Filling a Need: Developing training for stormwater managers about the influence of trees on urban stormwater

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Training is based on:

- Current research review and extrapolation, modeling of KC area watersheds (Trisha Moore's) presentation.
- Informed by survey results of stormwater managers.
- Meta-analysis of co-benefits database.
- Healthy, growing trees provide the most benefits.

Acknowledge several excellent review reports

- Maximizing Stormwater-Related Benefits at the Tree or Site Scale
  - 2014, Stone Environmental for U&CF, VT Dept. Forests, Parks & Recreation, J. Moore, A. Macrellis, K. Bailey.

- Urban Watershed Forestry Manual (part 1, 2, 3)
  - 2005, 2006a, 2006b, CWP for USDA-FS, NA-S&PF, K. Cappiella et al.

Training Products

- Delivered via an archived webinar hosted by the Water Research Foundation. cbarden@ksu.edu.
- Review of refereed research on stormwater impacts of trees.
- Factsheet on predicting urban tree contributions to runoff.
- Factsheet on incorporating forestry into stormwater management.
- Database meta-analysis of co-benefits (Access, Excel) with factsheet and user guide bulletin.

Stormwater manager's survey

- Online Qualtrics survey conducted May-June 2018
- Promoted via email and newsletter invitation
- 52 respondents from across the US, 16 states
- One third were from 3 states, CA, FL, and TX

Stormwater manager's survey

- Overall results were positive, but showed room for improvement
- $\geq$ 60%
  - Consider trees and wooded areas in planning
  - Incorporate trees in engineered stormwater structures
  - Promote trees for their effect on stormwater
- 67% collaborate with city arborist/forester
- Similar survey distributed to Arborists, but only 9 replies

When planning a new stormwater project, do you consider the projected amount of tree canopy in the development watershed?

- 44% yes
- 6 out of the 21 yes respondents provided the method
  - GIS-based canopy coverage data x 2
  - Tree canopy reflected in runoff curve number
  - Measure caliper and canopy of existing trees, unsure if this is used in project modeling
  - NRCS runoff curve number

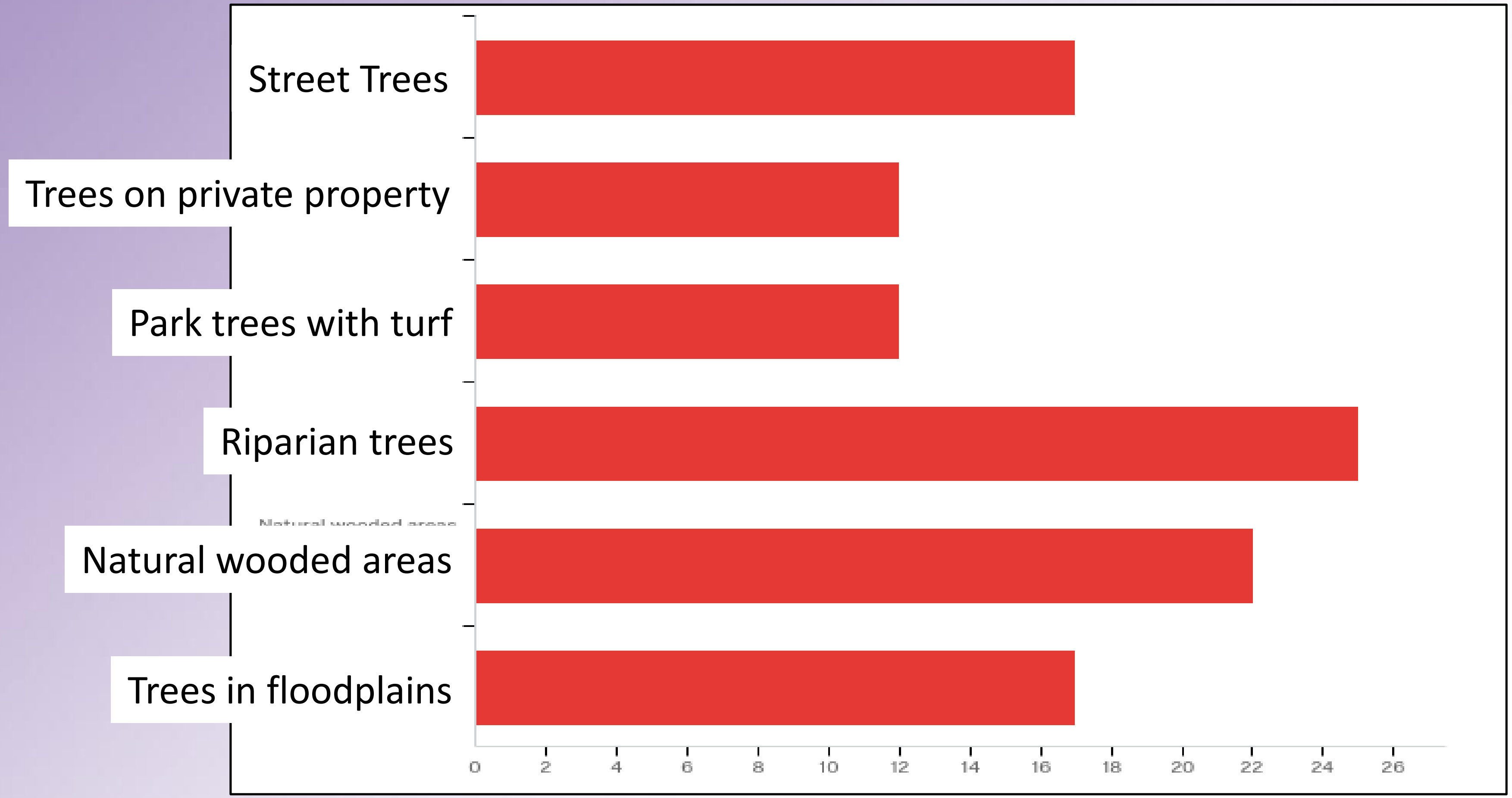
Modified Simple Method

Rv = (%N× RvN + (%C) × RvC + (%I) × RvI

where: Rv = weighted site runoff coefficient

%N = percent of site in natural cover
AN = area of post-development natural cover (ft2)
%C = percent of site in compacted cover
AC = area of post-development compacted cover (ft2)
%I = percent of site in impervious cover
AI = area of post-development impervious cover (ft2)
SA = total site area (ft2)
RvN = runoff coefficient for natural cover (0.00)
RvC = runoff coefficient for compacted cover (0.25)
RvI = runoff coefficient for impervious cover (0.95)

What tree locations do you consider when assessing stormwater effects?

