

Toward Wildfire Alternatives:

Mitigating Wildfire Risk Through Landscape-Based Resilience

Jinlai Song | 21/06/2023

Mentors: Nikos Katsikis, Daniele Cannatella

TU Delft, Faculty of Architecture Master of Science Architecture, Urbanism and Building Sciences

Personal Motivation

A large wildfire in Chongqing, China

FIRE

RESCUE

Personal Motivation
Mediterranean wildfire



From the beach, tourists watch a massive wildfire that engulfed a Mediterranean resort region on Turkey's southern coast near Marmaris on July 30, 2021. - ILYAS AKENGIN/AFP via Getty Images

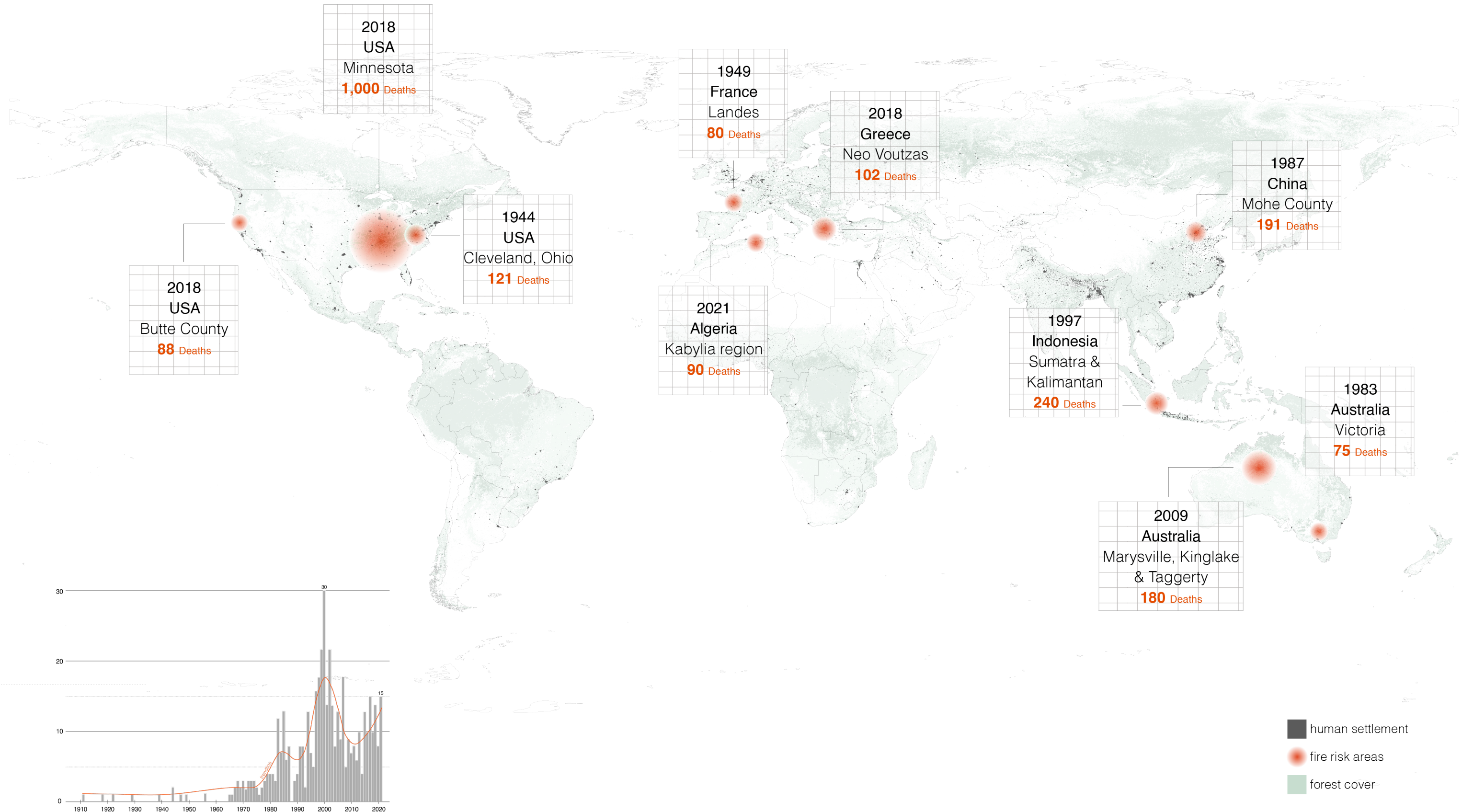
Personal Motivation
Mediterranean wildfire



A farmer tries to save his goat during a forest fire in the village of Makrimalli on the island of Evia, northeast of Athens, on August 14, 2019.
Angelos Tzortzinis/AFP/Getty Images

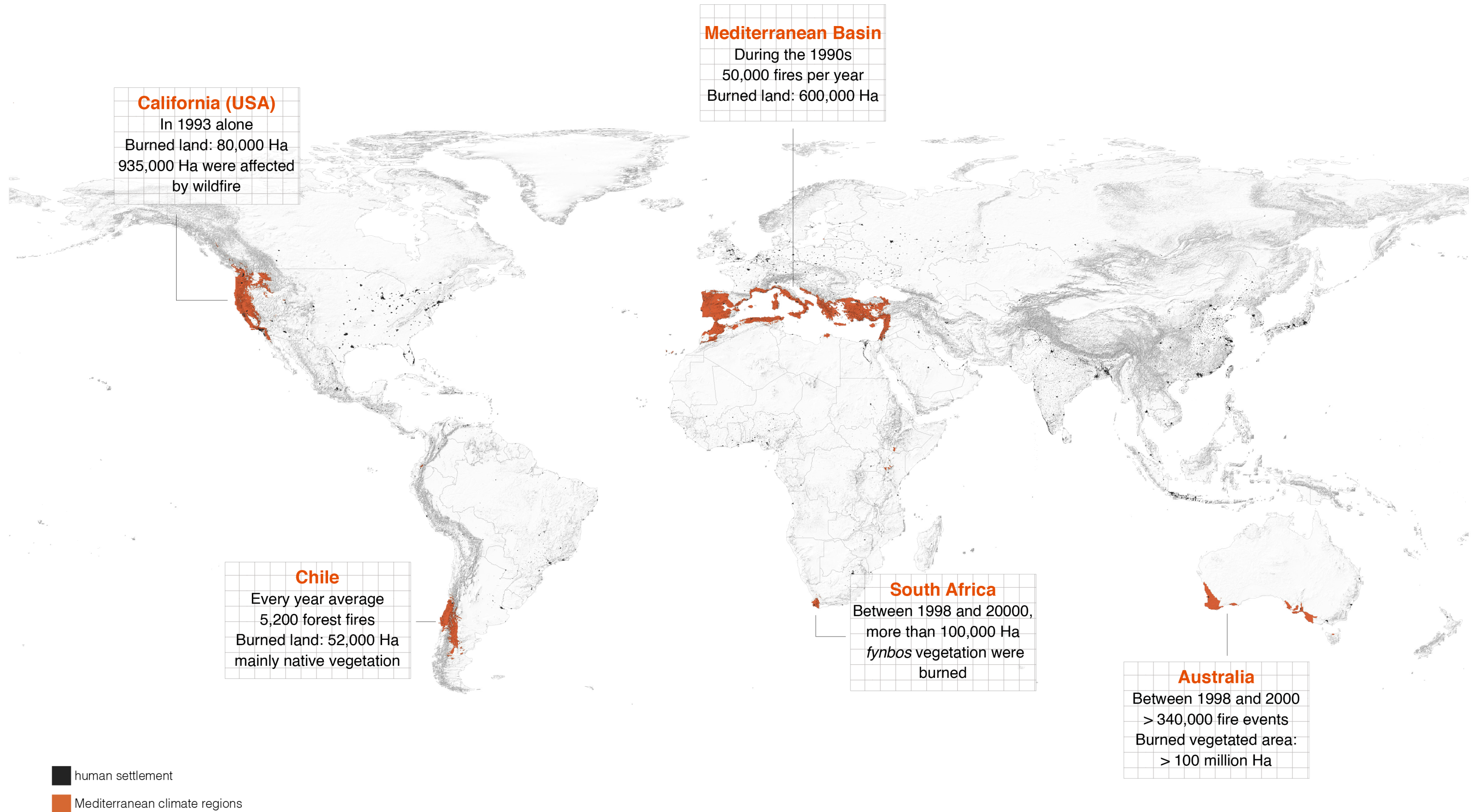
Problematization

Wildfire as a global risk



Problematization

Wildfire in the Mediterranean Climate Regions (MCRs)



Problematization

Suppression-led fire fighting



A firefighter tries to extinguish a wildfire in the village of Casais de Sao Bento in Macao in central Portugal.
Photography by Patricia de Melo Moreire, AFP/GETTY IMAGES

Problematization

Forest fire in the Mediterranean Basin

2000-2011



2012-2022



Source: Forest Fires in EU (2000-2022) by Dick Vogel, <https://esrinederland.maps.arcgis.com/apps/instant/slider/index.html?appid=62ababfde6364097b07c2c6ee8563bb5>

Problematization

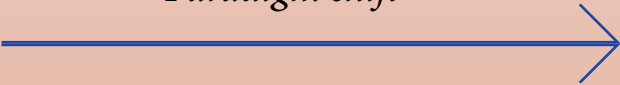
Paradigm shift toward landscape-based approaches

Existing

Future

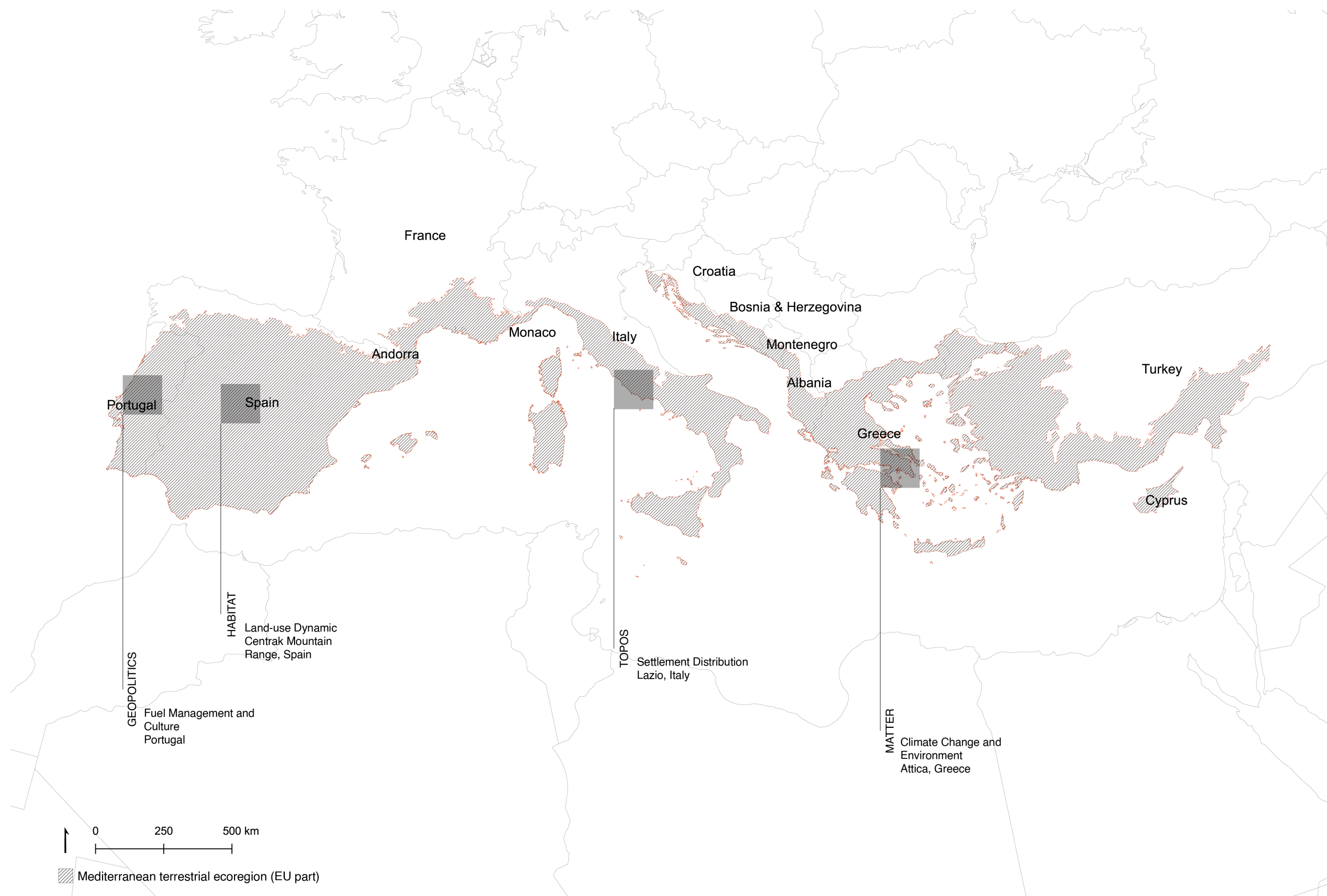
Suppression-led
fire fighting

Paradigm shift

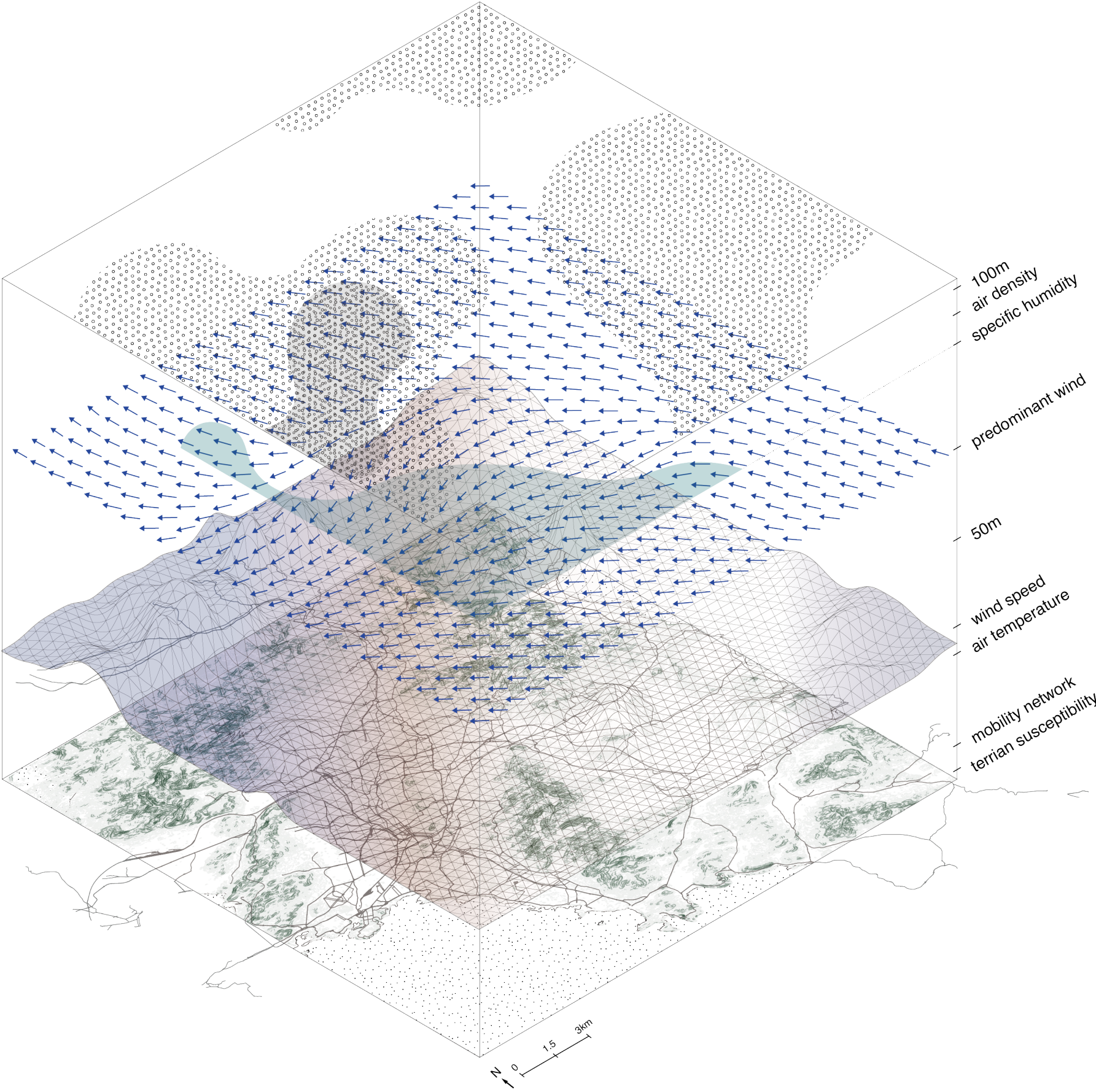


Landscape-based
fire resilience

Landscape Monograph
Landscape dynamics and fire regimes interaction

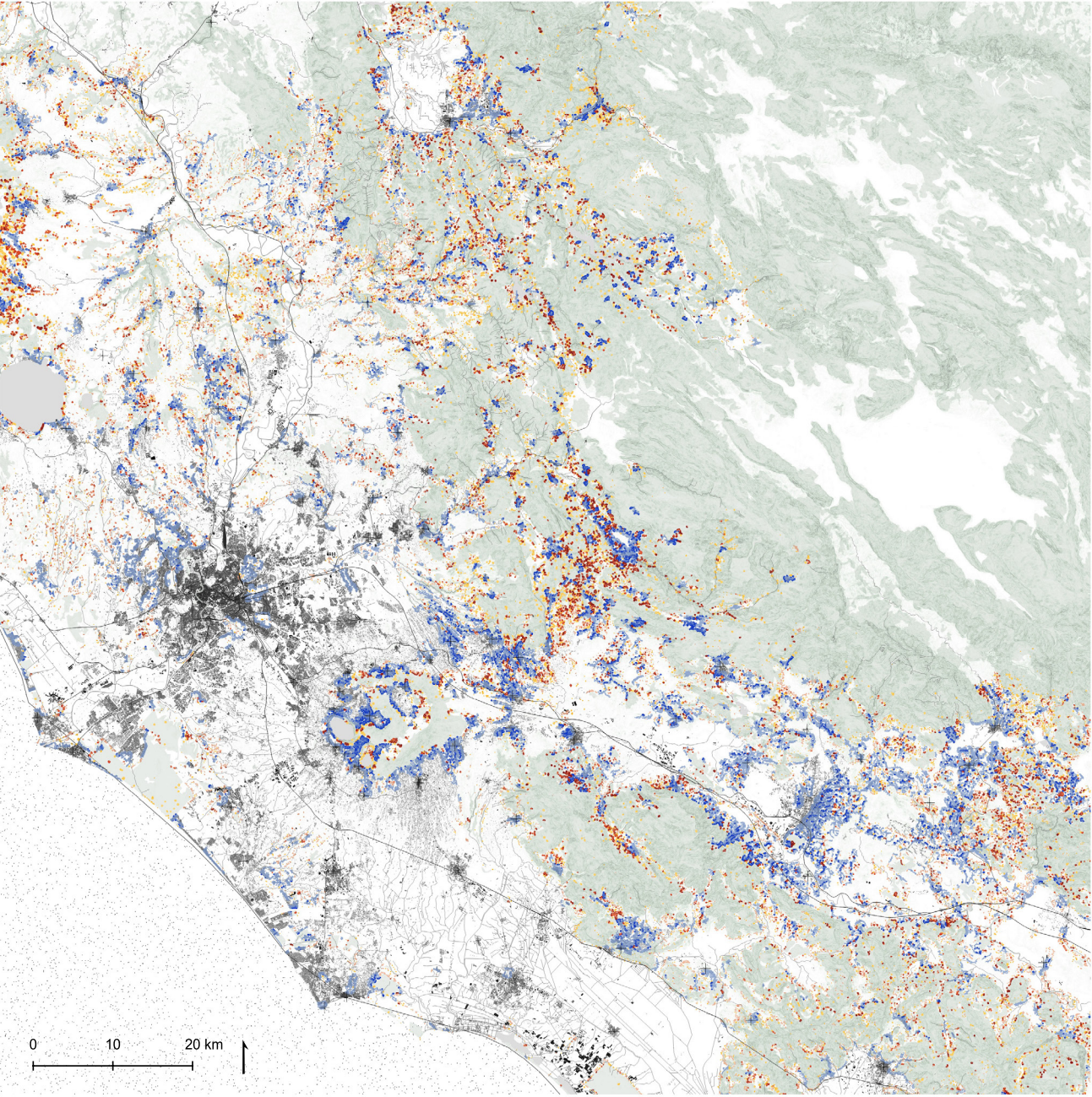


Landscape Monograph
Climate change and environment | Athens, Greece



Landscape Monograph

Settlement distribution and tree density | Rome, Italy

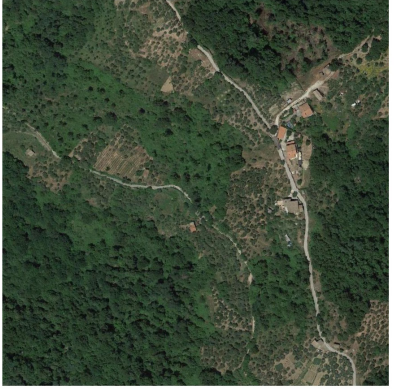


- Isolated buildings and low tree canopy cover
- Isolated buildings and medium tree canopy cover
- Isolated buildings and high tree canopy cover
- Scattered buildings and low tree canopy cover
- Scattered buildings and medium tree canopy cover
- Scattered buildings and high tree canopy cover
- Clustered buildings and high tree canopy cover
- Clustered buildings and medium tree canopy cover
- Clustered buildings and low tree canopy cover
- + Human settlement
- Mobility
- Hydrological network
- Building density
- Water
- Fuel bed

Low canopy



Medium canopy



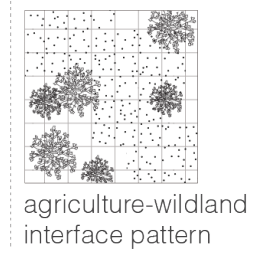
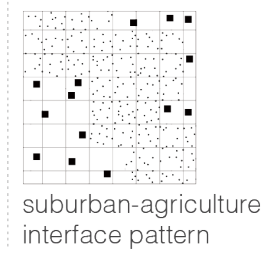
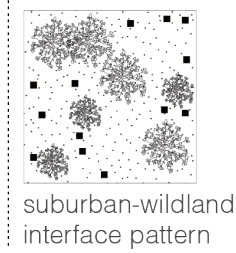
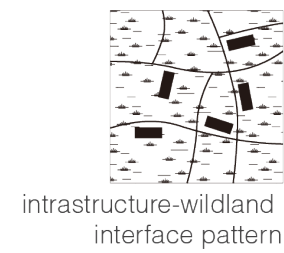
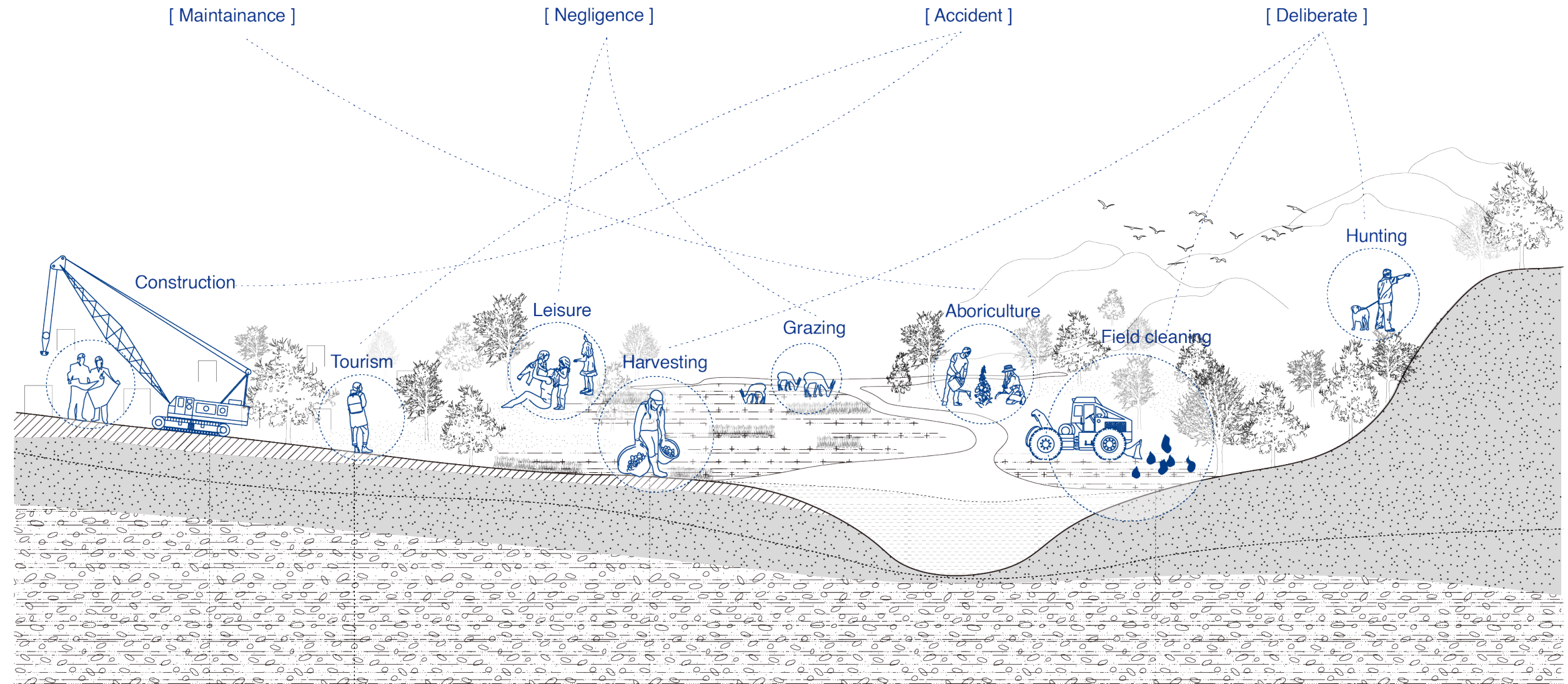
High canopy



- Isolated Dwelling (ID)
- Scattered Dwelling (SD)
- Clustered Dwelling (CD)

