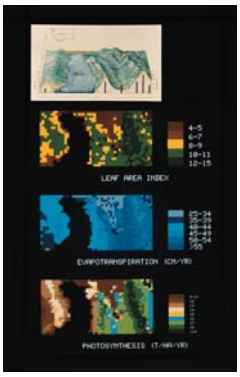
Ecological processes at the landscape scale

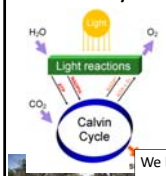
Landscape ecology studies the interaction of landscape patterns and ecological processes.

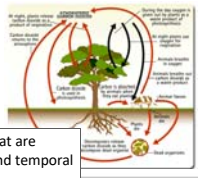
When we use the term 'ecological process', what processes are included?



Turner et al. 2001 Chapter 9

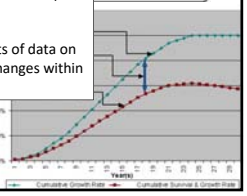
Ecosystem Processes in the Landscape





We have all these processes that are occurring at different spatial and temporal scales.

And we have varying amounts of data on their response to different changes within the landscape.



Reading: Chapter 9

Ecosystems- Review

- The term "ecosystem" was first proposed and defined by the British ecologist A.G. Tansley in 1935.
- Tansley (1935) defined it as "The whole system,… including not only the organism-complex, but also the whole complex of physical factors forming what we call the environment".
- An ecosystem is described as a discrete unit that consists of living (biotic)and non-living (abiotic) parts interacting to form a system (Allaby 1994).
- Fundamental parts of the ecosystem perspective include
  - the flow of energy through the food webs,
  - the biogeochemical cycling of nutrients,
  - hydrologic flows,
  - species movement through time and space,
  - and many other processes.

What are the spatial and temporal scales of an "ecosystem"?

Image: US Dept Commerce, NOAA, National Coastal Data Development Center

Ecosystem Processes

- What are the most important (or best known) ecosystem processes that should be considered in landscape ecology?

  Aspects that can be challenging to incorporate:

- How can we incorporate the effects of variability across broad spatial scales?
- How can the importance of temporal scale quantified (or even qualitatively assessed) be included in our consideration?

Patterns of biomass production, productivity and carbon sequestration

What is the difference between 'production' and 'productivity'?

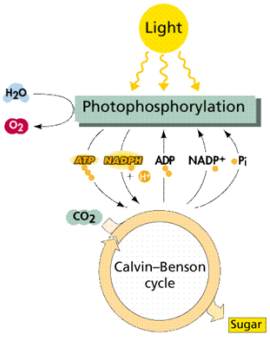
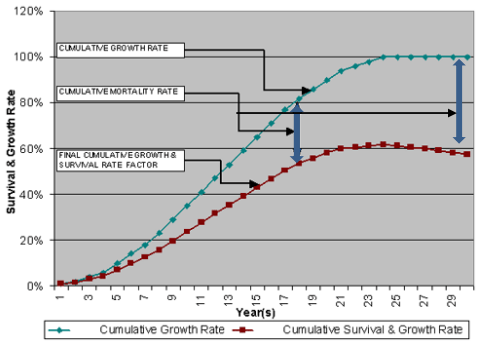


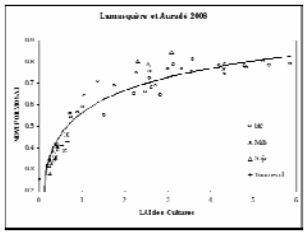
Image: Estrella Mountain Community College

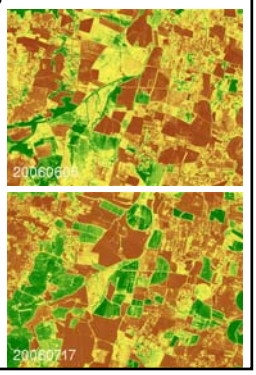
Cumulative growth and mortality rate



Sacramento Municipal Utility District

Remote sensing of biomass





- Relationship between NDVI and LAI
- NDVI saturates at some level

Demarez, V. et al. 2007, Estimation of leaf area
Agric. Forest Meteorol.

