Preventing erosive risks after wildfire in Spain: advances and gaps

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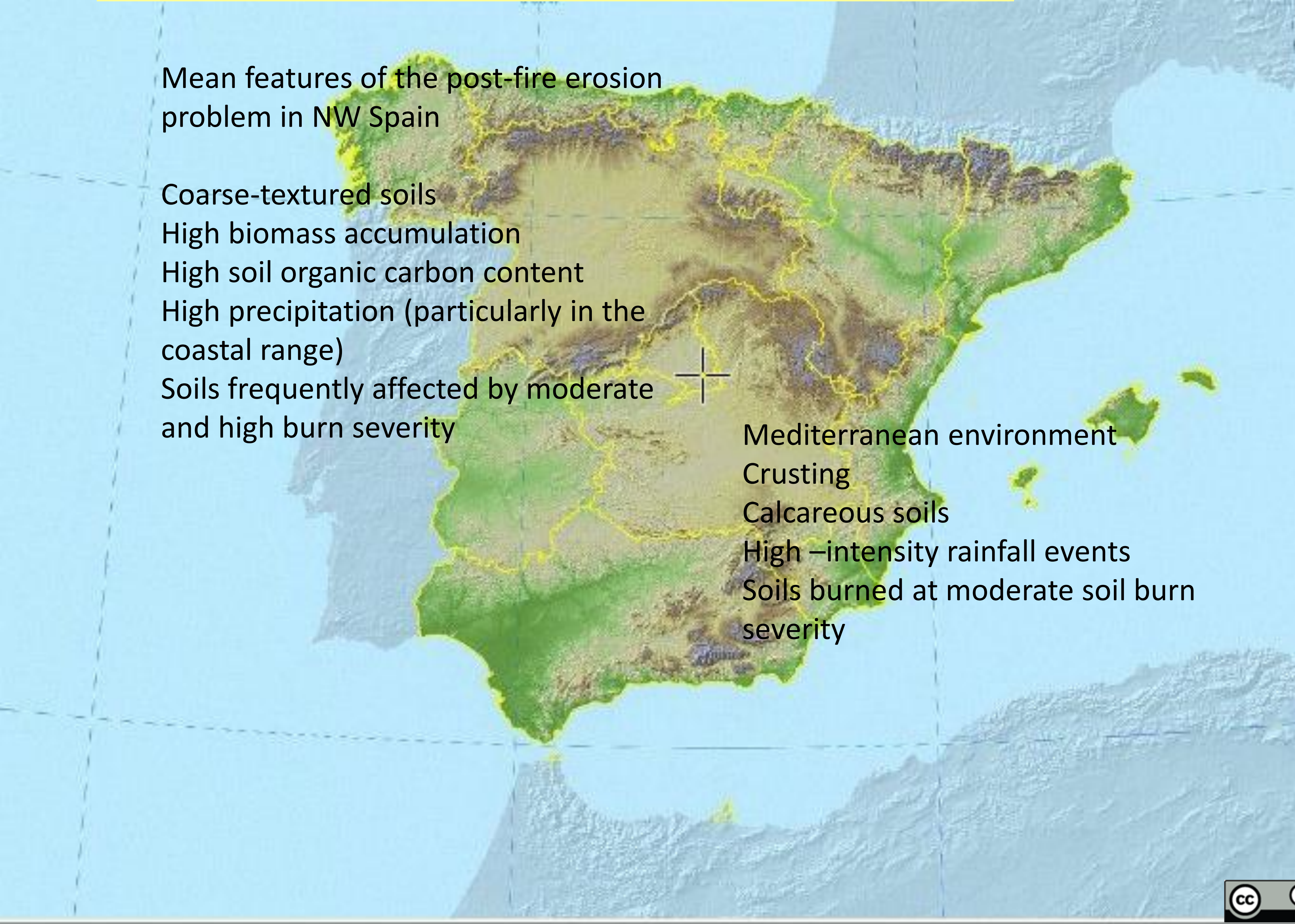
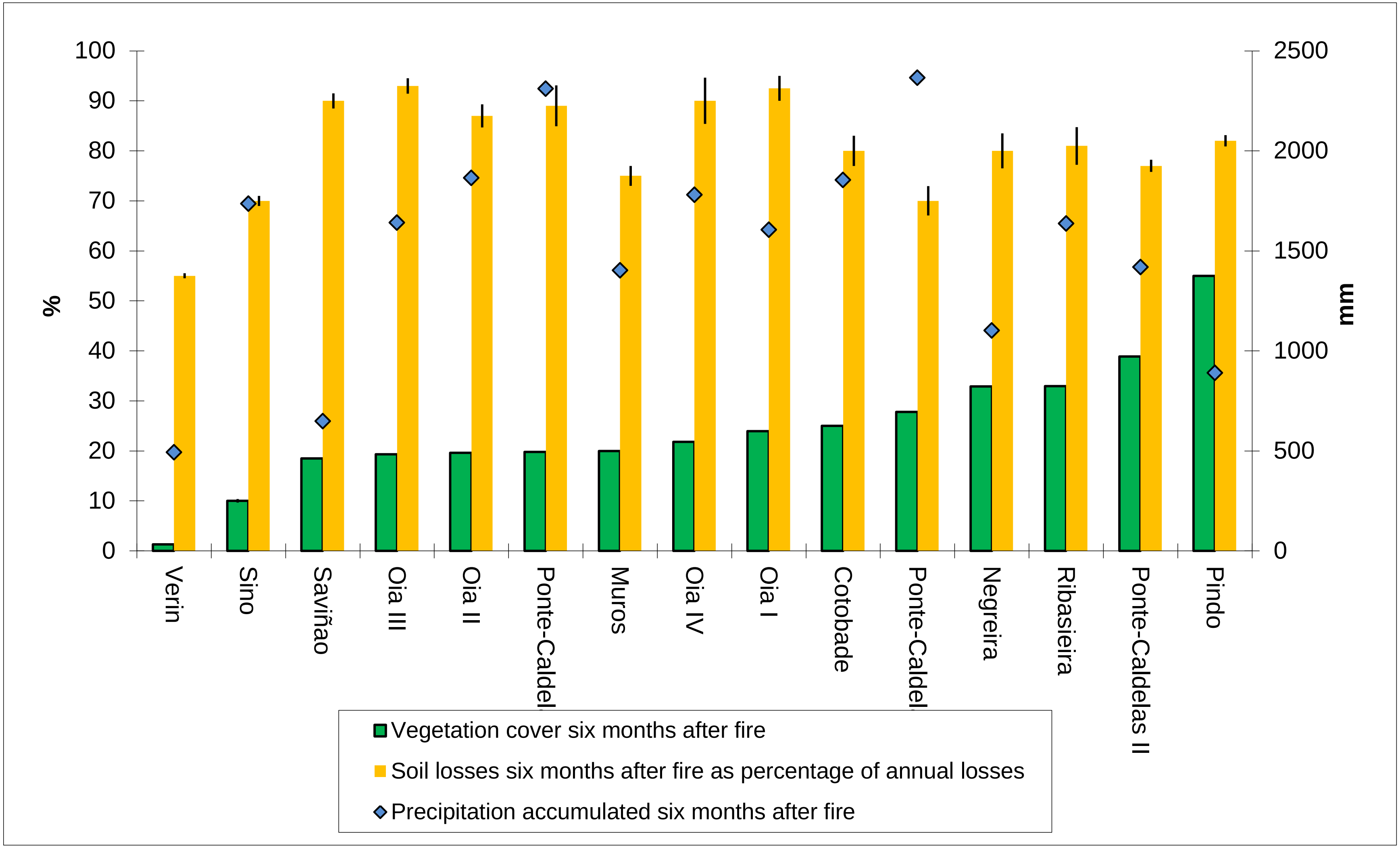
DIFFERENT EROSIVE RISK FEATURES



Mean features of the post-fire erosion problem in NW Spain

Coarse-textured soils
High biomass accumulation
High soil organic carbon content
High precipitation (particularly in the coastal range)
Soils frequently affected by moderate and high burn severity

Mediterranean environment
Crusting
Calcareous soils
High –intensity rainfall events
Soils burned at moderate soil burn severity



In NW Spain, soil losses are concentrated in the first months after fire (> 80% in the first 6 post-fire months).

In that period vegetation cover is ineffective for soil protection.

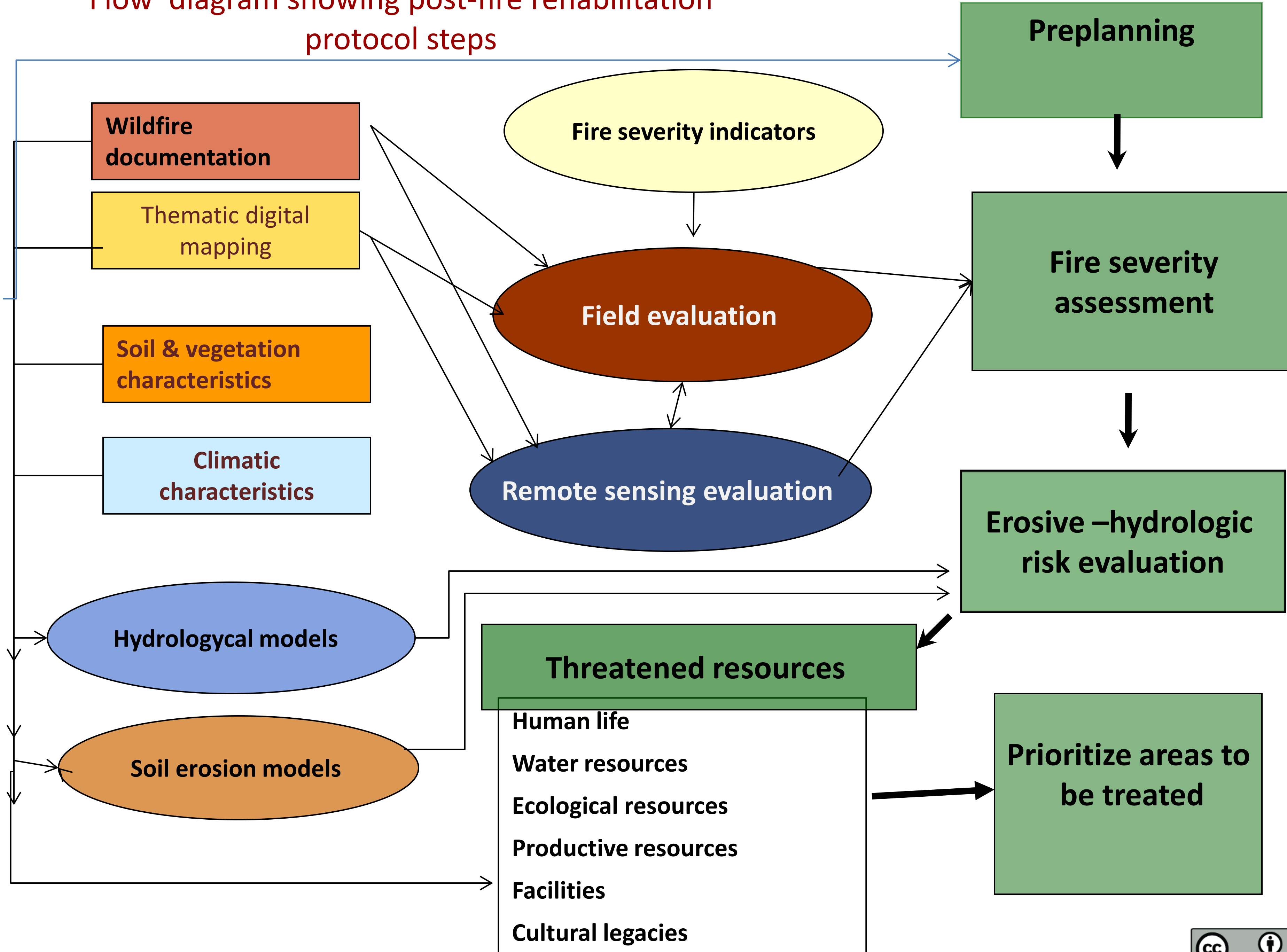
The emergency stabilization actions are urgent reactions developed for post-fire risk management.