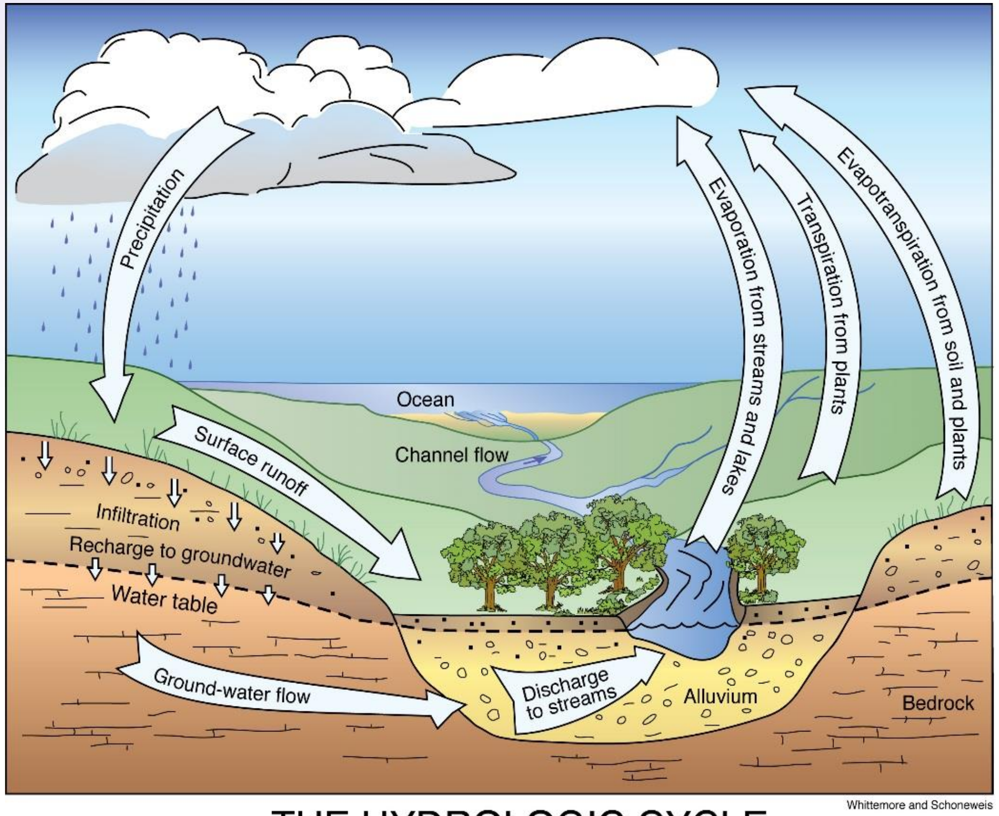


What values and benefits to do you attribute to the location of trees?

- Street trees
- Trees on private property
- Park trees with mown grass groundcover
- Trees in riparian (streamside areas)
- Natural wooded areas with understory plants and a ground cover
- Trees in floodplains

Incorporating Forestry Factsheet

- Basic Hydrology
- Streamflow components
- Goal of green infrastructure
- Development effects on the hydrograph



THE HYDROLOGIC CYCLE

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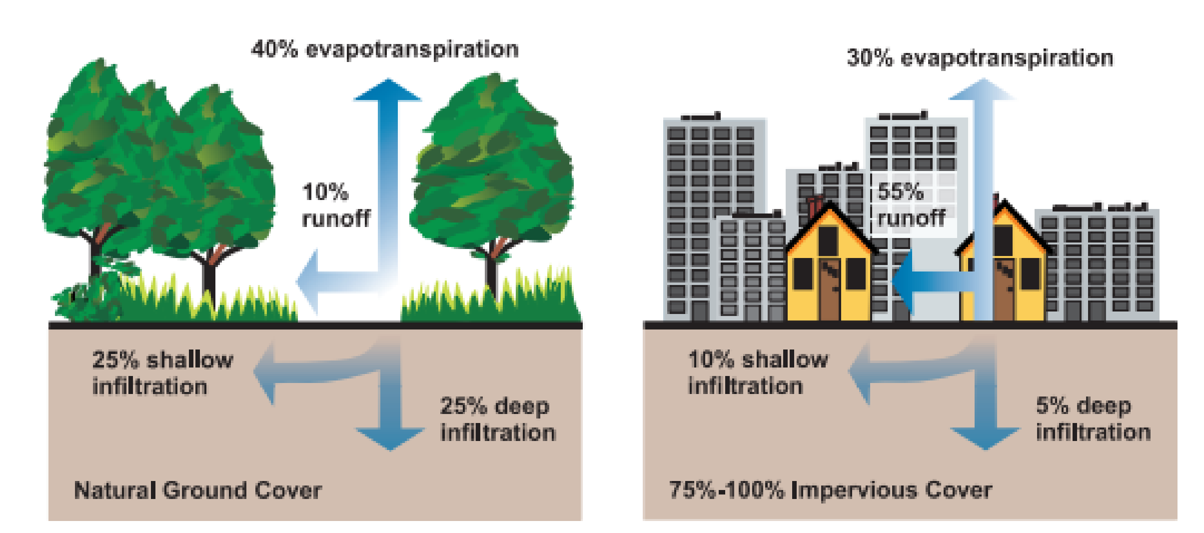
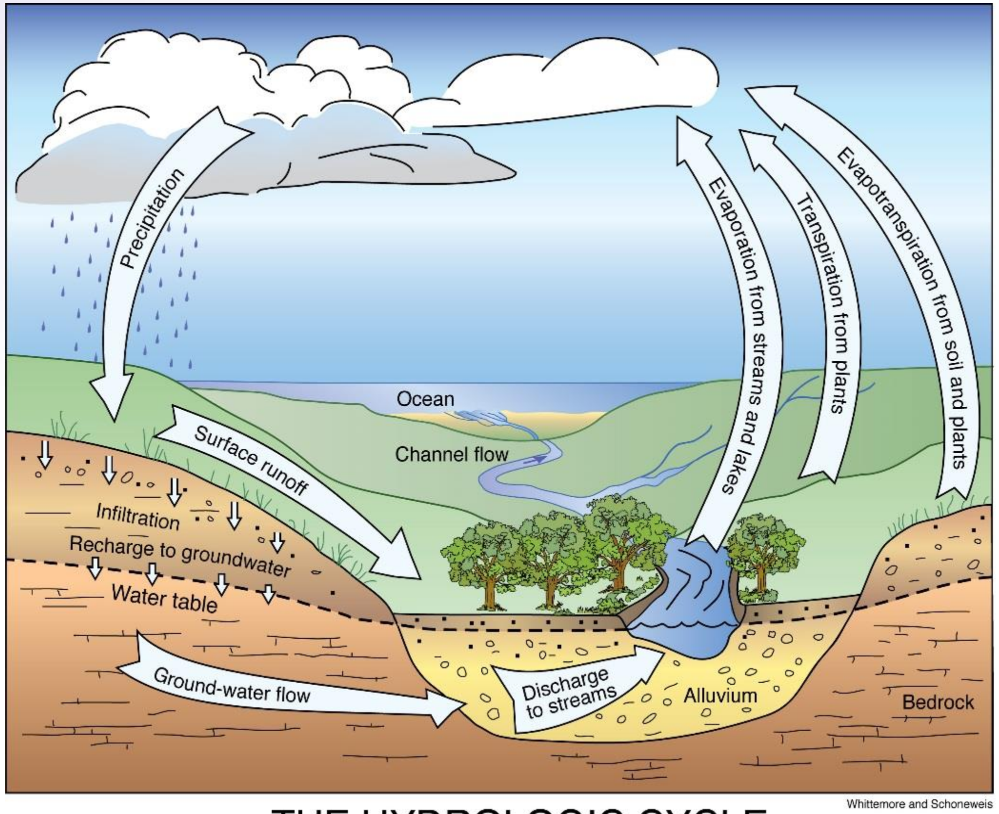
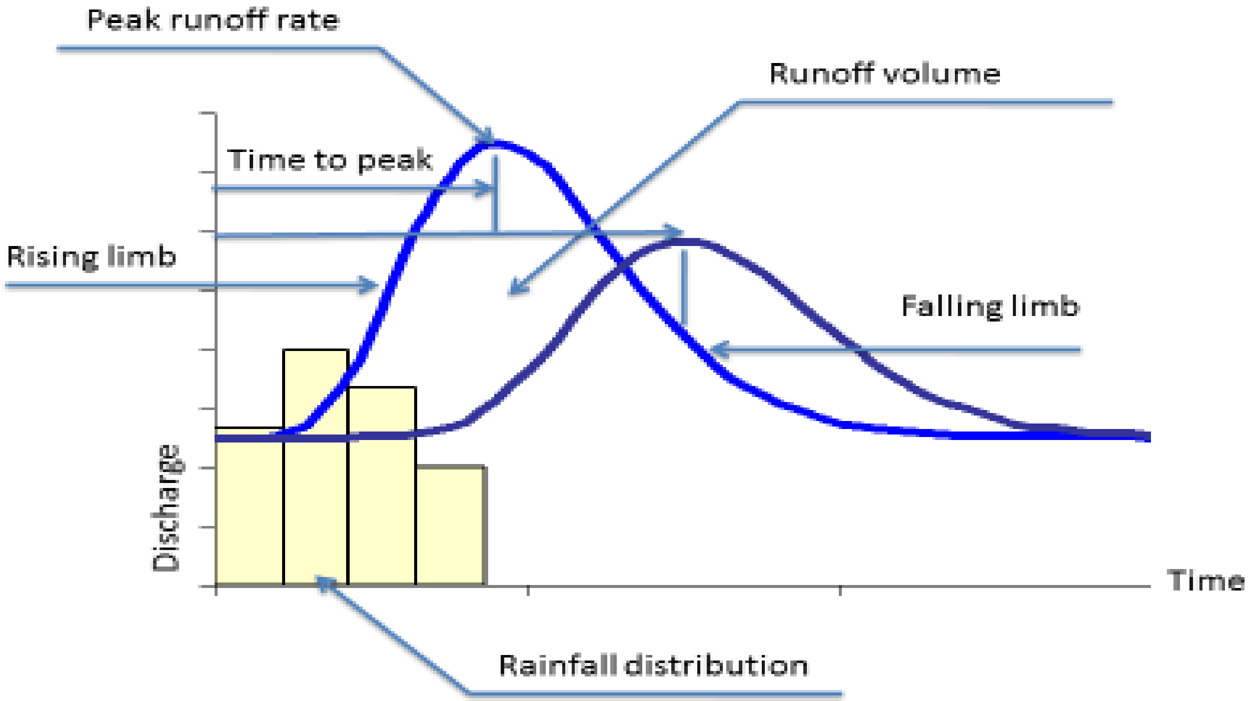




