Growing ideas through networks

CONVERGES
European Riparian Ecosystems

Riparian trees responses to multiple stressors under global changes: how to scale up from individuals to ecosystem impacts

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cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

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Madrid 29-30 January 2020- COST CONVERGES WG1 Meeting

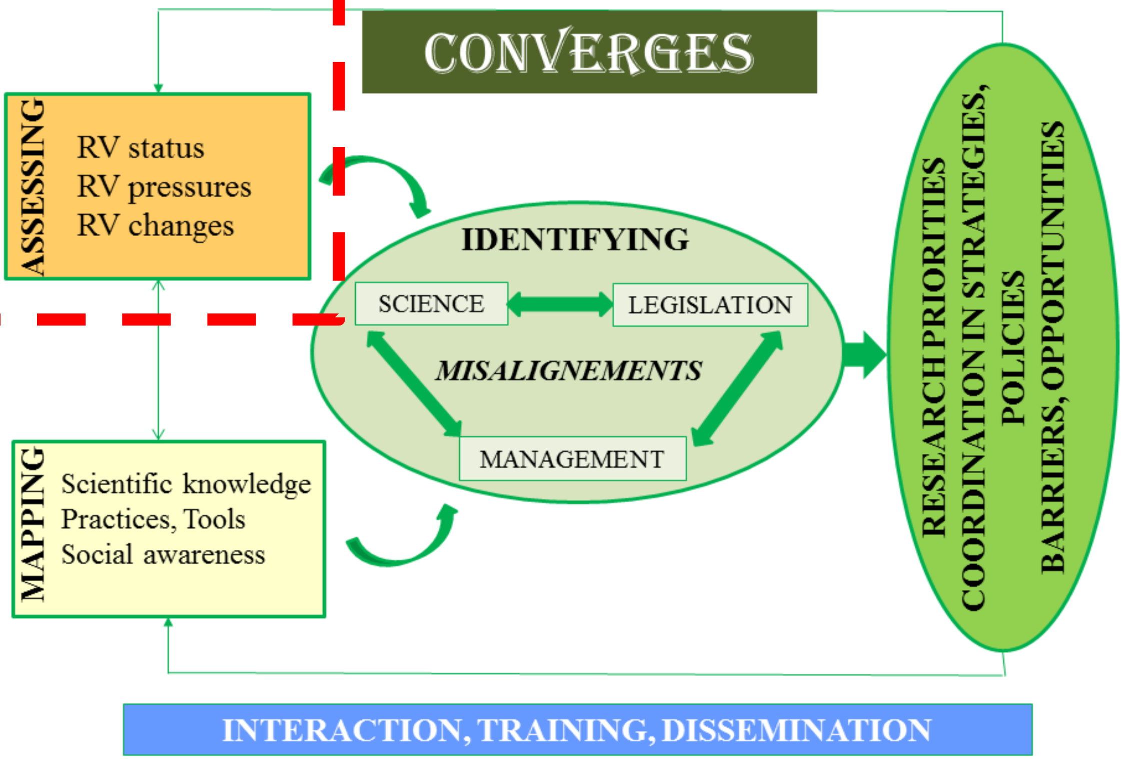
OUTLINE

1. Multiple stressors in Riparian vegetation
2. Trees responses… indicators of change?
3. Case studies
4. Scaling up and application to CONVERGES

Goals – COST Action CONVERGES

WG1: Characterising degradation of riparian vegetation

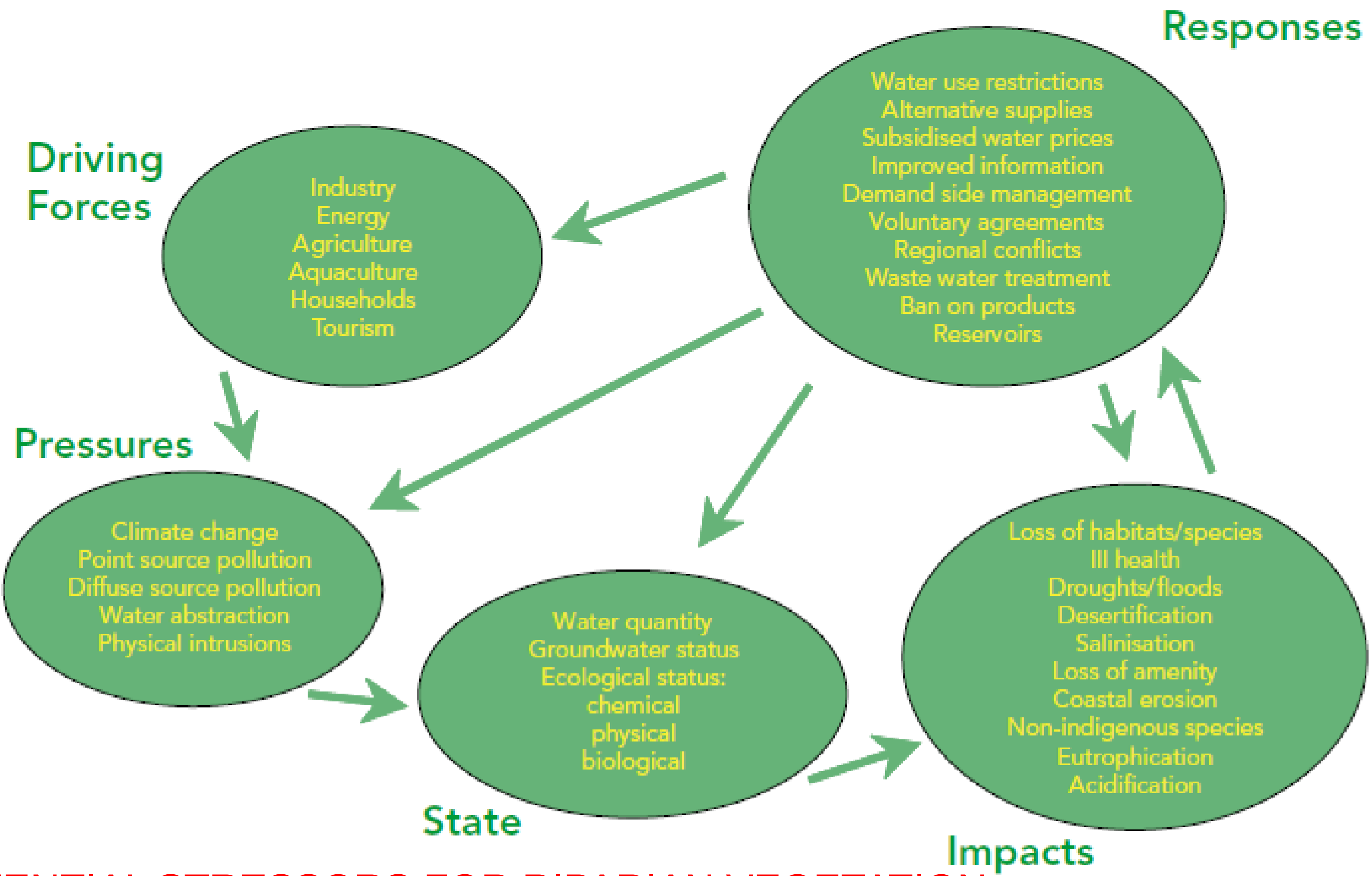
WG2: Visualisation of European responses



WG 3: Establishing misalignments

WG 4: Dissemination and outreach of results and outcomes

DPSIR FRAMEWORK



POTENTIAL **STRESSORS** FOR RIPARIAN VEGETATION

https://www.eea.europa.eu/publications/topic_report_2003_1

Definitions

- **Natural disturbance** discrete events that disrupt biological communities and typically result in a pulse of mortality, reduced biomass and altered physical conditions; i.e. floods (Picket 1987). Natural part of the fluvial environment
- **Stressor** refers to any external abiotic or biotic factor that moves a biological system out of its normal operating range
  - Less discrete events, inducing conditions that restrict biomass production; i.e. shortages of light, water, or mineral nutrients and suboptimal temperatures (Grime 1977). Anthropogenic or natural origin.
    - stressors can be defined according to their specific effects on the **biological receptors** (Segner et al., 2014), which can be defined at the organism, population, community, or ecosystem levels

Grime, 1977. Am. Nat. 111, 1169; Pickett, et al., 1987. Bot. Rev. 53, 335;
Segner, et al, 2014. Assessing the Impact of Multiple Stressors on Aquatic Biota: The Receptor's Side Matters, Environ. Sci. Technol. 48, 7690.
Stella & Bendix(2019). Chapter 5 - Multiple Stressors in Riparian Ecosystems. In S. Sabater, A. Elosegi & R. Ludwig (Eds.), *Multiple Stressors in River Ecosystems (pp. 81-110): Elsevier.*