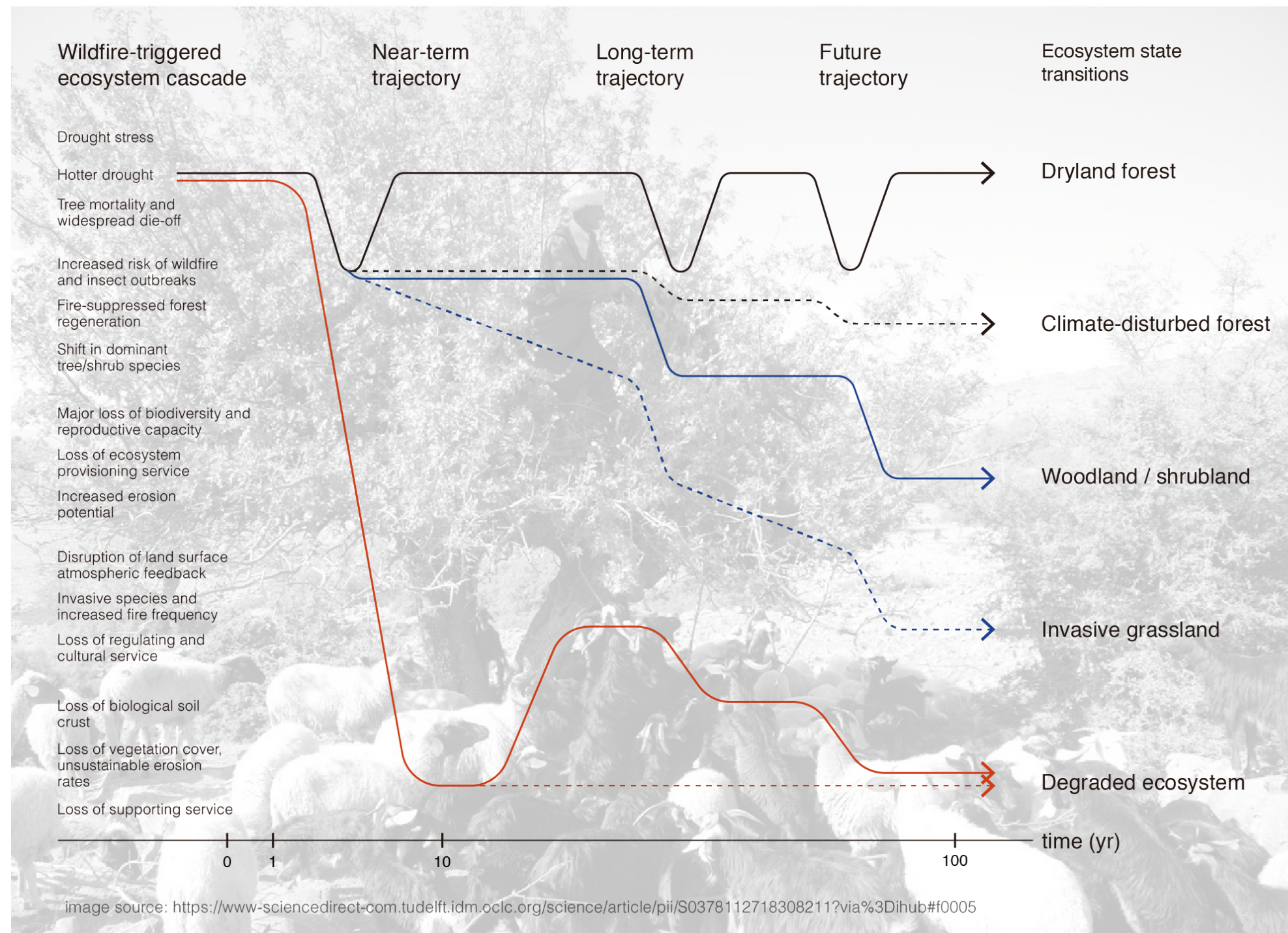
Landscape Monograph

Human behaviours | Rome, Italy



Landscape Monograph

Fuel management | Portugal



Research Question

Mitigate wildfire in Euro-Mediterranean Basin

Research question

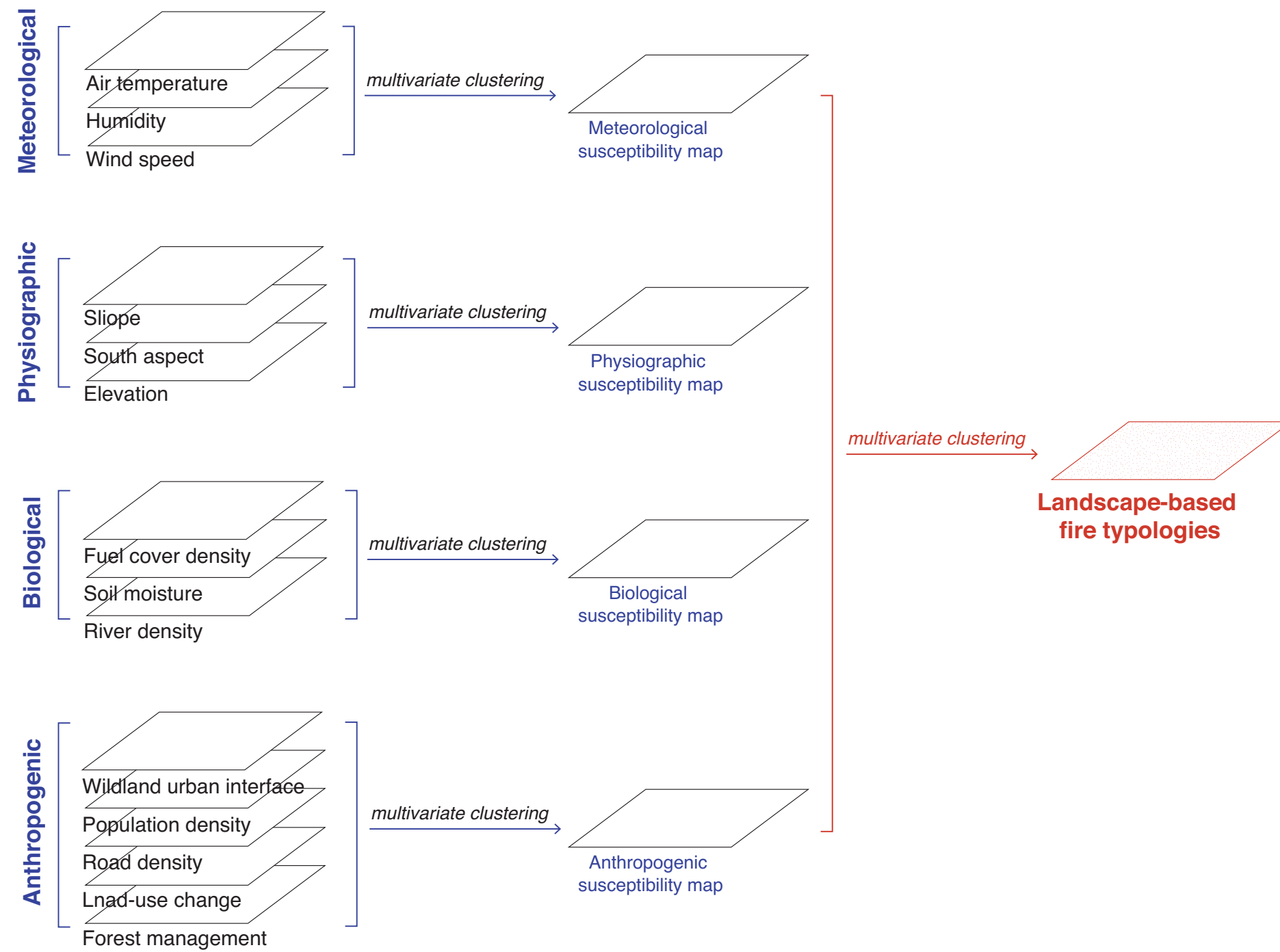
Under the intensifying challenges posed by agri-cultural abandonment and the rapid growth of tourism, how to facilitate territorial **adaptation and resilience** to wildfire risk by establishing the landscape-based fire typologies in **Euro-Mediterranean Basin?**

Sub-questions

- What are driving forces of wildfire regimes especially in the aspect of agriculture and tourism and how can they reshape and transform our territories?
- How to identify and characterize the landscape dynamics in the Euro-Mediterranean Basin?
- What are the socioeconomic and cultural values of these fire typologies?
- How to develop adaptive and resilient strategies in view of landscape-based fire typologies?
- How these typologies and strategies are applied in a multiscalar way (from Mediterranean to local scale) ?

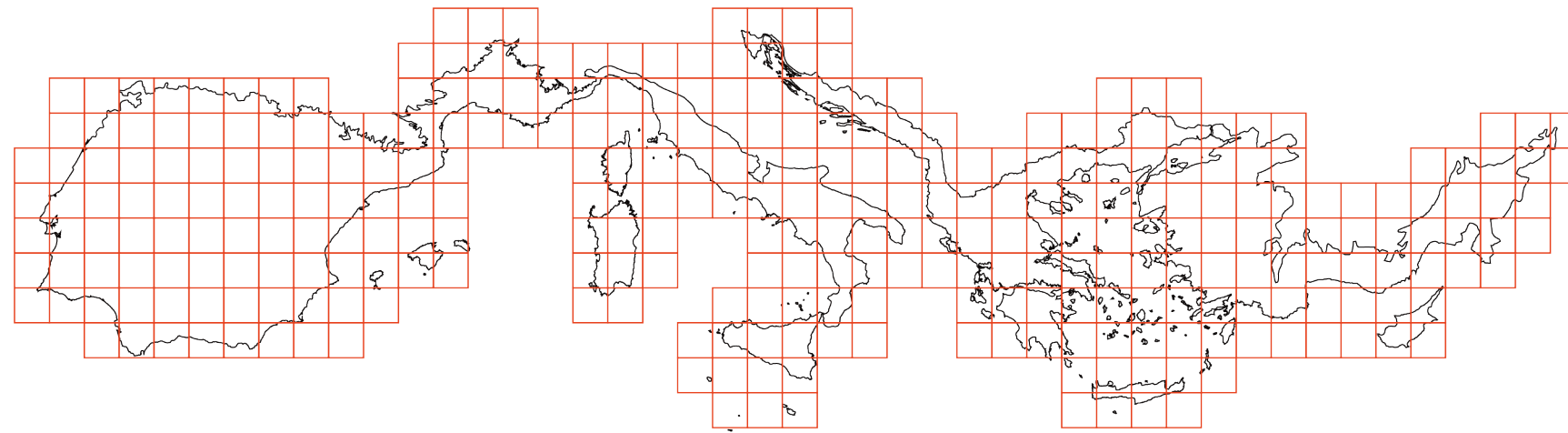
MED Atlas

GIS-based methodology | Combining landscape factors

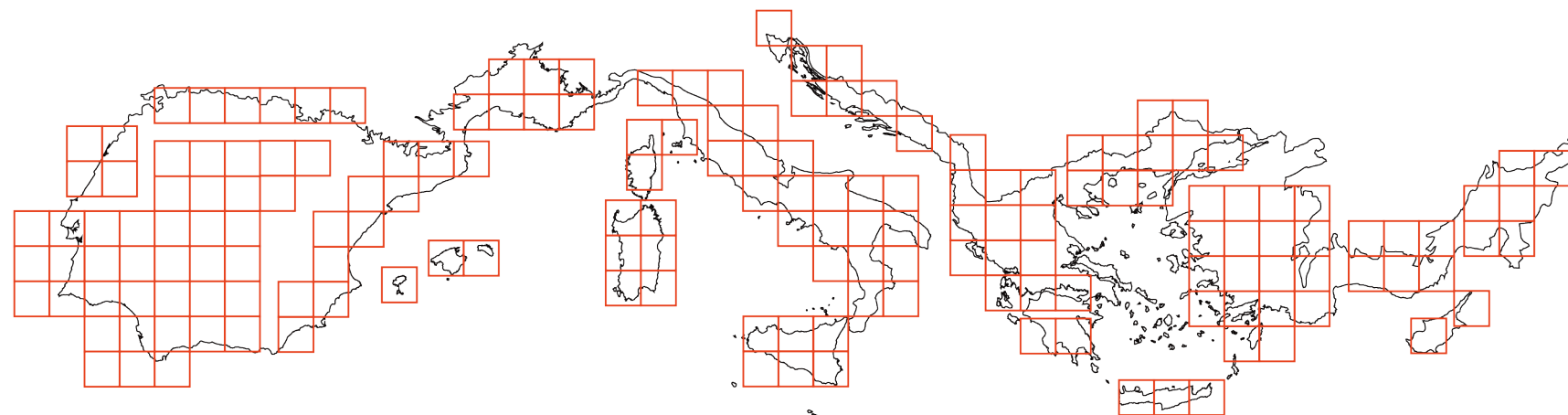


MED Atlas

GIS-based methodology | Multivariate clustering



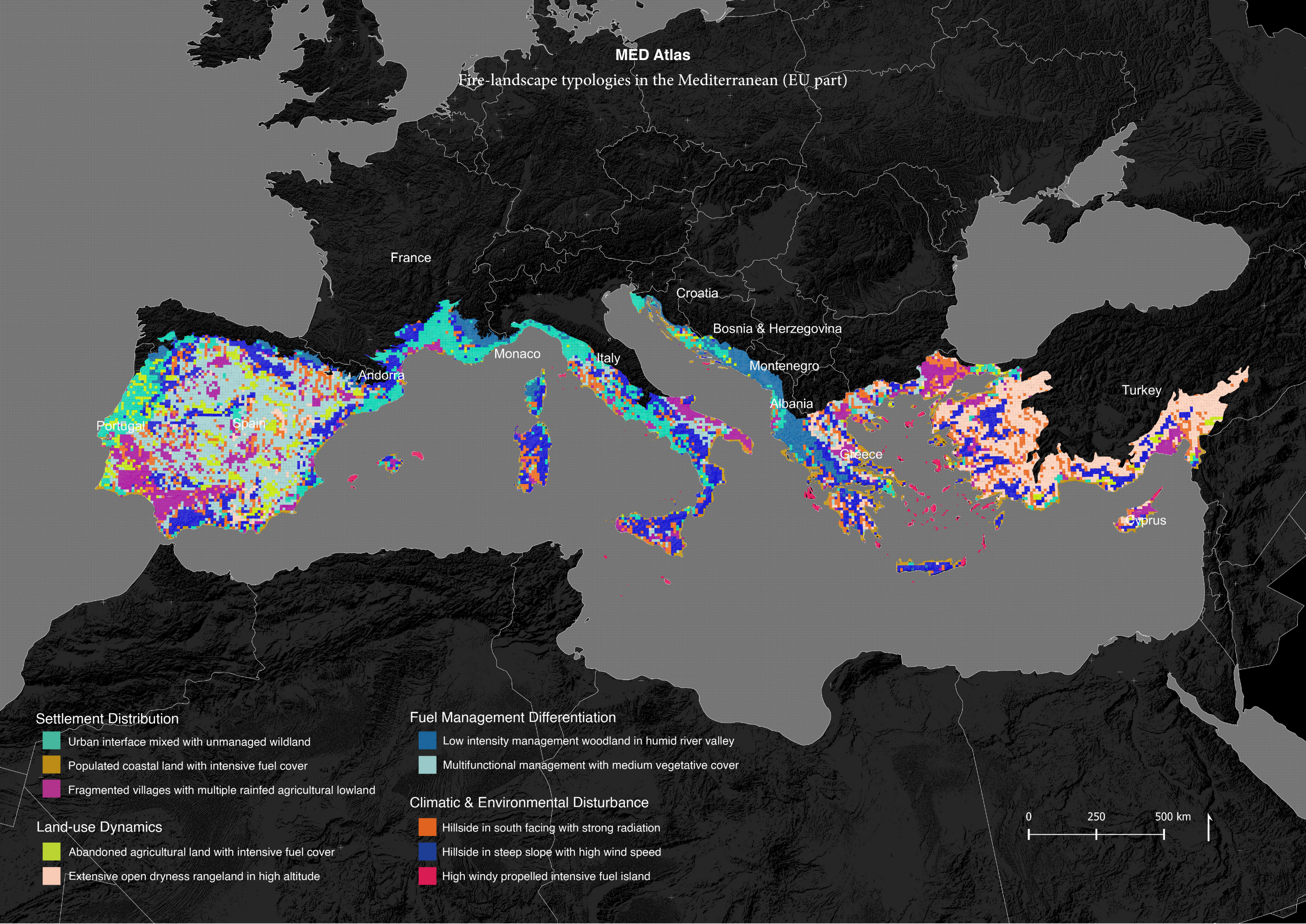
10km*10km grid



Clustered grid

MED Atlas

Fire-landscape typologies in the Mediterranean (EU part)



Settlement Distribution

- Urban interface mixed with unmanaged wildland
- Populated coastal land with intensive fuel cover
- Fragmented villages with multiple rainfed agricultural lowland

Land-use Dynamics

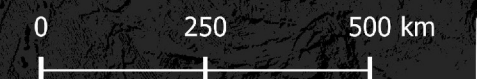
- Abandoned agricultural land with intensive fuel cover
- Extensive open dryness rangeland in high altitude

Fuel Management Differentiation

- Low intensity management woodland in humid river valley
- Multifunctional management with medium vegetative cover

Climatic & Environmental Disturbance

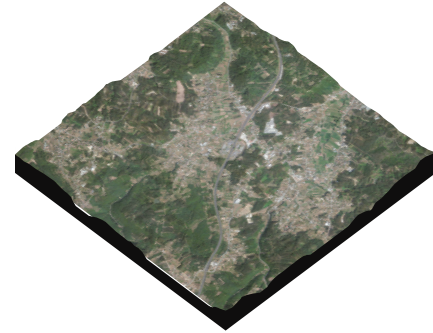
- Hillside in south facing with strong radiation
- Hillside in steep slope with high wind speed
- High windy propelled intensive fuel island



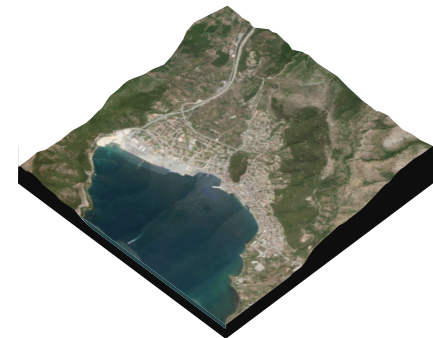
MED Atlas

Representing landscape system through the lens of fire

Settlement Distribution



Typology 1: Urban interface mixed with unmanaged wildland

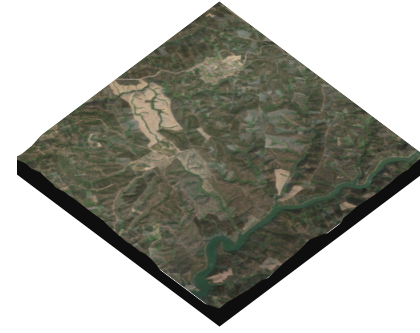


Typology 2: Populated coastal land with intensive fuel cover

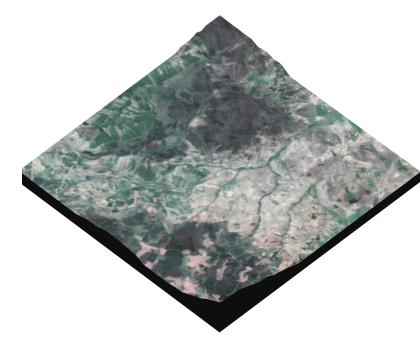


Typology 3: Fragmented villages with multiple rainfed agricultural lowland

Land-use Dynamics

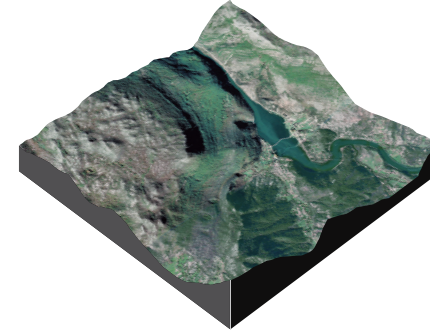


Typology 4: Abandoned agricultural land with intensive fuel cover

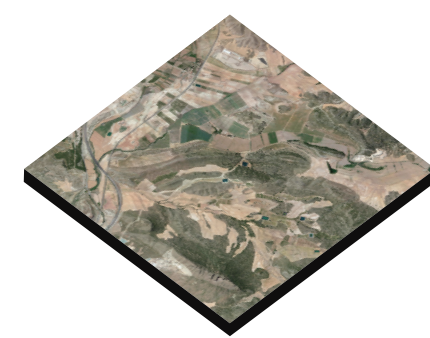


Typology 5: Extensive open dryness rangeland in high altitude

Fuel Management Differentiation

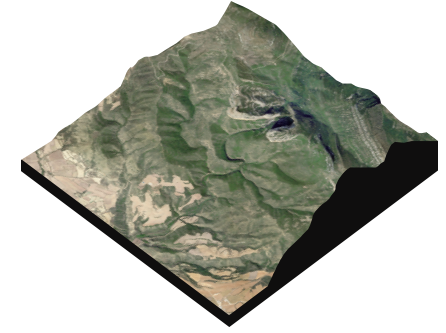


Typology 6: Low intensity management woodland in humid river valley

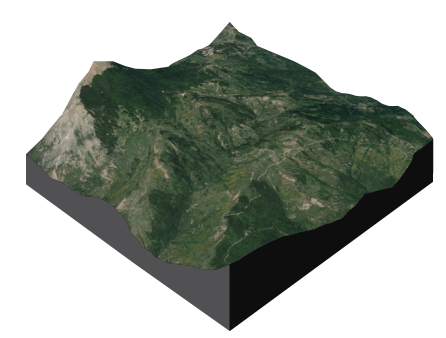


Typology 7: Multifunctional management with medium vegetative cover

Climatic & Environmental Disturbance



Typology 8: Hillside in south facing with strong radiation



Typology 9: Hillside in steep slope with high wind speed



Typology 10: High windy propelled intensive fuel island

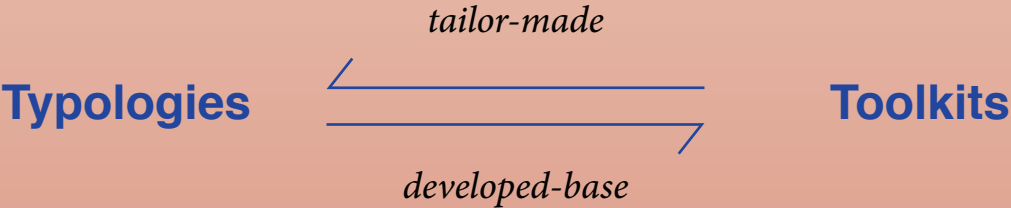
Landscape-based Intervention
Downscaling work towards design perspective

Research :

How can we use the result of fire-landscape typologies?

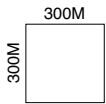


Intervention :



Landscape-based Intervention

Toolkits based on the risk cycle



PREPAREDNESS

RESPONSE

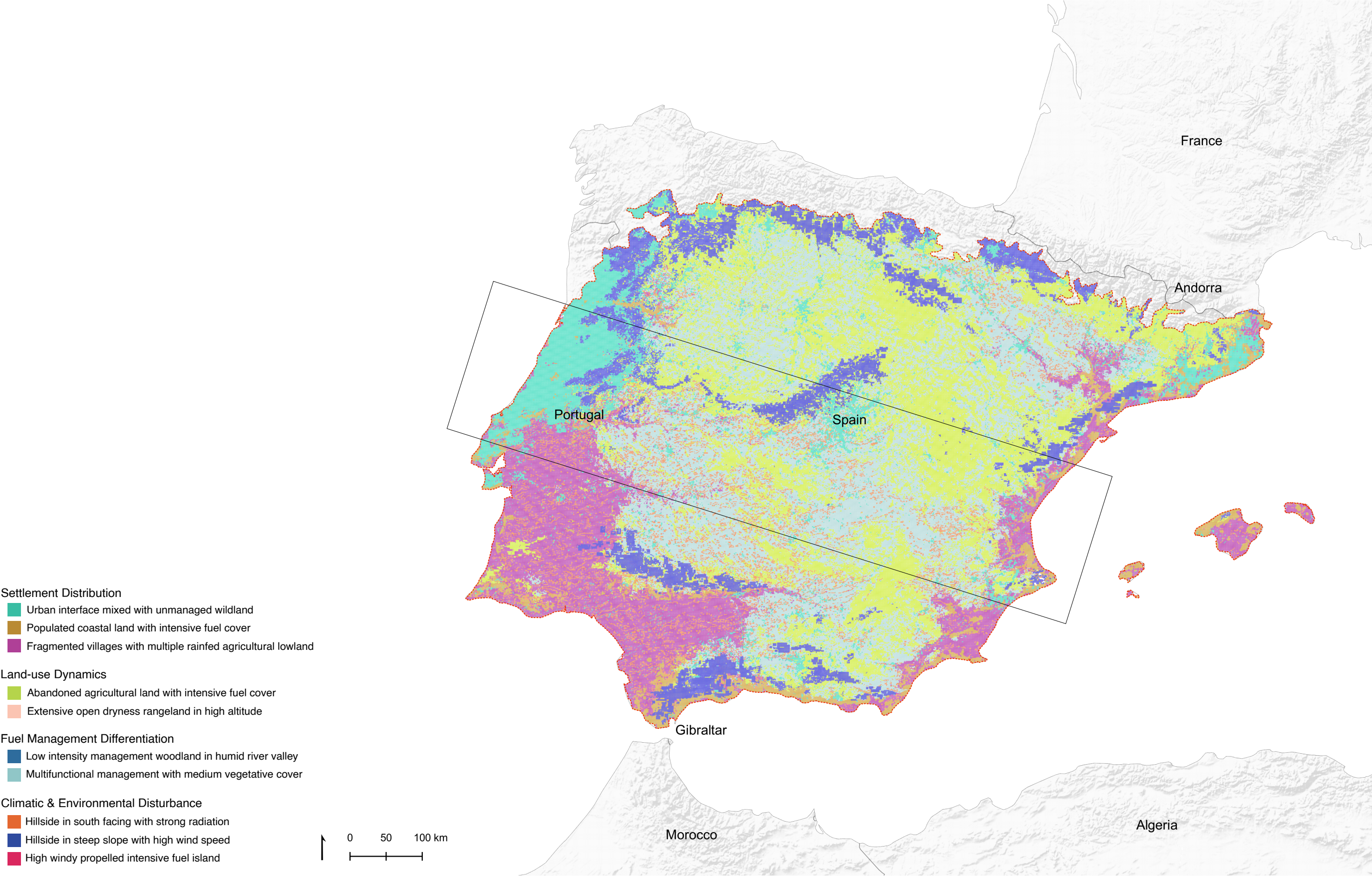
RECOVERY

PREVENTION

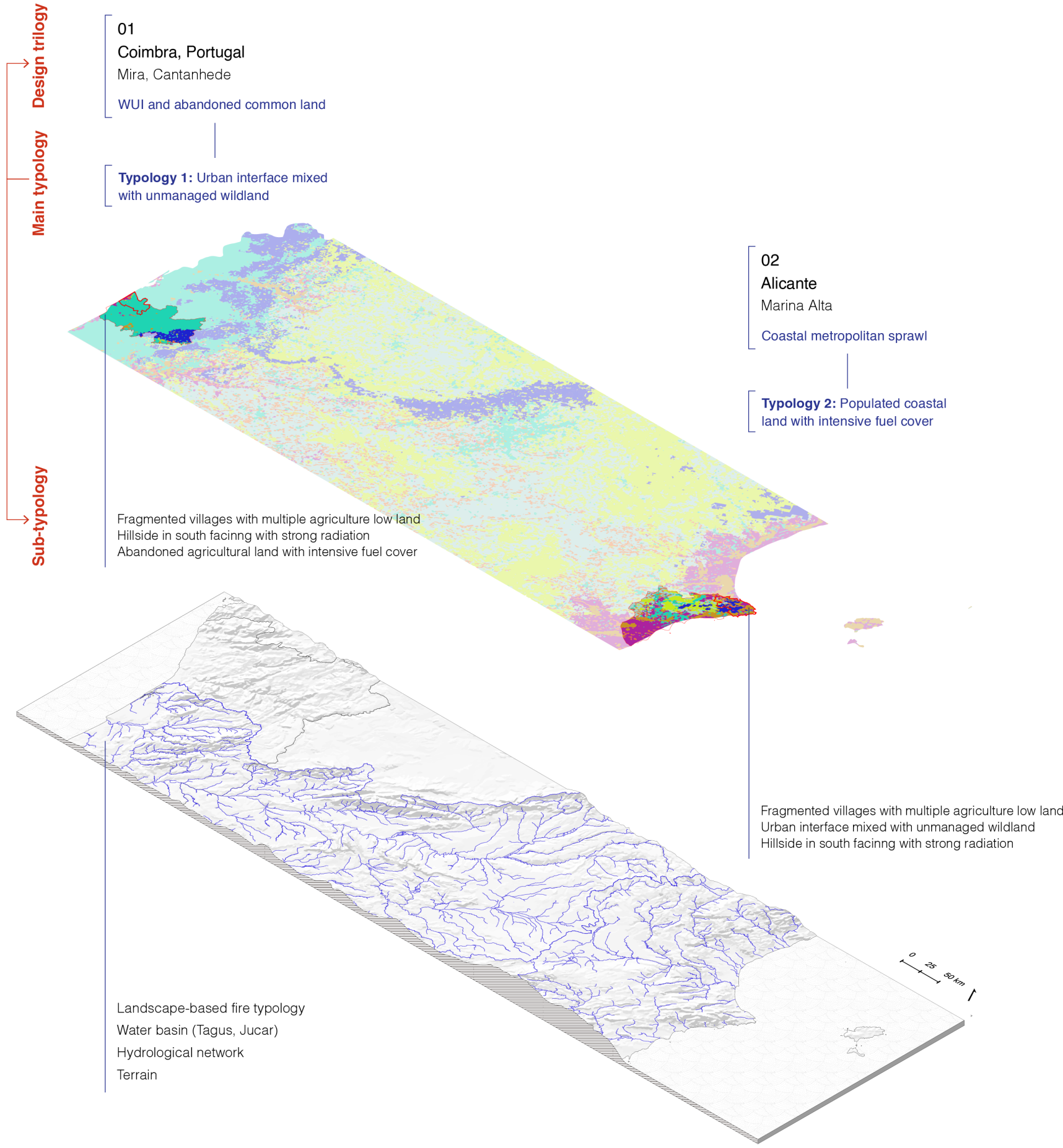
MITIGATION

<p>Pp.1 ESCAPE ROUTE PLANNING</p>	<p>Rp.1 CARBON CAPTURE</p>	<p>Rc.1 FIRE-RESISTANT MATERIAL</p>	<p>Pv.1 PRESCRIBED BURNING</p>	<p>M.1 VEGETATION FIRE-BREAKING</p>
<p>Pp.2 DEFENSIBLE SPACE</p>	<p>Rp.2 TEMPORARY SHELTERING</p>	<p>Rc.2 SMART REFORESTRATION</p>	<p>Pv.2 FUEL SPATIAL MODIFICATION</p>	<p>M.2 PLANTS SPACING</p>
<p>Pp.3 COMMUNITY AS TERRITORY</p>	<p>Rp.3 TERRAIN CONTROL LINES</p>	<p>Rc.3 LAND-USE REPLANNING</p>	<p>Pv.3 AGROFORESTRY MOSAICS</p>	<p>M.3 TRANSITIONAL BUFFER</p>
<p>Pp.4 MULTIFUNCTIONAL CASCADING WATER SYSTEM</p>	<p>Rp.4 LANDSCAPE HARDENING</p>	<p>Rc.4 WATERSHED PROTECTION</p>	<p>Pv.4 LINEAR PRODUCTIVE GRAZING</p>	<p>M.4 REWETTING INFRASTRUCTURES</p>

