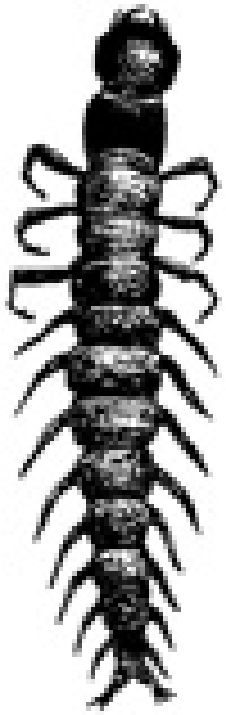
Macroinvertebrates & Land Use Change

Cary Institute
of Ecosystem Studies



Predict what you think happened to each of these land use types between 1936 and 2000

Topic	Loss	Gain
Forests		
Agriculture		
Housing		
Roads		

Predictions?

Manhattan Island in 1609 and 2009; Mannahatta Project

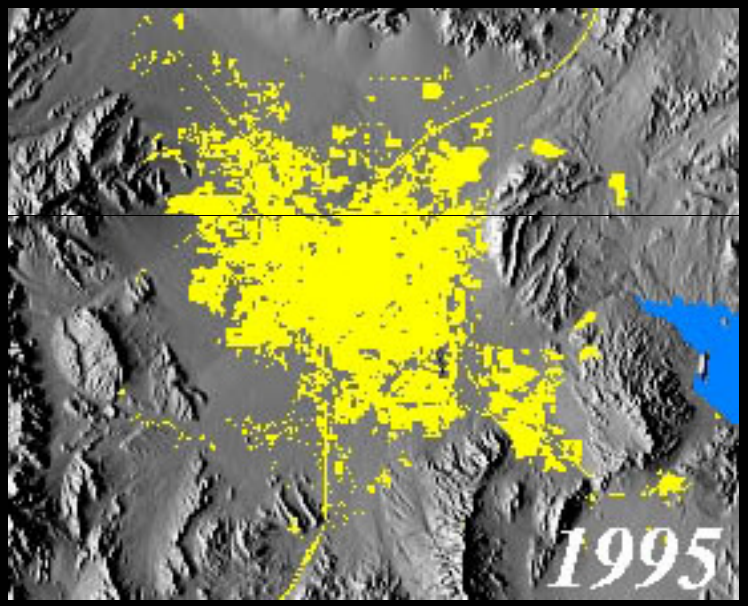
Global Land Use Change

2000: Rondonia region of western Brazil, images from NASA

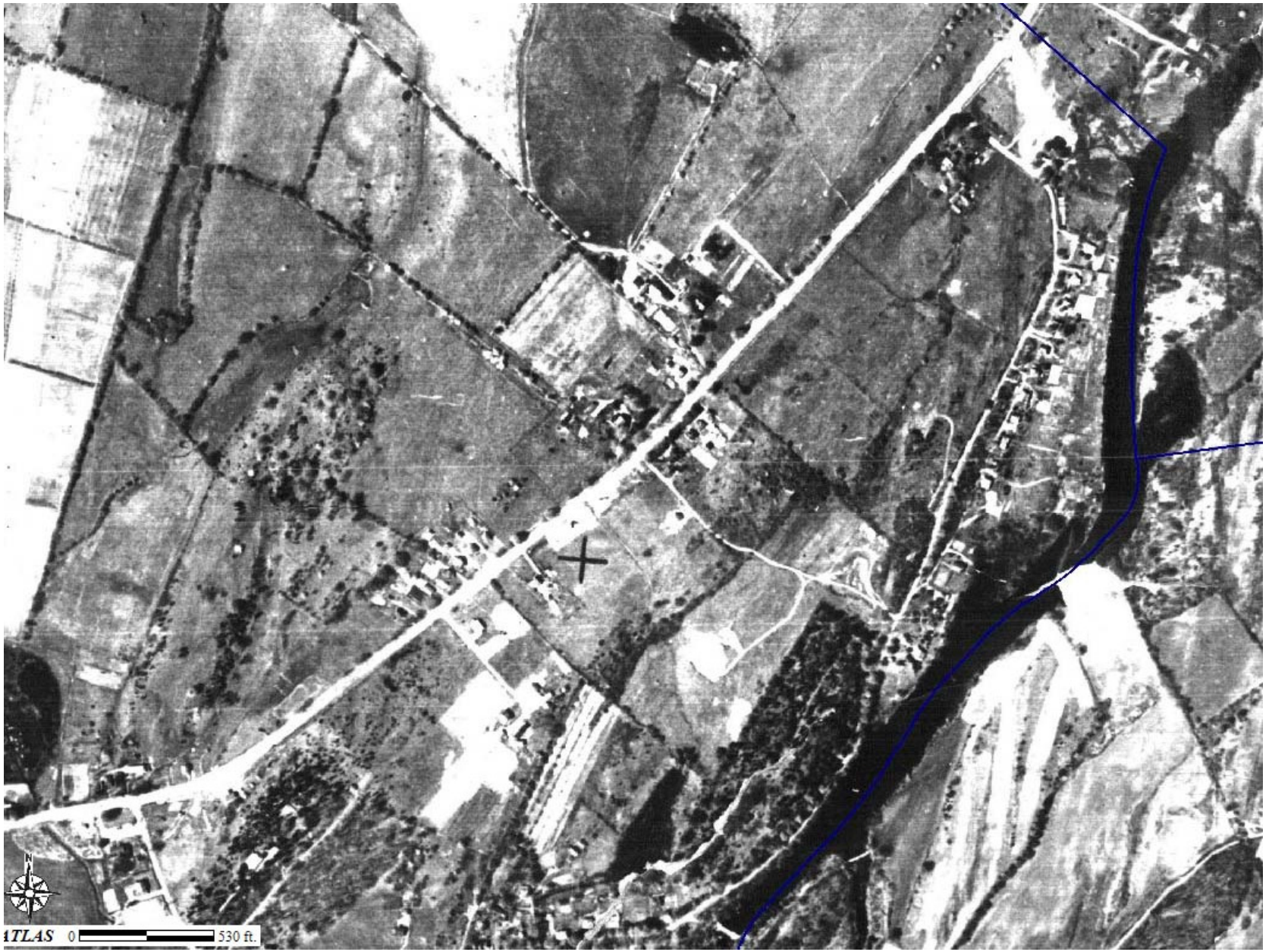
2008: Rondonia region of western Brazil, images from NASA

Las Vegas – Fastest growing metropolitan area in the United States

- 1973: A small settlement
- 2000-2006:The landscape is now dramatically modified



