URBAN WATERSHED FORESTRY SEMINAR

The Gateway, Warrington
Wednesday 9 July, 2014

Chair, Pat McCloskey

#UWFseminar

URBAN WATERSHED FORESTRY

Introduction

Paul Nolan, The Mersey Forest

Benefits of Urban Watershed Forestry: the evidence

Prof. John Handley, University of Manchester
With Dr Susannah Gill, The Mersey Forest

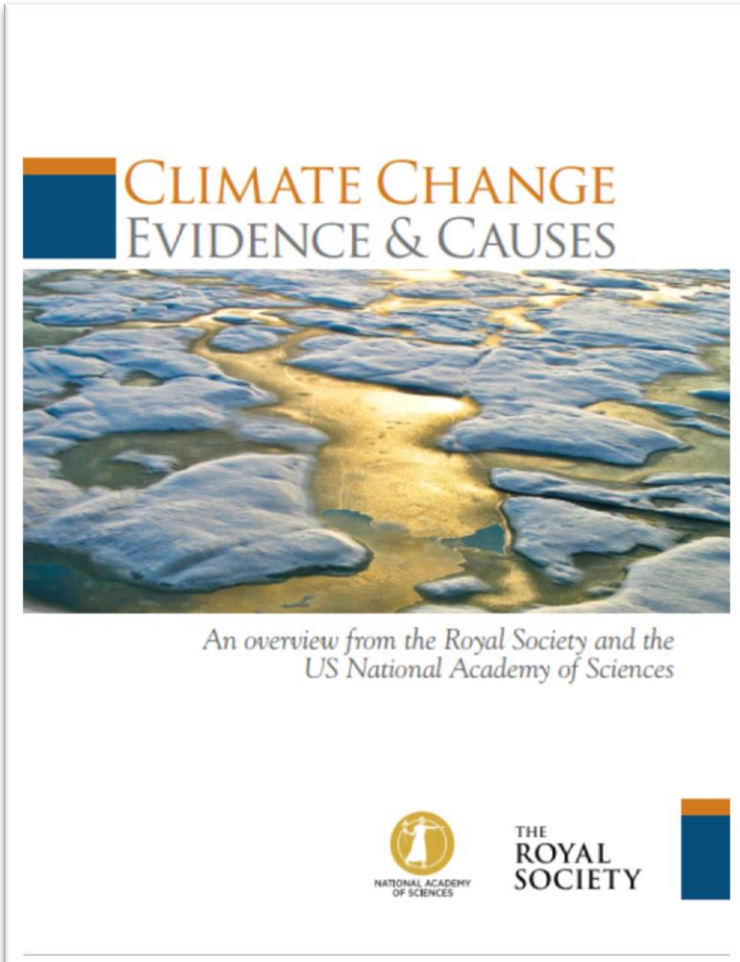
Overview

- The challenge of climate change
- The nature of flooding
- Recent UK flood events
- Assessing flood risk in the Mersey Basin
- The role of trees and woodland

  a) Combating flooding at the catchment scale

  b) Combating intra-urban flooding
- Capturing the economic value of ecosystem services

The Challenge of Climate Change

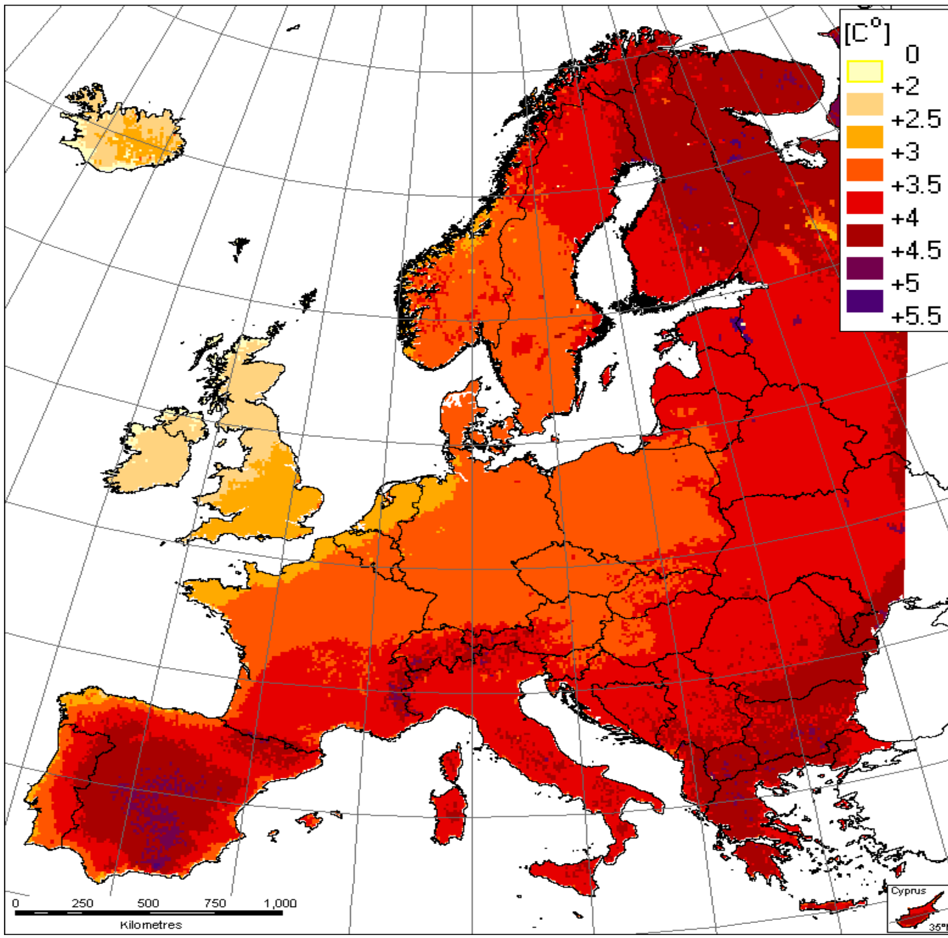


‘Earth’s lower atmosphere is becoming warmer and moister as a result of human emitted greenhouse gases. This gives the potential for storms and certain severe weather events ….heavy rainfall and snowfall events are becoming more frequent …(particularly) in North America and parts of Europe especially in winter’

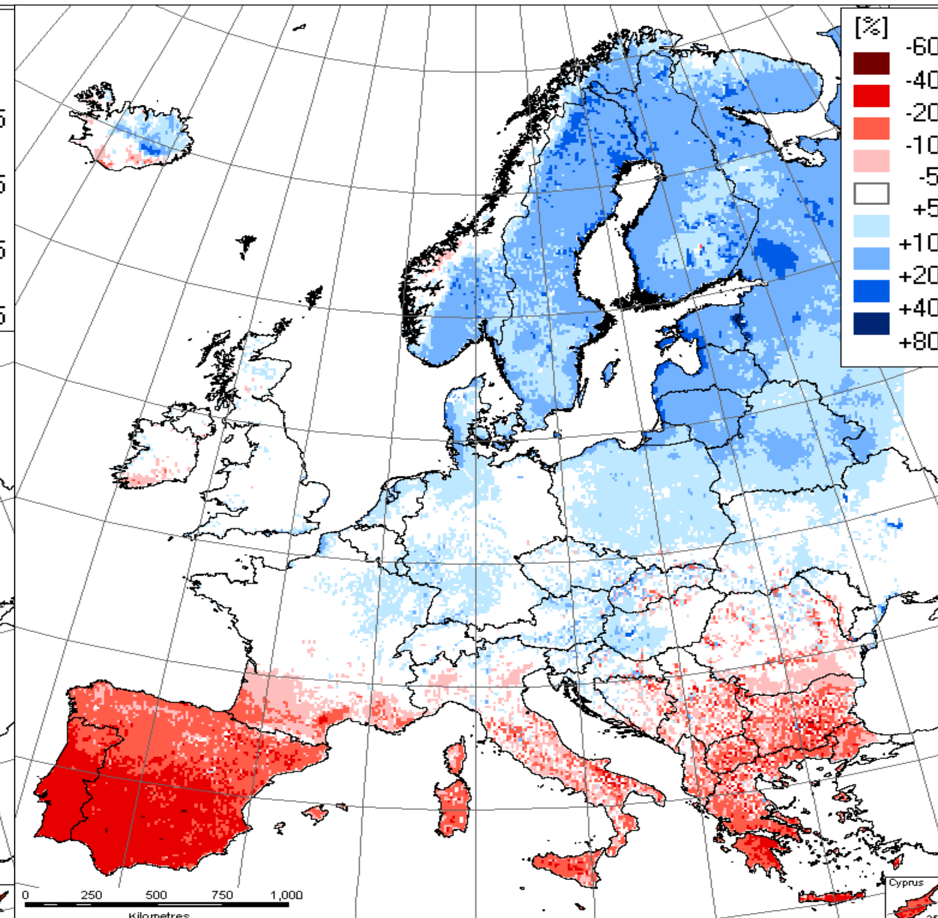
Climate projections for Europe

Change in mean annual temperature and precipitation by the end of this century, based on IPCC SRES Scenario A2

Temperature: change in mean annual temperature [C°]



Precipitation: change in annual amount [%]



Source: EC Green Paper, 2007

The nature of flooding

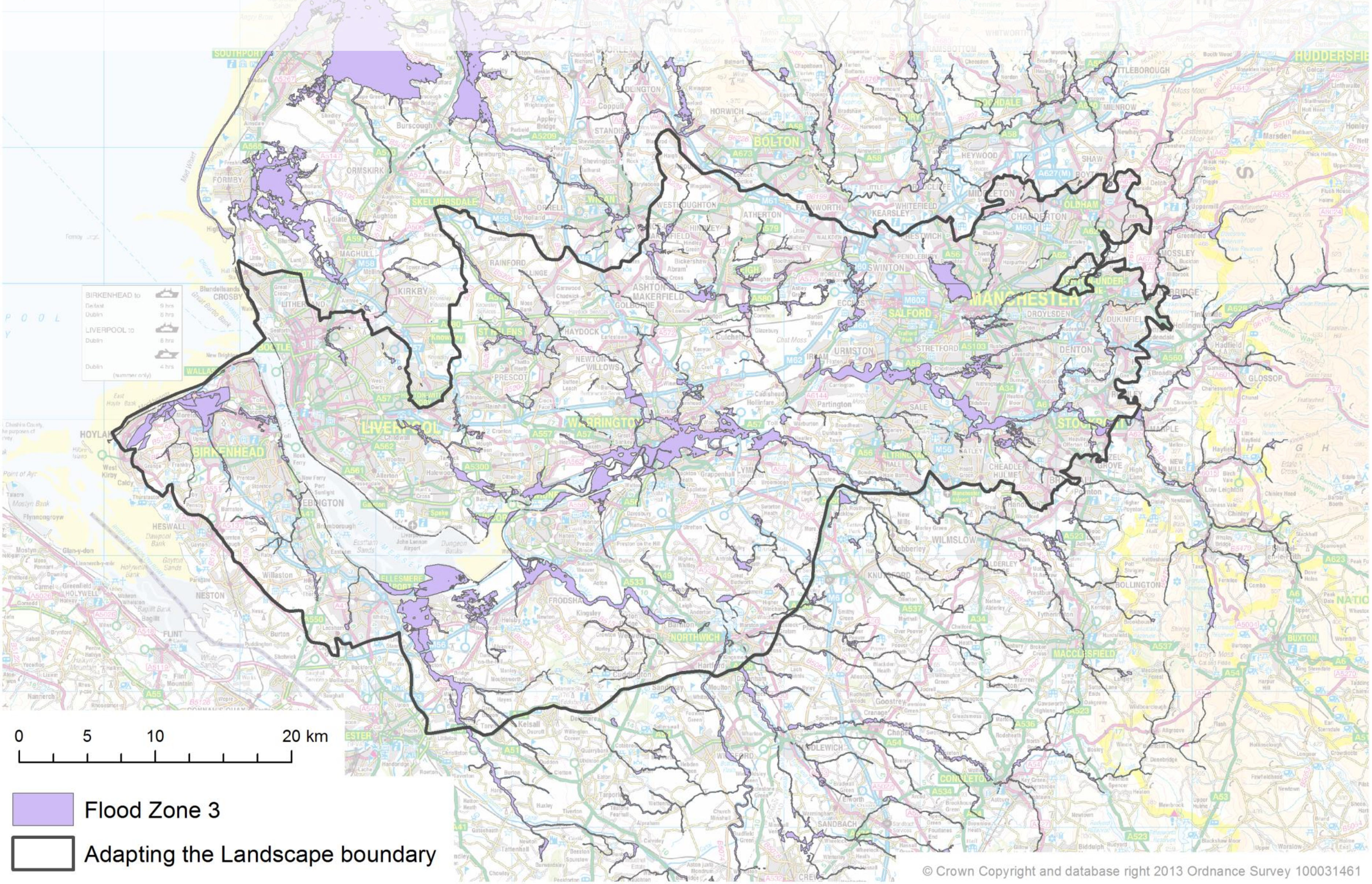
- Flooding occurs from a number of sources
  - River (fluvial)
  - Surface water (pluvial)
    - Insufficient capacity of natural & man-made drainage systems
  - Groundwater
  - Coastal

(Pitt Review, 2008)

Recent UK flooding

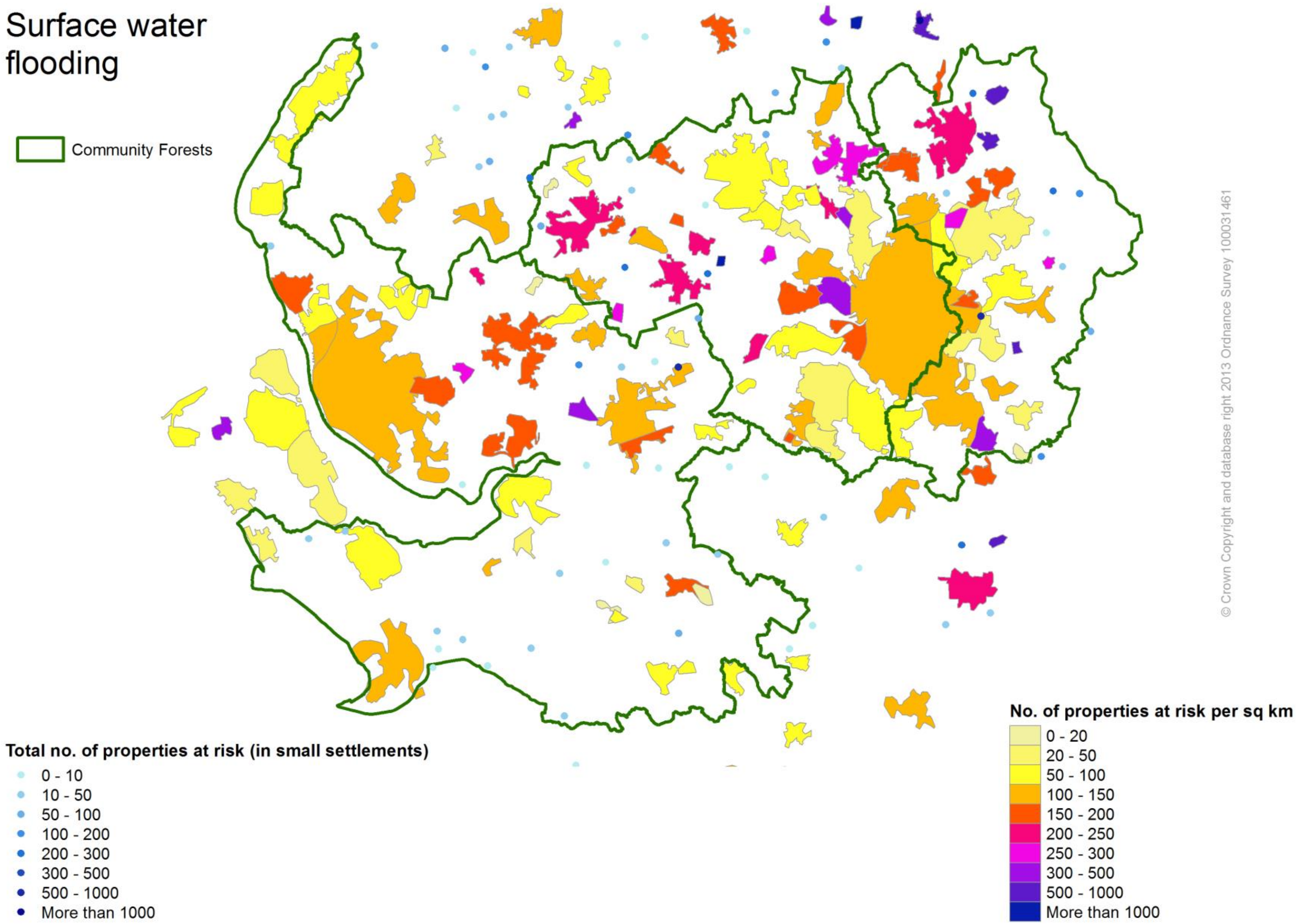
- Summer 2007 (Pitt Review, 2008)
  - South Yorkshire & Hull, Gloucestershire, Worcestershire &Thames Valley
  - Fluvial & pluvial flooding – pluvial a significant proportion & will be with climate change
  - Impacts: 55,000 properties flooded, 7,000 people rescued, 13 deaths, 0.5 m people without water or electricity, transport networks failed, emergency facilities out of action, tens of thousands of people homeless (and still homeless a year later), businesses out of action for months
  - Economic costs: insurance industry paid out over £3 billion; costs for central government, local public bodies, businesses & individuals
- Winter 2013-2014 (Met Office & CEH, 2014)
  - Southern England
  - Tidal, pluvial (flash), fluvial & groundwater flooding – flash flooding exacerbated by climate change, land management & land use practices (particularly extension of impermeable areas)