Design for Duality
Reanalysis of the Iberian peninsula

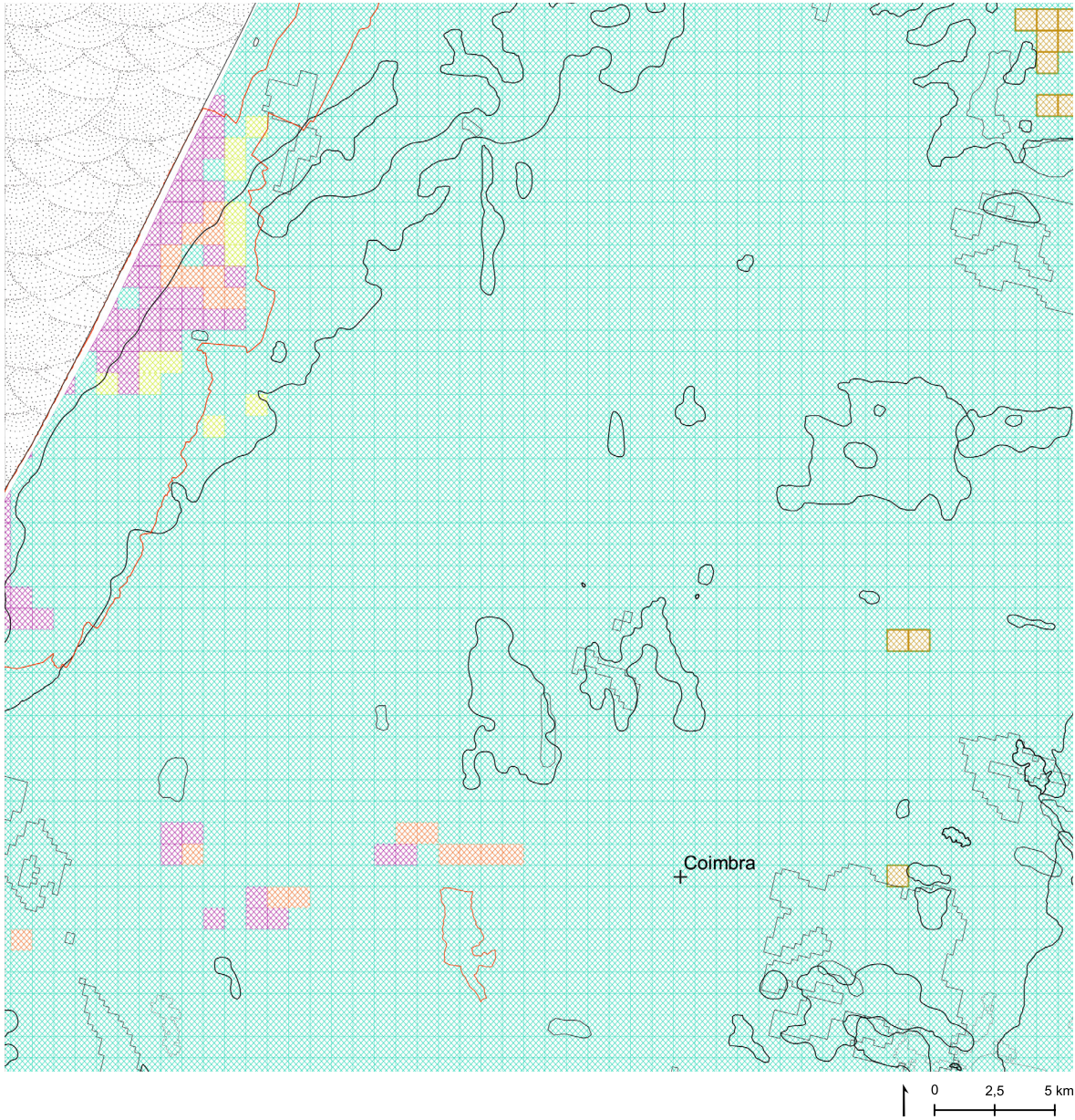


Design for Duality
Site selection



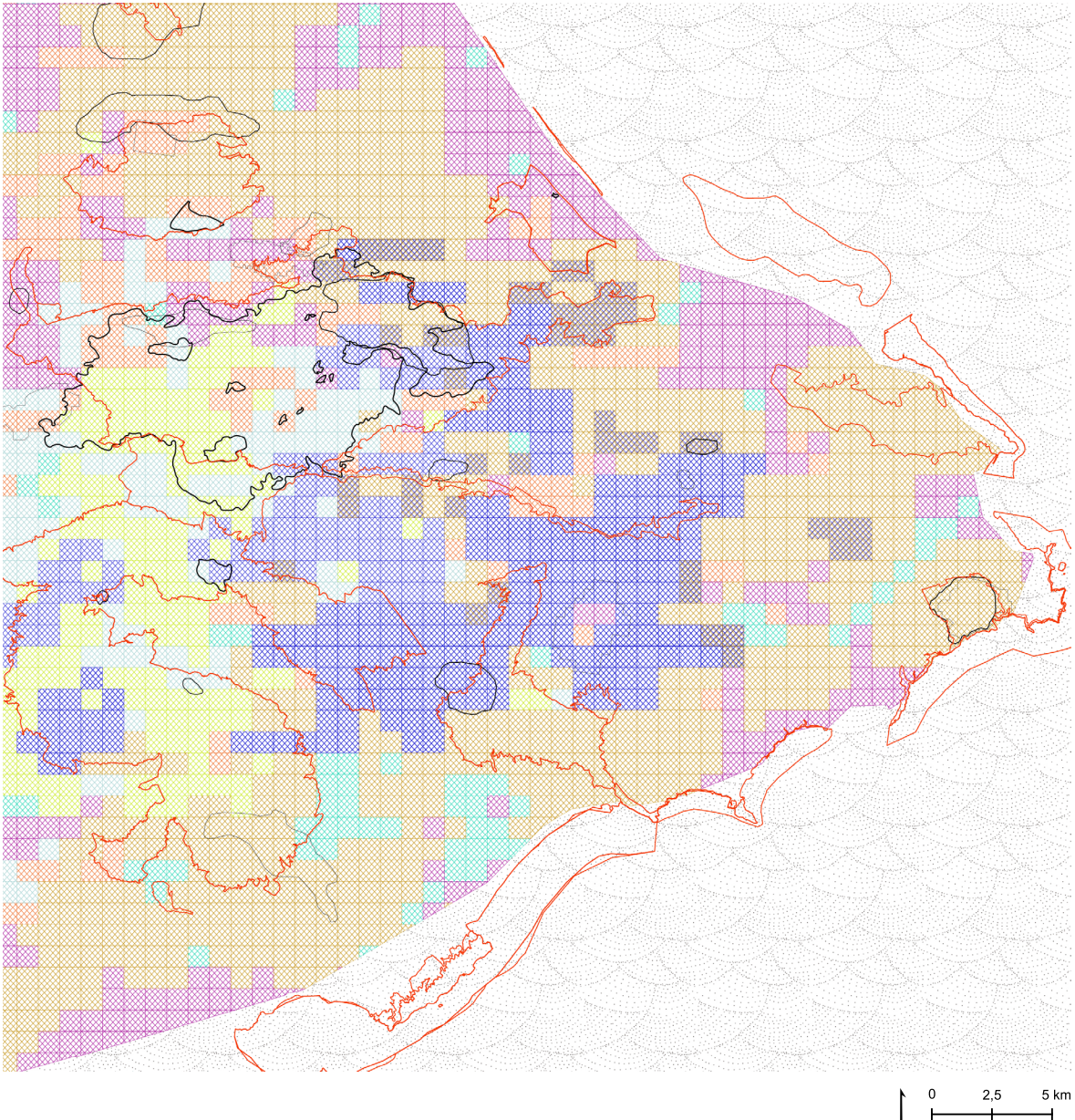
Design for Duality
Fire-landscape typologies of three sites

Site 01
Coimbra, Portugal



Interface typology

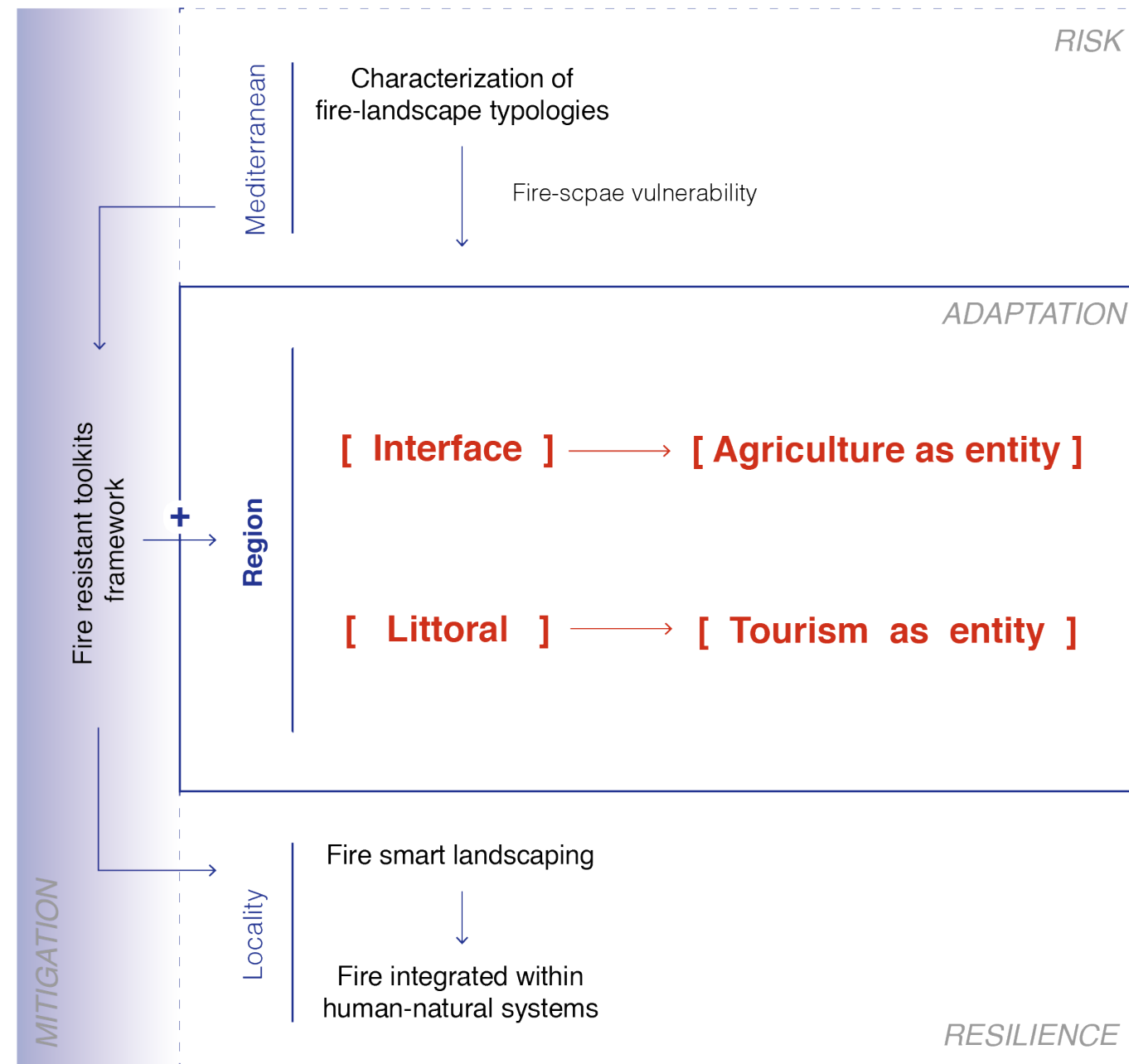
Site 02
Alicante, Spain



Populated coast typology

Design for Duality

Conceptual theme | Unlock landscape potentials



Re-analysis :

Site 01_Interface typology

Coimbra, PL



What are the landscape elements included in the interface?

How these dynamics shaped this fire-prone interface?

Re-analysis of regional specificity _ Site 01

Afforestation activities

Tree planting in Serra do Soajo (1902)



Sowing in the National Bear Forest (1907-1908)



Sowing in the dunes of Ovar (1933)



Source: "About forestry services", by José Mateus de Almeida Mendia (1945)

Re-analysis of regional specificity _ Site 01

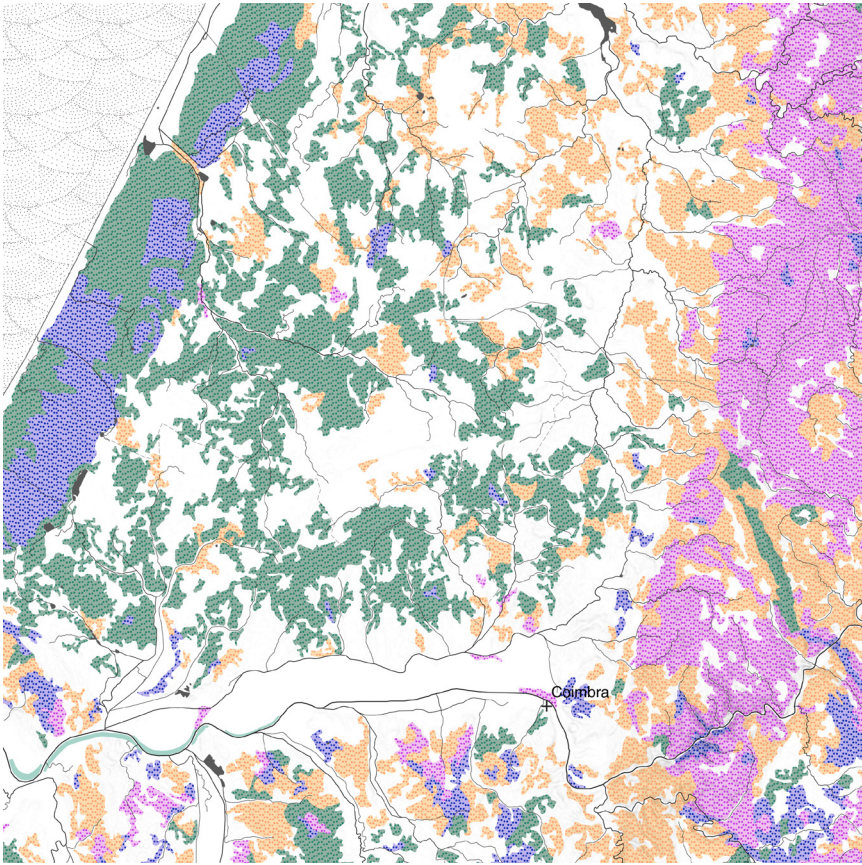
Forest dynamics

20th
Increasing of forest

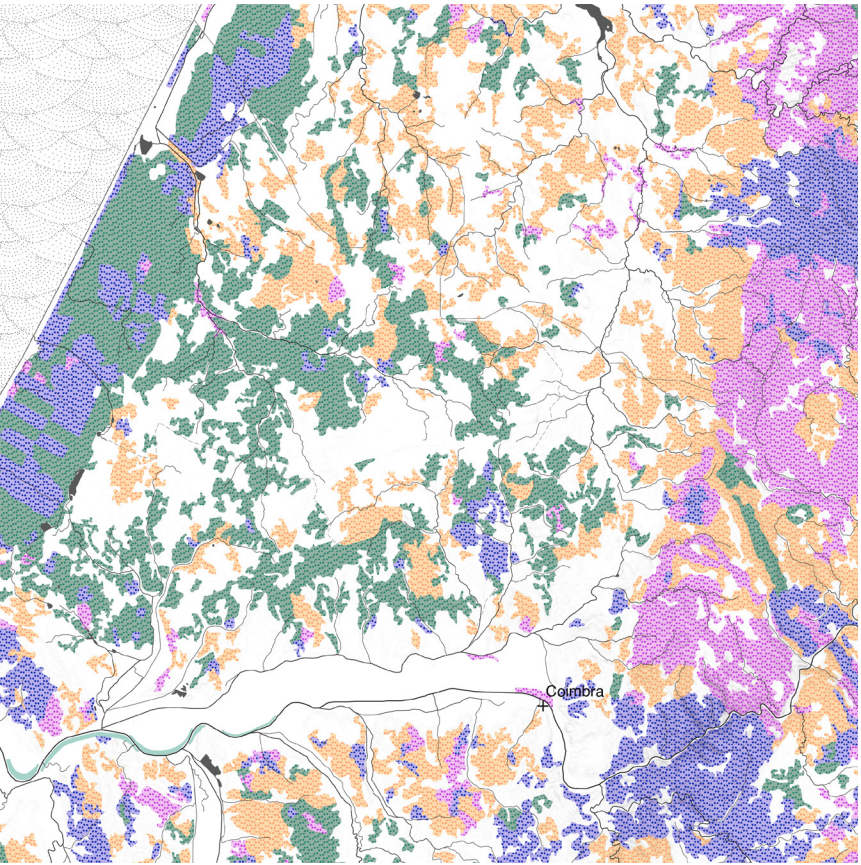


21th
Dynamics between forest, agrarian and uncultivated land

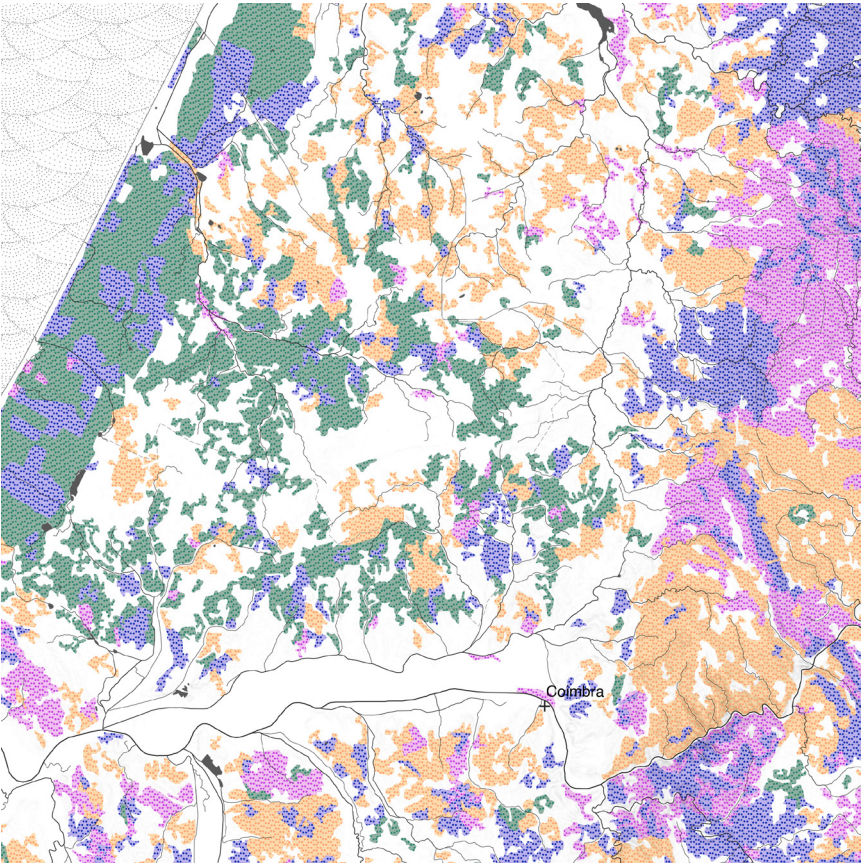
1990



2006



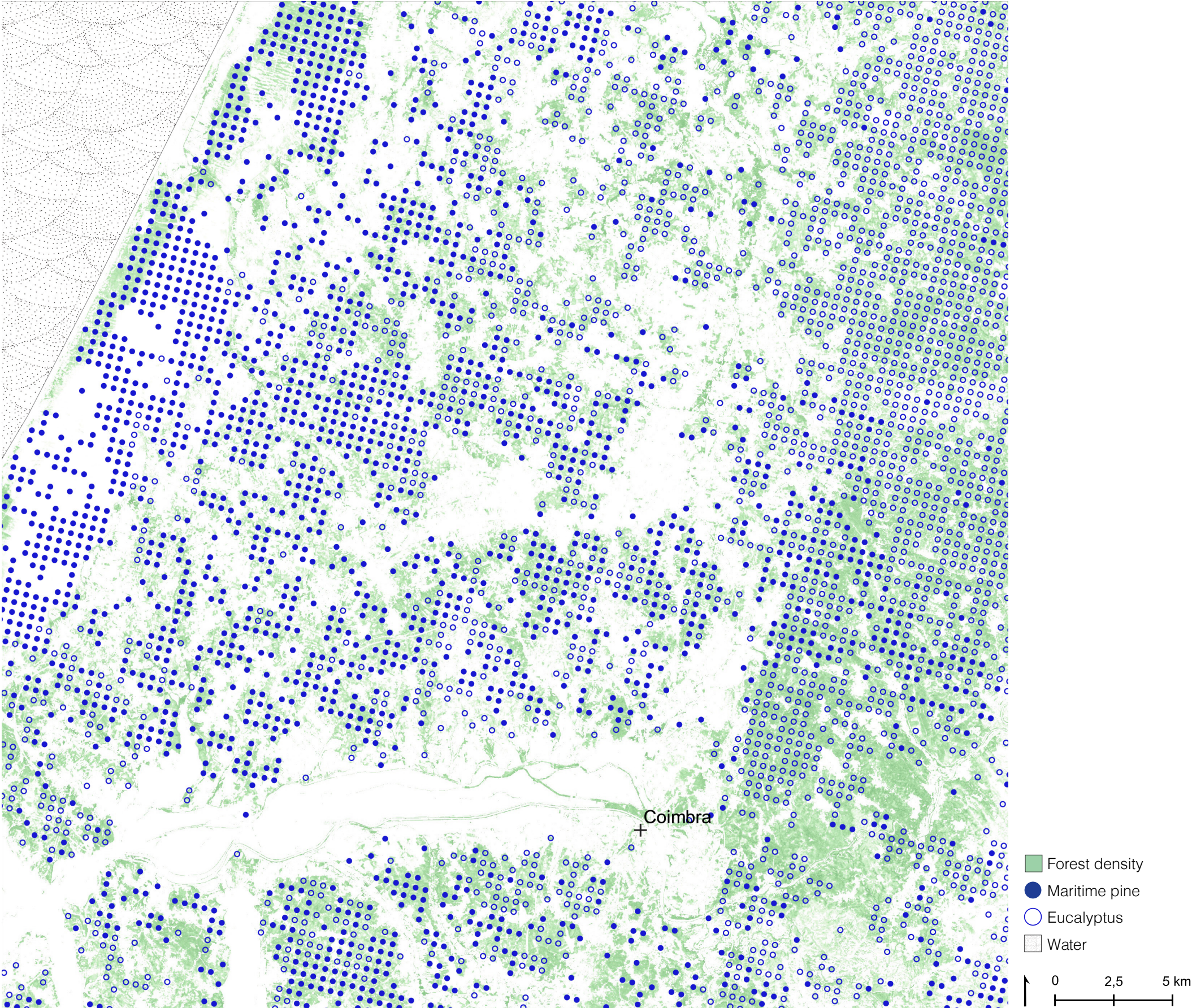
2018



- | | |
|-----------------------------|-------------------------|
| Broad-leaved forest | Hydrographic system |
| Coniferous forest | Waterways |
| Mixed forest | Administrative boundary |
| Natural grassland | Slope |
| Transitional woodland-shrub | |

Re-analysis of regional specificity _ Site 01

Flammable forest today



Re-analysis of regional specificity _ Site 01

Flammable forest today



Eucalyptus forest
(Source: The Portugal News)



Burning eucalyptus forest
(Source: Portugal's 'killer forest')

Portugal: 28 years ago a village fought against eucalyptus. The land never burned again

WRM Bulletin 238 9 July 2018

In 1989, there was a war in the valley of Lila, Portugal. Hundreds of people gathered to destroy 200 hectares of eucalyptus, fearing that the trees would rob them of their water and bring fire.

