The influence of vegetation on flood change

Lenka Plavcová1,2, Julia Hall1, Rui A. P. Perdigão1, Günter Blöschl1

1) Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology, Vienna, Austria
2) Current affiliation: Institute for Systematic Botany and Ecology, Ulm University, Ulm, Germany
Contact email: plavcova@hydro.tuwien.ac.at

Introduction:
It has been suggested that land use change and climate change might lead to an altered magnitude and frequency of floods. However, the mechanisms underlying such changes in flood generation still need to be elucidated.

The objective of this study is to uncover how changes in vegetation and concomitant changes in soil properties, arising as a result of land use change or climate change, may translate into increased flood hazard over decadal or centennial timescales.

The main focus of the current study is on changes in catchment response (run-off generation) caused by altered vegetation and soil characteristics rather than changes in precipitation regime due to vegetation-climate feedbacks.

Land use change and climate change perturb vegetation to different extents. The question then is whether such changes will significantly alter catchment response or not.

Perceptibility of change

<table>
<thead>
<tr>
<th>Land use change</th>
<th>Climate change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in vegetation cover type (e.g. deforestation, grassland to arable land conversion)</td>
<td>Change in plant functional type (e.g. tree line shift to higher altitudes and latitudes, woody plants encroachment)</td>
</tr>
<tr>
<td>Change in species composition (e.g. conversion of mixedwood forest into monoculture, planting different crop)</td>
<td>Change in species composition (e.g. selective dieback of drought susceptible species)</td>
</tr>
<tr>
<td>Less conspicuous (local knowledge)</td>
<td>Inconspicuous (more sophisticated measurements)</td>
</tr>
</tbody>
</table>

Changes in interception, water infiltration and soil water storage may lead to altered catchment response to precipitation.

Changes in interception, water infiltration and soil water storage influenced by vegetation cover and associated biological activity in soil?

Hydrological processes:
- Interception
  - Percent rainfall intercepted
  - Characteristics of throughfall and stemflow

- Water infiltration
  - Topsoil infiltrability
  - Subsoil hydraulic conductivity

- Preferential flow

Biological influences: (traits or processes)
- Interception
  - Characteristics of precipitation by canopy: leaf area index, plant architecture, leaf size, angle and hydrophobicity, bark roughness

- Water infiltration
  - Sheltering by the litter and canopy: prevention of soil sealing and crusting

- Soil water storage
  - Biometric influences on soil structure: root activity, associated microbial activity, soil organic matter

- Soils
  - Macropores created by biotic agents: decayed root channels, meso- and macro-fauna

- Soil water storage
  - Biometric influences on soil formation: litter addition and decomposition, enhanced weathering (root activity, increased acidity due to respired CO₂)

- Prevention of erosion: slope stabilization by root systems, sheltering from water and wind

- Biometric influences on soil structure: root activity, associated microbial activity, soil organic matter

- Transpiration: reduction of soil moisture content

- Sheltering by litter & canopy: decrease in soil evaporation

Vegetation affects catchment response directly, during the flood generating rainfall event, as well as indirectly, through its effect on antecedent soil moisture conditions.

Future Directions:
- Look for these changes in vegetation and soil properties in real catchments and link them with altered hydrological behavior
- Model these changes and integrate them with other factors that may cause flood changes such as altered precipitation patterns and river training

Examples of change in vegetation and soil characteristics happening over decadal and centennial timescales that may lead to changed catchment response:

- Plant acclimation = structural and physiological adjustment to novel environmental conditions (e.g. the advancement of leaf flushing date in response to increasing temperature)
- Migration of species tracking the environmental change (e.g. the shift of species range to higher latitude in response to increasing temperature)
- Dieback of species triggered by environmental stress (e.g. Norway spruce dieback due to bark beetle infestation, quaking aspen decline due to drought)
- Development of plow pan (subsoil compaction) in arable soil
- Changes in soil organic matter content (e.g. due to soil plowing, enhanced soil erosion, changed microbial activity driven by changed temperature or moisture)