Fundamentals in Ecology

Week 14

Applied Ecology

Grossiord Charlotte

Schedule of the lectures

Important dates:

- Deadline practical report: June 6th at 23h59

- Final exam: June 16th in GC B3 31 and GC C3 30 between 9h15 and 12h15 (no documents allowed)

WEDNESDAY - LECTURES - ENV 220			Week	Teacher
19/2/2025	10h15-12h	The nature of ecology (introduction)	1	T. Battin
26/2/2025	10h15-12h	The physical environment	2	T. Battin
5/3/25	10h15-12h	Adaptations to the environment/Physiological ecology	3	C. Grossiord
12/3/25	10h15-12h	Population structure, dynamics, and regulation	4	C. Grossiord
19/3/25	10h15-12h	Community Ecology I	5	C. Bachofen
26/3/2026	10h15-12h	Community Ecology II	6	C. Grossiord
2/4/26	10h15-12h	Ecosystem ecology I	7	T. Battin
9/4/26	10h15-12h	Ecosystem ecology II	8	T. Battin
16/4/2026	10h15-12h	Biodiversity and conservation ecology	9	C. Grossiord
23/4/2025		Easter Holiday		
30/4/2025		ENAC Week		
7/5/24	10h15-12h	Climate Change impacts on terrestrial ecosystems	10	C. Grossiord
14/5/2024	10h15-12h	Climate Change impacts on aquatic ecosystems	11	T. Battin
21/5/2025	10h15-12h	Restoration ecology. Principles of ecosystem restoration, case studies	12	T. Battin
28/5/2025	10h15-12h	Applied ecology. Review and course wrap-up	13	C. Grossiord

1. What is applied ecology?

Applied ecology = the application of the science/concepts of ecology to real-world (usually management) questions.

- Effective management of natural ecosystems depends on ecological knowledge.
- Applied ecologists use observation, experimentation, and modeling.

Example of applications:

- Agro-ecosystem management
- Biodiversity conservation
- Ecosystem restauration
- Environmental engineering
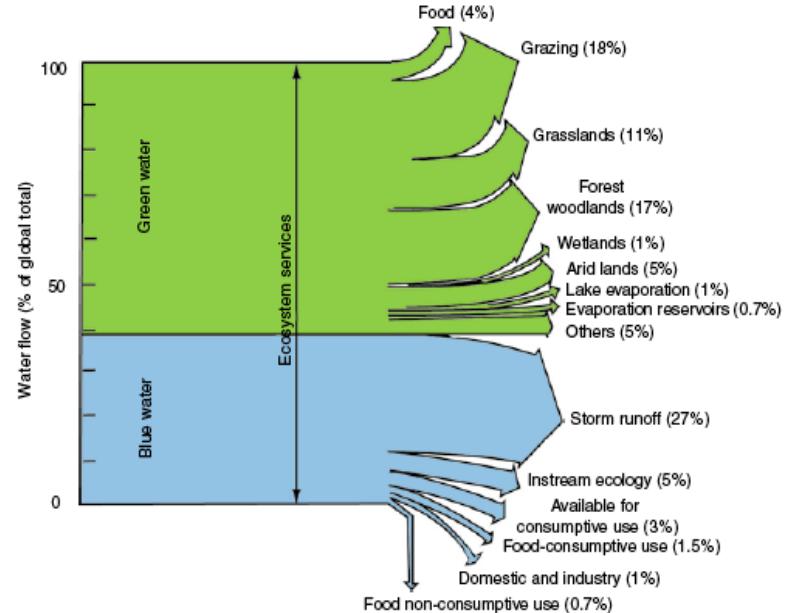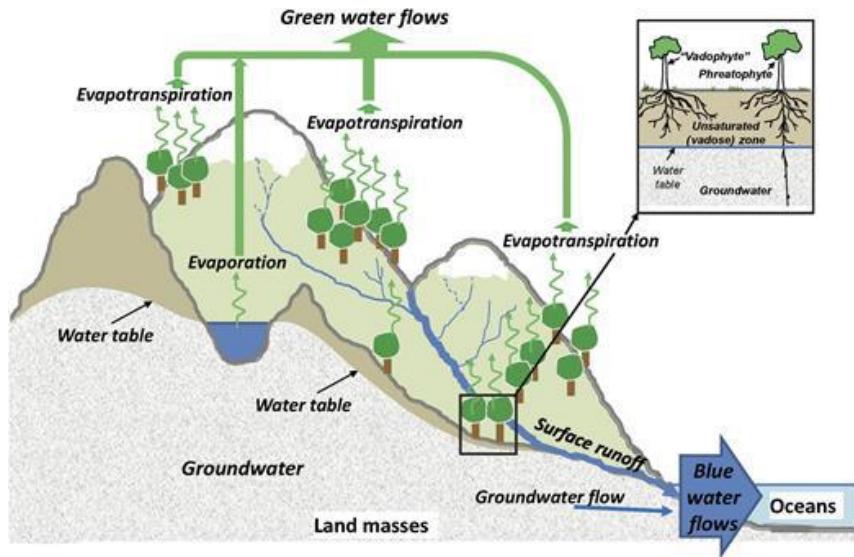- Invasive species management
- Protected areas management
- Wildlife management

Example of an applied case study:
Forest and fire: impact on the local water resources of a mega city

# 2. Context

What is Blue and Green water ?

Blue water and green water flow that support global ecosystem services. Chapin et al. 2011. "Blue water" is the rainfall that enters lakes, rivers and groundwater. This is the main source of water that we use and manage for industrial, domestic and irrigation purposes. Only 30-35% of all water within the hydrological cycle is blue water. "Green water" is the rainfall that is either intercepted by the vegetation or enters the soil and is picked up by plants and evapotranspired back into the atmosphere. Some 65% of all rain water is cycled through the green water cycle and is the water source for rainfed agriculture.

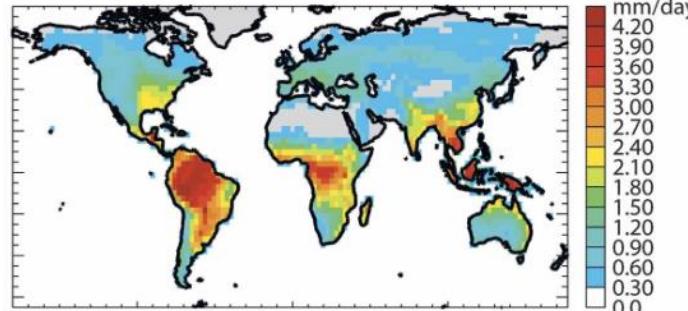# 2. Context

Total Evapotranspiration (ET)
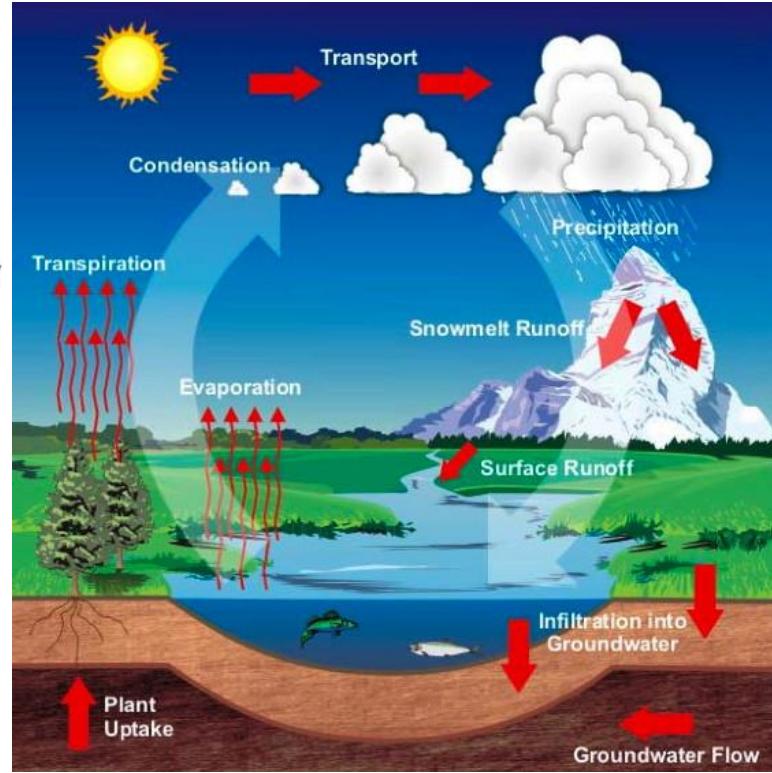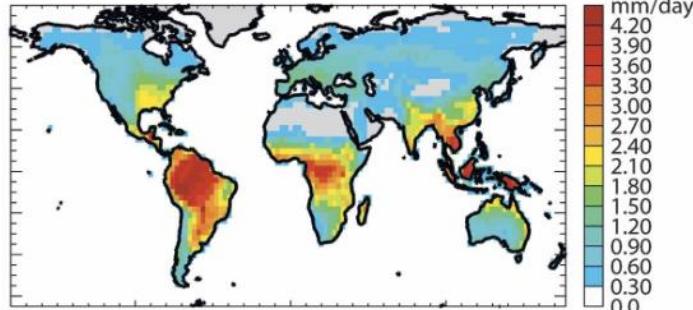
Lawrence DM, Thornton PE, Oleson KW, Bonan GB. 2007. The partitioning of evapotranspiration into transpiration, soil evaporation, and canopy evaporation in a GCM: Impacts on land-atmosphere interaction. *Journal of Hydrometeorology* 8: 862–880.
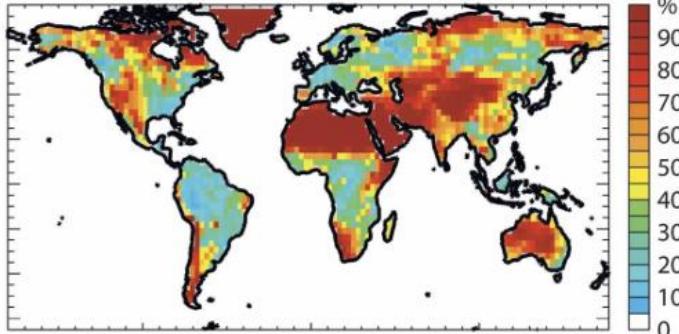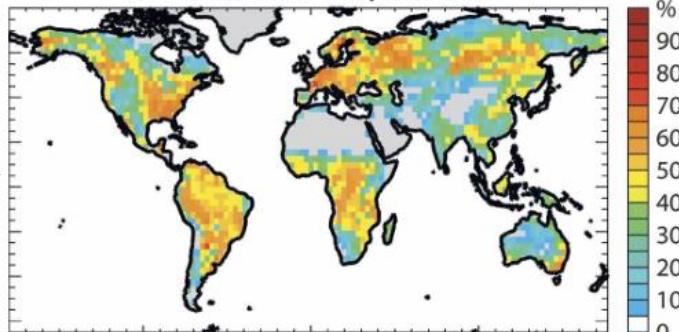
2. Context