Images courtesy USGS

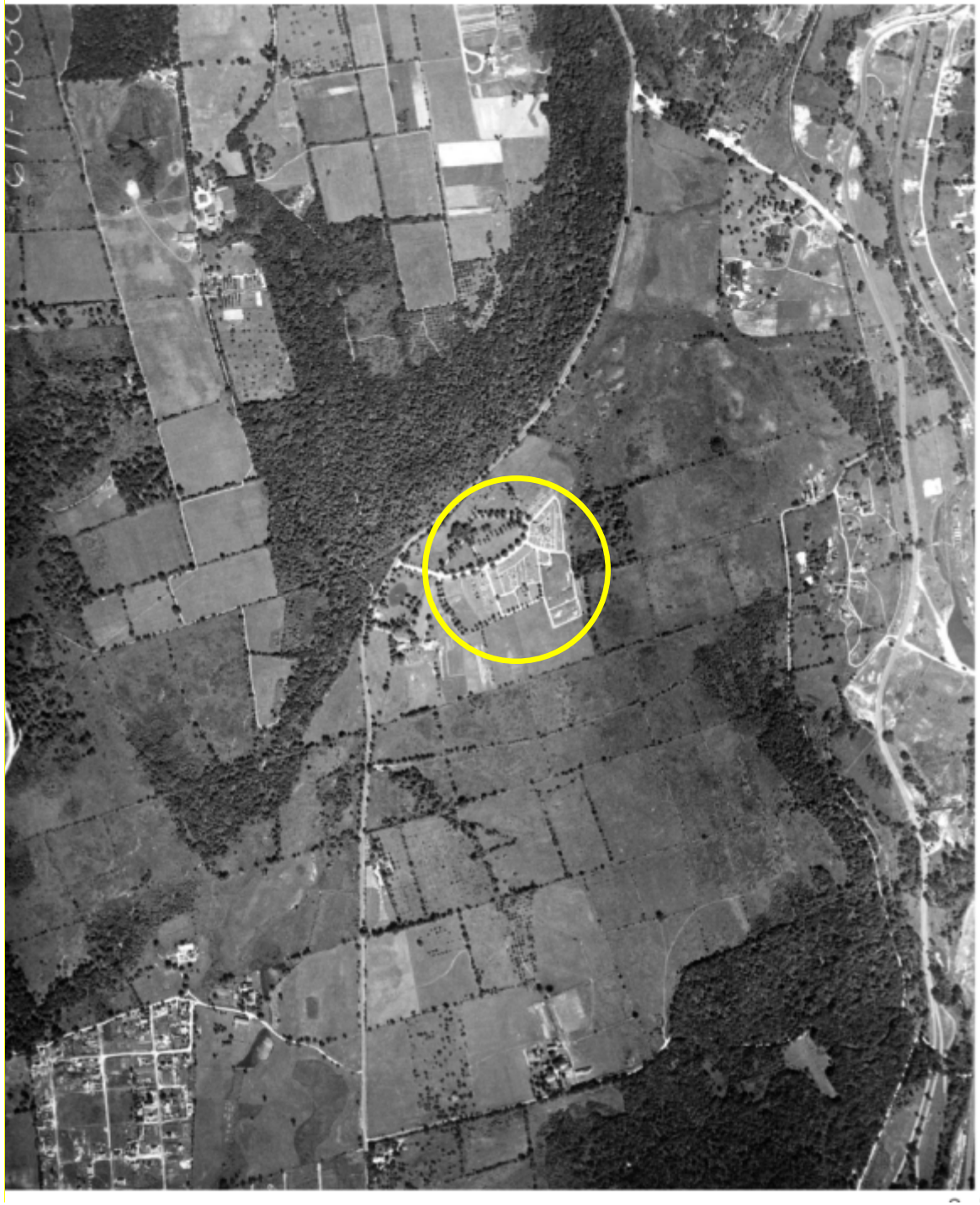


1936: Pleasant Valley along Rt 44

2004: Pleasant Valley along Rt 44; Wappingers Creek on the right hand side

1936: Rt 9, site of current Galleria mall,
small quarry visible next to river

2004: Poughkeepsie Galleria on right hand side, gravel quarry next to river



White Plains, 1925

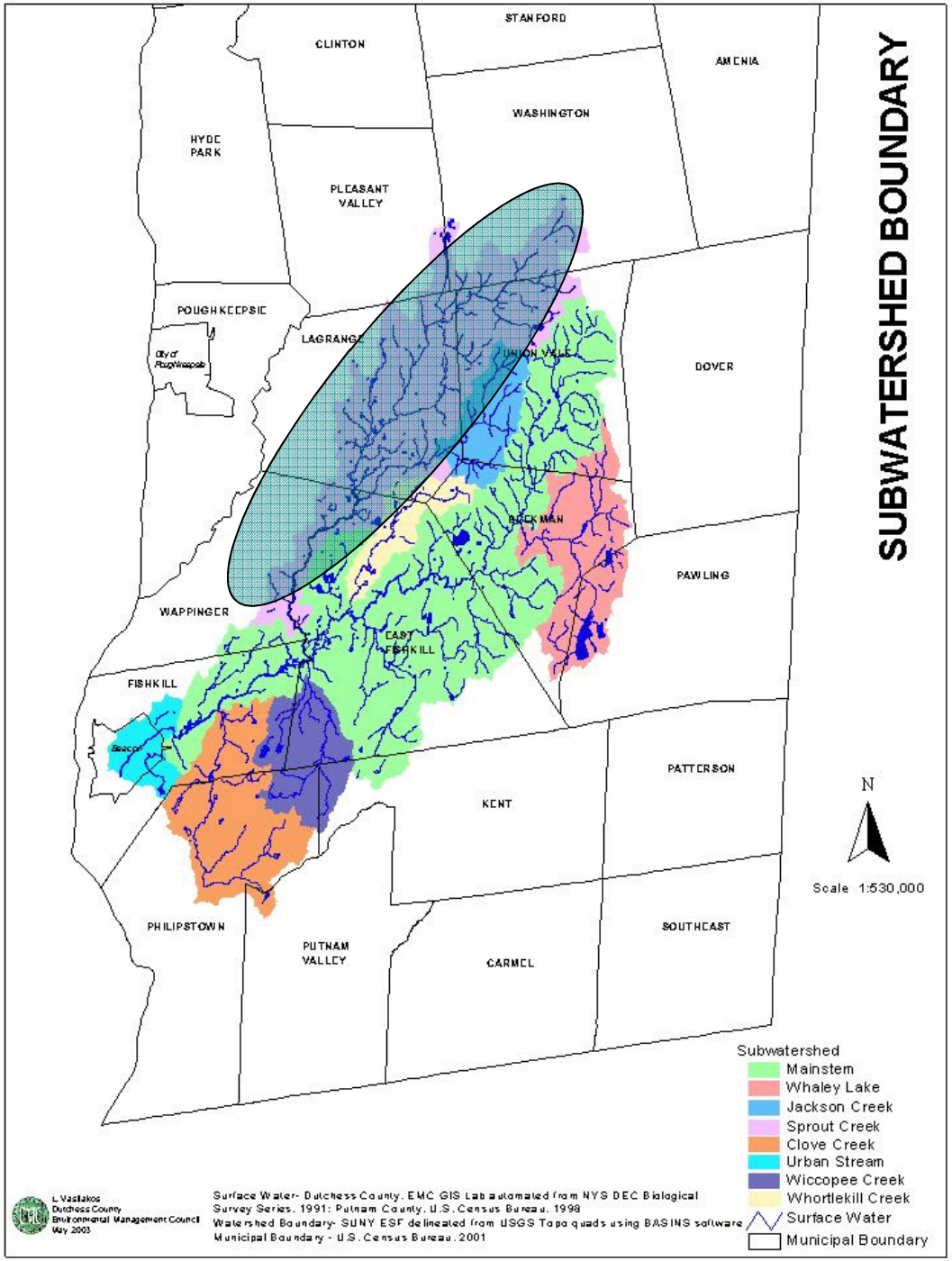
(although the images do not match up exactly, you can see the contour outline of the trees in the second image, along with the development that is circled)

White Plains, 1995

Interstate 287/87

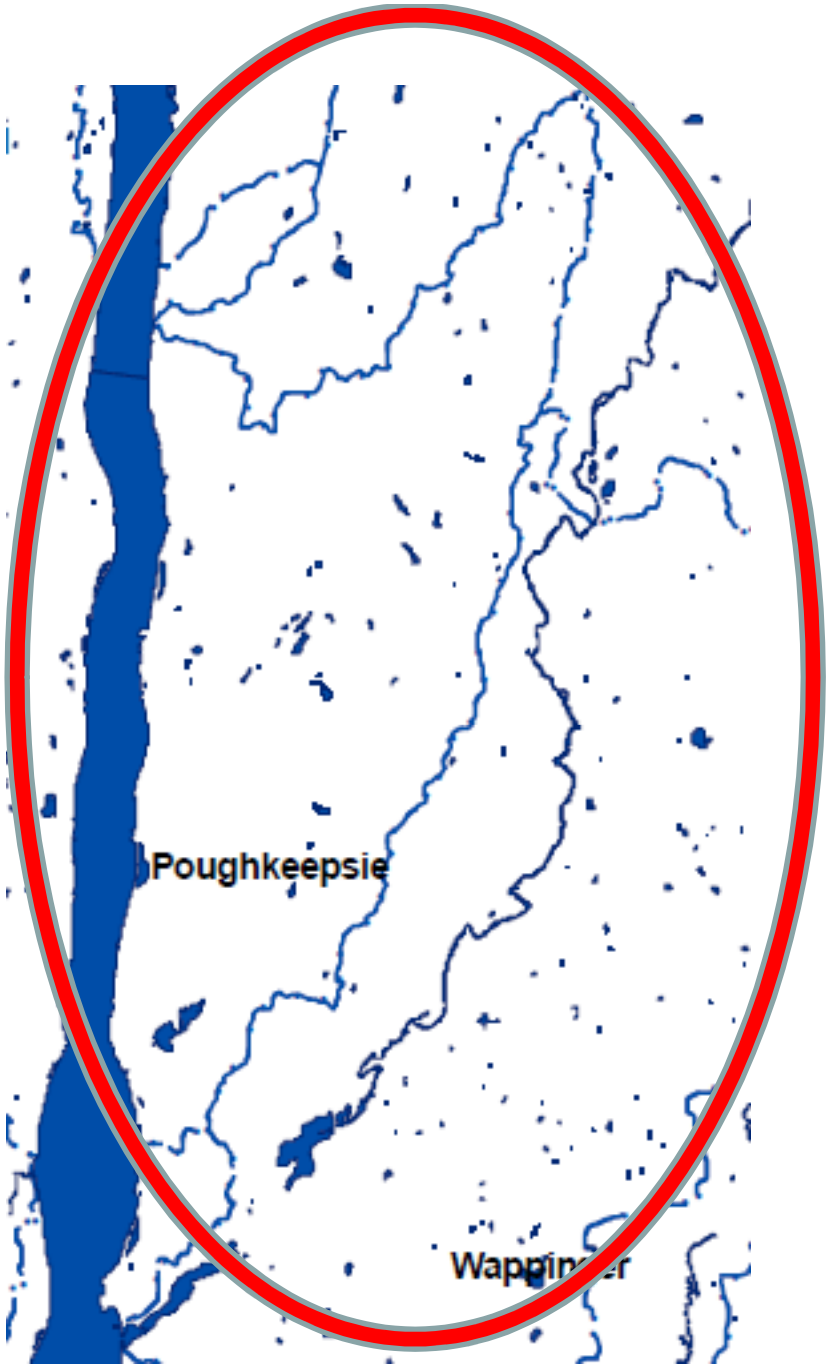
Watersheds

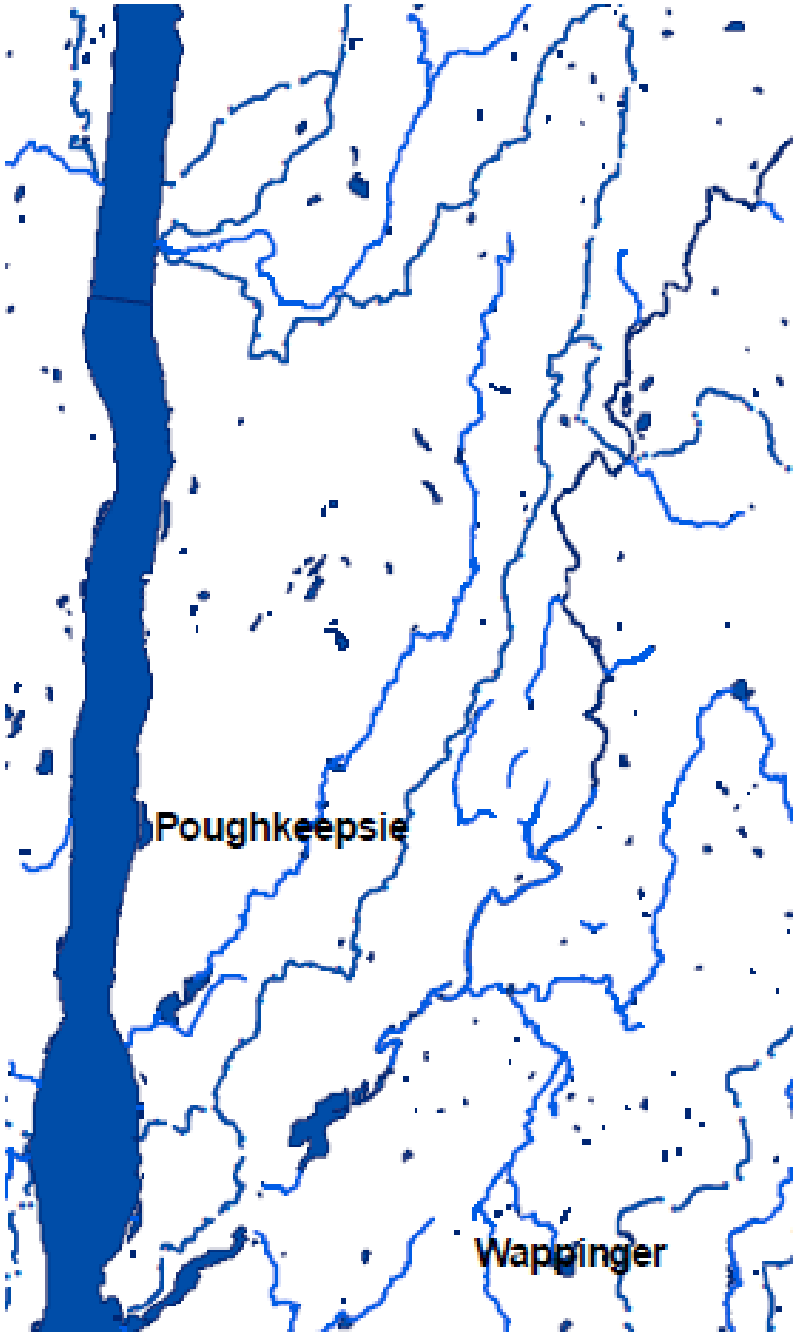
Comparison watersheds: Casperkill (runs through Poughkeepsie, NY) and the East Branch (runs through Millbrook, NY)