THE HYDROLOGIC CYCLE

Anatomy of a hydrograph: pre- to post-development



Knowledge for Life

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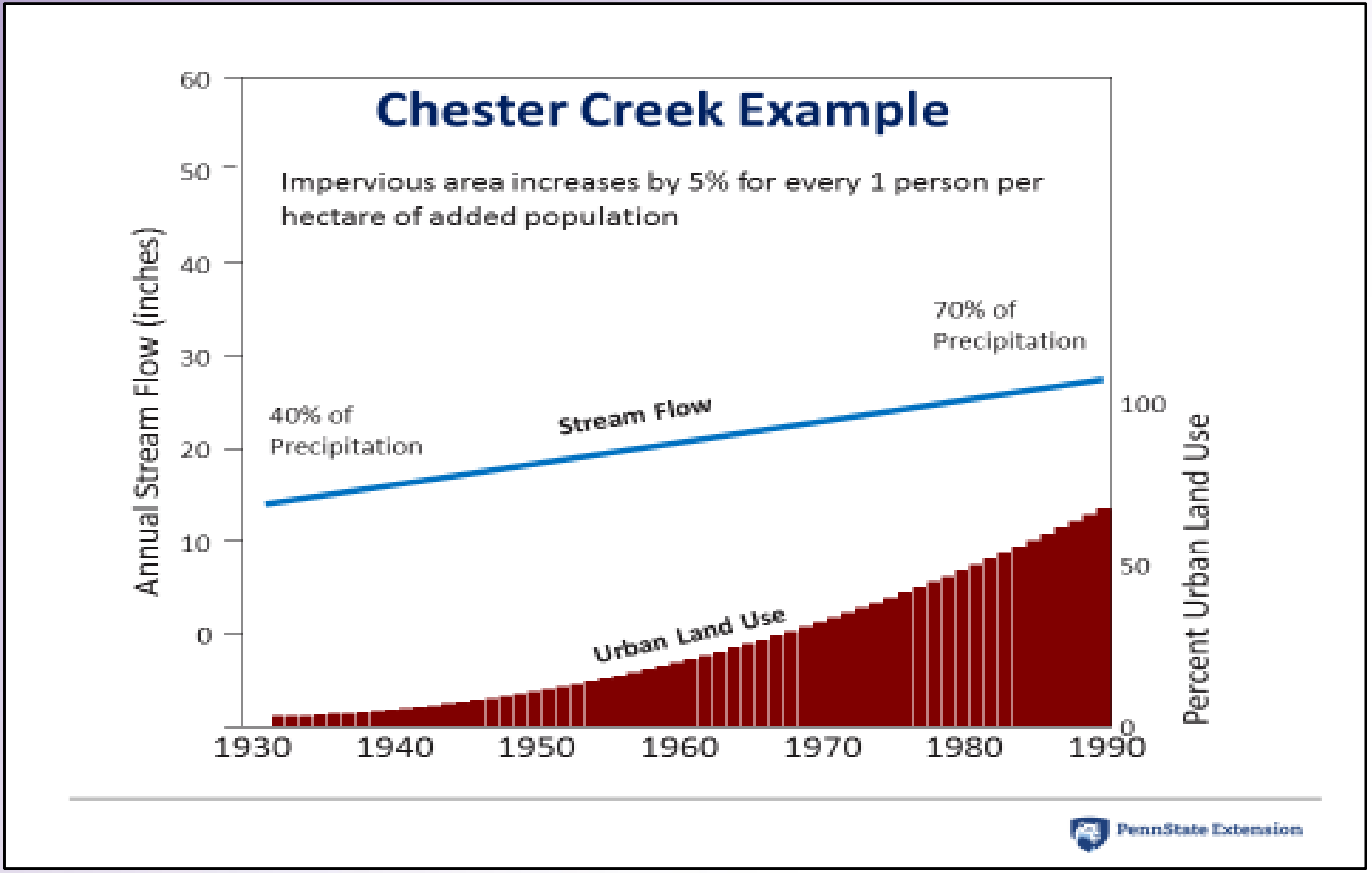

