

Climate Change and Related Impacts on Forest Hydrology

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Overview

- Forests and regional hydrology
- Forest components and processes that impact hydrology at the stand and watershed scales
- Climate change, forest disturbances, and related impacts on forest hydrology
- Additional impacts of climate change on forest components and hydrology
- Management implications



Forests and Regional Hydrology

- Regulating ecosystem services
 - Flood mitigation
 - Erosion mitigation
 - Promotion of soil water recharge
 - Improvements to water quality



Source: parks.ky.gov



Forests and Regional Hydrology



Source: fs.usda.gov

- Cultural ecosystem services
 - Recreation
 - Tourism
 - Local, regional, state economic impacts



Hydrologic Processes within Forests

- Precipitation
- Interception
- Infiltration
- Soil moisture storage
- Percolation
- Evapotranspiration

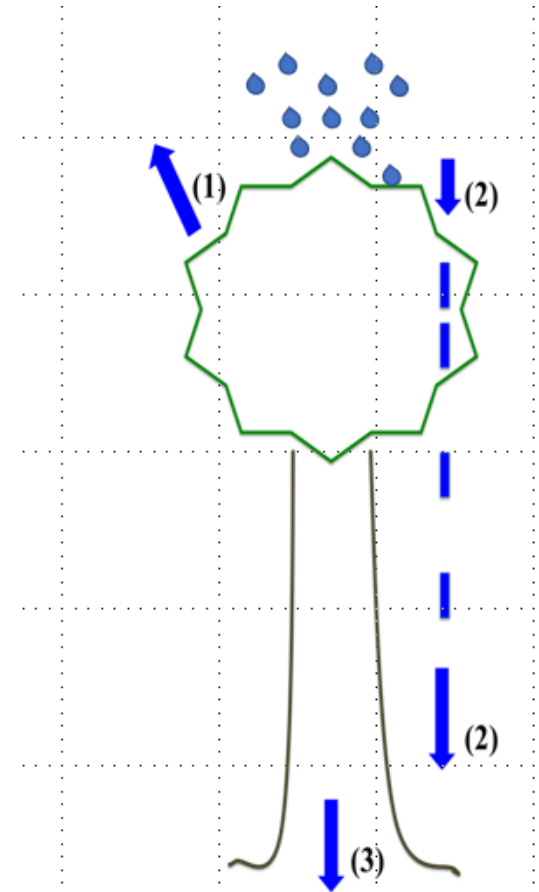


Figure: Partitioning of precipitation into (1) interception, (2) throughfall, and (3) stemflow. Adapted from [Levia and Frost \(2006, Figure 1\)](#).



Collectively, these processes are governed by and impact forest dynamics, with larger effects seen at the watershed scale in terms of streamflow, peakflow, and water quality.



Forest Components and Processes that Impact Forest Hydrology



Forest Components and Processes that Impact Forest Hydrology

- **Canopy and leaf area**
 - Related impacts on interception
 - Related impacts on water inputs to soil