MODIS Leaf Area Index Product

- Developed from reflectance in the red and near infrared
- Quantifies relative amounts of green cover
- The more leaf area the higher photosynthetic capability
- Images since year 2000
- 1000 m spatial resolution
- 4-8 day temporal resolution

Visibleearth.nasa.gov

Seasonal changes in biomass production

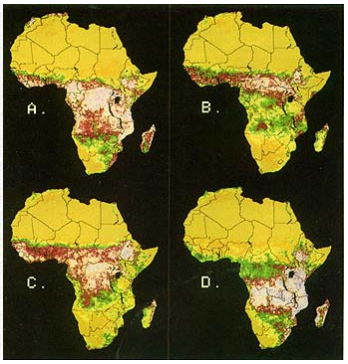
Based on AVHRR data

A. April 12-May 2, 1982

B. July 5-25, 1982

C. Sept. 27-Oct. 17, 1982

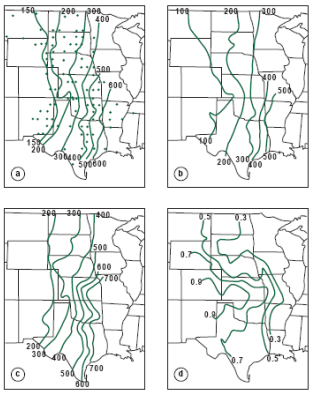
D. Dec. 20, 1982-Jan. 9, 1983.



Biomass production changes from year to year

Above ground net primary production for the US central grassland region

a: years with average precipitation
b: years with below average precipitation
c: years with above average precipitation
d: relative variability of production



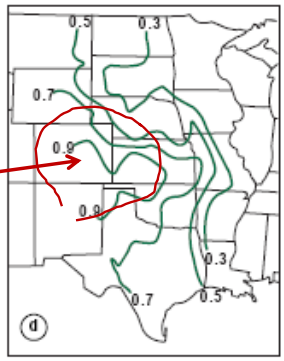
T,G & O. 2001. Figure 9.2

Relative Variability of Production

Relative variability estimated as

$(ANPP_{wet} - ANPP_{dry}) / ANPP_{average}$

Higher variability in the semi-arid regions of the Great Plains



T,G & O. 2001. Figure 9.2

What are some of the important biogeochemical cycles to consider?

Florida everglades

Global Carbon Cycle- Quantified

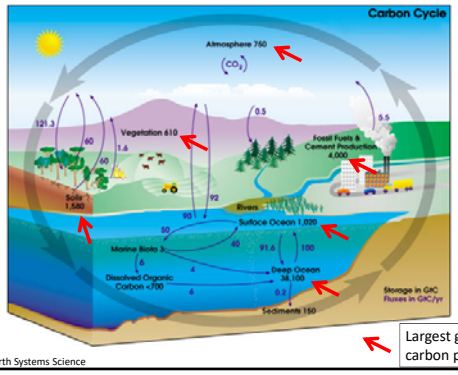
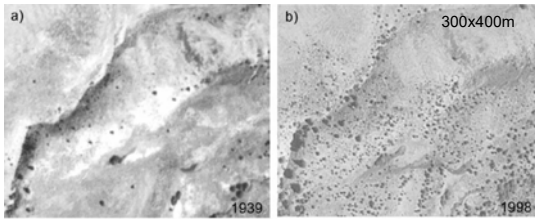


Figure: Earth Systems Science

Largest global carbon pools

Application of method to aerial photograph of western juniper:

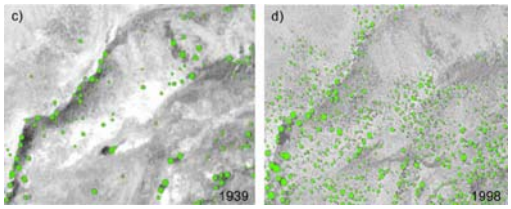


Owyhee Mountains (*Artemisia arbuscula* /*Juniperus occidentalis* habitat type)