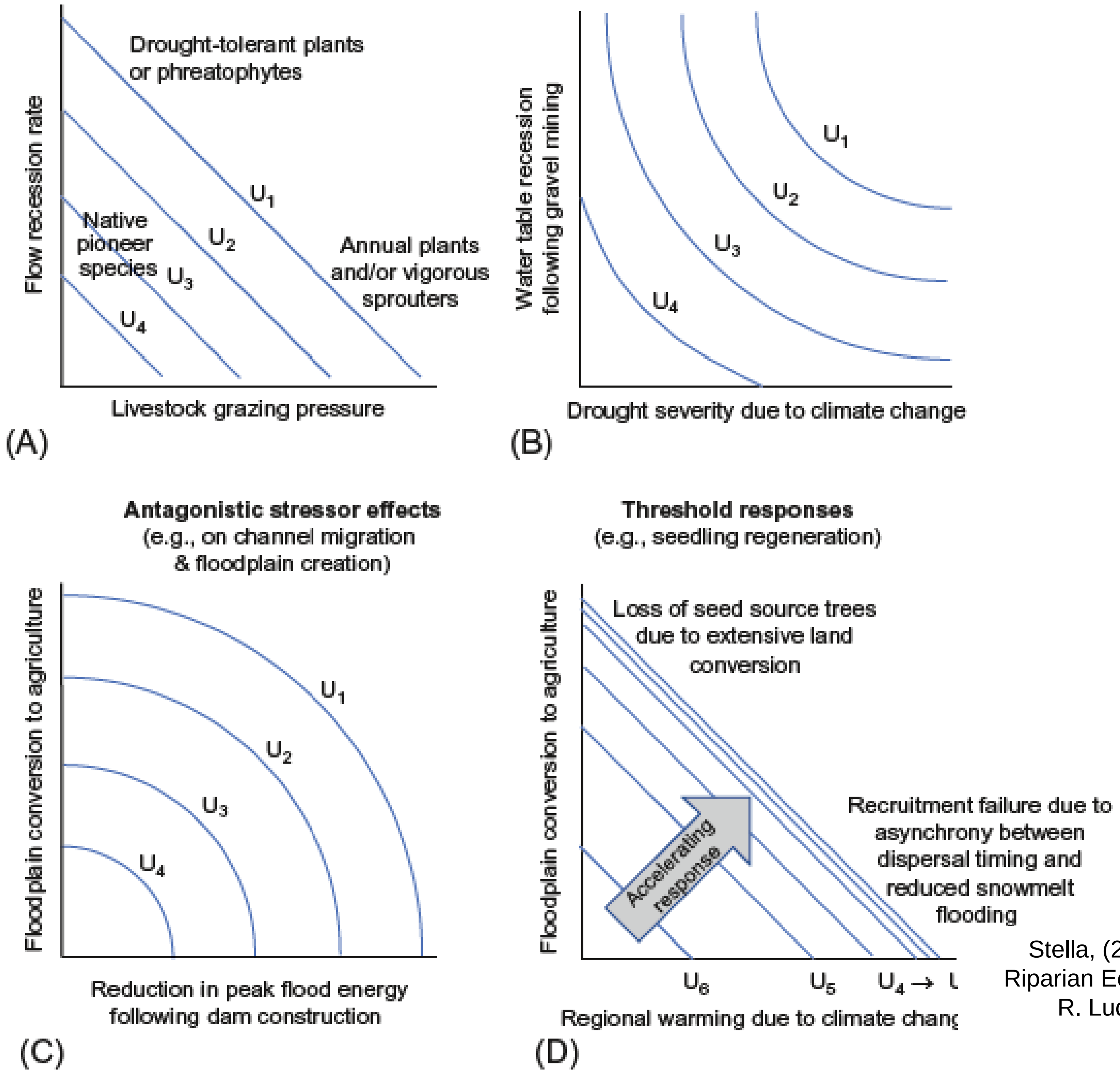
Multiple stressors

Refers to the multiple sources of ecosystem deterioration, which affect ecological and chemical status, water quantity and ecosystem functions and services.

Multiple stressors occur in concert and may interact additive with no direct relationships, synergistically (i.e. self-energising), antagonistically (i.e. attenuate each other) or non-linear (threshold effect)
For example, intensive land use activities may include water pollution and abstraction, with stronger pollution effects (i.e. less dilution) under reduced discharge.

http://www.freshwaterplatform.eu/index.php/glossary.html#stressor

Multiple stressors in riparian systems

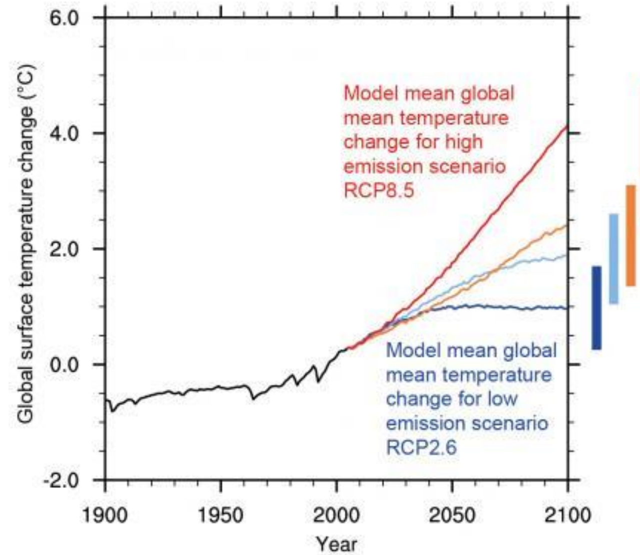


Stella, (2019). Chapter 5 - Multiple Stressors in Riparian Ecosystems. In S. Sabater, A. Elosegi & R. Ludwig (Eds.), *Multiple Stressors in River Ecosystems (pp. 81-110): Elsevier.*

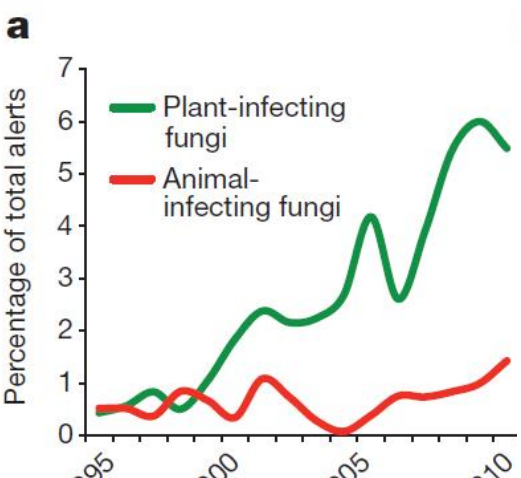
Multiple stressors in riparian systems (abiotic/biotic)

Land use intensification

Climatic and hydrologic alterations



Emerging pests and diseases



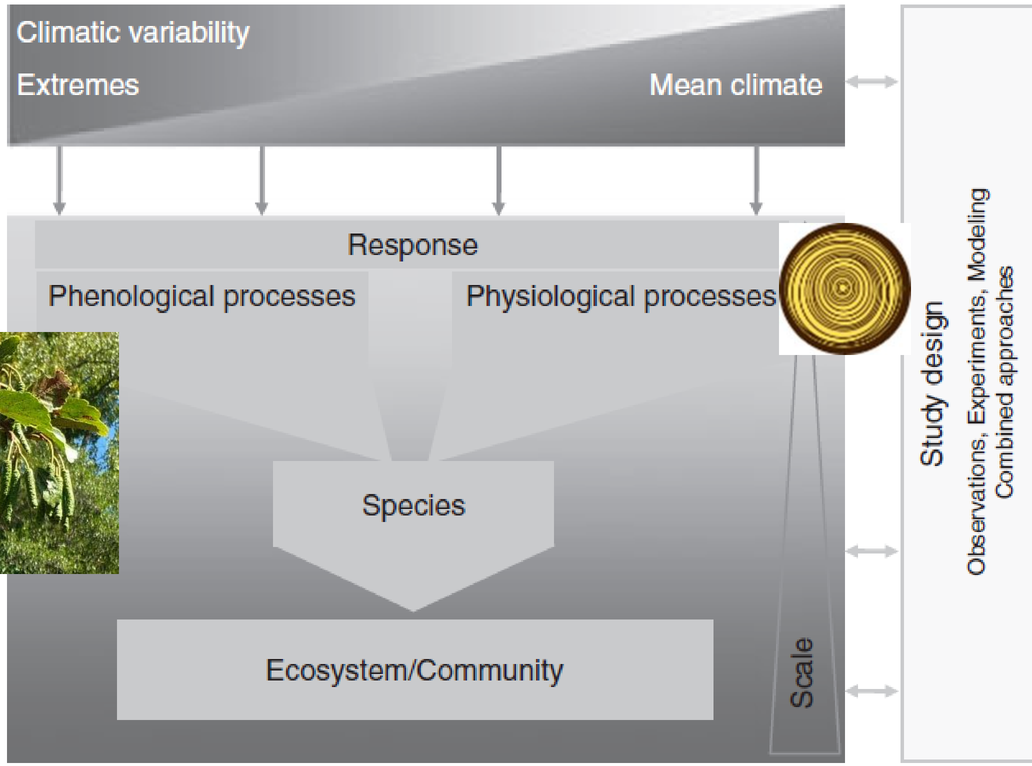
Biological invasions

New environmental condition

Vegetation responses?

https://www.ipcc.ch/report/ar5/wg1/

GLOBAL STRESSORS AND RESPONSE OF TREES



Although changes in the mean values are important, there is evidence that plant distribution (Chapin et al., 1993; Bokhorst et al., 2007), survival (Van Peer et al., 2004) or net primary productivity and species diversity (Knapp et al., 2002) respond to extreme rather than to average conditions

Consequences at community and ecosytem level

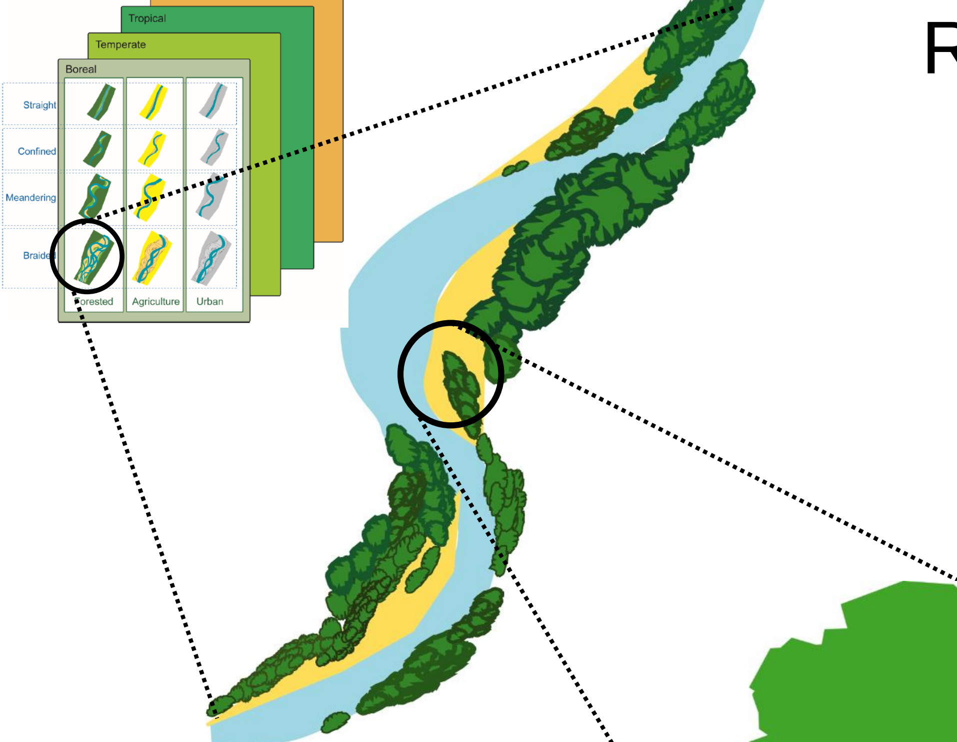
Reyer, et al. (2013) A plant's perspective of extremes: terrestrial plant responses to changing climatic variability. Global Change Biology, 19, 75-89.

