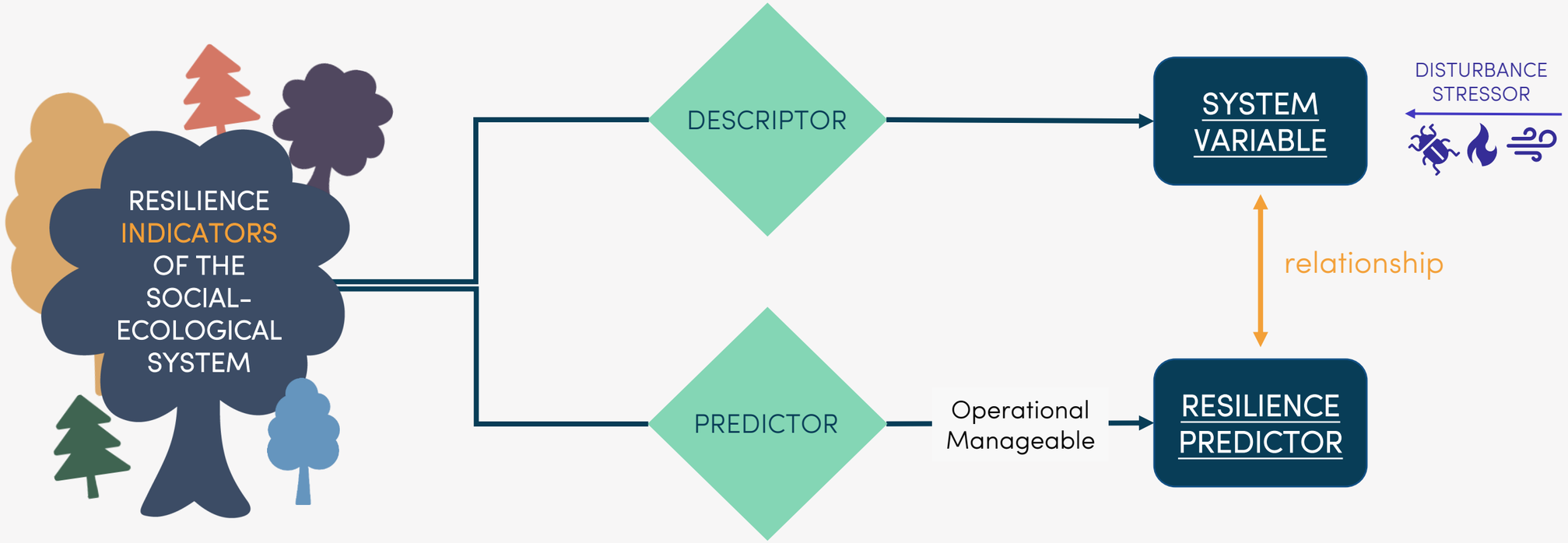
This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101000574.

REFERENCE GUIDE OF RESILIENCE INDICATORS

Authors: Luciana Jaime, Pilar Hurtado, Josep María Espelta, Francisco Lloret.

START

What are resilience indicators?



more information

select indicators

What are resilience indicators?

SYSTEM VARIABLES – Resilience OF what?

- Quantitative parameters **describing characteristics of the social-ecological system** (e.g., related to forest ecosystem services) that respond to disturbances and/or stressors.

- System variables correspond to the system properties of interest **whose resilience is going to be analysed** and can be explained or **predicted by resilience predictors**.

Example: the resilience of carbon storage under climate can be estimated by the performance of the system variable "forest stand biomass".

back

What are resilience indicators?

RESILIENCE PREDICTORS – Are there parameters which allow to PREDICT resilience, and which can be MODIFIED/MANAGED to enhance resilience?

- Variables reflecting the underlying mechanisms of the system functioning and provide **estimations of prospective resilience.**

- They are OPERATIONAL → they can become a target of management to enhance resilience.