Issues: [Seeds of Hope](#) / [Seeds of Hope](#) / [Large-Scale Tree Plantations](#) / [Timber](#) / [Struggles Against Tree Monocultures](#)

Countries: [Portugal](#)

Special section: [21/09/2018](#)

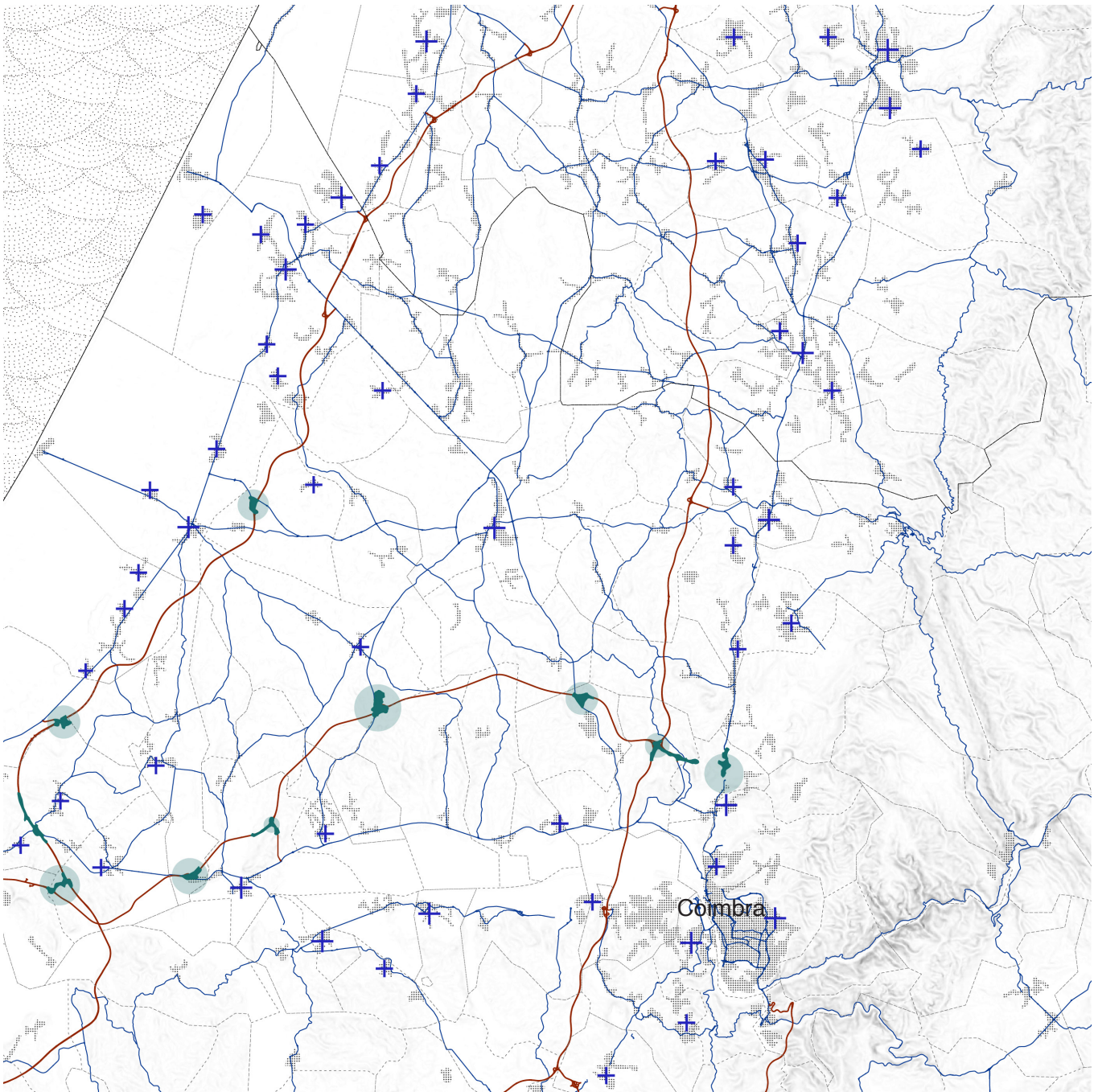
Languages: [English](#) / [Español](#) / [Français](#) / [Português](#)



"Violent" afforestation
(Source: World Rainforest Movement)

Re-analysis of regional specificity _ Site 01

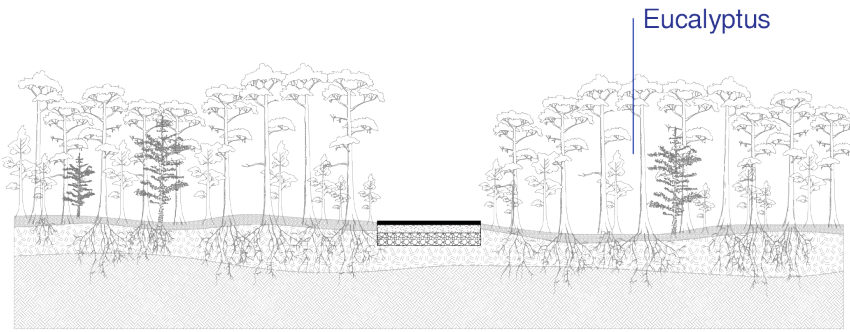
Mobility network & surroundings



0 2,5 5 km

- Primary road
- Secondary road
- Settlement
- Settlement along the mobility network

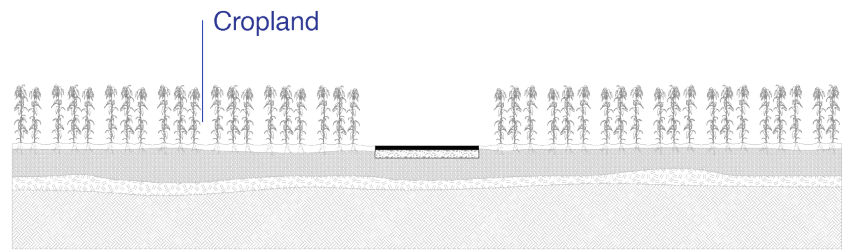
- Mobility associated land
- Community boundary
- EU NUTS 3



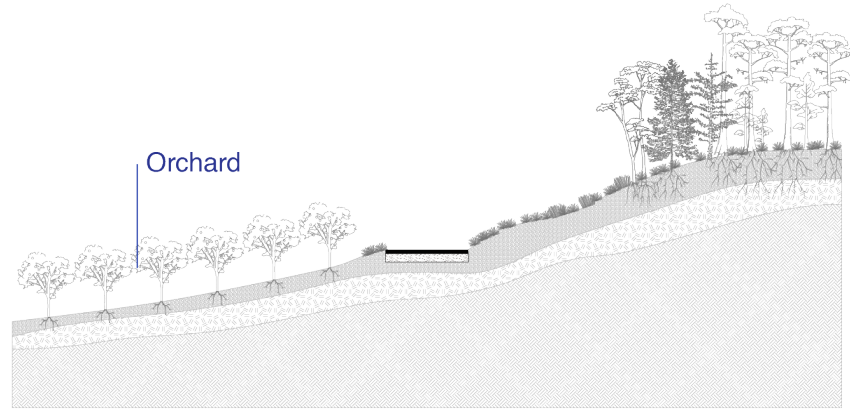
Section AA'



Section BB'



Section CC'

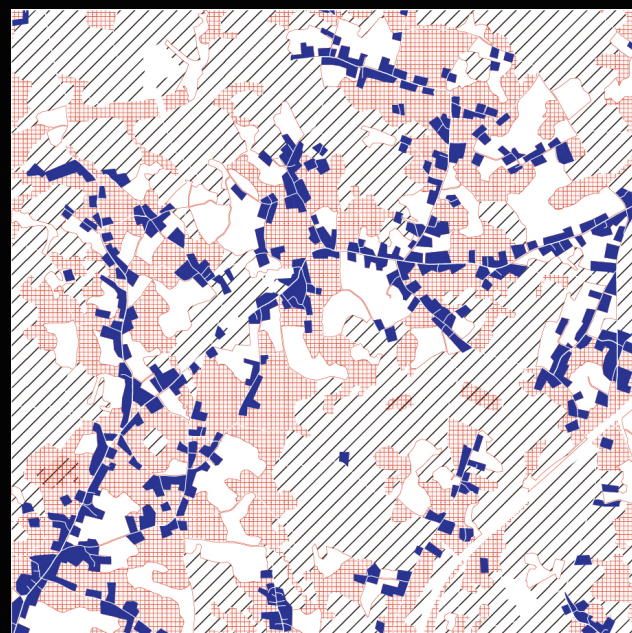


Section DD'

Re-analysis of regional specificity _ Site 01

Urban wildland interface

01 Finger-shaped



■ Built surface ■ Forest ■ Cropland ■ Pasture

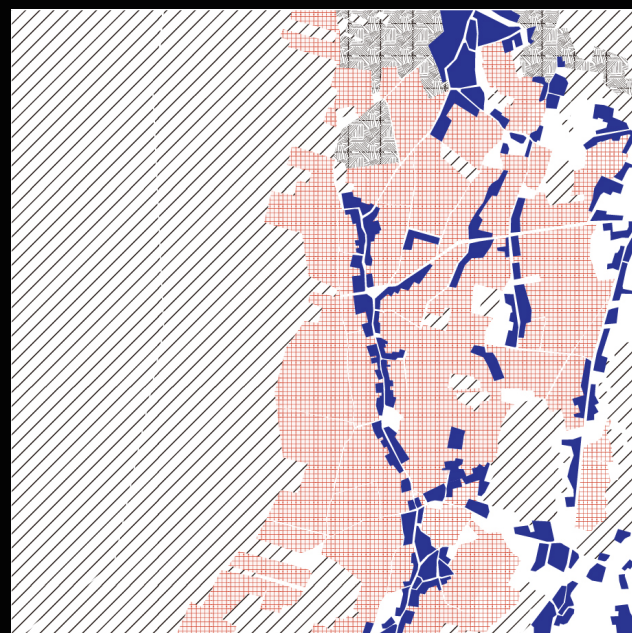


Source: <https://florestas.pt/valorizar/baldios-o-passado-e-o-presente-das-terras-comuns/>

Re-analysis of regional specificity _ Site 01

Urban wildland interface

02 Transition



Built surface Forest Cropland Pasture

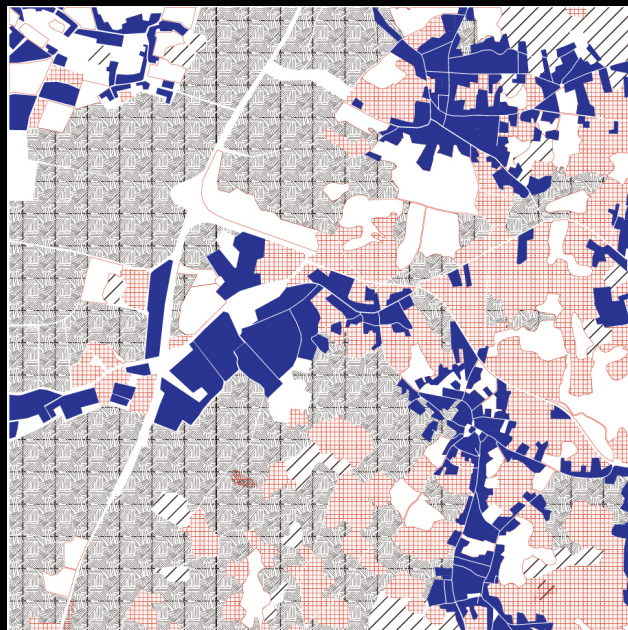


Source: <https://florestas.pt/conhecer/o-uso-do-fogo-em-portugal-da-tradicao-a-tecnica/>

Re-analysis of regional specificity _ Site 01

Urban wildland interface

03 Cropland-surrounded



■ Built surface ■ Forest ■ Cropland ■ Pasture

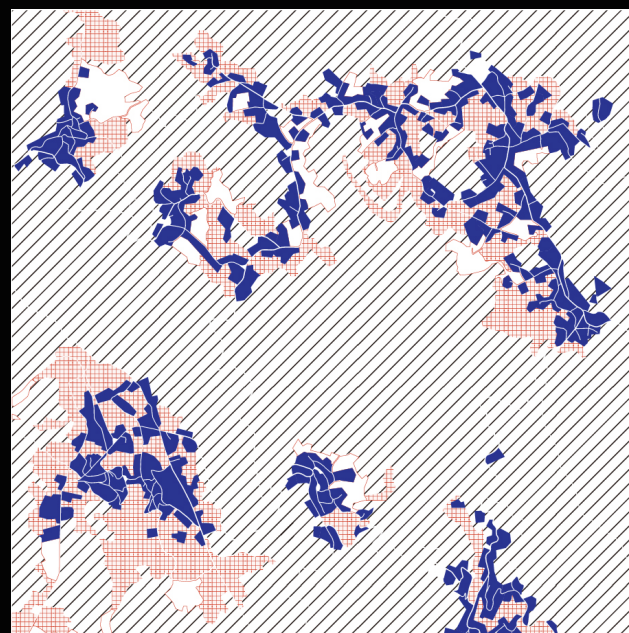


Source: Julie Dawn Fox

Re-analysis of regional specificity _ Site 01

Urban wildland interface

04 Forest-surrounded



Built surface Forest Cropland Pasture



Source: <https://issuu.com/gsdharvard/docs/canary-in-the-mine/s/16382651>

Re-analysis of regional specificity _ Site 01

Flows of community unit and common land

External rural-urban flows

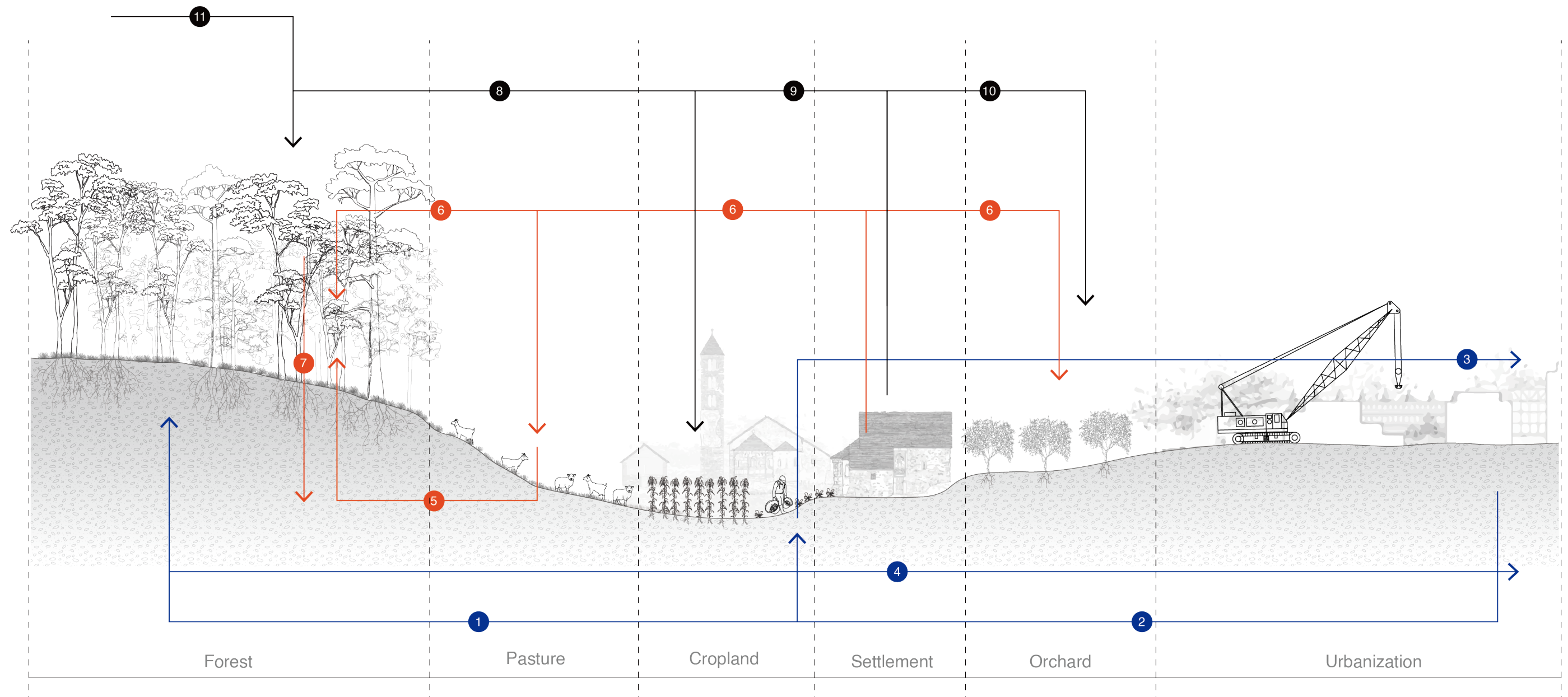
- 1 Utilization of forests by villagers
- 2 Urban technique support
- 3 Depopulation of villages
- 4 Wood production transport

Internal flows of village

- 5 Fuel consumption from grazing
- 6 Operations on silviculture, grazing and agricultural planting
- 7 Nutrient exchange with soil

Flows of forest and agriculture management

- 8 Management on cropland from urban agency
- 9 Management on cropland from rural agency
- 10 Orchard management
- 11 Forest management



Re-analysis of regional specificity _ Site 01

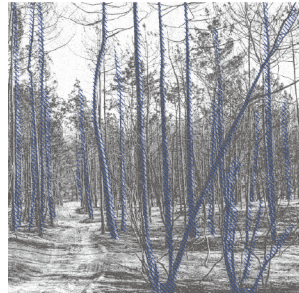
Conclusion of re-analysis



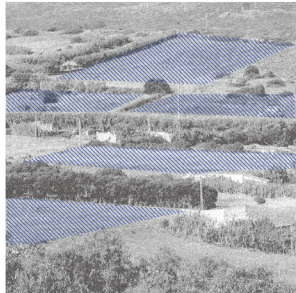
Agro-silvo-pastoral-ism (Montado)



Violence of forestation



Common land restoration (Baldio)



Recreation place



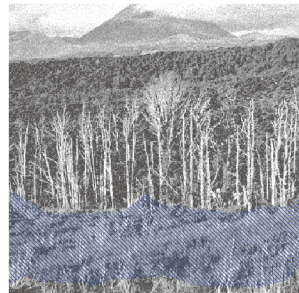
Mobility construction



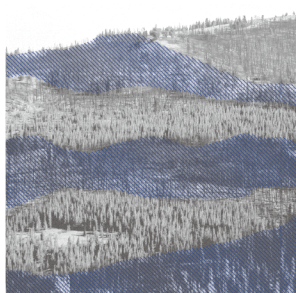
Rural community



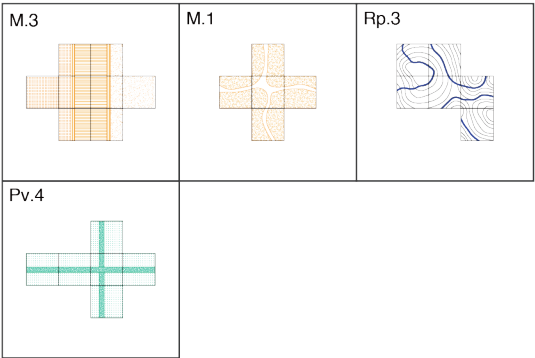
Unmanaged wildland



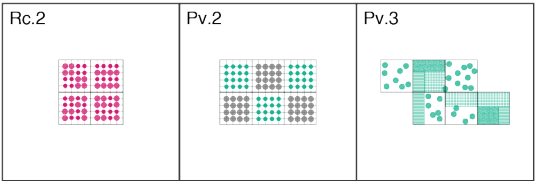
Burned scar



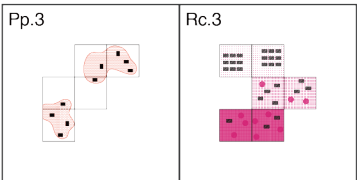
- M.3 Transitional buffer
- M.1 Vegetation fire-breaking
- Rp.3 Terrain control lines
- Pv.4 Linear productive grazing



- Rc.2 Smart reforestration
- Pv.2 Fuel spatial modification
- Pv.3 Agroforestry mosaics



- Pp.3 Community as territory
- Rc.3 Land use replanning



STRATEGY A
Regional fire break network

STRATEGY B
Fuel spatial modification

STRATEGY C
Community-based management

Design intervention :