Fluvial & Coastal Flood Risk in the Mersey Basin



Source: UK Environment Agency

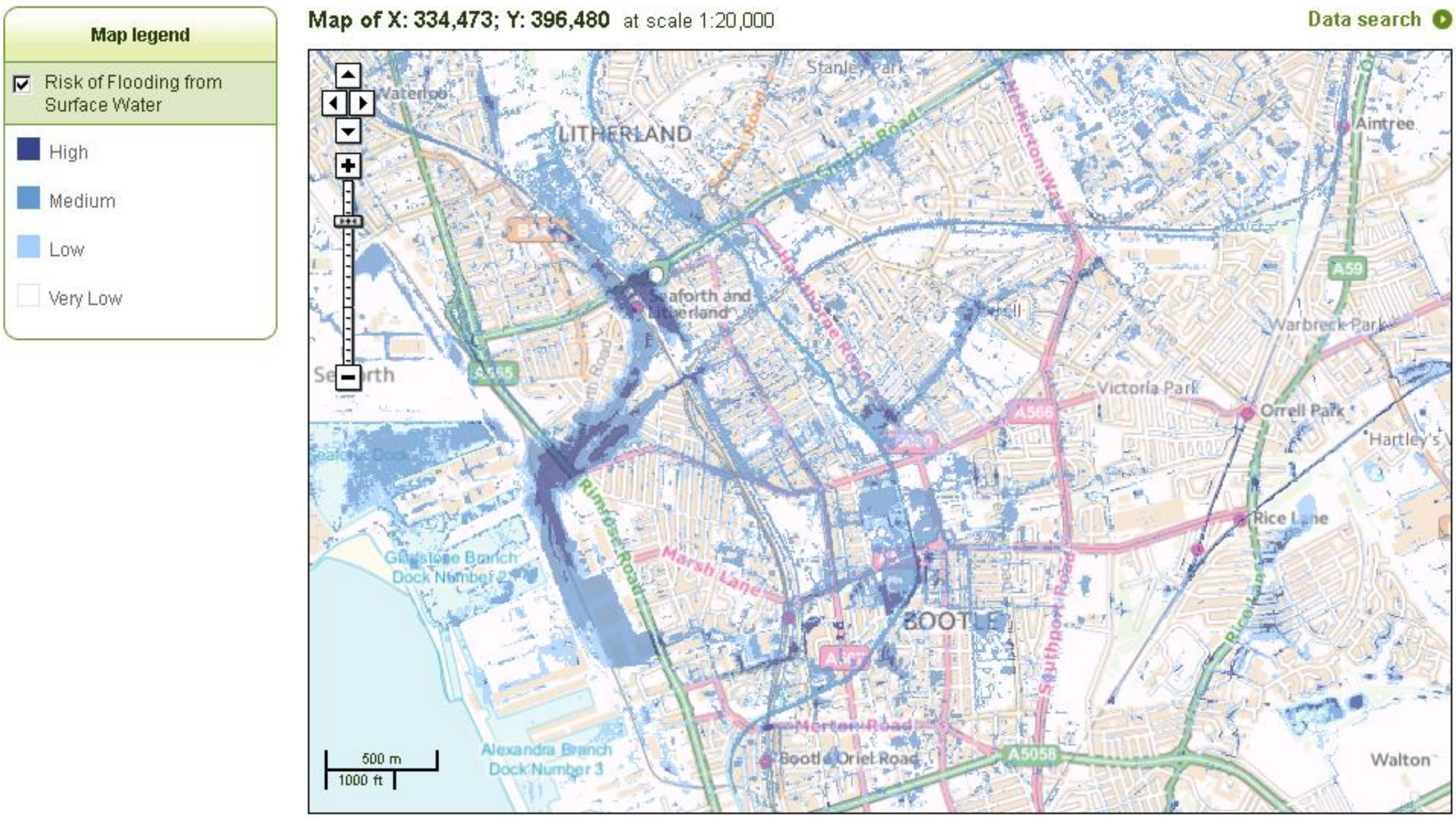
Surface Water Flood Risk in the Mersey Basin



Data source: UK Environment Agency

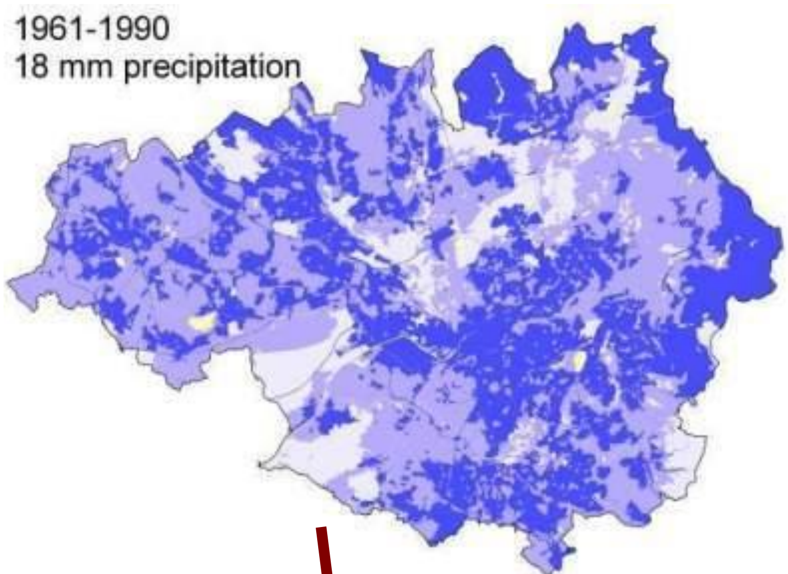
EA Surface Water Flooding Maps

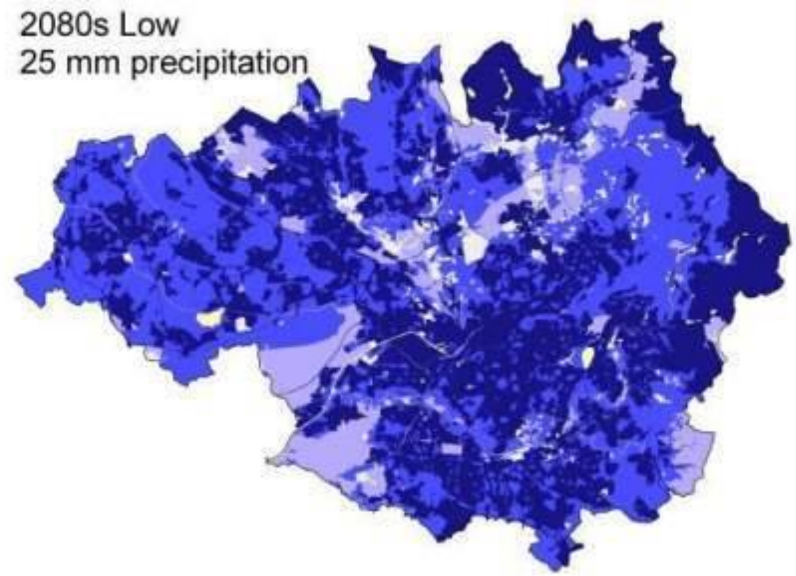
http://watermaps.environment-agency.gov.uk/wiyby/wiyby.aspx?topic=ufmfsw#x=357683&y=355134&scale=2



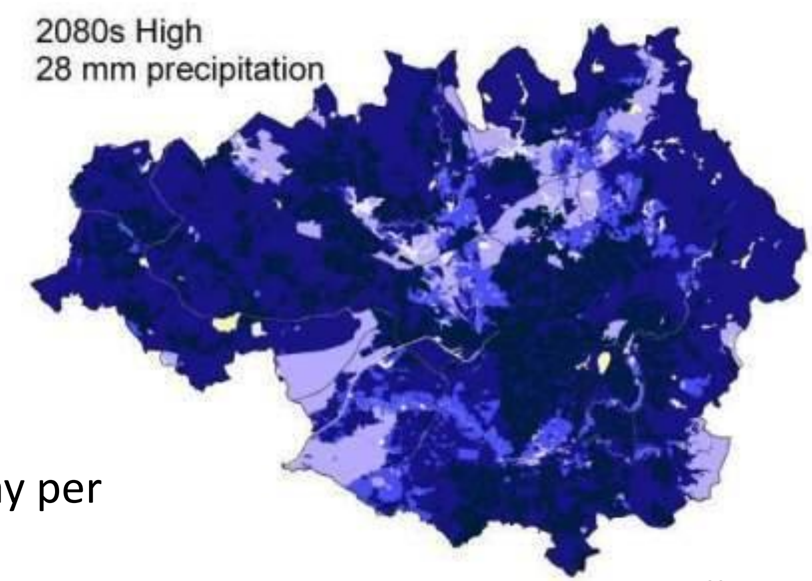
Problems of pluvial flooding in Heywood, Rochdale

Surface Runoff with Climate Change in Greater Manchester





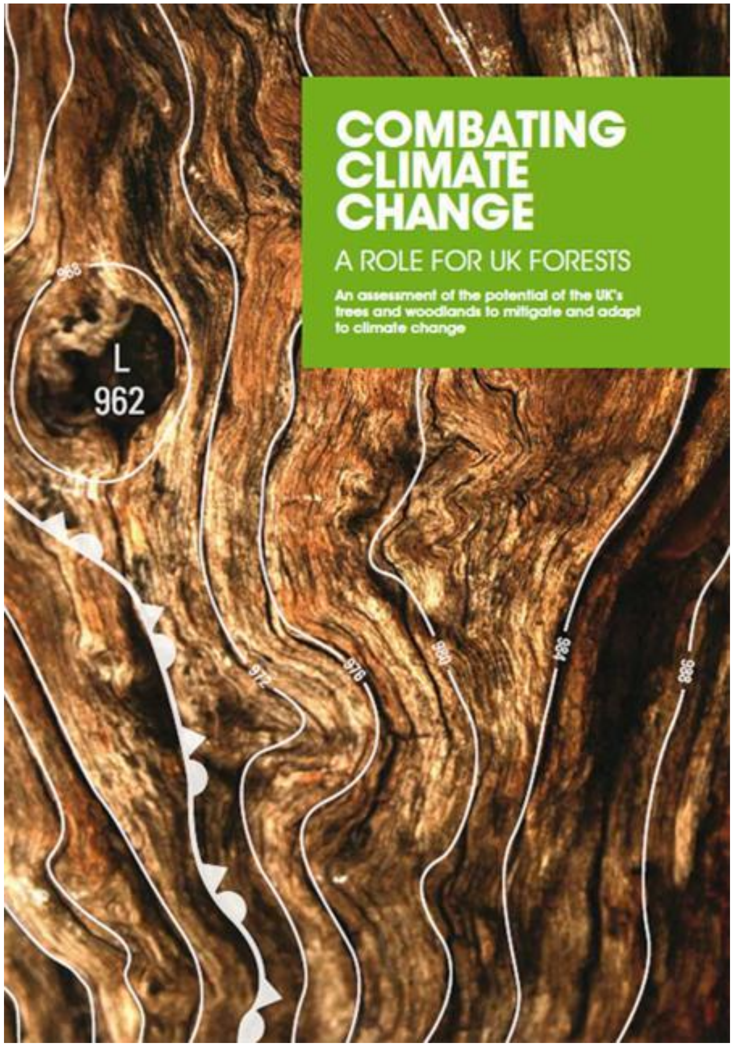
56% more rain results in 82% more runoff



For a precipitation event occurring on average one day per winter, with normal antecedent moisture conditions

Gill, 2006

Combating Climate Change: A Role For UK Forests



This report assessed the impact of trees and woodland on;

I. Water Supply
II. Fluvial Flooding
III. Managing Surface Water Runoff (Pluvial Flooding)

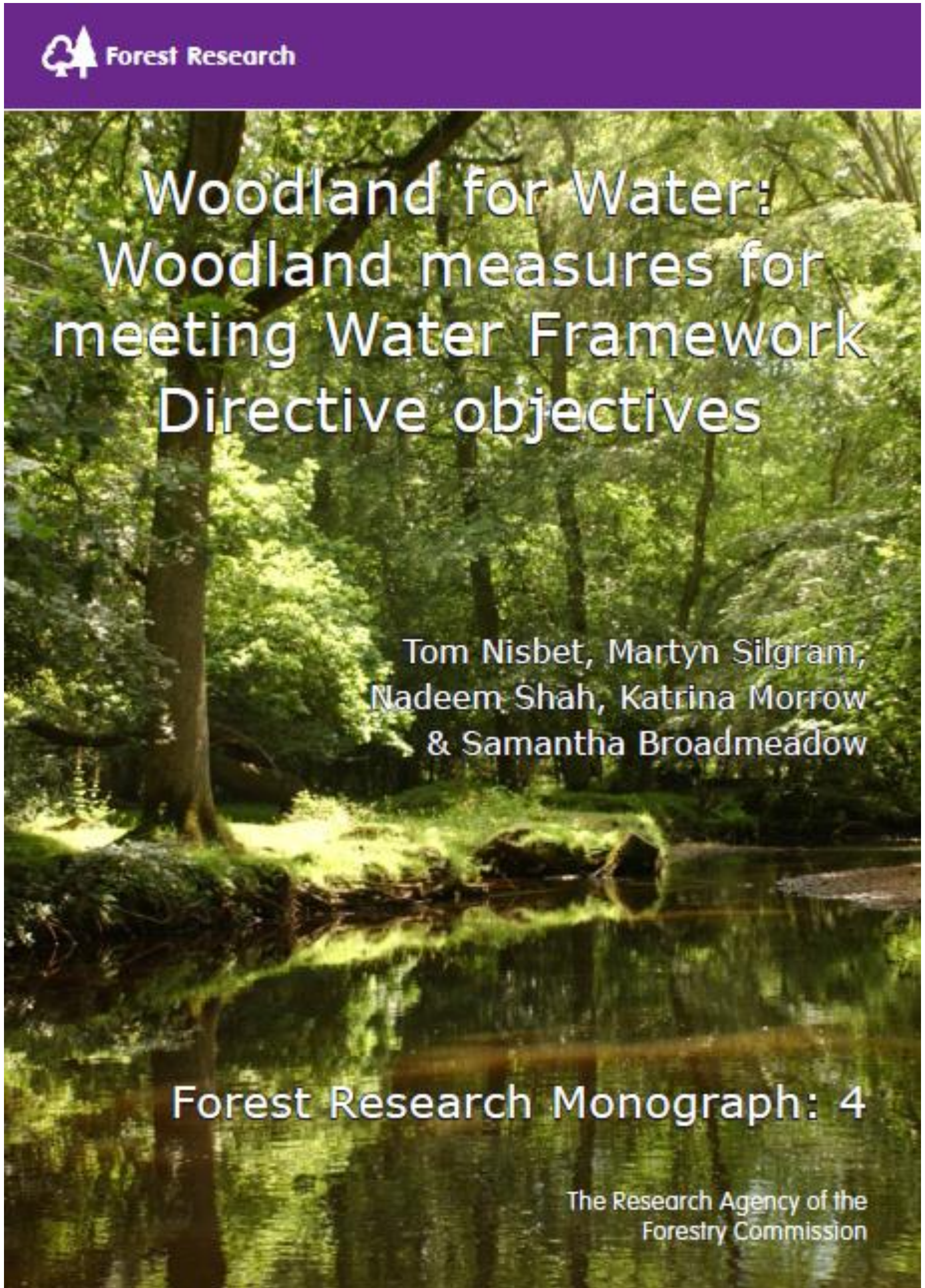
Ref: Read et al 2009

Benefits of trees and woodland in moderating flooding at catchment scale

Whilst large-scale woodland creation could not be justified on grounds of flood control alone, the following interventions are beneficial:

- Planting woodland buffers on compacted upland pastures
- Riparian planting along stream sides
- Planting on disused and derelict land
- Flood plain forests to increase storage and attenuate flow

Source; Read et al 2009



- Strong evidence to support woodland expansion in appropriate locations for soil & water benefits
  - Benefits greatest for riparian & floodplain woodland
  - Also targeted planting of buffers along mid-slope or downslope field edges, or on infiltration basins
  - 'Opportunity mapping' to direct woodland to preferred sites
- Calls for closer integration of forestry & water policy
- Highlights need for more research to quantify water benefits & evaluate how woodland can be best integrated with urban activities for water & wider benefits

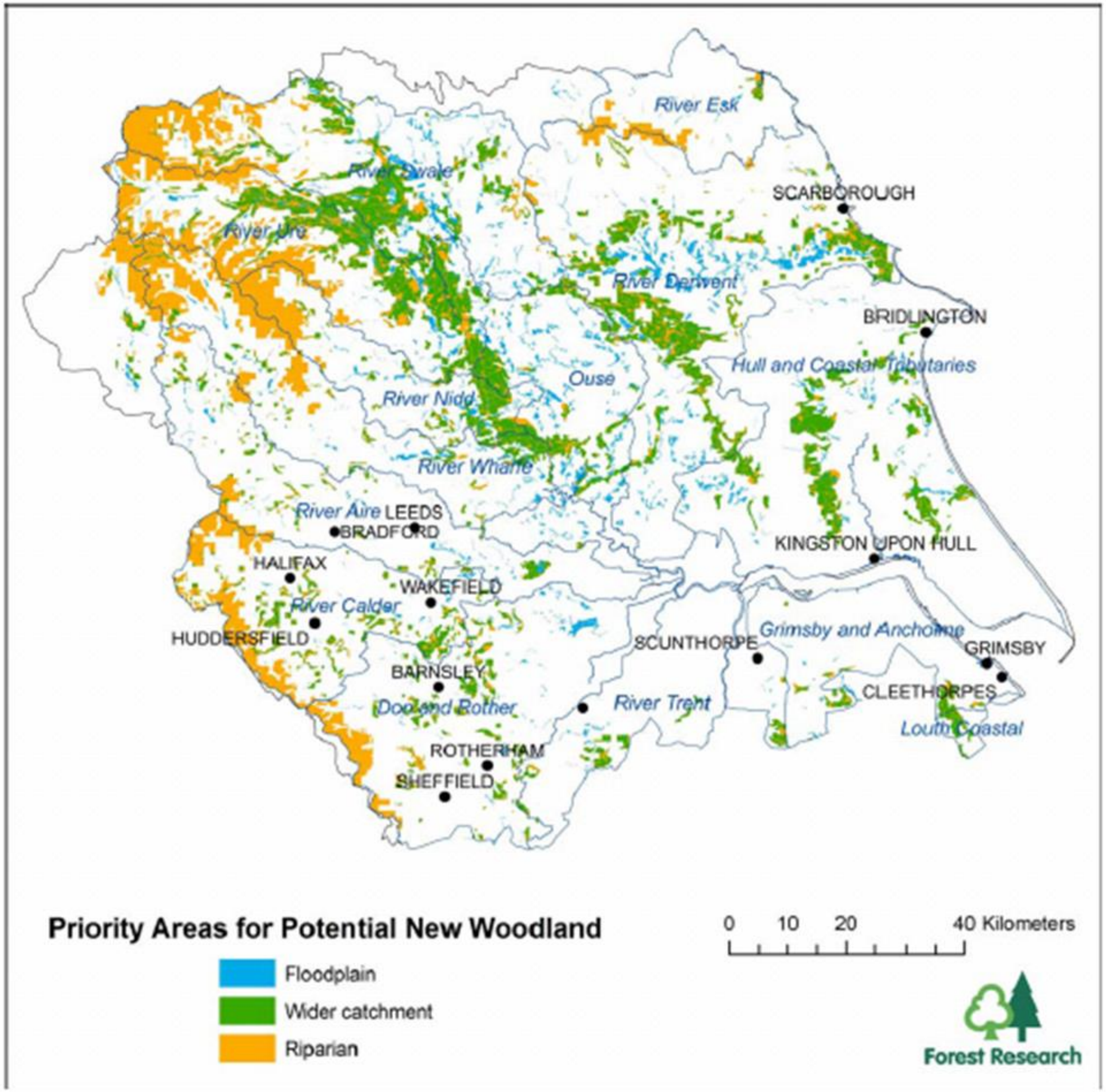


Figure 15. Regional mapping can help identify opportunities for planting floodplain woodland to reduce downstream flood risk. Map shows opportunities for planting floodplain, riparian and other woodland within the Yorkshire and Humber Region in Northeast England to deliver a range of water benefits, including improved flood management (from Broadmeadow and Nisbet, 2009).

Impact of trees and woodland in managing surface run-off in urban areas

Impacts of impervious cover on hydrological cycle

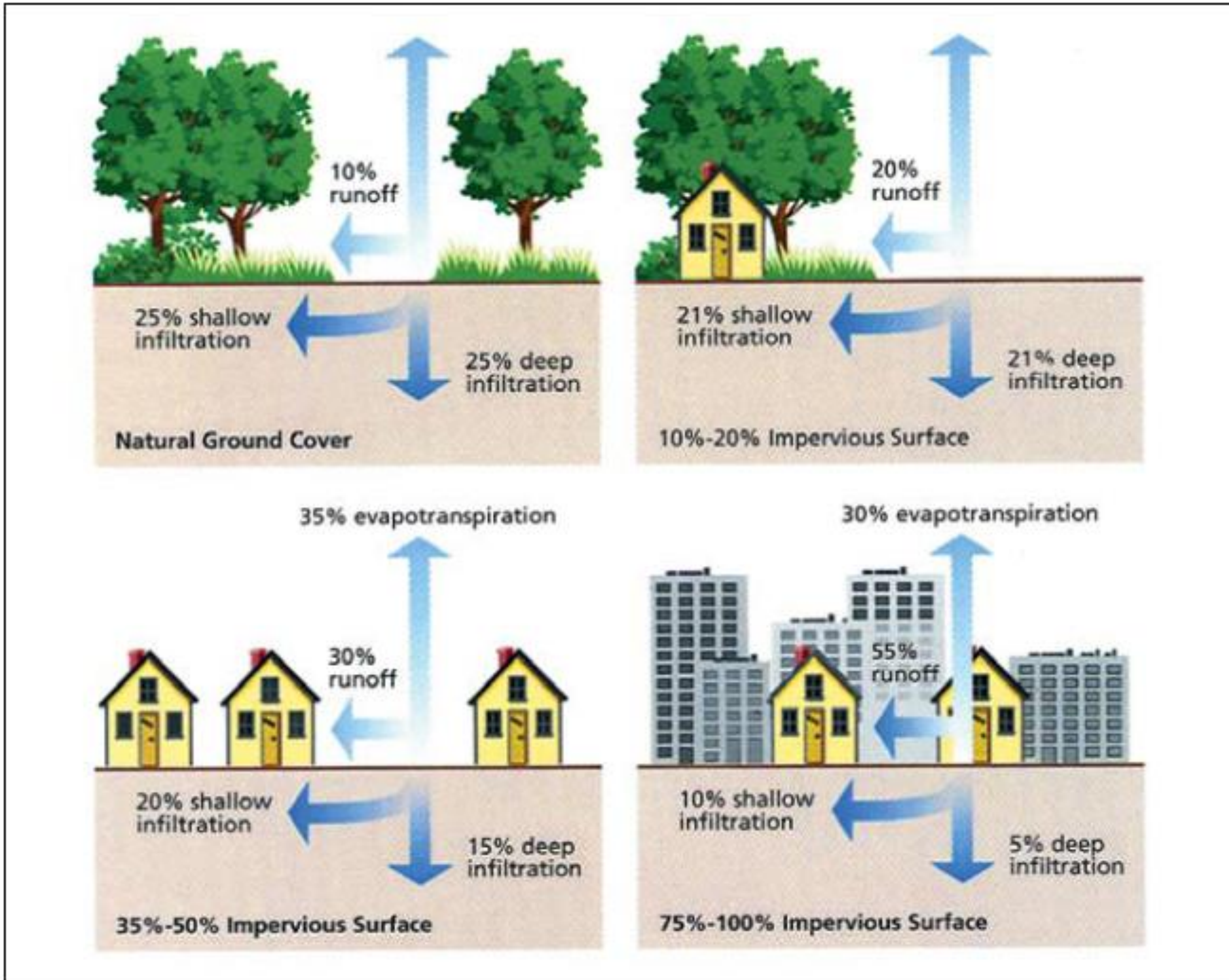
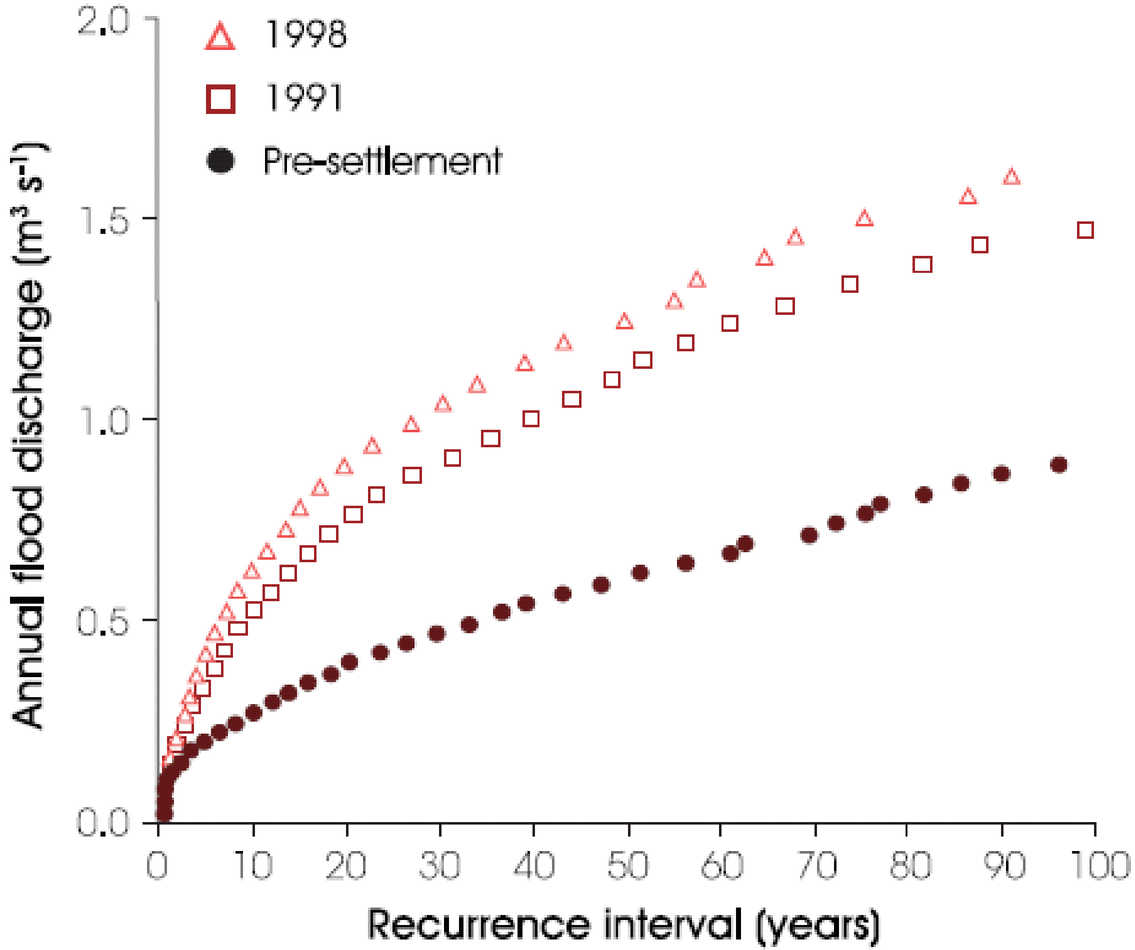


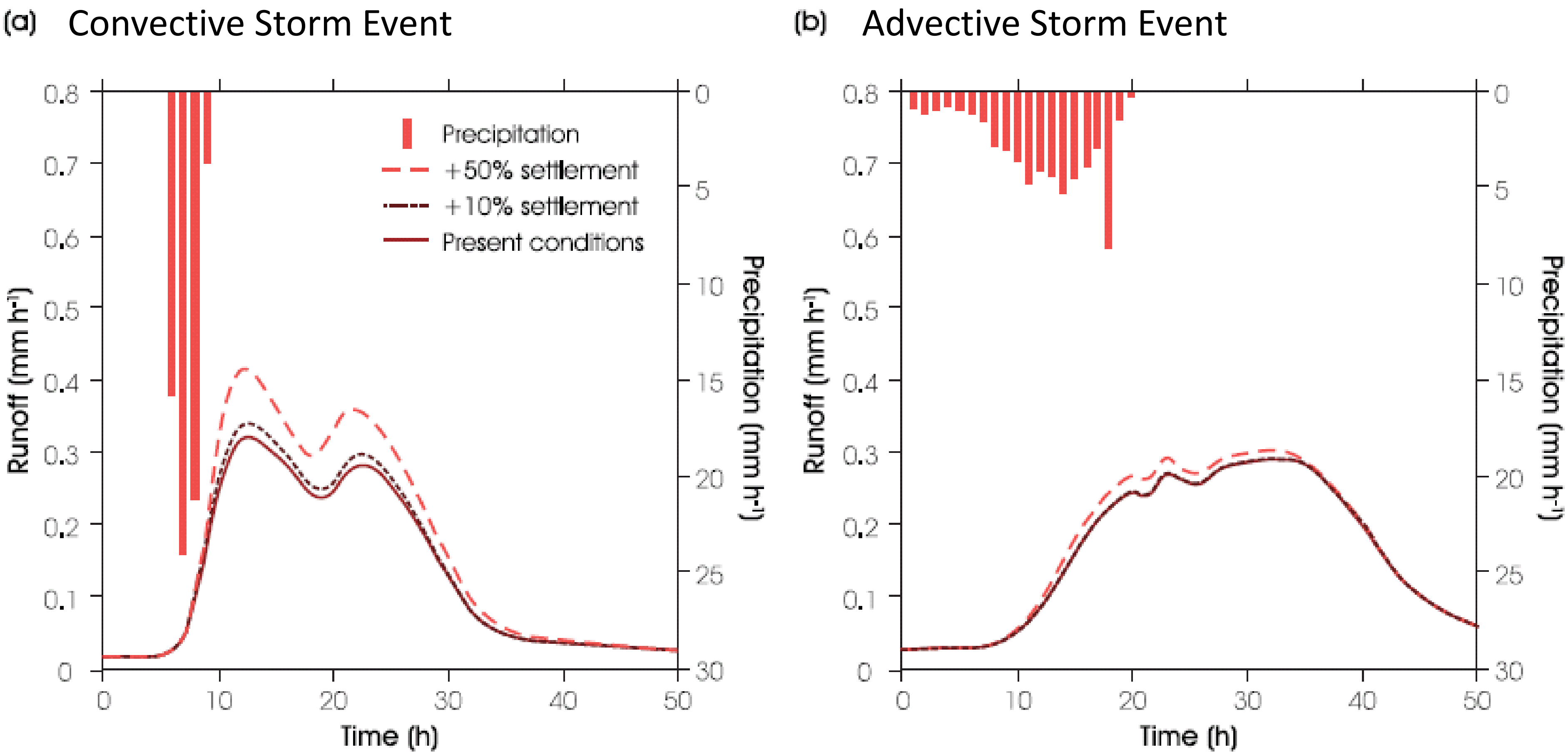
Figure 2. The Impacts of Impervious Cover on the Hydrologic Cycle (Source: FISRWG, 1998, p. 3-21)