Dark Junipers on a Sagebrush Landscape

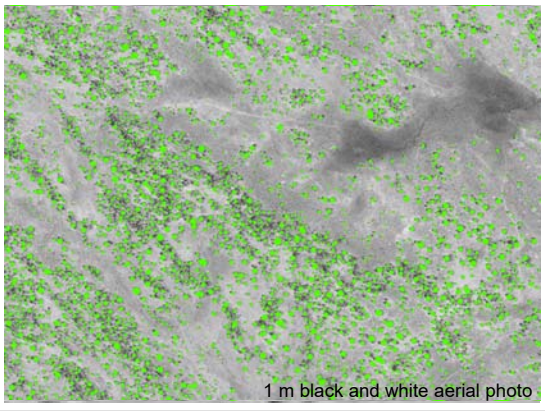
Image Resolution = 1m

Application: Change in Cover From 1939 to 1998

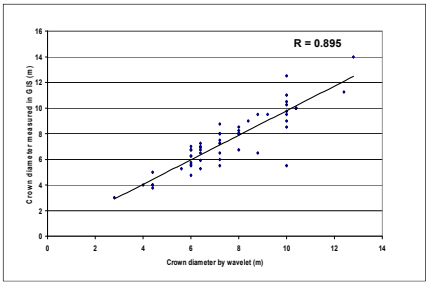


Cover 1939: 2.7%

Cover 1998: 7.3%



Correlation between wavelet and GIS estimated crown diameter



Allometric relationships for western juniper

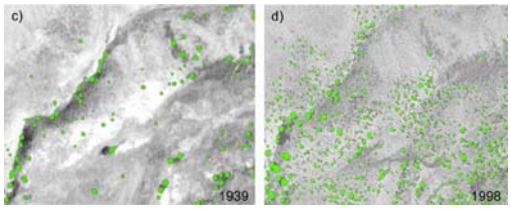
$$\ln (Y) = A + B * \ln (X)$$

Y = biomass (kg)
X = stem diameter
A, B are empirically determined coefficients

Stem biomass
- *Live branch biomass*
- *Dead branch biomass*
- *Leaf biomass*

Gholz 1980

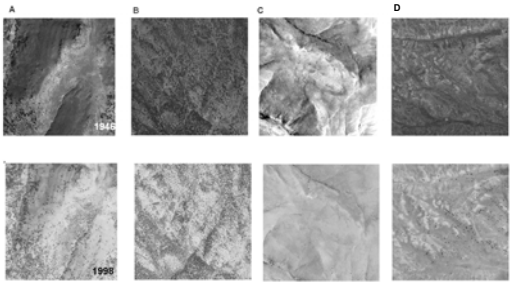
Change in biomass and above ground carbon



7630 kg C 63000 kg C

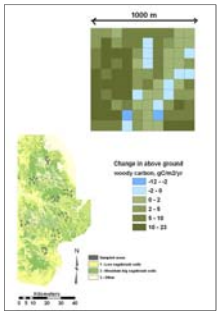
- Net increase in above ground woody plant carbon stock 730%
- Carbon sequestration rate of 3.0±0.6 g C m^{-2} yr^{-1}.

Change in four photos 1946 to 1998



Encroachment | High cover in both time periods | Low cover in both time periods | Slow recovery after a burn

Carbon accumulation analysis at three scales



I. Total area sampled (n=1)
Wavelet: 3.3 $gCm^{-2}yr^{-1}$
Texture: 10.0 $gCm^{-2}yr^{-1}$

Adjusted: 4.3 – 5.6 $gCm^{-2}yr^{-1}$

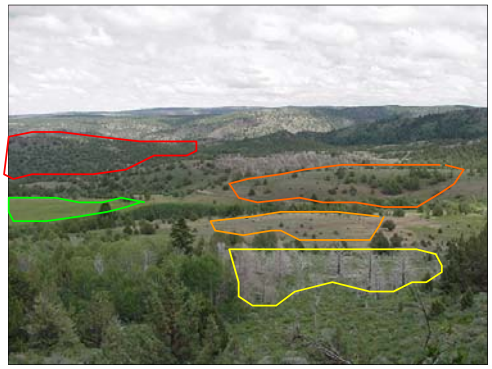
1000 x 1000 m (n=48)
Wavelet : -1.7 to 9.9 $gCm^{-2}yr^{-1}$