Main objectives:

- Mitigation of the threaten to the human life and resources
- Reduction of soil erosion
- Limitation of soil degradation
- Reduction of flood, debris flow and mudflow risk.
- Accelerate natural regeneration of the ecosystem

Protocols agreed between managers and researchers can be a useful tool
In fact, this guide is currently being used for post-fire emergency stabilization response in NW Spain

Flow diagram showing post-fire rehabilitation protocol steps



COPING WITH FIRE SEVERITY EVALUATION ISSUE AND OFFERING APPROACHES

FIRE SEVERITY

A key issue to:

Understand the role played by fire in the ecosystem

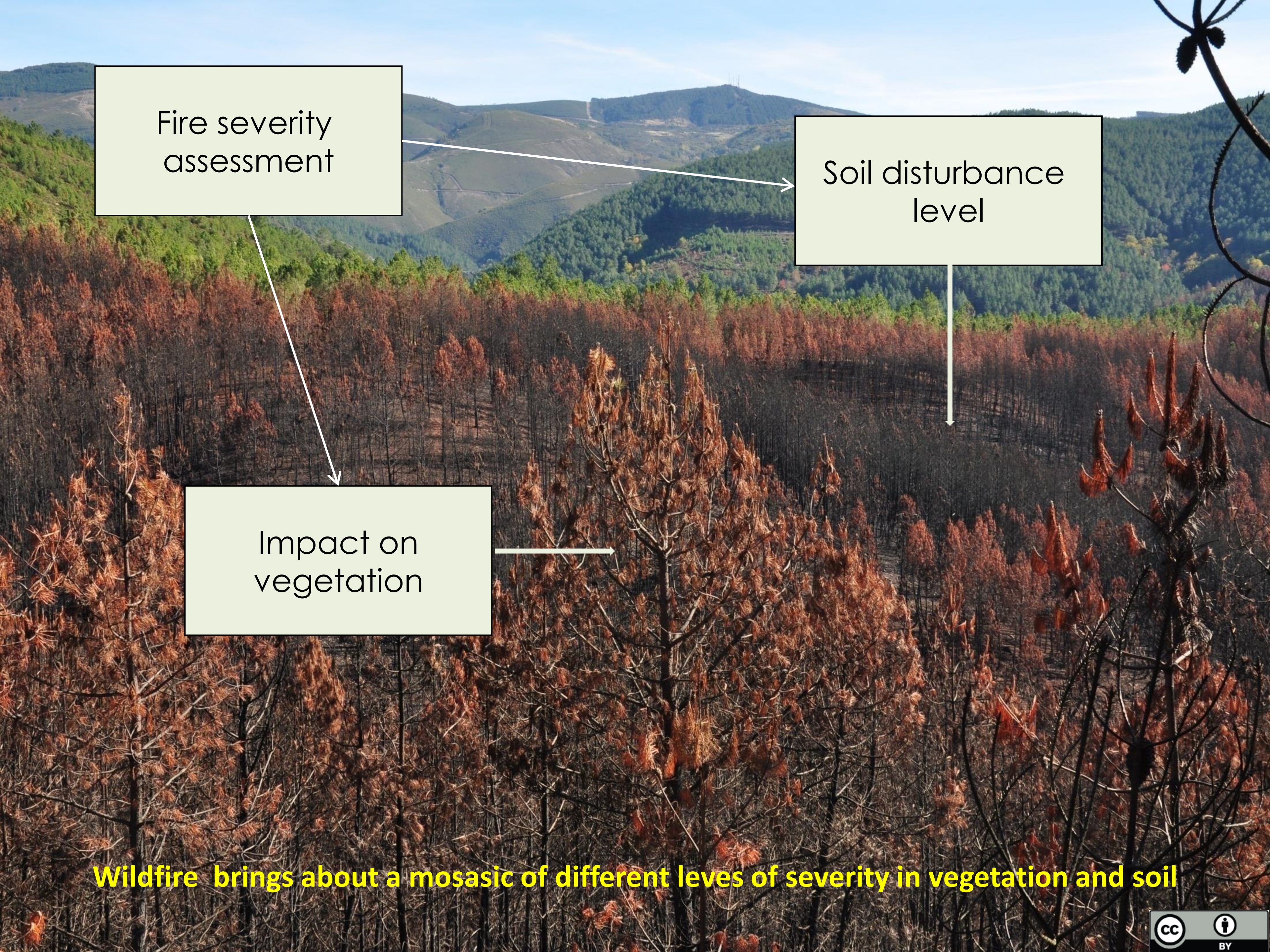
(Major Fire regime parameter)

Assess its environmental impact

Prioritize areas for post-fire emergency rehabilitation

Use fire as an ecological tool

Address more efficiently fuel and fire management



Fire severity assessment
Soil disturbance level
Impact on vegetation
Wildfire brings about a mosasic of different leves of severity in vegetation and soil

Operational fire severity evaluation and mapping usually needs four steps

- A first general aerial survey of the burned area.
- Pre and post multispectral remote sensed- images to obtain indexes based on changes in reflectance of the burned area
- Field sampling to collect vegetation and soil fire severity information in situ
- Validation of the satellite information through comparison with ground information
- Mapping process

* Five levels of soil burn severity

* Five attributes:

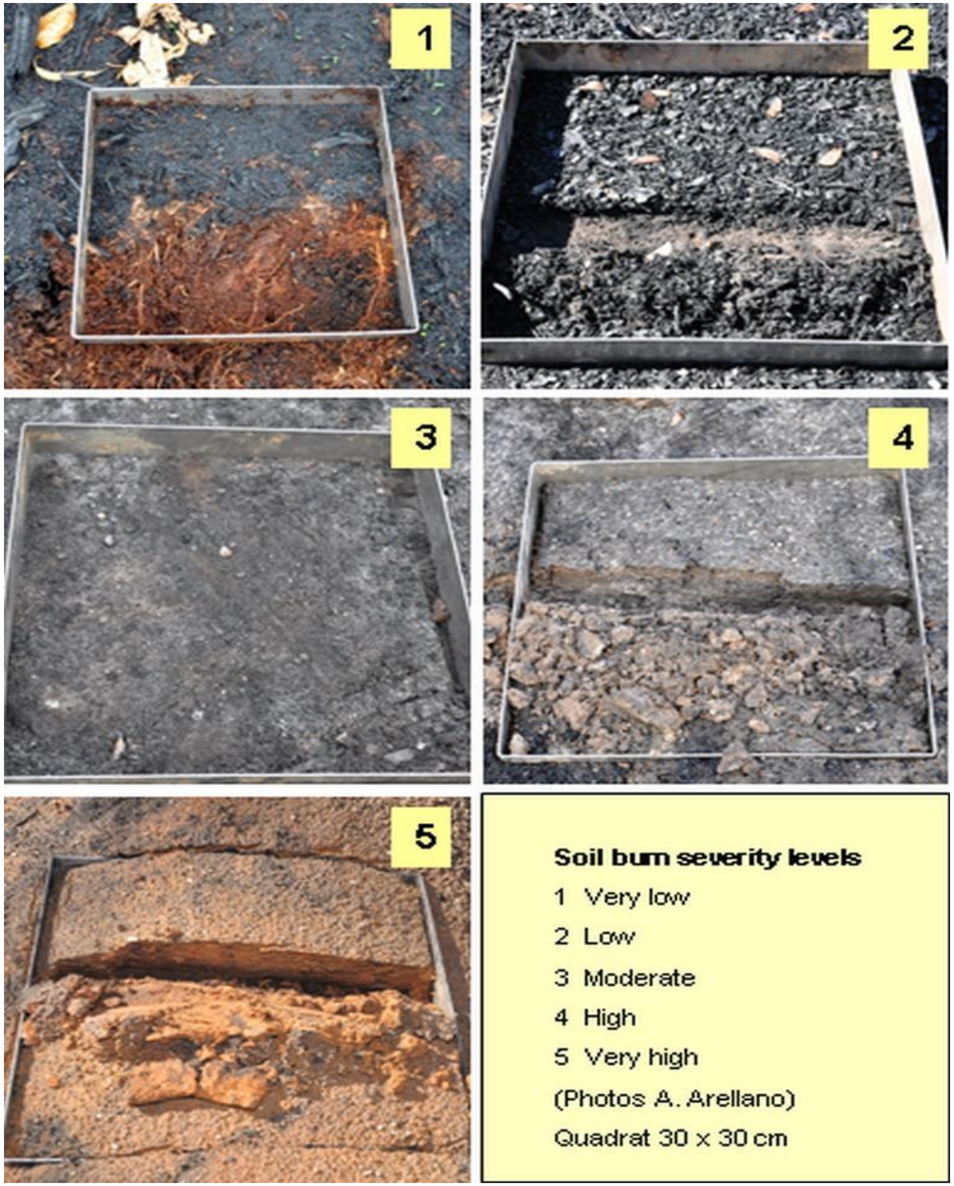
-ground cover: amount , conditio n and depth

-ash colour and depth

- soil structure and colour

-roots condition

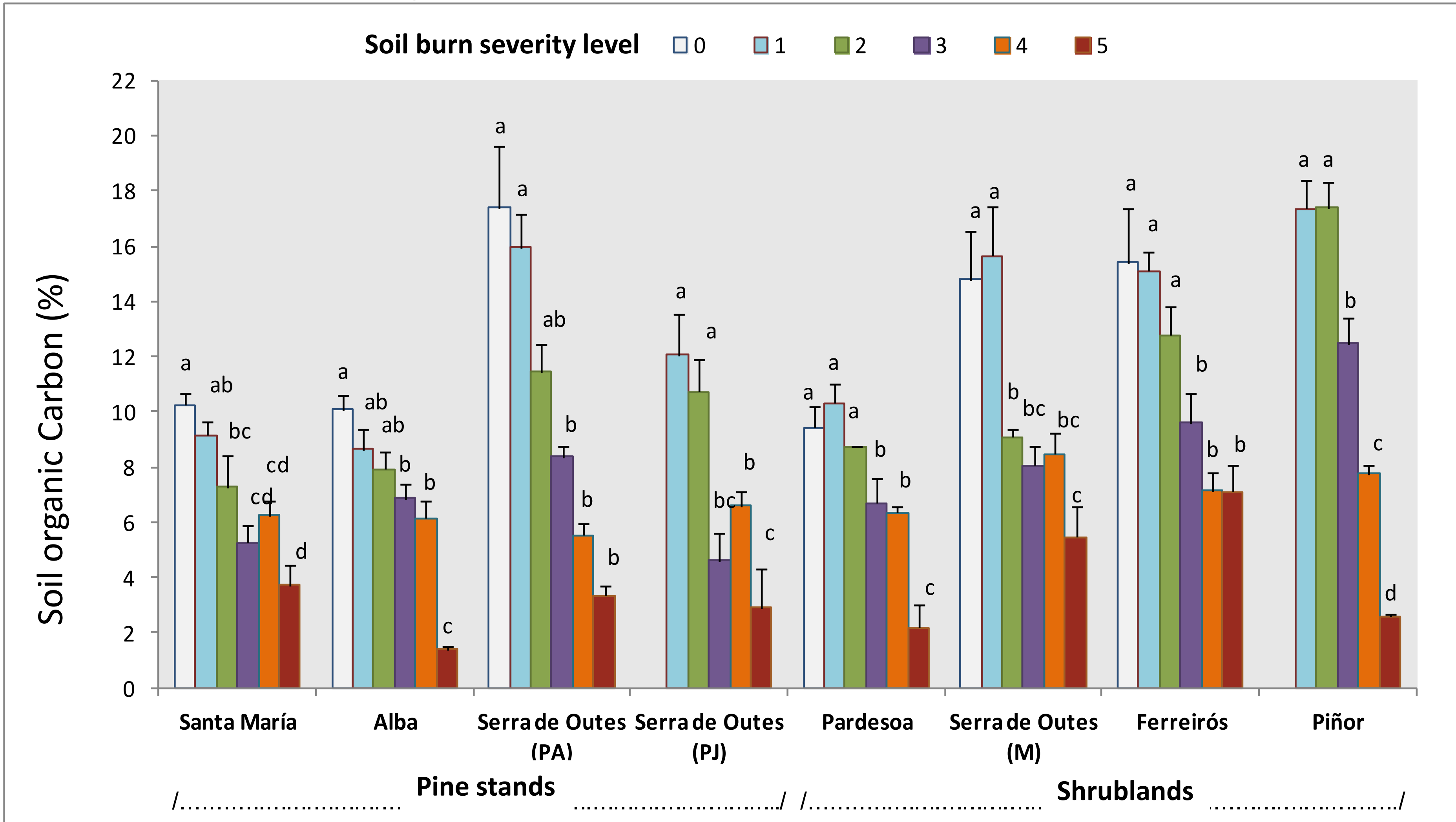
-water repellency



Vega J.A.; Fonturbel, M.T; Merino, A.; Fernández, C.;Ferreiro, A.; Jiménez, E. 2013. Testing the ability of visual indicators of soil burn severity to reflect changes in soil chemical and microbial properties in pine forests and shrubland. Plant and Soil.369:73-91

Why those five levels of severity?