Simulated Flood-Frequency Curves with urbanisation at Maplewood Creek



Source: Wissmar et al 2004, in Read et al 2009

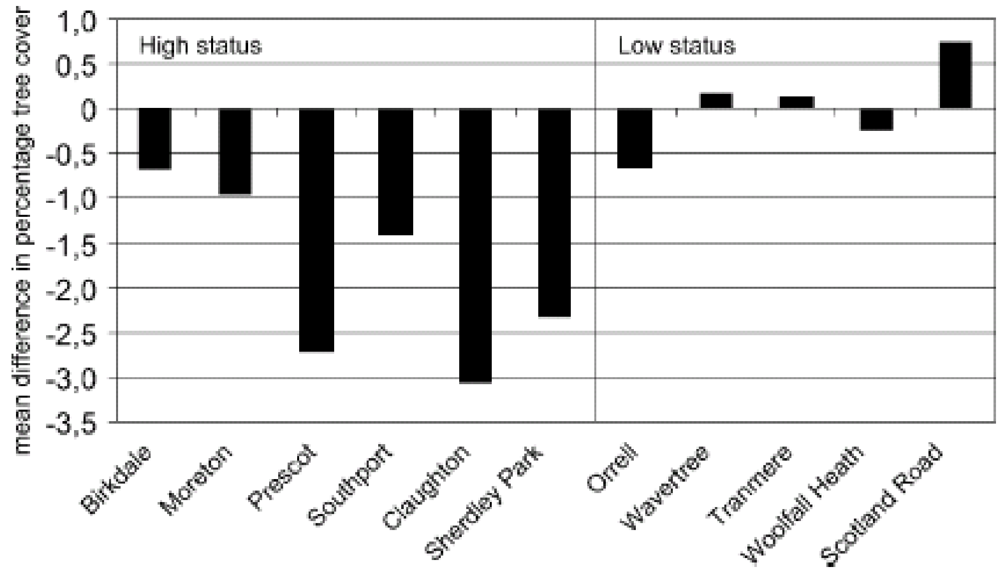
Simulated flood events with urbanisation in the Lein catchment



Source: Bronstert et al 2002 in Read et al 2009

Trend to loss of vegetated land in urban areas

- 11 residential areas in Merseyside 1975-2000 (Pauleit et al, 2005)
  - Increase in built surfaces, decrease in vegetated
  - +7% impermeable; -6% vegetated; -1% trees
  - Greatest changes in least deprived areas
  - + 4% runoff overall
- House curtilages in Keighley 1971-2002 (Duckworth, 2005)
  - Pervious surface cover decreased by 15-21%, depending on residential density



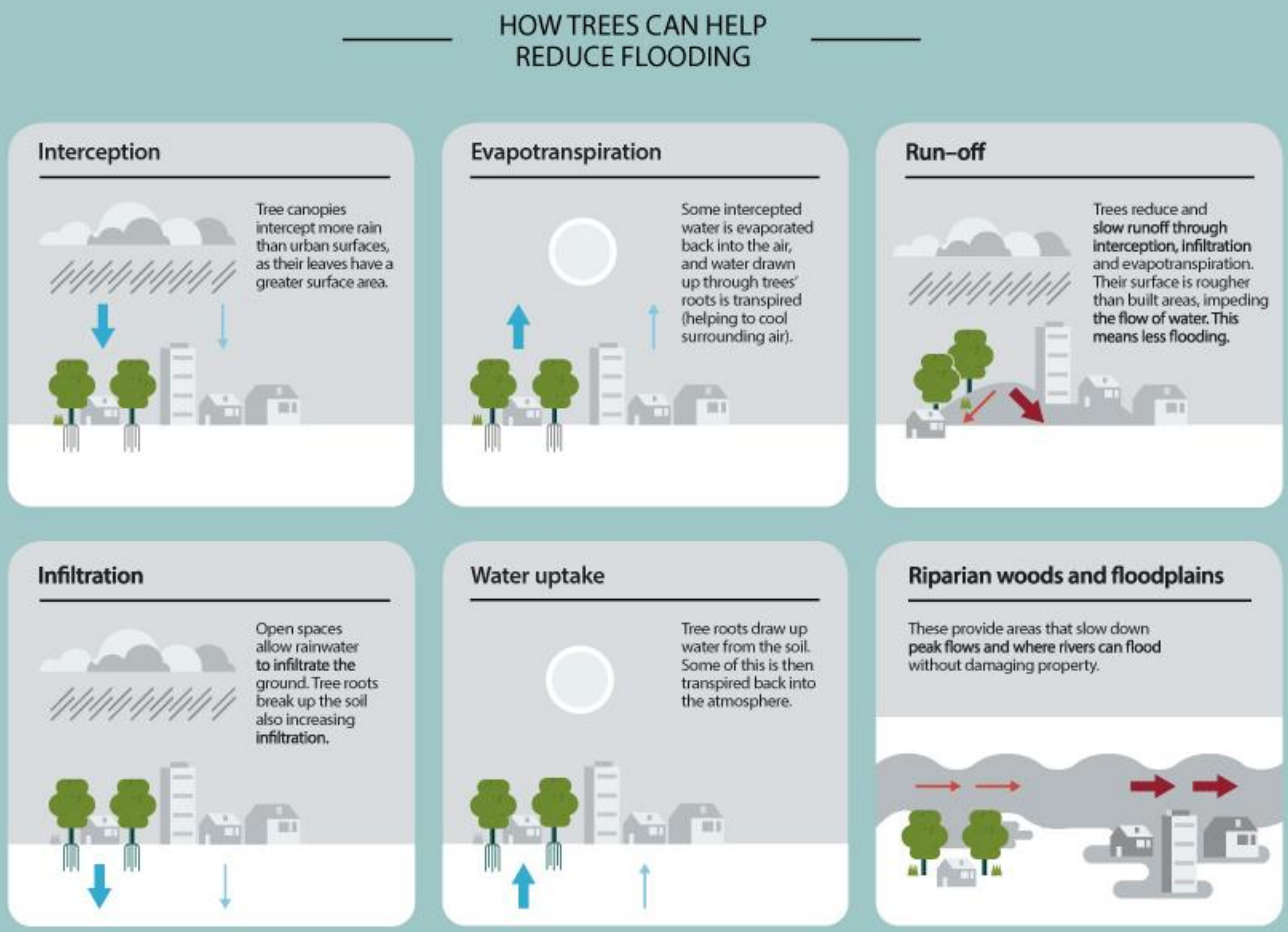
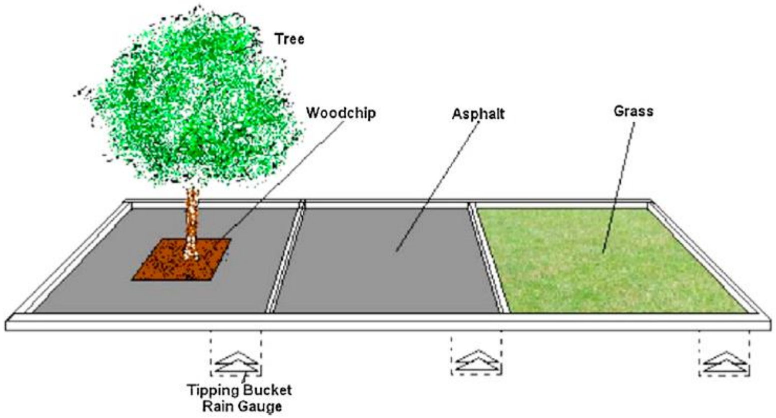


Diagram by The Mersey Forest

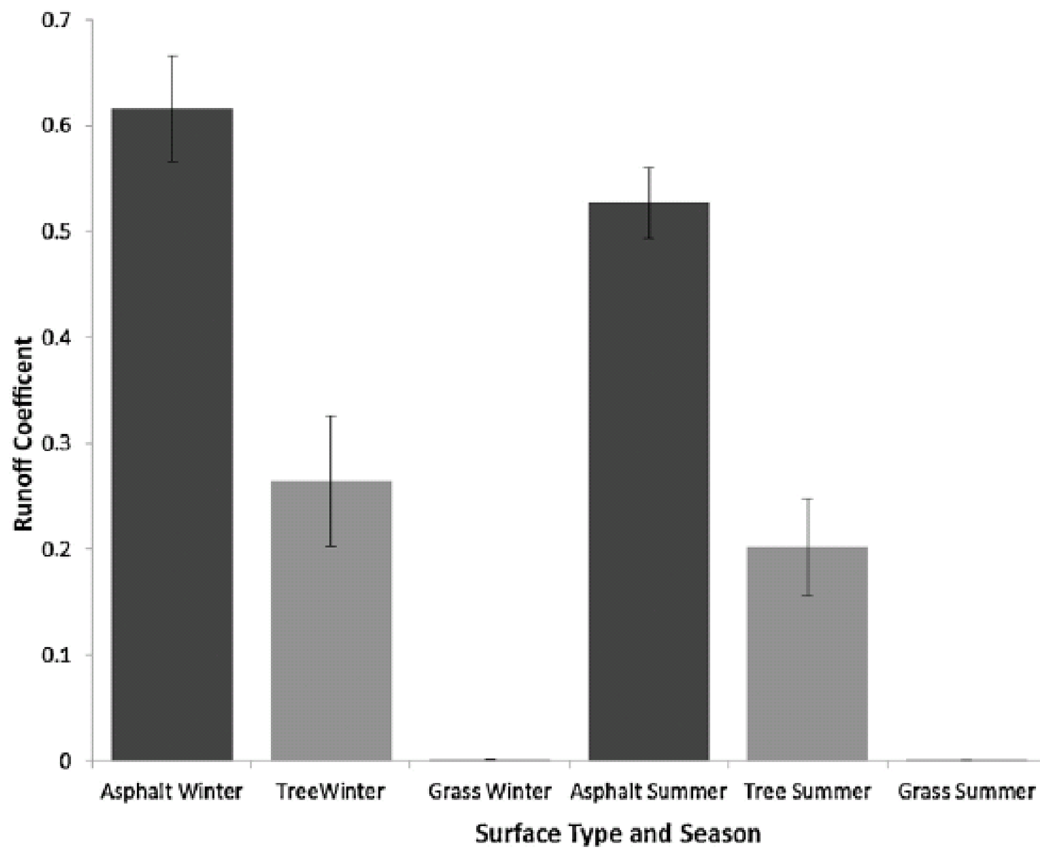
The Mersey Forest Plan (2014). www.merseyforest.org.uk/plan

Recent monitoring study in Manchester: runoff results

Armson , Stringer, Ennos, 2013



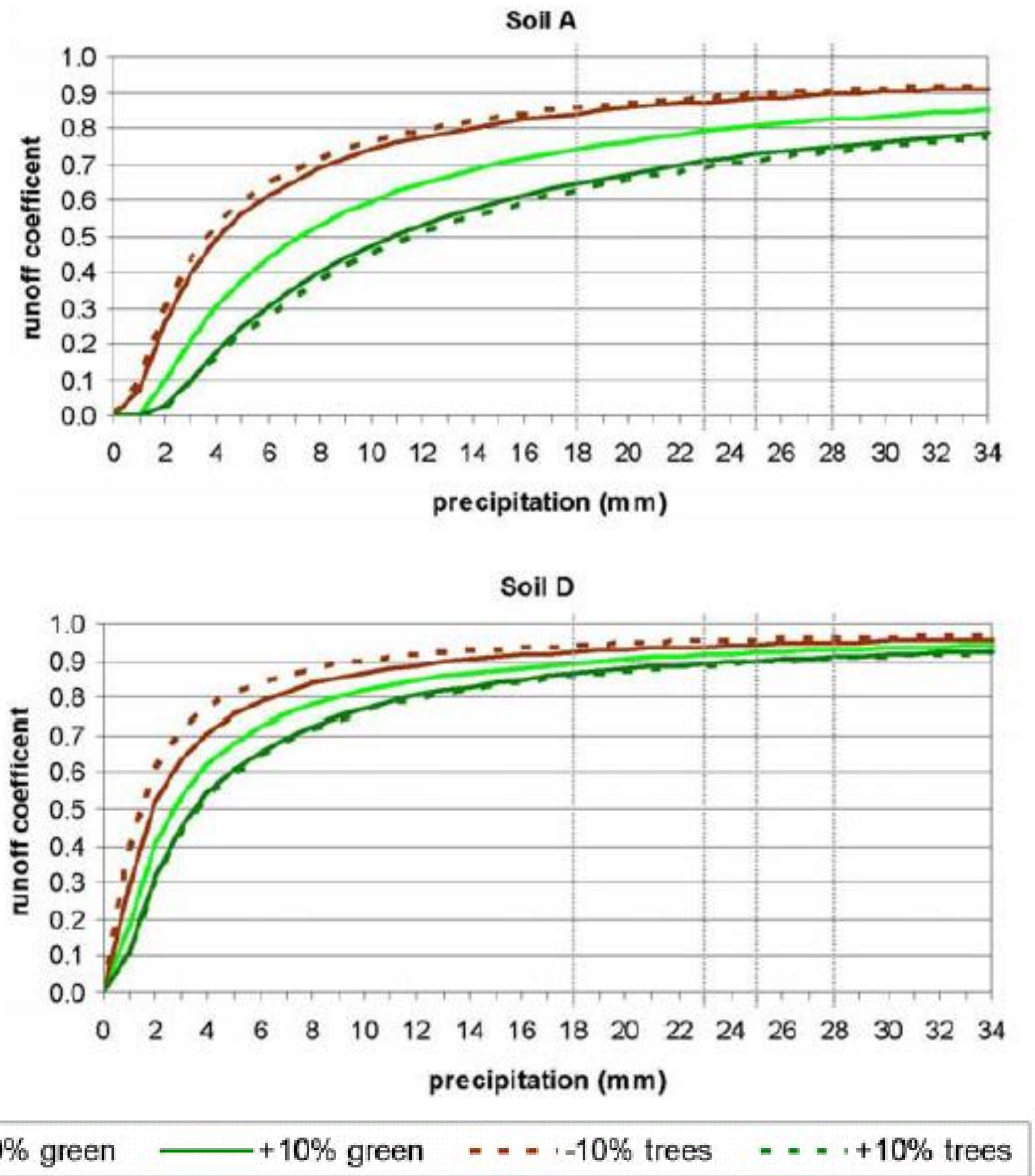
Test plots



Effect of surface type & season on runoff coefficients for asphalt, tree over asphalt, and grass test plots

Modelling runoff for GM town centres; soil A sandier, D more clay

(Gill, 2006)



Capturing the economic value of ecosystem services


Natural England Research Report NERR057

Microeconomic Evidence for the Benefits of Investment in the Environment 2 (MEBIE2)

www.naturalengland.org.uk

NATURAL ENGLAND

- "There are examples where the natural environment offers much better value for public investment than the alternative. For example natural water filtration can be much cheaper than the alternative; natural flood defence even more so. Cost savings to the public purse due to investment in the natural environment could lead to a reduced need for taxation, which can translate into increases in economic output".

