

Catterline, November 16<sup>th</sup> 2022



# Catterline Braes & Nature-based Solutions



Horizon 2020

**Dr Alejandro Gonzalez Ollauri**  
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OPEN-air laboRATORies for Nature based  
solUtions to Manage hydro-meteo risks



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Credit: R. Reglinski

A. Gonzalez-Ollauri



Horizon 2020

2019



- Legend
- Field
  - Bull ditch
  - Ditch
  - Diode
  - Action 1
  - Plow with brown layer (P20 200)
  - Live drainage feature
  - Action 2
  - Vegetated strip le aris wall
  - Action 3
  - Live at open grid
  - Action 4
  - Two level wooden vegetated palisade
  - Vegetated live at open grid
  - One level wooden vegetated palisade
  - Action 5
  - Brown layer
  - Action 6
  - Photo walling with Hydro CXX
  - Action 7
  - Orchard drain ar
  - Two level formal wooden palisade
  - Action 8
  - Vegetated strip le aris wall
  - Two level wooden vegetated palisade
  - Live at open grid
  - Action 9
  - Brown layer
  - Action 10
  - Low area oris wall
  - Action 11
  - Live at open grid



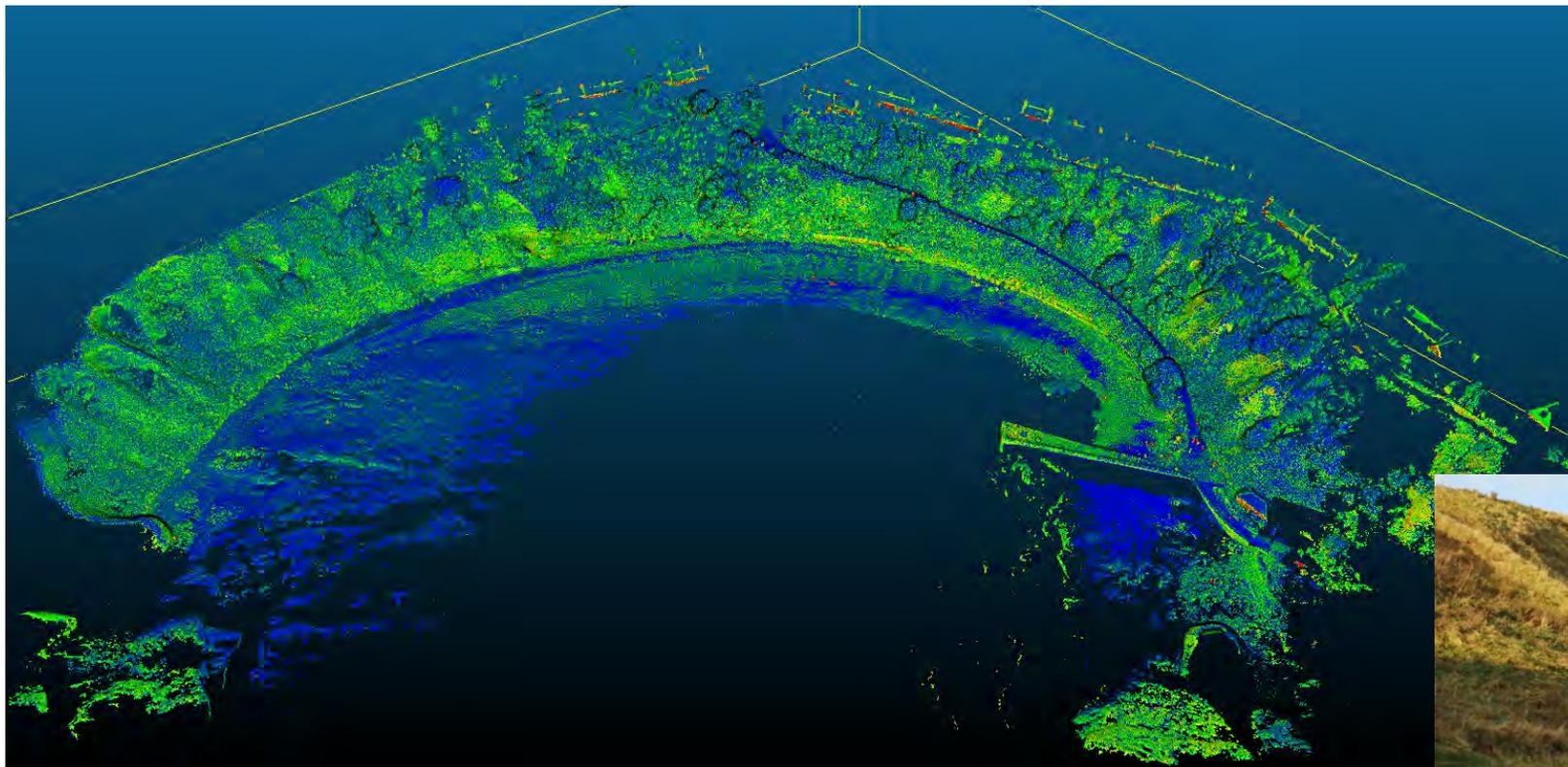
2019



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Horizon 2020

2019



# Community Attitude and Preferences of Nature-based Solutions (NbS)



March 2019

Dr Karen Munro  
Glasgow Caledonian University  
[karen.munro@gcu.ac.uk](mailto:karen.munro@gcu.ac.uk)



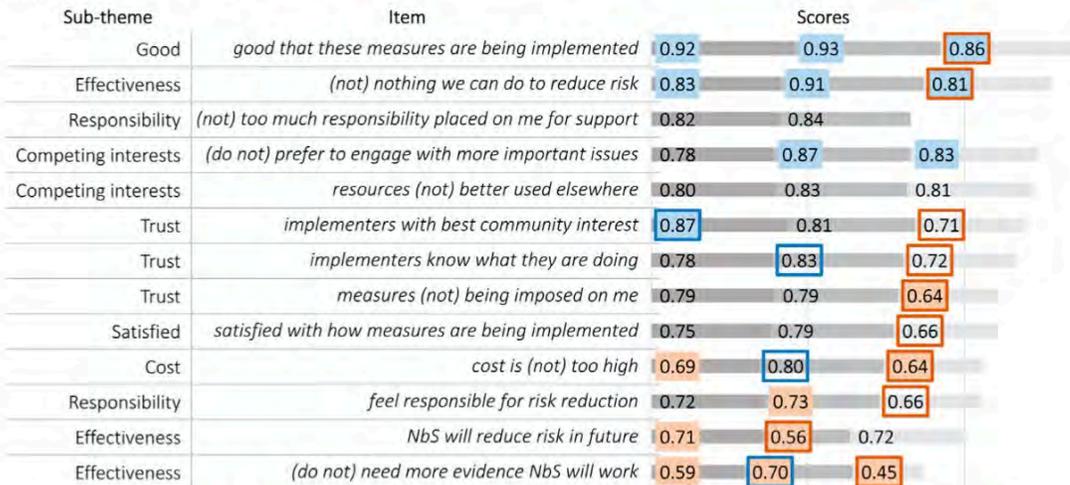
A. Gonzalez-Ollauri



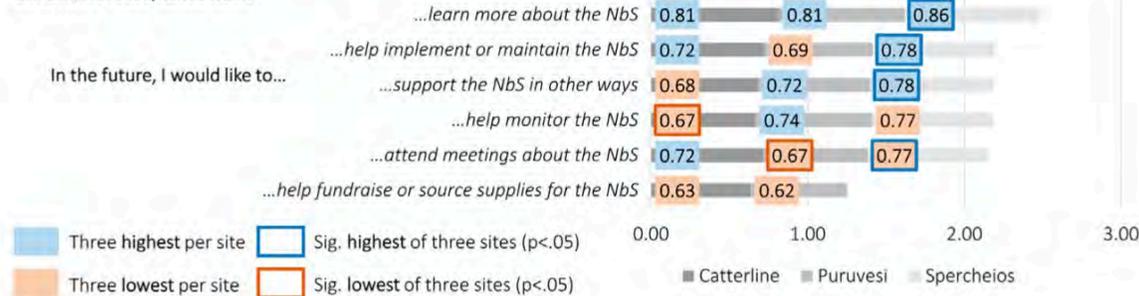
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Attitudinal acceptance items



Behavioural acceptance items



# Public Acceptance of Nature-Based Solutions for Natural Hazard Risk Reduction: Survey Findings From Three Study Sites in Europe