III. 100 x 100 m (n=4800)
Wavelet: -11 to 23 $gCm^{-2}yr^{-1}$

…..other research

Western Juniper Idaho 1946-1998	**Regional estimate**	**4-6 $gCm^{-2}yr^{-1}$**	**This study**
Western juniper Idaho 1946-1998	**1 ha scale**	**11 to 22 $gCm^{-2}yr^{-1}$**	**This study**
Mesquite (*Prosopis glandulosa*) Texas 1937-1999	Regional estimate	1.9 $gCm^{-2}yr^{-1}$	Asner et al. 2003
Mesquite (*Prosopis glandulosa*) Texas	Plot scale age 20-60	35-50 $gCm^{-2}yr^{-1}$	Hughes et al. 2006
Oak savanna, Minnesota, includes soil & below ground C	Regional estimate	16.9 $gCm^{-2}yr^{-1}$	Johnston et al. 1996
Oak savanna, Minnesota, includes soil & below ground C	Plot scale age 0-59	180 $gCm^{-2}yr^{-1}$	Tilman et al. 2000

Landscape variability



Global Water Cycle

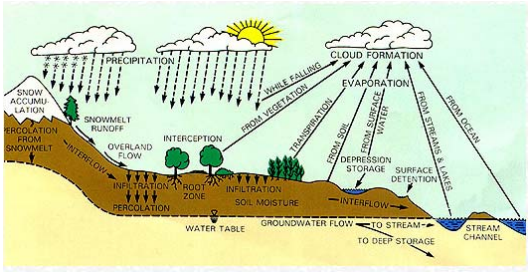
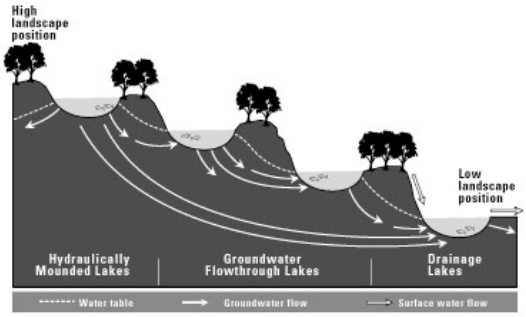


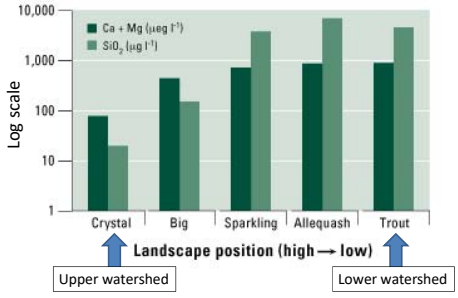
Figure: Earth Systems Science

Concept of landscape position as applied to lakes and ground water flow



T,G & O. 2001. Figure 9.3

Relationship between landscape position and Ca+Mg and dissolved reactive silica concentrations