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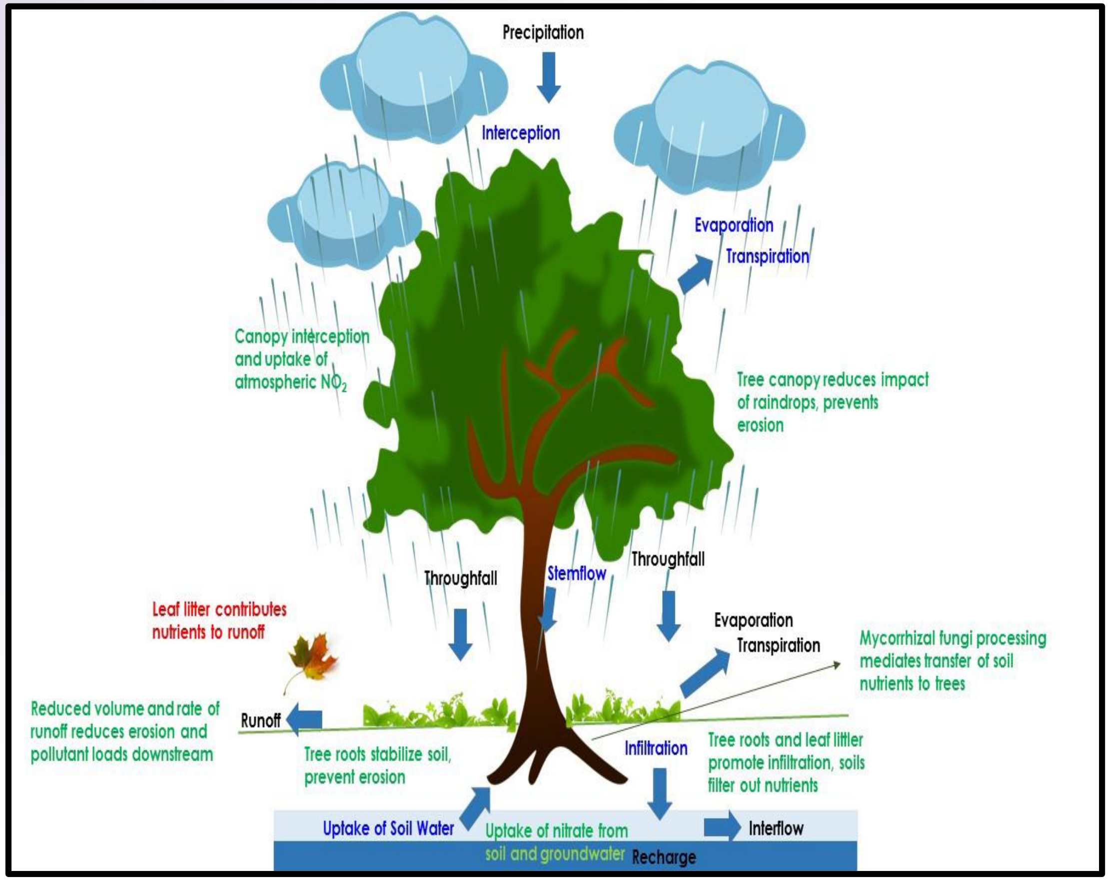
How do trees reduce stormwater volumes?

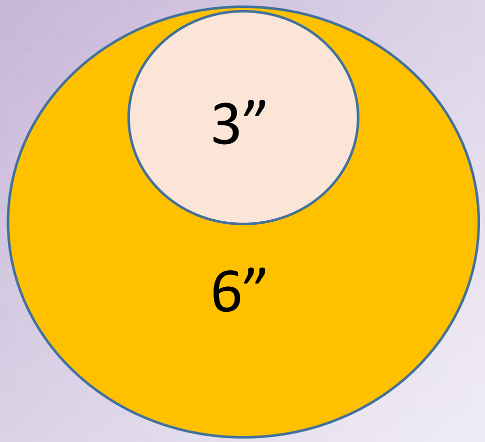
- High evapotranspiration Et rates
- Interception (17%-31%)
- Reduced energy and volume of throughfall
- Stemflow with infiltration at base of tree



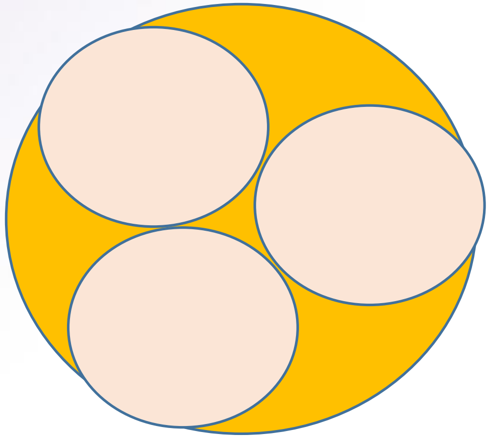
Knowledge for Life

Tree characteristics that maximize stormwater benefits

- Larger trees greatly increase stormwater control and other co-benefits, based on area of the crown or trunk cross section.
- A 6” diameter tree will have >3 times the impact of a 3” tree.
- Area of a circle 3.14 x radius ^{2}