Transpiration mostly exceeds evaporation in the global water cycle
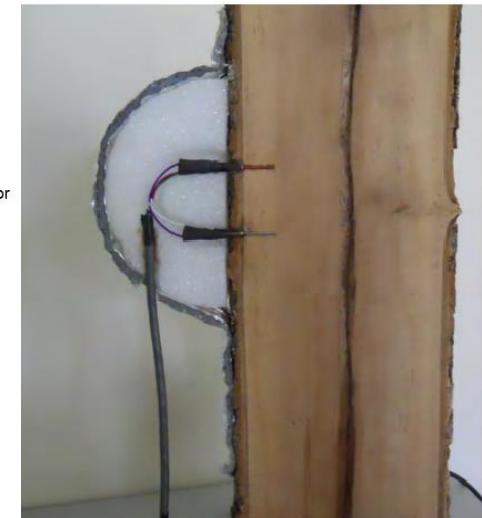

Transpiration in % from ET
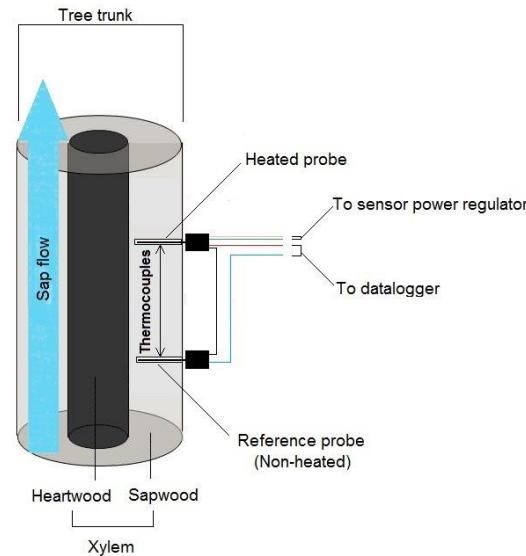
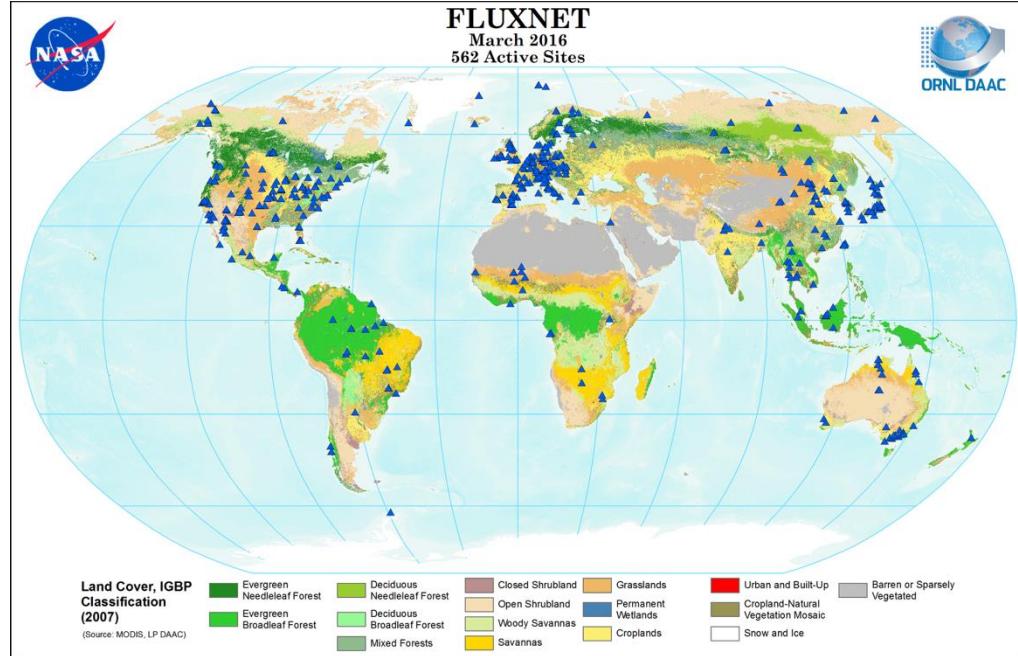Total Evapotranspiration (ET)

Evaporation in % from ET

2. Context

How much water does a tree consume per day?

Highly variable but can be up to **1000L per day** for large tropical trees

Sap flux sensors

2. Context

How much water does a whole forest consume per day?

Switzerland
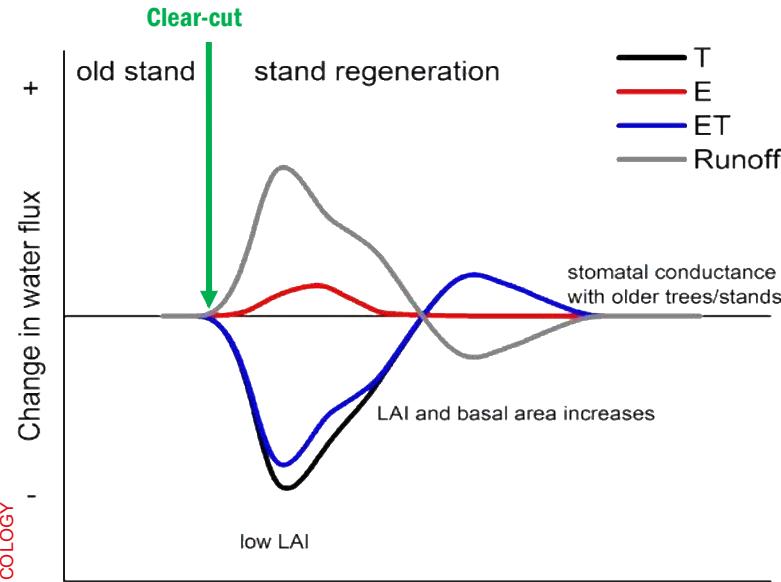
French Guiana

Eddy Covariance system

Highly variable but can be up to **75% of the precipitation that falls on a forest.**
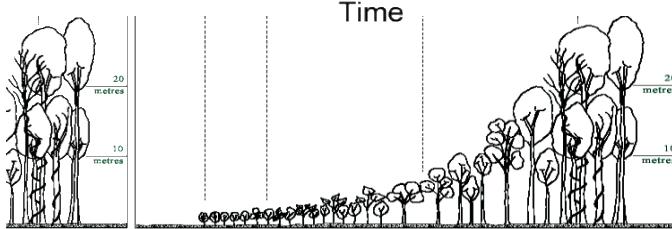
2. Context

How does stand development impact water use?

Old stand → Old stand

During regeneration, most water entering the system as precipitation leaves it through runoff and evaporation.