Carl C. Anderson<sup>1\*</sup>, Fabrice G. Renaud<sup>1</sup>, Stuart Hanscomb<sup>1</sup>, Karen E. Munro<sup>2</sup>, Alejandro Gonzalez-Ollauri<sup>2</sup>, Craig S. Thomson<sup>2</sup>, Eija Pouta<sup>3</sup>, Katriina Soini<sup>3</sup>, Michael Loupis<sup>4,5</sup>, Depy Panga<sup>4</sup> and Maria Stefanopoulou<sup>4</sup>

<sup>1</sup>School of Interdisciplinary Studies, University of Glasgow, Dumfries, United Kingdom, <sup>2</sup>The BEAM Research Centre, School of Computing, Engineering and Built Environment, Glasgow Caledonian University, Glasgow, United Kingdom, <sup>3</sup>Natural Resources Institute Finland (Luke), Helsinki, Finland, <sup>4</sup>Innovative Technologies Centre, Athens, Greece, <sup>5</sup>General Department, National and Kapodistrian University of Athens, Athens, Greece



2020



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**NATURE-BASED SOLUTIONS (NBS):**  
protecting the Catterline Braes

**AN EVENT by Glasgow Caledonian University (GCU)**  
and Naturalea within the OPERANDUM Project (EU Horizon 2020)  
in collaboration with Catterline Braes Action Group (CBAG) and UNESCO

**MARCH 26<sup>TH</sup> - 28<sup>TH</sup> 2020**  
Nature-Based Solutions for Slope Protection Workshop  
26th - Station Hotel, Stonehaven  
27th & 28th - Catterline

**FOR MORE INFORMATION AND REGISTRATION:**  
<https://nbscatterline.eventbrite.co.uk>  
Or contact Karen Munro (karen.munro@gcu.ac.uk)  
or Alejandro Gonzalez Ollauri (alejandro.ollauri@gcu.ac.uk)

GCU: [gcu.ac.uk/assetmanagement](http://gcu.ac.uk/assetmanagement)  
CBAG: [cbag.org.uk](http://cbag.org.uk)

OPERANDUM: [operandum-project.eu](http://operandum-project.eu)  
Naturalea: [www.naturalea.eu](http://www.naturalea.eu)



Horizon 2020

2020



Credit: [bbc.co.uk](https://www.bbc.com)

2020



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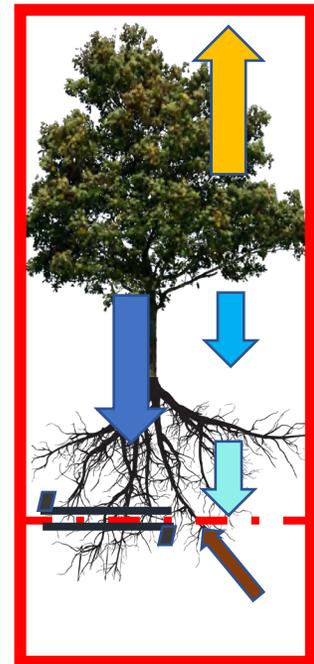
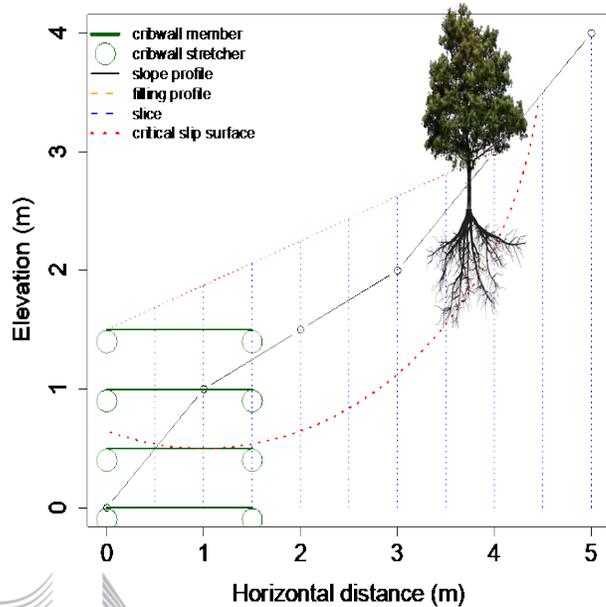
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**Vegetated cribwall “very” effective against landslides**