7.1 in^2 vs
28.3 in^2



21.3 in^2 vs
28.3 in^2

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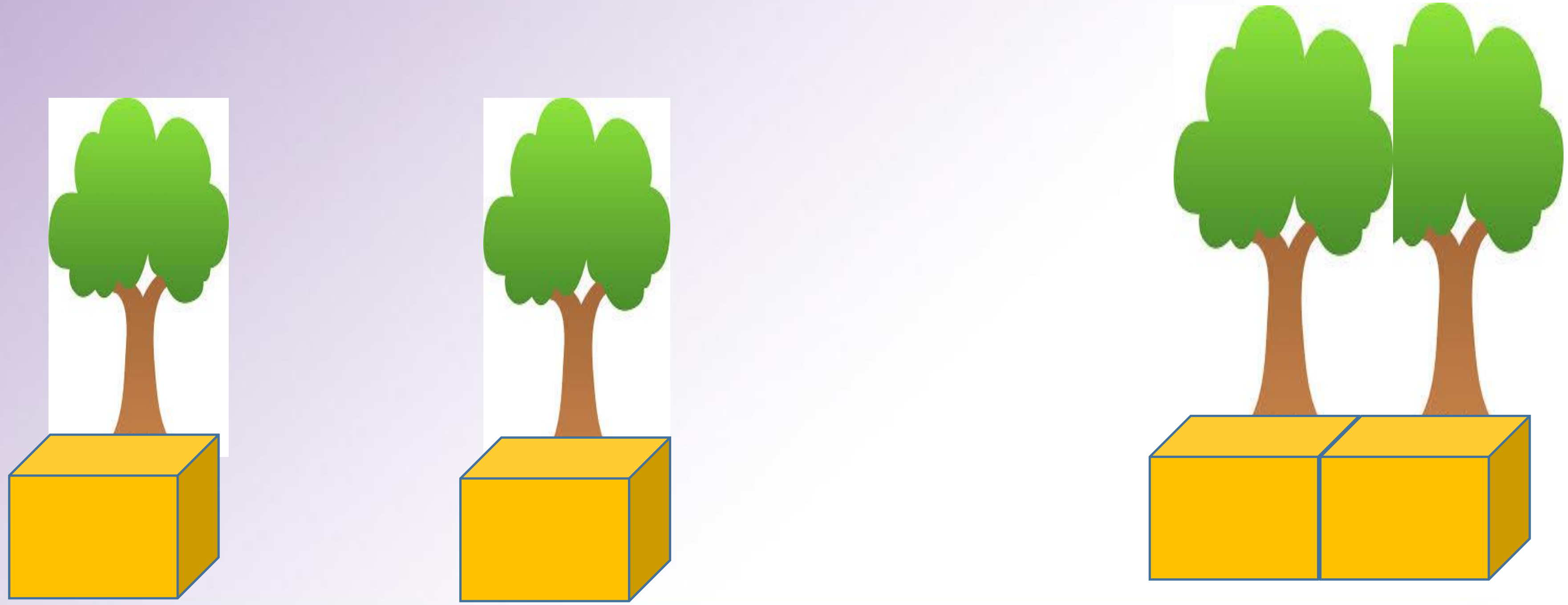
How to grow larger trees?

- Select species that are well adapted to the site conditions.
- Increase available rooting volume
  - One large planter (96 $ft^{3)}$ will grow two trees larger, than two small planters each 48 ft^3
  - Use structural soil or suspended pavement to allow root growth



Use evergreen trees wherever feasible

- Evergreens have higher annual interception rates and much higher winter Et.
- Produce lower volumes of litter annually, with much lower nutrient concentrations than deciduous species.

Scaling up benefits

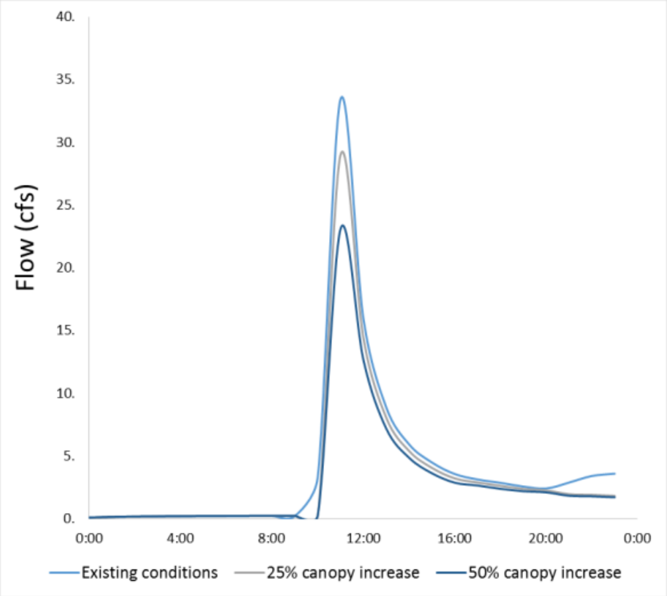
- More and larger trees
- Retention or planting of riparian buffers
- Allow a forest floor of leaves and twigs to develop under extensive plantings

2006

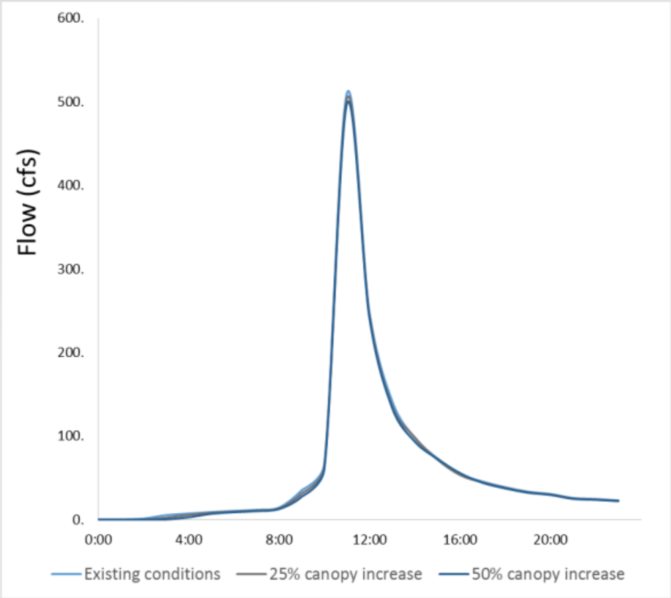
2014

Flood reduction

- Green infrastructure will **not** prevent flooding
- Primary benefit is to reduce stormflow peaks and volumes from routine, frequent precipitation events



1 inch rainfall



5 .2 inch rainfall

Cost-benefit database tool

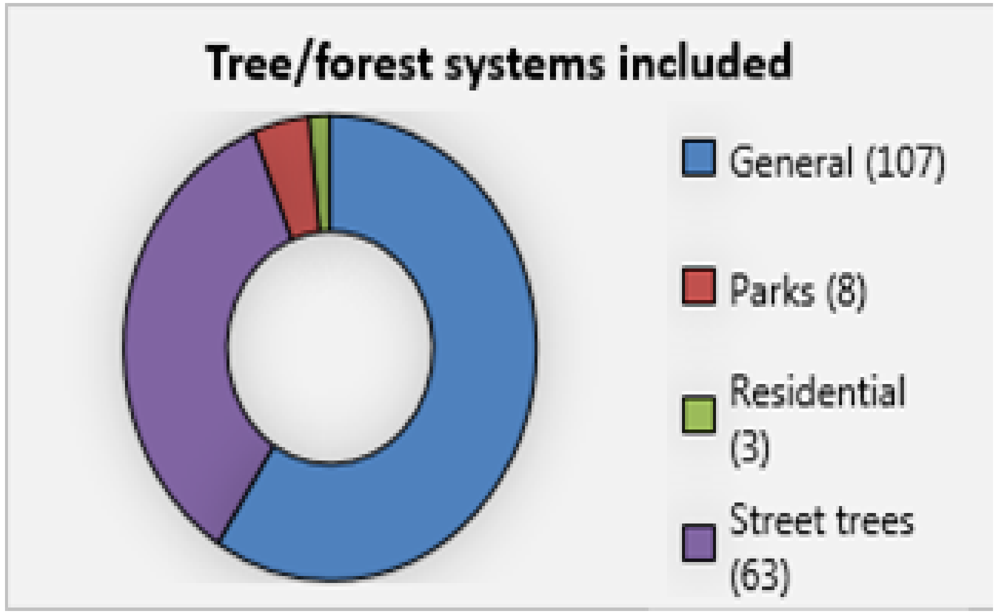
Objectives:

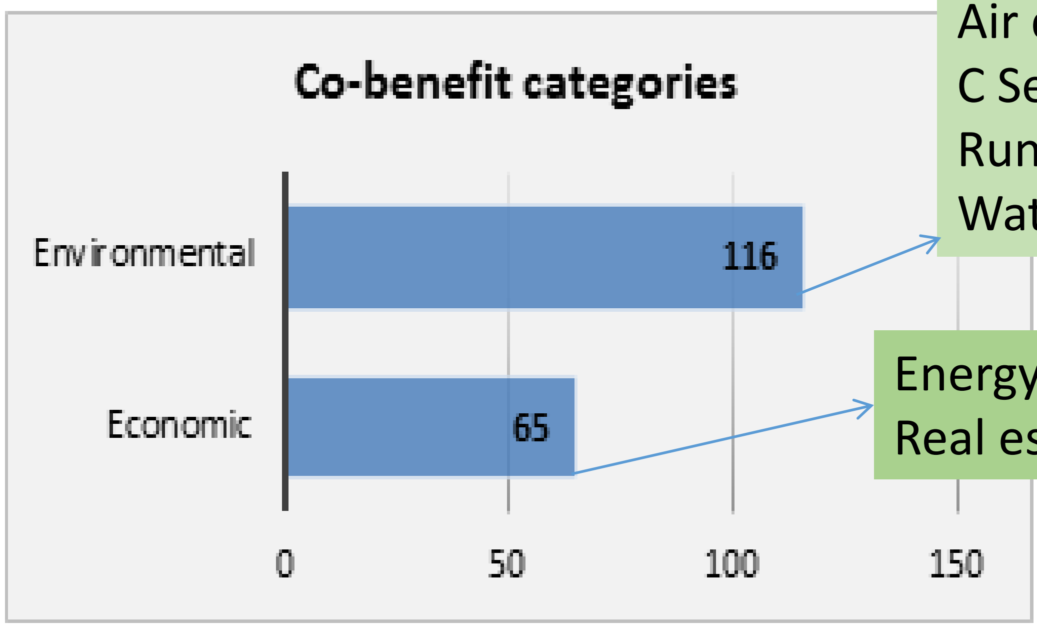
1. Provide a **comprehensive compilation** of datasets in which costs and/or benefits of urban trees have been economically valued
2. **Produce a searchable tool** with which stormwater managers or others interested in assessing costs, benefits, and/or return on investment (ROI) associated with urban tree systems can obtain this information

Database at a glance

38 unique studies
25 Cost data points
- Based on reported cost data

182 Co-benefit value data points
- 59% used i-Tree software





Air quality (42)
C Sequestration (43)
Runoff volume (29)
Water quality (1)

Energy savings (44)
Real estate value (18)

Database at a glance

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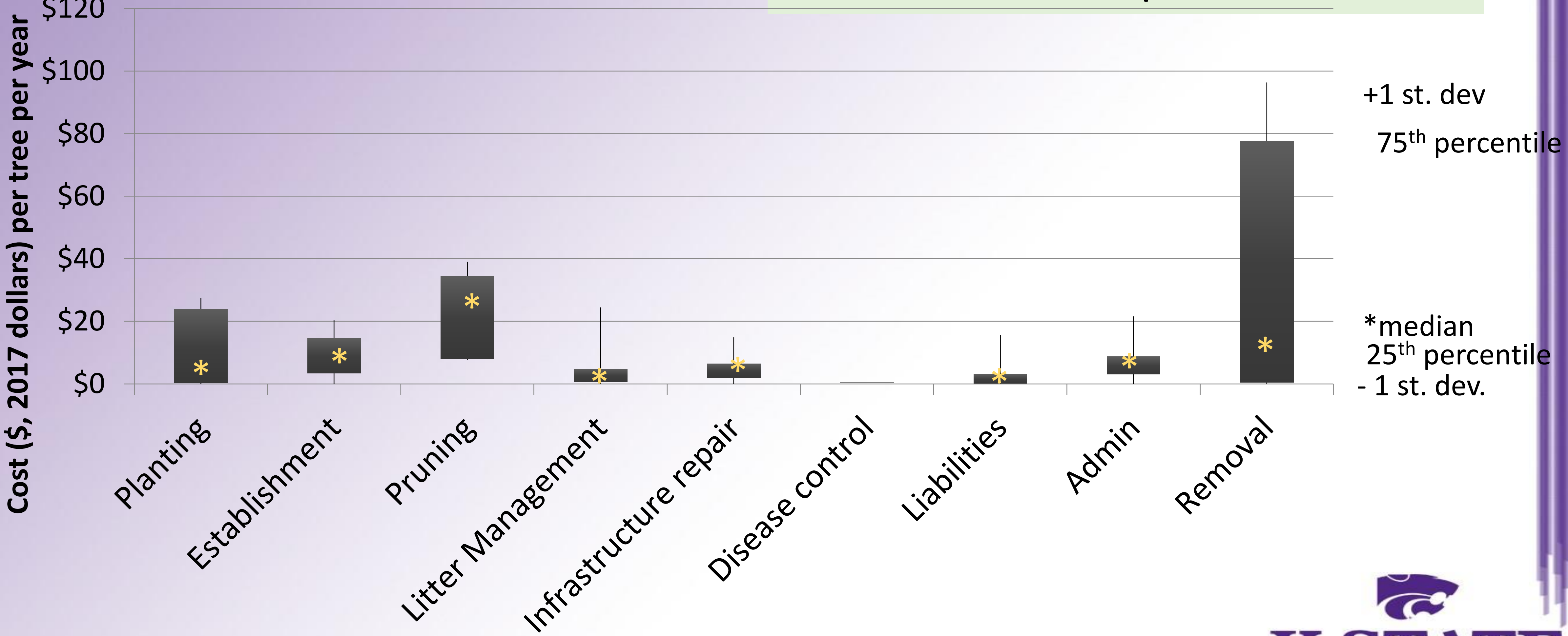
- Based on reported cost data



