious	0.59	33,238,913
Change % below		Pervious	0.07	25,522,443
65%		Water		
* portion of canopy loss		Impervious	0.79	379,743,705
that becomes		Bare earth	0.63	74,231,842
impervious surface				**532,725,873**

That's 5,327,259 bathtubs of stormwater!

It also calculates change in Nitrogen, Phosphorus and Sediment loadings.

Stormwater Uptake Calculations: Scenarios

Modeling Possible Canopy Area and Stormwater Benefit in the Incorporated Area

What if? Percent of PCA Planted
Change % below
50%
Decrease in Runoff Yield
5.9%

Land Cover Class	P Q Runoff (in)	1-inch storm 1.00 Runoff (gals)
Tree over pervious	0.02	18,293,099
Woodlands A	0.00	-
Woodlands B	0.00	-
Woodlands C	0.04	2,317,008
Woodlands D	0.11	830,488
Tree over impervious	0.59	54,793,613
Pervious	0.07	25,520,944
Water		
Impervious	0.79	353,829,856
Bare earth	0.63	13,756,840
		469,341,848

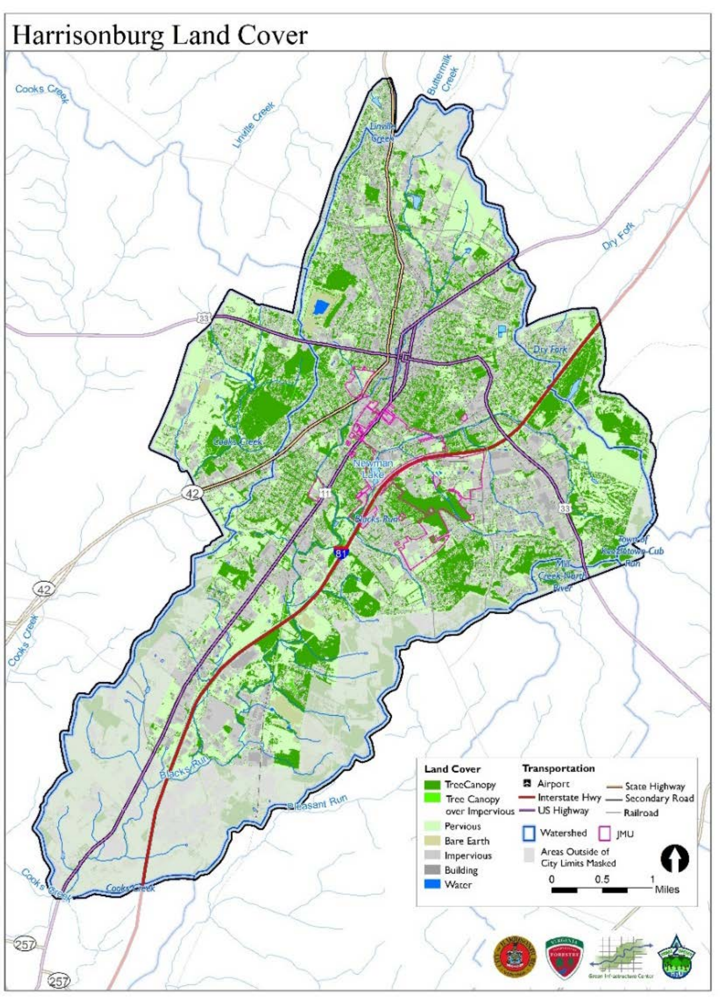
Knowing the current tree canopy coverage and possible planting area, develop tree canopy goals for the community.

That's 4,693,418 bathtubs of stormwater!