Source: fs.usda.gov



Forest Components and Processes that Impact Forest Hydrology



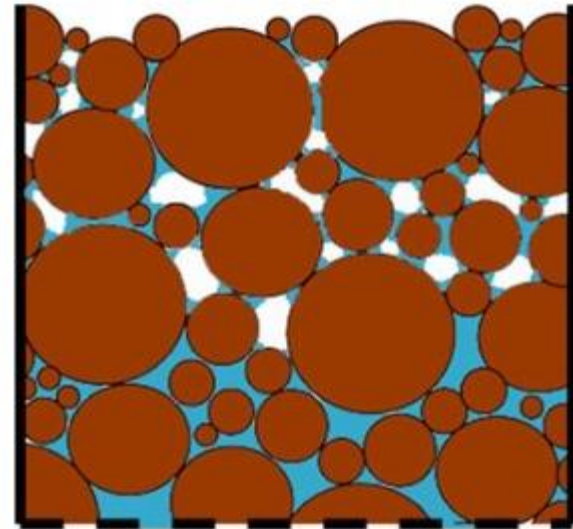
Source: www.japanfs.org

- **Litter and soil surface**
 - Related impacts on soil moisture storage



Forest Components and Processes that Impact Forest Hydrology

- **Soil porosity**
 - Related impacts on infiltration



Source: UC ANR



Forest Components and Processes that Impact Forest Hydrology

- **Rooting depth**

- Related impacts on percolation
- Related impacts on evapotranspiration

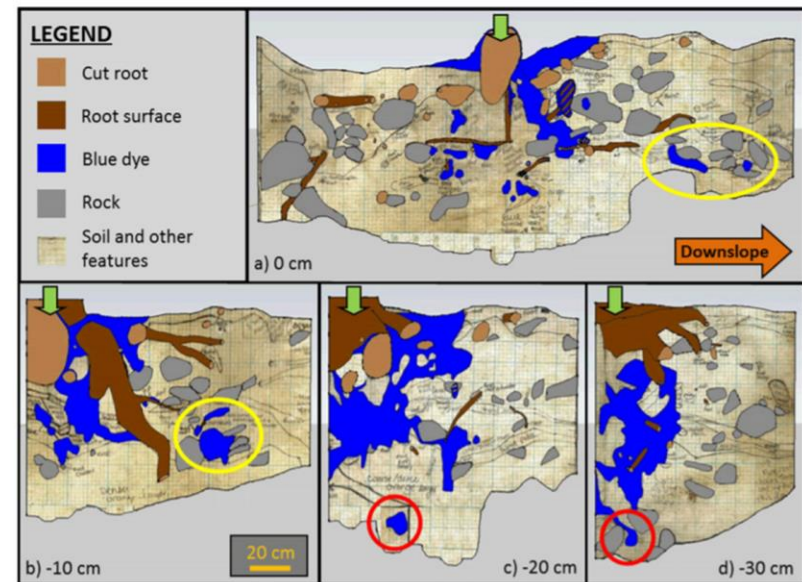


Figure 8. Diagrams showing the distribution of blue dye, roots, and large stones for SIE 1. Yellow circles in (a) and (b) indicate where stemflow flowed laterally downslope beyond 50 cm from the tree. Red circles in (c) and (d) indicate the maximum stemflow infiltration depth at 122 cm below the surface. Distances are given relative to the edge of the tree (distance of 0 cm), with negative numbers representing excavation profiles to the east. The tree stem is indicated by the green arrow. The orange arrow indicates the direction of the hillslope and is the same for all subplots

Source: Spencer et al. 2016

These forest components and their related impacts on forest hydrology can all be impacted by an array of natural and anthropogenic forest disturbances.



Forest Disturbances and Related Impacts on Hydrology

- Pest and Pathogens
 - Reduced transpiration
 - Reduced canopy cover
 - Reduced interception
 - Higher streamflows
 - Dynamic in that altered hydrology may be delayed from initial occurrence of infestation



Example: Mountain Pine Beetle



3 Stages of Attack | 3 Stages of Hydrologic Response
(Decreased transpiration, decreased leaf area, tree mortality)



Forest Disturbances and Related Impacts on Hydrology

- Wildfire



Source: Andy Vander Yacht

Forest Disturbances and Related Impacts on Hydrology

- Wildfire
 - Reduced canopy cover
 - Related impacts on interception and evapotranspiration
 - Volatilization of waxes and oils in leaf litter → hydrophobic soils with reduced infiltration capacity
 - Destabilization of hillslopes
 - Increased risks: erosion, flooding, mudslides, compromised water quality



Forest Disturbances and Related Impacts on Hydrology

- Drought
 - Impacts water usage by forest vegetation
 - Subsequent impact on soil water storage capacity



Forest Disturbances and Related Impacts on Hydrology

- Windthrow, Ice storms
 - Altered forest structure
 - Reduced canopy cover and evapotranspiration
 - Higher streamflow possible