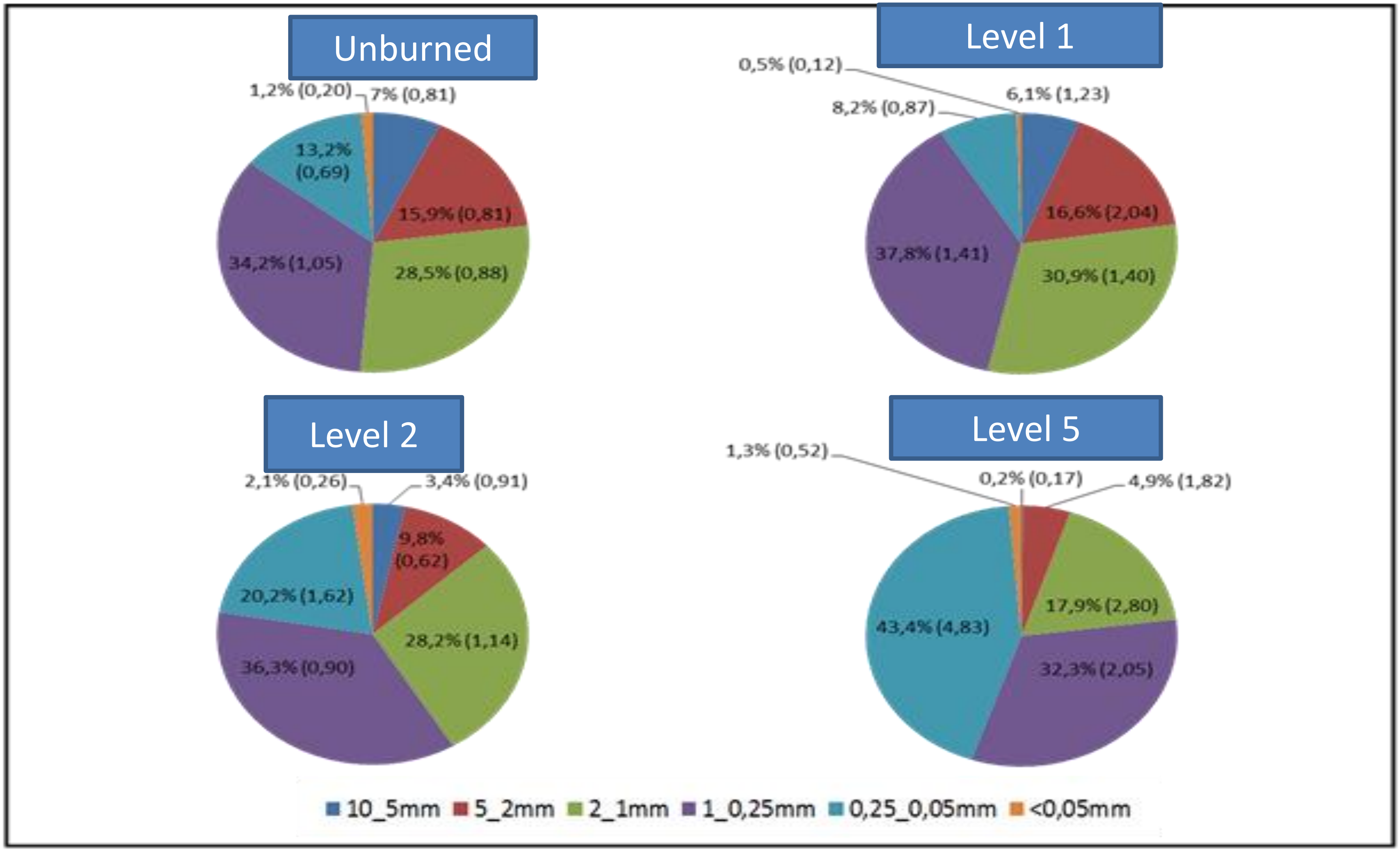
EFFECT OF WILDFIRE ON SURFACE SOIL ORGANIC CARBON CONTENT in pine stands and shrubland in Galicia



Vega et al. (2013)

Relative decreases of between **54** and **86%** respect to control in **level 5**

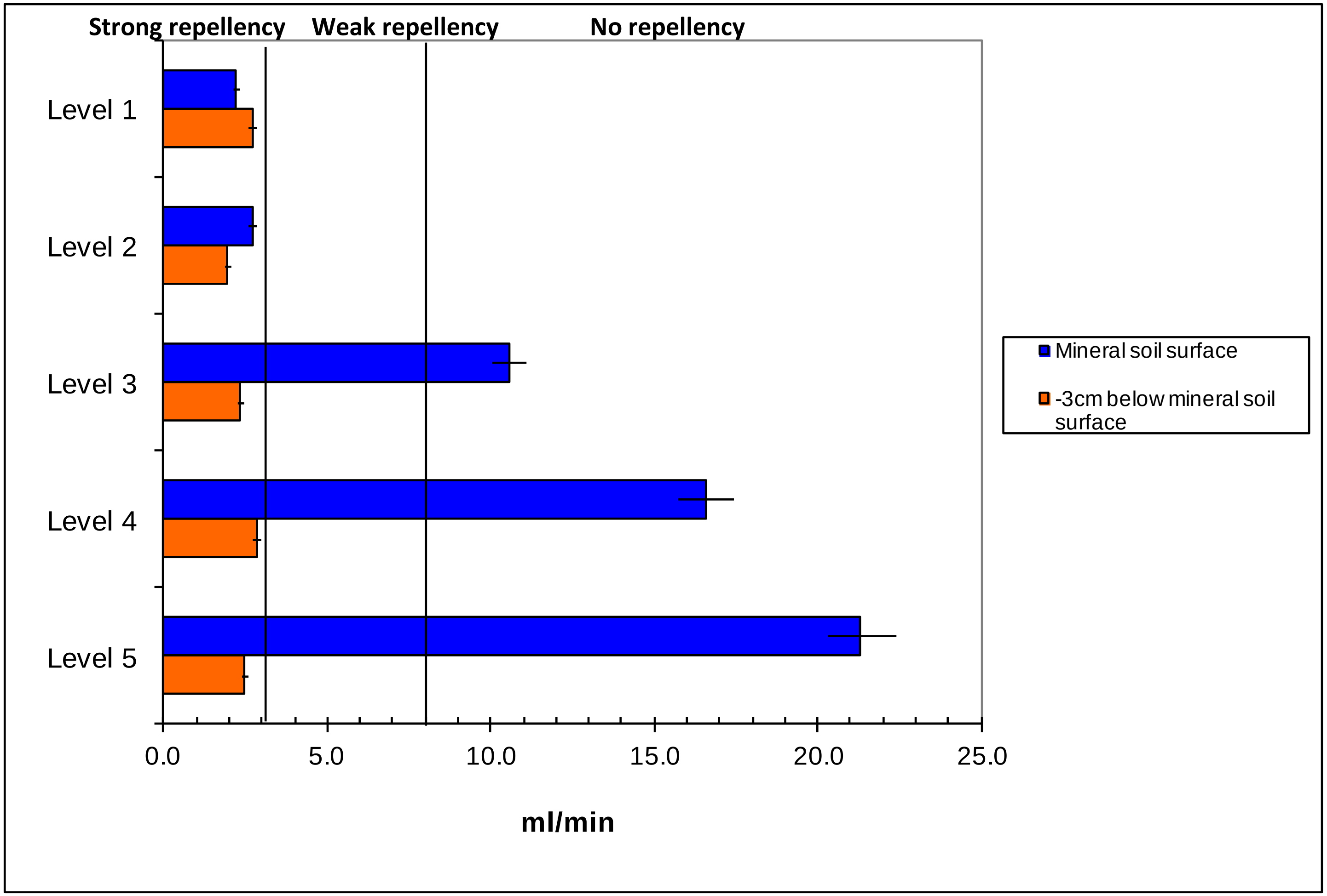
Changes in percentage of soil aggregates size ranges of soil monoliths experimentally burned



↑ Temperature/heat duration → organic C ↓ → Macroaggregates ↓

Regueira, N.; Benito, E.; Fontúrbel, T.; Fernández, C.; Jiménez, E.; Vega, J.A. 2015. Efectos de quemas experimentales de diferente severidad en el carbono orgánico y en propiedades físicas del suelo. Flamma. 6(3): 129-133.

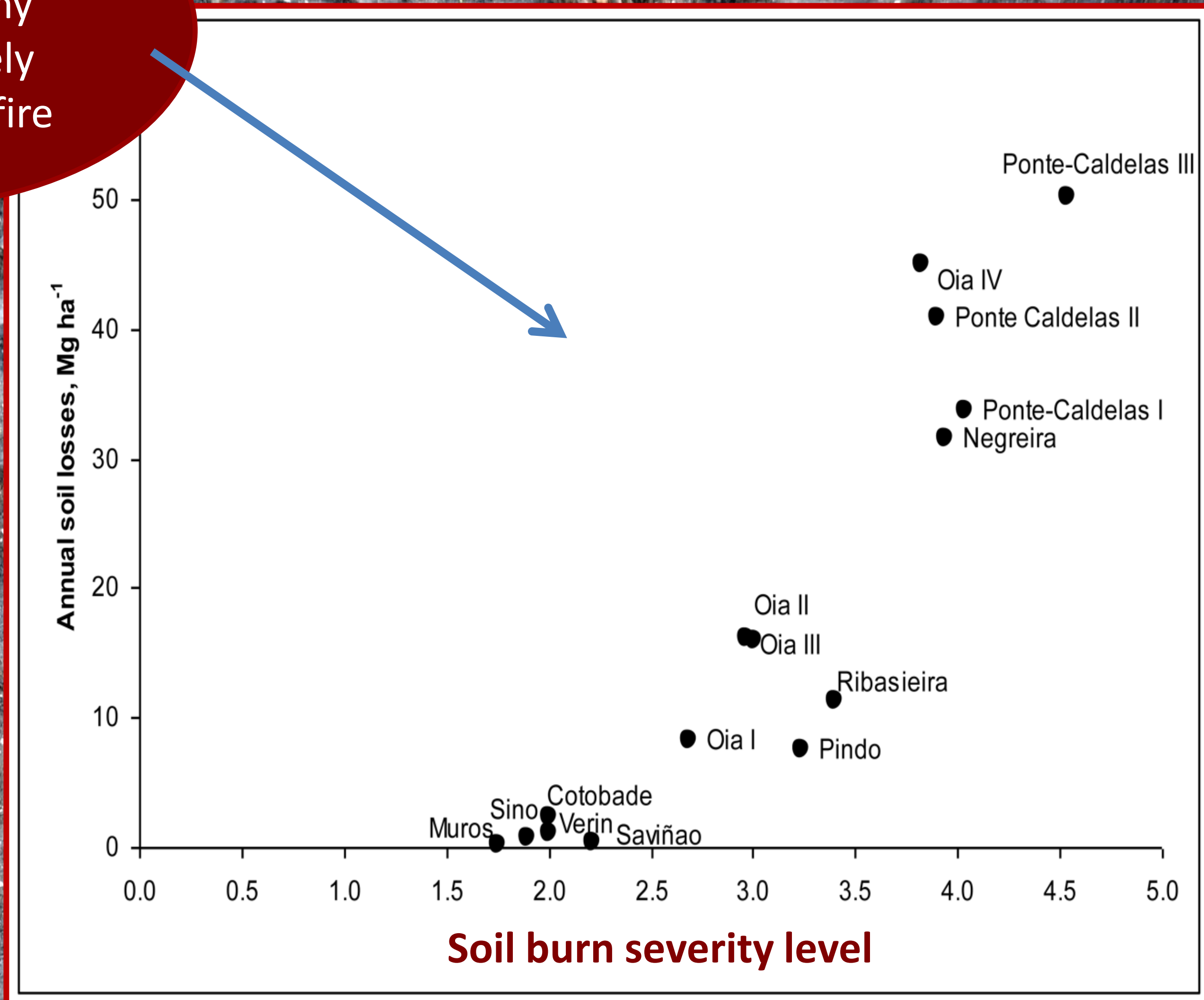
Effect on burn severity on water repellency (measured as infiltration velocity with minidisc-infiltrometer in wildfire-affected soils in Galicia)



Water repellency reduction in the higher soil burn severities

Fernández, C.; Vega, J.A. ; Fontúrbel, T. 2013. Severidad del fuego y repelencia al agua en el suelo después de incendios forestales en Galicia. VI Congreso Forestal Español.

