

Overview of Natural and Human-Made Change Processes in Watersheds

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Key Points

Watersheds are dynamic systems, therefore, change is a natural and essential feature of watersheds. Identification of change processes or agents of concern is critical to watershed management

- Role of change in watersheds.
- Natural Agents of Change
- Anthropogenic (man-made agents of change)
- Impacts of agents of change on watershed
- Most vulnerable watershed processes

Important Terms

Dynamic Equilibrium

Like all ecological systems watersheds are also in a state of dynamic equilibrium. Whereby its components persist through time and adapt to or are modified by disturbances.

Disturbance

Here disturbance would mean processes or events that causes changes in the physical or biological components of the watershed (e.g. Floods)

Stress

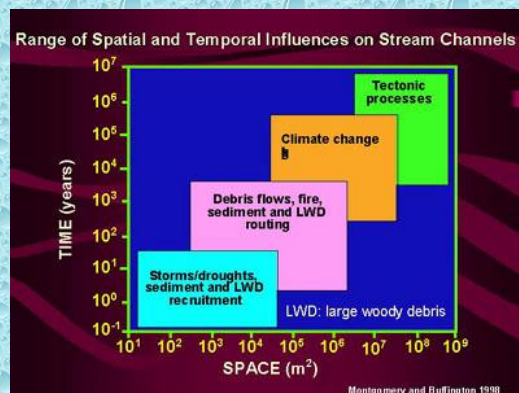
The adverse effect of change in the wake of disturbance on any component of the watershed (e.g. floods may erode fertile soil)

Stressor

The source of these adverse effects (e.g. climate change, extreme weather, deforestation among others are stressor in the above scenario)

Scale Concepts

- Environmental changes is brought about by a wide scale of processes that occur through space and over time
- Evolutionary events i.e. tectonic uplift, volcanic eruption, 100 year flood etc.
- Developmental processes i.e. plantation, forest succession, denudation, seasonal depth and velocity changes



How do you characterize change?

- Sources/Causes
 - Effect
 - Frequency
 - Duration
 - Intensity/Magnitude
- Changes of concern**
- Alteration or loss in the primary process or structural component of the watershed beyond normal range.
 - Most are human induced or triggered.

Natural Agents of Change

- Flood
- Drought
- Fires
- Windstorms
- Erosion/Sediment Deposition
- Glacial Movement
- Climate Change
- Tectonic Activity
- Volcanic Eruptions

Flood as an Agent of Change

Redistribution of organic material and organisms downstream

Transport of nutrients and sediments to the flood plain

Intense floods may form entirely new channels, displacement of riparian soils, may trigger landslides and debris torrents, leading to ecological re-colonization



Previously cultivated braids in river swat are now left barren after the 2010 floods

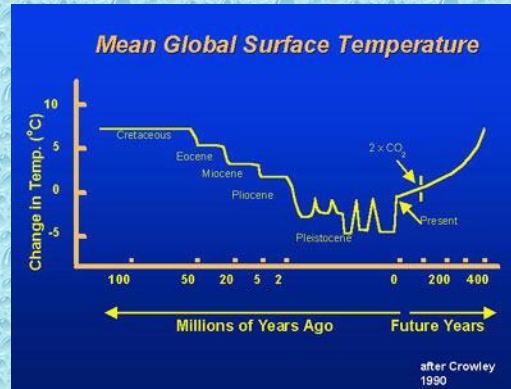
Drought as an Agent of Change

- Meteorological Drought
- Agricultural Drought
- Hydrological Drought
- Socio-economic Drought
- Affects water volume, water chemistry
- Drying up of ephemeral lakes and streams
- Changes in thermal regime of lakes
- Severe droughts may cause a shift in dominant vegetation
- Increases erosion of the top soil



Climate Change

- Climate change is a natural process occurring gradually over broad spatial scales.
- The oldest populations of giant sequoia in California national parks experience generally drier conditions relative to when they were established, 2,000 - 3,000 years ago.