T,G & O. 2001. Figure 9.4

Major disturbances in ecosystems

Fire

Photo by Dale Wade, forestryimages.org

Herbivory

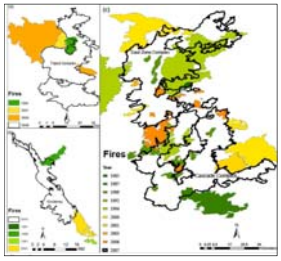
Human activities

Photo by James Henderson, forestryimages.org

Climatic variation

Photo by James Solomon, forestryimages.org

Prior wildfires influence burn severity of subsequent large fires



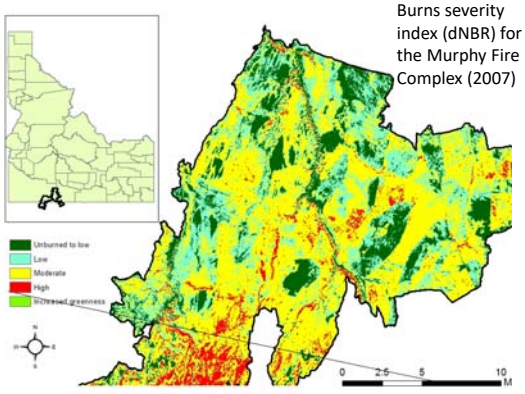
Areas burned in the last 30 years, at any severity, had significantly lower severity in the subsequent fire.

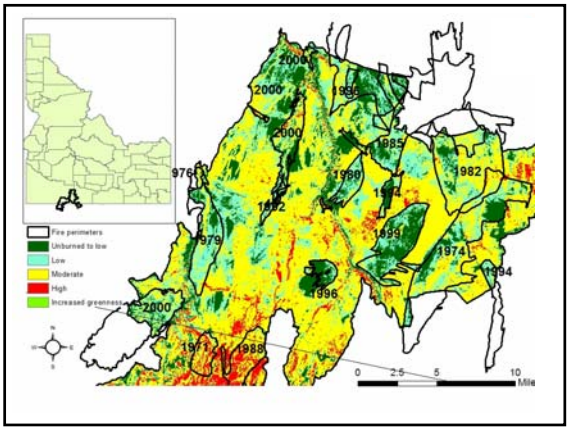
Final models included maximum temperature, vegetation cover type, slope, and elevation as common predictors.

Conclusion: Burned landscapes mitigate subsequent fire effects even under extreme fire weather conditions.

Canadian Journal of Forest Research, Stevens-Rumann et al. 2016

Burns severity index (dNBR) for the Murphy Fire Complex (2007)

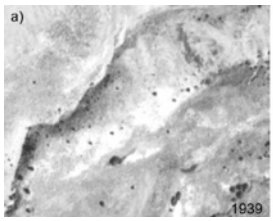


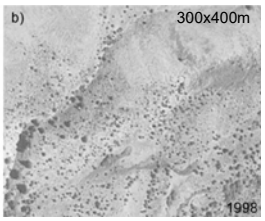


Recruitment: Essential for species persistence and/or species replacement (succession)

We have discussed previously the important factors for recruitment of species in landscapes.

Can we quantify recruitment processes?





B&W aerial photography 1939

Aerial photography
Multispectral imagery
Hyperspectral imagery
LIDAR

How does western juniper spread?

Western Juniper Life History

Juniperus occidentalis
Cypress Family (*Cupressaceae*

- Growth form: Single branched trunk 10-25 ft tall
- Leaves: Evergreen
- Bark: Rough, shreddy, reddish-brown
- Cones: Berry-like ¼- ½ inch, matures during second season
- Seed production: Begins at 20 years and becomes prolific at 50-70 years of age (Miller and Rose, 1995)

Succession in a Western Juniper Community

Grassland after fire

Mountain big sagebrush steppe

Stand initiation juniper

Open young juniper

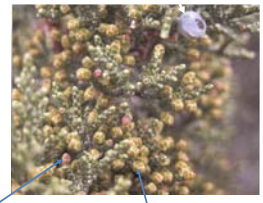
Young multistory juniper

Old multistory juniper

Seed production and dispersal

✓ Gravity
✓ Overland flow
✓ Animal transport

- Seeds are initially dormant
- Germination is enhanced by cool-moist periods
- Seeds are persistent in the seed bank



Male cone

Female cone

Who spread the seeds?