Example: higher values of the resilience predictor "tree functional diversity" may lead to higher values of the resilience of the system variable primary production in the face of drought and other disturbances.

back

More information

Resilience indicators reported are **system variables and resilience predictors** whose **relationship** was assessed based on the literature review of 303 scientific articles between 2000 and 2022.

Deliverable 1.1. Inventory of forest resilience indicators and metrics reported in the literature with an assessment on their applicability to RESONATE case studies

Deliverable 1.2. Resilience indicators and metrics assessment

Criteria to pair system variables and resilience predictors to be shown in this Reference Guide:

- Relationship between system variable and resilience predictor found in more than 10 scientific articles.
- Significant relationship between the system variable and the operational resilience predictor in more than 65 % of cases.
- When more than 4 resilience predictors met the criteria, we show the best of them.

definitions

select indicators

On which category of **system variable** would you like to promote its **resilience** to disturbances or stressors?

Forest functioning

Biodiversity

Forest structure

Landscape

Soil

definitions

Forest functioning

system variable

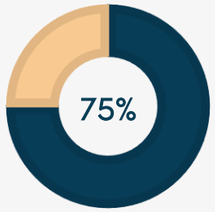
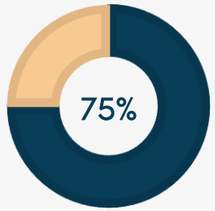
stand primary production

stand biomass

biogeochemical cycles

back to other categories

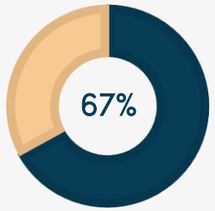
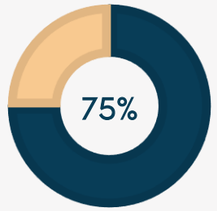
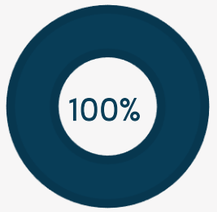
Forest functioning

system variable	resilience predictor	significant relationship*	example	literature
stand primary production	forest type		natural *vs* plantation	Chen and Chen 2021
e.g. net primary productivity; NDVI	vegetation cover		plant species composition	Shinoda et al. 2014
	plant functional diversity		functional diversity	Silva Pedro et al. 2015 Stuart-Haëntjens et al. 2018
	species identity		tree species identity	Danielson et al. 2015 Díaz-Delgado et al. 2002

**percentage of studies in which a given relationship is significant out of the total number of studies in which such relationship is present.*

back

Forest functioning

system variable	resilience predictor	significant relationship*	example	literature
stand biomass	non-canopy stand structure		understory vascular plant community	Wardle and Jonsson 2014
e.g. aboveground biomass; total carbon in living biomass	plant functional diversity		functional diversity	Duveneck et al. 2016 Silva Pedro et al. 2015
	tree/stand age		stand age	Yang et al. 2018
	tree size		tree height	Sakschewski et al. 2016 Hlásny et al. 2021

**percentage of studies in which a given relationship is significant out of the total number of studies in which such relationship is present.*

back

Forest functioning

system variable	resilience predictor	significant relationship*	example	literature
biogeochemical cycles	forest type		coniferous *vs* deciduous	Creed et al. 2014
	management intensity		shoot harvested *vs* remnant shoot *vs* crown shading	Domingo et al. 2020
	plant functional diversity		functional diversity	Schmitt et al. 2019
	tree size		basal area	Domingo et al. 2020

**percentage of studies in which a given relationship is significant out of the total number of studies in which such relationship is present.*

back

Biodiversity

system variable

non-plant functional diversity

non-plant taxonomic diversity

plant functional diversity

plant taxonomic diversity

back to other categories

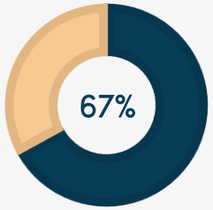
Biodiversity

system variable	resilience predictor	significant relationship*	example	literature
non-plant functional diversity	land use		urban park *vs* preserved forest	Estevo et al. 2017
e.g. insect guild diversity	management treatment		level of timber harvesting	Summerville et al. 2013
	non-canopy stand structure		patch size of native vegetation	Pardini et al. 2010
	vegetation type		seeder *vs* resprouter	Arnan et al. 2006