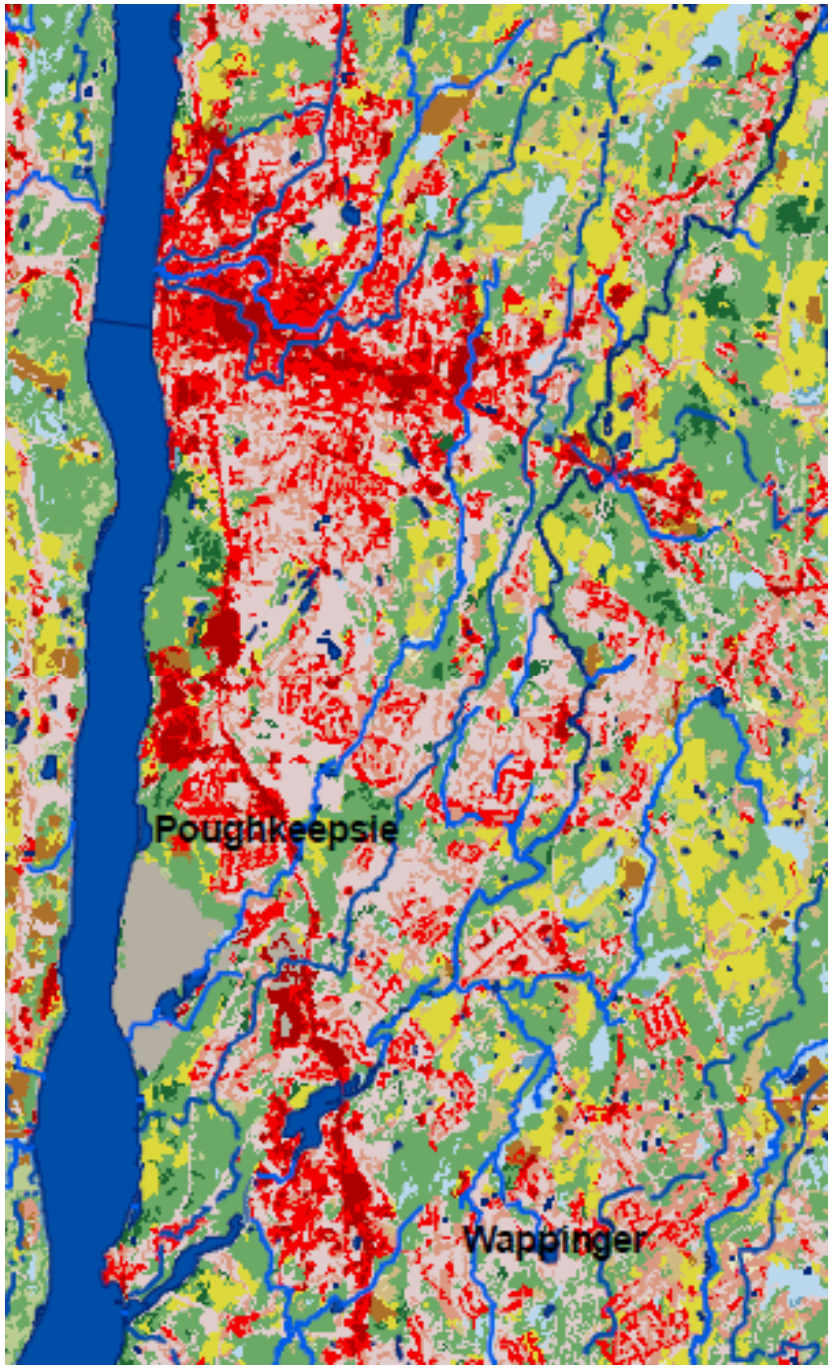


Watershed:

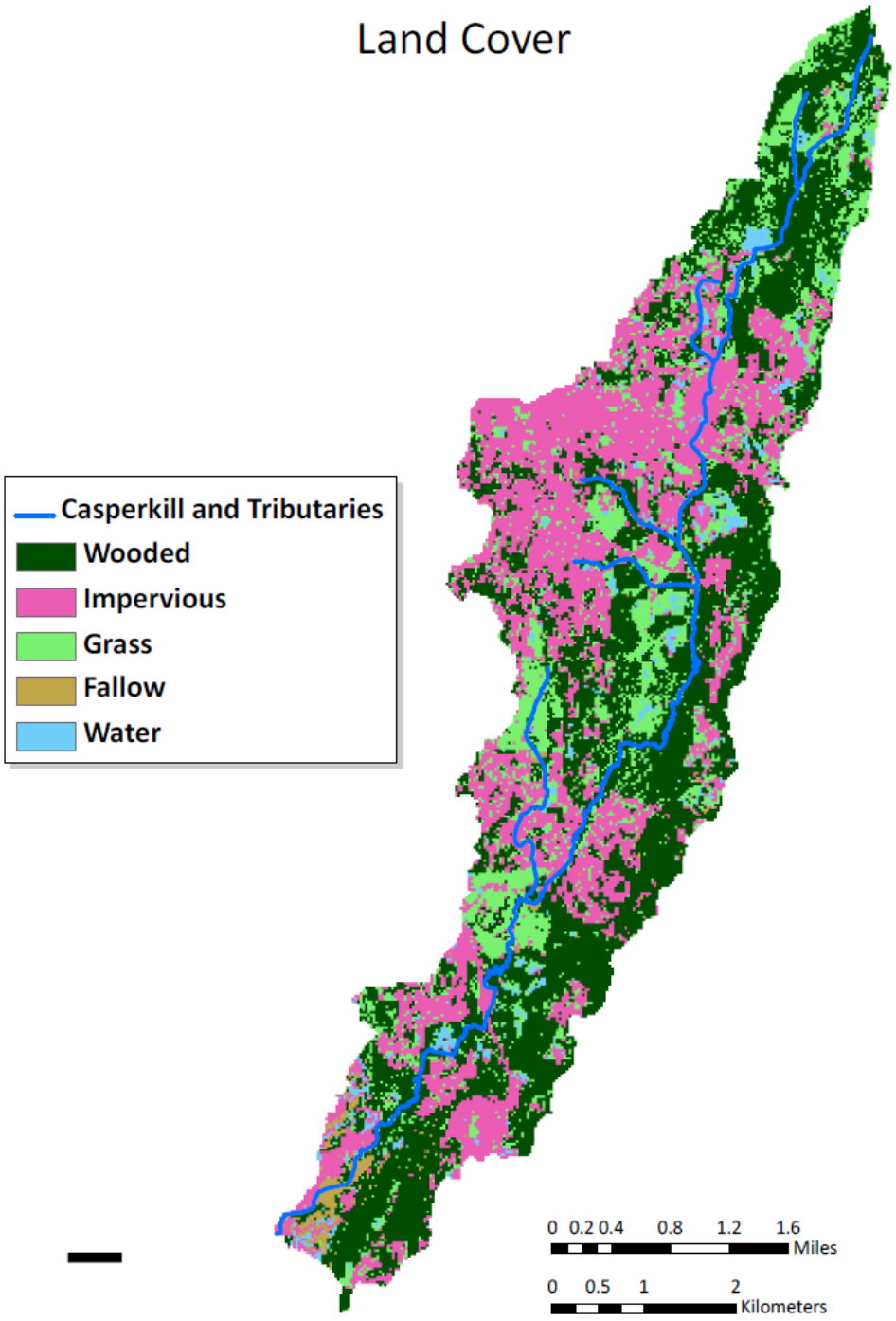
A watershed is the piece of land where all of the water that is under it or on top of it drains into the same lake, river or ocean.

