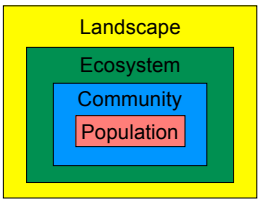
Restoration Ecology

- Explore fundamental ecological theory as it applies to restoration
- Hierarchical approach:



Landscape

- Ecosystems do not function independently from surroundings
- Spatial relations very important
- E.g. streams connect wetlands, airborne pollution travels great distances, human activities in one area can affect distant ones

Landscape

- Variety of definitions over the years
- A spatial matrix at the human scale in which interactions of biotic and non-biotic elements take place
  - Concrete part of Earth's surface
  - Has boundaries
  - Has a history
  - At least a few square kilometers
  - Can be photographed, mapped

Landscape

- Processes occur at various spatial scales
- Small scale processes tend to be more dynamic and erratic
- Biosphere -> Biome -> Landscape -> Ecosystems
- But scale is affected by perception
  - What you consider small (e.g. dandelion) would be huge for a beetle!

Landscape

- For restoration must keep in mind the scale of the target
  - Single small species vs. watershed function

Landscape

- Heterogeneity: landscapes are mosaics of different patches
  - Patches are parts of the landscape that are uniform (e.g. forest)
  - "Patches" are scale dependent

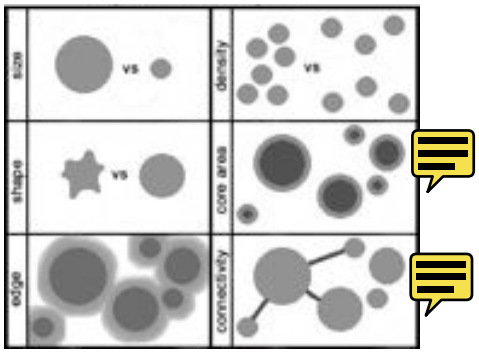
Landscape

- Groups of patches form a pattern
- Patterns can result from:
  - Topography (e.g. elevation, slope)
  - Natural disturbances (e.g. fire, flooding)
  - Human activities (e.g. farming, building)

Landscape

- Connectivity: patches may be connected
  - Exchange of matter and organisms (dispersal)
- Corridors may enhance connectivity between isolated patches
  - Effectiveness of corridors depends on scale

Landscape

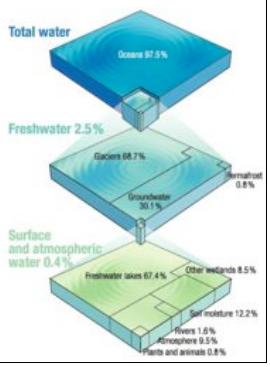


Flows between landscape elements

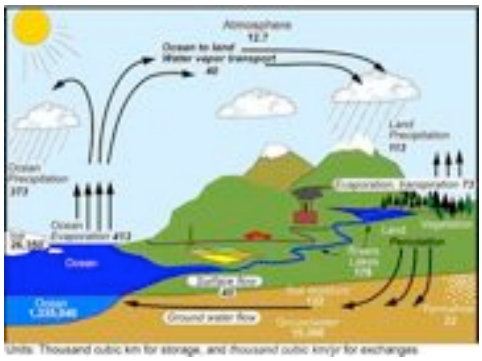
- Water flows
- Transport of matter
  - By airflows, water or humans
- Movement of organisms
  - Dispersal

Water flows

- Most water is stored in oceans
- Freshwater exchanged between atmosphere and continents
  - Precipitation
  - Evaporation



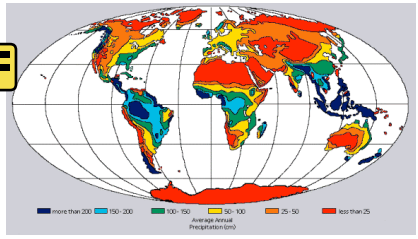
Water flows



Units: Thousand cubic km for storage, and thousand cubic km/yr for exchanges

Water flows

- Water flows on surface (rivers) and under ground (groundwater)
- Distribution of water is very uneven