Fire as an Agent of Change

- Fires intensity and frequency depends on soil moisture, ignition sources, fuel build up.
- Small scale fires help in keeping habitat diversity and complexity, also helps in the release of much needed nutrients.
- Large scale fires may result in increased erosion and run-off, water temperatures, and make watersheds vulnerable for future disturbances.



Small fires like this one in Wenatchee, WA help maintain a mosaic of different plant communities within a given watershed, thereby increasing habitat complexity.



Regrowth of pines following the Yellowstone National Park wildfires of 1988

Erosion and Sediment Transport

- Stream Morphology
- Streambed Composition
- Loss of fertile land
- Gully Erosion
- Rill Erosion
- Sheet Erosion

Anthropogenic Agents

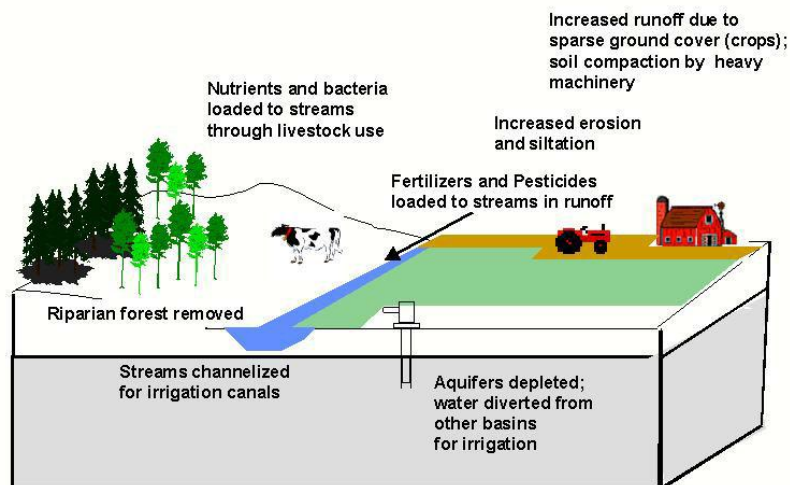
- Modification of River flow
- Agriculture
- Urbanization
- Accelerated Climate Change
- Deforestation
- Mining
- Introduction of Exotic Species
- Harvesting of Fish and other Wildlife

Modification of River flow

- Diversion of river water for agriculture and drinking water supplies.
- Impoundment of water in dams.
- Flow amplitude is reduced, baseflow variation increases, temperature regime is altered, and mass transport of materials declines.
- Overall connectivity between upstream and downstream reaches of the river and between the river and its floodplain are compromised.
- As a consequence, sediment transport downstream is limited, changes in temperature regimes and dissolved oxygen result in habitat degradation.