Forest Disturbances and Related Impacts on Hydrology: Anthropogenic



Thinning



Harvesting



Plantations

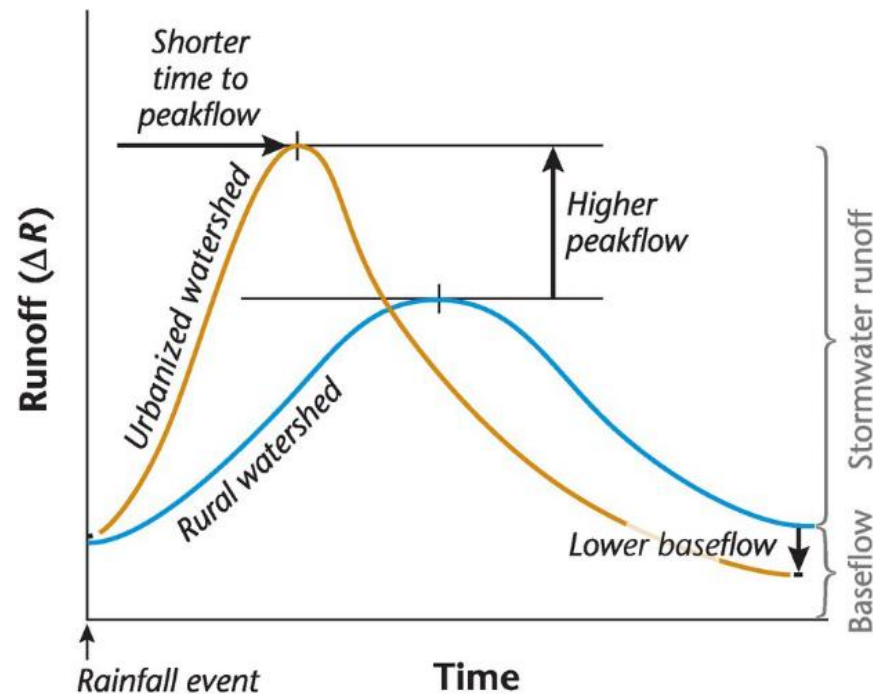


Urbanization



Forest Disturbances and Related Impacts on Hydrology: Anthropogenic

Similar impacts on forest hydrology, with noted shifts to hydrograph



Climate Change, Forest Disturbances, and Related Impacts on Forest Hydrology

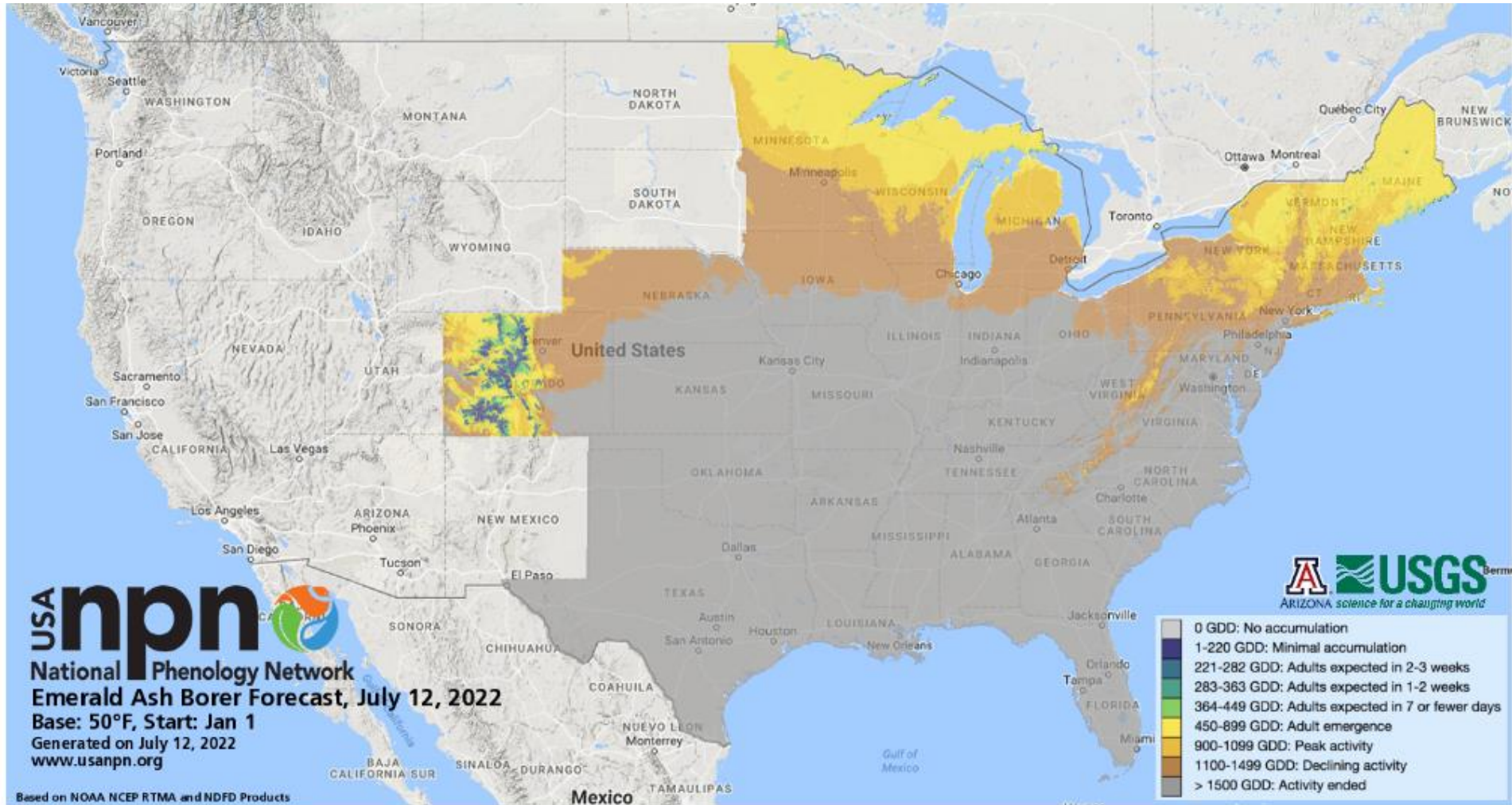
- Climate prediction: **Increased wildfire occurrence**
- Predicted impacts on forest hydrology:
 - Canopy cover loss
 - Reduced infiltration capacity in soils
 - Increased erosion
 - Increased threats to water quality



Climate Change, Forest Disturbances, and Related Impacts on Forest Hydrology

- Climate prediction: **modified spatial distribution of insect and pathogen outbreaks**
- Predicted impacts on forest hydrology:
 - Canopy cover loss
 - Reduced interception and evapotranspiration
 - Decreased soil moisture with greater exposure to UV radiation (due to increase in canopy gaps)
 - Modified streamflow





Climate Change, Forest Disturbances, and Related Impacts on Forest Hydrology

- Climate prediction: **increased frequency and severity of storm events**
- Predicted impacts on forest hydrology:
 - Canopy cover loss
 - Reduced interception and evapotranspiration
 - Decreased soil moisture with greater exposure to UV radiation (due to increase in canopy gaps)
 - Modified streamflow



Additional Impacts of Climate Change on Forest Components, Structure, and Hydrology

- **Increased CO₂:** increased forest growth → increased ET, decreased runoff
- **Higher global atmospheric temperature:** expansion of forests into higher latitudes and altitudes → altered water budgets at regional scale
- **Intensification of hydrologic cycle:** increased reliance on trees and vegetation to mitigate flood risk



Management Implications

- Manage with resilience in mind
- Aim for:
 - Structural diversity (size, age)
 - Species heterogeneity
- Strategic management facilitate resilience against disturbances and changing climatic conditions and buffer against extreme hydrologic response to changes



Thank You & Questions

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