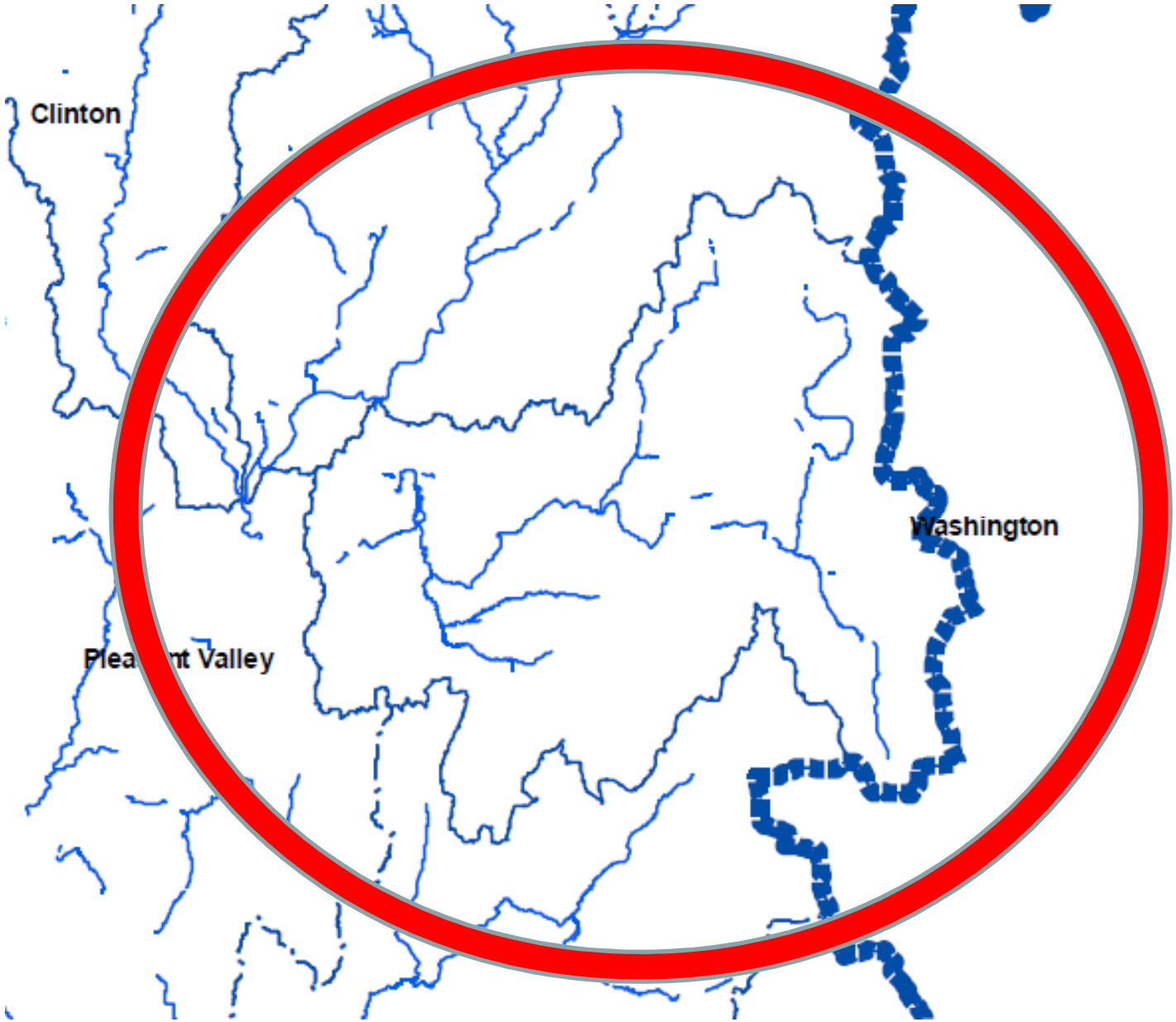

Poughkeepsie

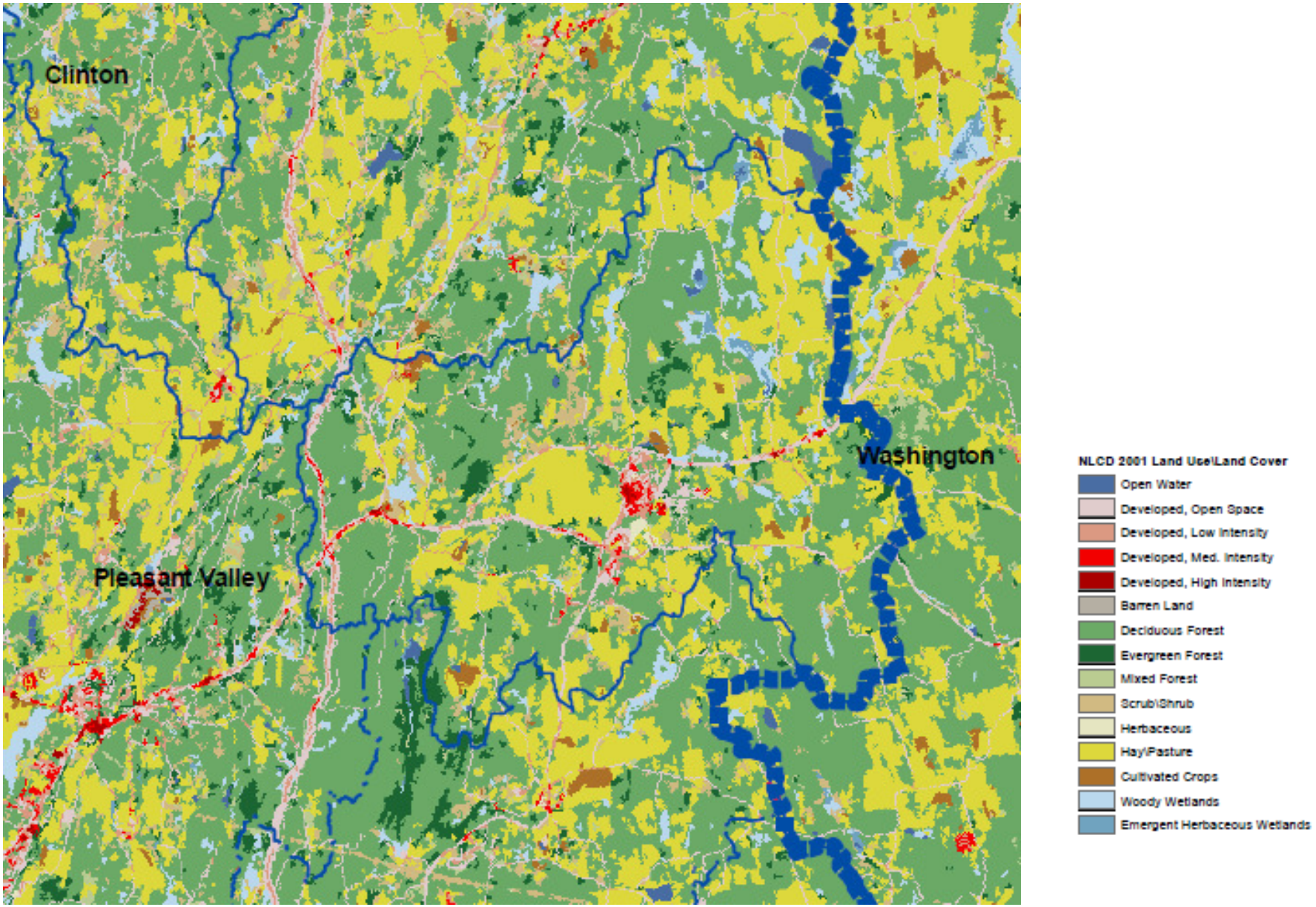

Poughkeepsie
Wappinger


Poughkeepsie
Wappinger

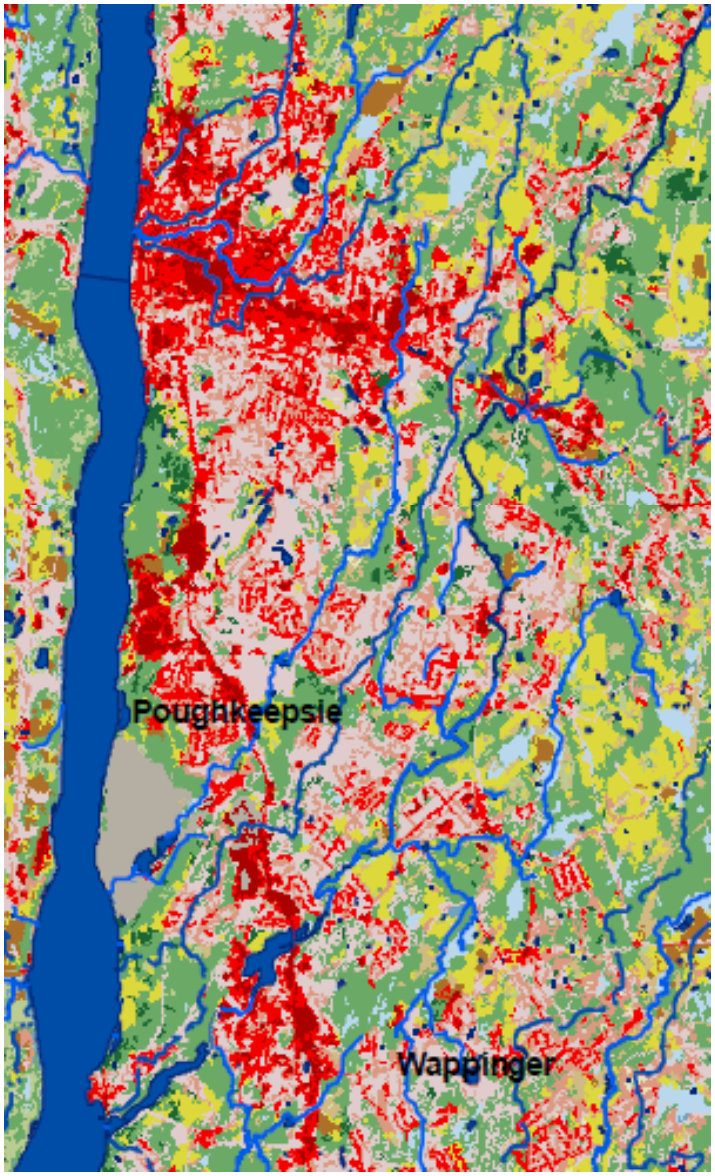
Land Cover


Casperkill and Tributaries
Wooded
Impervious
Grass
Fallow
Water
0 0.2 0.4 0.8 1.2 1.6
Miles
0 0.5 1 2
Kilometers

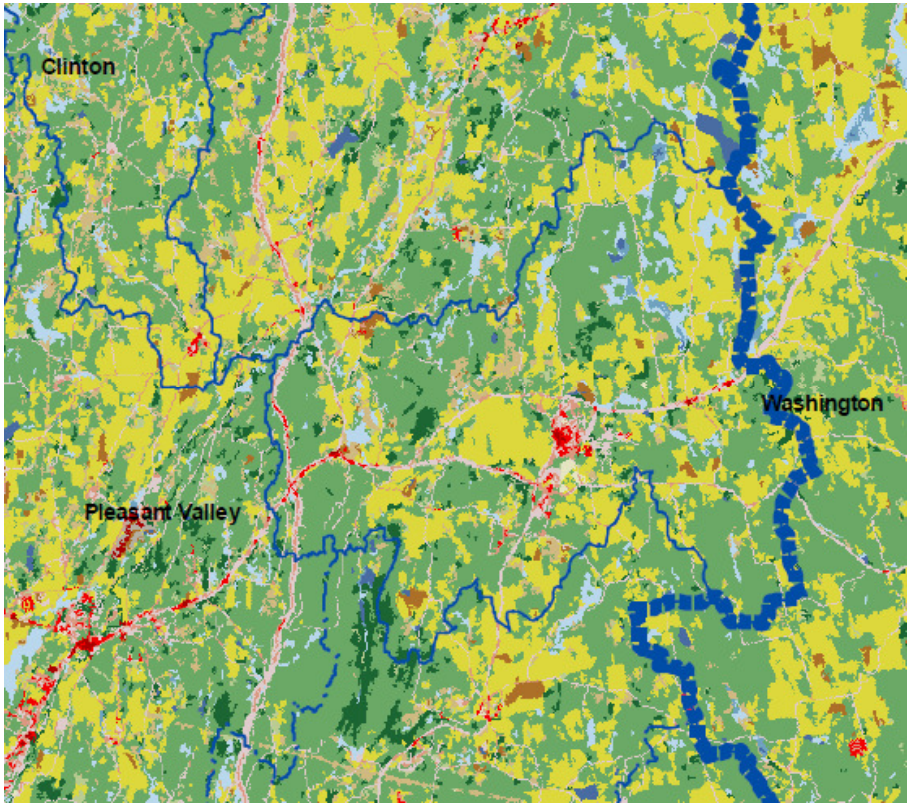

Clinton
Washington
Pleasant Valley


Clinton
Washington
Pleasant Valley
NLCD 2001 Land Use\Land Cover
Open Water
Developed, Open Space
Developed, Low Intensity
Developed, Med. Intensity
Developed, High Intensity
Barren Land
Deciduous Forest
Evergreen Forest
Mixed Forest
Scrub\Shrub
Herbaceous
Hay\Pasture
Cultivated Crops
Woody Wetlands
Emergent Herbaceous Wetlands