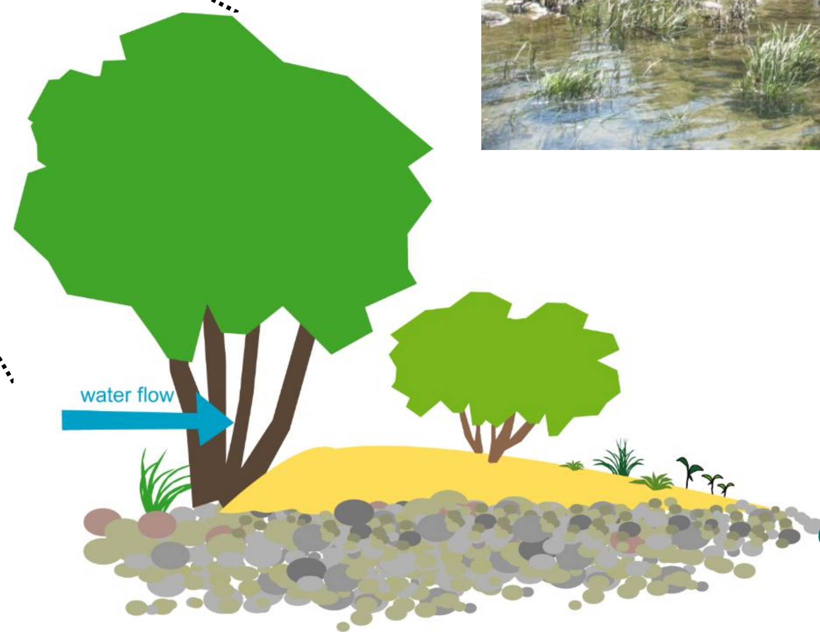
EXAMPLES OF BIOTIC AND ABIOTIC STRESSORS ON RIPARIAN TREE SPECIES

species	stressor	Type of threat	Population-receptor responses	Citations
Populus nigra	Hydromorphological alteration, drought	A	Growth reduction, mortality	*Stella et al. (2013). Geomorphology, 202(0), 101*
	Plantations of closely related taxa	B	Genetic erosion	*Lefèvre et al 1998. Gen Sci Evol 30; Villar 2011, PhD.*
Alnus glutinosa	Hydrologic alteration	A	Growth reduction	*Rodríguez-González, et al. (2014). Plant Ecology, 215(2), 233-245*
	Disease: *Phythophthora* induced decline	B	Mortality	*Bjelke, et al. (2016). Freshwater Biology, 61(5), 565*
Fraxinus spp	Increased drought severity and recurrence	A	Reduction of resilience	*Gomes Marques, et al. (2018). Dendrochronologia, 52, 167*
	Disease: *Hymenoscyphus fraxineus* induced decline	B	Mortality	*Enderle et al (2017). iForest - Biogeosciences and Forestry, 10(3), 529*
Salix salviifolia	Population fragmentation, drought	A	Genetic inbreeding	*Rodríguez González et al, 2019. Scientific Reports, 9(1): 6741*
Tsuga canadensis	Pest: *Adelges tsugae*	B	Growth reduction, mortality	*Livingston, et al. (2017). Biological Invasions, 19(5), 1577*
	Herbivory pressure	B	Lack of recruitment	*Preisser, et al. (2011). Canadian Journal of Forest Research, 41(12), 2433-2439.*

A: Abiotic stressor
B: Biotic stressor

Riparian trees are considered Foundation species





***Salicaceae* – Ecosystem Engineers**

Modulate physical condition and facilitate colonization by other species

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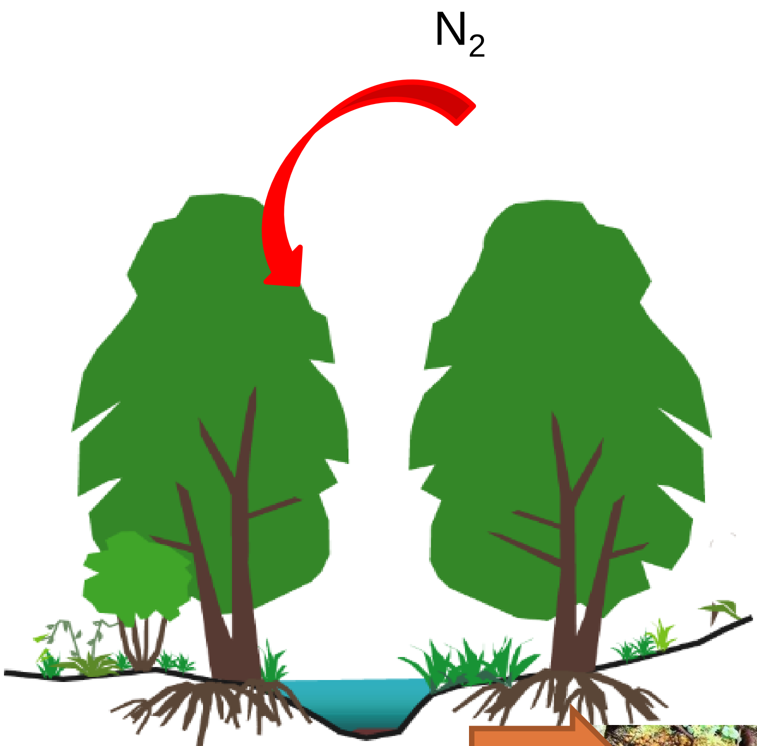
Ellison et al. (2005) Loss of foundation species: consequences for the structure and dynamics of forested ecosystems. *Frontiers in Ecology and the Environment, 3, 479-486.*
Gurnell, A.M. (2014). Plants as river system engineers. Earth Surface Processes and Landforms, 39, 4-25.

Riparian trees are considered Foundation species

Alnus glutinosa – Nitrogen fixation



actinorhizal symbioses

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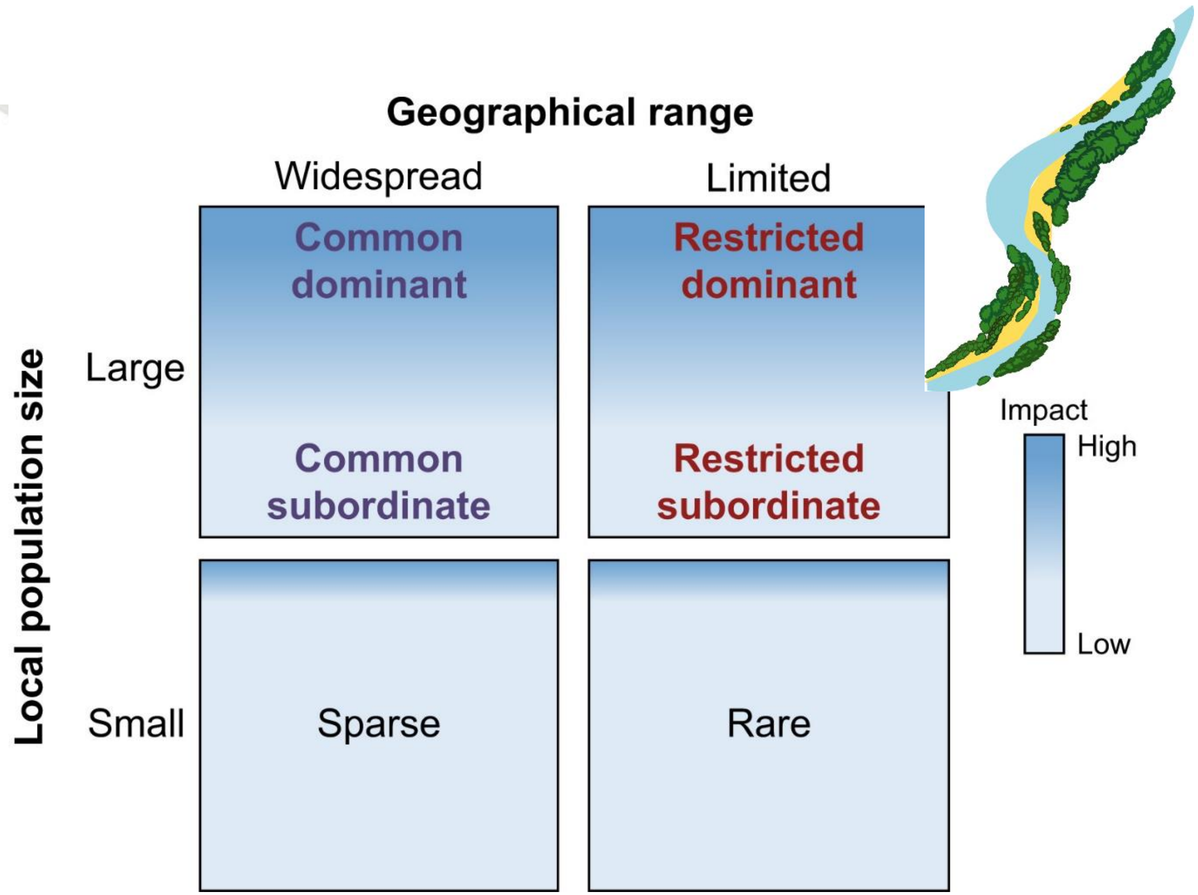
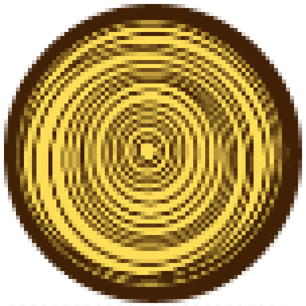
Dominant species