Summary

- Surface water flooding a significant issue in urban areas, & will increase with climate change and more sealing of surfaces
- Urban trees have a significant role to play in managing surface water, helping to reduce flooding & costs associated with water treatment
- Some useful research findings and tools available or becoming available – is the time right for an action research project on Urban Watershed Forestry in the UK?

Urban Watershed Forestry: Trees in the Ultra-Urban Environment

Bryan Seipp

Center for Watershed Protection

Mersey Forest Urban Watershed Forestry Workshop

CENTER FOR WATERSHED PROTECTION

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

SOCIETY OF AMERICAN FORESTERS 1900

About the Center

CENTER FOR WATERSHED PROTECTION

- National non-profit 501(c)3 organization founded in 1992
- Headquarters in Ellicott City, MD
- Staff in New York, Pennsylvania, Maryland, and Virginia

What we do

- Distill research into practical tools
- Provide local watershed services
- Train others to manage watersheds

Outline

- What is Urban Watershed Forestry
- Why use UWF as a tool
- Stormwater Benefits of Trees
- Crediting Trees as a Stormwater Practice
- Tree Issues to Contend With
- Example projects




Objectives:

- preserve forests and natural vegetation in watersheds
- enhance urban & suburban tree canopy
- protect trees at development sites
- reclaim vacant lands and reduce turf
- increase the use of trees in stormwater practices

"Urban Watershed Forestry"

"**Watershed forestry** *is the use of forests and the practice of forestry to protect, restore, and sustain water quality, water flows, and the health and function of watersheds."* *(WFAP federal register)*

"**Urban** is ….well….urban - developed and developing areas"

Why Urban Watershed Forestry?

- integrate urban and community forestry and watershed planning and management
- set watershed goals for the urban forest
- create more functional urban landscapes in terms of hydrology
- build tools to assess, protect, and enhance urban green space as a part of storm water management

Link between forest cover and stream health

- Stream health rating of Excellent requires no more than 6% IC and at least 65% riparian forest cover (Goetz et al, 2003)
- Stream health rating of Good requires no more than 10% IC and at least 60% riparian forest cover (Goetz et al, 2003)
- Watersheds with at least 65% forest cover usually had a healthy aquatic insect community (Booth, 2000)

influence of forests and imperviousness on the health of streams

<u>For 245 watersheds</u>

Recommendations:

No more than 6% IC
At least 65% riparian forest cover for Excellent score

No more than 10% IC
At least 60% riparian forest over for Good score

Runoff Reduction

- The main way trees provide stormwater benefits are by reducing the total volume of stormwater runoff.
  - Studies have shown that:
    - Mature Deciduous trees can intercept 500-700 gal/yr *(Envirocast, 2003; CUFR, 2001)*
    - Mature Evergreen trees can intercept 4,000 gal/yr *(Portland, 2003; CUFR, 2001)*
    - A review of field studies of interception, transpiration and infiltration associated with trees found that these combined processes can be expected to significantly reduce annual rainfall runoff by an estimated 30% (based on data for conifers in the Pacific Northwest) *(Herrera, 2008).*

Hydrologic and Water Quality Befits of Trees

Plant Benefit	Per Tree Annual Quantification of Benefit	Source and Description
Rainfall interception	760 gal/tree/yr.	Annual rainfall interception by a large deciduous tree* (CUER, 2001)
Evapotranspiration	100 gal/tree/yr.	Transpiration of poplar trees for one growing season (EPA, 1998)
Nutrient Uptake	0.05 lbs/N/yr.	Based on daily rate of nitrogen uptake (Licht, 1990)

* 40-year old London plane tree growing in a semi-arid climate.

Transpiration

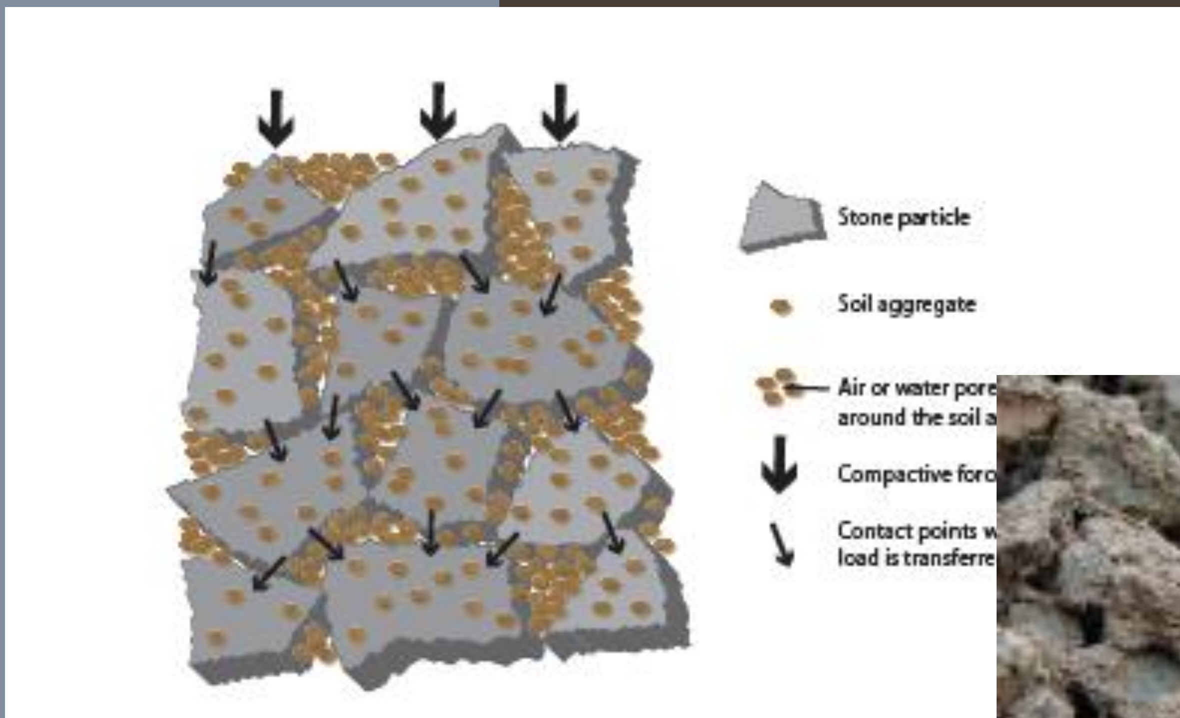
Transpiration Rates of Various Tree Species (Source: ITRC, 2001)		
Plant Name	**Plant Type**	**Transpiration Rate***
Cottonwood	Tree (2 years old)	2.00-3.75 gpd/tree
Hybrid poplar	Tree (5 years old)	20-40 gpd/tree
Cottonwood	Full mature tree	50-350 gpd/tree
Weeping willow	Full mature tree	200-800 gpd/tree
* gpd = gallons per day		

- A single tree can transpire up to 100 gallons of water a day on a sunny summer day (Metro, 2002; EPA, 1992).
- An open grown hardwood tree will consume from 1.2 to 1650 gallons of water per day, depending on the size of the tree and the evapotranspiration (ET) rate (Perry, 1994).

Infiltration

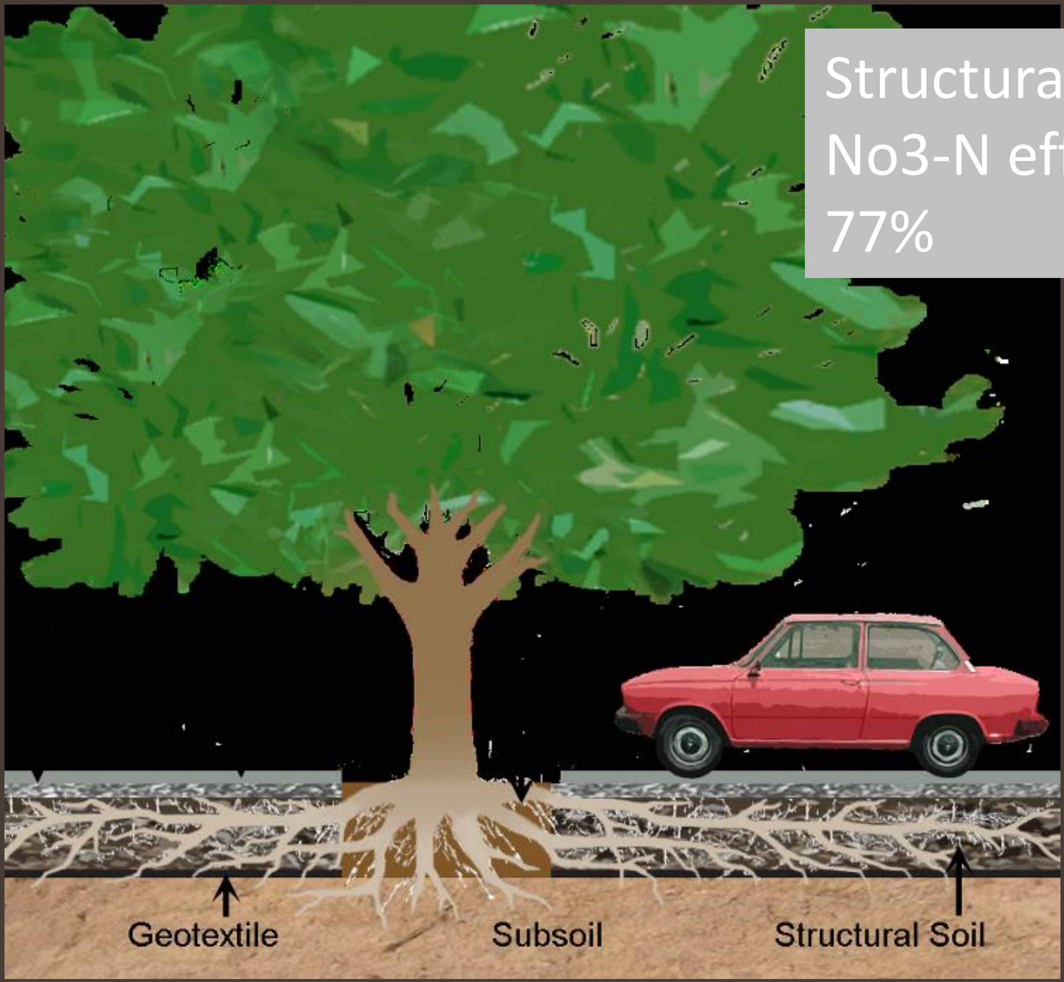
- In a Virginia Tech study roots of Black Oak and Red Maple increased infiltration rates in compacted soils 153%
- In the most restrictive cases trees increased infiltration up to 27 fold
- Another study found that adding trees to structural soils increases infiltration both in the engineered soil and the soil below the system.

Structural Soils

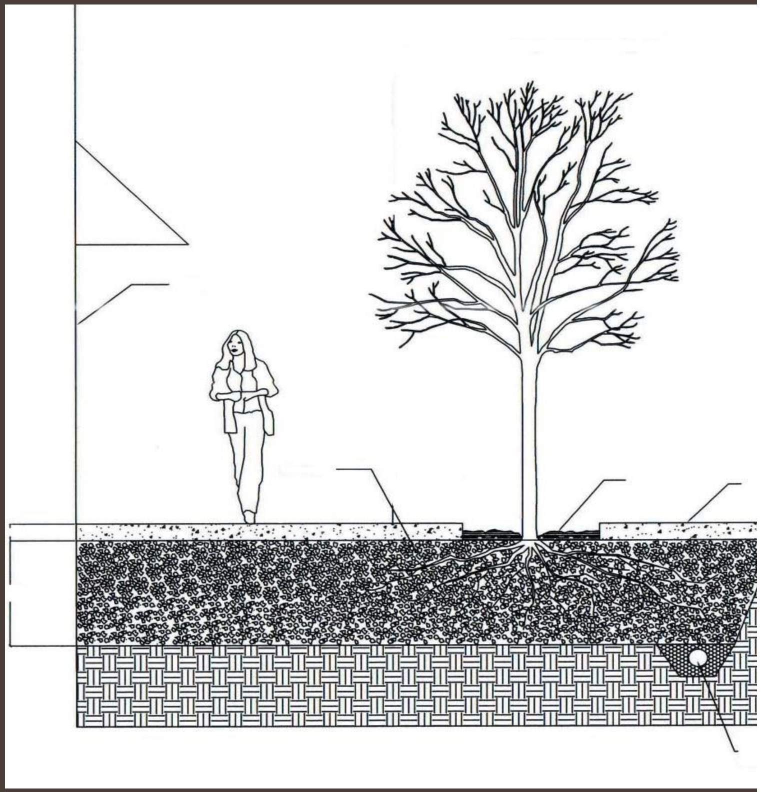


From : *S.D. Day and S.B. Dickenson, 2008, Managing Stormwater for Urban Sustainability Using Trees and Structural Soils*

Structural Soils alone-
No3-N efficiency 73%-
77%



Pollutant removal rates are strongly related to they type and size of rainfall events.



Size of Rain Event (inches)	Required Reservoir Depth (inches)
1.8	6
3.6	12
5.4	18
7.2	24
9	30
10.8	36

Table 2. Reservoir depths and the corresponding levels of mitigated rain events based on the 30% void space within the structural soil mix (assuming an empty reservoir). Numbers in the gray box illustrates the depths necessary to accommodate optimum healthy tree root development.
Table by Ted Haffner.

Credits and Nutrient Reduction

Practice	Reduction Efficiency		
	TN	TP	SED
Forest Buffer	25%	50%	50%
Tree Planting	Land Use Change		
Infiltration Practice w/ sand, veg	85%	85%	95%
Bioretention	25-80%	45-85%	55-90%

- From Chesapeake Bay Model Phase 5 Documentation

Existing Approaches and Examples	
Forest Conservation	Forest conservation areas are subtracted from the site area or IC when computing WQv (MD, NJ, GA)
Reforestation	Same as above, except credit is generally 1/3 to ½ of what would be given for conservation (VT)
Preservation of individual trees	IC underneath half the existing tree canopy may be subtracted from the site IC when calculating treatment volume (Portland, OR, Indianapolis) Runoff reduction credit of 10-20 gallons per inch is given, based on tree DBH (Pine Lake, GA)
Planting individual trees	A portion of IC (generally 100-200 ft^2) underneath tree canopy may be subtracted from the site IC when calculating treatment volume (Sacramento)

Existing Approaches and Examples	
Pennsylvania- Retained Trees	Volume reduction credit based on tree canopy. Tree must be within 100 ft of impervious cover- Volume reduction (ft^3)=Existing tree caopy (ft^2) x 1/2" / 12 *(no more than 25% of runoff volume can be mitigated with trees)*
Pennsylvania- Newly Planted	Tree must be a min 2" caliper and 6 ft in height. Volume Reduction (ft^3)= 6 ft^3 deciduous trees = 10 ft^3 evergreen trees
Seattle- Retained Trees	Impervious surface reduction credit. Trees must be 6" DBH Impervious surface reduction (ft^2)= deciduous trees -10% canopy area (min 50 ft^2) evergreen trees - 20 ft^3 Canopy area (min 100 ft^2)
Seattle- Newly Planted	Trees must be planted within 20 ft of impervious surface, deciduous trees must be min 1.5" caliper Impervious surface reduction (ft^3) = 20 ft^2 deciduous trees = 50 ft^2 evergreen trees

Green Area Ratio

What is it?

- A flexible green site design requirement that varies by zone.

How Achieve?

- Choose from a range of environmental landscape practices each of which have been assigned an environmental performance ranking.

Examples may include…

- Permeable pavement
- Green roofs
- Natural ground cover
- Rain gardens
- Trees & shrubs
- Green facades

GAR: How Does it Work?