Watershed A: Poughkeepsie



Watershed B: Millbrook

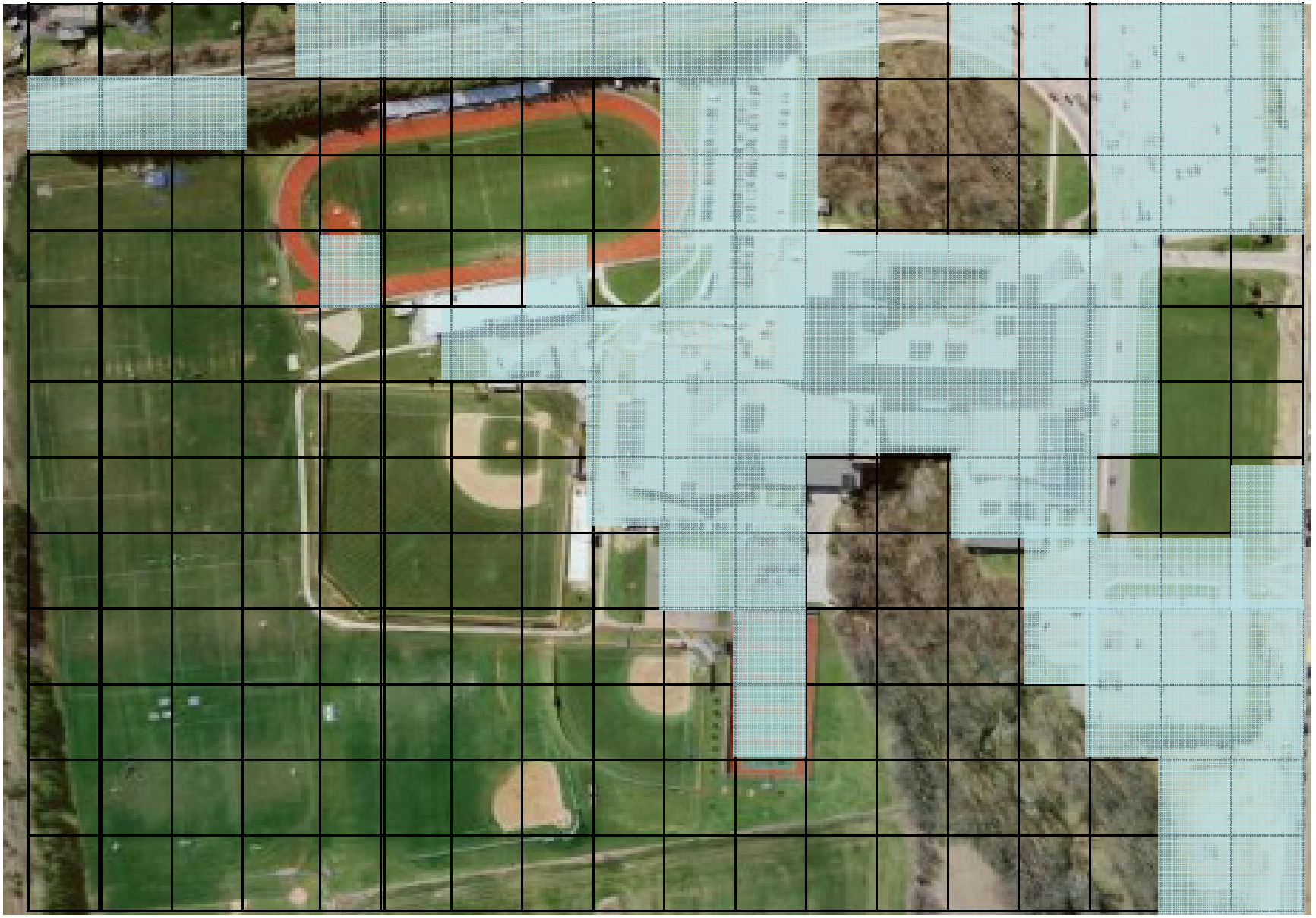


You can calculate percent imperviousness for you area

- Decide on your study area
- Find an aerial photo of the area
- Overlay grid
- Color grid based on cover type
- Calculate percentage of area with impervious cover

Start with something easy, like your schoolyard…

Students color in grids corresponding to land use type:



Calculations:

18x12 grid = Total of 216 squares

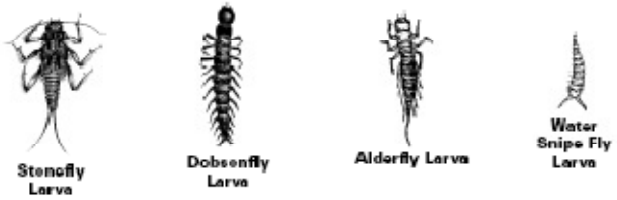
Blue= impervious =78 squares (36%)

Total of 36% impervious for this schoolyard

Your turn

Calculate % impervious for your watershed (A or B)- follow directions on handout (Step 2 in the worksheet)

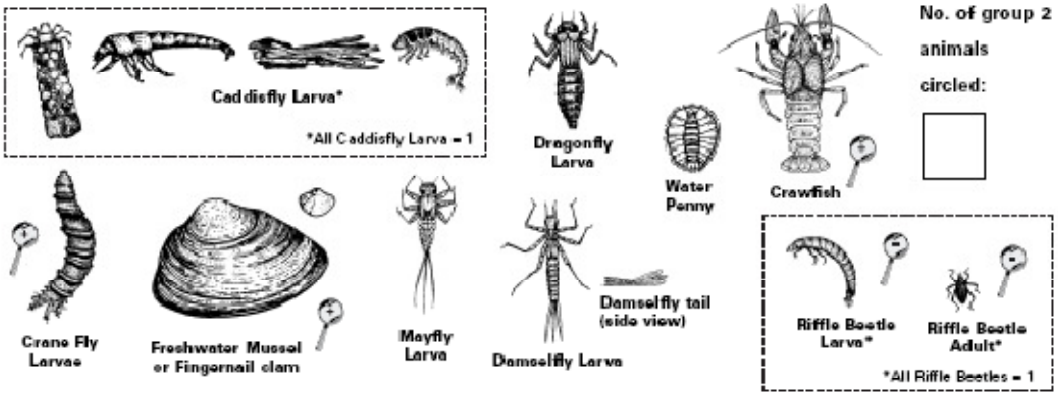
Group 1: These are sensitive to pollutants. Circle each animal found.



No. of group 1 animals circled: ☐

Relative Size Key:
= larger than picture
= smaller than picture

Group 2: These are semi-sensitive to pollutants. Circle each animal found.

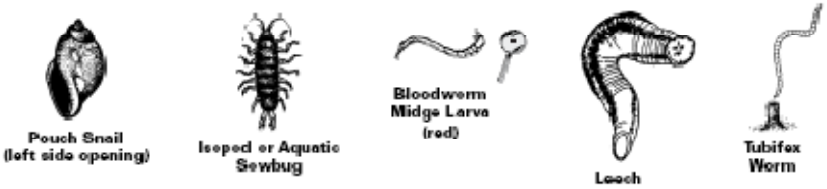


No. of group 2 animals circled: ☐

Group 3: These are semi-tolerant of pollutants. Circle each animal found.

No. of group 3 animals circled: ☐

Group 4: These are tolerant of pollutants. Circle each animal found.



No. of group 4 animals circled: ☐

Water Action Volunteers

<u>Indicators of good water quality</u>
Mayfly larvae
Caddisfly larvae
Stonefly larvae
Gilled snails
Riffle Beetle - adult
Planaria
Water Peeny
Hellgramite

<u>Indicators of fair water quality</u>
Crayfish
Riffle Beetle - larva
Dragonfly
Cranefly larvae
Damselfly
Scuds
Alderfly
Sowbug
Watersnipe Fly
Whirligig Beetle - larva
Fishfly
Clam or Mussel

<u>Indicators of poor water quality</u>
Midge fly larvae
Blackfly larvae
Leeches
Aquatic worms
Lung snails

Macroinvertebrate surveys are a common tool for scientists: cheap, fast, and relatively easy to do

Table 1. Stream-quality assessment criteria for Chester County, Pennsylvania, streams (adapted from Bode, 1993)

[EPT, Ephemeroptera, Plecoptera, and Trichoptera; HBI, Hilsenhoff's biotic index; >, greater than]

Stream-quality assessment	Taxa richness	EPT taxa richness	HBI
Nonimpacted	>30	>10	0 - 4.50
Slightly impacted	21 - 30	6 - 10	4.51 - 6.50
Moderately impacted	11 - 20	2 - 5	6.51 - 8.50
Severely impacted	0 - 10	0 - 1	8.51 - 10

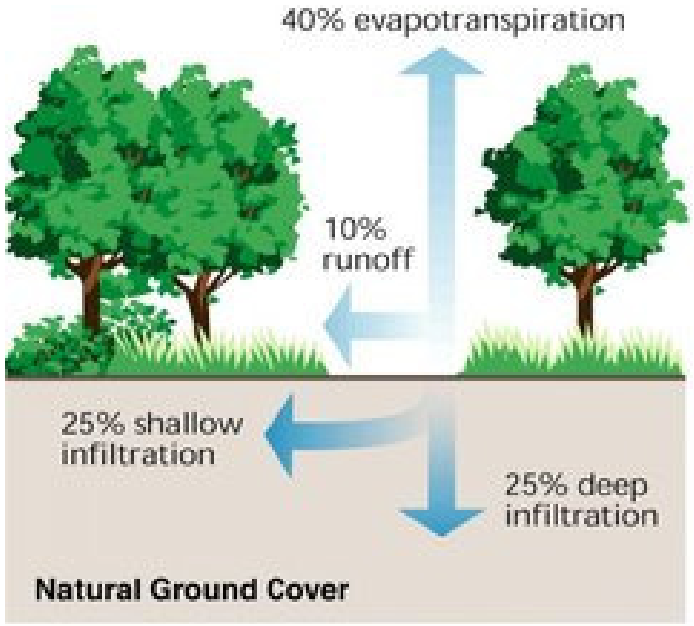
Source: http://www.tased.edu.au/tasonline/dorsetww/macroinv.htm