Strategy A: Regional fire break network

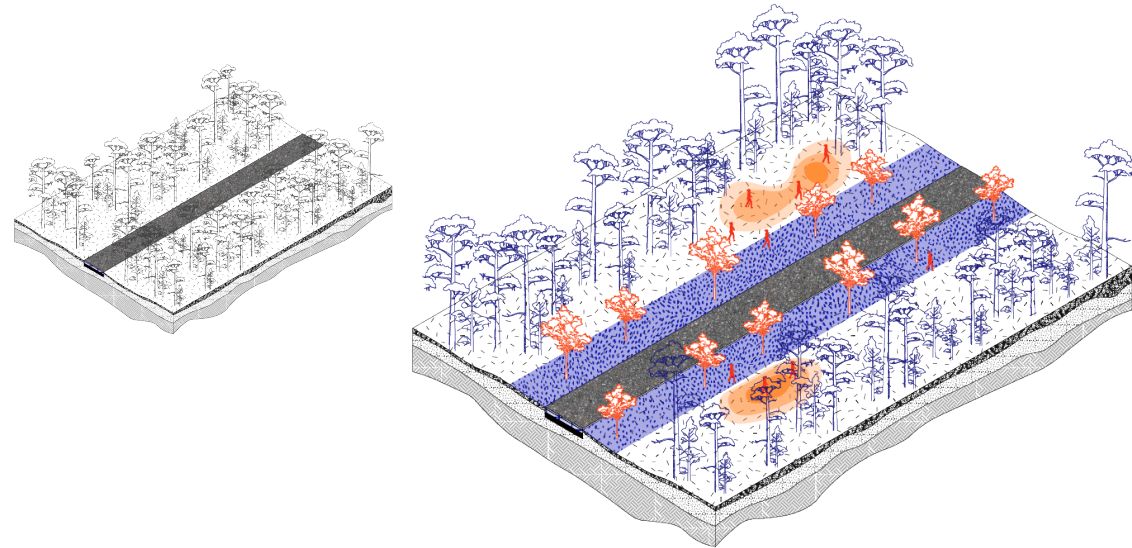
Strategy B: Fuel spatial modification

Strategy C: Community-based management

Design Intervention _ Site 01
Strategy A: Regional fire break network

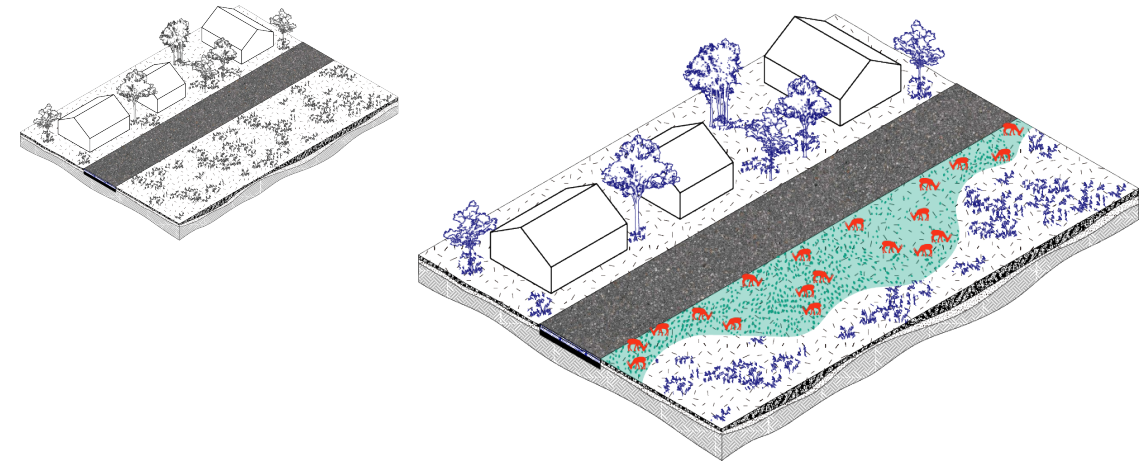
Type 1

Thining operation in the dense conifer and eucalyptus forest



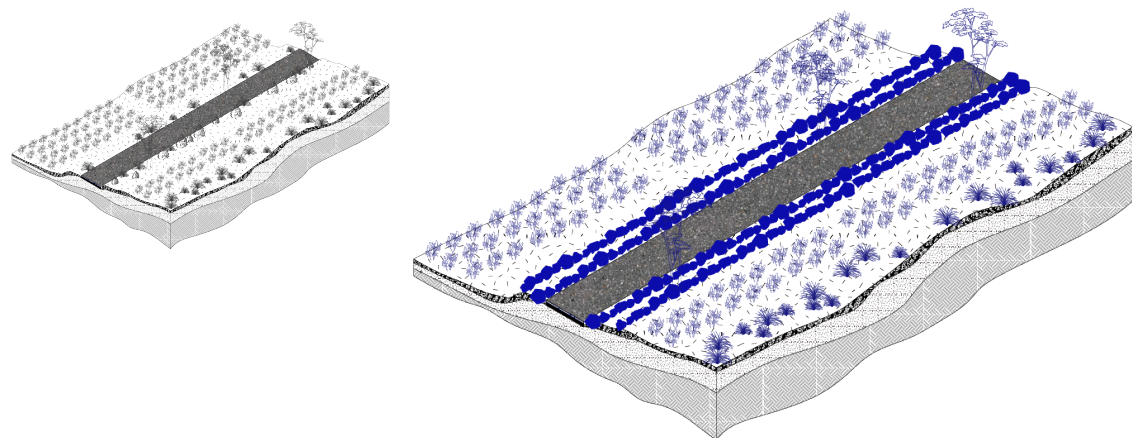
Type 2

Linear grazing along the settlement mobility network



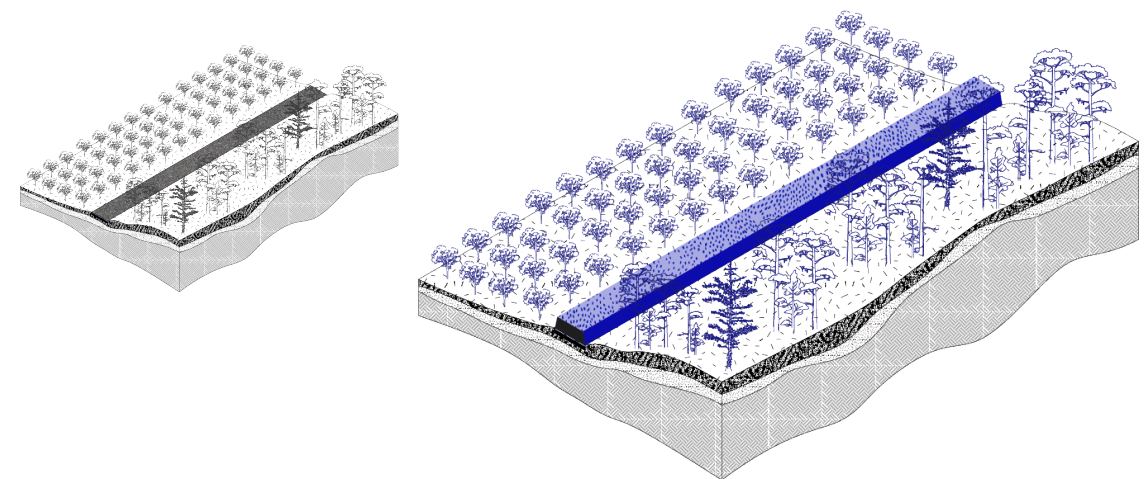
Type 3

Fire control line along roadbed in the hill cropland



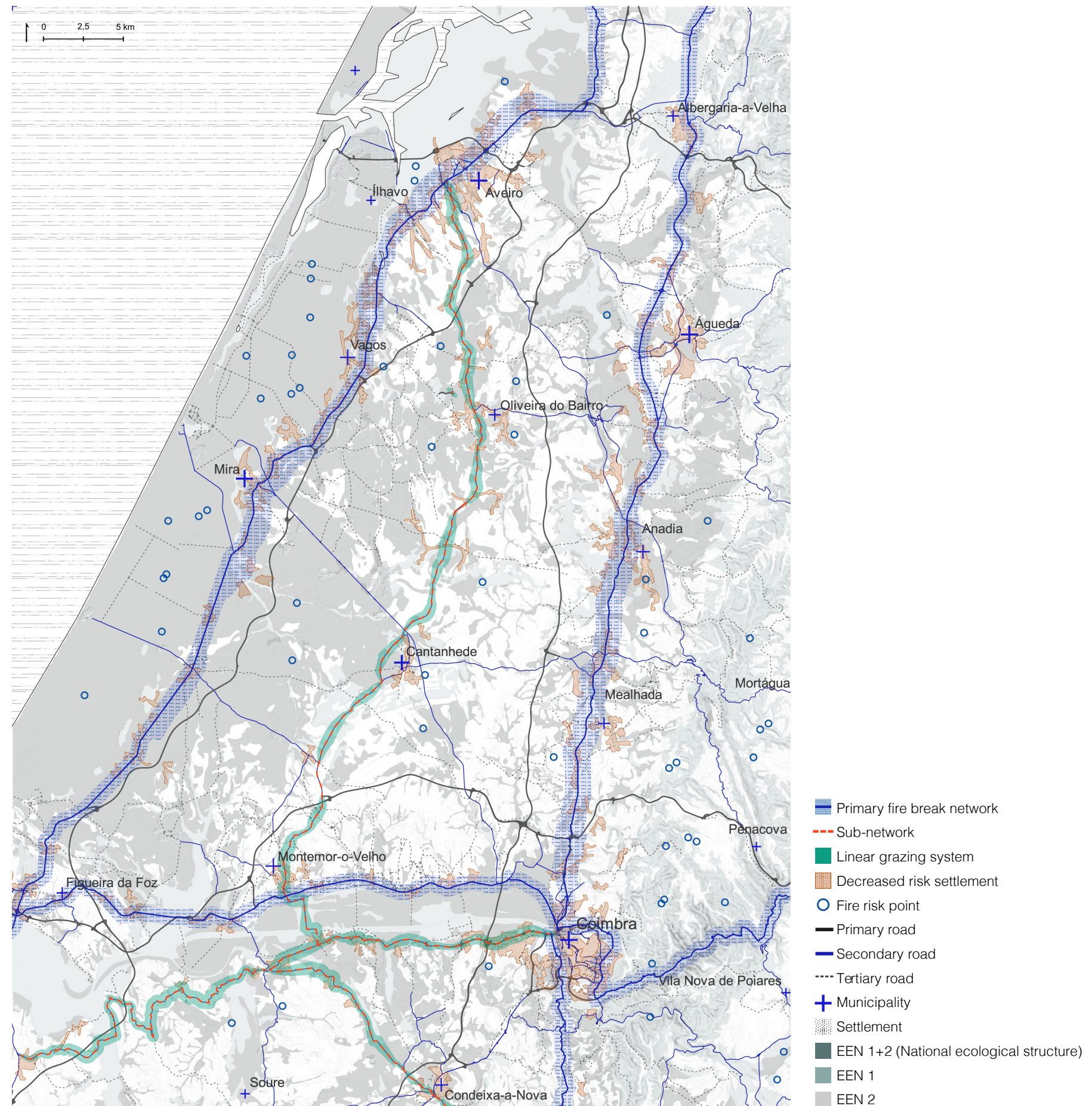
Type 4

Raised hill roadbed between wild forest and orchards

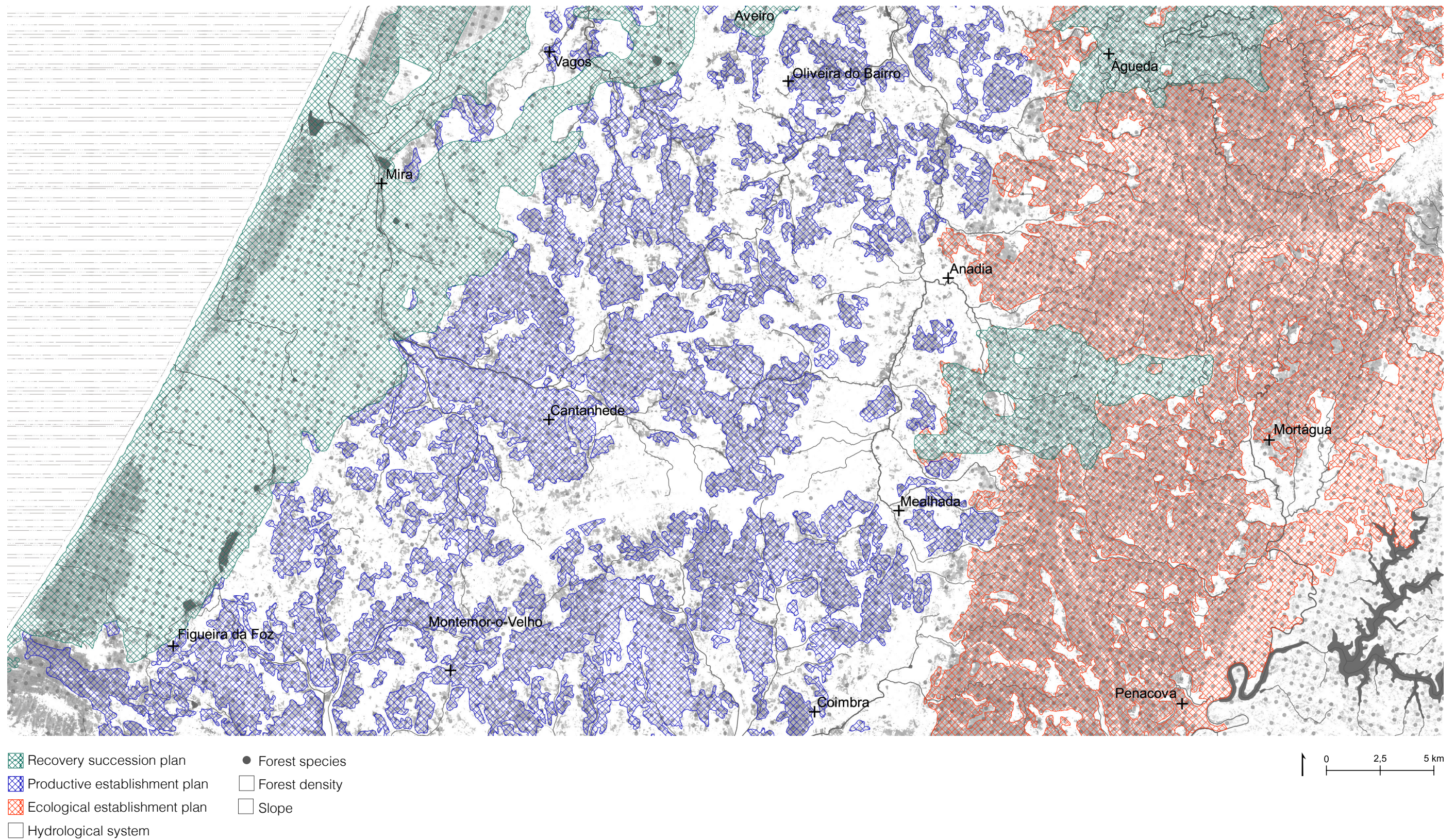


Design Intervention _ Site 01

Strategy A: Regional fire break network



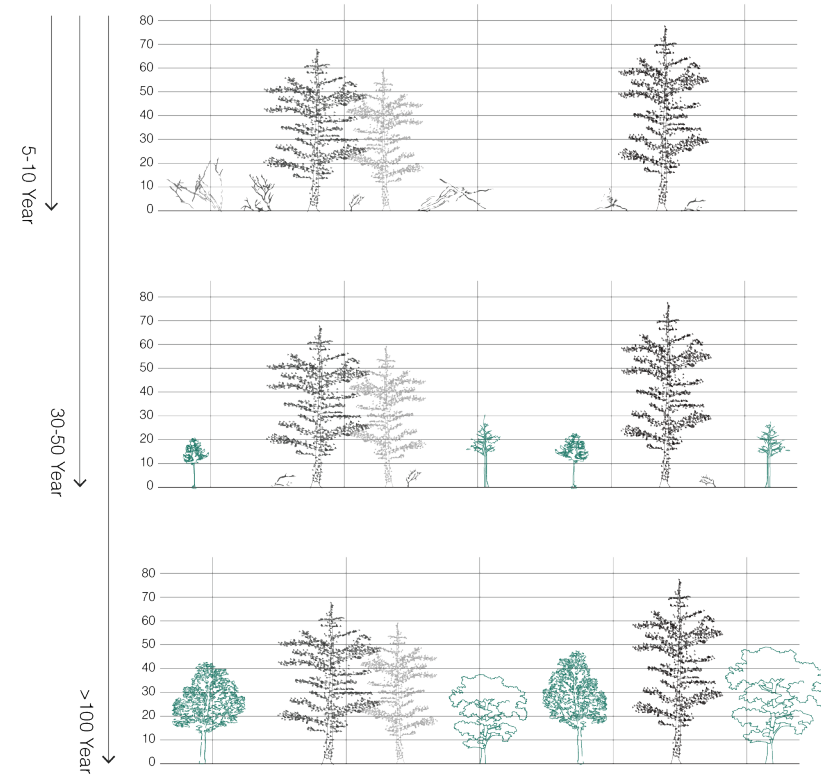
Design Intervention _ Site 01
Strategy B: Fuel spatial modification



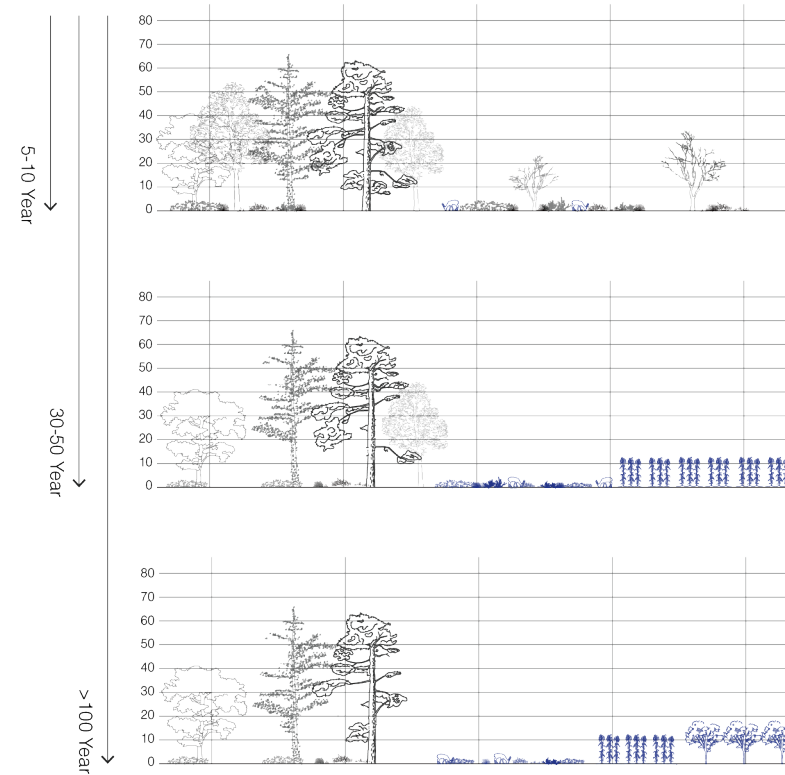
Design Intervention _ Site 01

Strategy B: Fuel spatial modification

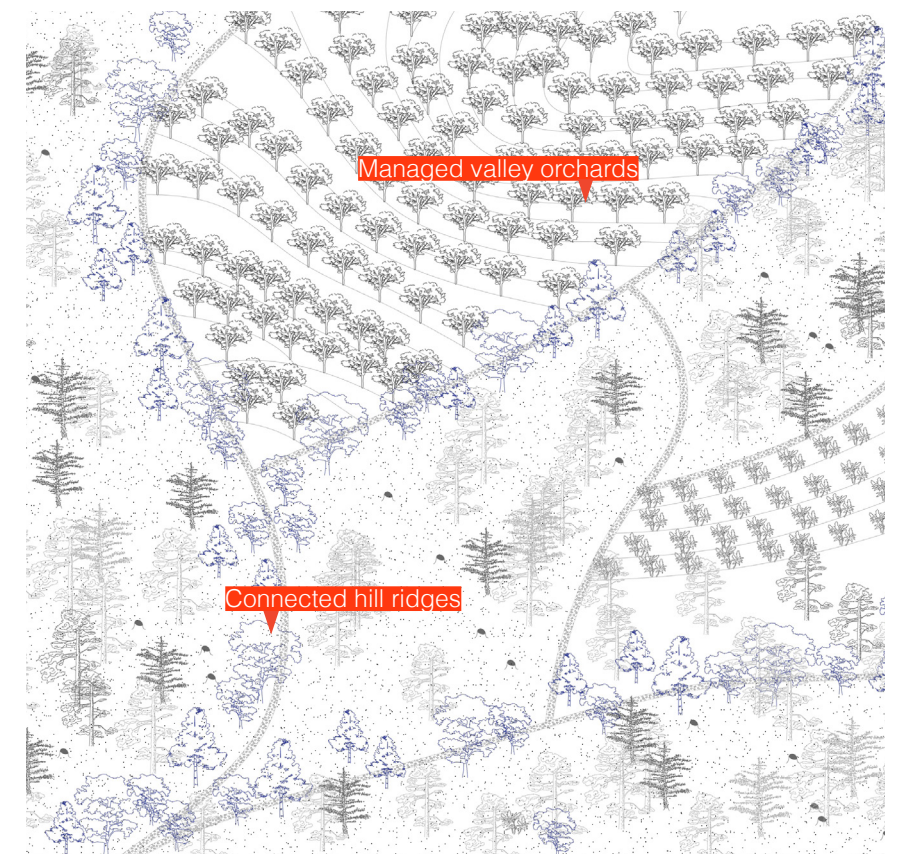
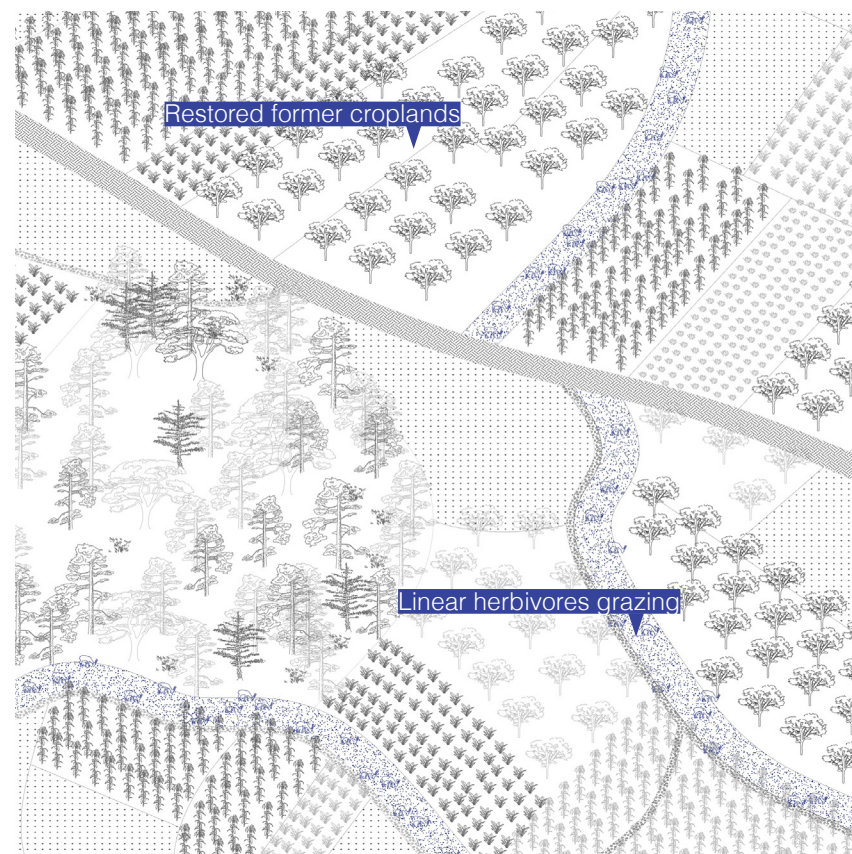
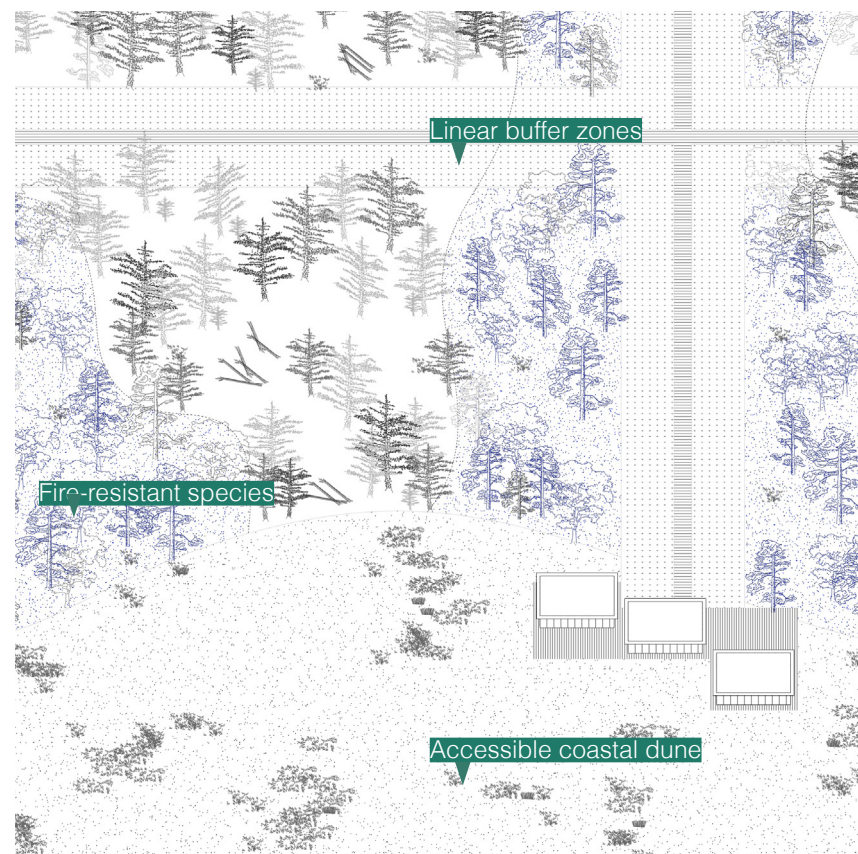
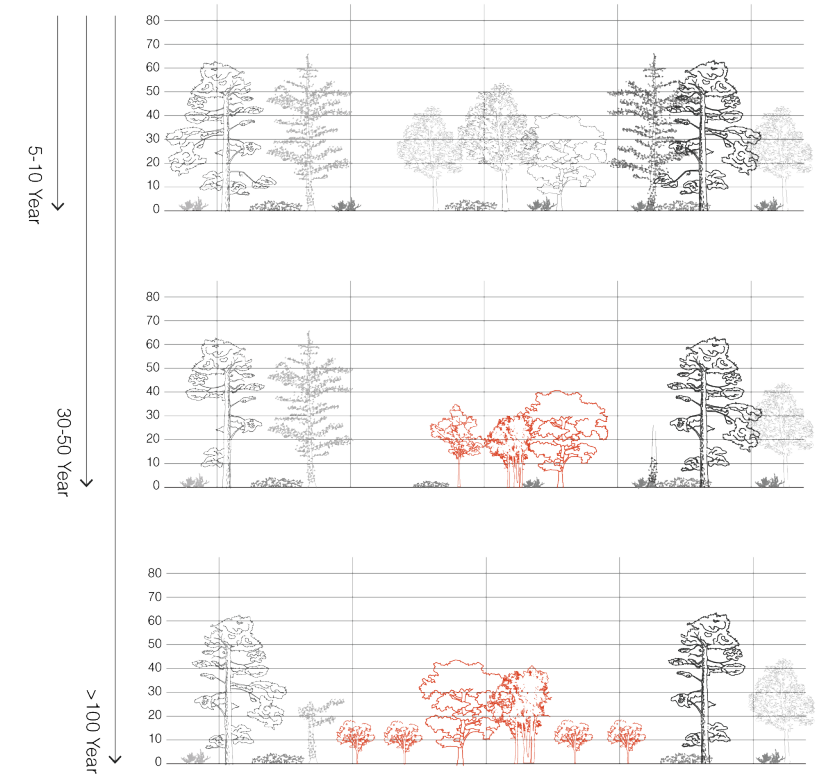
Recovery Succession