How to calculate:

- **Add up landscape elements by number or size**
  - # trees
  - Size of green roof
  - Size of rain garden
  - # of plants
  - Soil depths
- **Divide by lot area**
- **= GAR score**

DISTRICT DEPARTMENT OF THE ENVIRONMENT

green forward

Common engineering concerns and possible solutions	
Tree litter may clog outlets and drainage pipes	Use alternate outlet structures that do not clog. Select species that do not produce excessive litter.
Increases difficulty removing sediment from practices that require periodic sediment removal without harming or removing the trees.	Modify practice design so that trees are separate from areas where sediment is deposited (use a forebay).
Tree roots may puncture filter fabric or underdrains	Increasingly designers are moving away from the use of filter fabric between the filter media and site soil. Replace the function of the filter fabric with sand or pea gravel layer.
Trees can reduce storage or conveyance capacity,	Modify practice to account for trees.
Overgrowth of trees in maintenance areas may limit access.	Maintain trees in maintenance access areas and within 15 feet of these areas
Trees on embankments may compromise stability of embankment	Do not plant trees within 15 feet of embankment.

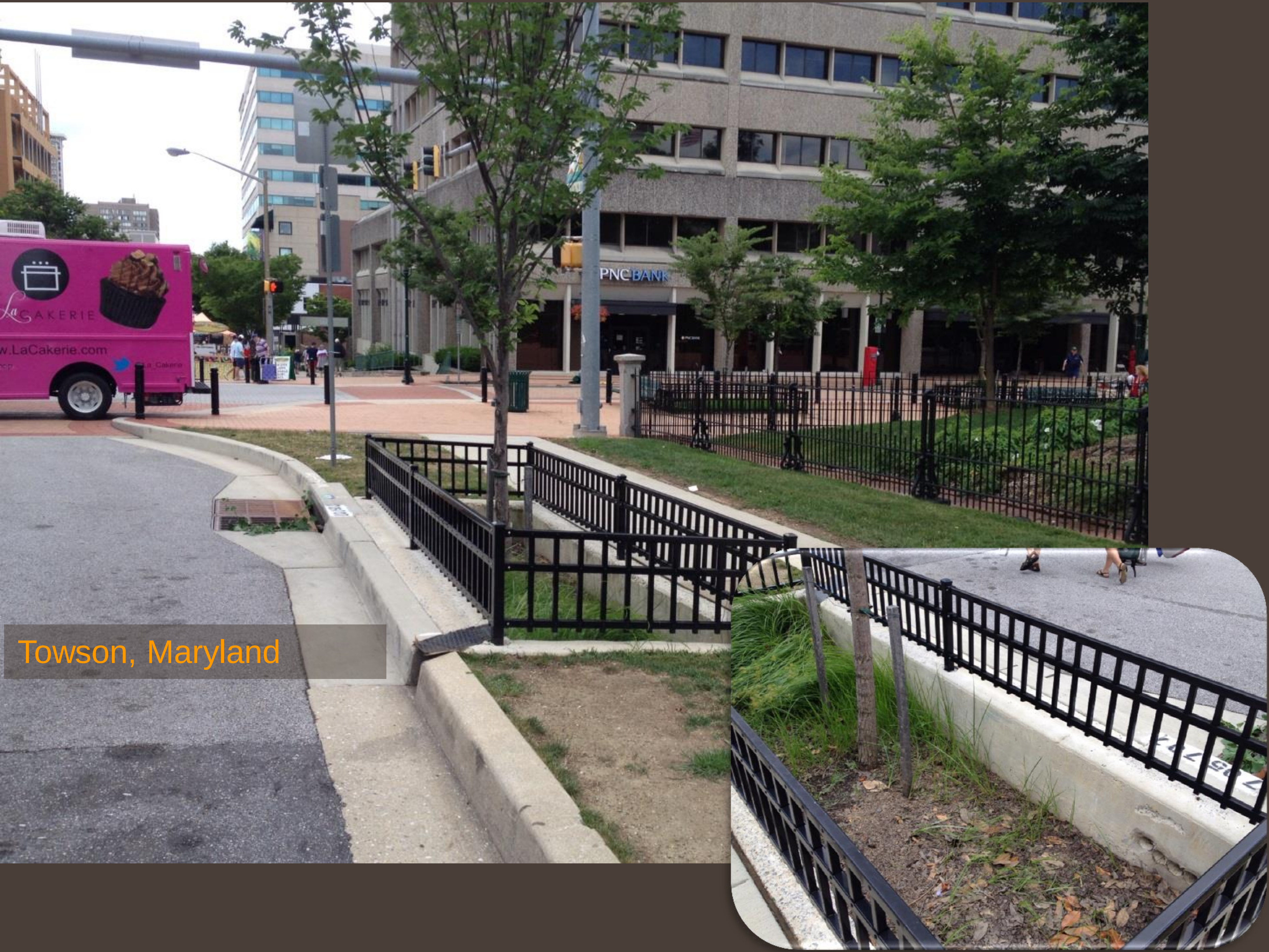
Tree Pits

Filterra claims 79-90% TSS 82% TP and 76% TN reduction efficiencies

Bicknell Avenue Green St. Project

City of
Santa Monica℠

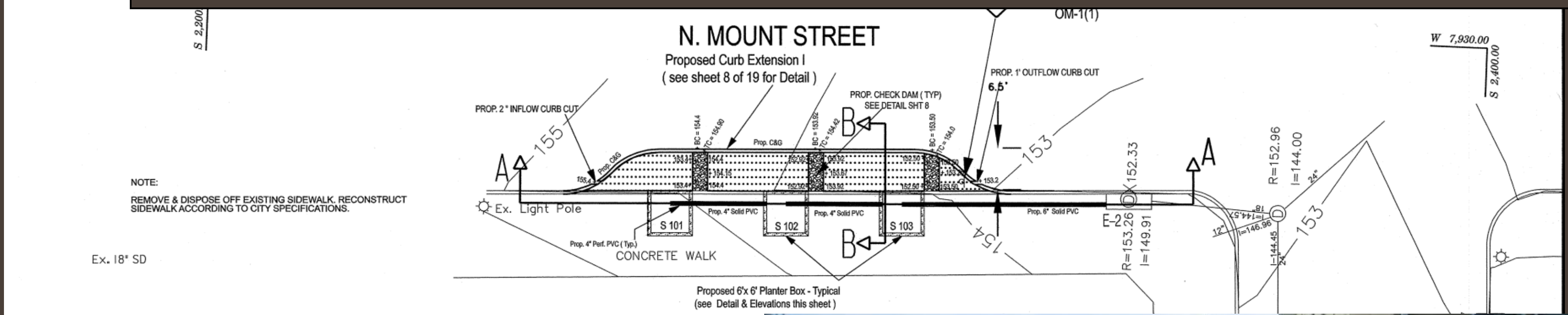
STORMWATER PLANTER, PORTLAND, OR

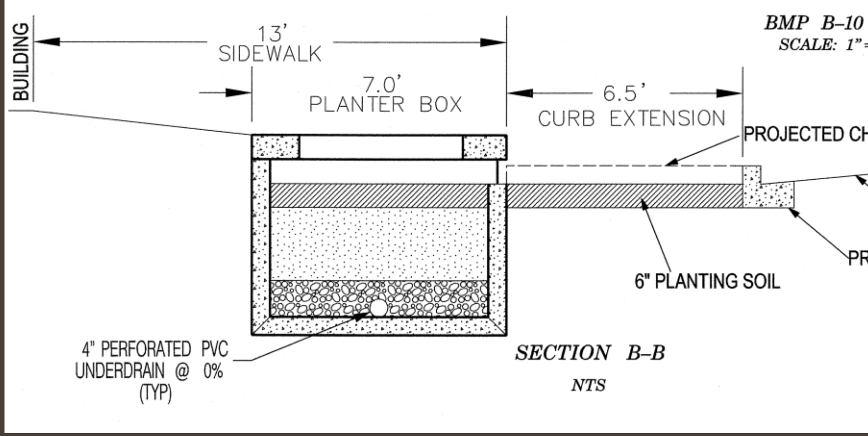


Towson, Maryland

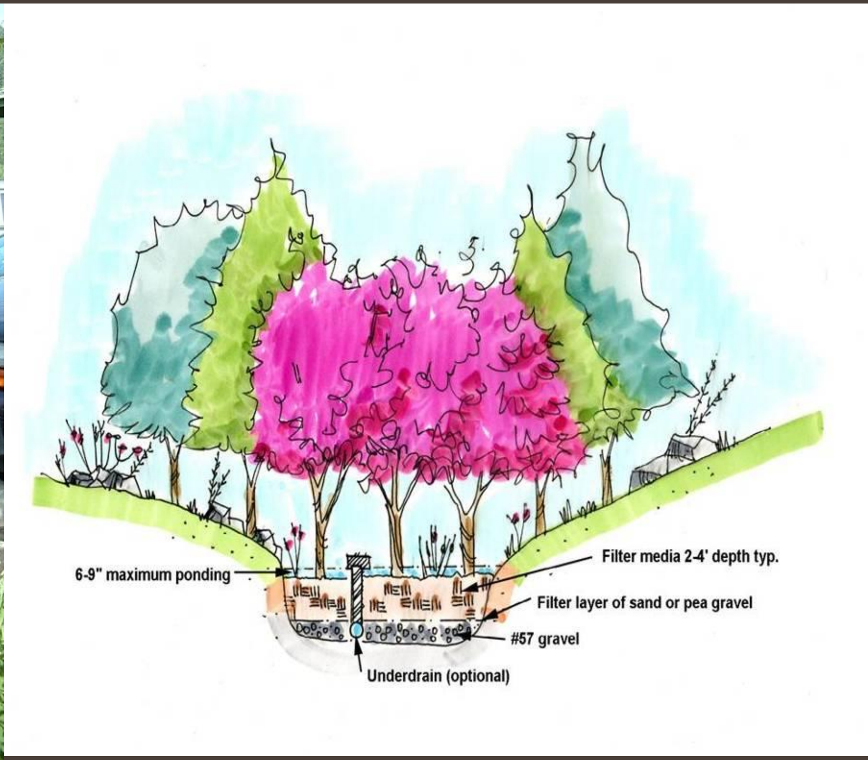
Rush University Medical Center, Hitchcock Design Group