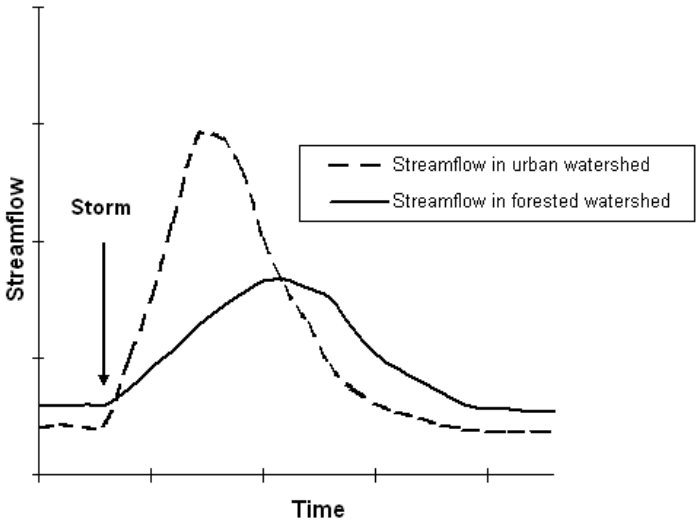
Source: http://www.koleopterologie.de

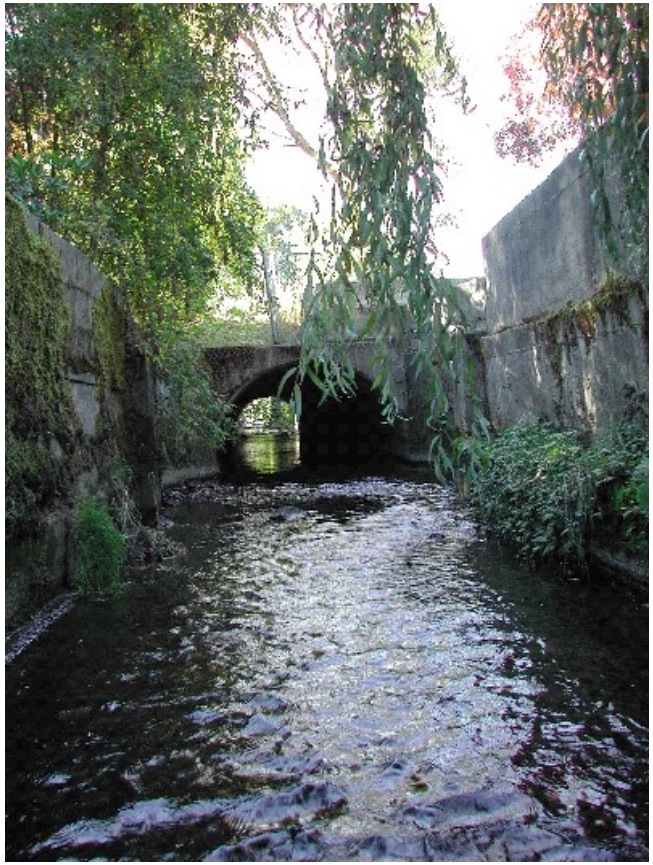
Source: http://collections.ic.gc.ca/biodiversity

Source: http://www.myrmecos.net/insects/Gerrid1.html

What happens to a stream as impervious surface amount increases?

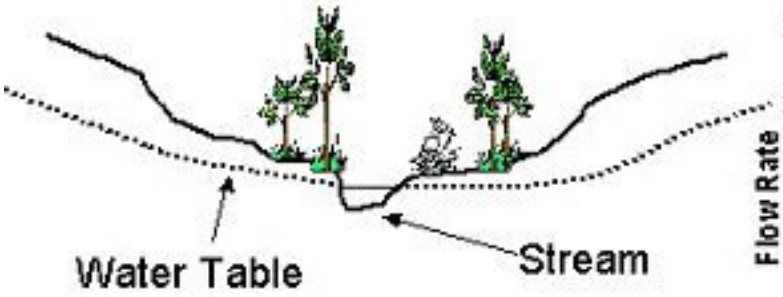

40% evapotranspiration
10%
runoff
25% shallow
infiltration
25% deep
infiltration
Natural Ground Cover

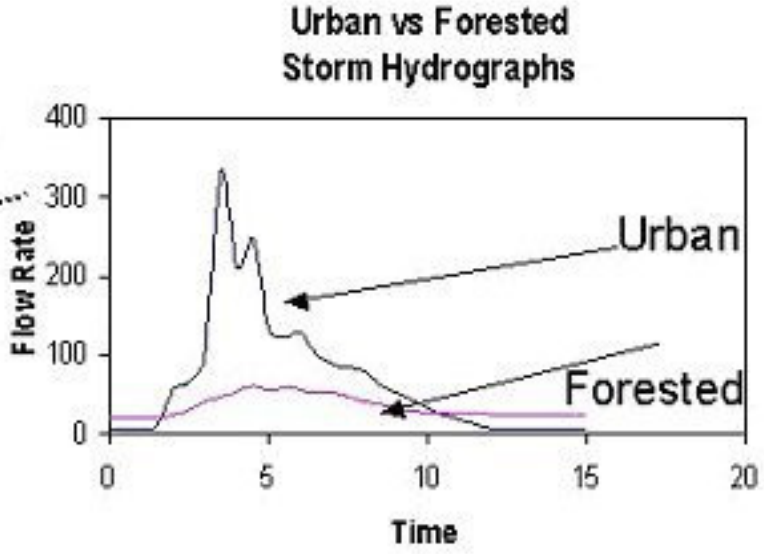

Streamflow
Storm
Streamflow in urban watershed
Streamflow in forested watershed
Time



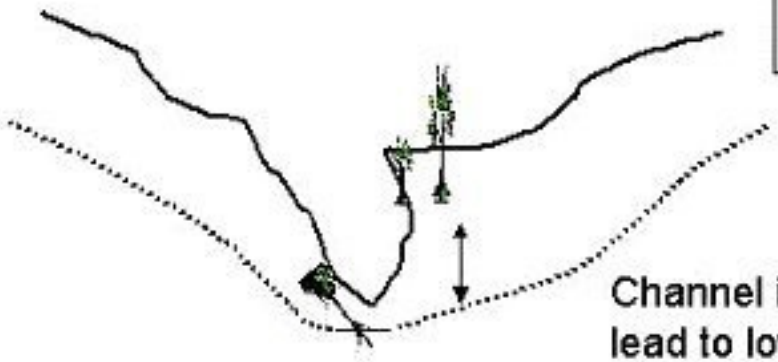
Reduced Infiltration

I. Natural Channel





II. Channel with Incision
Due to Increased Runoff

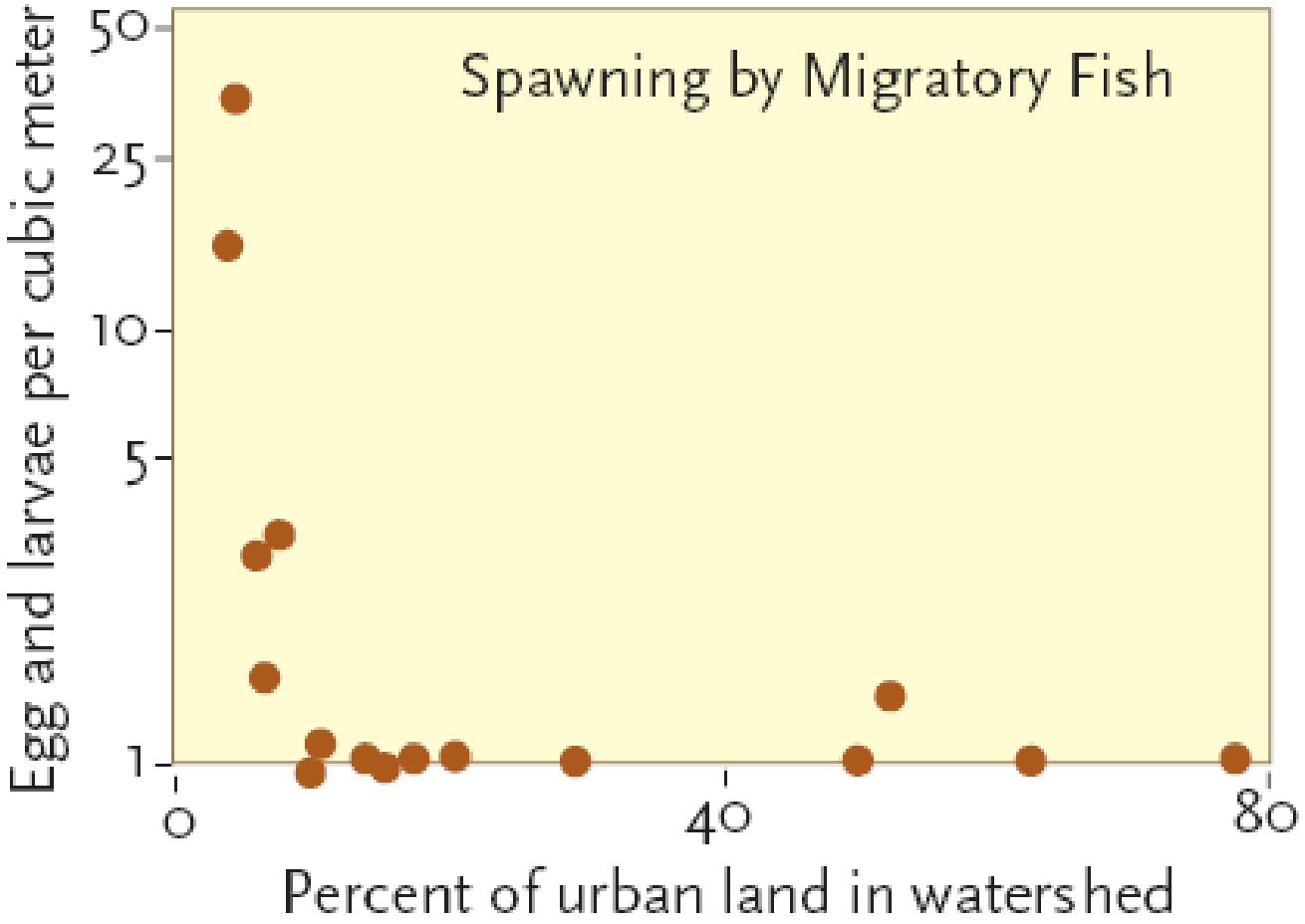


Urbanization leads to "flashier" storm flows which incise stream channels.