T = transpiration
E = evaporation
ET = evapotranspiration
Runoff

FUNDAMENTALS IN ECOLOGY

2. Context

Increasing runoff with reduced vegetation cover

Chapin FS III, Matson PA, Vitousek P. 2011. *Principles of terrestrial ecosystem ecology.*

2. Context

Increasing runoff with reduced vegetation cover

Chapin FS III, Matson PA, Vitousek P. 2011. *Principles of terrestrial ecosystem ecology.*

2. Context

Applied Ecology
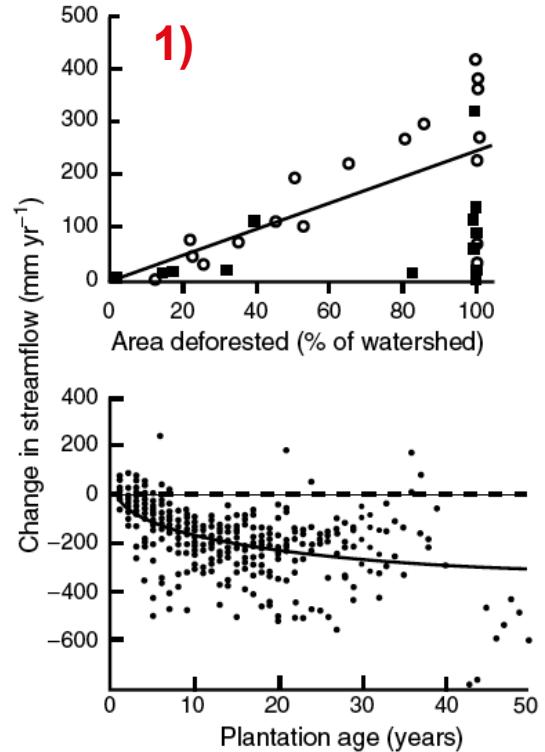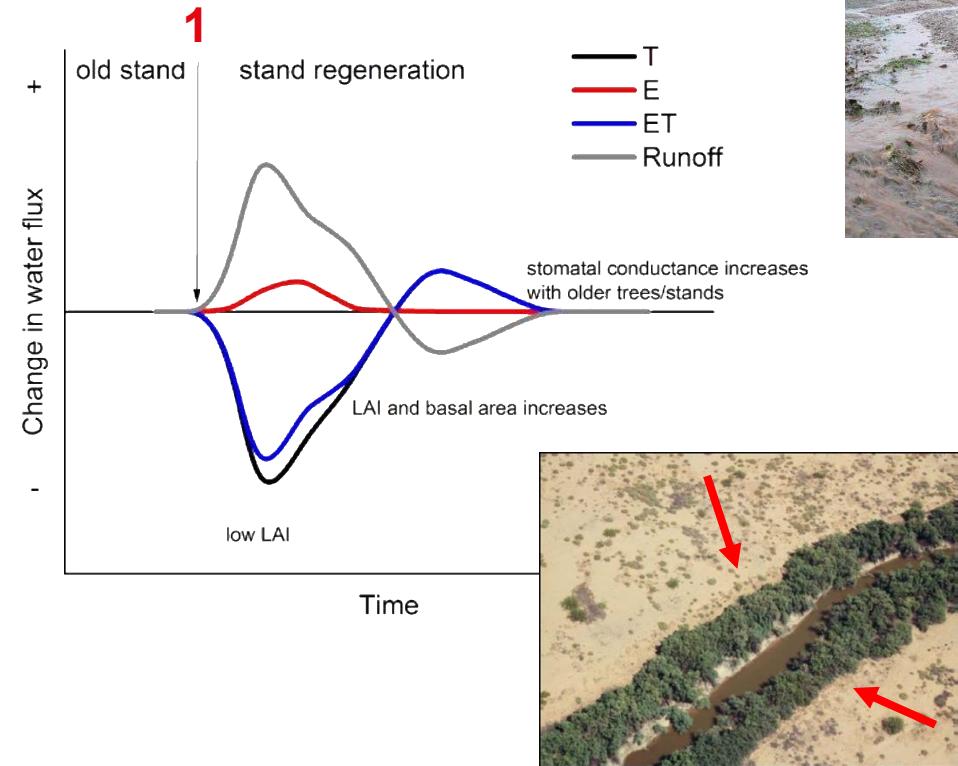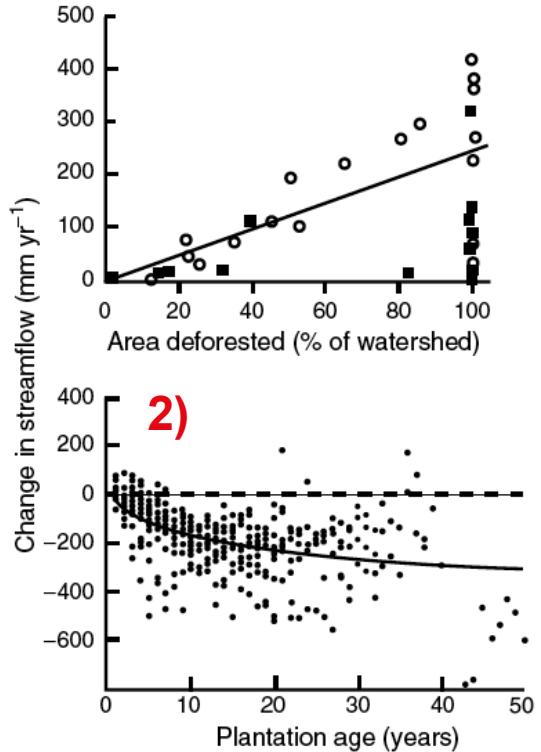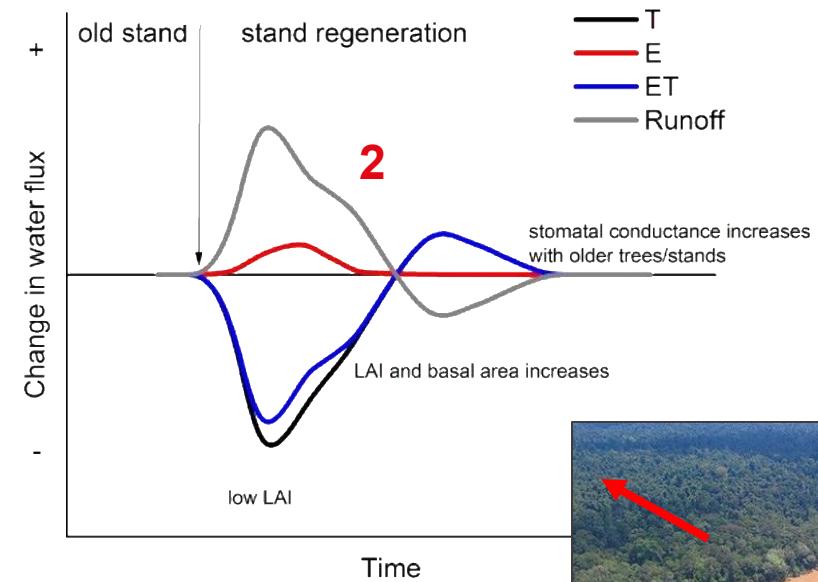
Impact of deforestation on precipitation
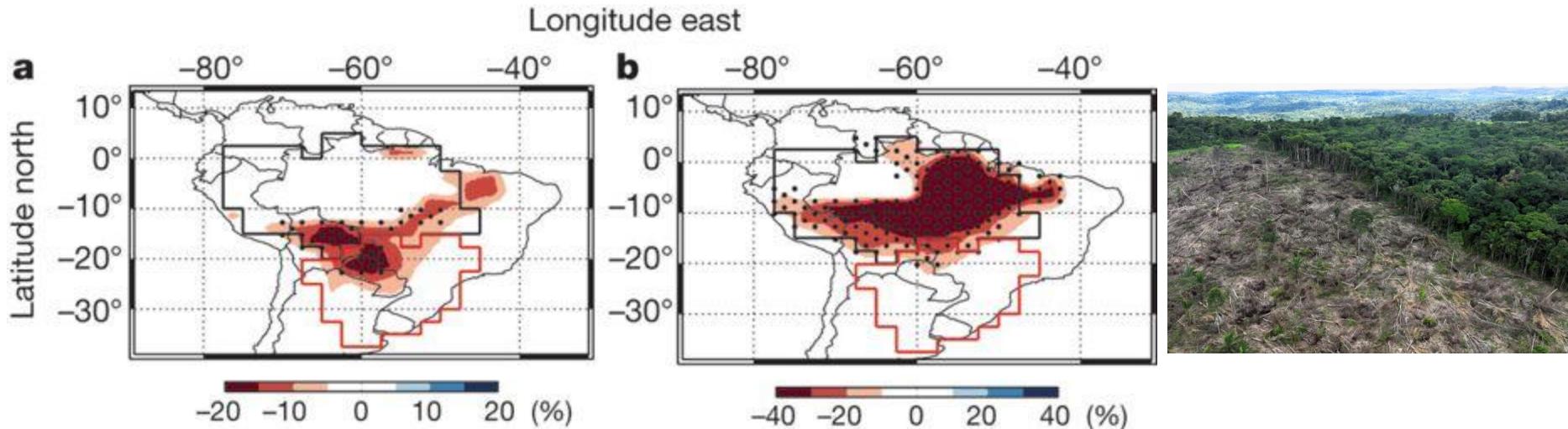
Simulated percentage change in precipitation due to 2000–2050 business-as-usual deforestation of the Amazon basin.