..BUT MOST OF ALL beacuse in temperate rainy climate is closely related to post-fire soil erosion



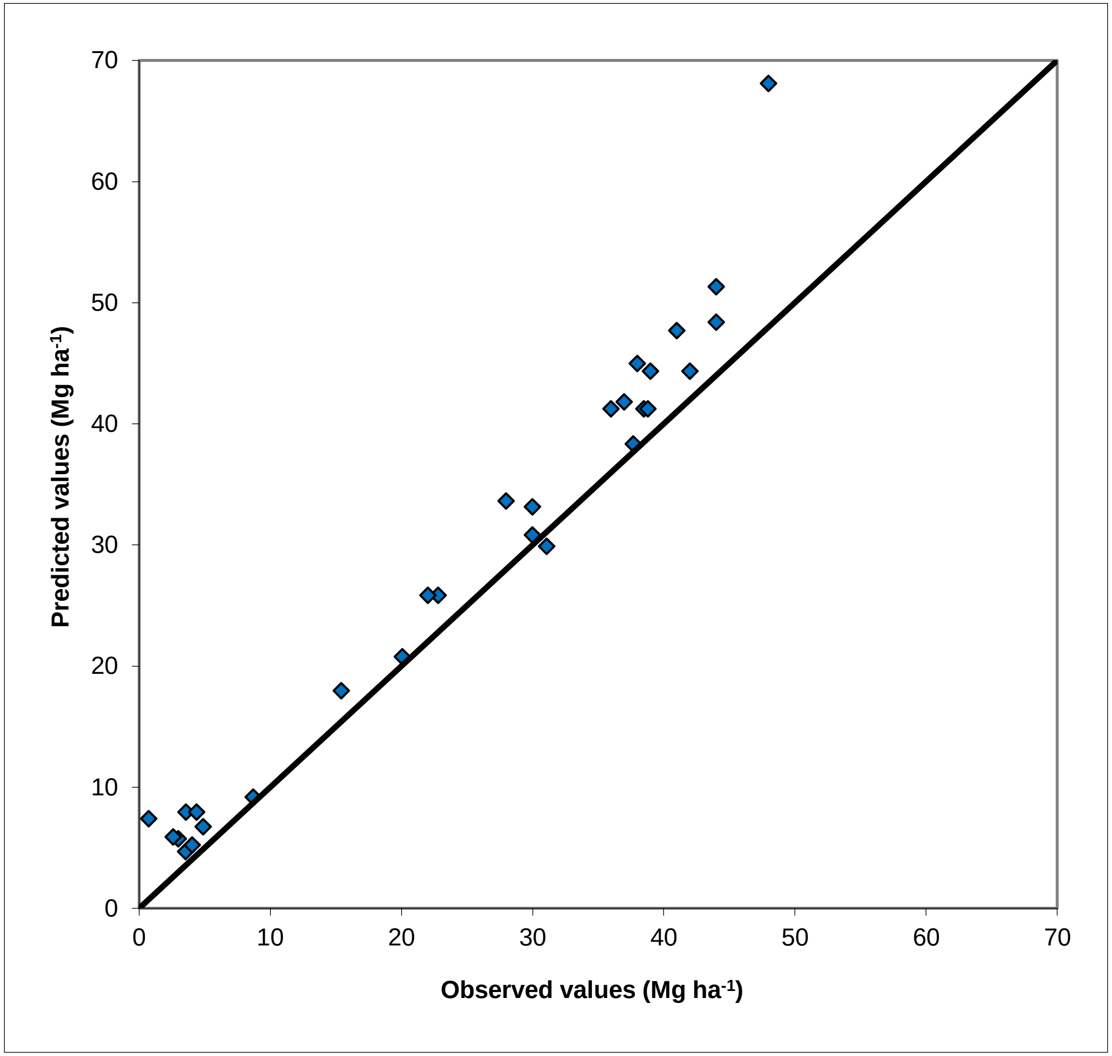
Fernández, C.; Vega, J.A. 2016.. Modelling the effect of soil burn severity on soil erosion at hillslope scale in the first year following wildfire in NW Spain. . Earth Surf. Process. Landforms 41, 928–935

$$SE = 0.0004 * \exp(0.7284\ SBSI) * P * LU$$

SE soil erosion first year following wildfire (Mg ha^{-1} $year^{-1}$)
SBSI soil burn severity level(1-6)
P accumulated precipitation during the 1st year post-fire, mm
LU land use factor . 1 :shrubland burned 5 years before fire and juvenile plantations with mecanized site preparation. 2: shrublands not burned or forest stands not harvested within 5 years before fire. 3 : pole size stands with a well developed forest floor or shrublands not burned at least within 10 years before fire and with a thick litter layer.

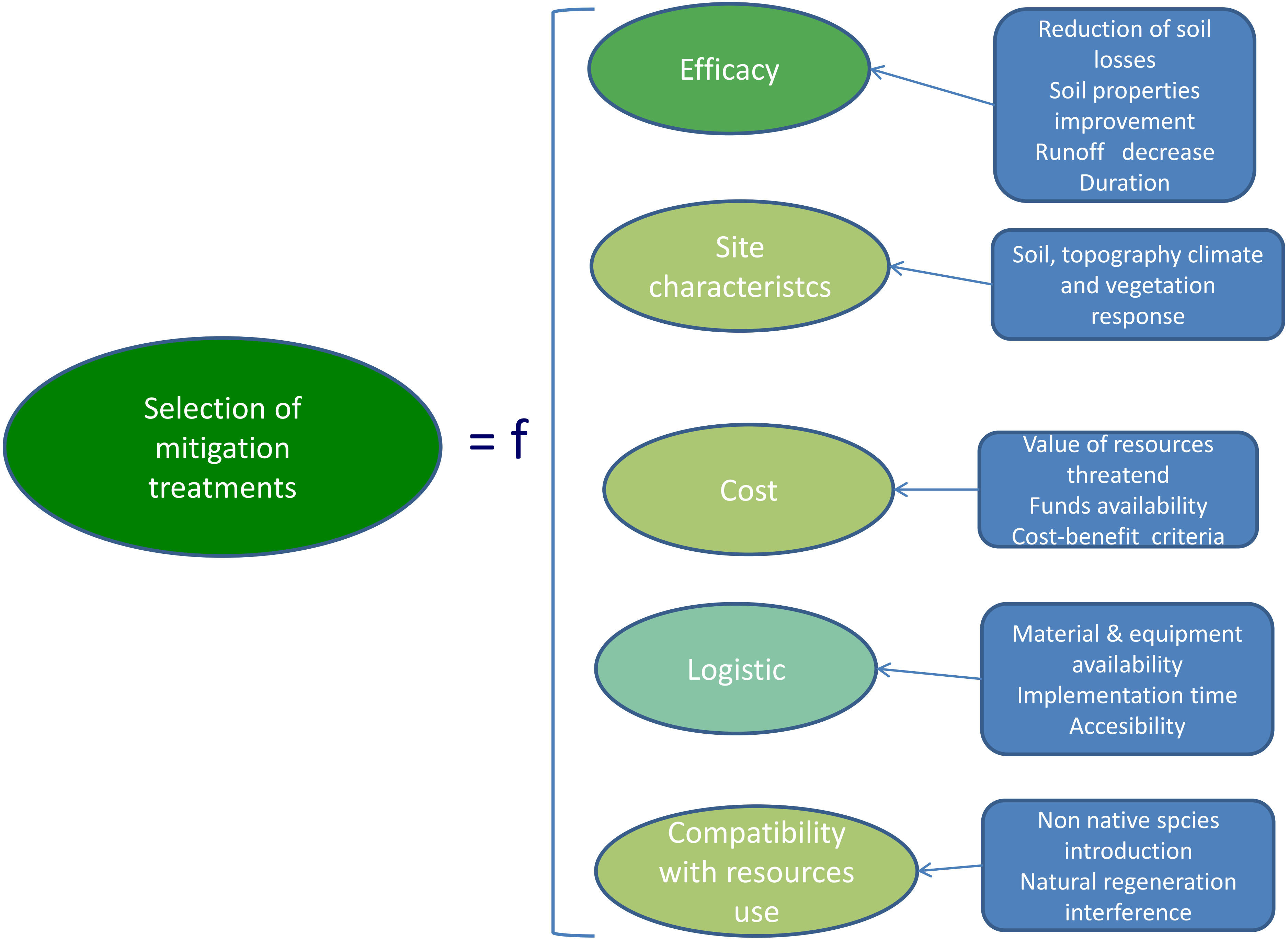
Data from
65 experimental (20 x 4 m) sediment fenced-plots from 10 wildfires in Galicia were used to construct the model
Validation was made with data from 32 plots-year

Fernández and Vega (2016)



Validation of that model yielded acceptable results. It seems that could be an alternative for soil losses prediction the first year after fire in NW Spain

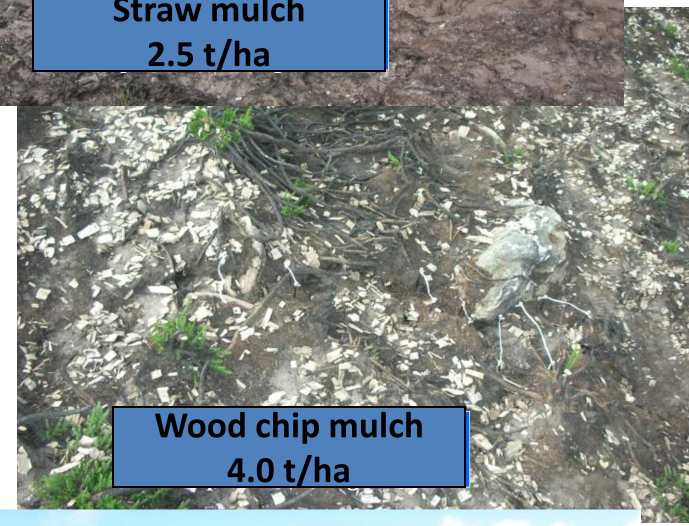
Fernández and Vega (2016)

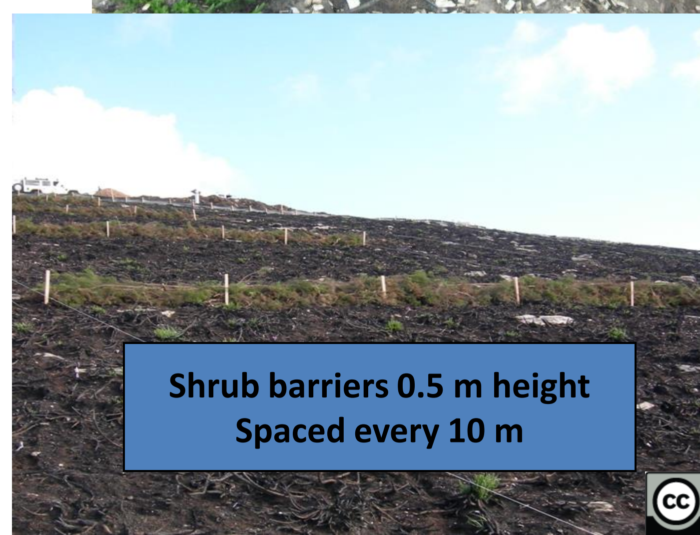

Selection of mitigation treatments
= f
Efficacy
Reduction of soil losses
Soil properties improvement
Runoff decrease
Duration
Site characteristcs
Soil, topography climate and vegetation response
Cost
Value of resources threatend
Funds availability
Cost-benefit criteria
Logistic
Material & equipment availability
Implementation time
Accesibility
Compatibility with resources use
Non native spcies introduction
Natural regeneration interference

Post-fire stabilization and rehabilitation treatments efficacy: Results from research and monitoring of treatments carried out at operational scale

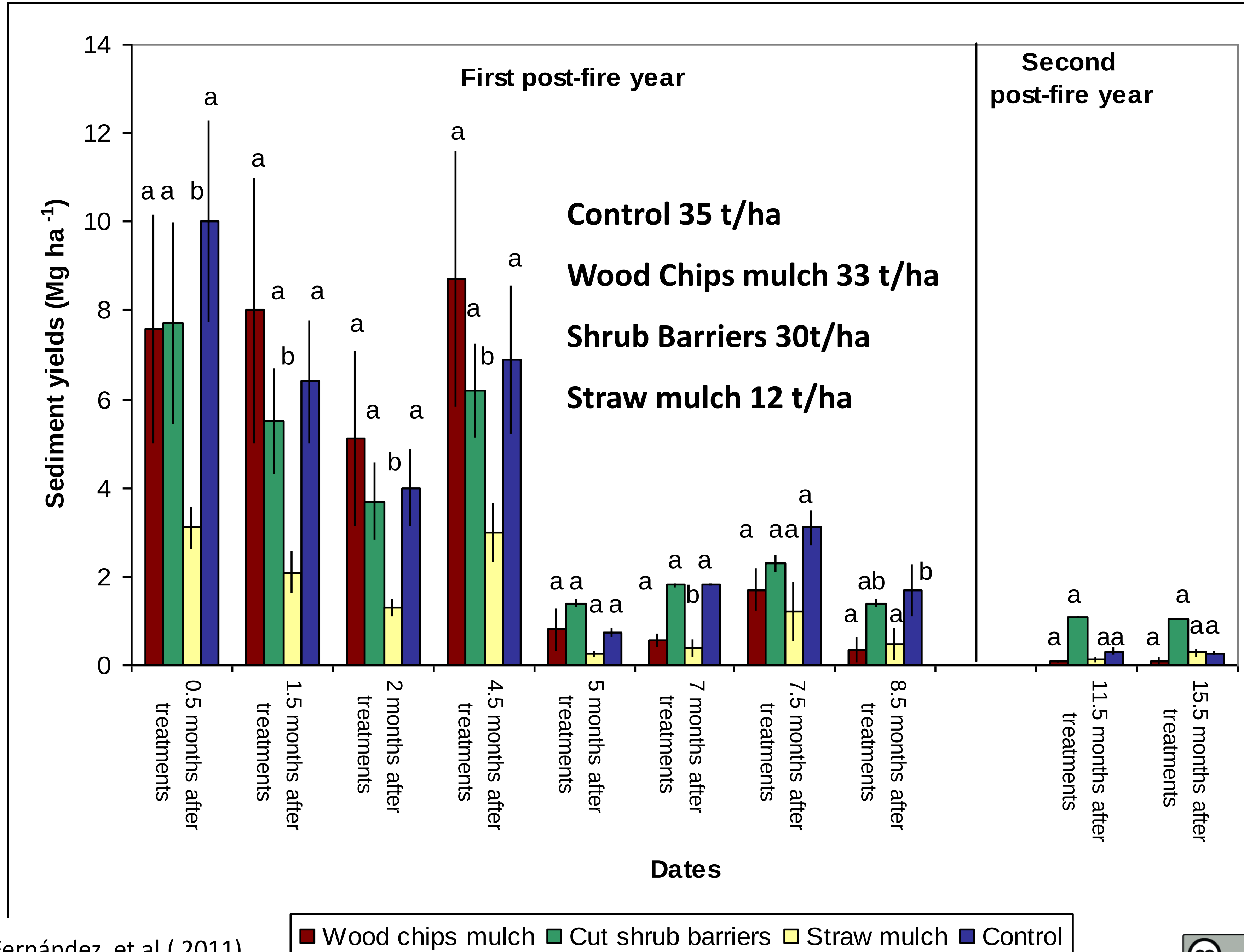
TREATMENTS:

Pardesoa wildfire 2006

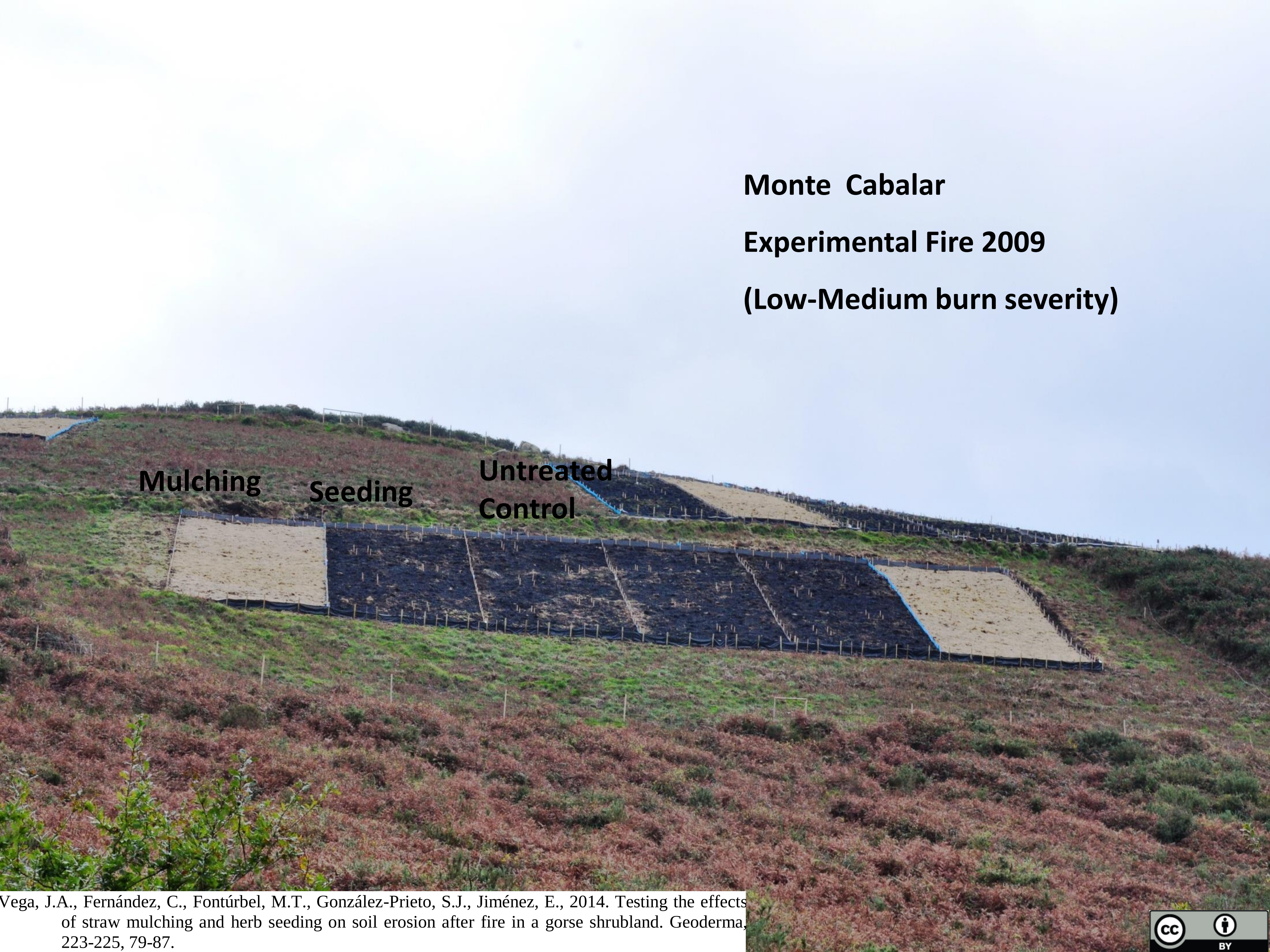




Fernández, C., Vega, J.A., Jiménez, E., Fonturbel, T., 2011. Effectiveness of three post-fire treatments at reducing soil erosion in Galicia (NW Spain). International Journal of Wildland Fire, 20, 104-114.

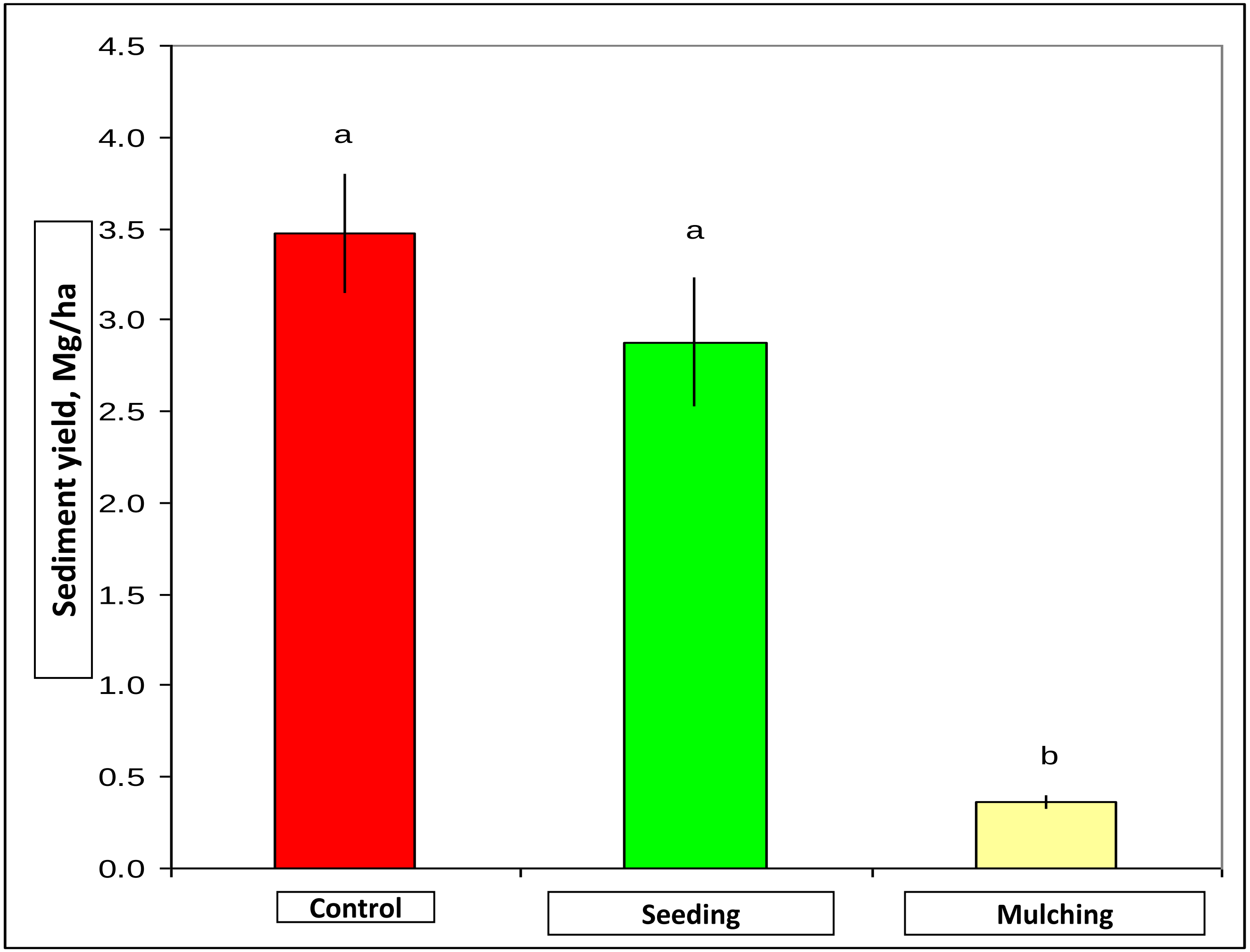


Fernández et al.(2011)

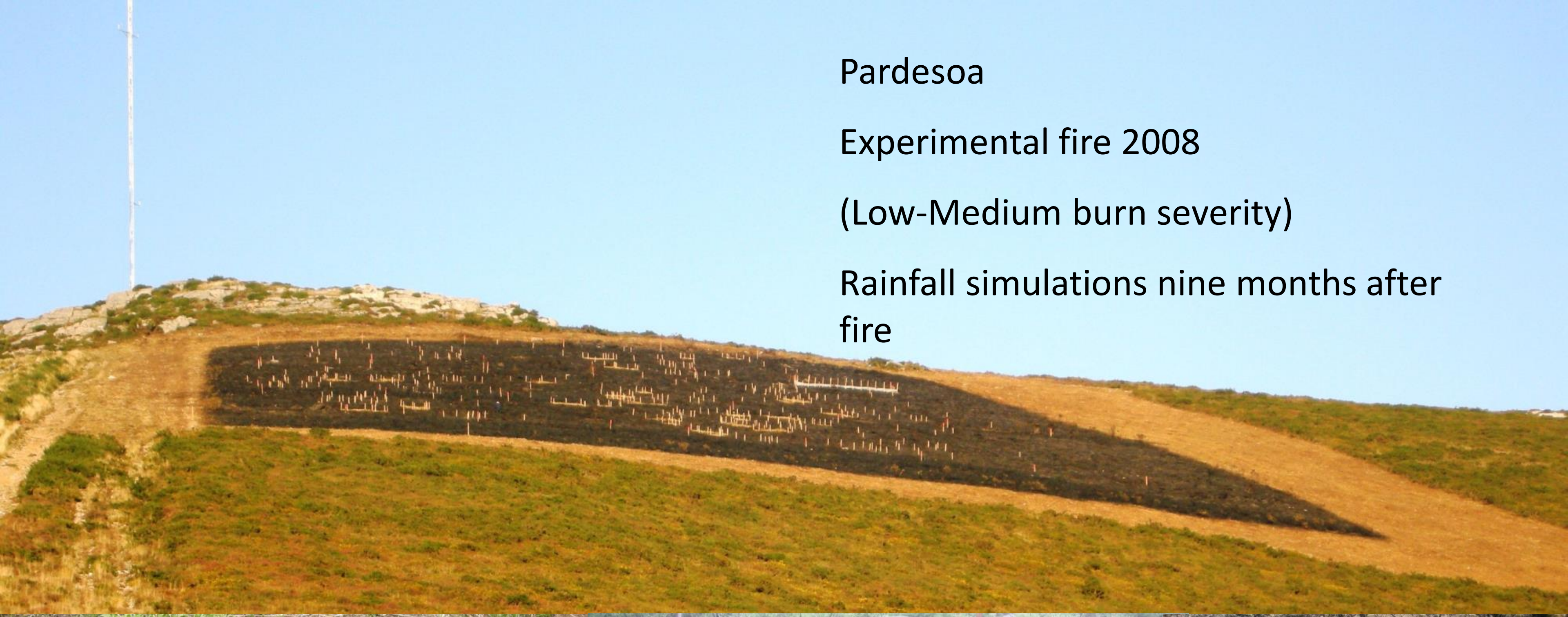


Vega, J.A., Fernández, C., Fontúrbel, M.T., González-Prieto, S.J., Jiménez, E., 2014. Testing the effects of straw mulching and herb seeding on soil erosion after fire in a gorse shrubland. Geoderma, 223-225, 79-87.