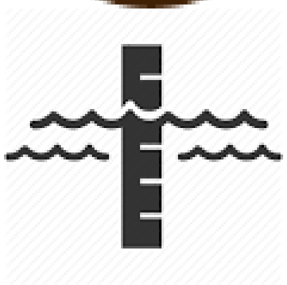


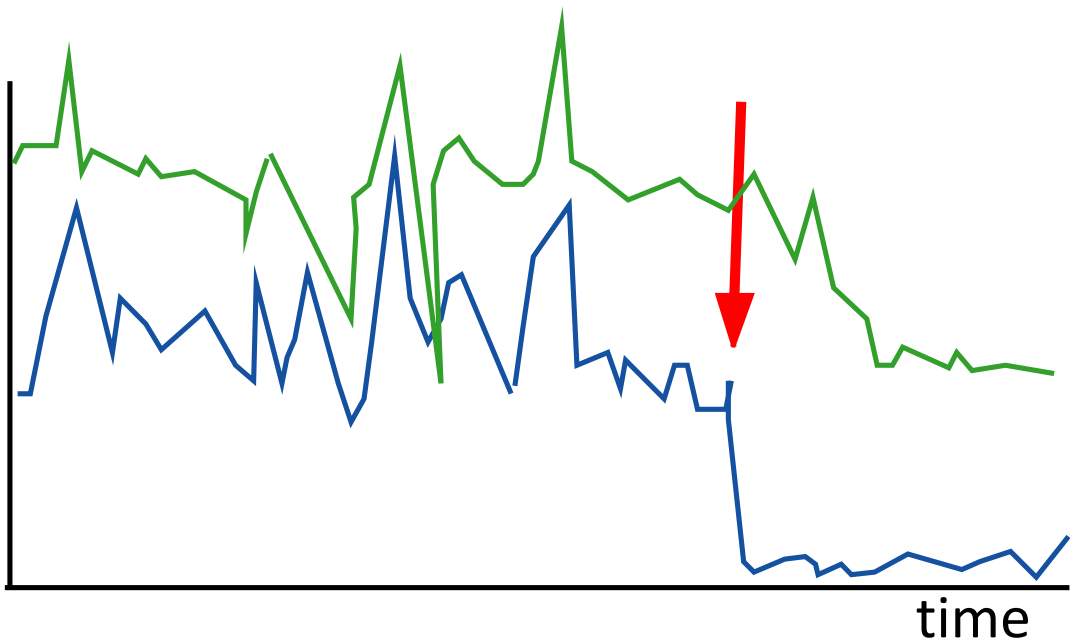
Species that have high abundance relative to other species in a community, and have proportionate effects on environmental conditions, community diversity and/or ecosystem function.
Dominant species can be common (widespread) or restricted in their range (limited)

Avolio, et al. (2019). Demystifying dominant species. *New Phytologist, 223(3), 1106-1126.*

Long lived – libraries of past change

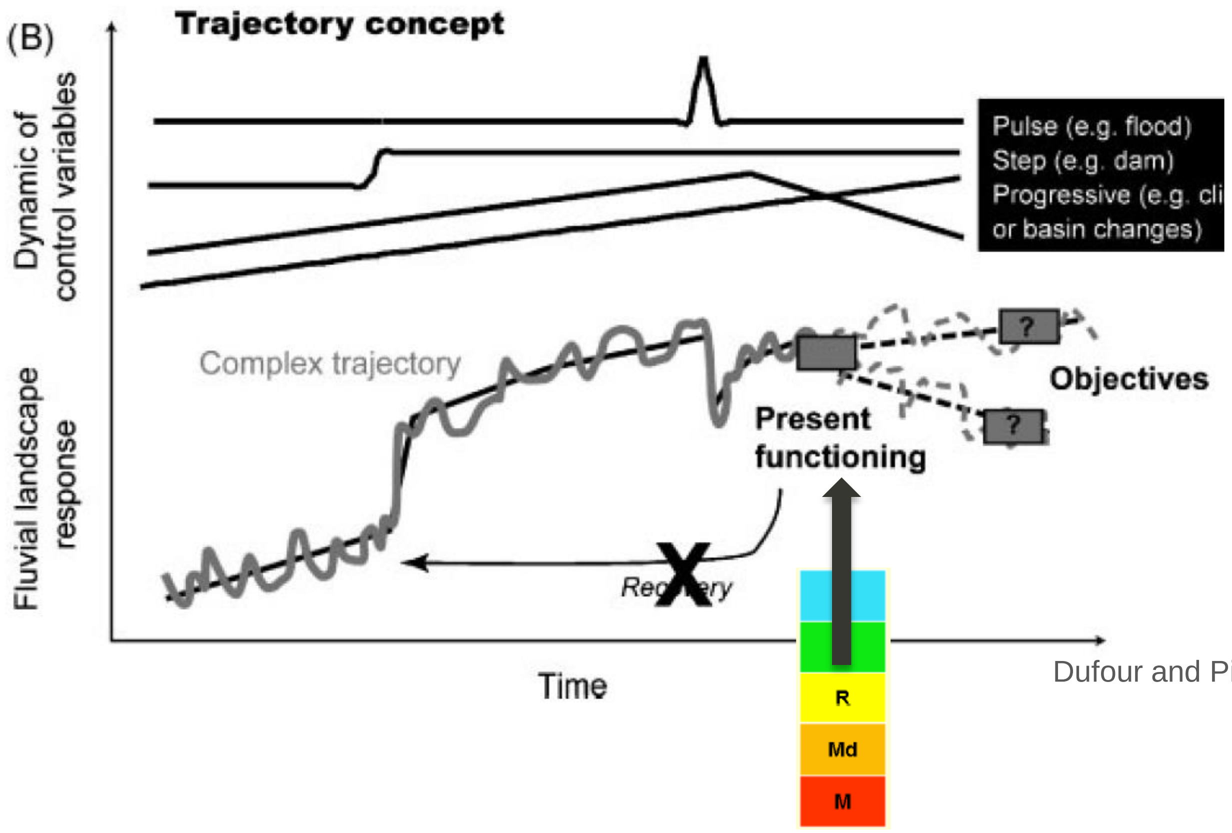






Trees are sessile and long-lived, their responses to changes (e.g. climate extremes) are substantially dependent on historical factors.

TRAJECTORY CONCEPT IN DETERMINING STATUS

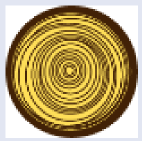


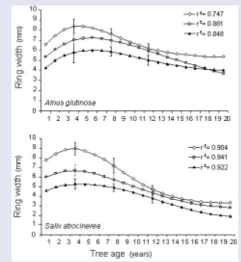
Dufour and Piégay, 2009

Trees can help understand past trajectory to predict and adapt to future alteration

3. Case studies using trees responses:

Dendroecology in major riparian trees (Ibero atlantic)





<u>Target species:</u>

Alnus glutinosa *Fraxinus angustifolia* *Salix salviifolia* *Salix atrocinerea*

Rodríguez-González et al 2014, Plant Ecology, 215:233
Rodríguez-González et al 2010, Forest Ecology and Management, 259: 2015
Marques et al 201, Dendrochronologia 52, 167

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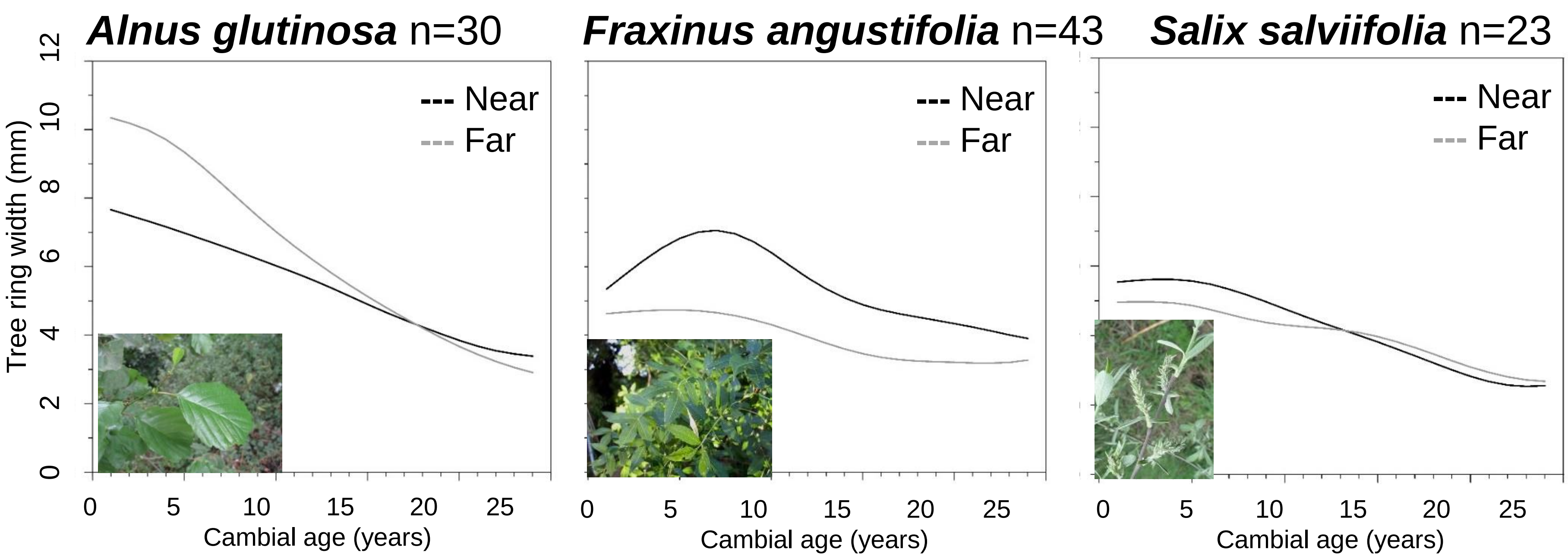
Cambial age growth curves according to position relative to active channel



Growth trends during the first years of life according to position to active channel:

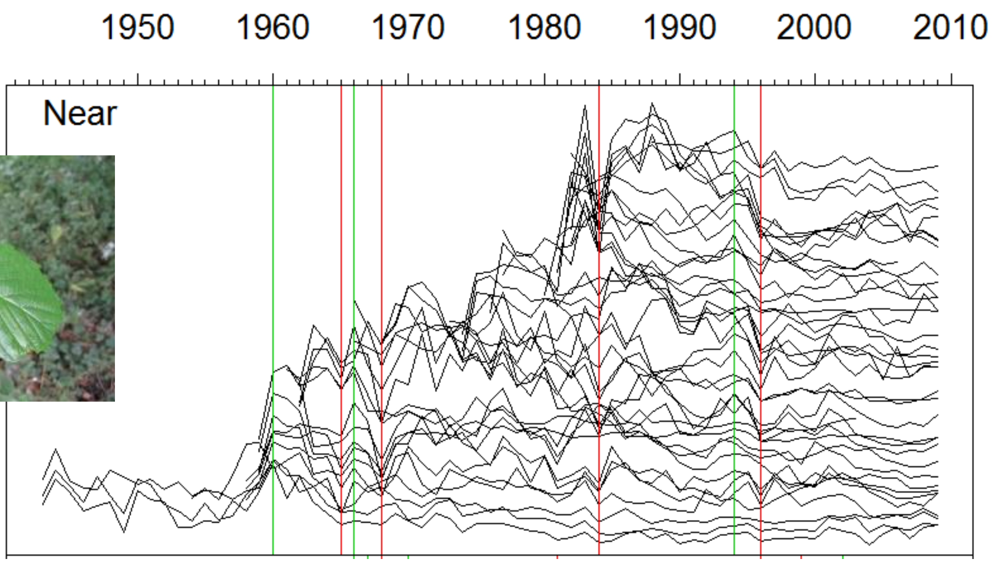
-***Alnus glutinosa*** tree-ring width tended to be narrower near to the active channel, whereas trees at far and less disturbed sites grew faster and, therefore, showed wider rings.