Amazonian deforestation could lead to 12 and 21 % reductions in wet-season and dry-season precipitation across the Amazon basin by 2050.

FUNDAMENTALS IN ECOLOGY

Spracklen et al. 2012, Nature

3. Case study

The hydrological cycle and urban water use in an environment prone to catastrophic events – A story from Melbourne

Black Saturday Bush Fires in 2009 – Modis Aqua satellite image

3. Case study
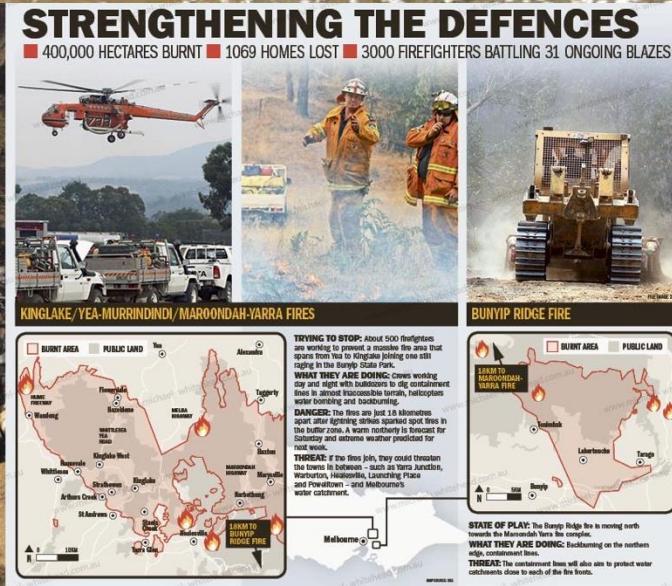
The hydrological cycle and urban water use in an environment prone to catastrophic events – A story from Melbourne

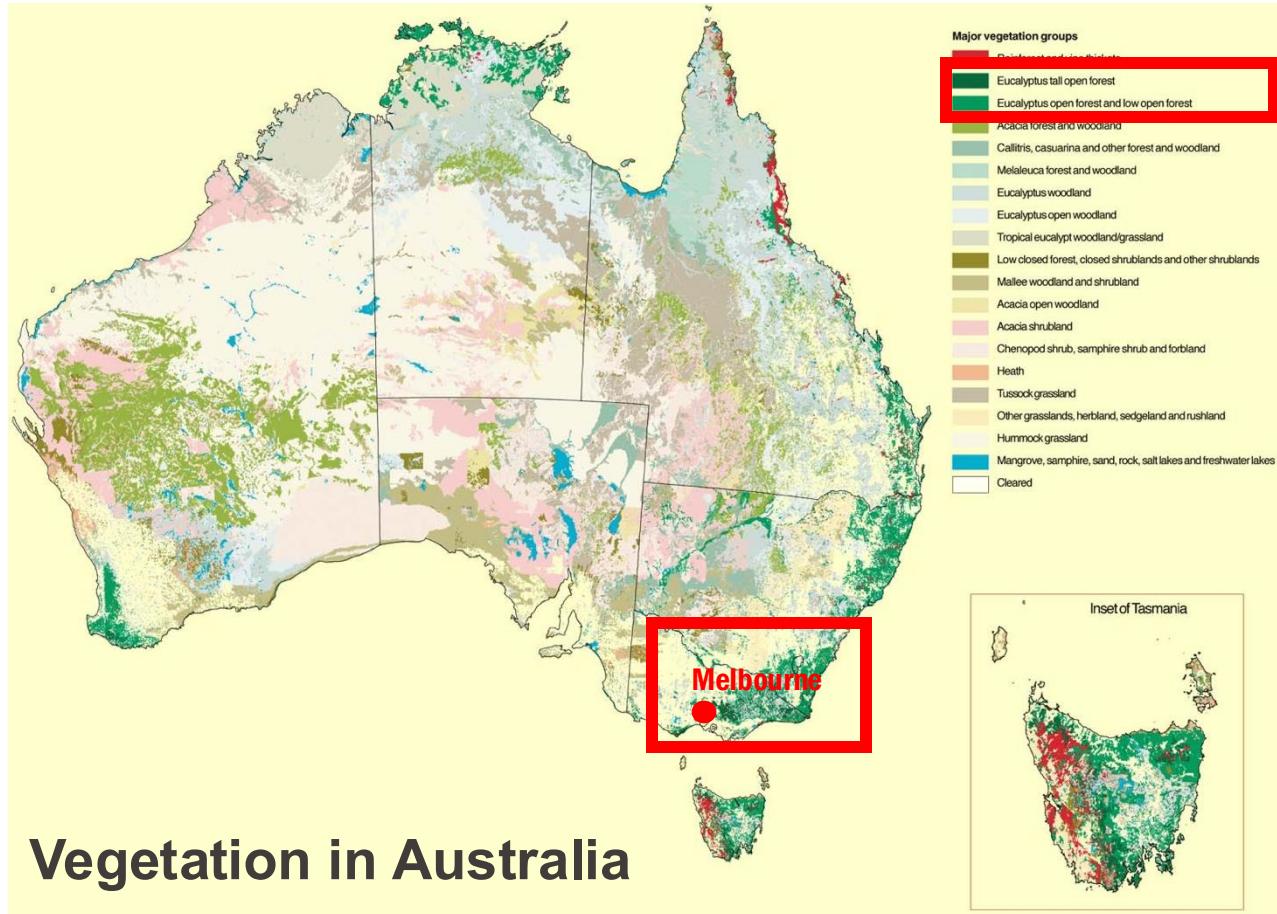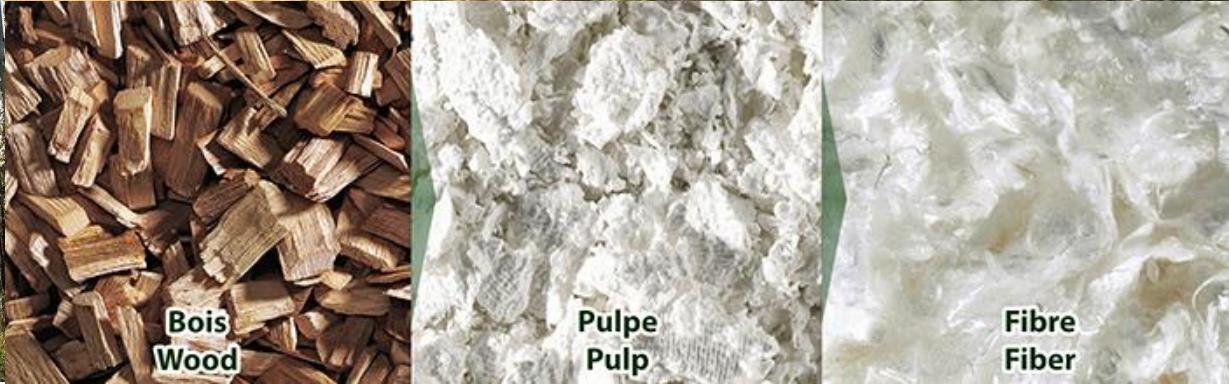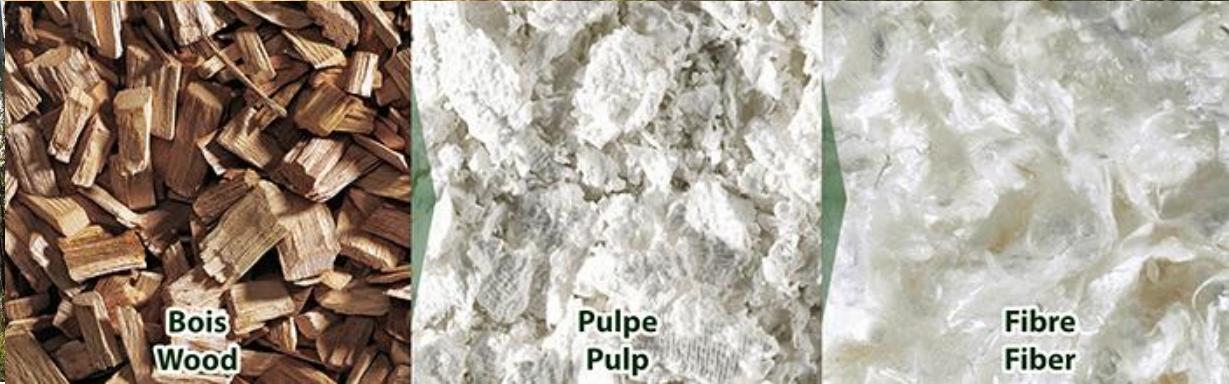Dust storm over Melbourne in February 1983