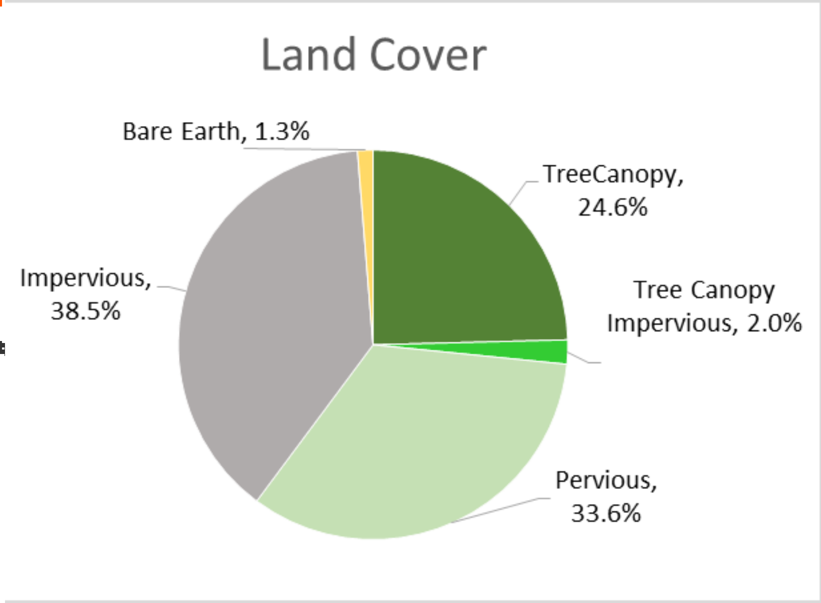
Use The Tool To Develop Tree Canopy Goals by Watershed.

Knowing the current tree canopy coverage and possible planting area, develop tree canopy goals for the community.

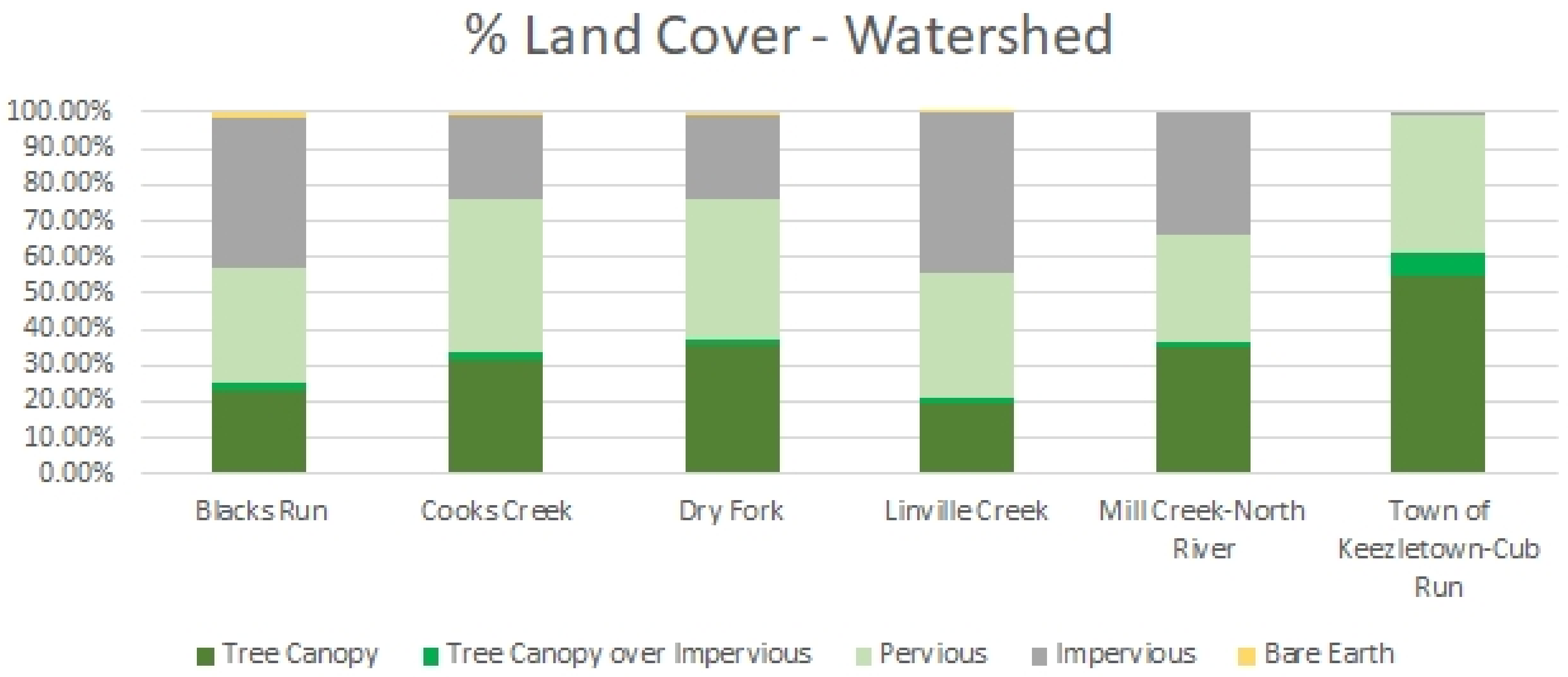
- Determine how tree canopy coverage goals will be met.
- Determine benchmarks for and ensure adequate funding for achievement of tree canopy coverage goals.