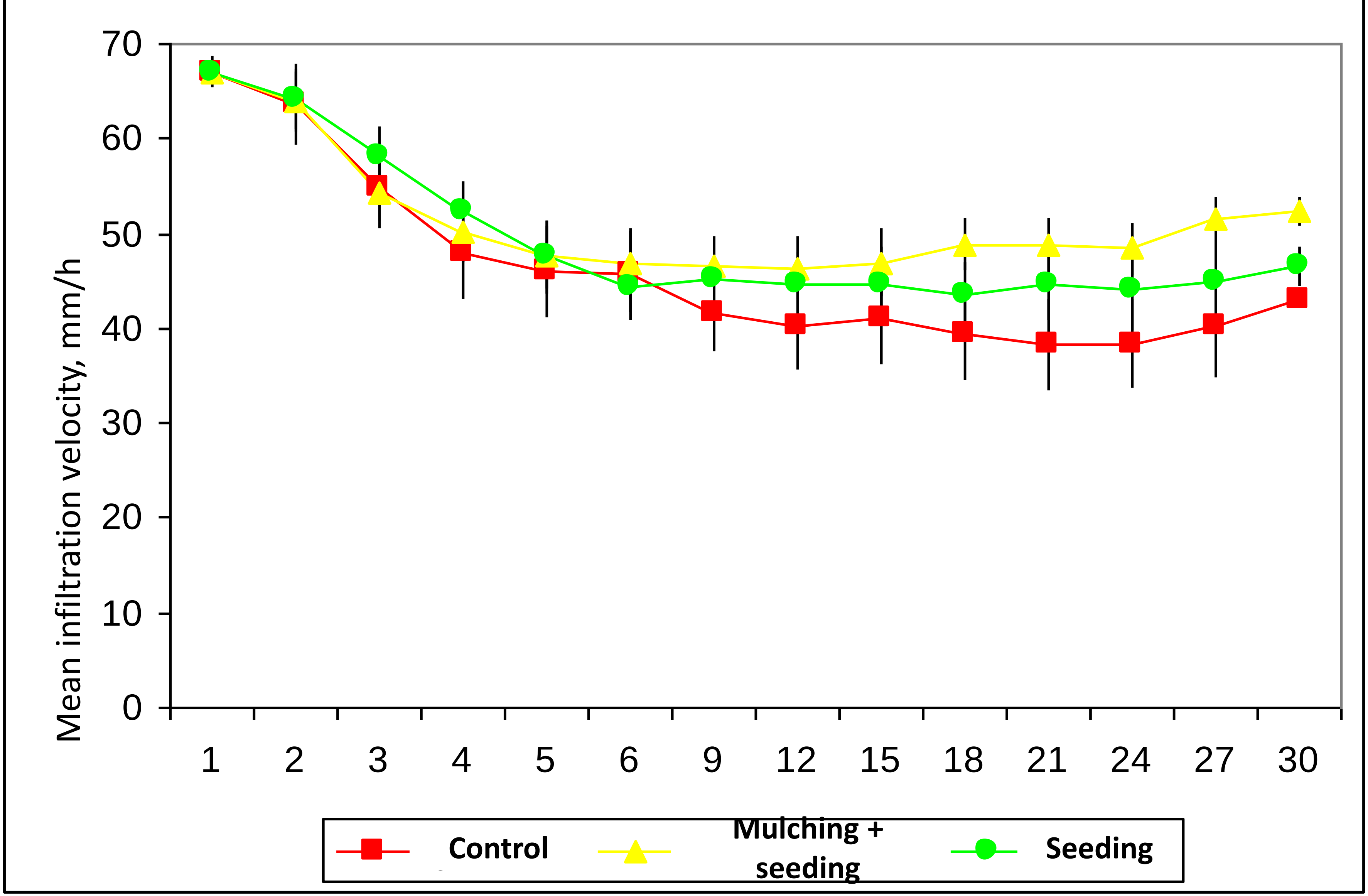
Soil erosion during the first post-fire year



Vega et al. (2014)



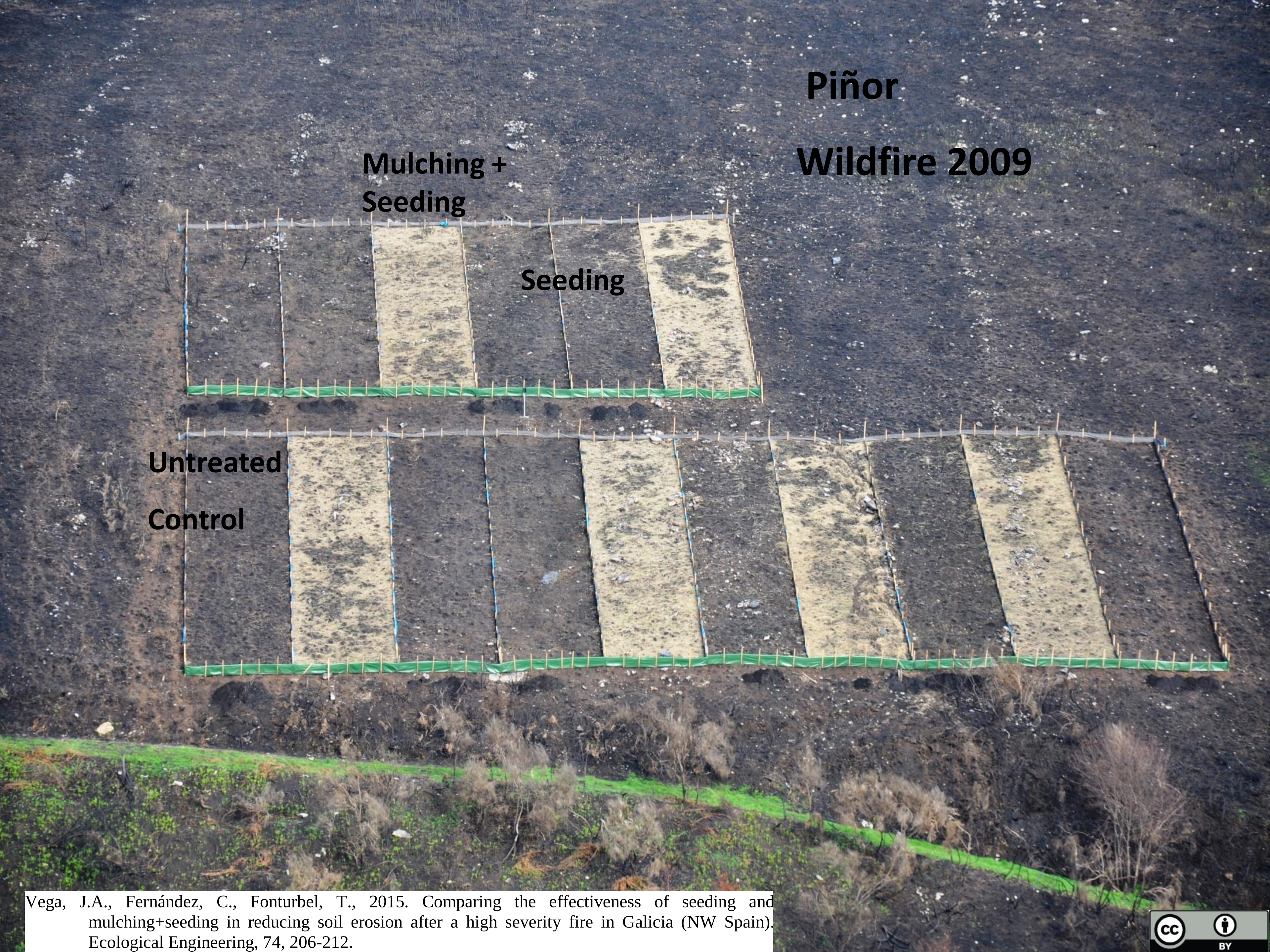
Fernández, C., Vega, J.A., Jiménez, E., Vieira, D.C.S., Merino, A., Ferreiro, A., Fonturbel, T., 2012. Seeding and mulching+seeding effects on post-fire runoff, soil erosion and species diversity in Galicia (NW Spain). Land Degradation & Development, 23, 150-156.



Sediments:

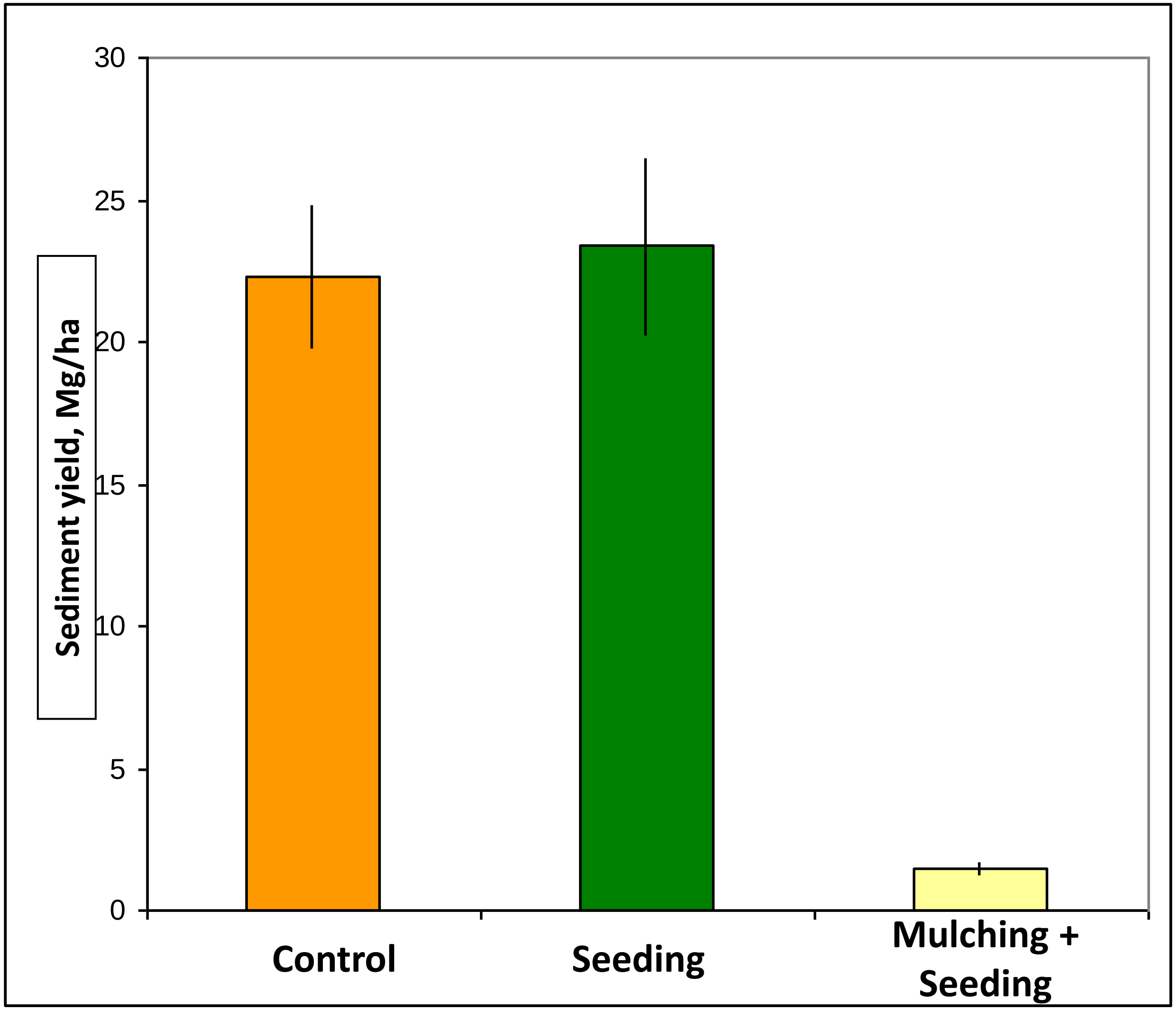
Fernández et al.(2012)

Control: 202 kg/ha; Seeding 96 kg/ha ; Mulching + seeding 76 kg/ha



Vega, J.A., Fernández, C., Fonturbel, T., 2015. Comparing the effectiveness of seeding and mulching+seeding in reducing soil erosion after a high severity fire in Galicia (NW Spain). Ecological Engineering, 74, 206-212.

FIRST POST-FIRE YEAR SEDIMENT YIELD



Vega et al.(2015)

Boiro wildfire (2010)

Fernández, C.; Vega, J.A. 2016.. Are erosion barriers and straw mulching effective for controlling soil erosion after a high severity wildfire in NW Spain? Ecological Engineering 87 :132–138

Log Barriers
(38 t /ha)

Control
(55 t/ha)

Fernández and Vega (2016)


Low dose of straw mulch: 125 g m-2
(26 t /ha)
Fernández and Vega (2016)

Soil erosion reduction

-Straw mulch (2t/ha) : 91%

-Eucalypt bark strands mulch (4 t/ha): 86%

Fernández, C., Vega, J.A., 2014. Efficacy of bark strands and straw mulching after wildfire in NW Spain: Effects on erosion control and vegetation recovery. Ecological Engineering, 63, 50-57.

