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

<table>
<thead>
<tr>
<th>Topic</th>
<th>Loss</th>
<th>Gain</th>
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<tbody>
<tr>
<td>Forests</td>
<td></td>
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<tr>
<td>Agriculture</td>
<td></td>
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<tr>
<td>Housing</td>
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<tr>
<td>Roads</td>
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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.
You can calculate percent imperviousness for your 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)
Indicators of good water quality
- Mayfly larvae
- Caddisfly larvae
- Stonefly larvae
- Gilled snails
- Riffle Beetle - adult
- Planaria
- Water Peeny
- Hellgramite

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

Indicators of poor water quality
- 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.
What happens to a stream as impervious surface amount increases?
Natural Ground Cover

40% evapotranspiration

10% runoff

25% shallow infiltration

25% deep infiltration
Reduced Infiltration

I. Natural Channel

Water Table
Stream

II. Channel with Incision Due to Increased Runoff

Urban vs Forested Storm Hydrographs

Time
Flow Rate

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)

The graph shows the relative abundance of EPT species versus the percent of watershed imperviousness. The data points indicate a trend where higher imperviousness is associated with lower abundance of EPT species.
Morgan & Cushman, 2005
NITROGEN FLOWS IN THREE WATERSHEDS

FORESTED WATERSHED

Atmosphere 11.2

Retained or lost other places 10.7

Lost in streamflow 0.5

AGRICULTURAL WATERSHED

Atmosphere 11.2

Fertilizer 60

Agricultural 16.4

Retained or lost other places 54.8

Lost in streamflow 0.5

SUBURBAN WATERSHED

Atmosphere 11.2

Fertilizer 14.4

Retained or lost other places 19.1

Lost in streamflow 6.5

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

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

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
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.

Rain Gardens

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

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

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