Productive Establishment

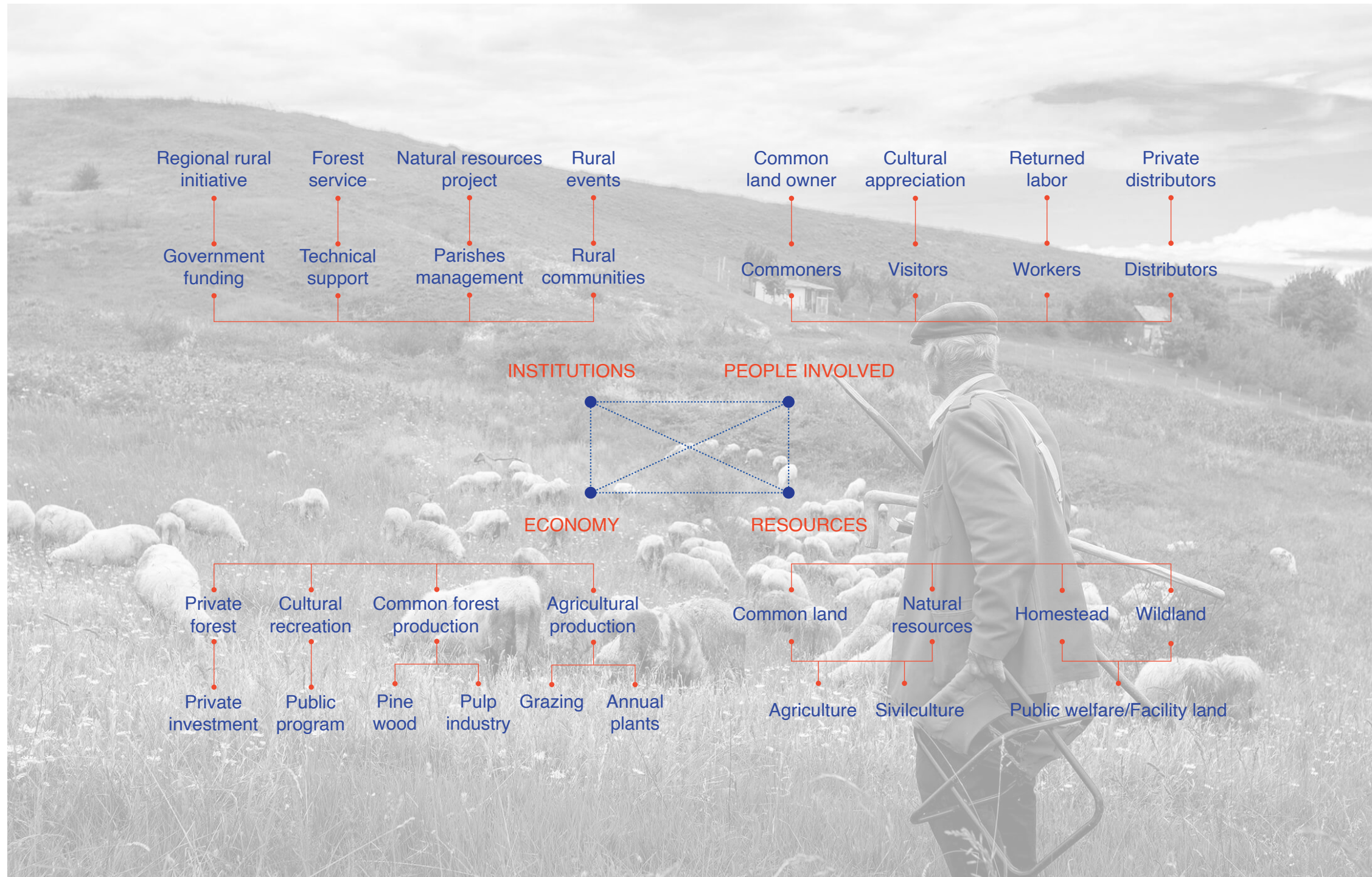


Ecological Establishment



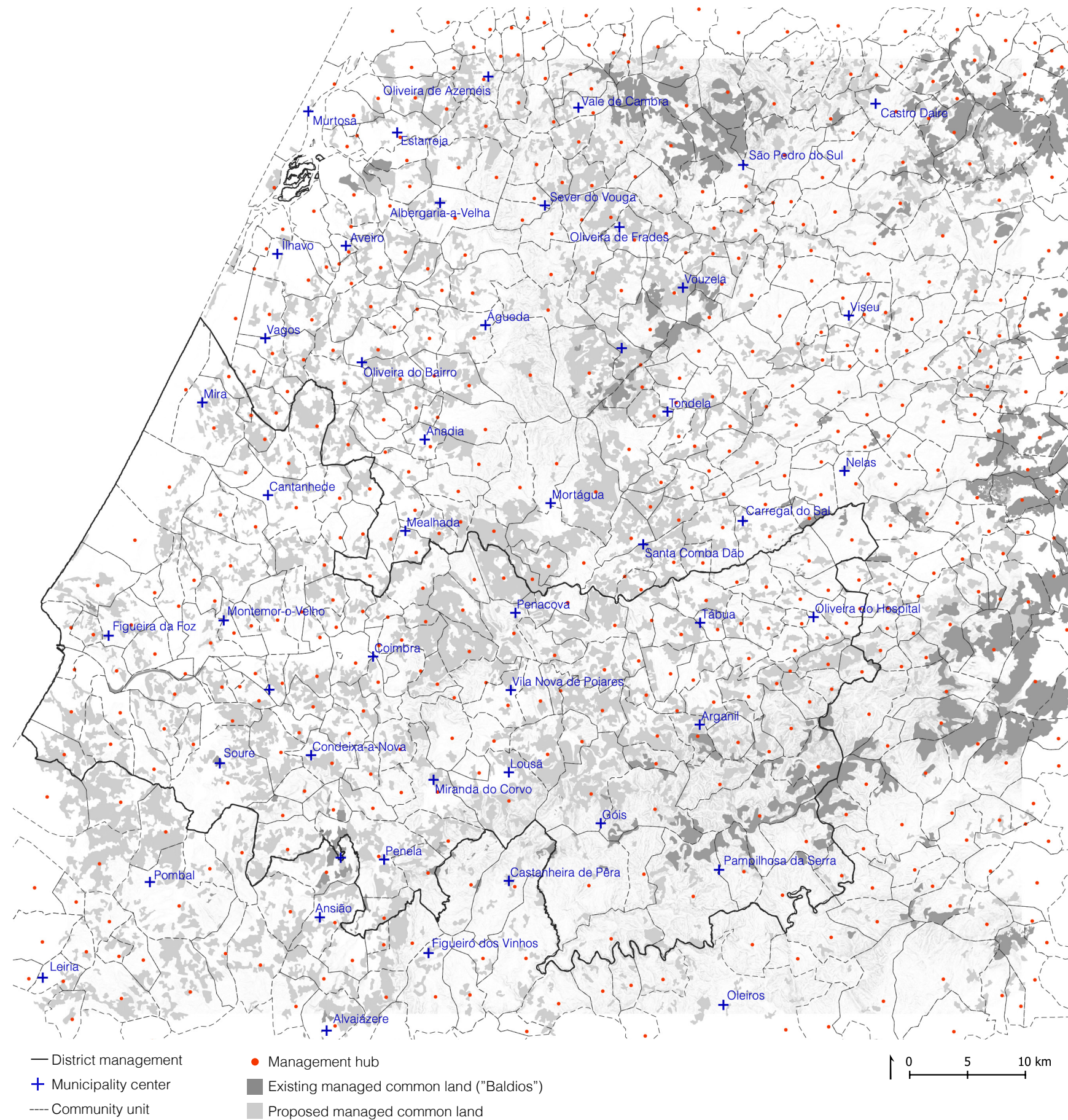
Design Intervention _ Site 01

Strategy C: Community-based management



Design Intervention _ Site 01

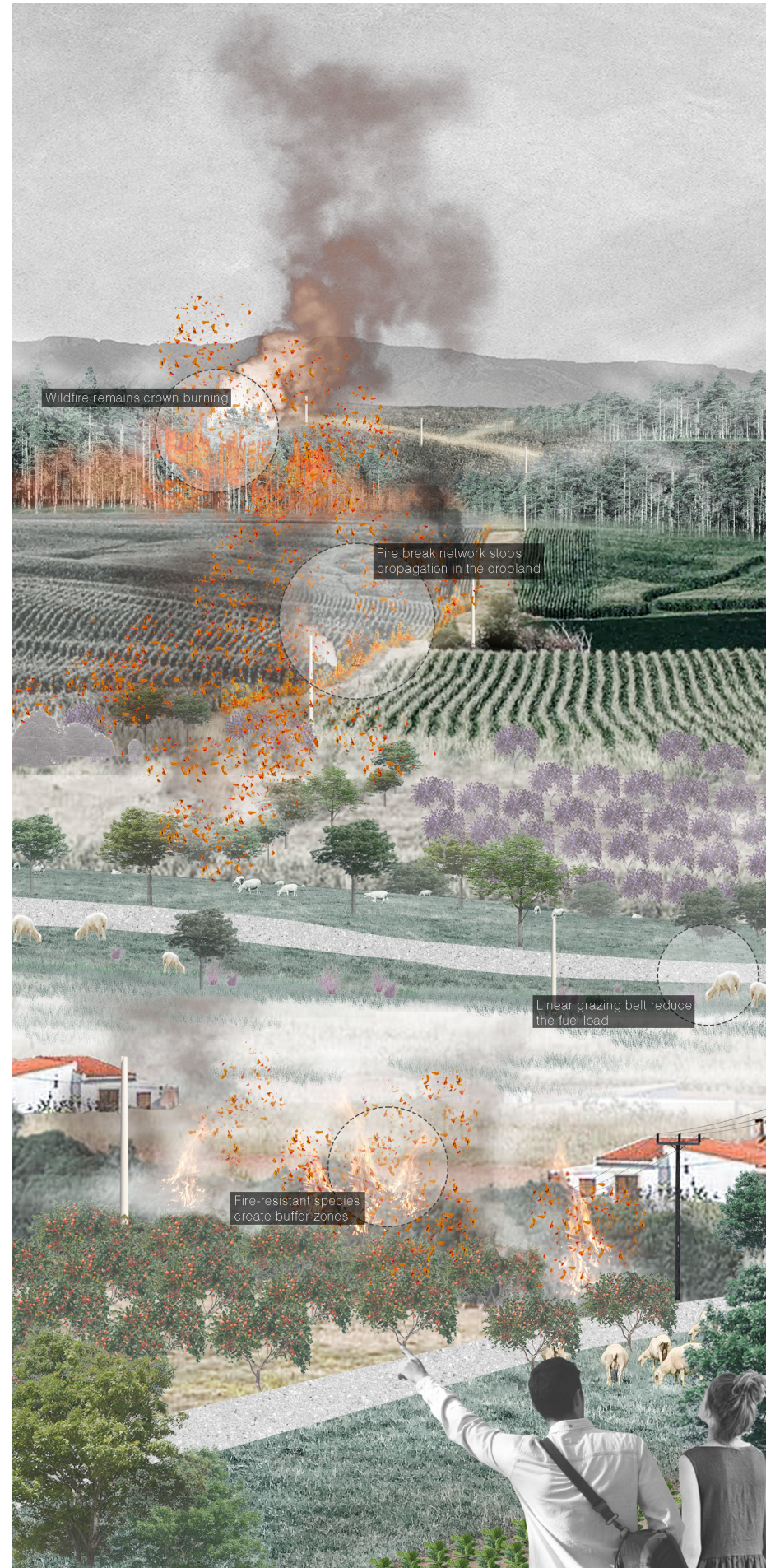
Strategy C: Community-based management



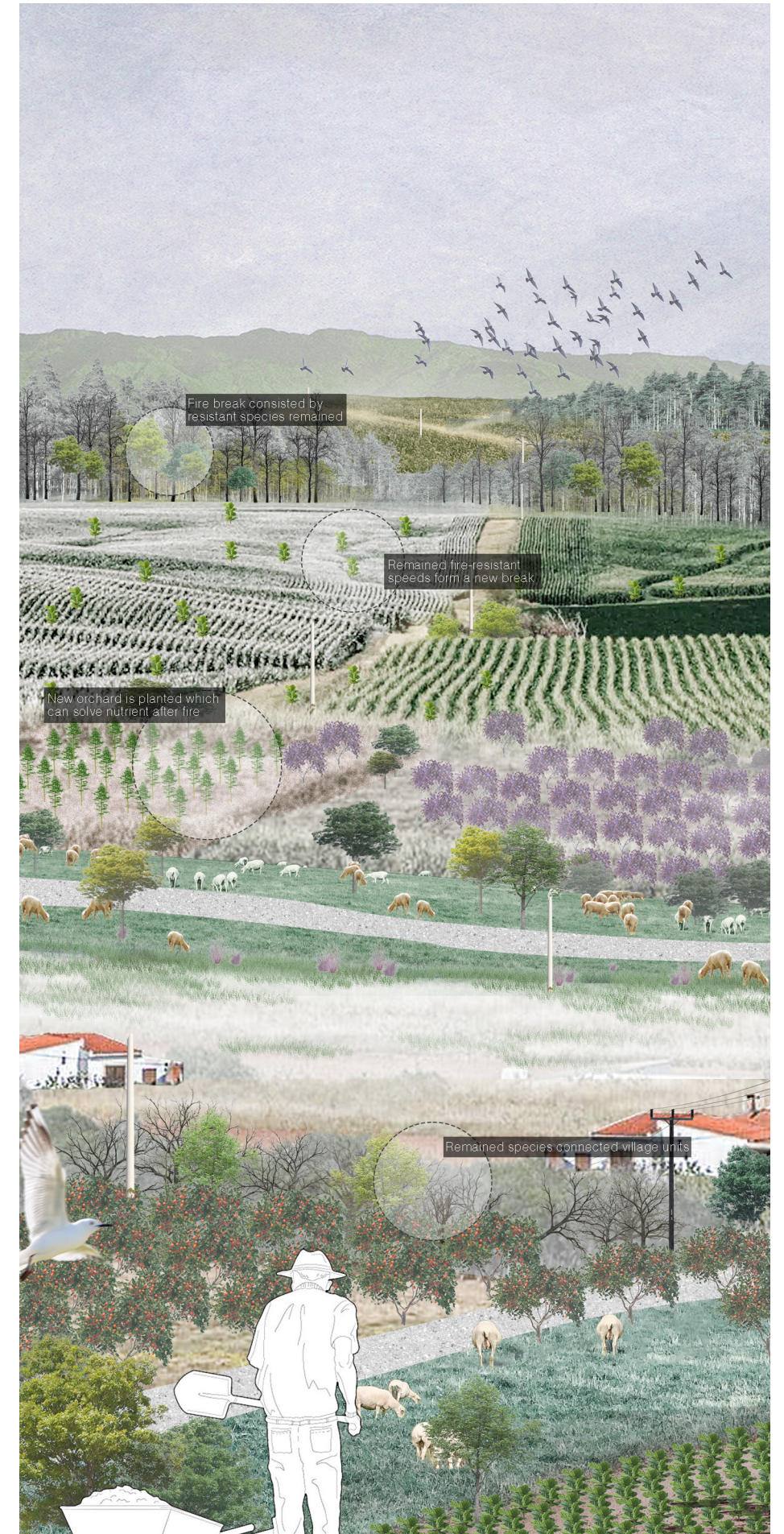
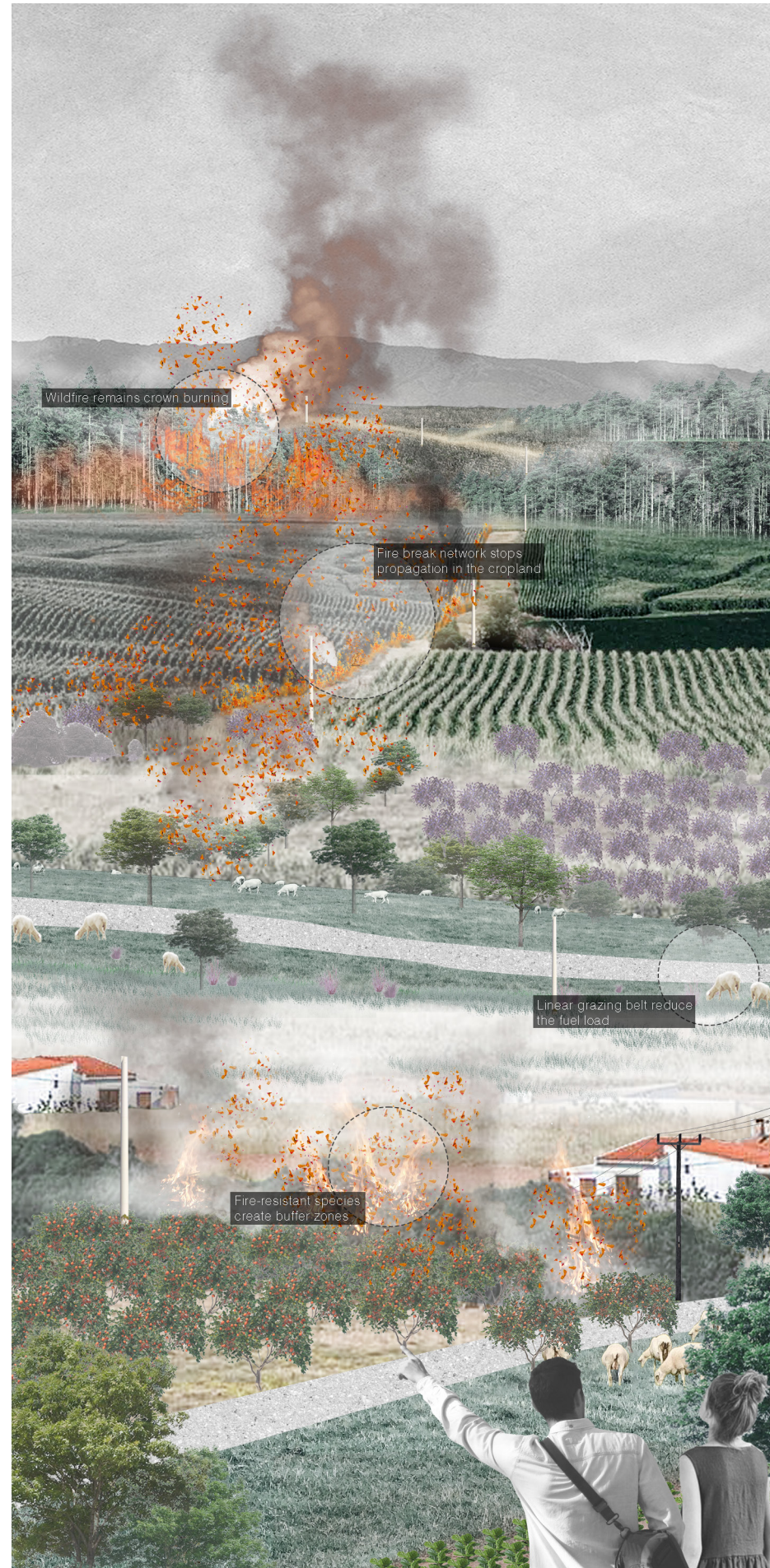
Design Intervention _ Site 01



Design Intervention _ Site 01



Design Intervention _ Site 01



Re-analysis :

Site 02_Populated coast typology

Alicante, SP

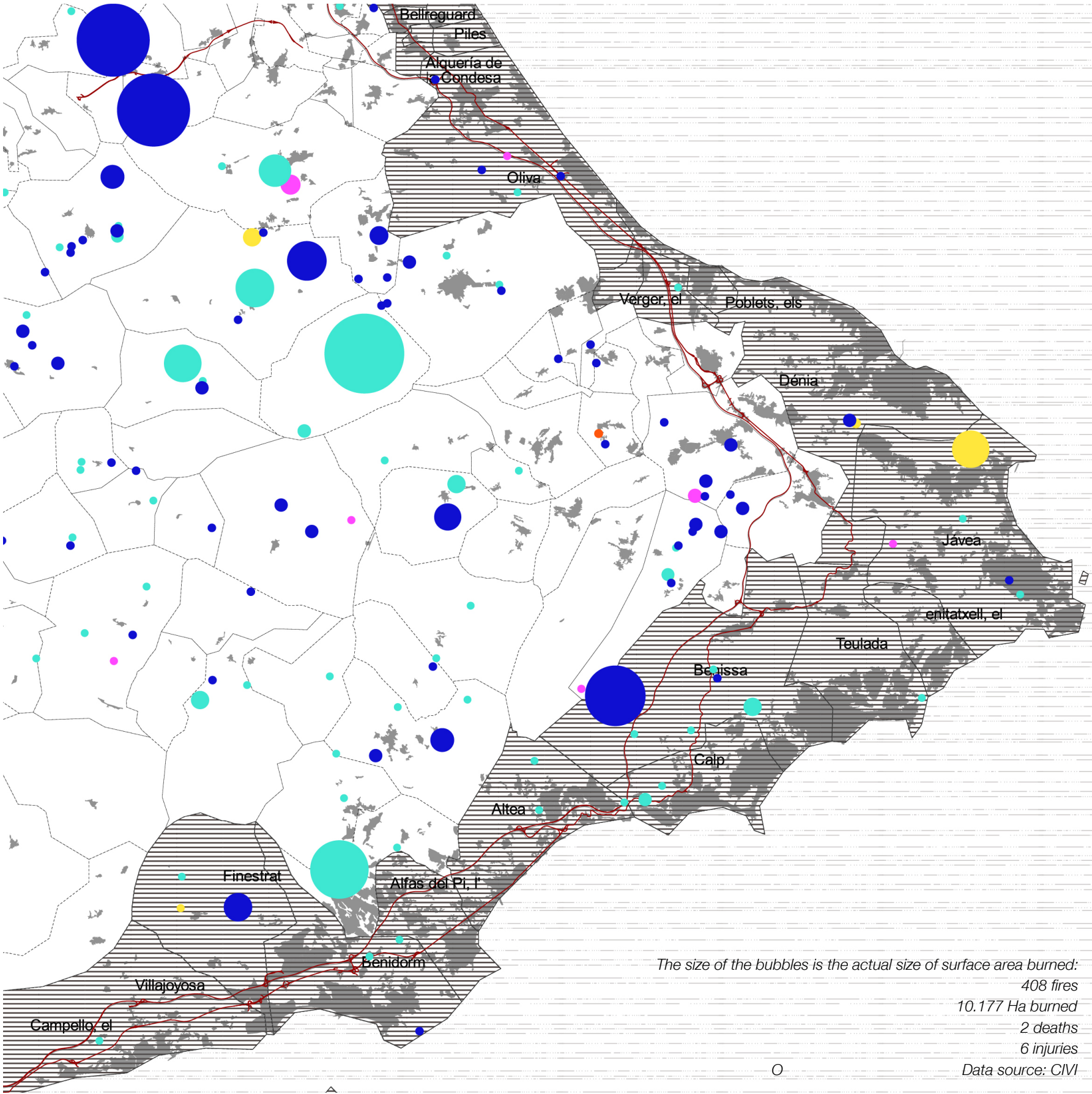


What is the process of littoralisation like?

How can littoralisation and seasonal variations in tourism make this region vulnerable?

Re-analysis of regional specificity _ Site 02

Fire category



Re-analysis of regional specificity _ Site 02

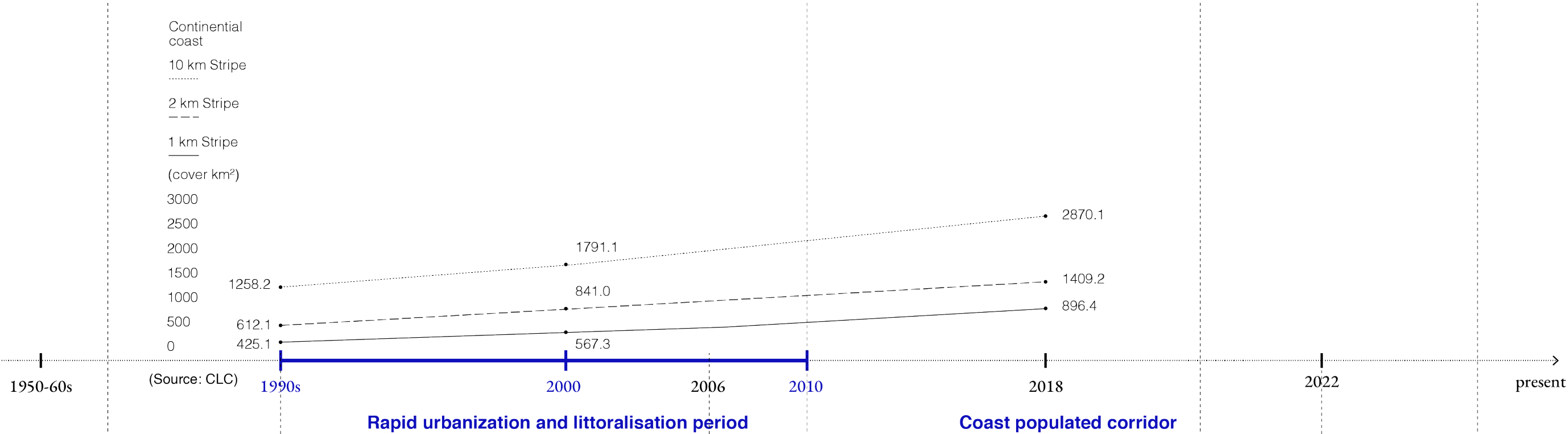
Littoralisation process

Peri-urbanization process
started slowly

Peak of the urbanization
process

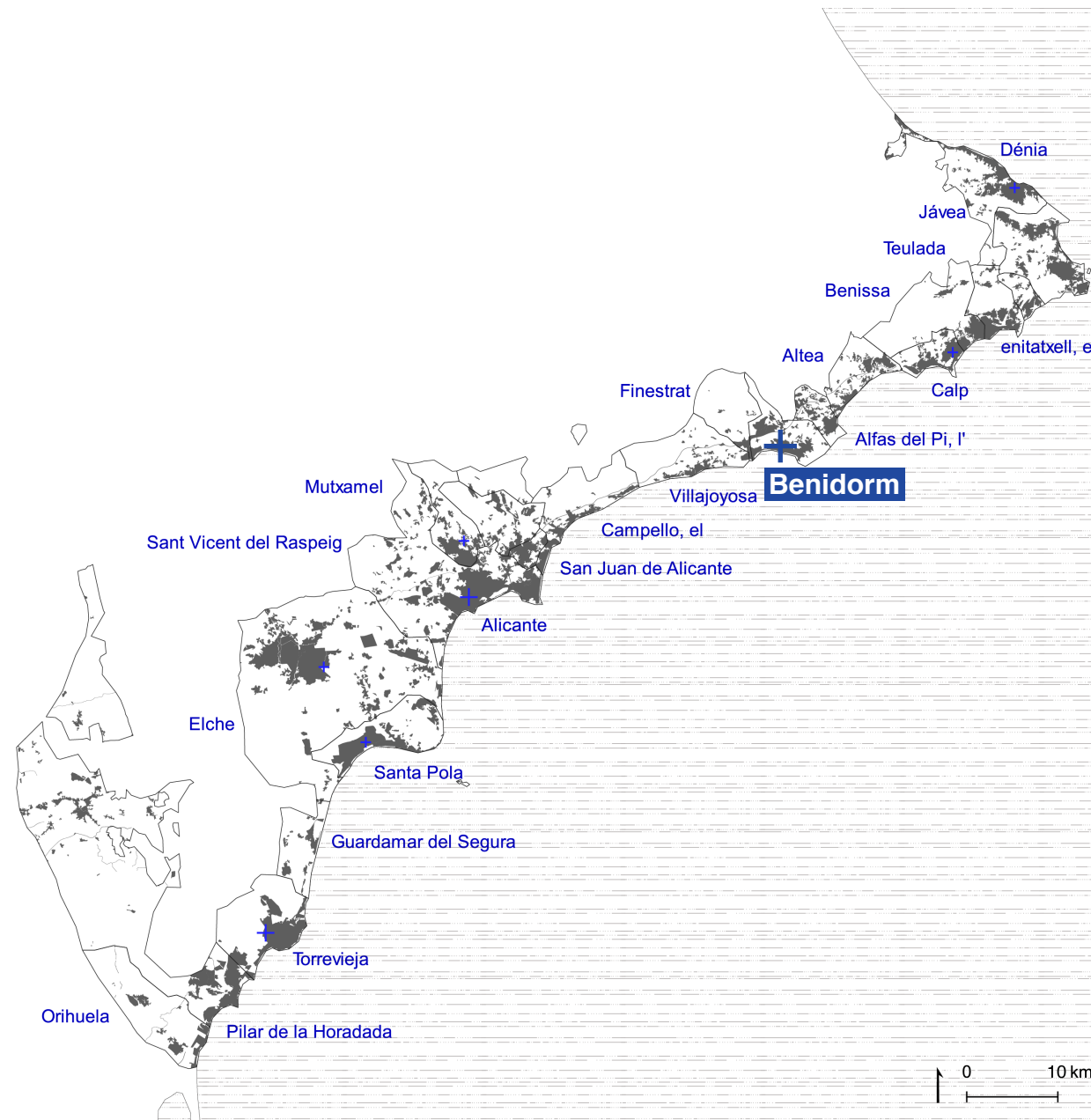
" Wall of cement "

Environmental
degradation



Re-analysis of regional specificity _ Site 02

Littoralisation process, Benidorm city



Re-analysis of regional specificity _ Site 02

Littoralisation process, Benidorm city

Before "tourism boom", Benidorm in 1950s, Posted by cbts on 4 December, 2020



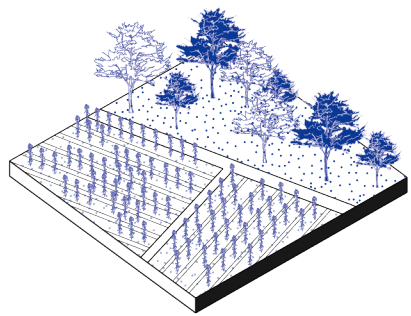
Benidormcoastal urbanization in 2022, photography by Sonneil

Re-analysis of regional specificity _ Site 02

Littoralisation process, Benidorm city

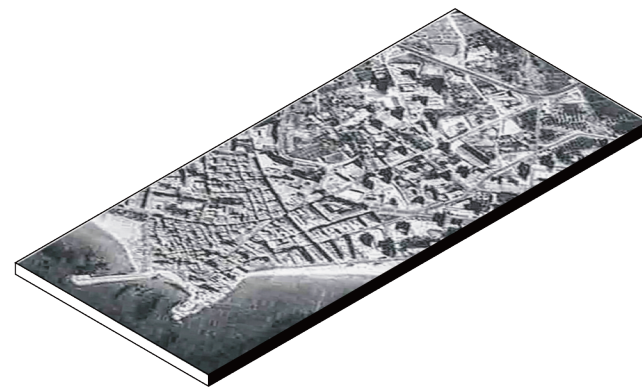
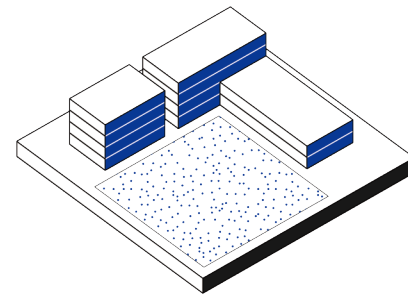
Stage 1

Traditional town + Active agricultural land



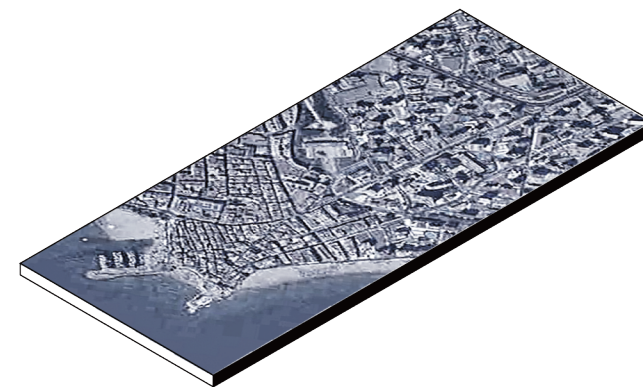
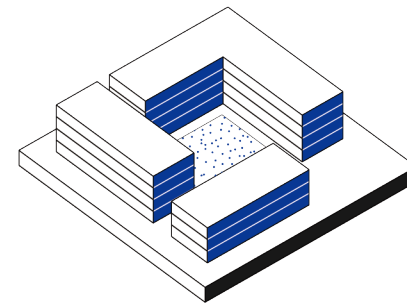
Stage 2