Mulching application in strips in a long hillside. (Petáns wildfire 2010)

Combining straw mulch strips with fiber rolls barriers in Fragas del Eume wildfire in 2012


Navia de Suarna 2015


Camba wildfire (2010)
First time helimulching was applied in Europe

Ponte Caldelas (2013)


Navia de Suarna (2015)

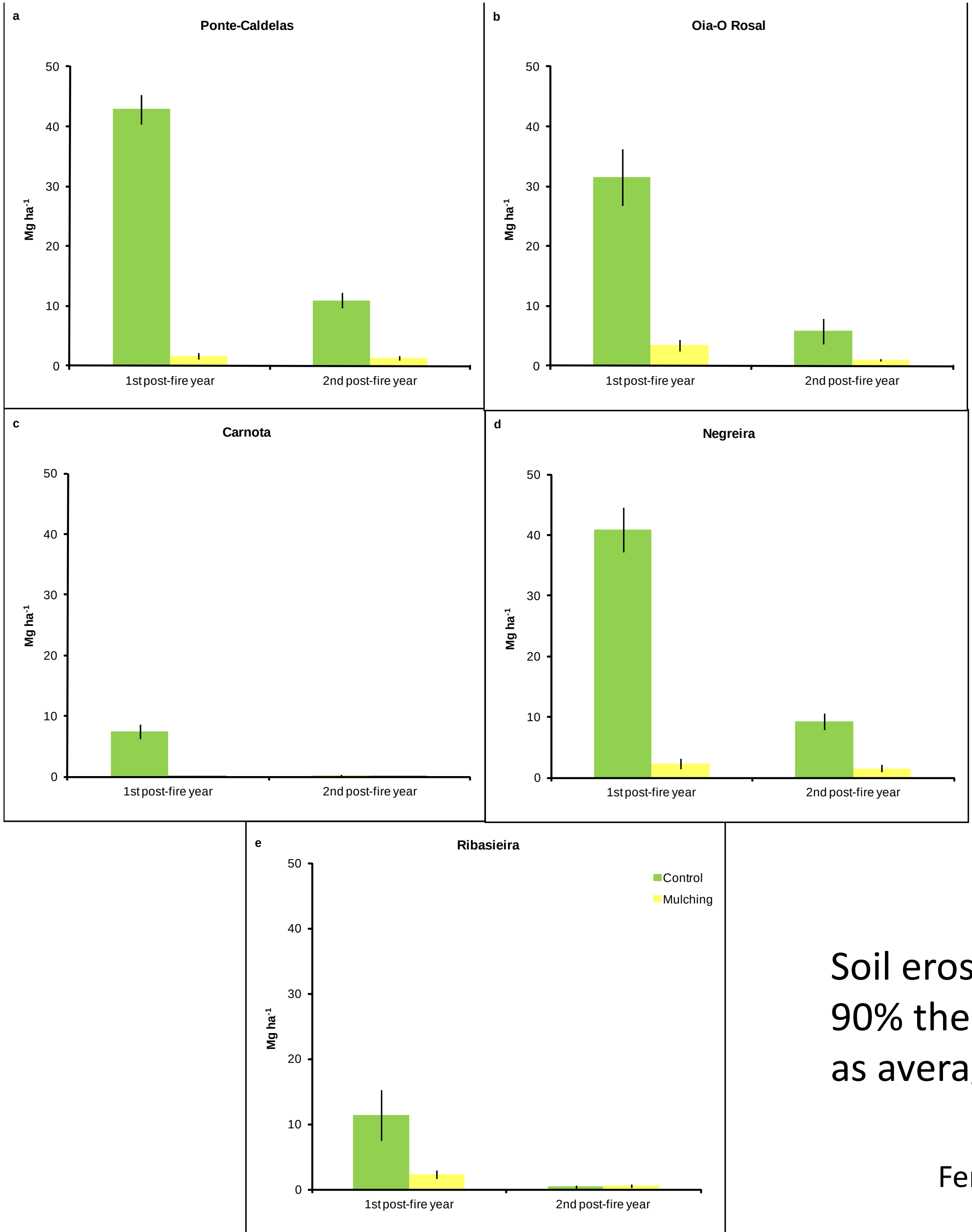

Arbo (2016)

Monitoring

Helimulching treatment monitoring for the first time in Europe

70 plots were setup in five wildfires in 2013

Fernández, C.; Vega, J.A, Fontúrbel, T. 2016.. Reducing post-fire soil erosion from the air: Performance of heli-mulching in a mountainous area on the coast of NW Spain. Catena 147 : 489–495



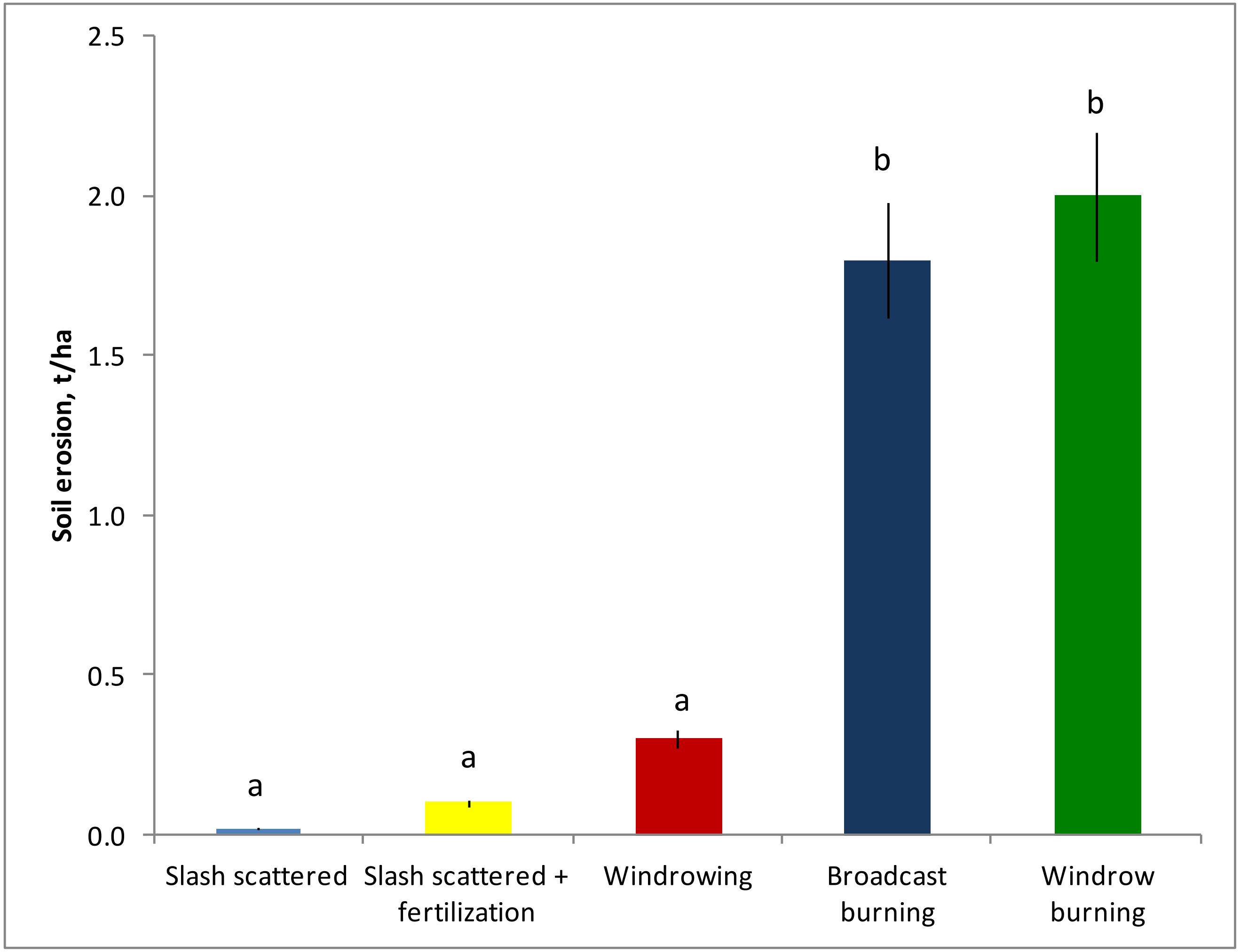
Soil erosion reduction was 90% the first post-fire year as average.

Fernández et al.(2016)

In many occasions, the profit from burned trees harvesting need to be balanced with soil conservation.

Field research concerning the effects of post-fire salvage logging on sediment production is still limited

Soil erosion after clearcutting in a *Eucalyptus globulus* stand: differences between logging slash disposal methods



Fernández, C.; Vega, J.A; Gras, J.M.; Fonturbel, M.T ; Cuiñas, P.;. Dambrine, E.; Alonso, M. 2004. Soil erosion after Eucalyptus globulus clearcutting: differences between logging slash disposal treatments. Forest Ecology and Management.. 195(1-2): 85-95

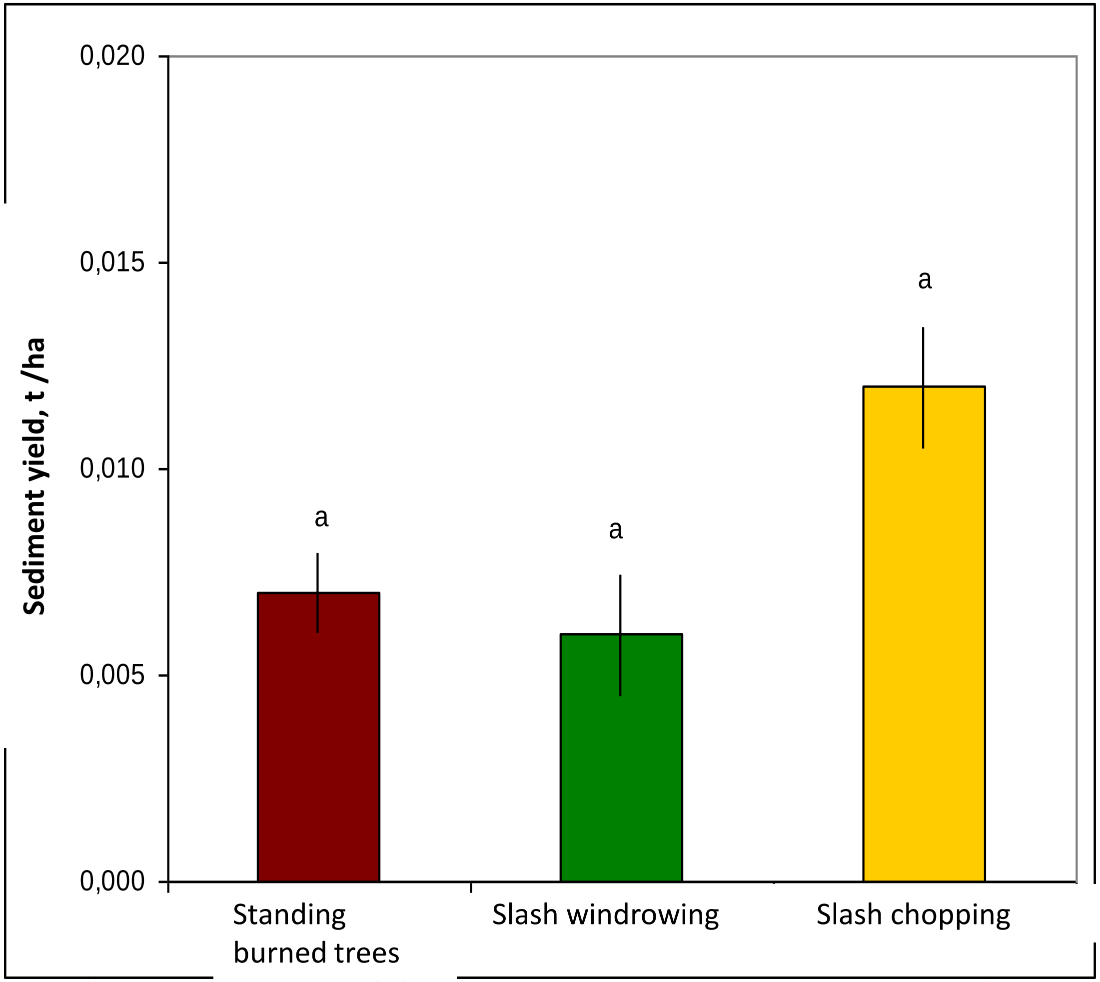
Soil losses after salvage logging in burned areas affected by moderate fire severity

(tree crown scorched generating a needle cast layer)