Black Saturday Bush Fires in 2009 – Modis Aqua satellite image

3. Case study

Major vegetation groups

Rainforest and vine thickets
Eucalyptus tall open forest
Eucalyptus open forest and low open forest
Acacia forest and woodland
Callitris, casuarina and other forest and woodland
Melaleuca forest and woodland
Eucalyptus woodland
Eucalyptus open woodland
Tropical eucalypt woodland/grassland
Low closed forest, closed shrublands and other shrublands
Mallee woodland and shrubland
Acacia open woodland
Acacia shrubland
Chenopod shrub, samphire shrub and forbland
Heath
Tussock grassland
Other grasslands, herbland, sedgeland and rushland
Hummock grassland
Mangrove, samphire, sand, rock, salt lakes and freshwater lakes
Cleared

Melbourne

Inset of Tasmania

Vegetation in Australia

4-7 years to reach 20 m

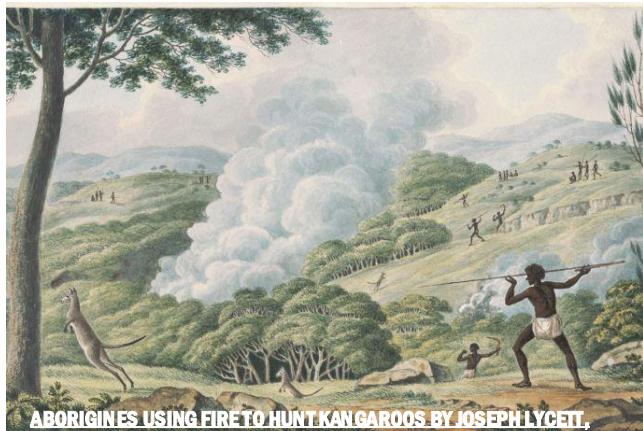Aracruz, Brasil

Bois / Wood

Pulpe / Pulp

Fibre / Fiber

3. Case study

Fires are an essential part of the ecology in Australia

Factors determining vegetation types:

    a) Water
    b) Temperature
    c) Nutrients
    d) Species interactions
    e) Disturbance → Fire

(A) (B) (C) (D)

Epicormic resprouting

Trends in Plant Science

ABORIGINES USING FIRE TO HUNT KANGAROOS BY JOSEPH LYCETT.

Lignotuber

Native vegetation has evolved to rely on frequent bushfires (e.g. lignotubers, epicormic resprouting).

3. Case study

Timber plantations are more susceptible to fires than natural forests
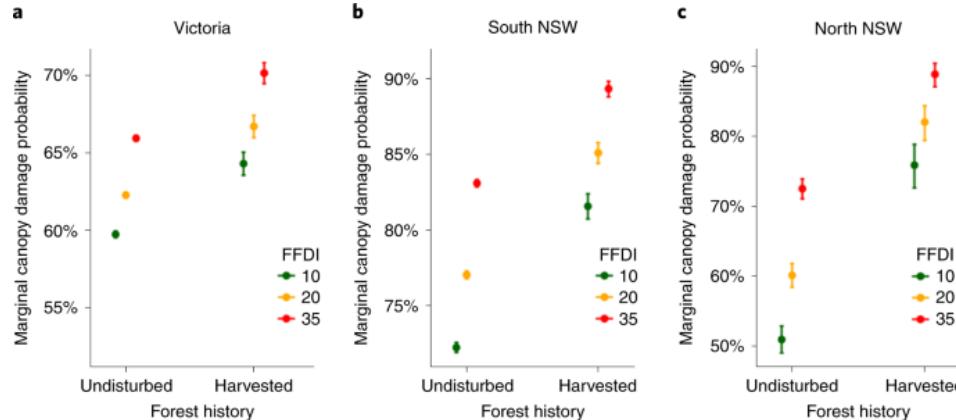
Logging increases the probability of canopy damage during fires by 5–20%

Check for updates

Logging elevated the probability of high-severity fire in the 2019–20 Australian forest fires

David B. Lindenmayer [1 ✉], Phil Zylstra [2], Robert Kooyman [3], Chris Taylor[1], Michelle Ward [4] and James E. M. Watson [4]
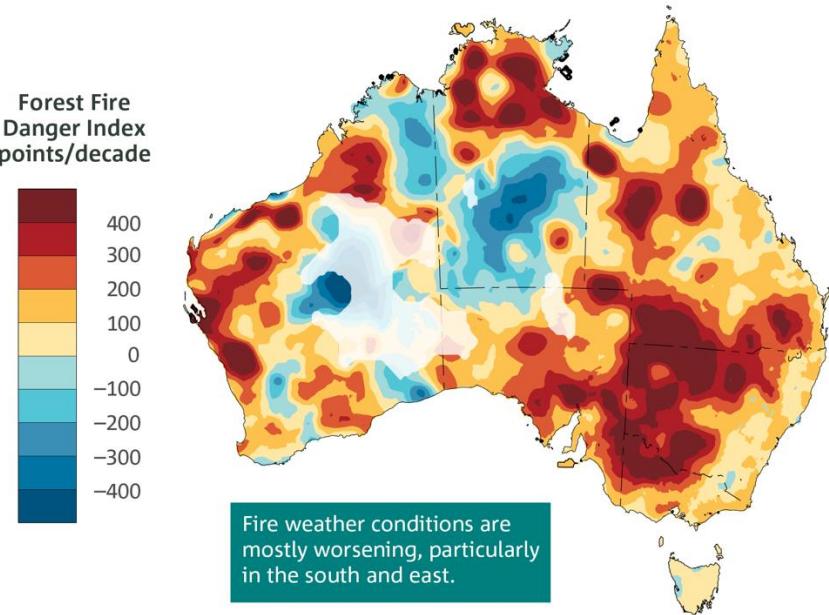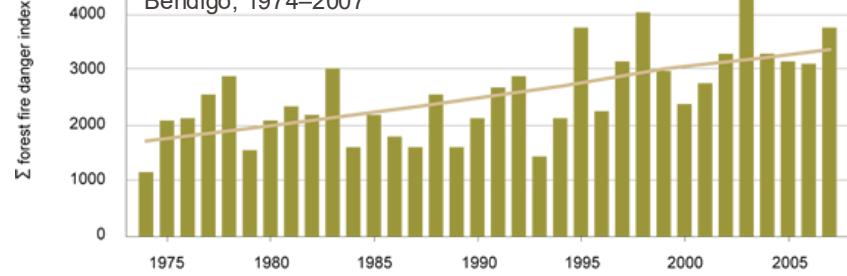
FUNDAMENTALS IN ECOLOGY

Bowman et al. (2021) Nature Ecology & Evolution

3. Case study

Fire frequency in Australia is increasing because of climate change

Cumulative annual total forest fire danger index, Bendigo, 1974–2007

FUNDAMENTALS IN ECOLOGY

Forest Fire Danger Index points/decade

	400
	300
	200
	100
	0
	−100
	−200
	−300
	−400

Fire weather conditions are mostly worsening, particularly in the south and east.

Source: Bureau of Meteorology

Trends from 1978 to 2017 in the annual sum of the daily Forest Fire Danger Index—an indicator of the severity of fire weather conditions. Positive trends, shown in the yellow to red colours, are indicative of an increasing length and intensity of the fire weather season.

3. Case study

Millennium drought (1996-2010)

The frequency of extreme heat events is increasing.

Source: Bureau of Meteorology
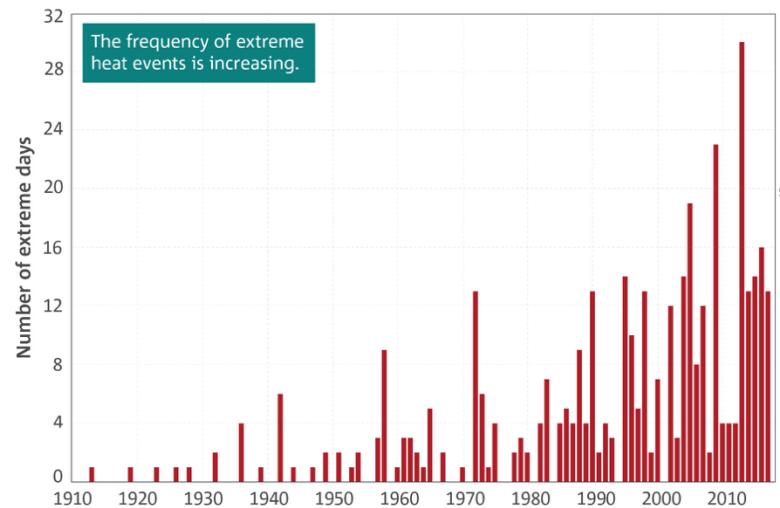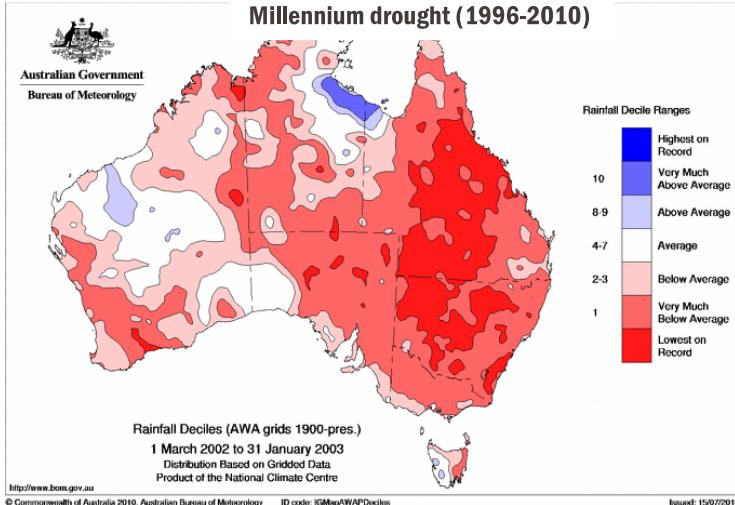
Number of days each year where the Australian area-averaged daily mean temperature is extreme. Extreme days are those above the 99th percentile of each month from the years 1910–2017.