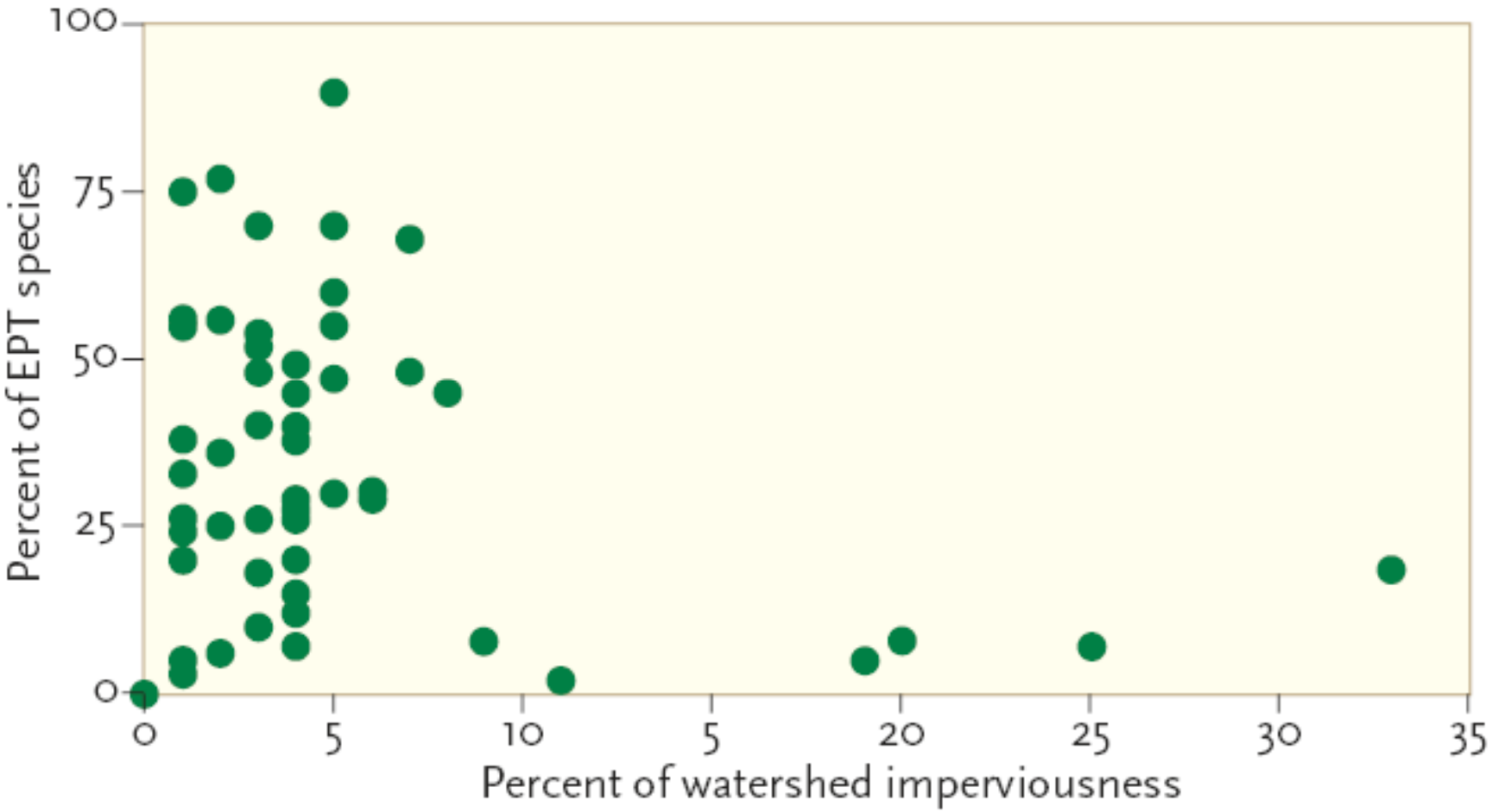
Channel incision and reduced infiltration in uplands lead to lower water tables in the riparian zone which results in a change from wetland to upland soils and vegetation, and less filtering of upland-derived nitrate.

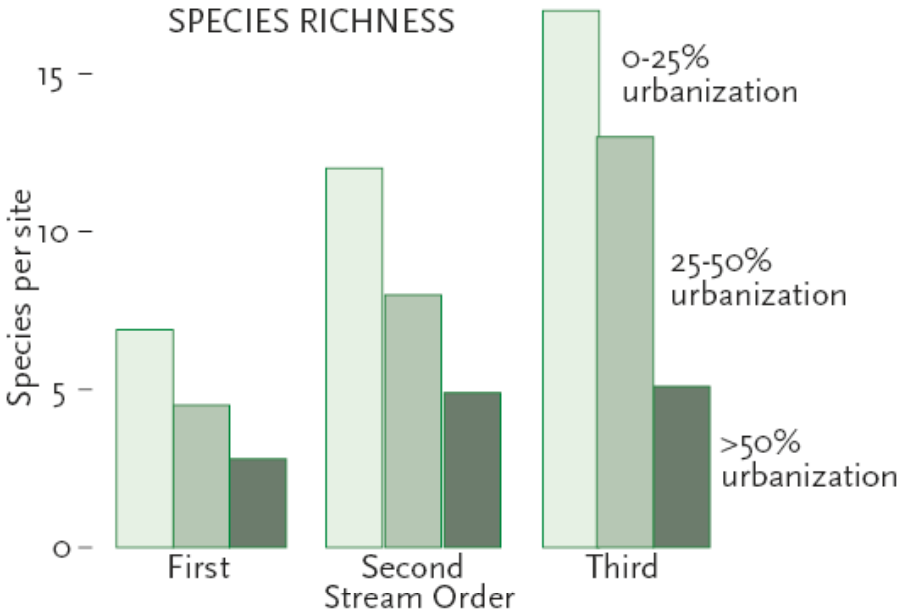
Baltimore Ecosystem Study

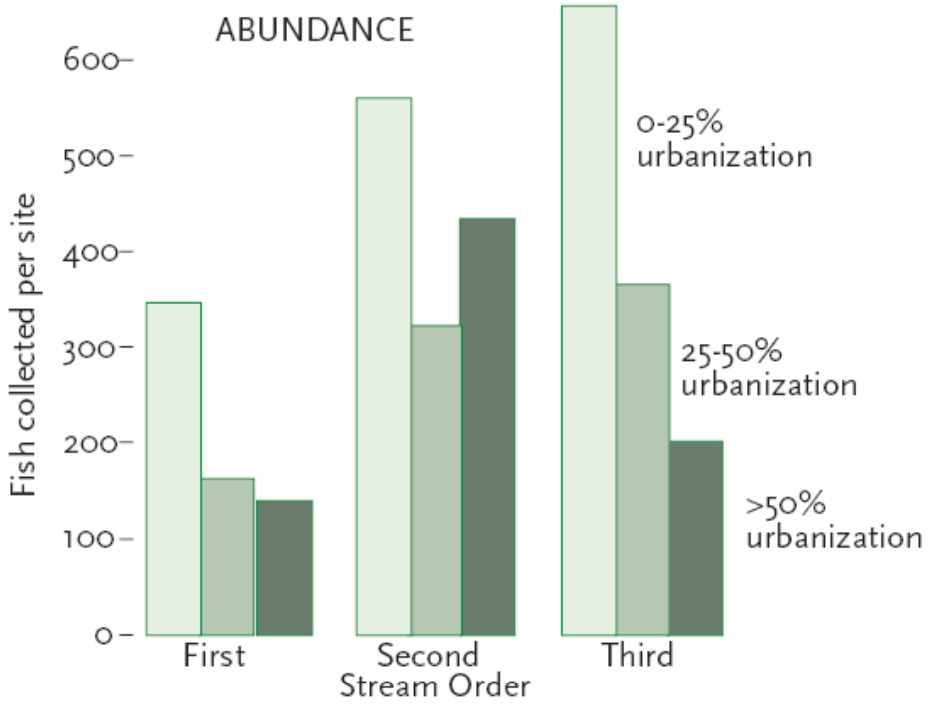
This graph shows the natural log of mean densities (#/m3) of eggs and larvae fish in 16 Hudson River tributaries. Anadromous fish spawn in freshwater and live in salt water, migrating between the two. (Modified with permission from Limburg 1990)



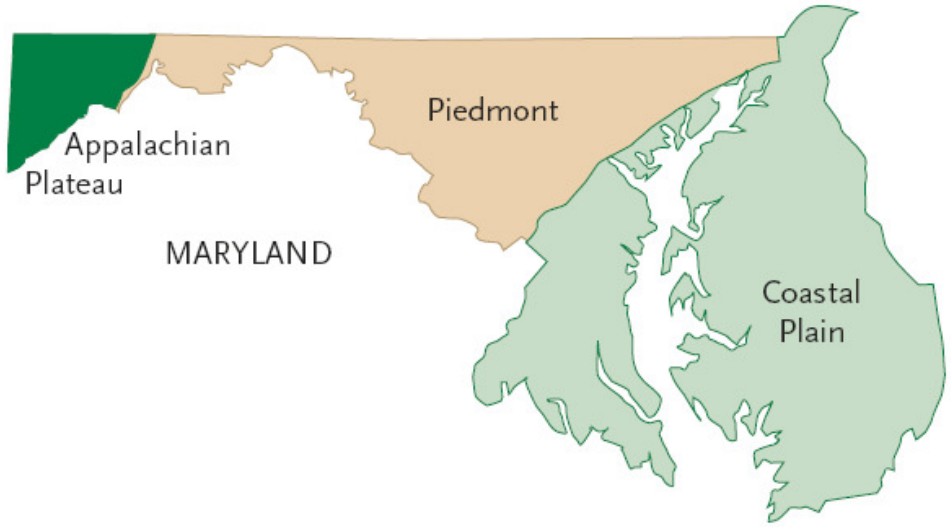
RELATIVE ABUNDANCE OF MAYFLIES, STONE FLIES, AND CADDIS FLIES (EPT)