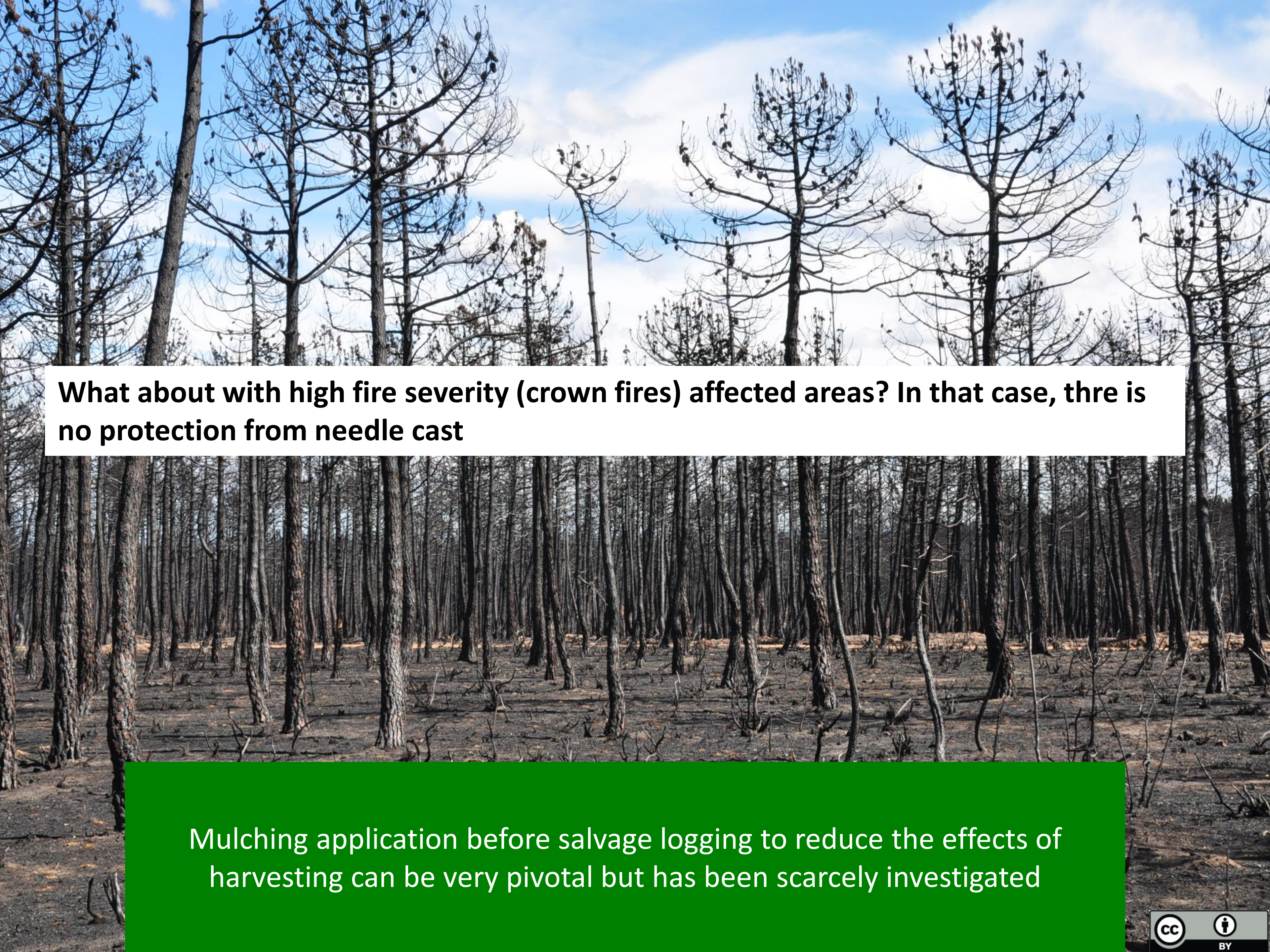
Standing burned trees (control)

Harvesting + slash windrowing

Harvesting + slash chopping



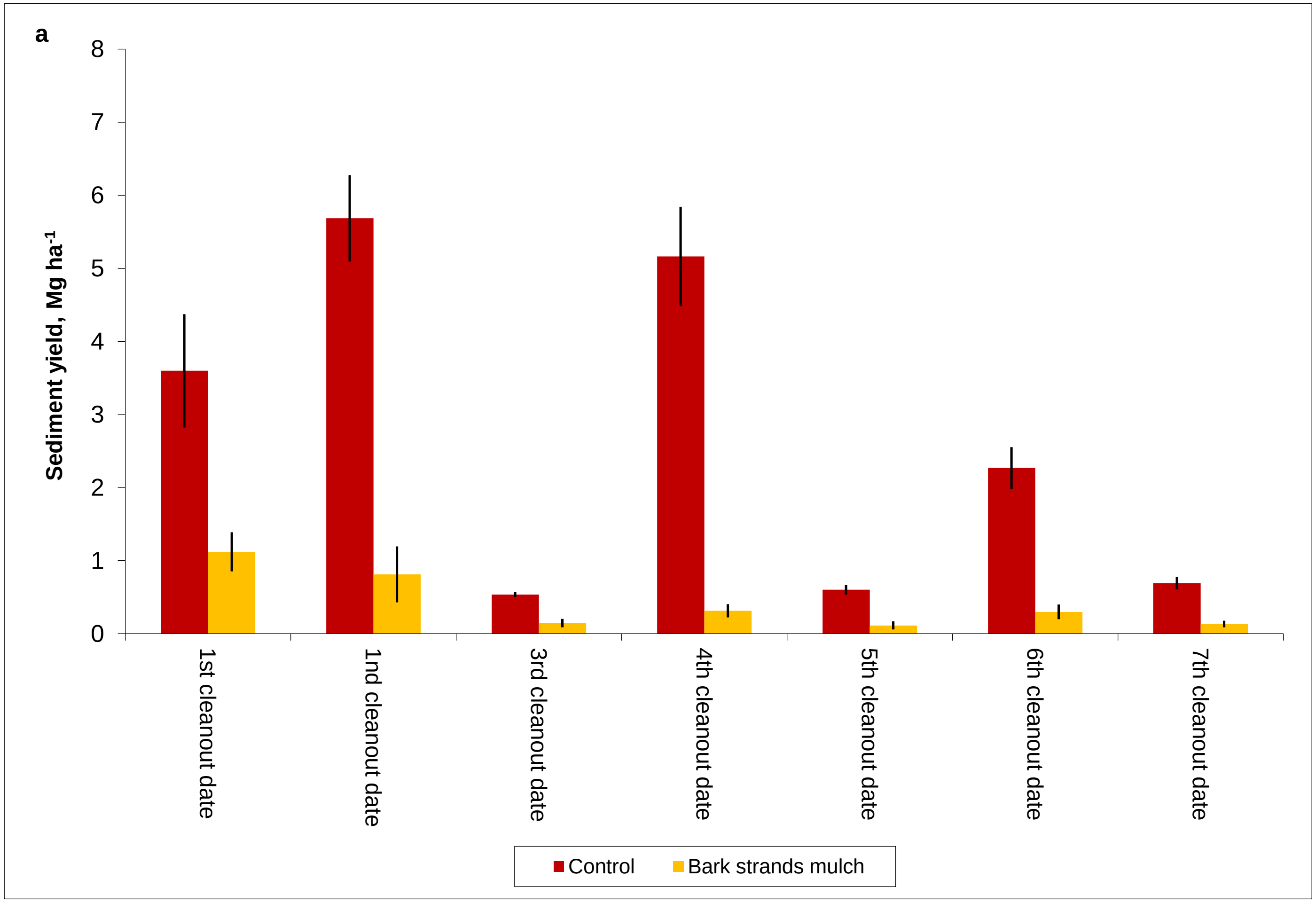
Fernández, C.; Vega J.A.; Fonturbel, M.T.; Pérez-Gorostiaga, P.; Jiménez, E.; Madrigal, J. 2007. Effects of wildfire, salvage logging and slash treatments on soil degradation. Land Degradation and Development 38 (6): 591-607.



What about with high fire severity (crown fires) affected areas? In that case, thre is no protection from needle cast

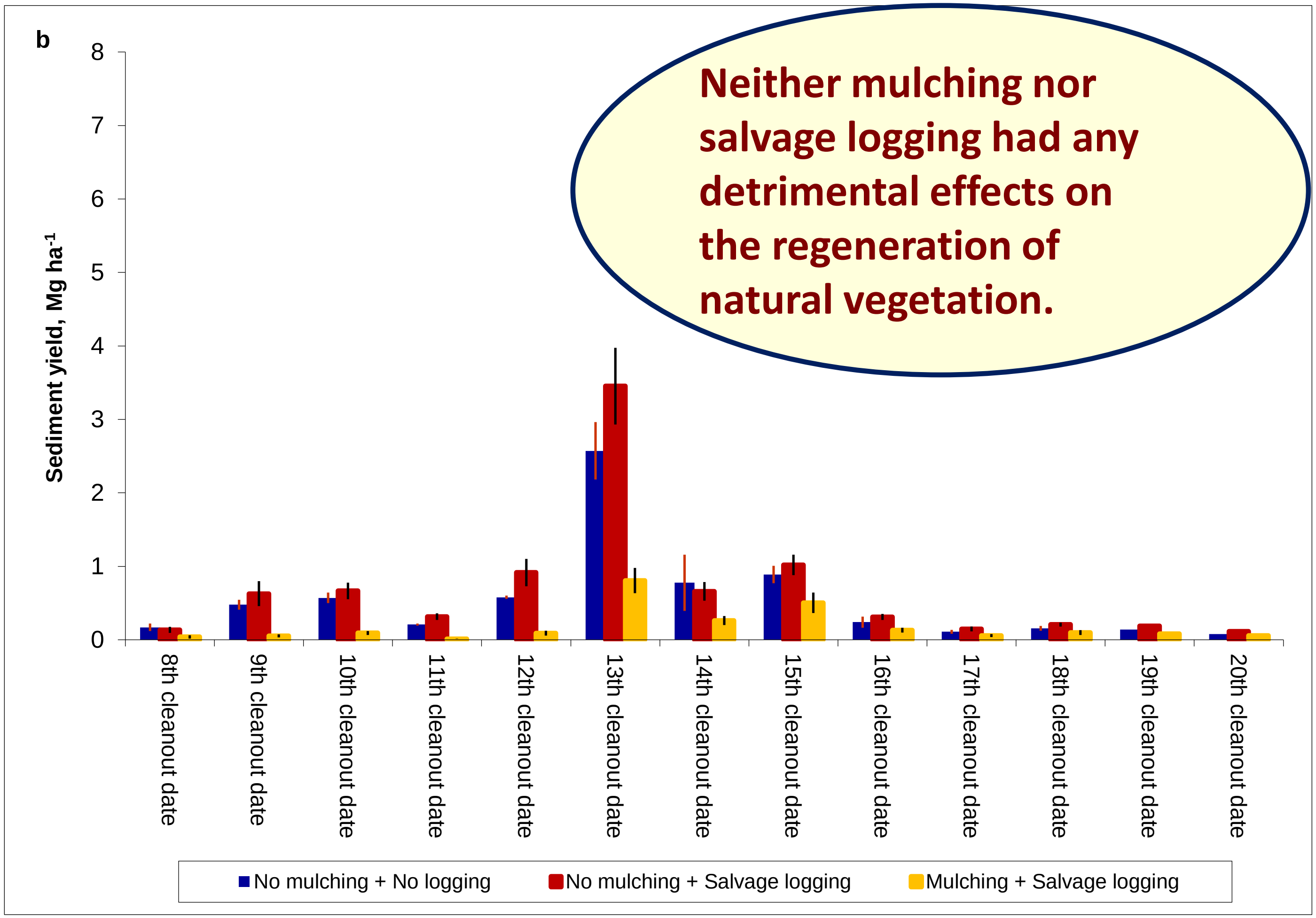
Mulching application before salvage logging to reduce the effects of harvesting can be very pivotal but has been scarcely investigated

During the six month between the wildfire and salvage logging, the average soil loss in the untreated burned soils was 18.5 Mg ha^{-1}. In that period, mulching significantly reduced soil loss (84%).



Fernández, C.; Vega, J.A. 2016. Effects of mulching and post-fire salvage logging on soil erosion and vegetative regrowth in NW Spain. Forest Ecology and Management. 375: 46-54.

In the 18-month period following salvage logging:
*** There was no increase in erosion due to logging (8.7 Mg ha^{-1}) compared with the unlogged treatment (7.0 Mg ha^{-1}) in the**
absence of mulch
*** Mulching continued reducing significantly soil losses even after logging (2.3 Mg ha^{-1}).**



Fernández and Vega (2016)

Conclusions:

A good conexion between researchers and land managers has allowed to go from experimental research plot scale to operational landscape scale.

The soil burn severity classification developed is currently used as an operational tool for rapid soil burn severity assessment in combination with remote sensing. Besides that, it has shown a good ability to reflect changes in key soil properties and soil erosion susceptibility.

Conclusions:

During the last 10 years, a variety of soil stabilization treatments has been tested in field plots. Mulching has shown the highest effectiveness. Helimulching is being applied for the first time in Europe.

Mulching before salvage logging in crown fire affected areas can reduce the soil losses before and after harvesting.

Some relevant research gaps related to post-fire hydrologic response:

-Sediments production modelling at catchment scale. How soil burn severity affects connectivity?

-Impact of climate change: How annual rainfall distribution and intensity shifts will affect soil losses after fire?

-To improve remote sensed severity assessment.

-Soil burn severity prediction.

-Introduction of uncertainty in the models: probability of high soil burn severity combined post-fire adverse meteorological events occurrence

-Vulnerability operational appraisal.

-Alternative biological treatments to accelerate post-fire recovery.


Thank you!
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