-***Fraxinus angustifolia*** tree-ring width was wider near to the active channel.

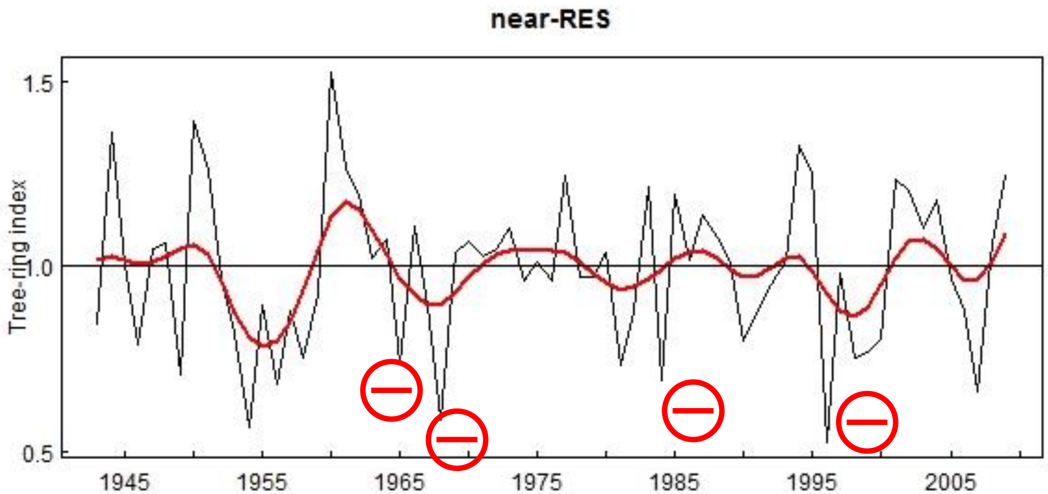
-***Salix salviifolia*** displayed no difference according to geomorphic position.

Rodriguez Gonzalez et al, 2014, Plant Ecology 215: 233

Growth responses of *Alnus glutinosa* to **hydrologic extreme events**



Ribeira de Odelouca

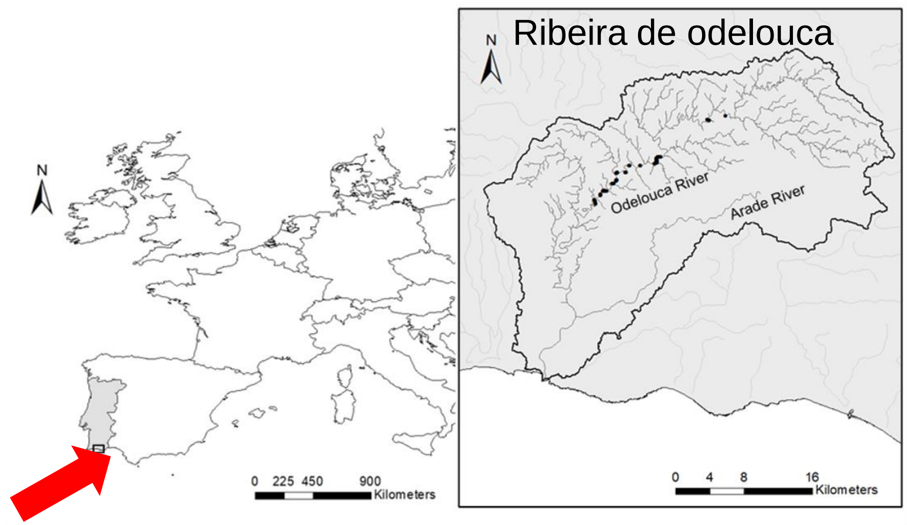


Negative pointer years (significant growth reduction) after high floods

Rodríguez-González et al 2014, Plant Ecology, 215:233
Rodríguez-González et al 2010, Forest Ecology and Management, 259: 2015

3. Case studies using trees responses: resilience and resistance

Resilience and resistance of riparian trees to temperature increase and cumulative drought events



Fraxinus angustifolia (75)

Alnus glutinosa (75)

39 *Fraxinus*

Tree ring analysis

(Lintab, 0.01mm precision)

30 *Alnus*

Growth chronology

Basal area increment

$$Resistance = \frac{Drought}{PreDrought}$$

$$Resilience = \frac{PosDrought}{PreDrought}$$

Resistance and Resilience of BAI (R package pointRes

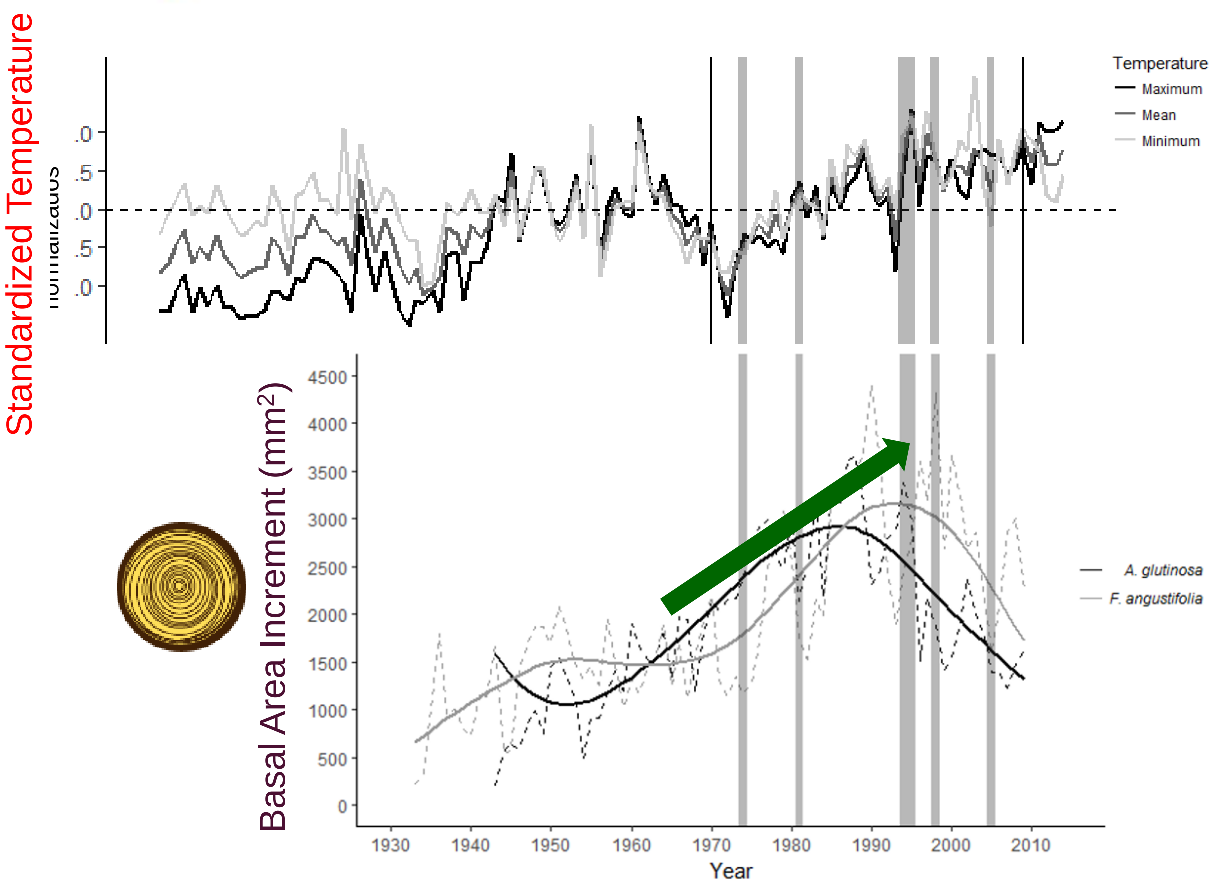
Climatic (CRU TS3.10-100y) and hydrologic variables

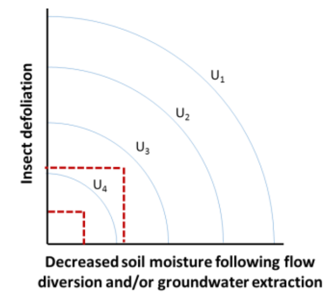
- Monntlhy precipitation Precipitação mensal
- Minimum temperature
- (SPEI) Standardised Precipitation-Evapotranspiration Index– 7 month
- Flow (Estação Monte dos Pachecos – 1960-2000)

Marques, F. Campelo, R. Rivaes, A. Albuquerque, M. T. Ferreira, P. M. Rodríguez González, 2018. Tree rings reveal long-term changes in growth resilience in Southern European riparian forests. Dendrochronologia 52, 167-176
Vicente-Serrano, 2010. A multiscalar drought index sensitive to global warming: the standardized precipitation evapotranspiration index. J. Clim. 23, 1696–1718
Lloret et al 2011, Components of tree resilience, European Atlas of Forest Tree Species, https://doi.org/10.1111/j.1600-0706.2011.19372.x.

Antagonistic effects on BAI

Stressors: increase higher temperature / CO_2





But, after 1990's net effect becomes negative, warming likely overhelming any benefits from CO_2 fertilization (Perry et al 2012, GCB)

Basal Area Increment (BAI) chronologies (dashed line) for both species, F. angustifolia in grey and A. glutinosa in black. Continuous lines are 32 yearsspline calculated from BAI values. Grey areas identify drought events.