• Maser and Gashwiler (1977) observed 12 species of birds eating *J. occidentalis* berries off of trees

• Maser and Gashwiler (1977) observed four mammal species eating *J. occidentalis* berries fallen to the ground or off trees

• 12 additional mammal species have been observed consuming various species of juniper berries

• Schupp et al (1997) claim that of all the mammals possibly dispersing seeds, only the ONE is important in dispersal of *J. occidentalis* seeds

Bird species observed to consume *J. occidentalis* berries

Stellar's jay (*Cyanocitta stelleri*)
Pinyon jay (*Gymnorhinus cyanocephalus*)
Clark's nutcracker (*Nucifraga columbiana*)
American robin (*Turdus migratorius*)
Townsend's solitaire (*Myadestes townsendi*)
Western bluebird (*Sialia Mexicana*)
Mountain bluebird (*Sialia currucoides*)
Bohemian waxwing (*Bombycilla garrulous*)
Cedar waxwing (*Bombycilla cedrorum*)
European starling (*Sturnus vulgaris*)
Brewer's blackbird (*Euphagus cyanocephalus*)
Evening grosbeak (*Hesperiphona vespertina*

Mammal species observed to consume *J. occidentalis* berries

Yellow pine chipmunk (*Eutamias amoenus*)
Deer mouse (*Peromyscus maniculatus*)
Mantled ground squirrel (*Spermophilus lateralis*)
Coyote (*Canis latrans*)

…..other mammals consuming berries from various juniper species

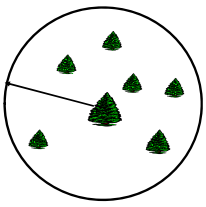
Woodrats (Neotama spp.)
Virginia opossum (*Didelphis virginiana*)
Nuttal's cottontail (*Sylvilagus nuttallii*)
Desert cottontail (*Sylvilagus audubonii*)
Black-tailed jackrabbit (*Lepus californicus*)
Red fox (*Vulpes vulpes*)
Gray fox (*Urocyon cinereoargenteus*)
Black bear (*Ursus americanus*)
Ringtail (*Bassariscus astutus*)
Raccoon (*Procyon lotor*)
Mule deer (*Odocoileus hemionus*)
White-tail deer (*Odocoileus virginianus*)
……various types of livestock

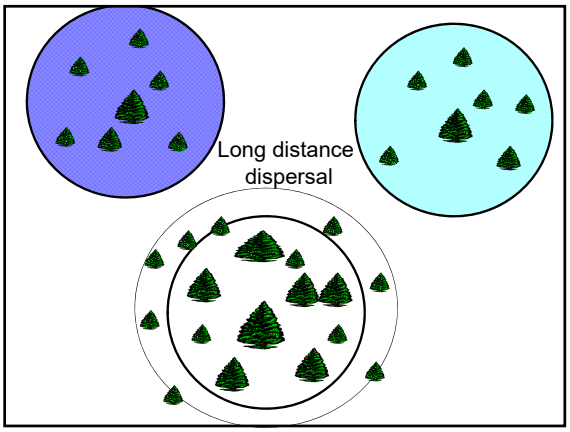
Short Distance Dispersal

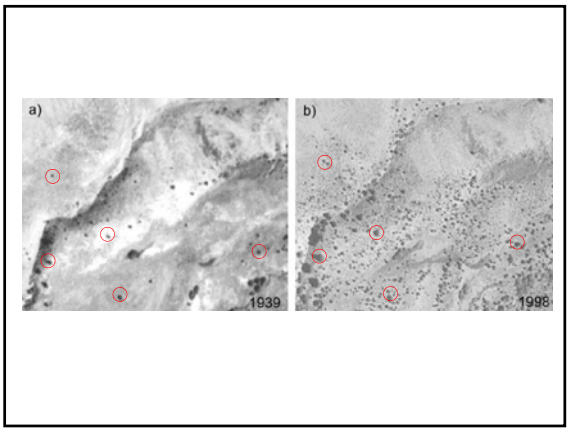
Birds with short gut-retention time

• Townsend's solitaire territories are on average 0.3-1 ha (Lederer 1977, Salomonson and Balda 1977)

• American robin's flew an average distance of 50 m between foraging and a post-forage perch (Chavez-Ramirez and Slack 1994)




Long distance
dispersal


a)
b)
1939
1998