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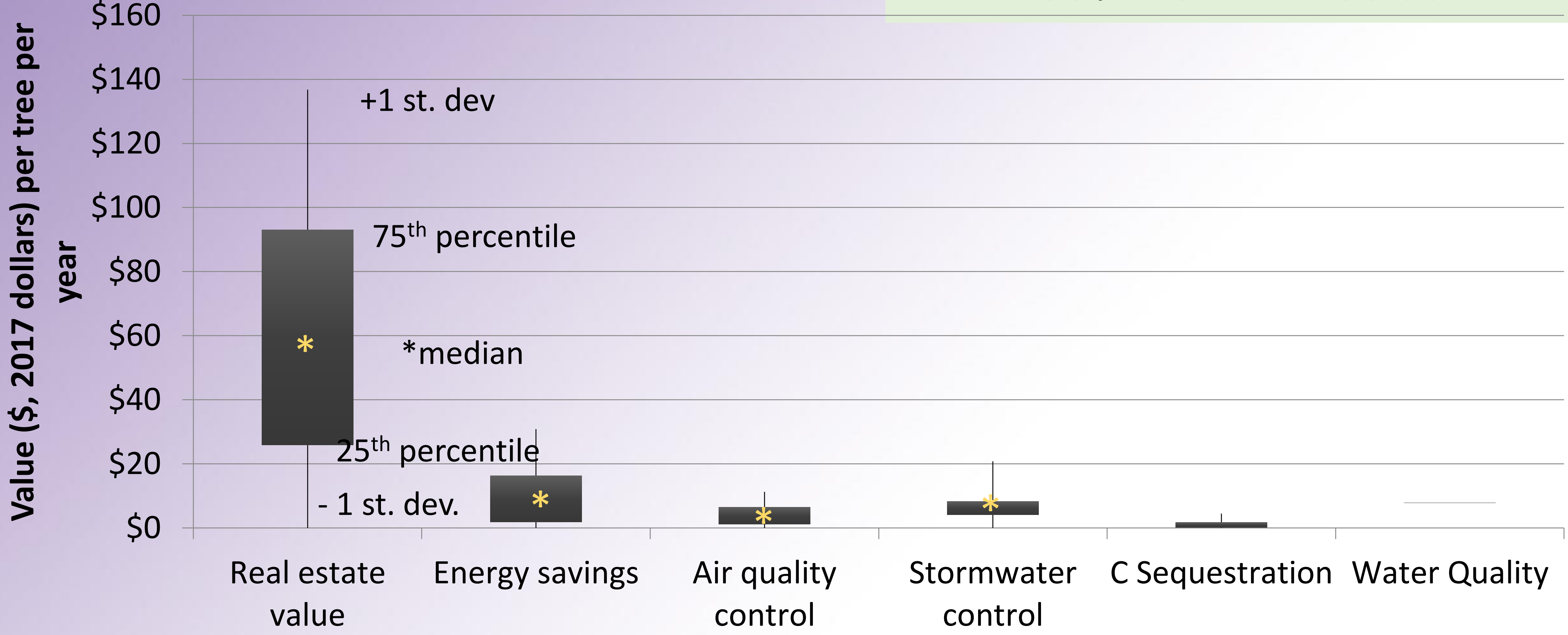

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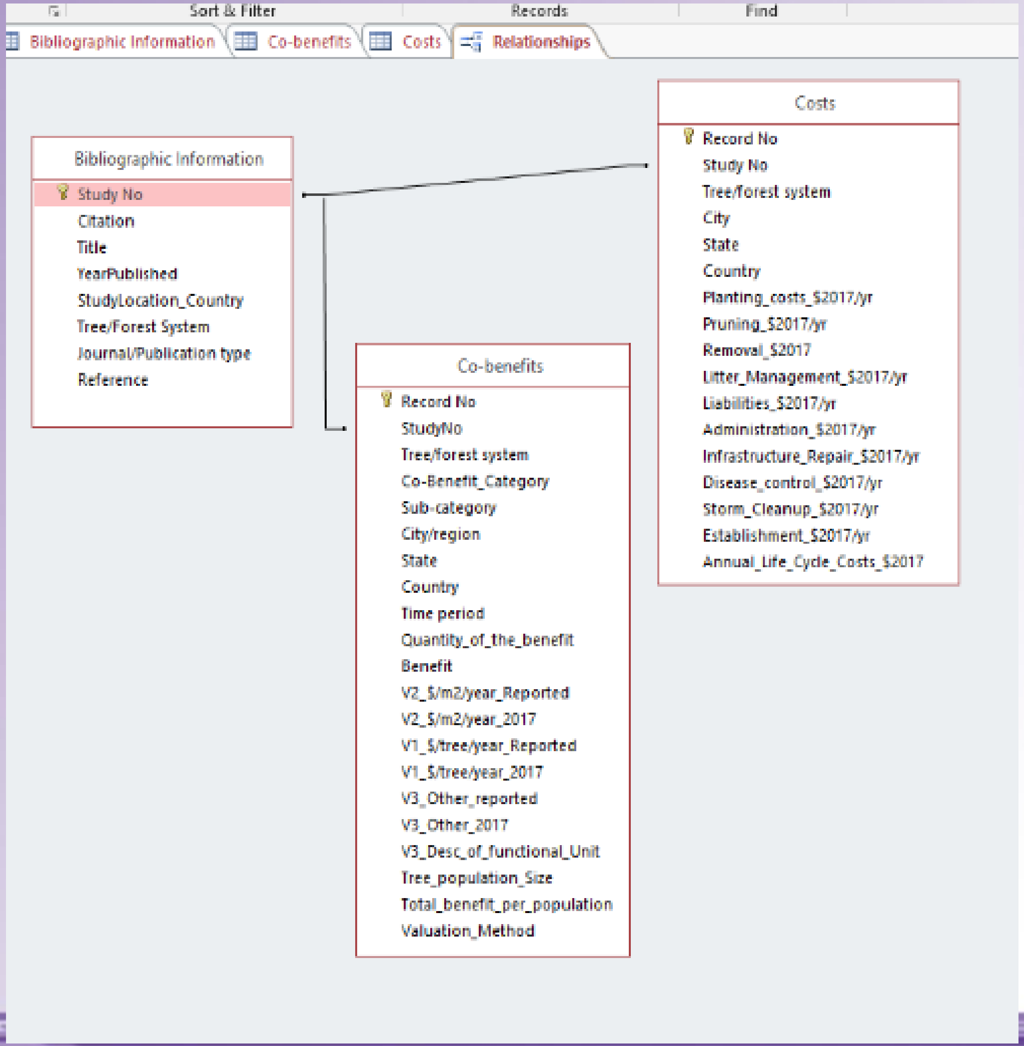
Database structure

Microsoft Access version



Microsoft Excel version (database light)

Co-benefit categories		Median value, 2017 $ per year
Environmental Co-benefits	**Include?**	
Air quality control	Yes	$2.43
C Sequestration	No	Not included
Stormwater control	Yes	$4.90
Water quality	Yes	$7.91
Economic benefits		
Energy Savings	Yes	$7.12
Increase real estate value	Yes	$54.86
Total annual co-benefit value		**$77.22**
Cost Categories	**Include?**	**Mean value, 2017 $ per year**
Planting	Yes	$2.05
Establishment	Yes	$4.36
Pruning	Yes	$25.21
Litter Management	Yes	$1.70
Infrastructure repair	No	Not included
Disease control	Yes	$0.49
Liabilities	Yes	$1.14
Administration	Yes	$5.96
Removal	Yes	$7.26
Total annual life cycle cost		**$48.16**
Return on Investment		**0.60**

Note: A ROI greater than 0 indicates the benefits provided by trees outweigh the economic expenses invested in tree planting, maintenance and other life cycle costs. A negative ROI indicates life cycle costs exceed benefits.