**percentage of studies in which a given relationship is significant out of the total number of studies in which such relationship is present.*

back

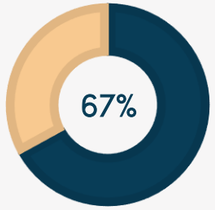
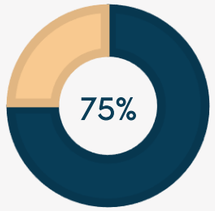
Biodiversity

system variable	resilience predictor	significant relationship*	example	literature
non-plant taxonomic diversity	land use		historical land use category	Willig et al. 2011
e.g. insect community composition	management treatment		level of timber harvesting	Summerville et al. 2013
	tree size		mean tree height	Malinga et al. 2014
	vegetation type		native forest *vs* agricultural	Chaer et al. 2009

**percentage of studies in which a given relationship is significant out of the total number of studies in which such relationship is present.*

back

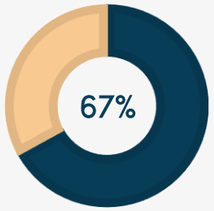
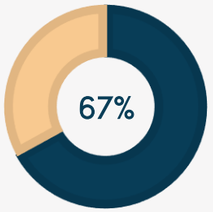
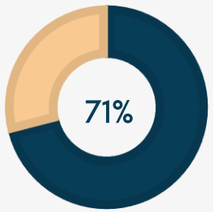
Biodiversity

system variable	resilience predictor	significant relationship*	example	literature
plant functional diversity	management treatment		stem-only harvest *vs* whole tree harvest	Curzon et al. 2016
e.g. leaf functional traits	tree size		stem length	López-Toledo et al. 2012
	tree/stand age		stand tree age	Seidl et al. 2017
	vegetation type		native forest *vs* agricultural	Chaer et al. 2009

**percentage of studies in which a given relationship is significant out of the total number of studies in which such relationship is present.*

back

Biodiversity

system variable	resilience predictor	significant relationship*	example	literature
plant taxonomic diversity	herbivory pressure		presence *vs* absence	Jacobs 2015
e.g. species richness; species evenness; Shannon index	vegetation cover		herbaceous and graminoid plants cover	Savage and Mast 2005
	management intensity		intensity of cutting	Zenner et al. 2013
	management treatment		stem-only harvest *vs* whole tree harvest	Curzon et al. 2016

**percentage of studies in which a given relationship is significant out of the total number of studies in which such relationship is present.*

BACK

Forest structure

system variable

- canopy characteristics
- demographic rates
- stand height
- non-canopy stand structure
- tree growth

back to other categories

Forest structure

system variable	resilience predictor	significant relationship*	example	literature
canopy characteristics	forest type		cork oak forest *vs* pine plantation	Chergui et al. 2018
e.g. canopy defoliation	management treatment		no active management *vs* prescribed fire	Halofsky et al. 2014
	plant functional traits		resprouting type	Lloret et al. 2004
	species identity		species identity	Lloret et al. 2004

**percentage of studies in which a given relationship is significant out of the total number of studies in which such relationship is present.*

back

Forest structure

system variable	resilience predictor	significant relationship*	example	literature
demographic rates	plant functional traits		species wood density	Curran et al. 2008
e.g. annual rates of mortality and growth	tree size		stem length	López-Toledo et al. 2012
	tree/stand age		tree age class	Xu et al. 2017
	stand density		stand density	Guz et al. 2021

**percentage of studies in which a given relationship is significant out of the total number of studies in which such relationship is present.*

back

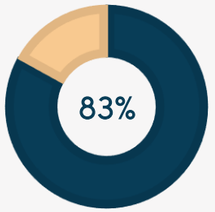
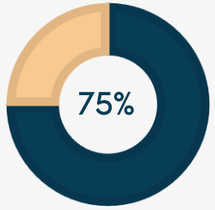
Forest structure

system variable	resilience predictor	significant relationship*	example	literature
stand height	plant taxonomic diversity		taxonomic category of the dominant species	Lloret et al. 2022
e.g. species richness; species evenness; Shannon index	tree size		basal area	Lloret et al. 2022