Agriculture

Effects of Agriculture on Stream Hydrology and Chemistry



Deforestation and Timber Harvest

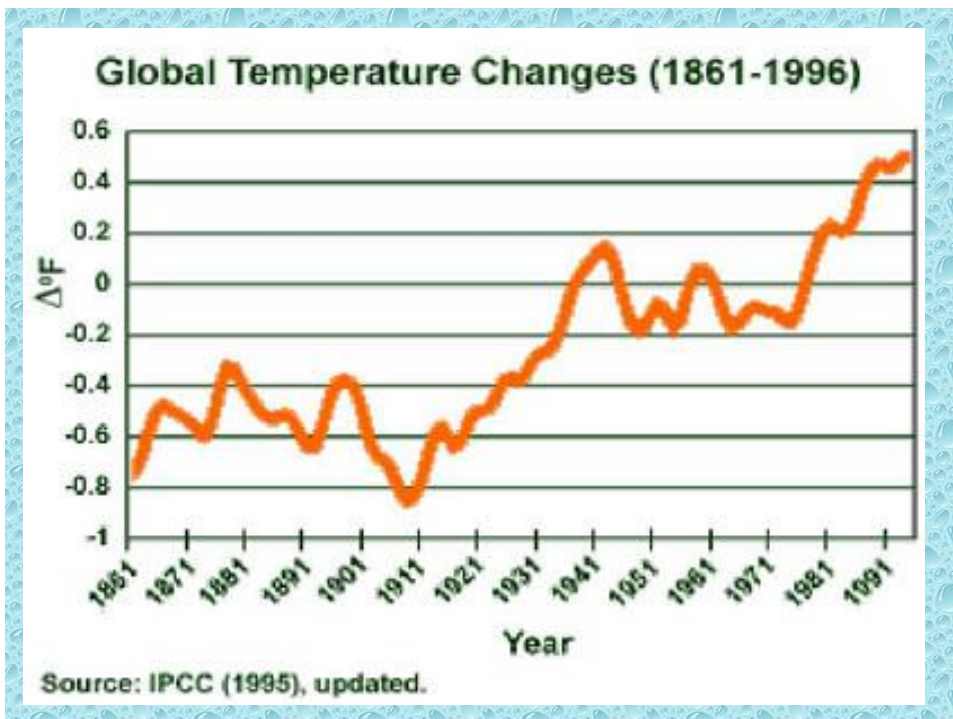
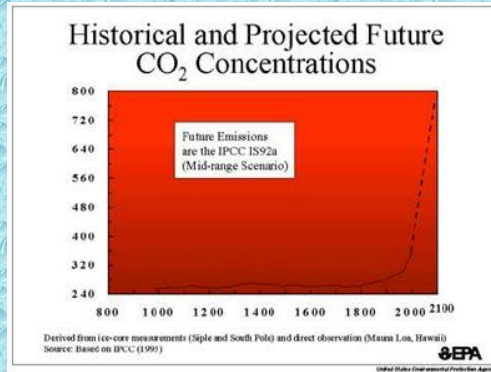
- Commercial forestry and deforestation of the natural forests for wood supplies.
- Aquatic impacts such as altered runoff and streamflow, increased sedimentation, and addition of nutrients can result from silvicultural operations
- Habitat destruction, impacts species diversity.
- Significant impacts on stream discharge and water quality, low vegetation covers leads to decrease in evapo-transpiration and correspondingly increased peak flows.