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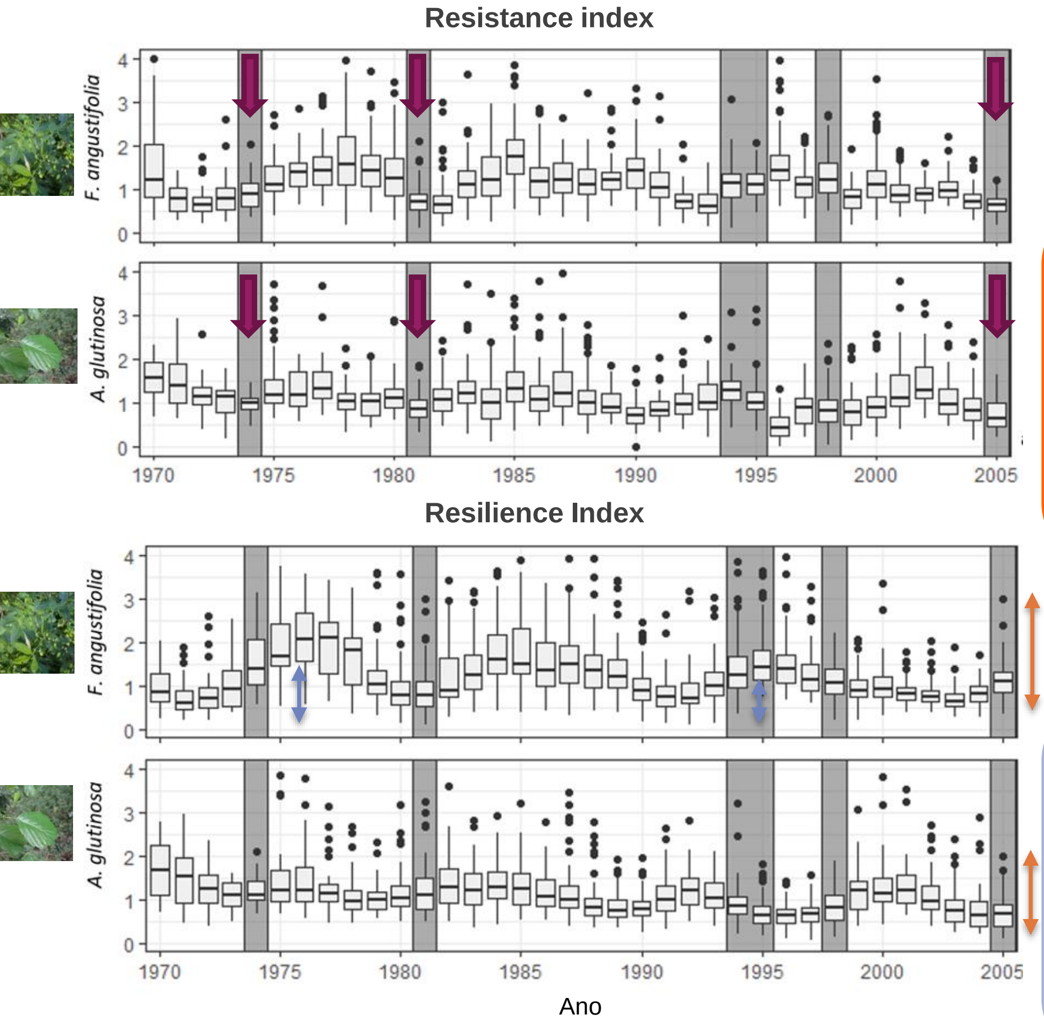
Marques et al 2018, Dendrochronologia 52: 167

Perry et al. (2012). Vulnerability of riparian ecosystems to elevated CO_2 and climate change in arid and semiarid western North America. Global Change Biology, 18(3), 821-842.

Resilience and resistance of riparian trees (cumulative drought events)



Severe drought events (1974, 1981, 2005) show common response across species (reduction in resistance)

Alnus: Local contribution of environmental conditions (temperature and soil moisture)

able to keep relatively stable growth during and after drought events (resistance and resilience)

Fraxinus: Located generally more distant from active channel, shallow root system

The amplitude between minimum and maximum values of resilience has decreased for *Fraxinus*

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Marques et al 2018, Dendrochronologia 52: 167

Resilience and resistance of riparian trees

RESILIENCE

Local environmental conditions

Regional climatic stressors

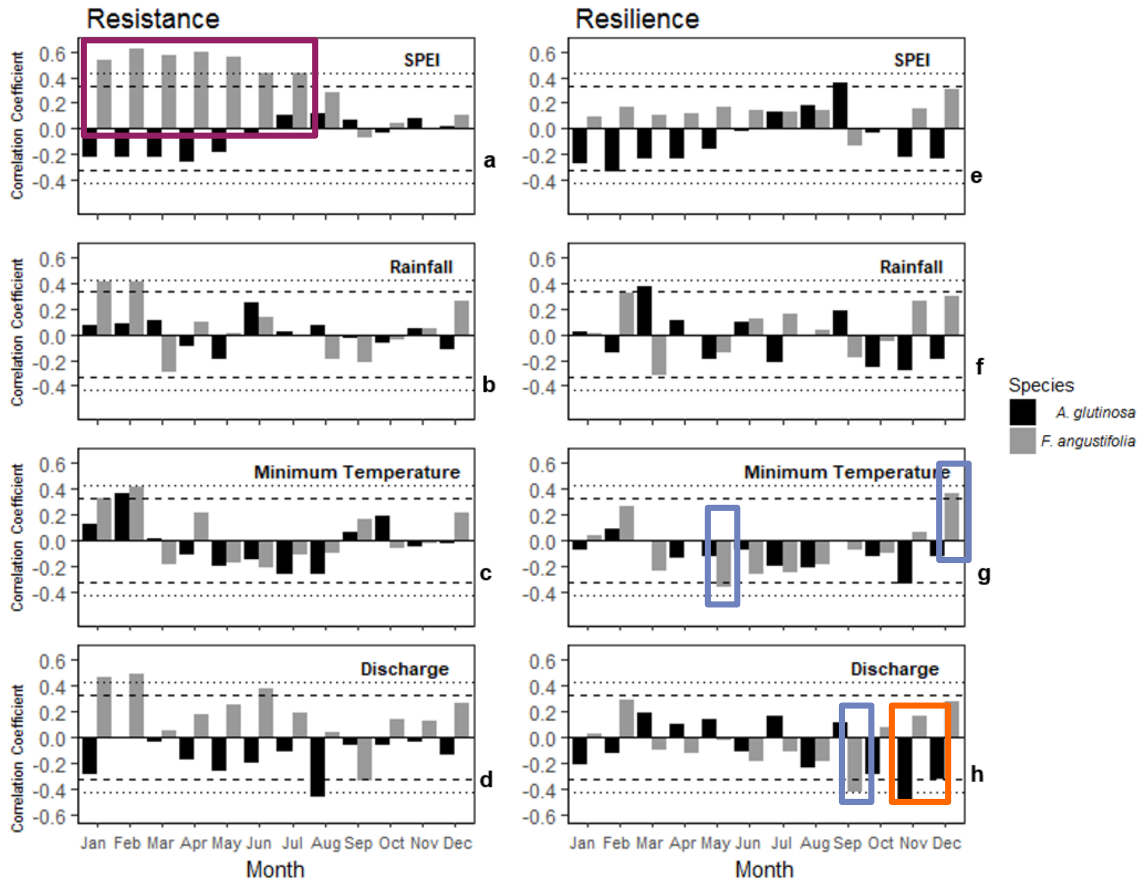
Alnus glutinosa

Fraxinus angustifolia

RESISTANCE

Environmental conditions in previous years are crucial in the ability of trees to overcome growth disturbances

<u>“Ecological Memory”</u>



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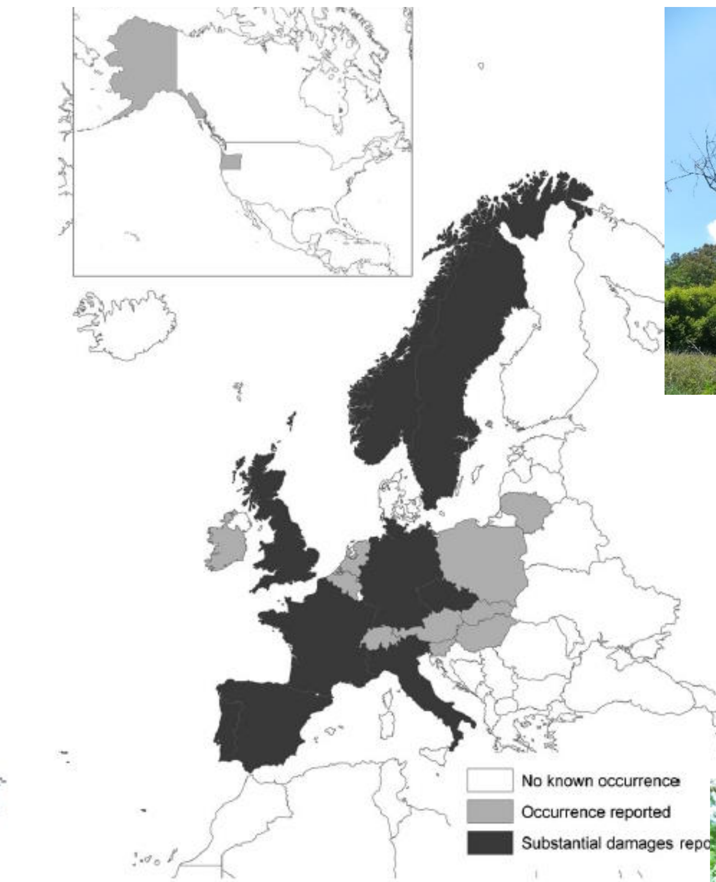
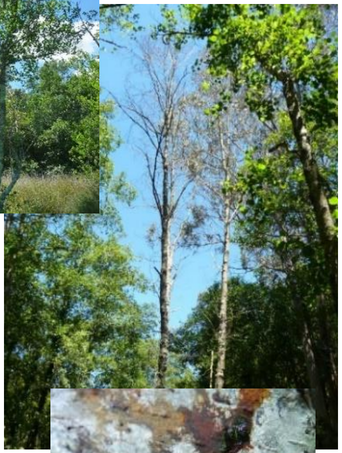
Marques et al 2018, Dendrochronologia 52: 167

3. Case studies using trees responses: Riparian forest decline

Decline of *Alnus glutinosa* caused by the *Phytophthora alni* complex



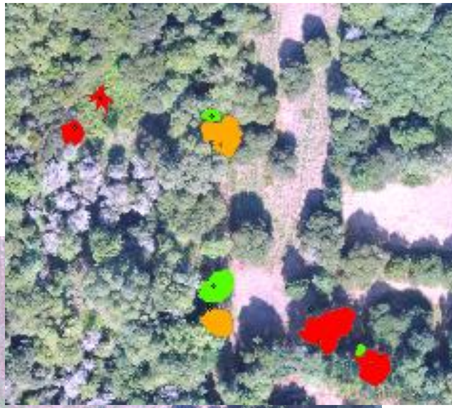


Bjelke, et al. (2016). Dieback of riparian alder caused by the Phytophthora alni complex: projected consequences for stream ecosystems. *Freshwater Biology, 61(5), 565-579.*

Solla, A., Pérez-Sierra, A., Corcobado, T., Haque, M.M., Diez, J.J., & Jung, T. (2010). Phytophthora alni on Alnus glutinosa reported for the first time in Spain. Plant Pathology, 59(7), 798.