Global change effects:
Heat waves/droughts → tree decline/mortality
→ +++ amount and dryness of fuel

→ Increasing fire risk

3. Case study

Bush fires reduce drinking water yields in forested areas in South-Eastern Australia

Increased water use by trees because of reduced WUE (green water)

⬇

Reduced drinking water yield (blue water)

3. Case study

Don't always believe textbook knowledge!
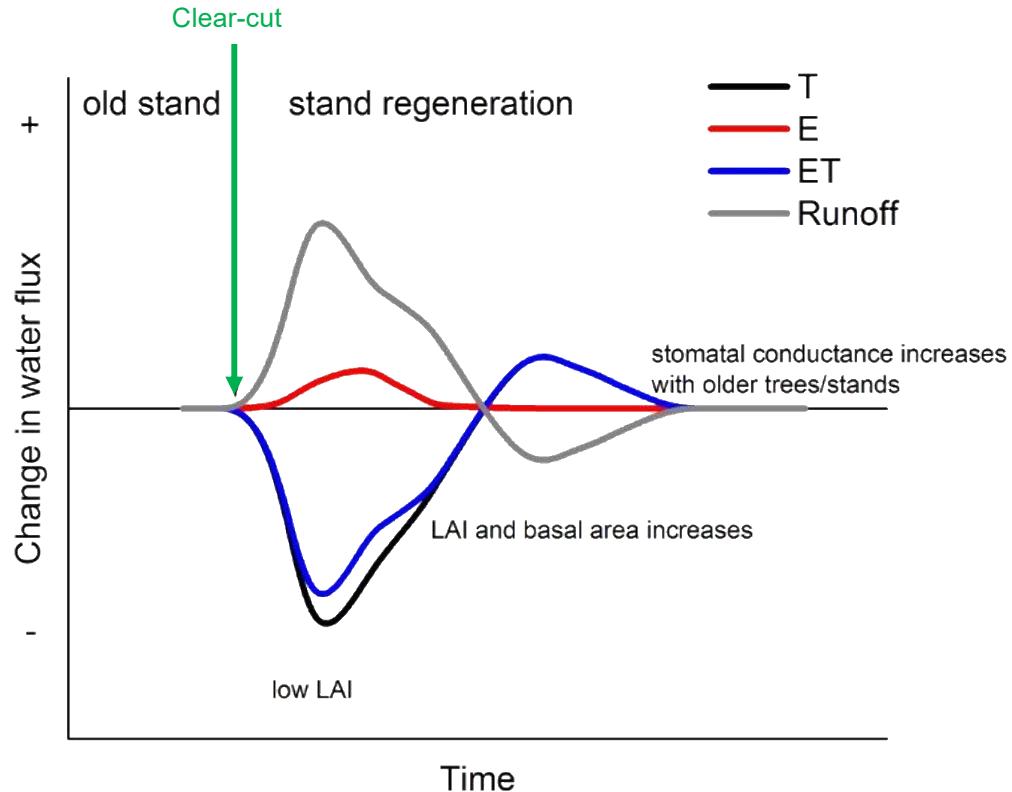
3. Case study

Reduced streamflow following a bushfire

Kuczera G. 1987. Prediction of water yield reductions following a bushfire in ash-mixed species eucalypt forest. *JOURNAL OF HYDROLOGY* 94: 215–236.
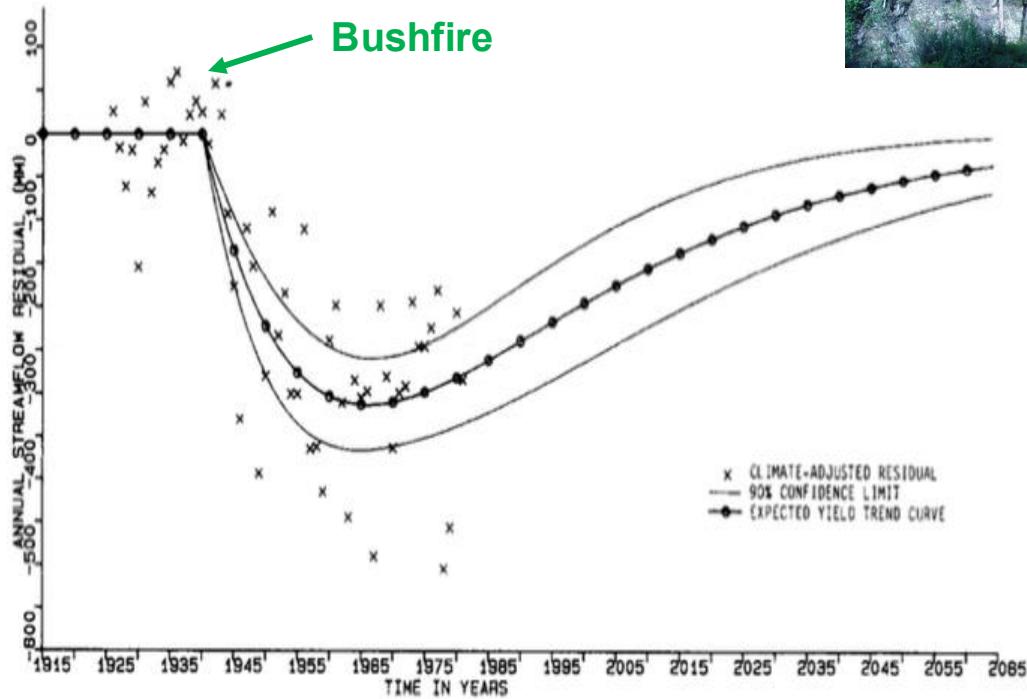
3. Case study

Old stand
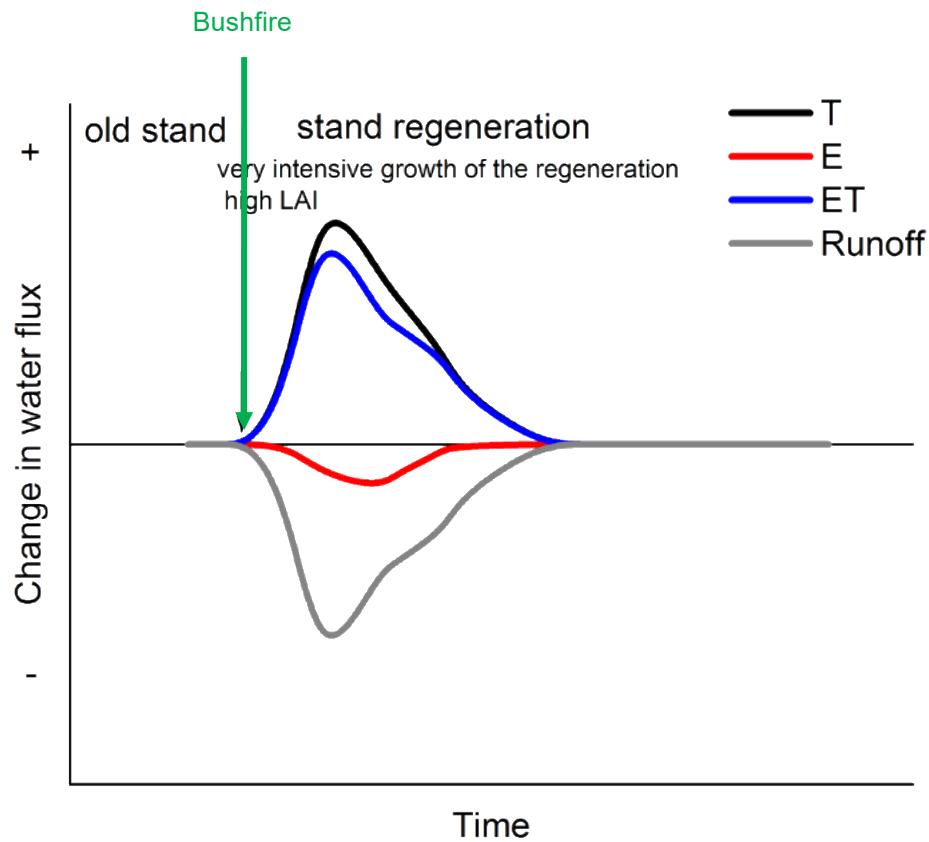
Young stand

Following the bush fire, increased tree transpiration (green water) and reduced runoff (blue water).

old stand stand regeneration

very intensive growth of the regeneration high LAI

Bushfire

+

Change in water flux

-

Time

— T
— E
— ET
— Runoff

3. Case study

Population in Melbourne

Melbourne
Population Forecast

RISKWISE
PROPERTY RESEARCH
Australia's most innovative property research house

Expected to reach close to 10 millions by 2050

Forecast to reach 5 million by 2021

SOURCE: RISKWISE PROPERTY, ABS

3. Case study

Rapid population growth in Melbourne over the past few years has increased water usage

- Melbourne's total water usage increased in recent years.