Harrisonburg VA Tree Cover

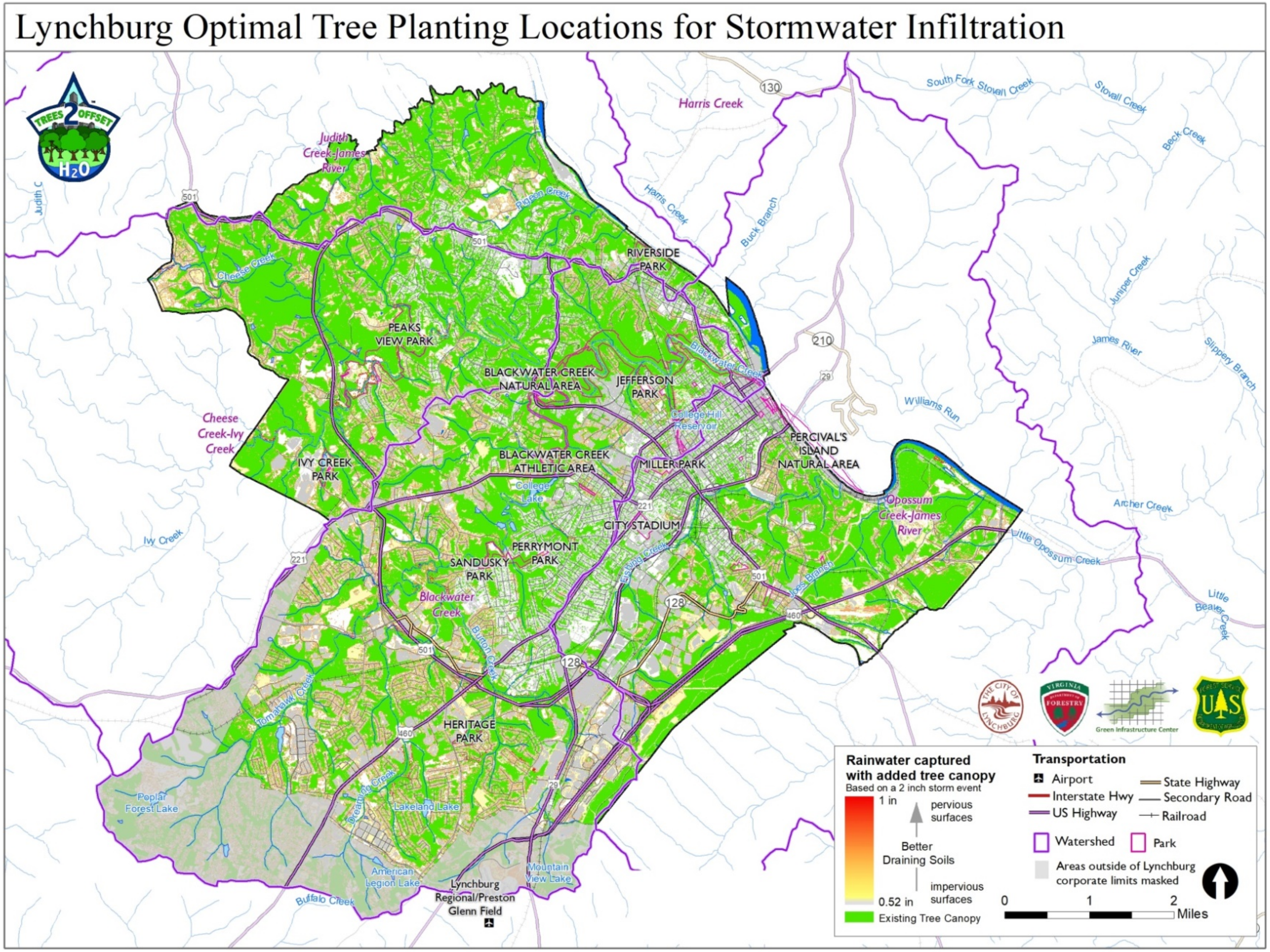


Harrisonburg Land Cover
How well treed is each watershed?