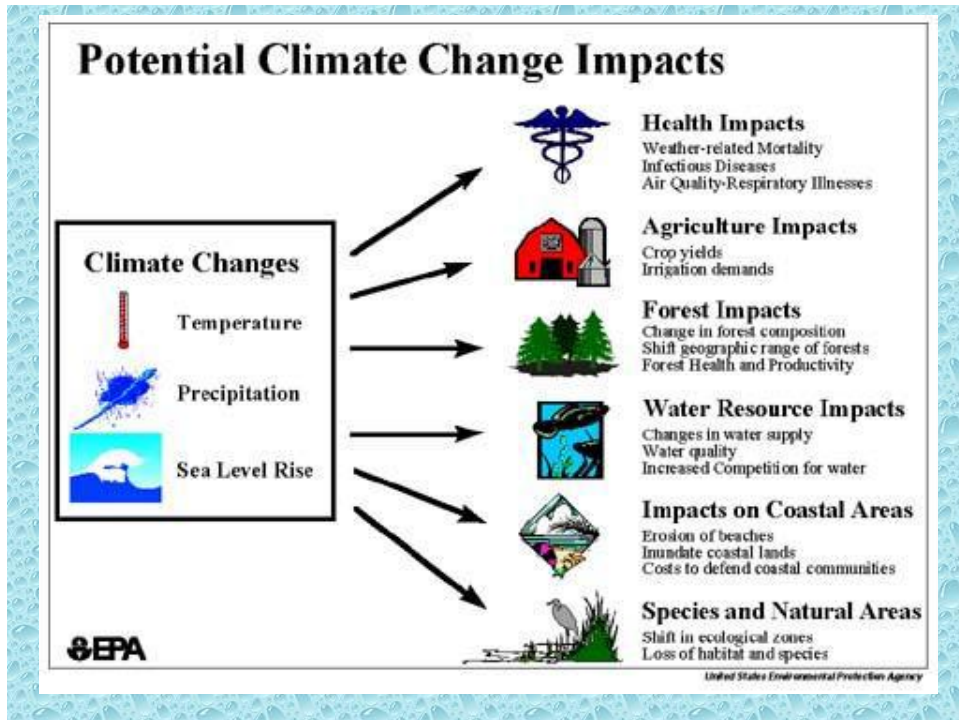
Urbanization

- Urbanization or urban drift is the physical growth of urban areas as a result of rural migration and sub-urban concentration in to cities.
- Has more severe impact on watershed than agriculture and timber harvest, as watershed vegetation is replaced with impervious surfaces, resulting in increased run off and reduced infiltration.
- “There is a direct relationship between urbanization (i.e. % watershed imperviousness) and the number of bankfull flows occurring annually (Leopold 1968). It has been estimated that a watershed with 25% impervious surfaces is subjected once every five years to an event of peak volume equivalent to the 100-year storm under completely forested conditions. At 38% imperviousness, this same event occurs every 2.5 years, and at 65% imperviousness it occurs annually (Klein 1979)”.

Accelerated Climate Change

- Since 1860 levels of CO₂ have increased from 280 ppm to 360 ppm.
- Measurements from ice cores extending back 160,000 years show that CO₂ levels and global temperature are strongly correlated





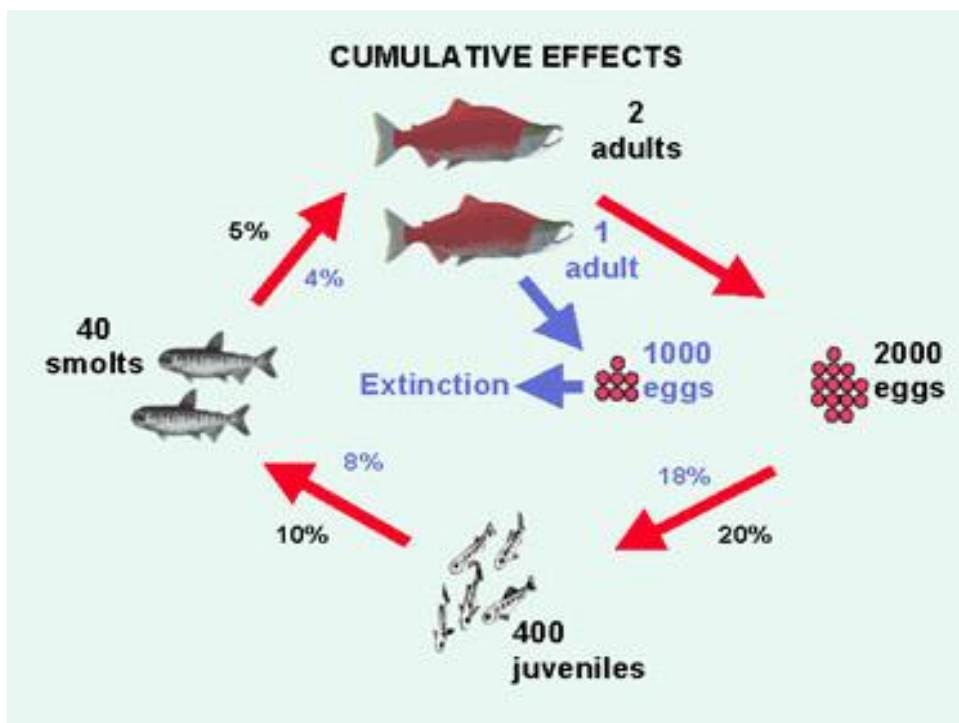
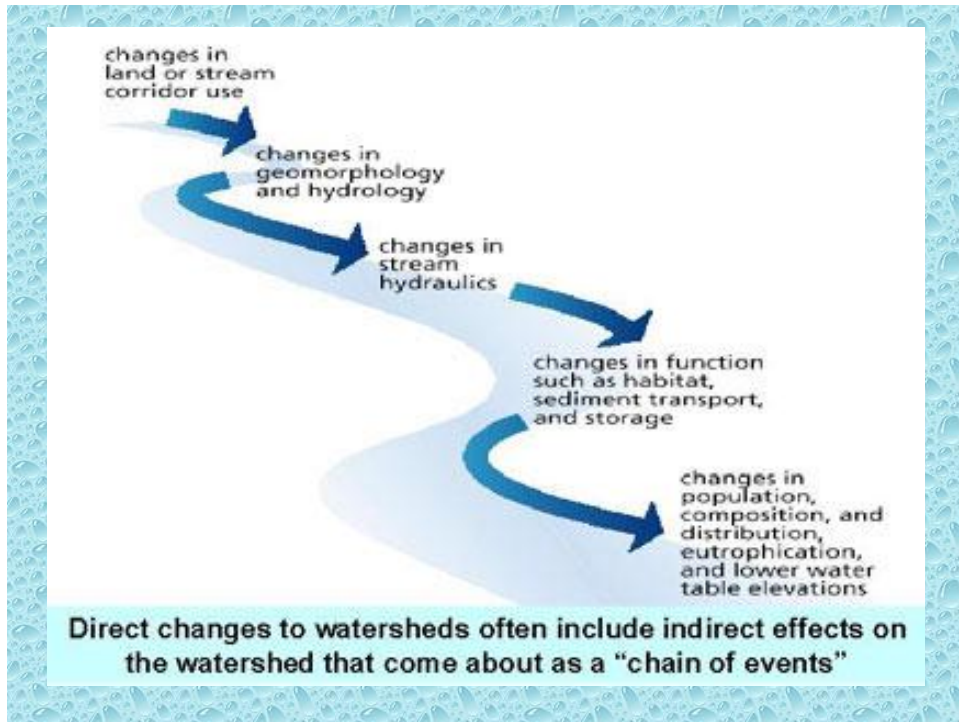
How do agents of change affect watershed processes?