LIFE FLUVIAL – Habitat 91E0*
Health status of *Alnus glutinosa* forests in Natura2000

- Georreferencing individuals
- Symptom survey
- UAV: multispectral + RGB



Health status of *Alnus glutinosa* forests: field protocol

ALNUS Project – FCT(PTDC/ASP-SIL/28593/2017)

The disease

Black alders in Europe are threatened by anthropic pressures, hydroclimatic cha emerging diseases. In the 90s, the oomycete complex *Phytophthora alni* was ob alders from the UK. Since then, *P. alni* disease (commonly known as alder decay from Northern Europe to Central and Southern Europe, currently being its leadi central Portugal.

The most common symptoms of alder decay are:

- Formation of small and yellow leaves
- Dieback of branches
- Canker and dark-stained necrosis in bark
- Early and increased fructification.

Alder decay mo

Small yellowish leaves

Dieback of branches

Dark-stained necros

Why are we doing this survey?

Our objective is to optimize management practices by using data from Portugal

- Obtain information on the current extension and status of alder decline
- Investigate which environmental variables are related to alder susceptil pathogen expansion.
- Model that predicts alder vulnerability across hydrographic networks

Essential equipment

In order to collect data, you will need at least:

20 %

10 %

5 %

bottom of the tree

3.8. Tree height (for trees with an inclination < 45° to the vertical axis, in meters) (H)

In case the tree is too tall to use with a measuring tape, you can follow this instruc the help of another person, using the marks in this page as a reference (*see figure page*):

a. One person would stand next to the tree
b. The other one would walk away from the tree, holding the card at arm's le top of the tree should line up with the mark in the paper called "top" and of the tree should line up with the "bottom" mark.
c. The person with the card should guide the person next to the tree to poin the 10 % mark shown in this paper.
d. Then, use the measuring tape to measure the height between this point a ground. This would be the 10% of the height of the tree. Multiply this num calculate the height of the tree.

If the tree is very tall you can use the 5% mark (in this case multiply the height by 2 the actual tree height) and if the tree is small you can use the 20 % mark (in this ca the height by 5 to obtain the tree height).

3.9. Tree length (for trees with an inclination > 45° to the vertical axis, in meters) (

3.10. Inclination of the tree to the vertical axis (degrees) (INC)

3.11. Diameter (Φ, in cm)

To standardize all data, diameter should be measured at breast height (at 1.30 m)

If the tree has several stands, select the bigger living stand to do it.

4. Disease symptoms

4.1. Canker or collar rot

Presence of tarry spots, reddish-brownish stains, bleeding cankers.

4.2. Injuries or damages in tree

Any physical damage in the tree that can facilitate the entrance of *Phytophthora*.

4.3. Class decay

See picture in the right side of the page.

4.4. Class yellowish trees

G – green leaves

Y – yellowish leaves

4.5. Stem incidence (SI)

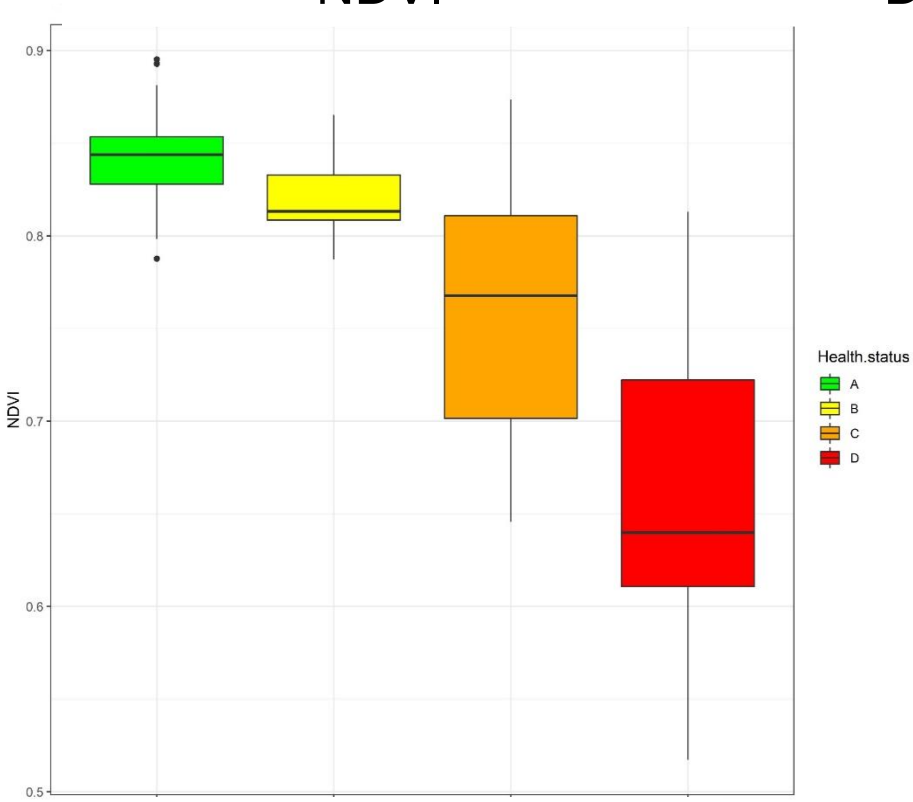
Number of affected stems from the total of stems.

4.6. Dead branches

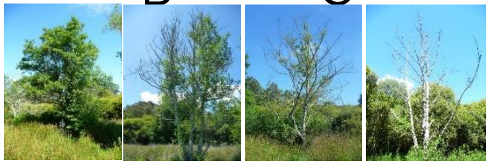
Number of dead branches

Health status of *Alnus glutinosa* forests: preliminary results UAV

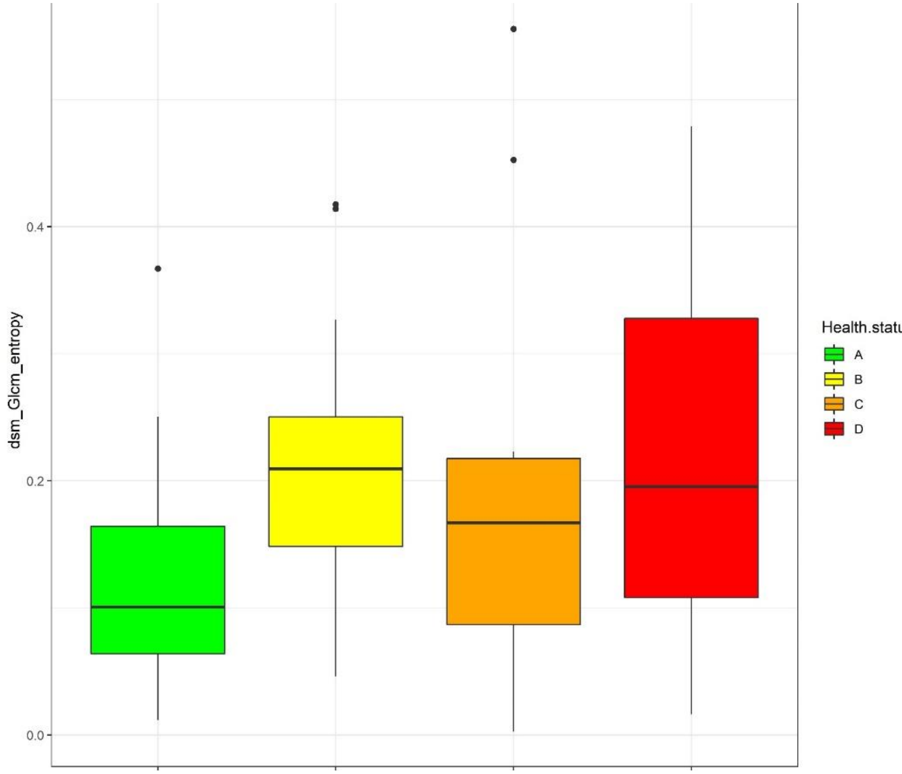

NDVI



A B C D



DIGITAL SURFACE MODEL ENTROPY



A B C D

HEALTH CONDITION

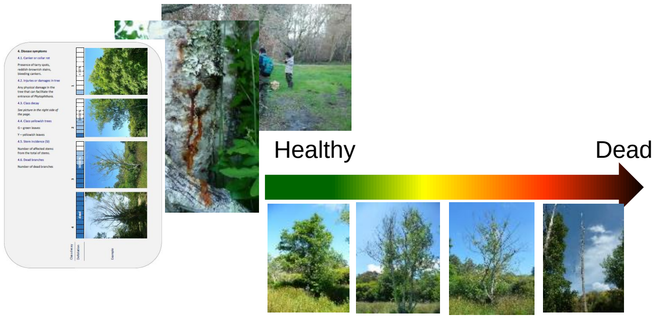
A=ASYMPTOMATIC; B=10-50% DEFOLIATION; C=>50% DEFOLIATION; D=DEAD

Guerra et al, in preparation

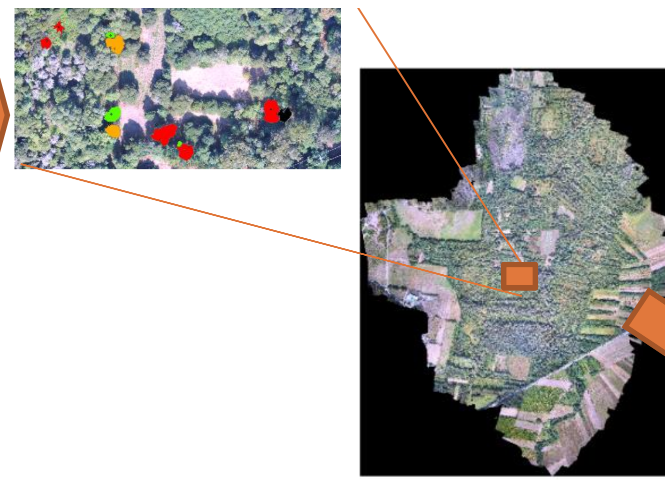
Prospects

Alnus glutinosa forests – integration of biotic and abiotic stressors for improvement of Habitat 91E0 conservation and management*

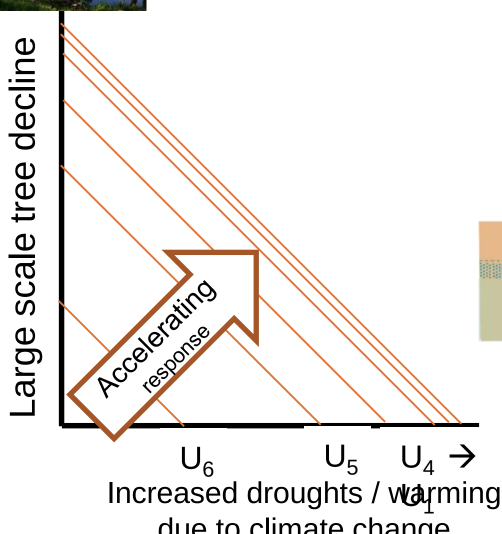
Field survey + UAV data

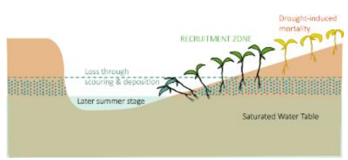


Mapping protected area



lack of seed source trees, extensive *Phythophthora* induced decline





Recruitment failure due increased soil moisture stress, low flows

Development of best practices for conservation of habitat 91E0*

PROYECTO TÉCNICO PARA LA MEJORA Y RESTAURACIÓN DE HÁBITATS NATURALES EN EL CORREDOR FLUVIOESTUARINO DE LA RÍA DE RIBADEO-RÍA DEL EO (ZEC RÍO EO-GALICIA ES1120002, ZEPA RIBADEO ES0000085, ZEC/ZEPA RÍA DEL EO ES1200016).