Leisure area + Abandoned agricultural land



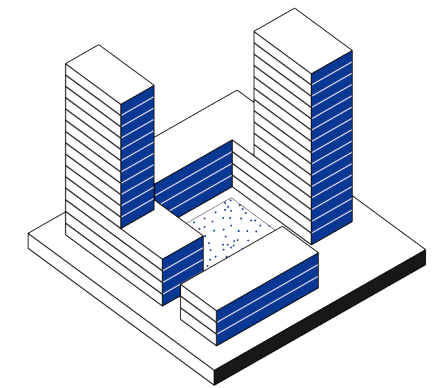
Stage 3

Low density + Horizontal urbanism



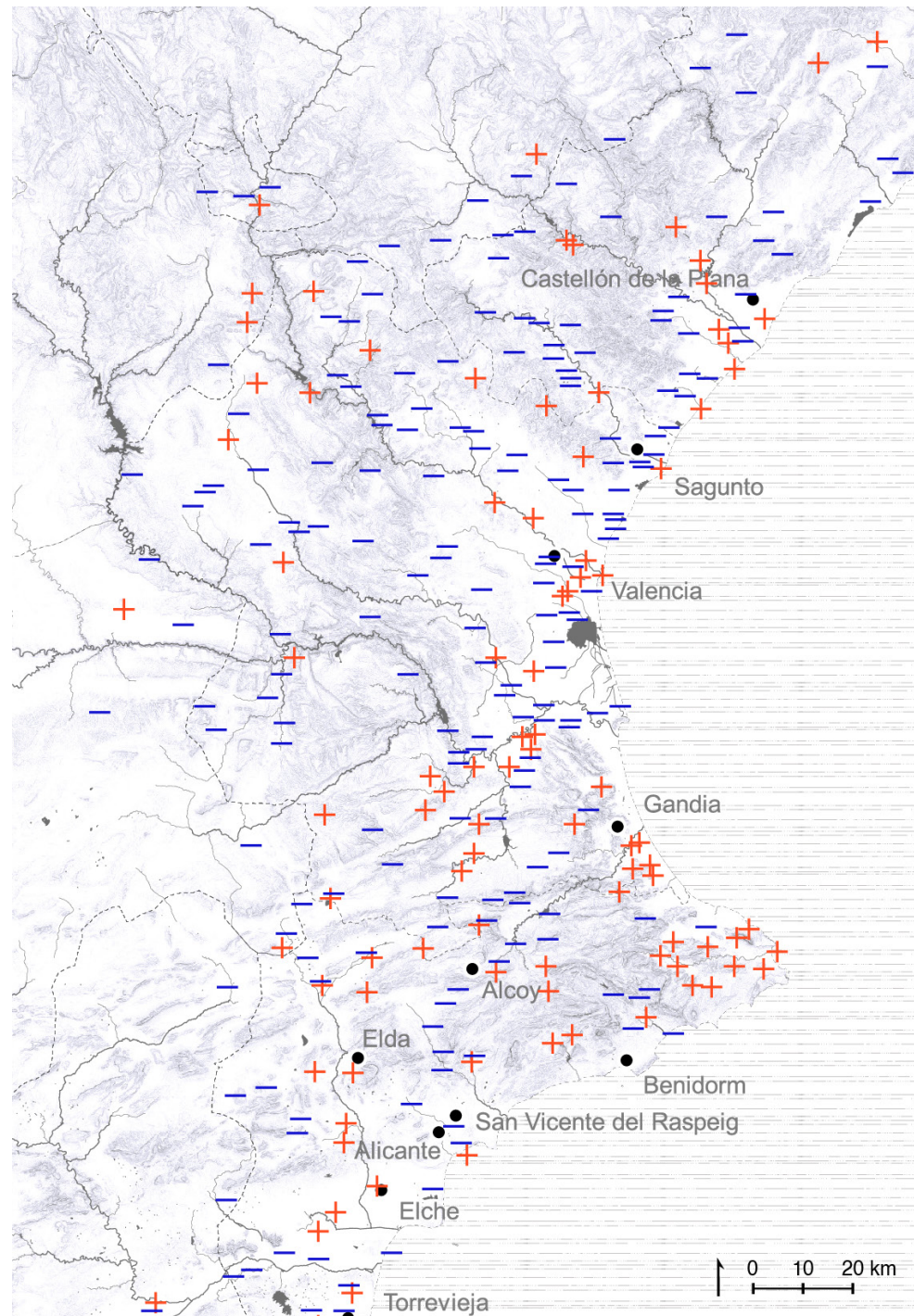
Stage 4

High density + Vertical urbanism

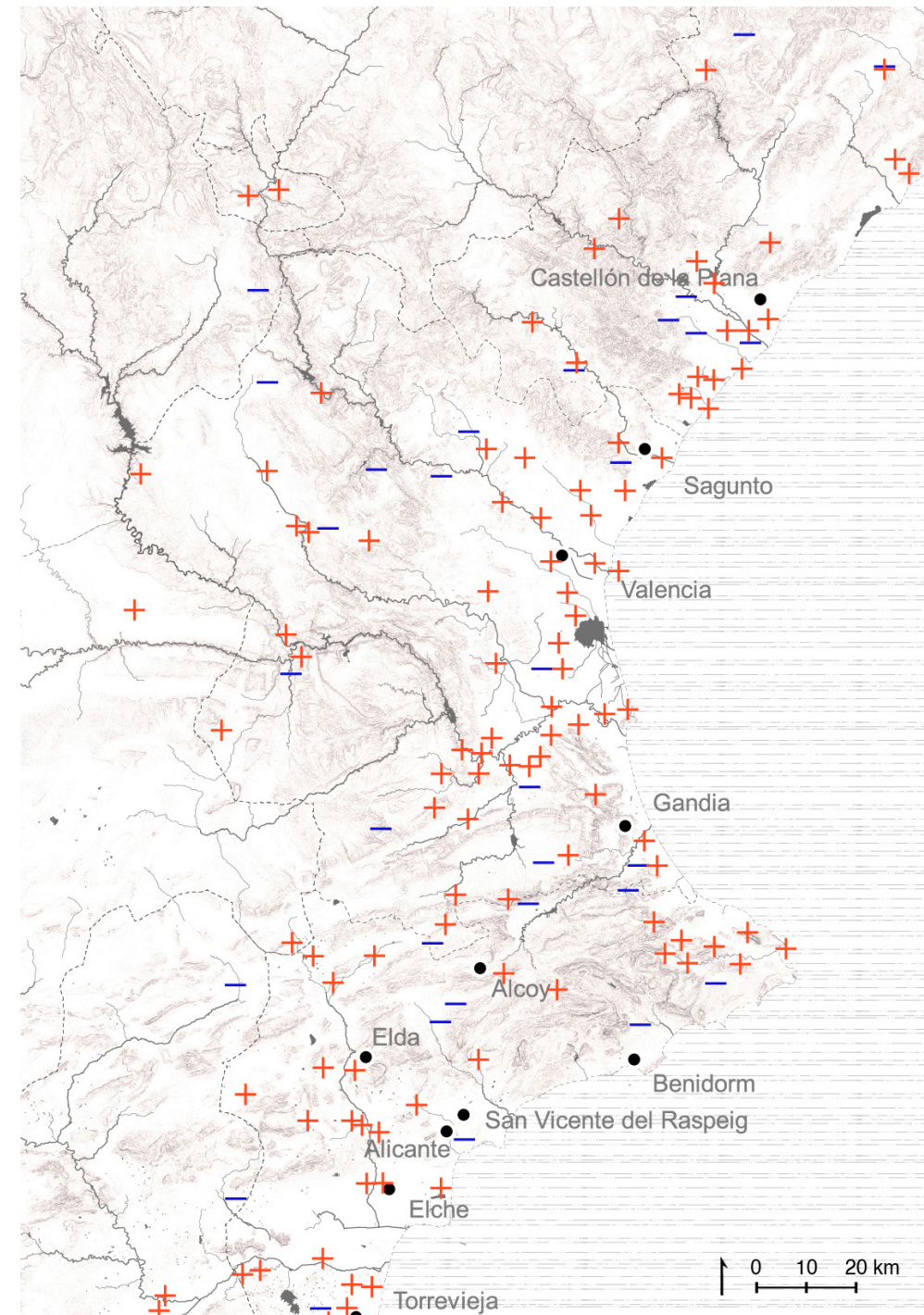


Re-analysis of regional specificity _ Site 02

Climate change



Summer rainfall



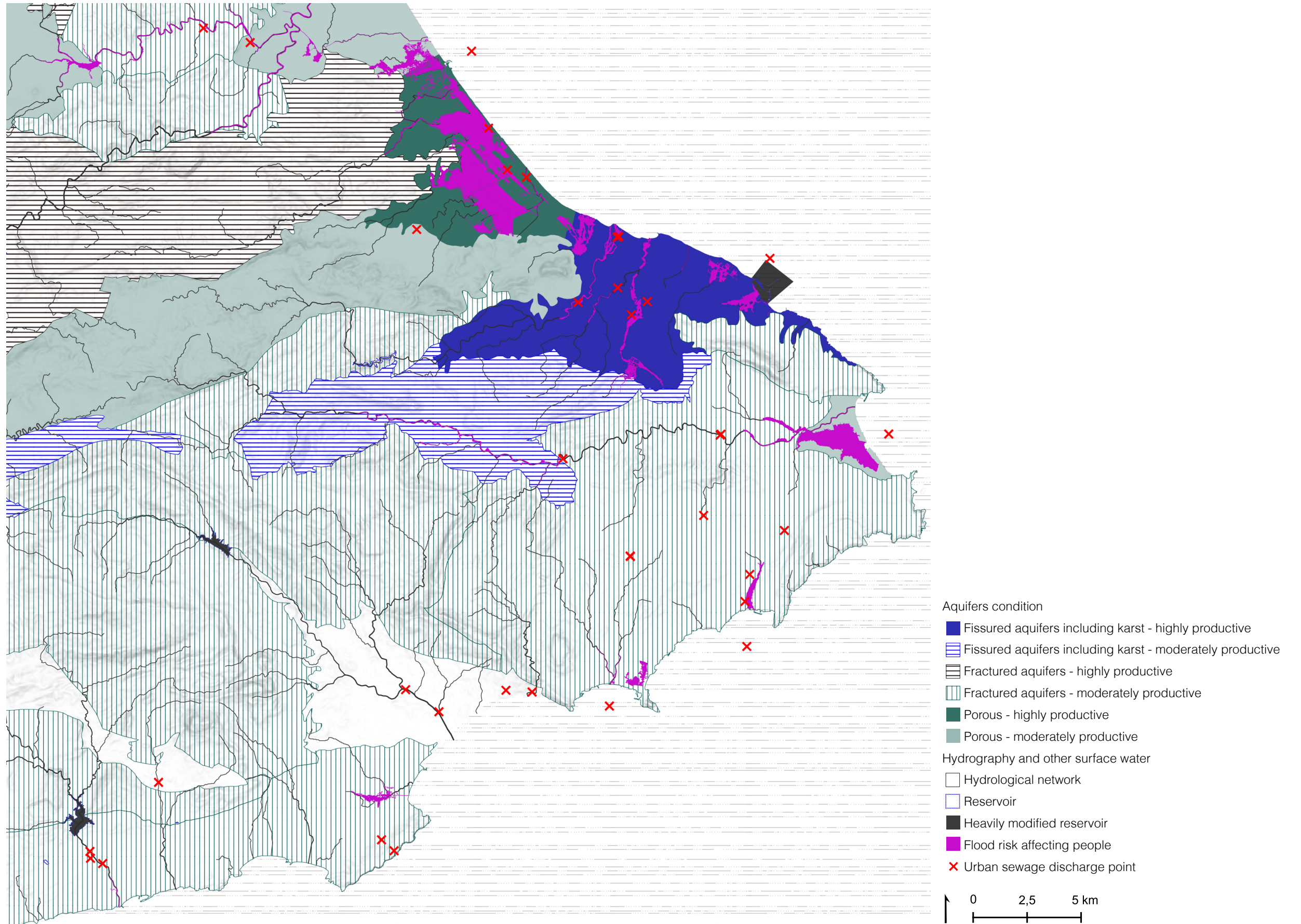
Summer temperature

Trends of increase + and decrease - (1950-2000)

Data source: Climatic data from 350 meteorological stations, National Meteorological Service

Re-analysis of regional specificity _ Site 02

Water challenges



Re-analysis of regional specificity _ Site 02

Conclusion of re-analysis

LANDSCAPE CRITERIA

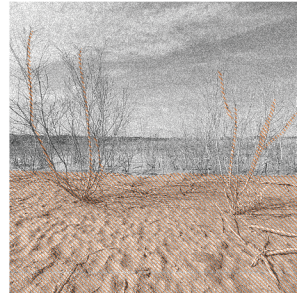
TOOLKITS APPLICATION

FIRE ADAPTIVE RESILIENCE

Hydrological system



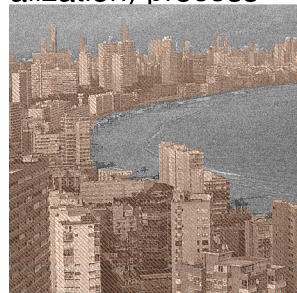
Water scarcity



Extreme heatwave



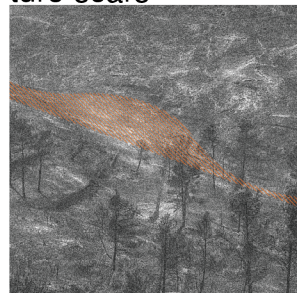
Urbanization (Littoralization) process



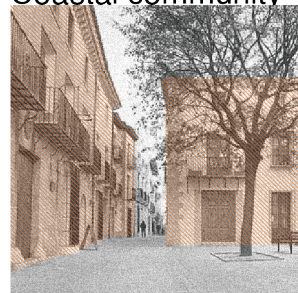
Coastal leisure area



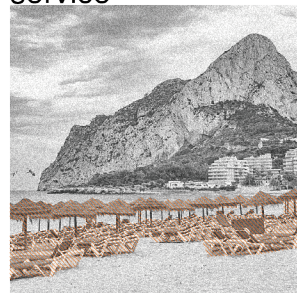
Burned infrastructure scars



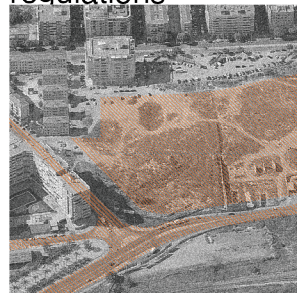
Coastal community



Seasonal tourism service



Urban planning & regulations

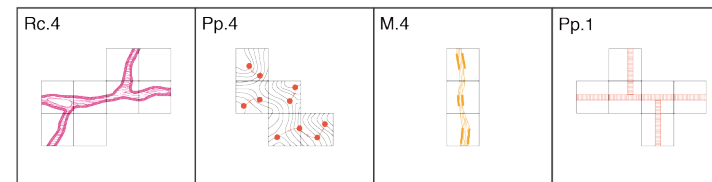


Rc.4 Watershed protection

Pp.4 Multifunctional cascading water system

M.4 Rewetting infrastructure

Pp.1 Escape route planning



STRATEGY A
Hydrography-based fire mitigation

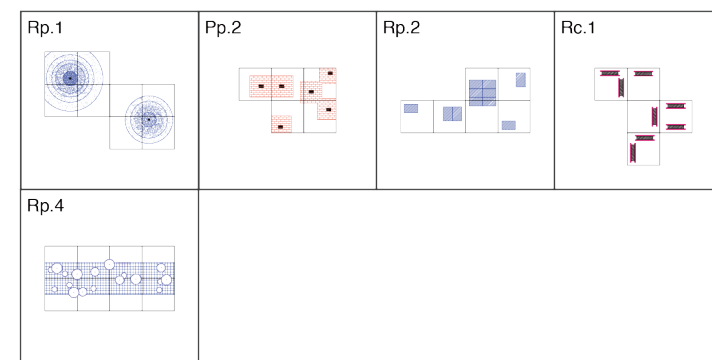
Rp.1 Carbon capture

Pp.2 Defensible space

Rp.2 Temporary sheltering

Rc.1 Fire-resistant material

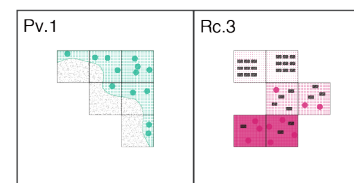
Rp.4 Landscape hardening



STRATEGY B
Urban emergency model

Pv.1 Prescribed burning

Rc.3 Land-use replanning



STRATEGY C
Seasonal tourism management

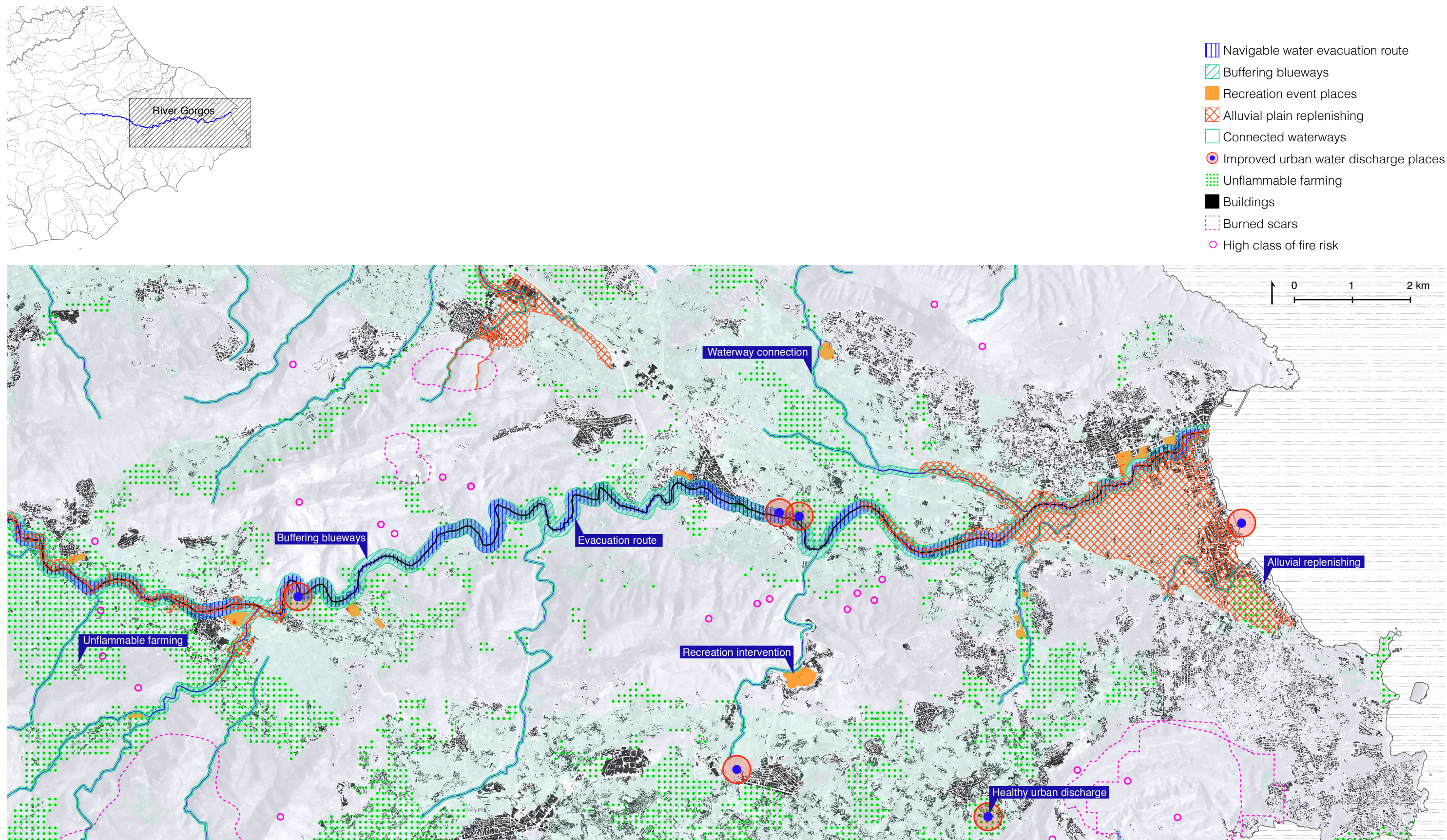
Design intervention :

Strategy A: Hydrography-based fire mitigation

Strategy B: Urban emergency model

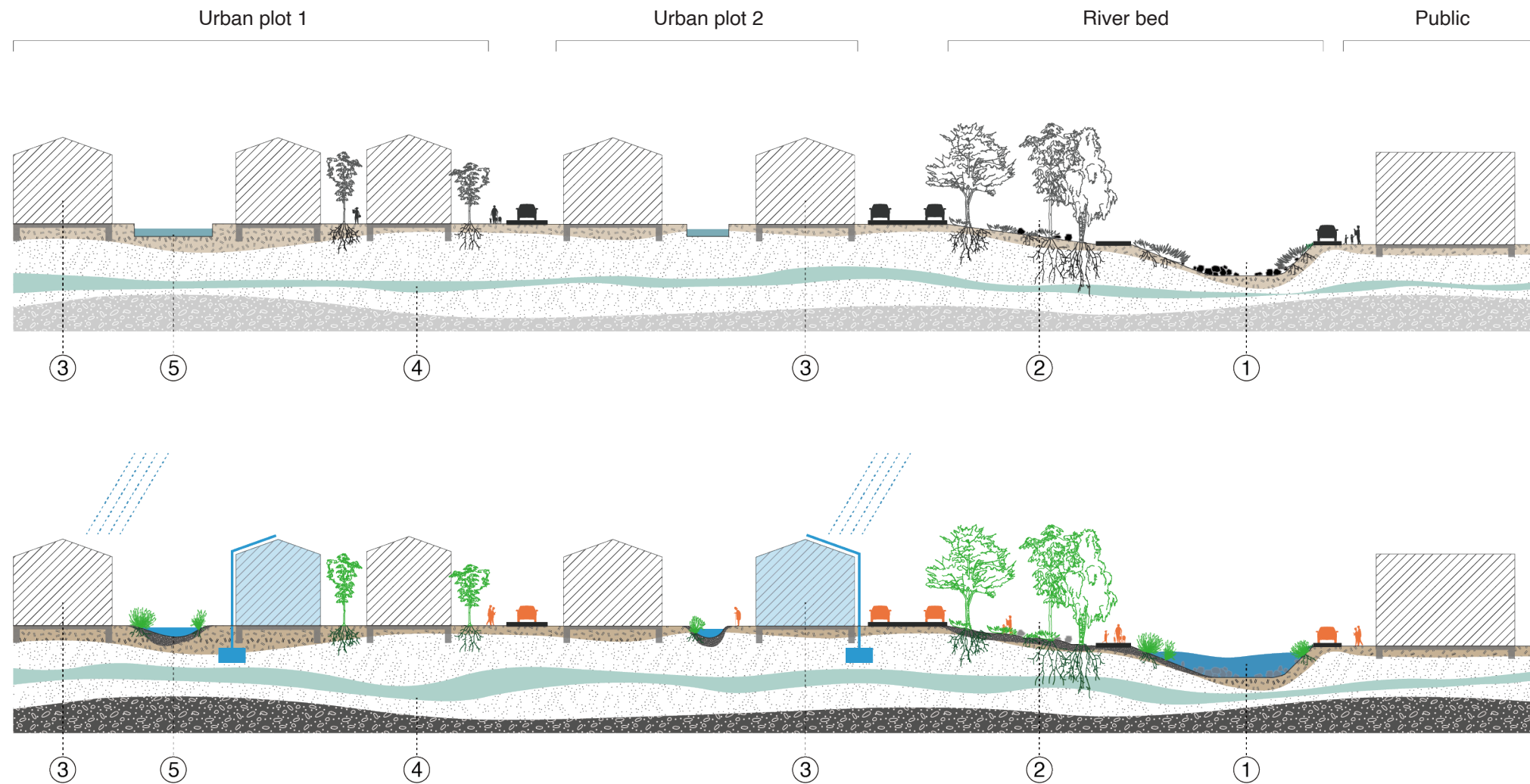
Strategy C: Seasonal tourism management

Design Intervention _ Site 02
Strategy A: Hydrography-based fire mitigation



Design Intervention _ Site 02

Strategy A: Hydrography-based fire mitigation

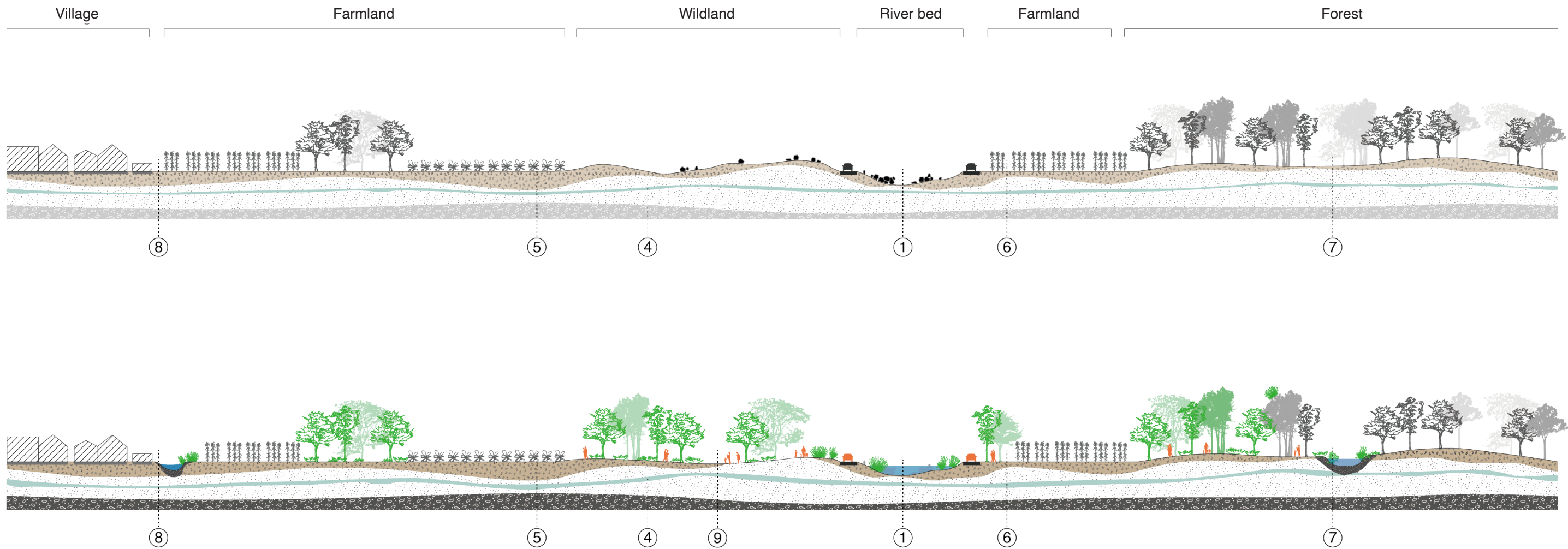


(Before / After)

- ① Dry river bed / Water evacuation route
- ② Riverside wildland / Bank restoration
- ③ Urban block / Fire-resistant roof and water collection
- ④ Aquifer / High productive aquifer
- ⑤ Swimming pool / Pool and rain garden



Design Intervention _ Site 02 Strategy A: Hydrography-based fire mitigation



(Before / After)

- ① Dry river bed / Water evacuation route
- ④ Aquifer / High productive aquifer
- ⑤ Swimming pool / Pool and rain garden
- ⑥ Farmland / Unflammable farming buffer
- ⑦ Forest / Forest moisture ponds
- ⑧ Village / Village rain garden and stream
- ⑨ Riverside wildland / Recreation intervention

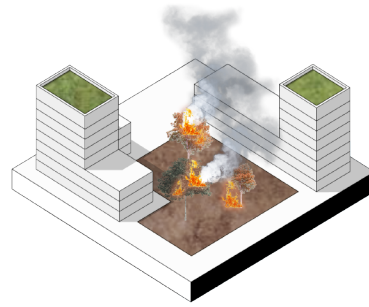


Design Intervention _ Site 02

Strategy B: Urban emergency model

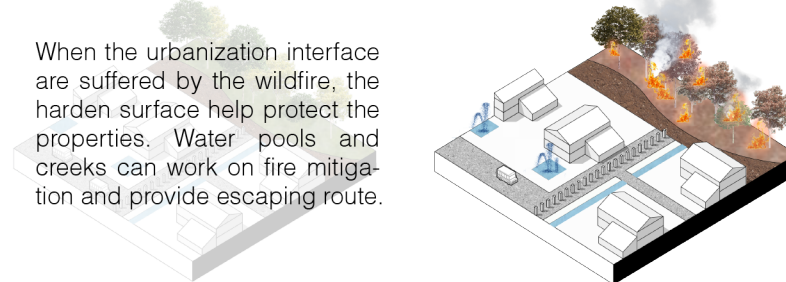
Low occupancy of buildings on plots

When low severity urban fire happens during the tourist seasons, larger public space can response quickly on the risk for evacuation and firefighters. Roof green remains.