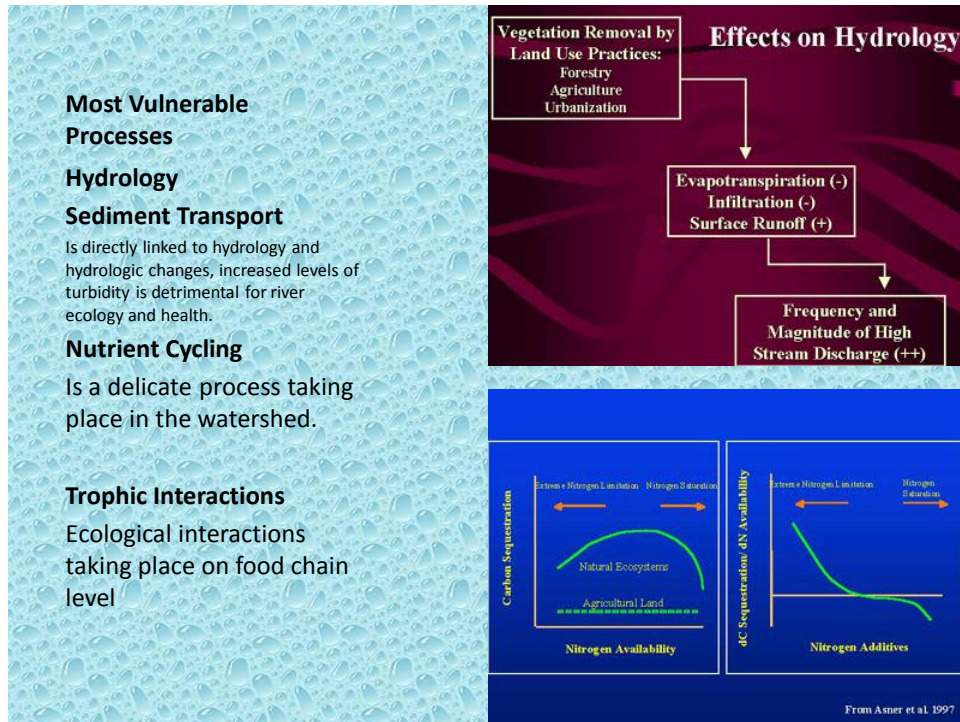
Interactive Effects

When two or more agents of change produce impacts that are more severe than their individual effect.

Threshold levels

That point beyond which damage is non recoverable.





Thank you