- Total water use remains below the levels experienced prior to the Millennium Drought (1997 – 2009), despite an increase in population.
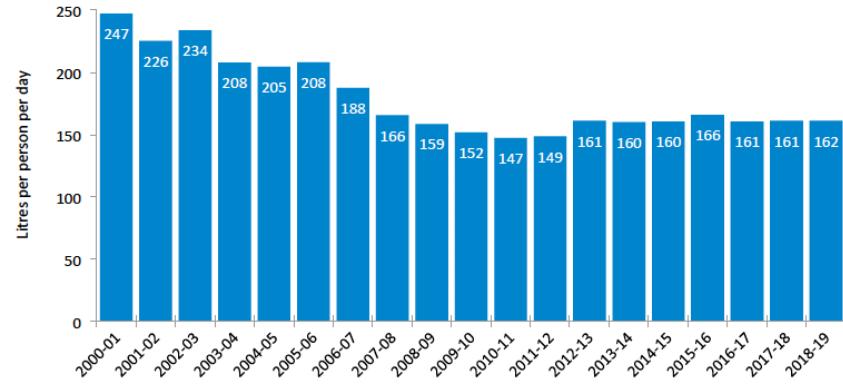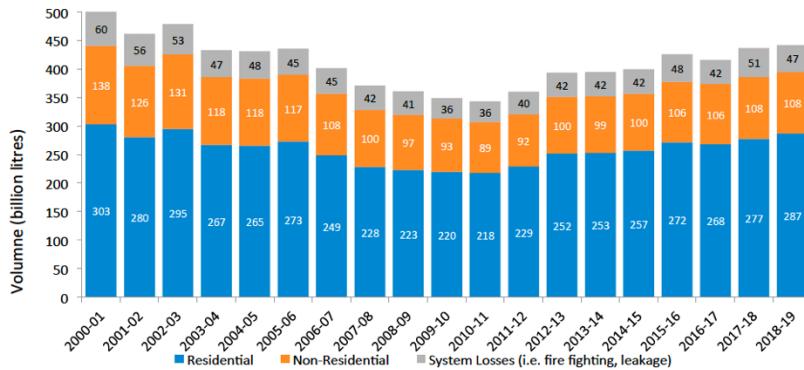
Figure 7: Melbourne's per capita residential consumption

Figure 5: Melbourne's total water use by segment

Residential water use comprised 64% of Melbourne's total water use in 2017-2018

Applied Ecology

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3. Case study

Water supply of Melbourne – catchments in forested areas

How water gets to you...

Wholesaler

Melbourne Water
manages the source and supply of water and manages delivery to retailers

Retailers
Provide water to your tap

- City West Water
- Yarra Valley Water
- South East Water

Metropolitan

Community

Western Water

Yarra Valley Water

City West Water

PORT PHILLIP BAY

Gippsland Water

South East Water

Barwon Water

WESTERN PORT

Westernport Water

South Gippsland Water

BASS STRAIT

Water supply storage reservoirs:

1. Greenvale
2. Toorourrong
3. Yan Yean
4. Sugarloaf
5. Maroondah
6. O'Shannassy
7. Upper Yarra
8. Thomson
9. Tarago
10. Silvan
11. Cardinia

Other sources of water :

12. Victorian Desalination Project
13. Sugarloaf (North-South) Pipeline

— Rivers
— Water corporation boundaries
— Water supply pipelines and aqueducts
----- Water pipeline owned by AquaSure
● Water supply catchment area
● Mid Yarra catchment

3. Case study

The project was announced in June 2007 (peak of the millennium drought) when Melbourne's water storage levels dropped to 28.4%.

The plant was completed in 2012. However, Melbourne's reservoirs were at 81% capacity, and the plant was immediately put into standby mode. The first water was released for public use in 2017. In 2018-2019, two orders were placed for 100 GL and 125 GL of water (1/4 of Melbourne's water demand), putting upward pressure on water prices.

It is a controversial part of Victoria's water system, with ongoing costs of $608 million annually.

© PR IMAGE

Applied Ecology

In August 2008, a 1,600-page environmental effects study report was prepared and found that; *"...several protected species could be affected by the plant's construction and operation –but none would be left "significantly" worse off."*. The community was given 30 business days to respond to the report. Watershed Victoria claimed that this was insufficient time for community groups to analyze the report and prepare submissions.

3. Case study

- **Brine**, also known as concentrate, is the by-product of the desalination process that harms the environment due to its high salinity.

Most common brine disposal methods in the United States and Australia.

- Surface Water Discharge ■ Sewer Discharge ■ Deep-Well Injection
- Evaporation Ponds ■ Land Application ■ Other
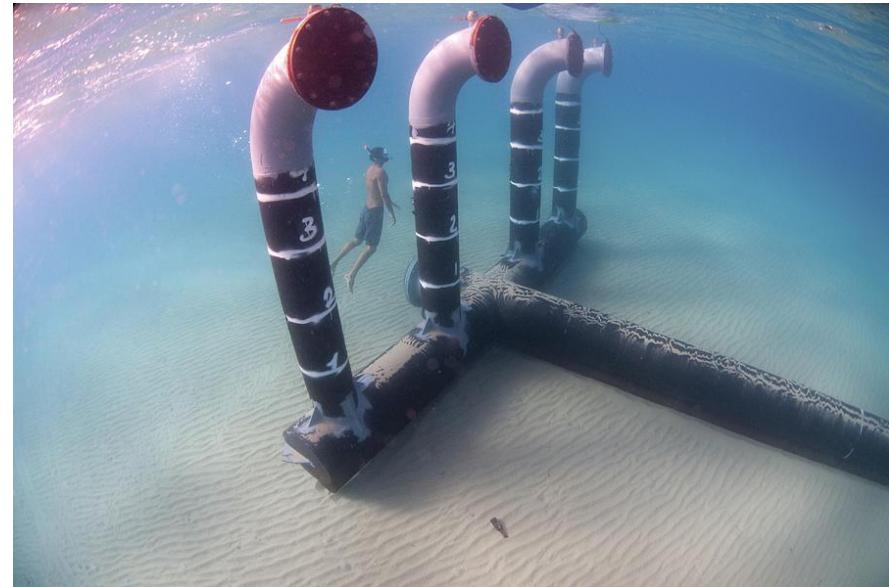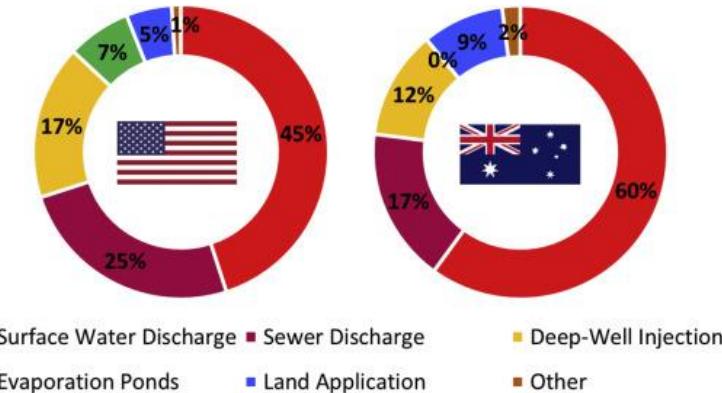
- Most forms of desalination are very **energy-intensive**. Desalination has the potential to increase fossil fuel dependence.

- Desalination surface water intakes are a huge **threat to marine life**.

- Desalination is **not very efficient**, requiring large amounts of seawater.

3. Case study

Long-term water supply and demand

With higher demands and high climate change impacts, we have enough water until around 2028.

With medium demands and medium climate change impacts, we have enough water until around 2043.

With lower demands and lower climate change impacts, we have enough water until beyond 2065.

Did you know that although unlikely, it is possible that in the lowest supply and highest demand scenario, we'll have a shortfall of water of **over 450GL by 2065**.

Average annual volume (gigalitres)

Highest approx supply level

Demand range

Medium demand

Medium supply

Lowest approx supply level

Source: *Water for a future-thriving Melbourne*, **2017**

3. Case study

Action plan to conserve water resources

We've identified a number of actions in each of our *Urban Water Strategies* and the *Melbourne Water System Strategy*, as well as the actions we've taken collaboratively in *Water for a future-thriving Melbourne*.

We've provided a summary of the key actions we're working on together and separately to enhance our water availability.