Incorporating other indicators

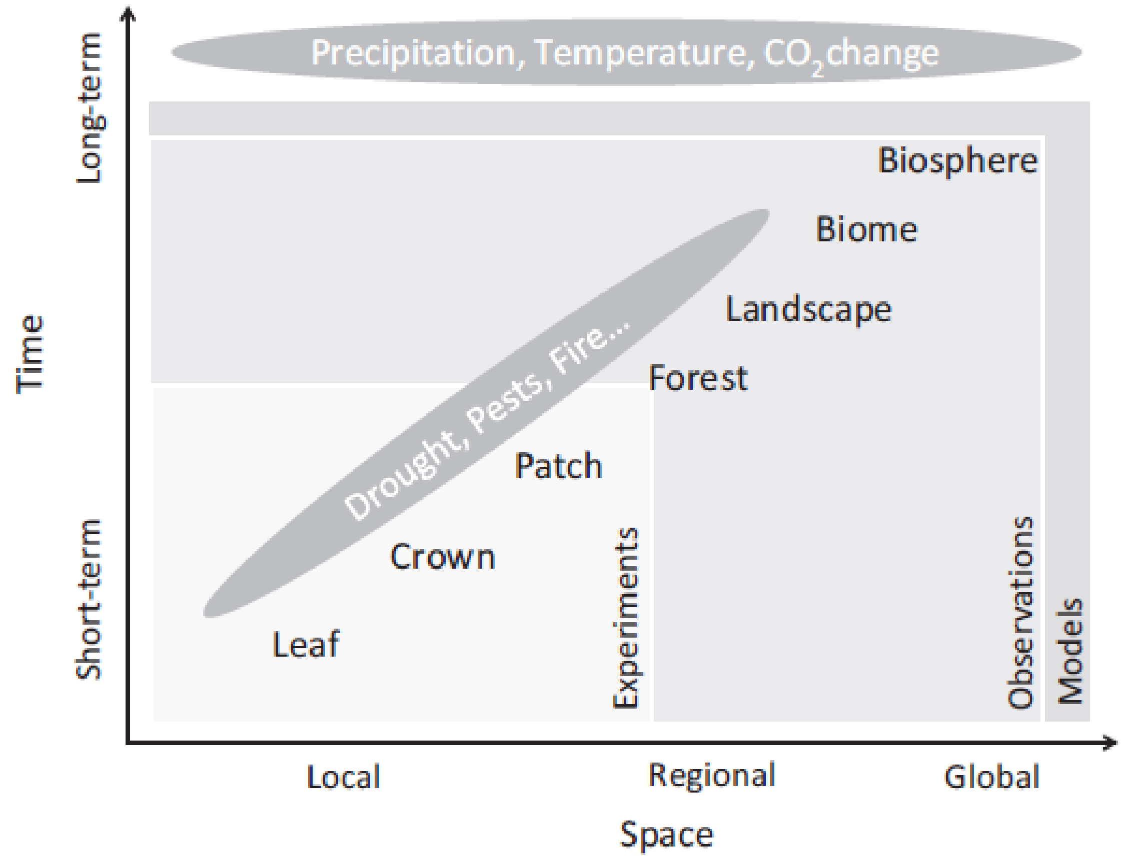
Alnus Recruitment

Floristic composition

4.SCALING UP ?

4.SCALING UP

TERRESTRIAL EXAMPLE



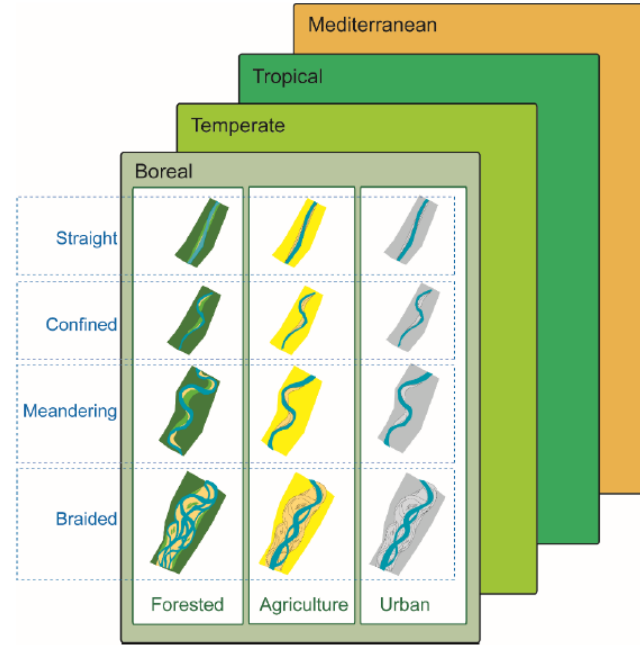
We refer to the process of taking information at a scale, spatial or temporal, and using it at a larger one.

Reyer, (2013). A plant's perspective of extremes: terrestrial plant responses to changing climatic variability. *Global Change Biology, 19(1), 75-89. doi: doi:10.1111/gcb.12023*

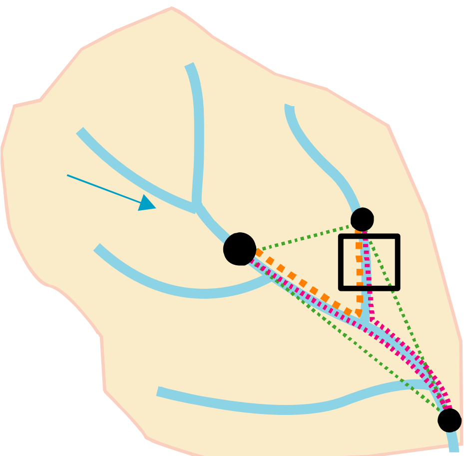
Review of upscaling techniques to produce maps of PTs, EBVs and EFPs from remote sensing data, http://www.trusteenetwork.eu/

4.SCALING UP

RIPARIAN HIERARCHICAL LEVELS

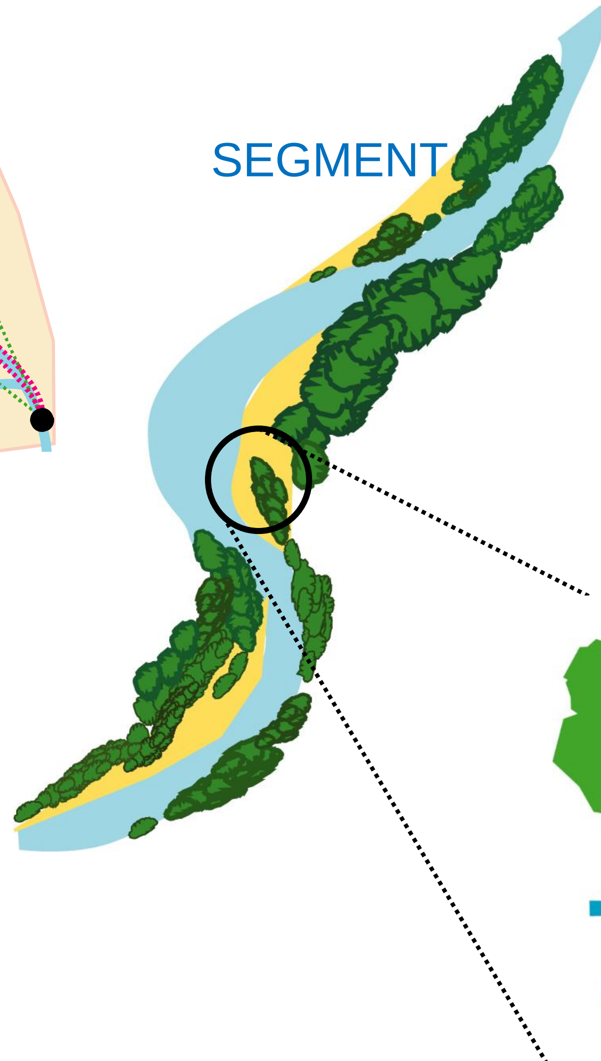


BIOCLIMATIC SETTING



CATCHMENT

SEGMENT



GEOMORPHIC UNIT
VEGETATION PATCH

INDIVIDUAL

POINTS FOR DISCUSSION – application to WG1/WG3

Research needs

-Biological receptors of stress? Incorporate lower levels of diversity (genetic), or higher (ecological networks?)

-Identification of proper indicators of sensitivity, vulnerability, traits, recovery

-Incorporation of multiple stressors – interactions among stressors (additive, synergistic, antagonistic, non linear…)

-Methods to scale up, and to address relevant timescales, incorporating uncertainty

Management challenges

-Relevance for management?
-Are we able to transfer with feasible approaches?
-Selection of common effect metrics
-What research is needed?

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Marques, IG; Vieites Blanco, C; Albuquerque, A., Rivaes, R., Ferreira, T., Pereira, J.S. (ISA, Ulisboa, Portugal)
Dufour, S, (Univ Rennes, France)
Stella, J (SUNY, USA)
Campelo, F (Univ Coimbra, Portugal).
Alex Solla (Unex, Spain)
David TS, Moreira AC (INIAV, Portugal)

FCT- Project ALNUS (PTDC/ASP-SIL/28593/2017) “Screening *Alnus glutinosa* resistance to an emerging disease under climatic stressors: predicting alder forests resilience across river networks”

LIFE FLUVIAL (LIFE16 NAT/ES/000771) “Improvement and sustainable management of river corridors of the Iberian Atlantic Region”

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Thank you for your attention!

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