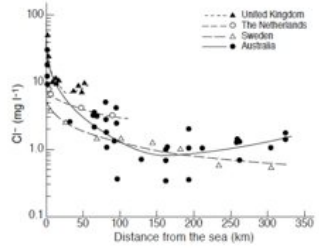


Water flows

- Water flows transport water!
- Hydrological processes are important for maintaining ecosystems
  - Wetlands
  - Arid habitats that depend on seasonal floods
- Groundwater stores excess water for use during dry periods

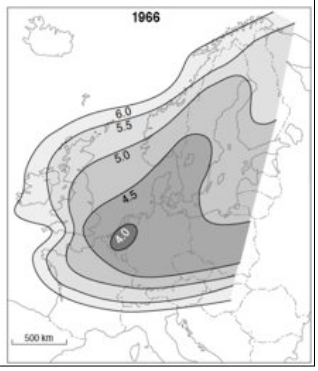
Transport of matter by airflows

- Especially prominent on continent edges where winds are strongest
  - E.g. movement of chloride



Transport of matter by airflows

- Wind transport can be over large distances & move large quantities
  - E.g. pollutants: sulphur, nitrogen, radioactive material



Transport of matter by water

- Surface water: rivers
  - Movement of solutes (nutrients), sediments & biomass
- Ground water
  - Movement of minerals

Transport of matter by humans

- Humans purposely move matter, especially water for agriculture
  - E.g. diversion of water from Aral Sea

Transport of matter by humans

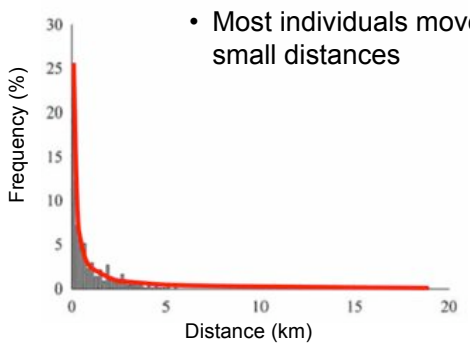
- Movement of nutrients, through fertilizer for agriculture
  - Many areas previously not able to support agriculture are huge producers due to higher nutrient loads
- These nutrients find their way into water and are transported further…

Movement of Organisms

- Organisms may move in a variety of ways and for a variety of reasons
  - Daily movements by animals to obtain food, find mates
  - Dispersal of pollen, seed, individuals
  - Migration - seasonal, short distance, long distance

Movement of Organisms

- Most individuals move small distances



Movement of Organisms

- Dispersal by airflows
  - Used extensively by plants to distribute seeds
  - Most seeds move very short distances
  - Rare long distance dispersal has big effects on gene flow

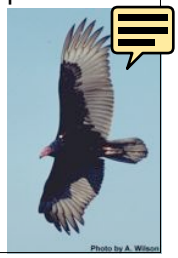
Movement of Organisms

- Seed dispersal in wetland plants

Species	*Seed production (seed m^{-2})*	*Terminal velocity (m s^{-1})*	*Height of release (cm)*	*Source area/ receptor area*
Agrostis stolonifera	25	1.64	57	0.2921
Anthoxanthum odoratum	2,258	1.52	32	0.3357
Holcus lanatus	7,383	1.68	60	2.2452
Lemna minor	–	–	–	0
Mentha aquatica	16,2	2.18	55	0.5099
Phalaris arundinacea	2,0	1.39	150	5.6288
Phragmites australis	18,0	0.21	200	44.4788
Plantago lanceolata	1,2	3.8	32	0.2032
Ranunculus acris	262	3.14	65	0.3862
Ranunculus repens	224	2.7	37	0.2599
Typha angustifolia	2,600,000	0.14	150	1,443

Movement of Organisms

- Landscape heterogeneity affects wind dispersal
- In heterogeneous landscapes dispersal follows corridors
  - Parallel to steep slopes, along edges of between different surface types
  - Thermal updrafts