**percentage of studies in which a given relationship is significant out of the total number of studies in which such relationship is present.*

back

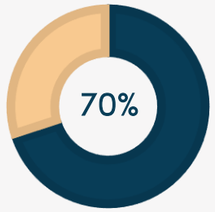
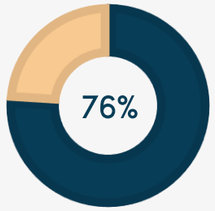
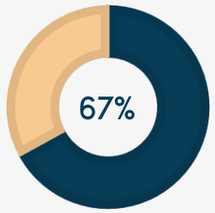
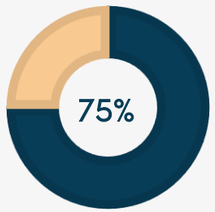
Forest structure

system variable	resilience predictor	significant relationship*	example	literature
non-canopy stand structure	herbivore pressure		grazing pressure	Moris et al. 2017
e.g. tree regeneration	vegetation cover		herbaceous and graminoid plants cover	Savage and Mast. 2005
	management treatment		fuel reduction treatment	Roccaforte et al. 2018
	vegetation type		eucalyptus *vs* understorey	Prior et al. 2022

**percentage of studies in which a given relationship is significant out of the total number of studies in which such relationship is present.*

BACK

Forest structure

system variable	resilience predictor	significant relationship*	example	literature
tree growth	management treatment		burned *vs* control	Bottero et al. 2017
e.g. basal area increment; shoot-growth	tree size		tree diameter; tree height	Carnwath and Nelson 2017 Gazol and Camarero 2016
	tree/stand age		tree age; stand age	Kuntz et al. 2018; Sohn et al. 2016
	species identity		species identity	Herrero and Zamora 2014

**percentage of studies in which a given relationship is significant out of the total number of studies in which such relationship is present.*

back

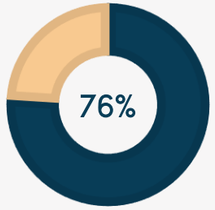
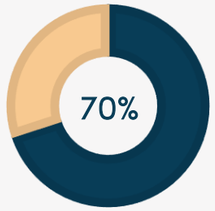
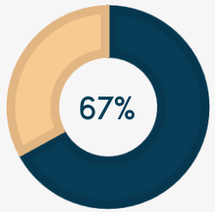
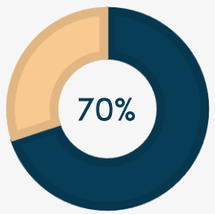
Landscape

system variable

vegetation cover

back to other categories

Landscape

system variable	resilience predictor	significant relationship*	example	literature
vegetation cover	management treatment		restored areas *vs* unrestored aeas	Jacobs 2015
e.g. cover of shrubland	plant functional traits		specific leaf area	Bernhardt-Römermann et al. 2011
	plant taxonomic diversity		Simpson's diversity index	Hancock and Legg 2012
	land use		land use system	García-Romero et al. 2004

**percentage of studies in which a given relationship is significant out of the total number of studies in which such relationship is present.*

back

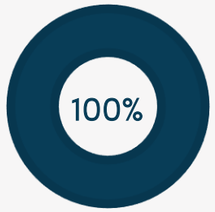
Soil

system variable

soil enzymatic activity

back to other categories

Soil

system variable	resilience predictor	significant relationship*	example	literature
soil enzymatic activity	species identity		tree species identity	Jacobs 2015
e.g. cellulase activity; and laccase activity	vegetation type		native *vs* agricultural	Chaer et al. 2009

**percentage of studies in which a given relationship is significant out of the total number of studies in which such relationship is present.*

back