Permanent Water Use Rules	Continuing to inform the community about the 'common sense' rules which ensure the wise use of water at all times.
Target 155 voluntary water efficiency program	Continuing to deliver the Victorian Government's Target 155 voluntary water efficiency program that encourages metropolitan Melbourne households to use water efficiently, aiming for 155 litres per person per day. The *Victorian Water Efficiency Strategy* identifies opportunities to work together to deliver water efficiency measures.
Community Rebates Program	This part-government funded program supports vulnerable customers to undertake plumbing improvements at home so they can avoid unnecessary and inefficient water usage. This includes engaging a plumber to do a water audit, and subsequently carry out minor plumbing works (e.g. replacement washers, dual-flush toilets, fixing leaking taps, replacement showerheads).
Integrated water management (IWM)	Actively supporting the Department of Environment, Land, Water and Planning (DELWP) in the formation and delivery of IWM forums, and leading the development of place-based IWM plans.
Desalinated water order advice	Annually reviewing the level of water availability and storage forecasts to provide advice to the Minister for Water on the desalinated water order volumes required to provide ongoing water security. In 2018-19, 15 gigalitres (GL) of desalinated water was ordered with the desalination water order advice including non-binding forecasts of 100 and 125 GL for 2019/20 and 2020/21 respectively. (Source: *2018/19 Desalinated Water Order Advice, Summary of Technical Analysis*)
Schools Water Efficiency Program (SWEP)	Continuing the schools program which helps schools identify leaks, faulty appliances and inefficient practices. Since 2012, SWEP has saved participating Victorian schools more than 4.7 billion litres of water equating to a saving of more than $13.7 million.
Network efficiency	Undertaking active leak detection, reticulation mains renewals, district metering and trialling intelligent network technologies to minimise non-revenue water.

3. Case study

Mitigation of fire impacts and risk

Prescribed burning

Prescribed burning is the process of planning and applying fire to a predetermined area, under specific environmental conditions, to achieve a desired outcome.

- to maintain biodiversity,
- **to mitigate the severity of bushfires and to help protect lives and property by reducing the build-up of flammable fuel loads, and**
- to rehabilitate vegetation after disturbance, such as timber harvesting and mining.

3. Case study

Mitigation of fire impacts and risk

Selective cutting → Decrease in leaf area
→ Decrease in transpiraton
→ Increase in Runoff

Selective cutting
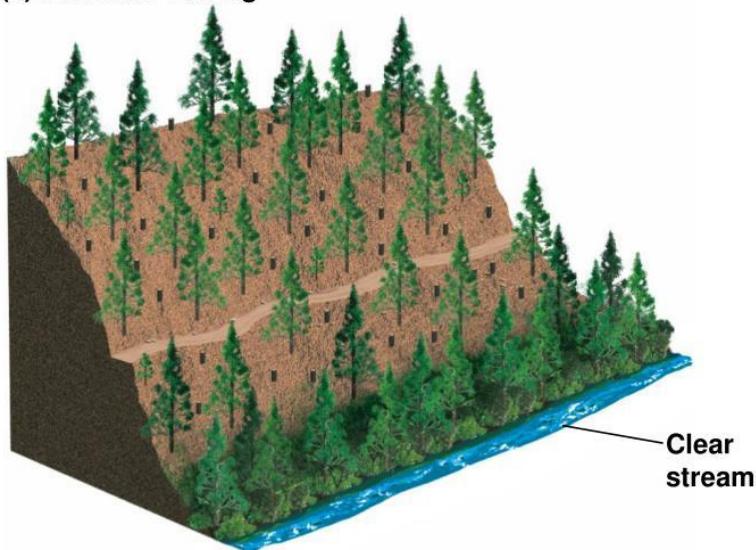

(a) Selective cutting

Clear stream

Fig. 9-6, p. 182

$y = 1.536x^{0.89}$ $r^2 = 0.91$

MEAN DAILY TRANSPIRATION (l day^{-1})
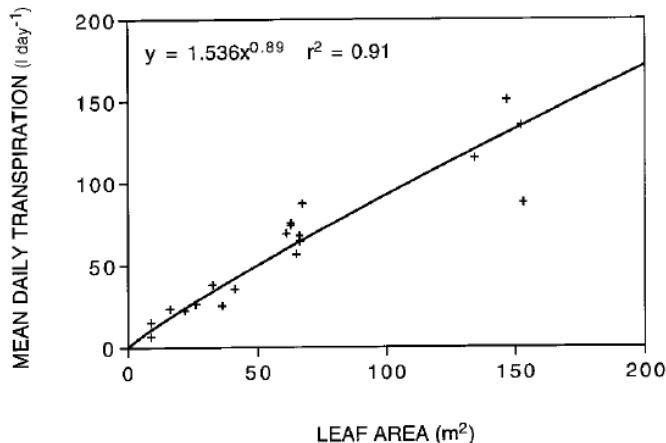
LEAF AREA (m^2)

Figure 8. Leaf area versus mean daily transpiration for the sampled mountain ash trees.

EPFL

3. Case study

Applied Ecology

Mitigation of fire impacts and risk

Stand structure, stand age, and species composition all affect the transpirational demand and thus the amount of discharge.

Mixed Eucalyptus/Acacia stands

Resource partitioning

Mixing different species with contrasting water use strategies (Acacia and Eucalypt trees):

- Acacia trees take up water from shallower layers than Eucalyptus (reduced competition)
- The taller Eucalyptus trees provide shading to Acacia trees during warm and dry periods.

FUNDAMENTALS IN ECOLOGY

4. How to prepare for the final exam

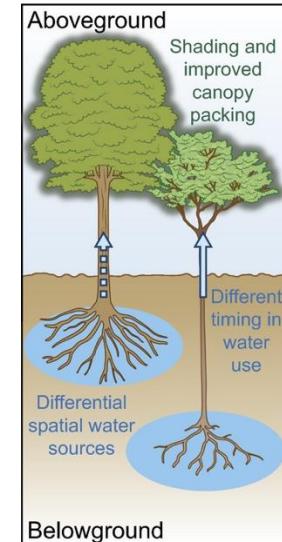**Short Answer Questions** (1 point per question / 10 questions in total)

1) _____ is the process of natural selection resulting in changes in the traits of populations over the course of generations.

Answer: Evolution

2) The process of using the sugars produced during photosynthesis to produce energy for cellular activities is called _____ .

Answer: Respiration

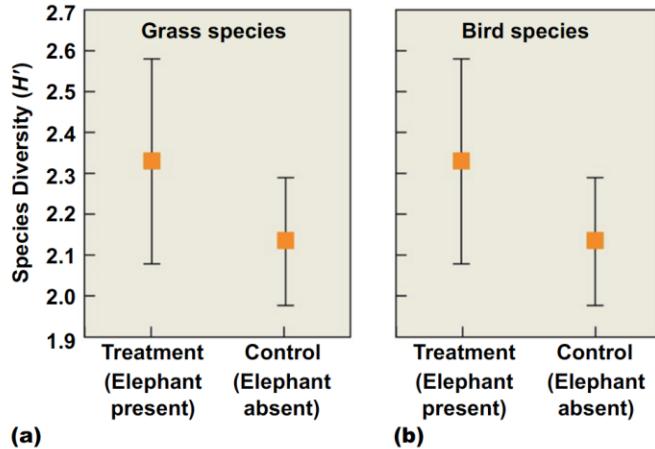**3)** A species with a high distribution range is referred to as_____.

Answer: Ubiquitous

4) _____are the random variation in the environment that can influence birthrates and death rates in a population.

Answer: Environmental stochasticity

4. How to prepare for the final exam

Essay Questions (maximum 200 words) **(10 points each / 3 questions in total)**

(a) Grass species — Treatment (Elephant present) / Control (Elephant absent)

(b) Bird species — Treatment (Elephant present) / Control (Elephant absent)

1) **Question:** (1) Describe what is depicted in the two figures above. (2) Explain the type of species Elephants represent in African savanna communities, and how (i.e., through which mechanism) they impact the diversity of grass and bird species. (3) Provide an example of another species with a similar role as elephants for aquatic communities.

Answer:
(1) The figure shows the impact of elephant removal in African savannas on grass and bird species diversity. The species diversity is indicated using the Shannon index (H'). The data shows that removing elephants from savanna communities reduces the grass and bird species diversity, thereby highlighting the fundamental role of elephants (**3 points**).
(2) Elephants are keystone species in the savanna (**1 point**). They impact the diversity of other species in the community because they eat woody vegetation, thereby reducing the density of trees and shrubs. Lower woody species density increases the grass diversity and biomass, in turn increasing the diversity of small vertebrates and large herbivores (**3 points**).
(3) Other species that are keystone in aquatic communities include beavers, sea stars, and sea otters (**3 points**).

Interpreting a graph

1. Always start by describing the figure

2. Make sure to answer each question

3. Stay short (200 words)

4. Exercise yourselves with the blank exam copies from previous years

Questions and feedback

Format of the class?
Format of the practicals?
Contents to explore further/less?
Other feedback?