Curb Bump-out with Tree Pit





Bioretention with Trees



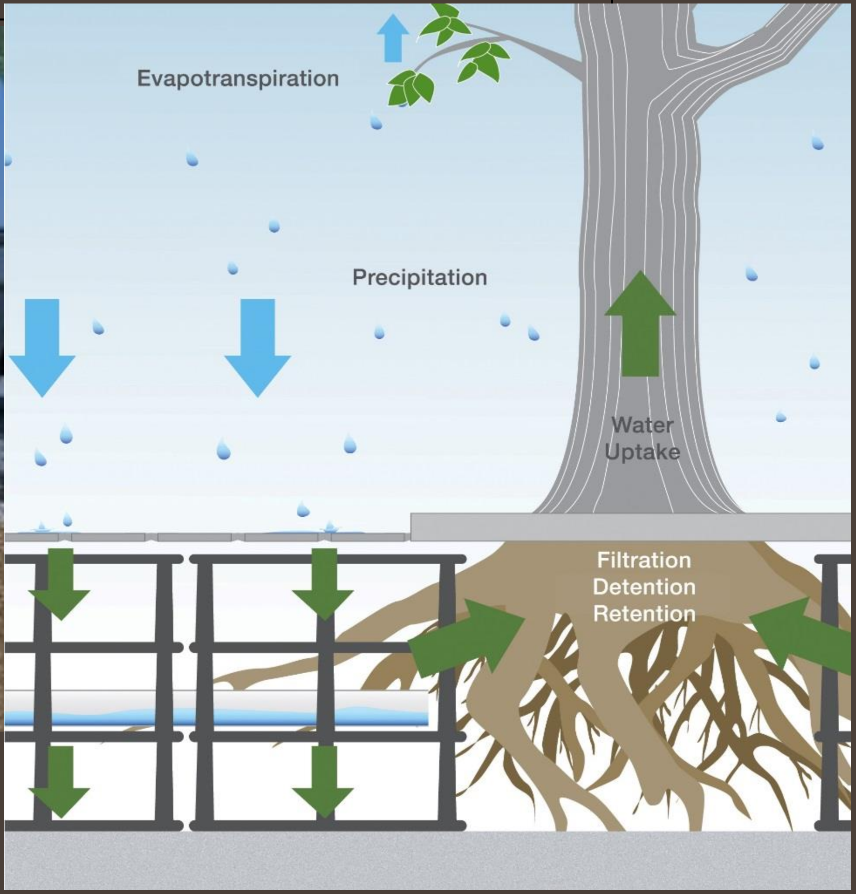
KELLER LIBRARY, NEW ORLEANS: SPACKMAN MOSSOP MICHAELS

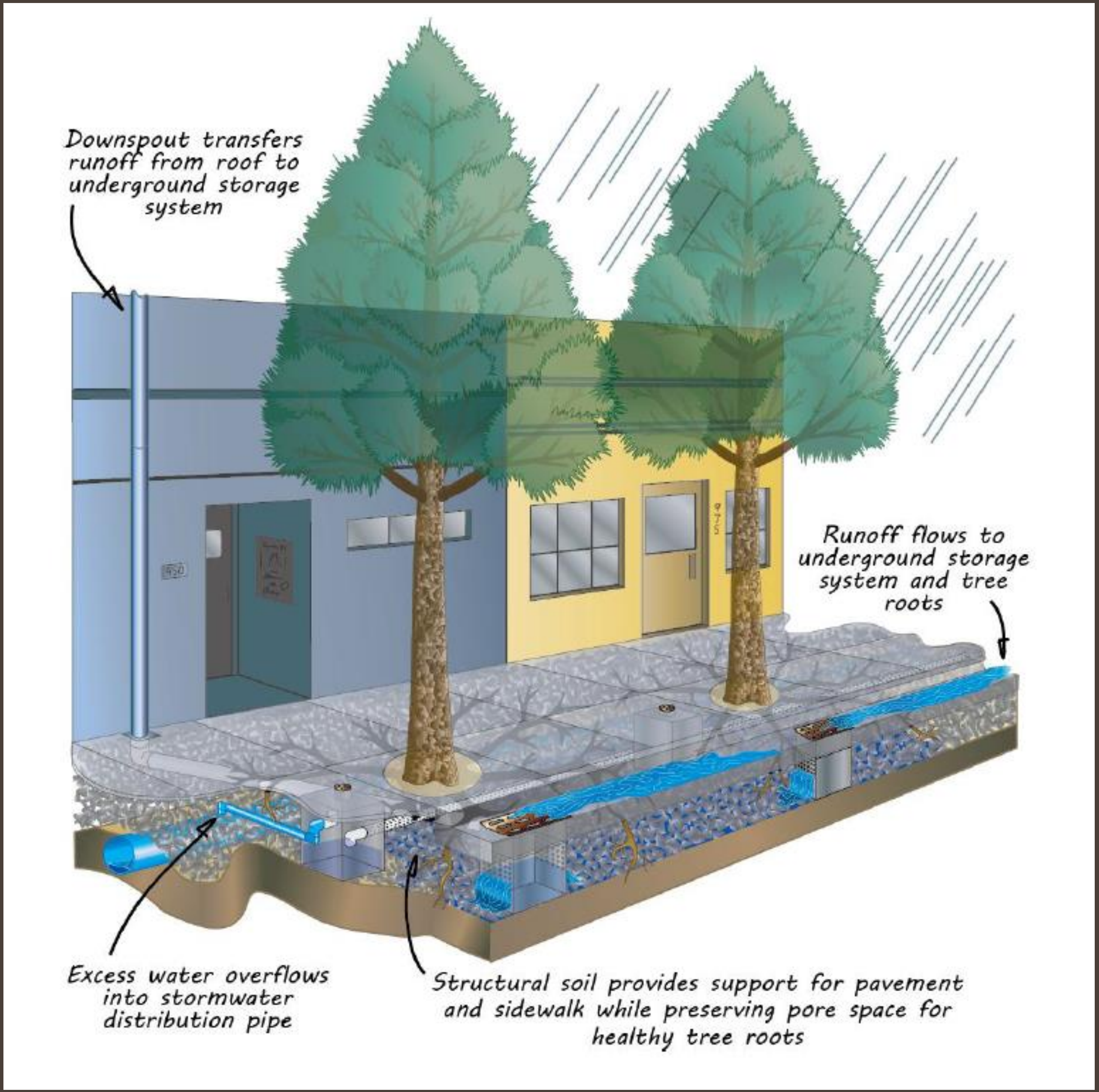
CASEY TREES HEADQUARTERS

Casey Trees Headquarters

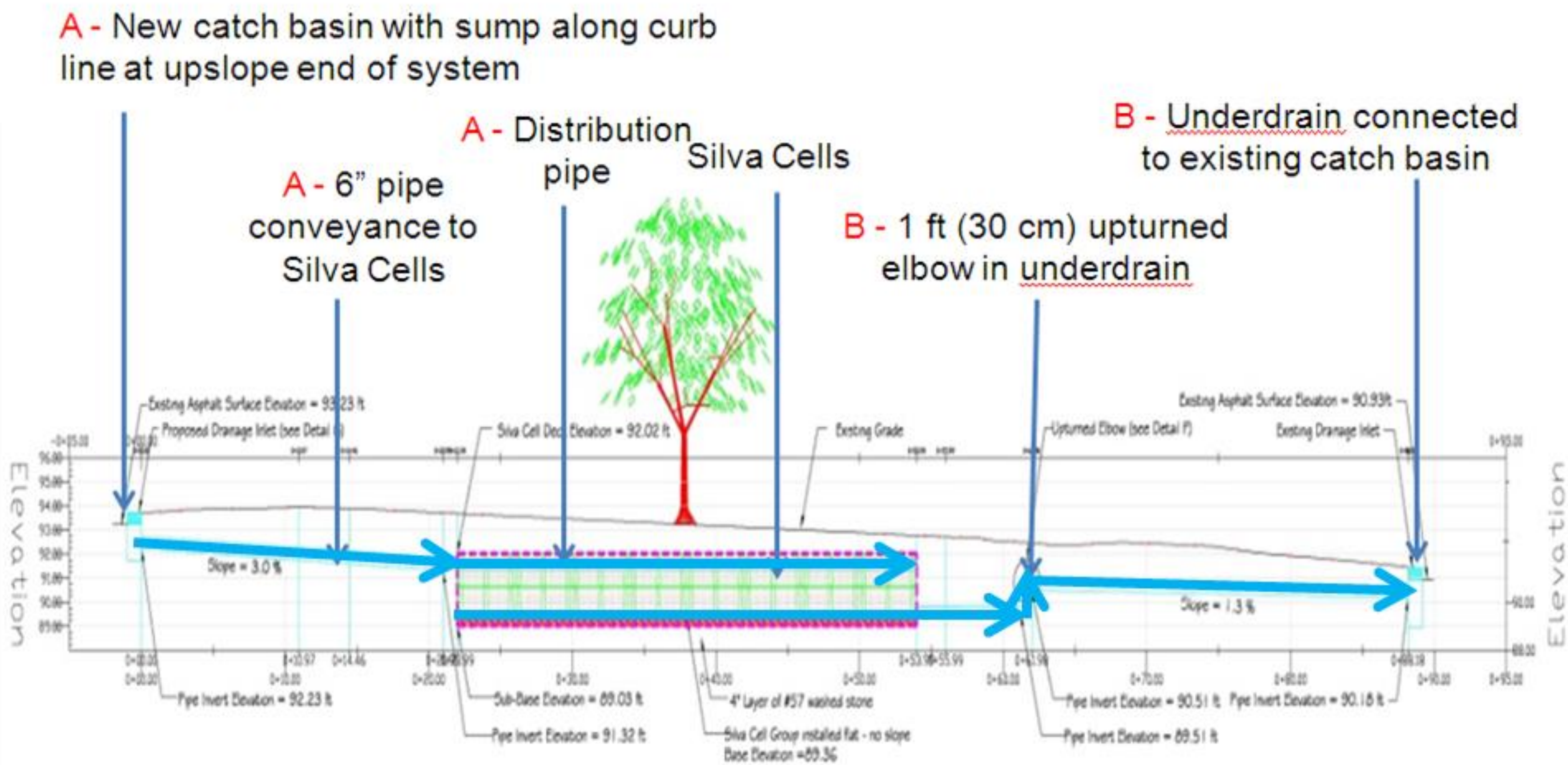
Casey Trees Headquarters

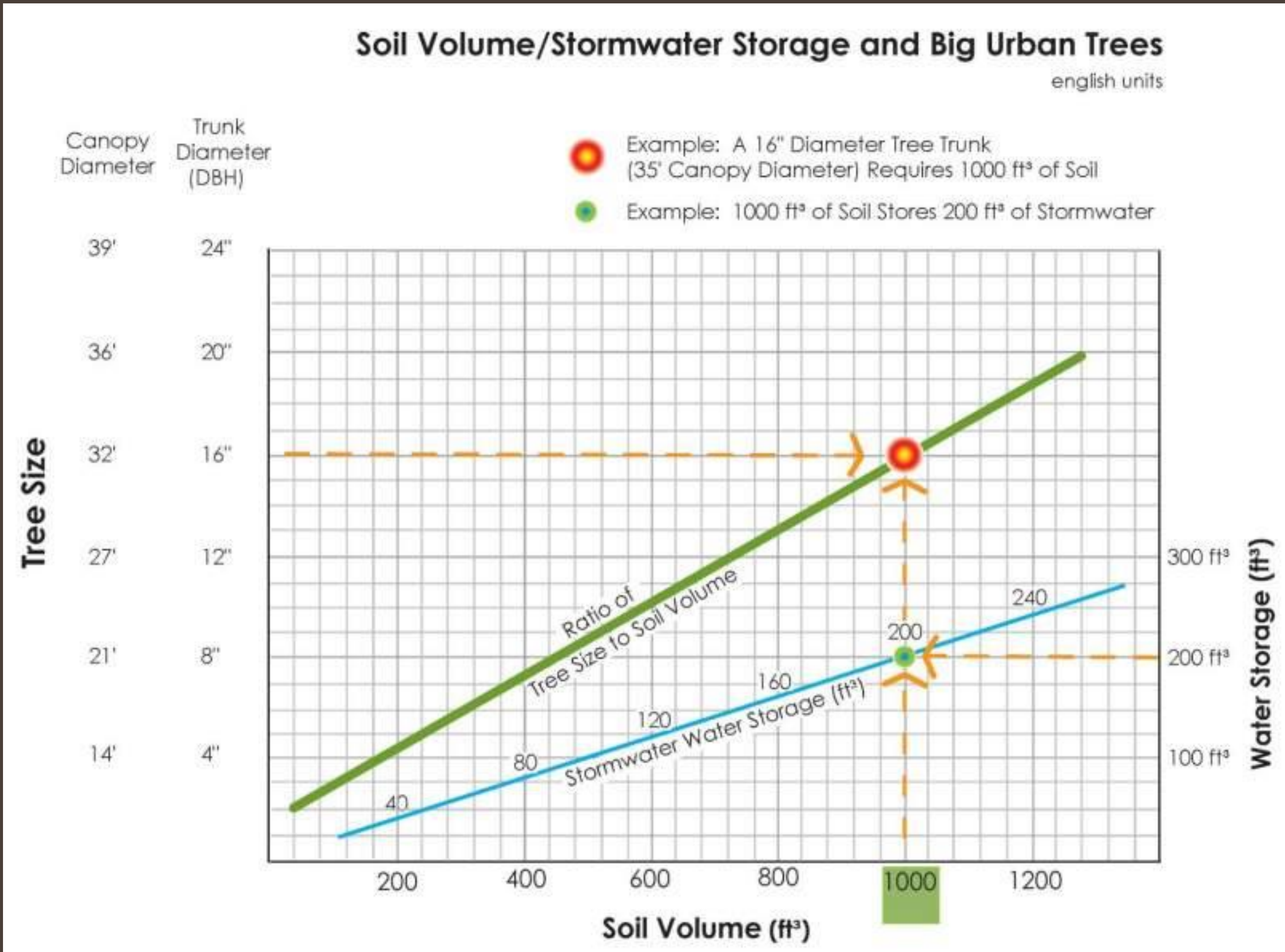
Structural Cells/Silva Cells




Downspout transfers runoff from roof to underground storage system
Runoff flows to underground storage system and tree roots
Excess water overflows into stormwater distribution pipe
Structural soil provides support for pavement and sidewalk while preserving pore space for healthy tree roots

Stormwater Routing Cross Section




Soil Volume/Stormwater Storage and Big Urban Trees
english units
Example: A 16" Diameter Tree Trunk (35' Canopy Diameter) Requires 1000 ft³ of Soil
Example: 1000 ft³ of Soil Stores 200 ft³ of Stormwater
Canopy Diameter
Trunk Diameter (DBH)
39' 24"
36' 20"
32' 16"
27' 12"
21' 8"
14' 4"
Tree Size
Ratio of Tree Size to Soil Volume
Stormwater Water Storage (ft³)
40
80
120
160
200
240
300 ft³
200 ft³
100 ft³
Water Storage (ft³)
200
400
600
800
1000
1200
Soil Volume (ft³)

Structural Cells and Soil Filtering Capabilities

80% Sand:20% Compost - Bioretention Soil Mix

Cumulative Percent Removal by Depth						
Laboratory/Field Summary						
Soil Depth	**Cells Deep**	**Cu** copper	**Pb** lead	**Zn** zinc	**P** phosphorus	**TKN** Keldahl nitrogen
12”	1	90	93	87	0	37
24”	2	93	99	98	73	60
36”	3	93	99	99	81	68

Data on bioretention removal rates of pollutants such as ammonium and total nitrogen is variable, so has not been included here.

Adapted from Prince George’s County Bioretention Manual

Queensway, Toronto

Cooperative Research between Ryerson University & University of Minnesota

Catch Basin

Perforated distribution pipe is installed to bring water from the catch basin through the Structural Cell system

Wilmington
Silva Cell

caption


Derby Midland Station

Outcomes:

Quick Facts:

- **Project Cost:** $950,000+
- **Total Linear Feet Restored:** 1700
- **Drainage Area Treated:** 144 Acres
- **Native Plant species** Planted 4,000+ stems including over 500 Atlantic White Cedar, a globally threatened wetland species
- **Construction time**: Mobilization began in December 2012, with final in-stream work completed in March, 2013.

Severn RIVERKEEPER®

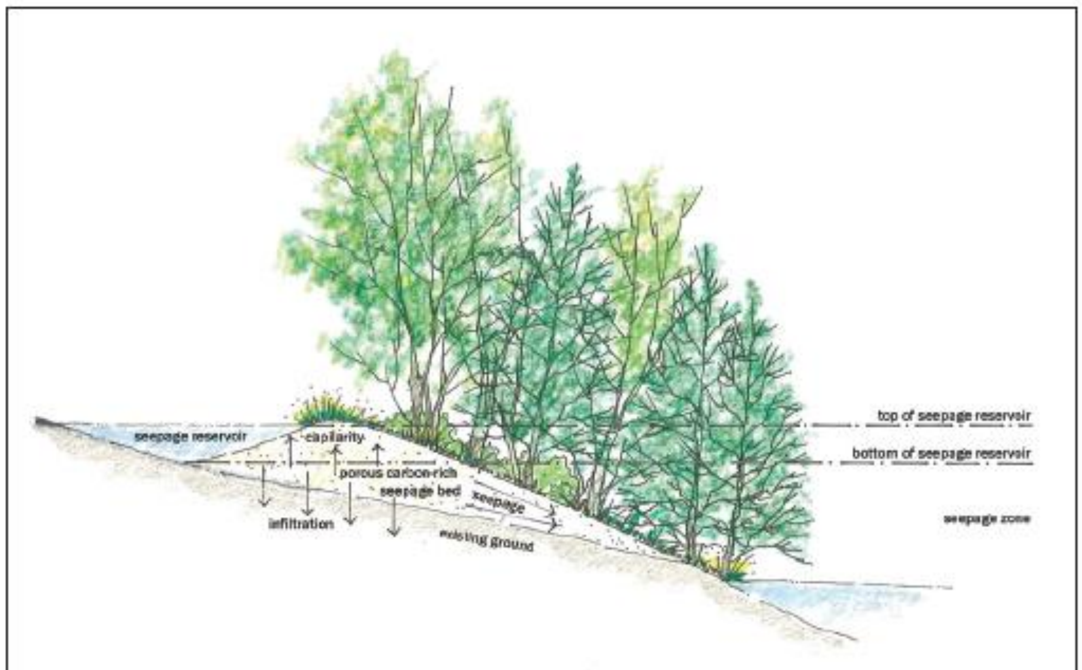
Created a Sand Seepage Wetland below the filled Right of Way

…a series of pools, stream reaches and cobble riffles extending nearly 500 linear feet and exiting into a threaded channel portion of Cabin Branch about a mile above tidal Saltworks Creek.

WOODBROOK LAGOON ENHANCEMENT PROJECT

Biohabitats
SOUTHEAST ATLANTIC BIOREGION

7.5 acres of a former sanitary sewerage lagoon and
1,100 linear feet of stream and floodplain in heavily development
225-acre watershed



Stormwater in the lagoon will
be temporarily impounded
behind a sand seepage berm, allowing water to slowly infiltrate. The berm, supports microbes which remove contaminants
as stormwater passes through it. The temporary impoundment also functions to attenuate stormflows within the subwatershed.

Questions?

Soapbox session

Brian Morrow, United Utilities
Frank Broom, Knowsley MBC
David Brown, Environment Agency
Andy Wood, JBA Consulting
Iain Taylor, Peel Holdings
Julia Thorpe, Liverpool Mutual Homes

Urban Watershed Forestry: the proposed project

Susannah Gill, The Mersey Forest
susannah.gill@merseyforest.org.uk

Aim & Objectives

- Aim
  - To develop an action research project to make a convincing business case to enable increased urban tree and woodland planting for water management benefits (both water quantity & quality)
- Objectives
  1. To review existing evidence
  2. To monitor & model selected urban catchments
  3. To engage, disseminate & mainstream findings to lead to action

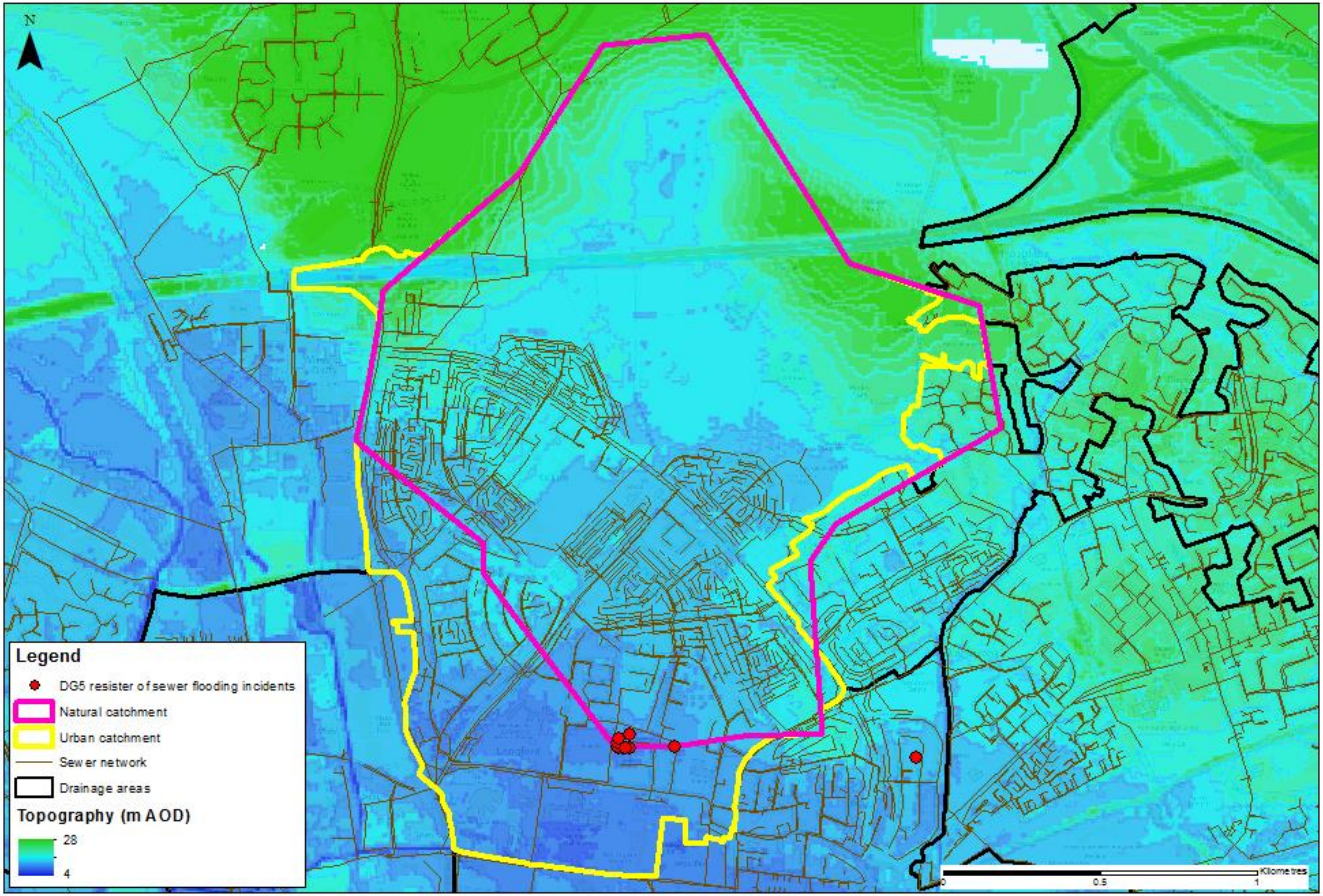
Obj 1. Review of existing evidence

- From UK & international
- Academic research, policy & practice
- Water-related benefits
- Methods to quantify these
- Financial models used to justify investment in water infrastructure