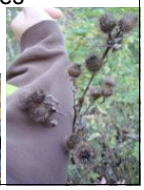
Movement of Organisms

- Dispersal by water
  - Running water a major route of seed dispersal
  - Unidirectional
  - Can travel large distances, fast

Movement of Organisms

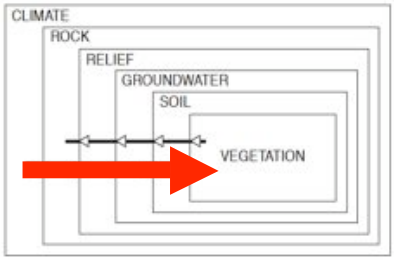
- Dispersal by animals and humans
  - Attach externally
  - Ingested
- Human dispersal can be large distances
  - Source of many alien, invasive species
  - Rotating grazing cattle



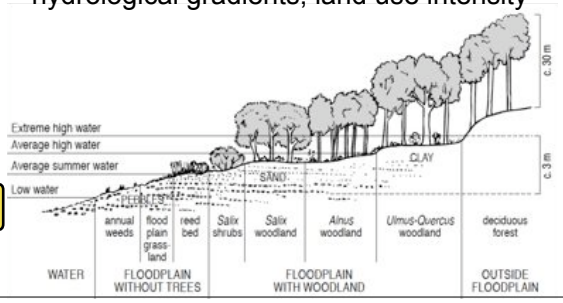
Patterns

- Driven by wide variety of factors & their interactions



Patterns

- E.g. Zonation: altitudinal gradients, hydrological gradients, land use intensity



Natural Landscapes

- Glaciation had pronounced effects on communities in polar & high altitude regions
- All species in North America and northern Europe recolonized after glaciers retreated
  - Rate of recolonization and final composition dependent on species specific factors

Natural Landscapes

- First colonizers are usually species with high dispersal ability
  - Mobile, high reproductive output (e.g. abundant seeds), generalists
  - Characteristics typical of "invasive" species
- As species diversity increases in an area, species enrichment slows down

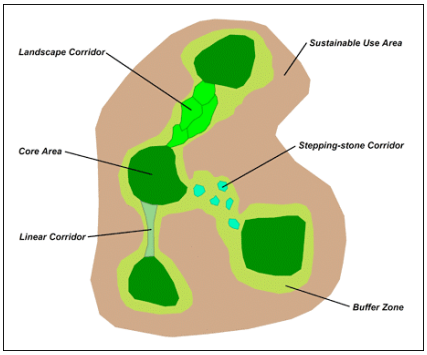
Human-affected Landscapes

- Humans have long been part of natural landscapes, with small, localized effects
- Larger & more pronounced effects occurred at different time points for different areas
  - Europe - intense in first centuries AD
  - North America - ~1800 (after European settlement)

Fragmentation

- Breaking up of large continuous habitat patches into smaller patches
  - Usually results in smaller patches
  - Often includes isolation between patches
  - Barriers (e.g. dams) can prevent movement

Fragmentation



Fragmentation

- Smaller patches = increased extinction
- Increasing distance between patches = lower probability of recolonization
- Many organisms are likely now found in small, spatially isolated relic populations

Fragmentation

- Modification of water flows has great effects on aquatic communities
  - Dams,canals & water diversion affect water quantity
    - Floodplain forests, wetlands
    - Some rivers run dry before they make it to the sea
  - Groundwater extraction can modify water table levels & water chemistry

Landscape Restoration

- Ideal to restore on a large scale
  - Provides best chances for long term survival of self-sustaining ecosystems
  - Very few examples exist at this scale

Everglades, Florida

- Largest restoration project in the world
- Major alteration of hydrology
- Massive effects on ecosystems
  - http://www.evergladesplan.org/index.aspx

Landscape Restoration

- Large scale projects focus on restoring ecosystem functions
  - Hydrological flow
  - Connectivity between patches
- Very expensive
- Public involvement