Application: example framing questions

1. What is the average value of stormwater (or other co-benefit) reported for street trees?
2. What is the average value of a co-benefit “bundle” provided by urban trees?
3. What is the Return on Investment (ROI) over the life cycle of an urban tree?
4. What is the life cycle cost per cubic meter of runoff reduction by an urban tree?

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What is the value of **stormwater reduction** benefits reported for **street trees**?

Field:	Tree/forest system	Co-benefit	V1_$/tree/year_2017
Table:	Co-benefits	Co-benefits	Co-benefits
Sort:			
Show:	☑	☑	
Criteria:	"Street Trees"	"Stormwater contr	
or:			

Co-benefits

- *
- Record No
- StudyNo
- Tree/forest system
- Co-Benefit_Category
- Co-benefit
- City/region
- State
- Country
- Time period
- Benefit indicator
- Benefit quantity
- V1_$/tree/year_Reported
- V1_$/tree/year_2017
- V2_Other_Reported
- V2_Other_2017
- V2_Other_Units

Tree/forest sys	Co-benefit	V1_$/tree/year_2017
Street trees	Stormwater control	$4.34
Street trees	Stormwater control	$58.60
Street trees	Stormwater control	$8.33
Street trees	Stormwater control	$4.73
Street trees	Stormwater control	$8.86
Street trees	Stormwater control	$4.23
Street trees	Stormwater control	$4.86
Street trees	Stormwater control	$3.11
Street trees	Stormwater control	$2.06
Street trees	Stormwater control	$2.35
Street trees	Stormwater control	$1.32
Street trees	Stormwater control	$7.99
Street trees	Stormwater control	$7.84

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What is the **Return on Investment (ROI)** over the life cycle of an urban tree?

Co-benefit categories		Median value, 2017 $ per year
Environmental Co-benefits	**Include?**	
Air quality control	No	Not included
C Sequestration	No	Not included
Stormwater control	Yes	$4.90
Water quality	Yes	$7.91
Economic benefits		
Energy Savings	Yes	$7.12
Increase real estate value	Yes	$54.86
Total annual co-benefit value		**$74.79**
Cost Categories	**Include?**	**Mean value, 2017 $ per year**
Planting	Yes	$2.05
Establishment	Yes	$4.36
Pruning	Yes	$25.21
Litter Management	No	Not included
Infrastructure repair	No	Not included
Disease control	Yes	$0.49
Liabilities	Yes	$1.14
Administration	Yes	$5.96
Removal	Yes	$7.26
Total annual life cycle cost		**$46.47**
Return on Investment		**0.61**

Note: A ROI greater than 0 indicates the benefits provided by trees outweigh the economic expenses invested in tree planting, maintenance and other life cycle costs. A negative ROI indicates life cycle costs exceed benefits.

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Database limitations

- Representative of available (peer-reviewed) published data and valuation methods
- Only includes co-benefits that have been economically valued. Thus, does not capture broader, non-monetary values
- Geographically limited
- Most representative of city-scale assessments
- Does not reflect forest structure (e.g., age, size, species, etc.)

Acknowledgments

- Funding and support originally from the Water Environment & Reuse Foundation (WERF)
- Merged with Water Research Foundation,
  Katie Henderson- project manager

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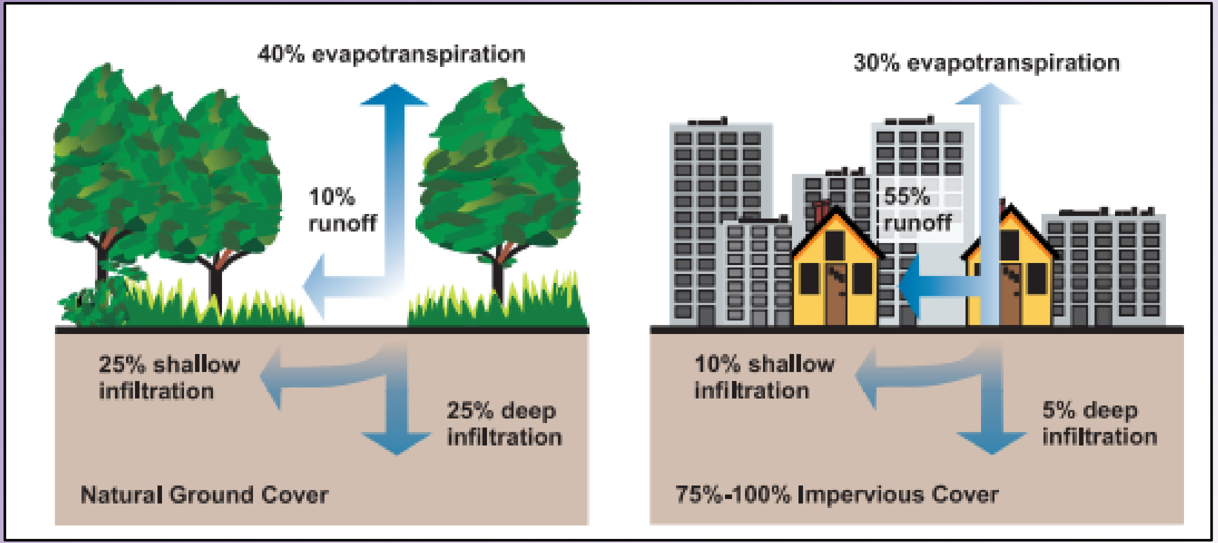
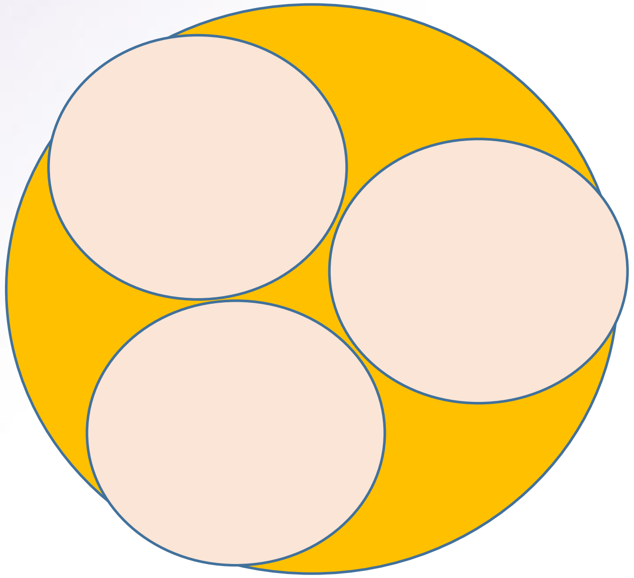
Questions?





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