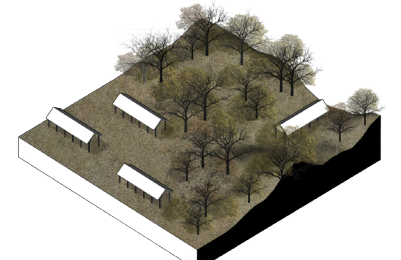
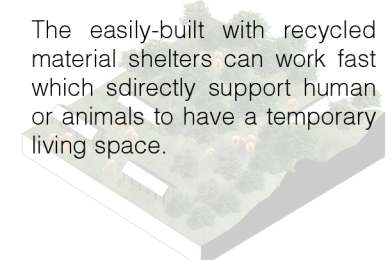
Landscape hardening for interface settlements

When the urbanization interface are suffered by the wildfire, the harden surface help protect the properties. Water pools and creeks can work on fire mitigation and provide escaping route.



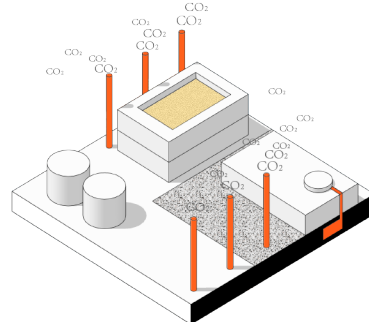
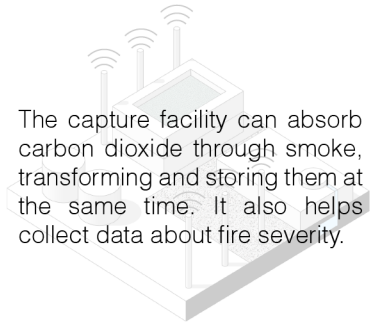
Temporary sheltering nearby the high risk areas

The easily-built with recycled material shelters can work fast which sdirectly support human or animals to have a temporary living space.



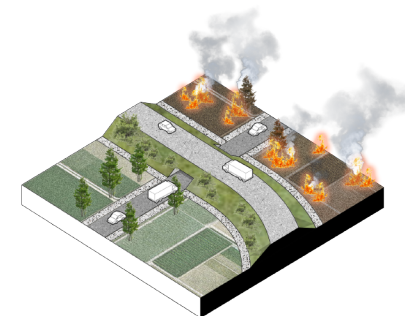
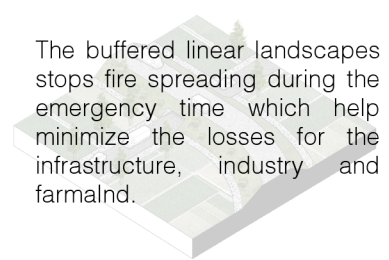
Carbon capture and monitor infrastructure

The capture facility can absorb carbon dioxide through smoke, transforming and storing them at the same time. It also helps collect data about fire severity.



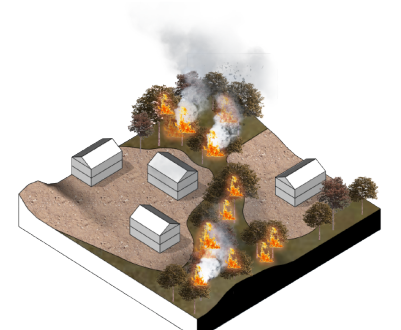
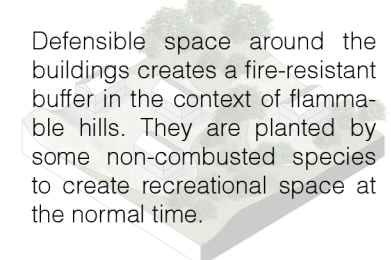
Landscape hardening for infrastructure

The buffered linear landscapes stops fire spreading during the emergency time which help minimize the losses for the infrastructure, industry and farmland.



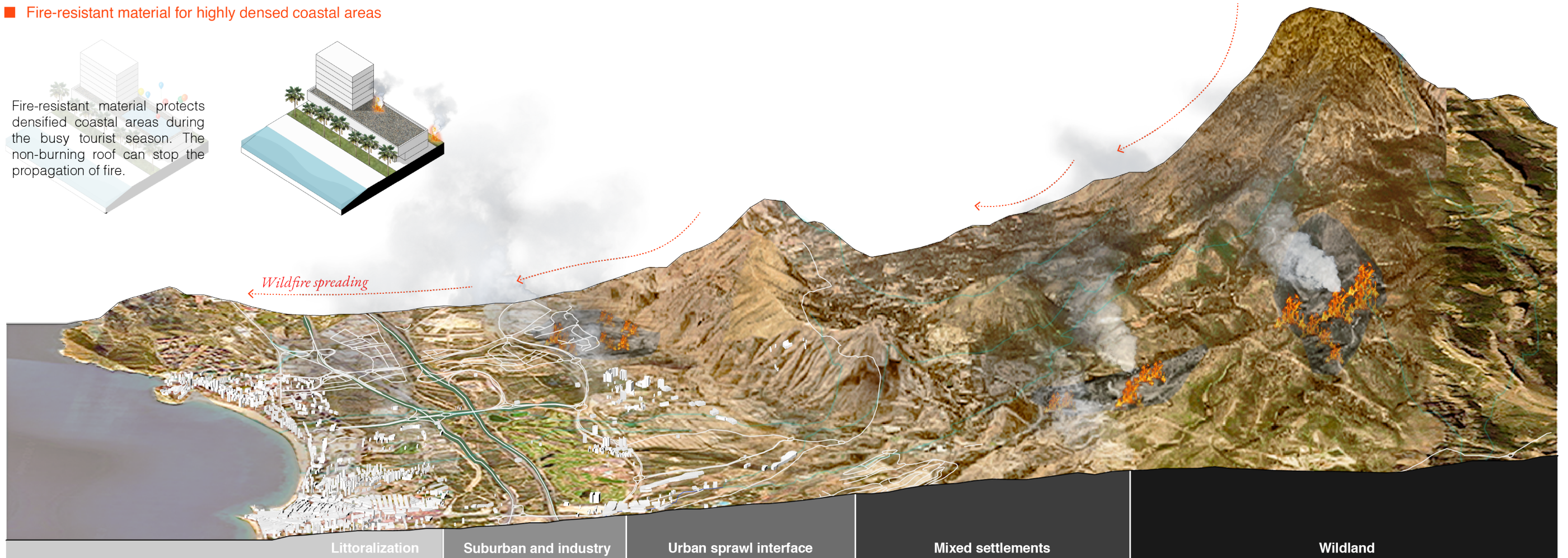
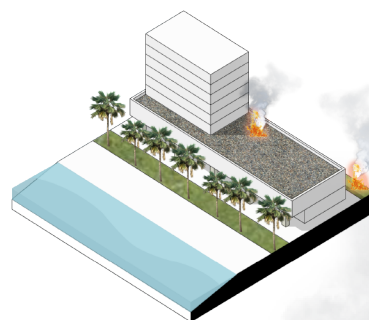
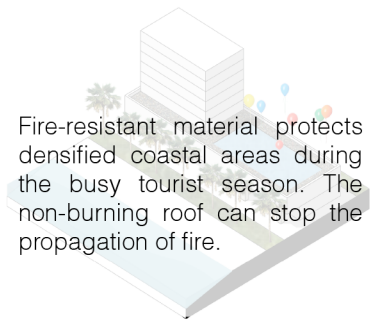
Defensible space for isolated villages

Defensible space around the buildings creates a fire-resistant buffer in the context of flammable hills. They are planted by some non-combusted species to create recreational space at the normal time.



Fire-resistant material for highly densed coastal areas

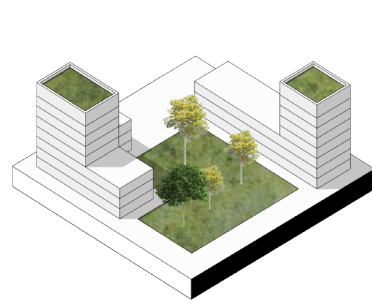
Fire-resistant material protects densified coastal areas during the busy tourist season. The non-burning roof can stop the propagation of fire.



Design Intervention _ Site 02

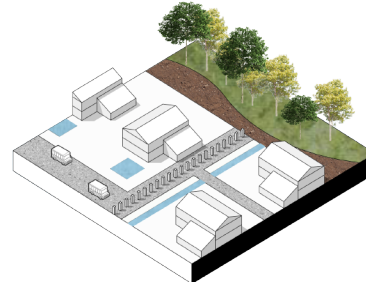
Strategy B: Urban emergency model

■ Low occupancy of buildings on plots



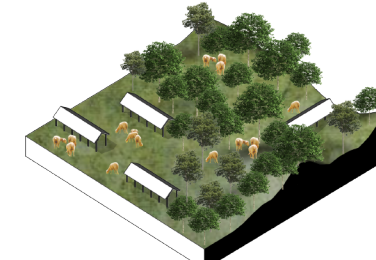
Low occupancy can create more public space for tourist and private use. It also create more space for evacuation and firefighting in the urban areas, especially along the coastal corridor.

■ Landscape hardening for interface settlements



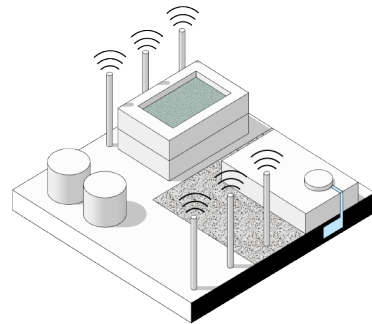
The interface of urbanization has high risk of wildfire. The hardening landscape along the settlements is needed to create a buffer to stop fire spreading and avoid damages of properties.

■ Temporary sheltering nearby the high risk areas



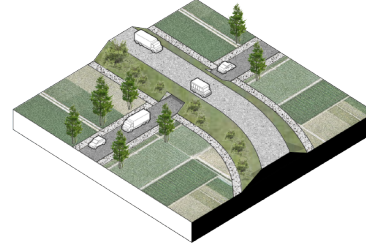
Temporary shelters are built with recyclable and degradable materials that can be use at the normal time for grazing, but at the same time, it creates safe space for wild species.

■ Carbon capture and monitor infrastructure



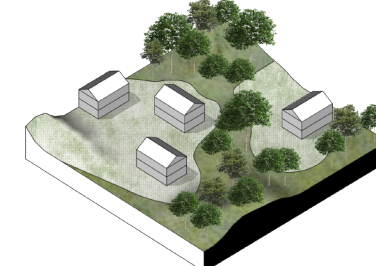
The infrastructure of CO2 capture works as a monitoring facility at normal time. It can evaluate on the climate conditions.

■ Landscape hardening for infrastructure



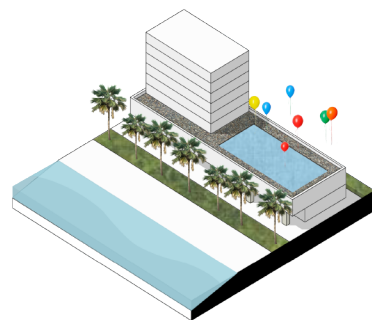
Landscape hardening can be used in the suburban areas in another way, which creates fire breaks to protect the mobility, industrial space and farmland.

■ Defensible space for isolated villages

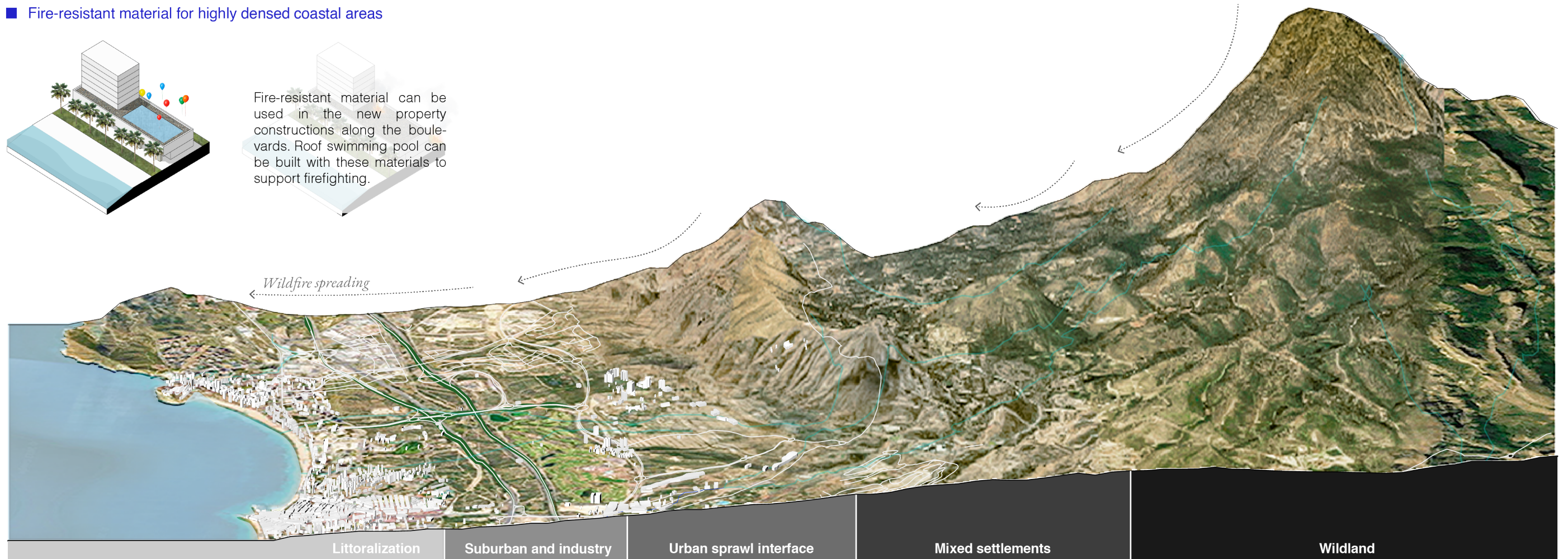


Defensible space around the buildings creates a fire-resistant buffer in the context of flammable hills. They are planted by some non-combusted species to create recreational space at the normal time.

■ Fire-resistant material for highly densed coastal areas



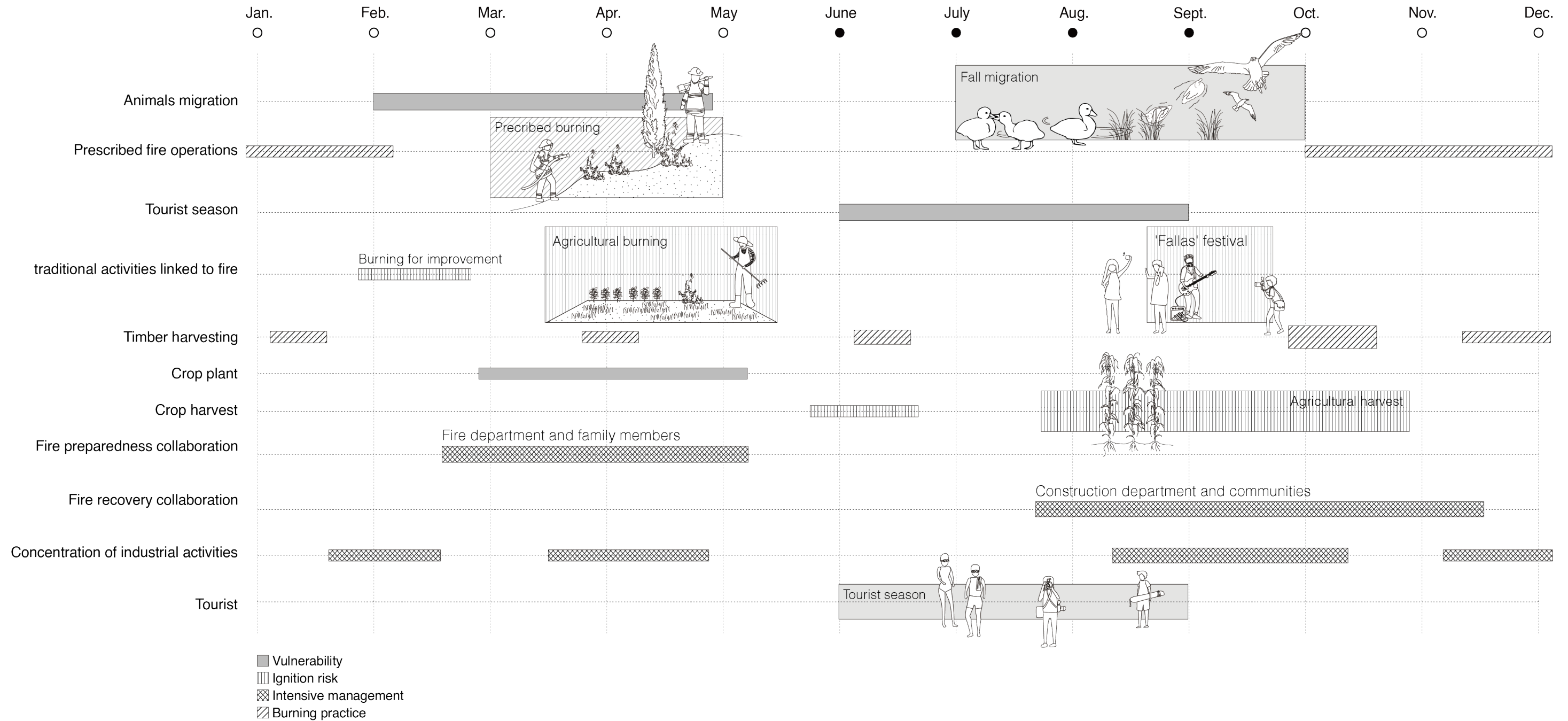
Fire-resistant material can be used in the new property constructions along the boulevards. Roof swimming pool can be built with these materials to support firefighting.



Design Intervention _ Site 02

Strategy C: Seasonal tourism management

Integrating seasonal events in to wildfire management



Design Intervention _ Site 02

Long-term resilience for local people



The dry gorge passing through Gata de Gorgos in the Province of Alicante, Spain. Image source: Keith Skingle, Alamy Stock Photo, 2019



Design Intervention _ Site 02

Long-term resilience for tourists



Benidorm city in the tourist season. Image source: <https://www.thesun.co.uk/travel/22359463/spain-holiday-tourist-tax-valencia-barcelona-benidorm-balearic-islands/>



Conclusion

Unlock landscape potential

To find alternatives :

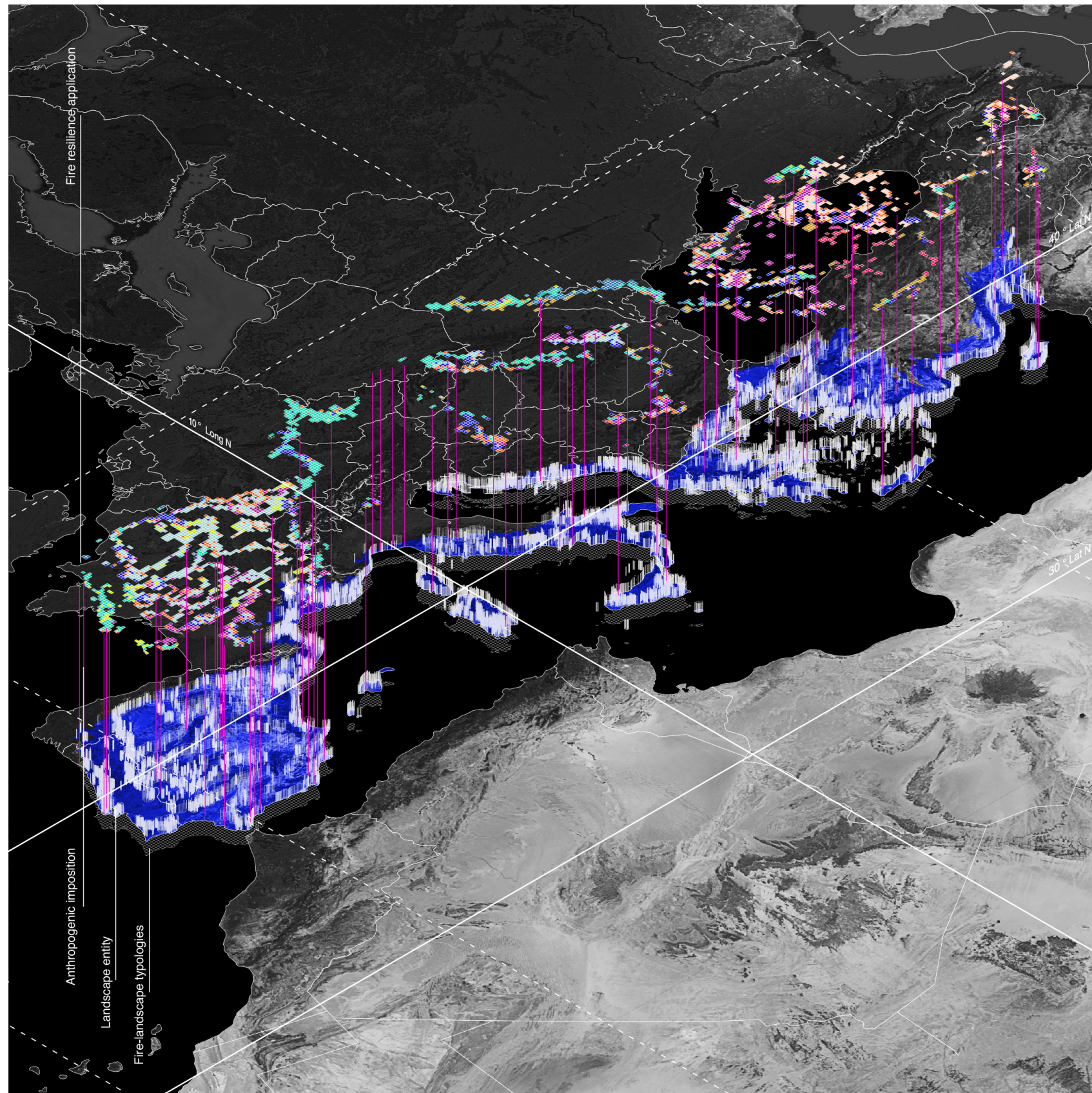
Unlocking the landscape potentials of Mediterranean

Agricultural dynamics

Tourism in urbanization

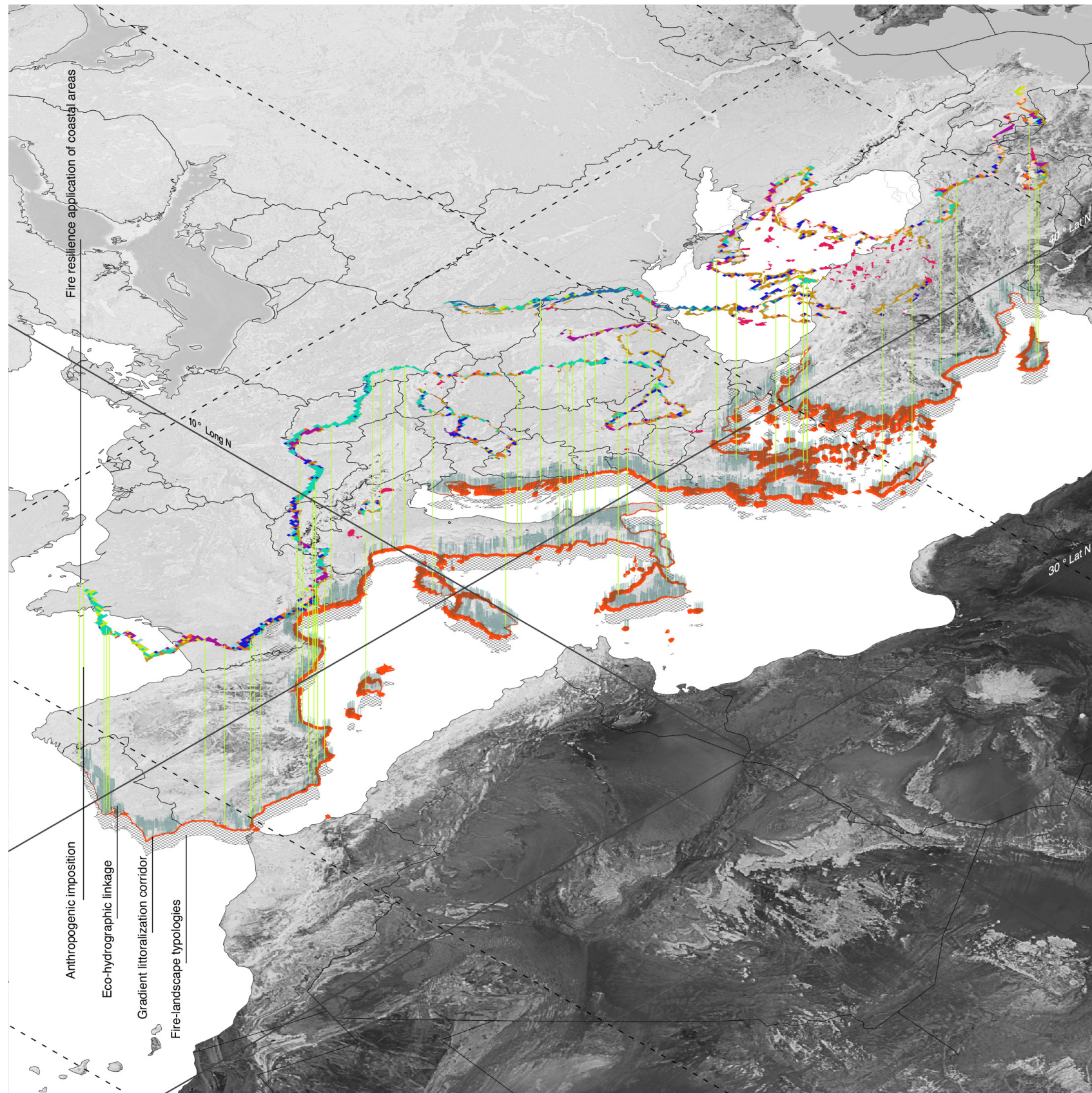
Design Synthesis I

Agro-pastoralism as a landscape asset



Design Synthesis II

Making Littoralization as a Porous Process



Limitation & Future Prospects

Limitation :

More alternatives of Mediterranean?

Reproduced in any other Mediterranean type region?

Future Prospects :

Investigation on other natural risk within this trajectory, e.g. flooding, earthquake, drought...

Thanks You For Your Attention