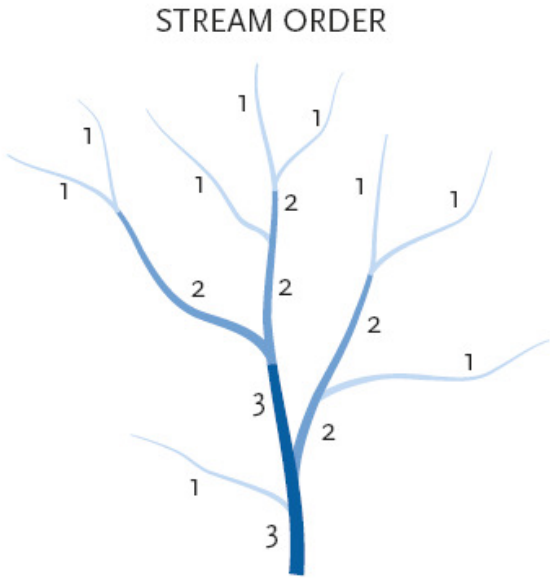




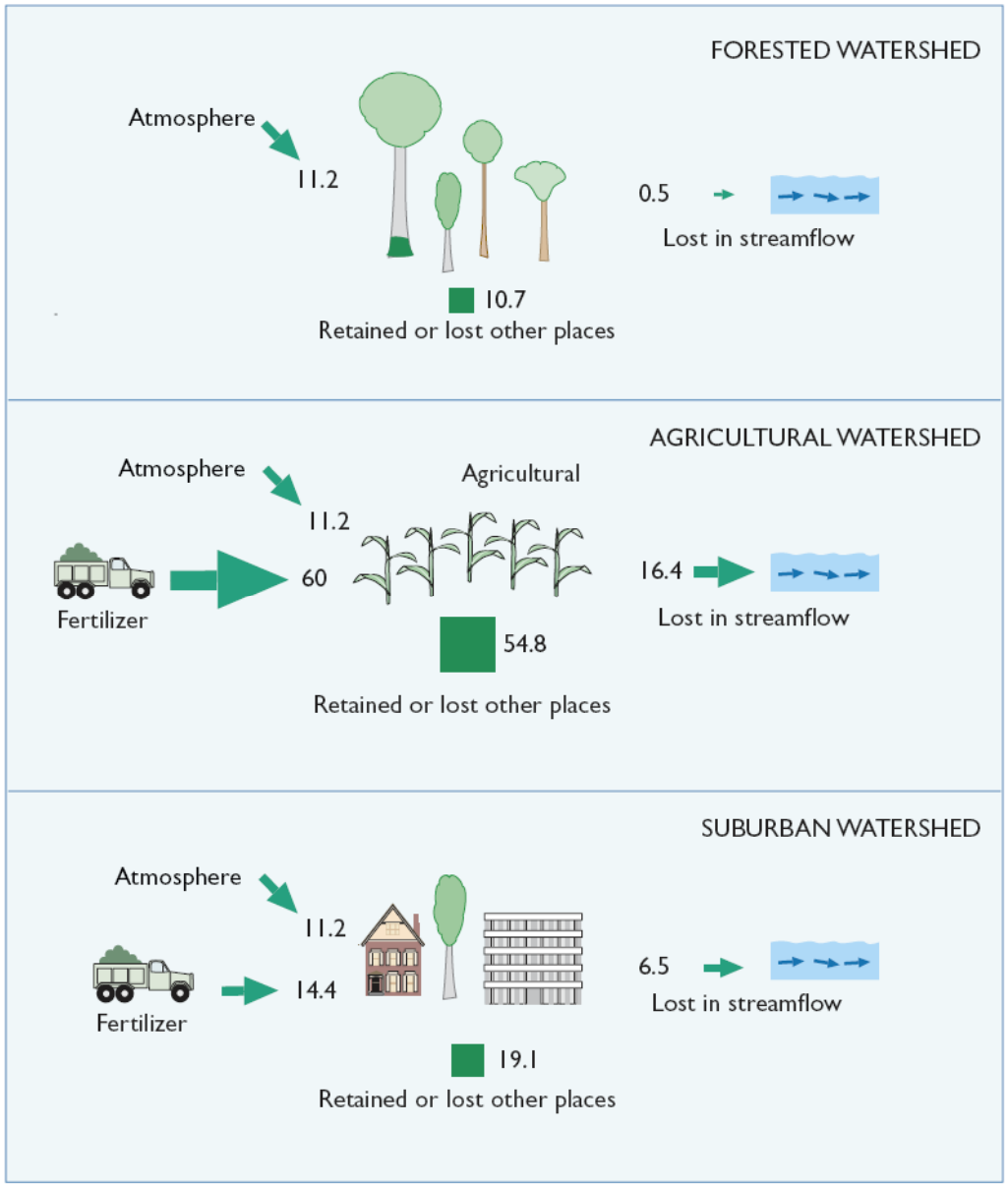


Morgan & Cushman, 2005





NITROGEN FLOWS IN THREE WATERSHEDS



Numbers are kilograms of nitrogen per hectare per year

Table 1: Comparison of One Acre of Parking Lot Versus One Acre of Meadow in Good Condition

Runoff or Water Quality Parameter	Parking Lot	Meadow
Curve number (CN)	98	58
Runoff coefficient	0.95	0.06
Time of concentration (minutes)	4.8	14.4
Peak discharge rate (cfs), 2 yr., 24 hr. storm	4.3	0.4
Peak discharge rate (cfs), 100 yr. storm	12.6	3.1
Runoff volume from one-inch storm (cubic feet)	3450	218
Runoff velocity @ 2 yr. storm (feet/second)	8	1.8
Annual phosphorus load (lbs/ac./yr.).	2	0.50
Annual nitrogen load (lbs/ac./yr.).	15.4	2.0
Annual zinc load (lbs/ac./yr.)	0.30	ND

Key Assumptions:

Parking lot is 100% impervious with 3% slope, 200 feet flow length, Type 2 Storm, 2 yr. 24 hr. storm = 3.1 inches, 100 yr. storm = 8.9 inches, hydraulic radius = 0.3, concrete channel, and suburban Washington 'C' values.

Meadow is 1% impervious with 3% slope, 200 foot flow length, good vegetative condition, B soils, and earthen channel.

Summary: urban streams tend to have…

- Elevated nutrients & contaminants
- Increased hydrologic flashiness
- Altered biotic assemblages

Who cares?

- 70% of human population will live in urban areas by 2050
- Most urban growth will occur in less developed countries
- Can we improve development strategies?

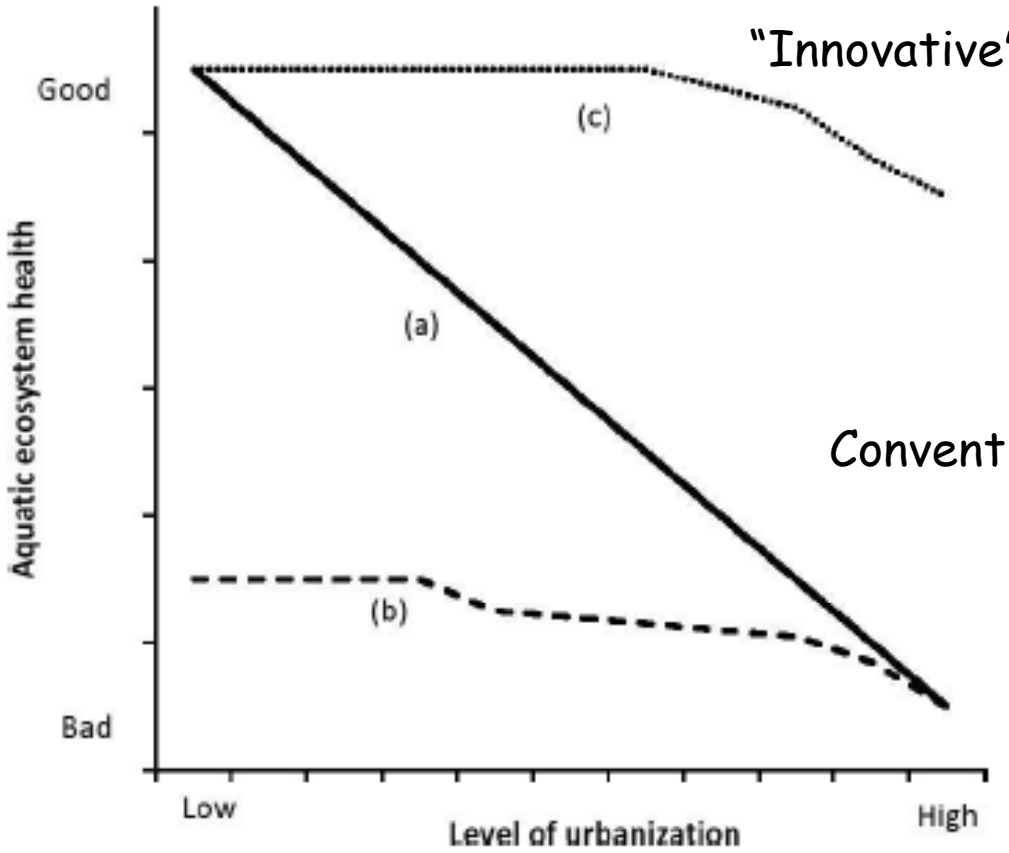
Battling Imperviousness

ProActive:

- Site planning
- Redevelopment

Responsive:

- Rain Gardens
- Green Roofs
- Asphalt Alternatives



"Innovative" development

Conventional development

FIG. 1. Projected changes in aquatic ecosystem health with increasing urbanization: a) conversion of native land to conventional urban development, b) conversion of land with historic legacy of other human land uses to conventional urban development, and c) hypothesized trajectory following conversion of native land to innovative forms of urban development.

Carter, et al. 2009

Rain Gardens

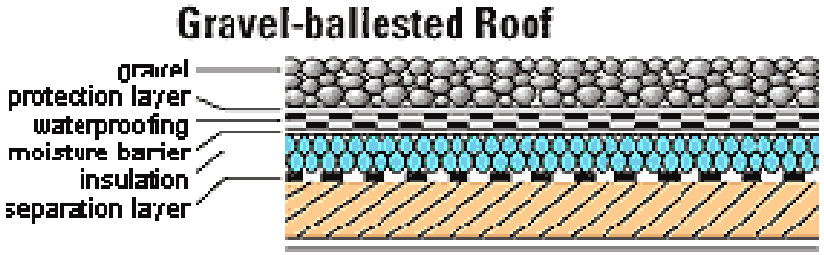
- Captures rain water and slows down runoff
- Creates habitat while slowing the water

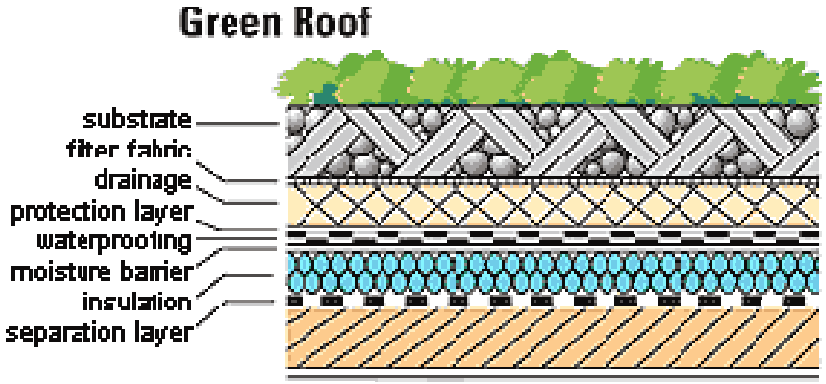
Rain garden

http://www.kbs.msu.edu/k12/resources/schoolyard.php

http://www.raingardens.org/Index.php

Green Roofs





- Buildings are impervious and the rainwater is generally directed immediately into a sewer system
- Green roofs use plants and soil to trap water and increases green space

http://www.greenroofs.org/pages/grhc2004_ford.htm http://www.hrt.msu.edu/greenroof/
http://www.environmentmichigan.org/uploads/mg/hy/mghyJR8KRvusDvqPyOseIA/Waterways_At_Risk.pdf

Alternatives to asphalt

- Durable surfaces that allow traffic but also allows water to percolate into the ground
- Replacing patios, parking lots, and other paved surfaces

http://fiesta.bren.ucsb.edu/~stormwater2/project.htm