Obj 2. Monitoring & modelling of selected urban catchments

- Monitoring
  - Network to monitor rainfall, surface water volumes, velocity & quality
    - Surface water & quality ‘hotspots’
    - Align with existing / planned monitoring of water system
  - Define ‘urban water catchment’ for each monitoring point
  - Characterise catchments
    - Land cover, tree cover, soil types, green infrastructure
  - Baseline monitoring of at least 1 year
  - Plant trees in some of the catchments
    - Need for longer term monitoring

Defining 'urban water catchment'



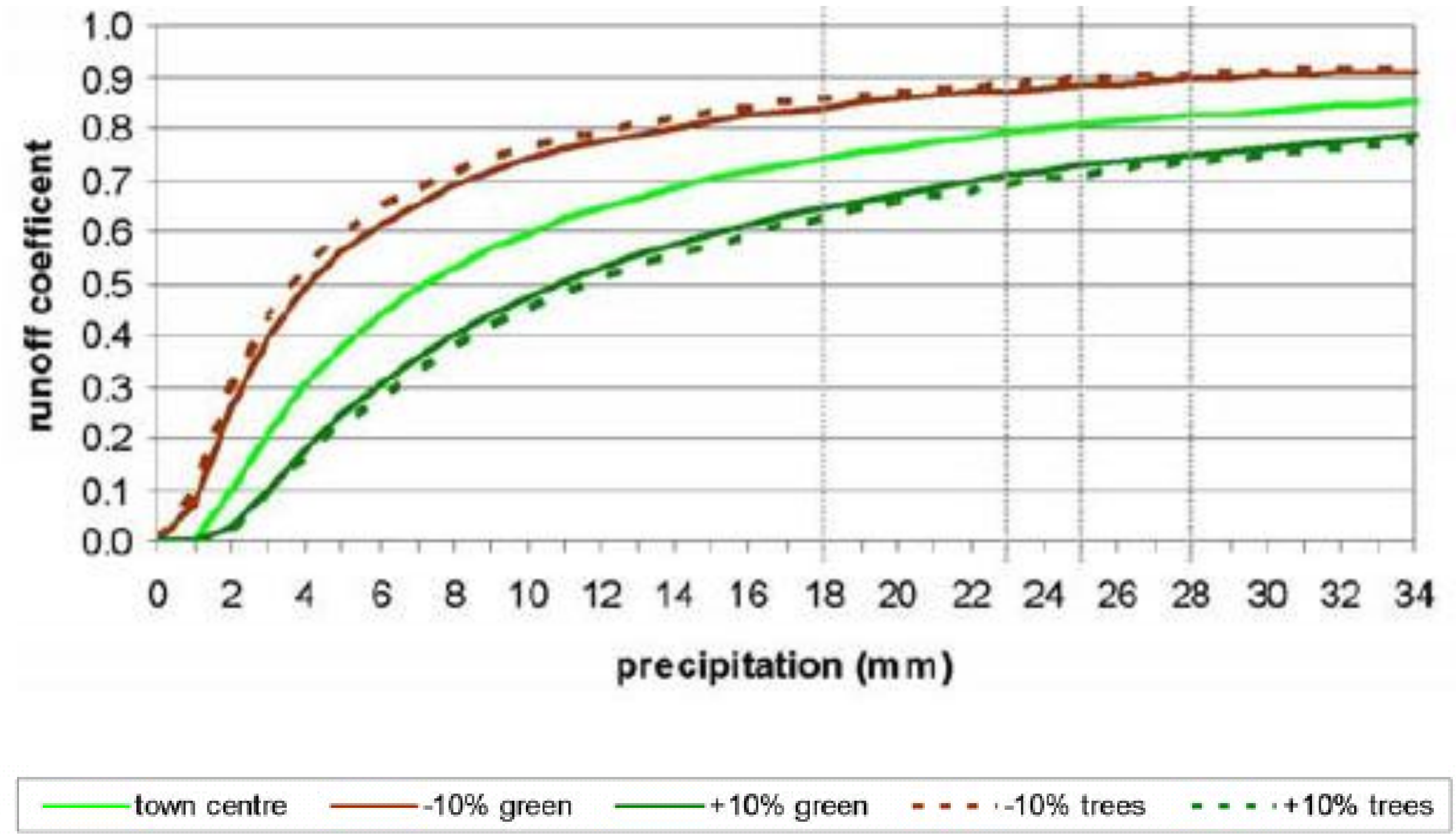
Obj 2. Monitoring & modelling of selected urban catchments

- Modelling
  - Run existing models for each catchment to see what runoff may be, testing different tree cover scenarios
  - Compare modelled & monitored results
  - Validate / refine models to produce an endorsed approach
  - Economic quantification of benefits

Modelling runoff: STAR tools

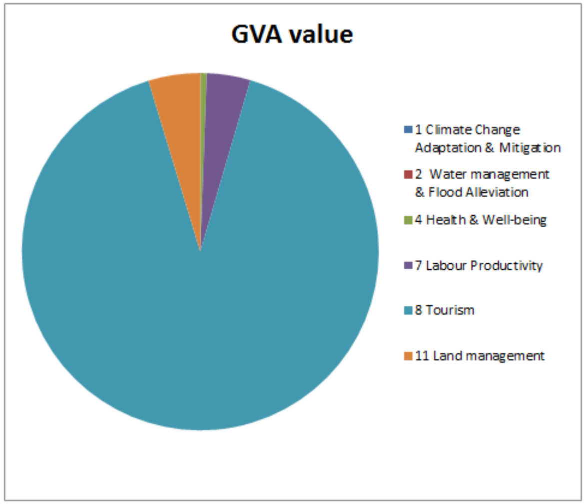
- Calculates surface runoff volumes & proportions for given rainfall events
- Define your area
- Change land cover & soil types
- Based on the US Soil Conservation Service ‘Curve Number’ approach
- www.ginw.co.uk/climatechange/startools

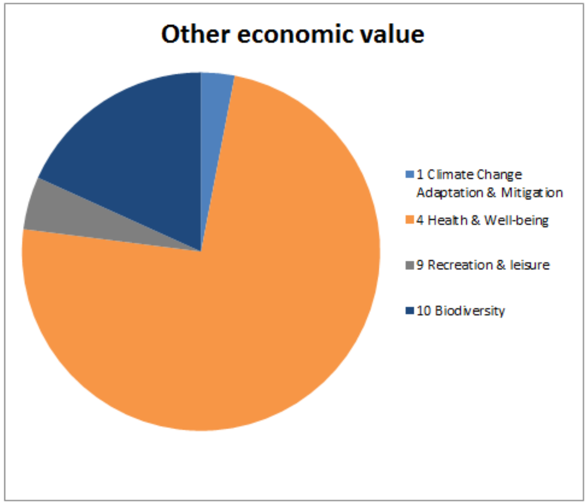
Example of STAR tool output



Quantifying economic benefit: GI Valuation Toolkit

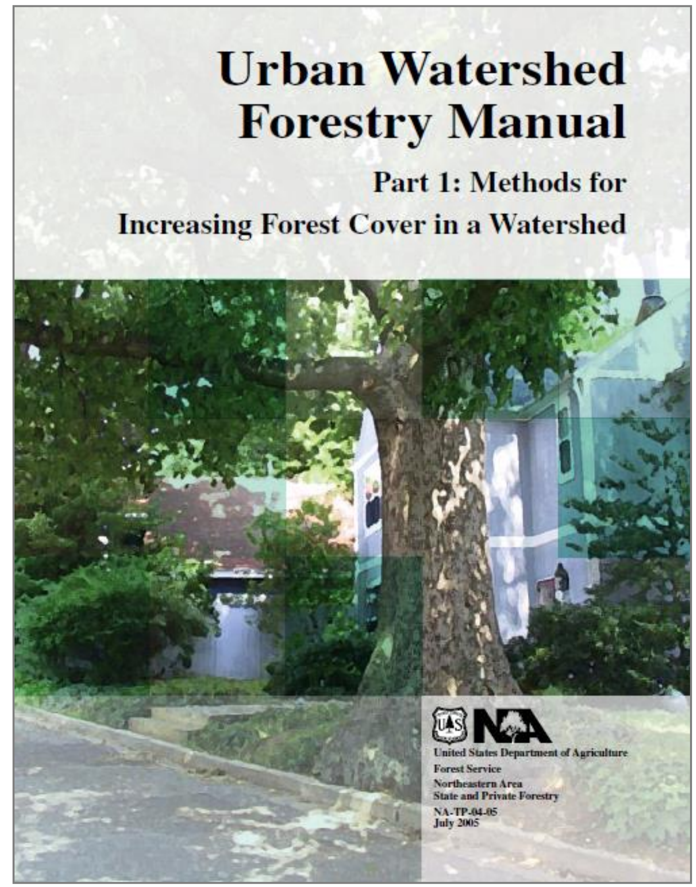
- Developed by a consortium
- The Mersey Forest continues to develop it with partners
- First version in 2010, version 1.3 in 2014
- Valuation tools for a range of benefits, including water management & flood alleviation
  - Energy & carbon savings from reduced stormwater volume entering combined sewers
  - Approach is aligned with the STAR tools
- http://bit.ly/givaluationtoolkit





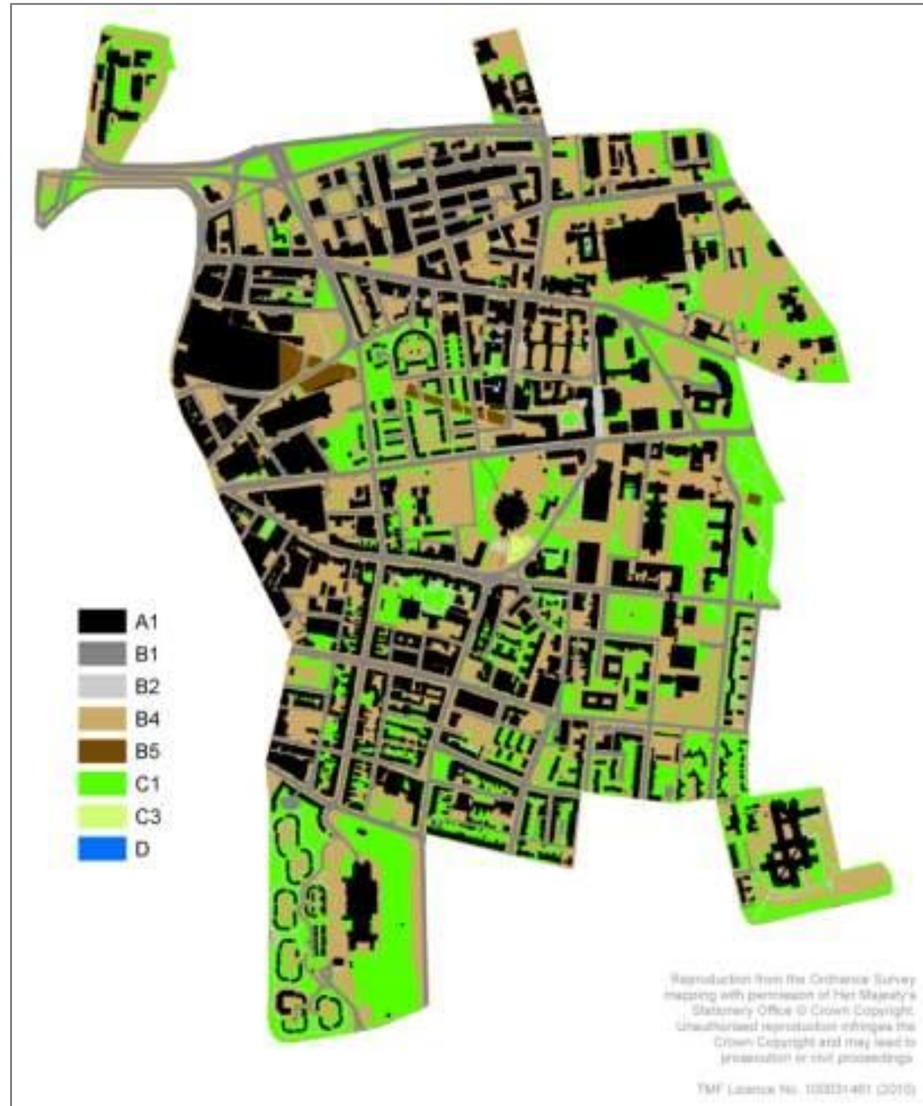
Obj 3. Engagement, dissemination & mainstreaming findings to lead to action

- Training for different audiences
- Dialogue between key sectors & professions
- Influencing & developing organisations' policies / tools to enable delivery
- UWF Manual
- Community engagement



Tool to enable delivery: GI Toolkit for Developers

- Determine GI Score & interventions to maximise benefits
- GI Score
  - Surface cover types assigned GI Factors
  - Multiply by area
  - Target is a pre-determined GI Score
- Adapted from approaches used in Berlin, Malmö & Seattle
- NWDA's Sustainability Policy for the Built Environment



Northwest communityforestsnorthwest TEP grabs INTERREG IVC

Potential partners

- Transnational partnership project
- Mersey & Red Rose Forest areas
  - Complementary research elsewhere
- National
- International
  - Europe – ForeStClim partners
  - US – Center for Watershed Protection

Timeline

End July	Final prospectus, to provide information to potential partners & funders
Summer	Investigate funding options, develop partnership & secure contributions
Late 2014 / 2015	Submit funding applications
5 years?	Duration of project – Long enough to collect baseline data & monitor change
Longer term	Longer term monitoring of change also desirable

Your Input

- Project idea is still in development
- Your views welcome today & after
  - Project concept & proposal
  - Related research
  - Partners
  - Priority funding sources

URBAN WATERSHED FORESTRY SEMINAR

Break Out Groups

#UWFseminar

Break Out Groups

- List has been circulated showing the group you have been allocated to
- Groups 1, 2 and 3 meet in here; Groups 4, 5 and 6 meet outside (flipcharts showing which number group is where)
- Grouped around key topics: Regulatory & Policy Issues, Research & Quantification Methods, Practical Implementation
- Volunteers to take notes would be appreciated
- Feedback 3 key points overall

Break Out Group Questions

- What are the target outcomes that the project should achieve?
- What opportunities are available to ensure that these are met, and how should these best be capitalised upon?
- What challenges are likely to be encountered and what needs to be done to overcome these?
- Which organisations or individuals need to be involved to ensure success?