Where Can We Fit Trees?

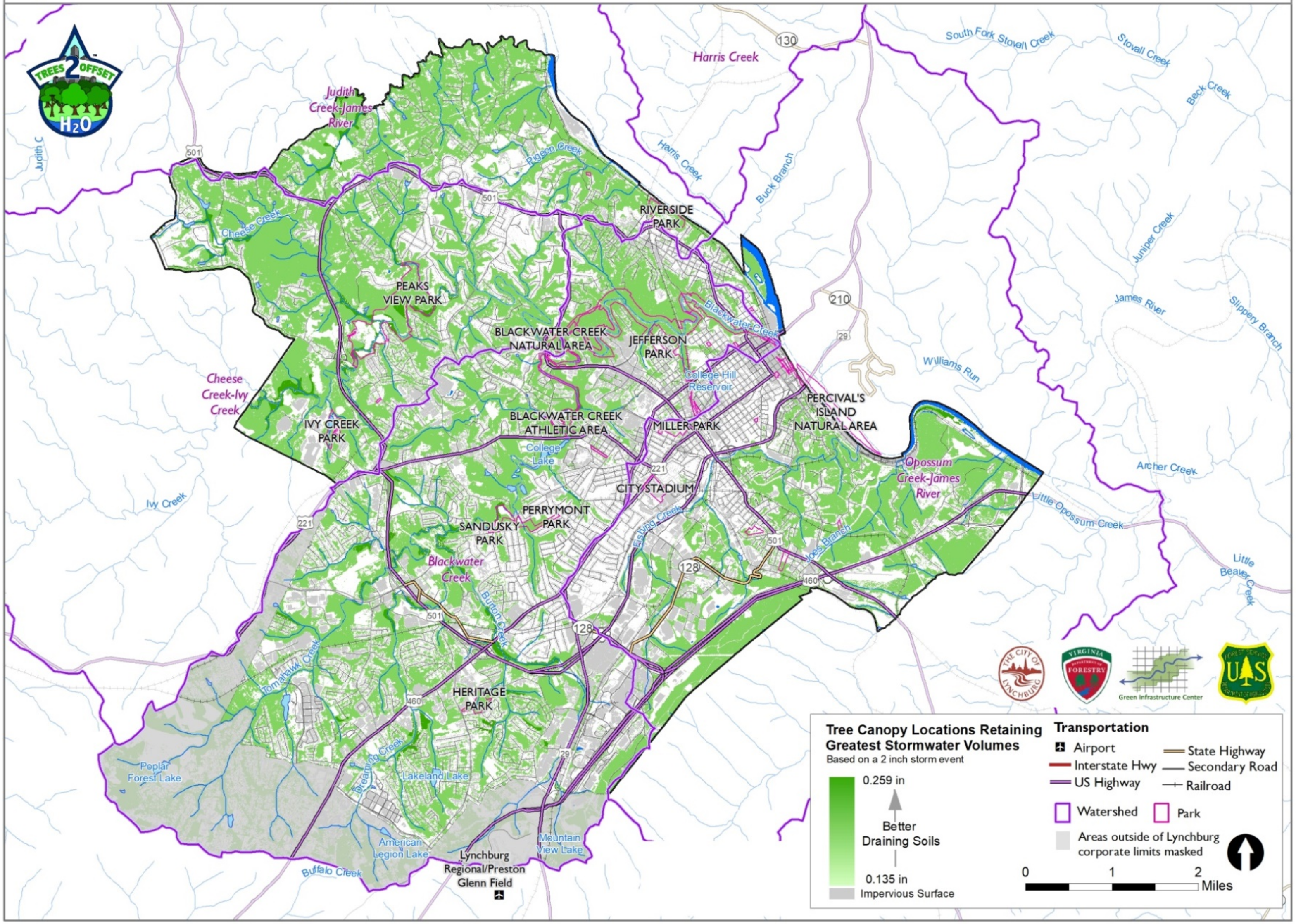
Possible Planting Areas



All planting areas are not created equal.

Optimal Tree Planting Location

Lynchburg Best Canopy Retention Locations for Stormwater Infiltration



Optimal places to retain canopy