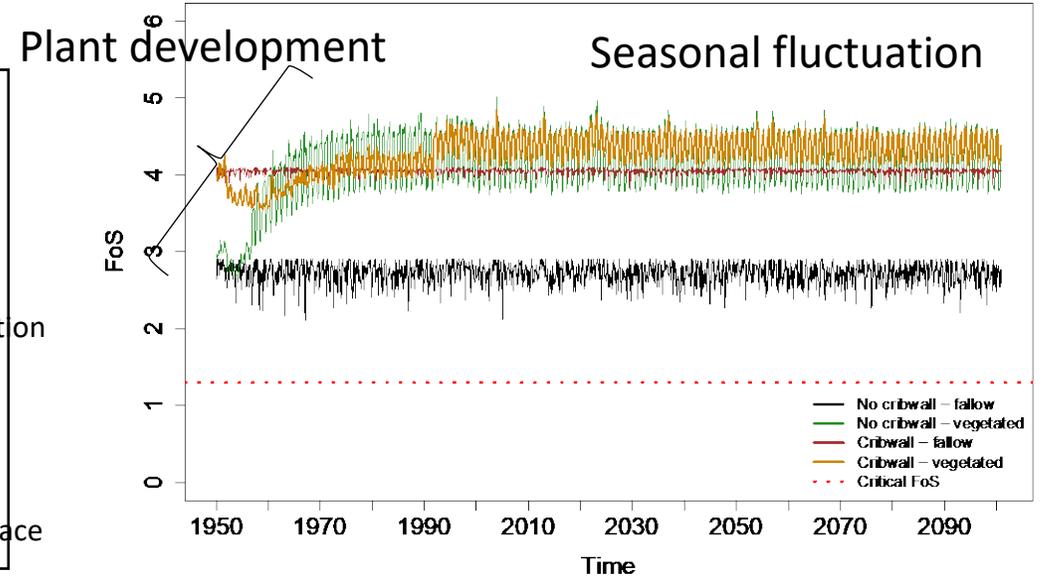
Gonzalez-Ollauri et al., 2021. *EGU21-5858*

Live Cribwall Sketch



- Stemflow
- Throughflow
- Infiltration
- Evapotranspiration
- Root pull-out
- Root breakage
- Critical slip surface

Live Cribwall – FoS rcp8.5



2020

Journal of Hydrology 582 (2020) 124448

Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

Research papers

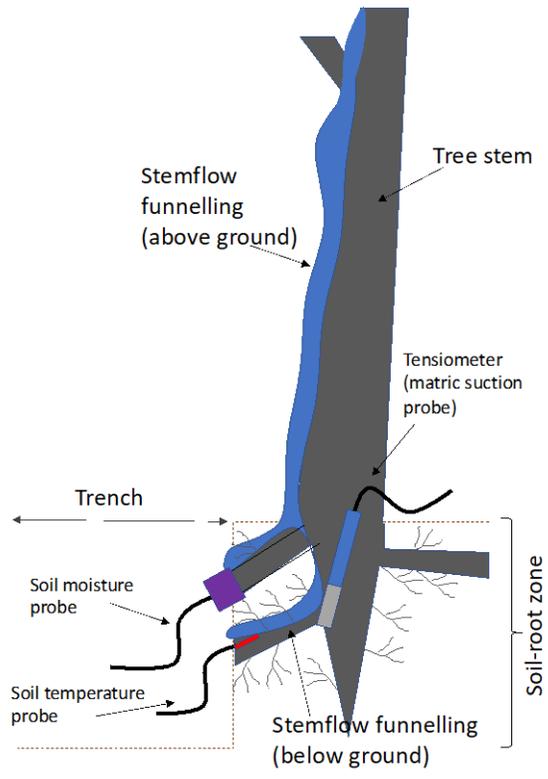
**A novel framework to study the effect of tree architectural traits on stemflow yield and its consequences for soil-water dynamics**

Alejandro Gonzalez-Ollauri<sup>a,\*</sup>, Alexia Stokes<sup>b</sup>, Slobodan B. Mickovski<sup>b</sup>

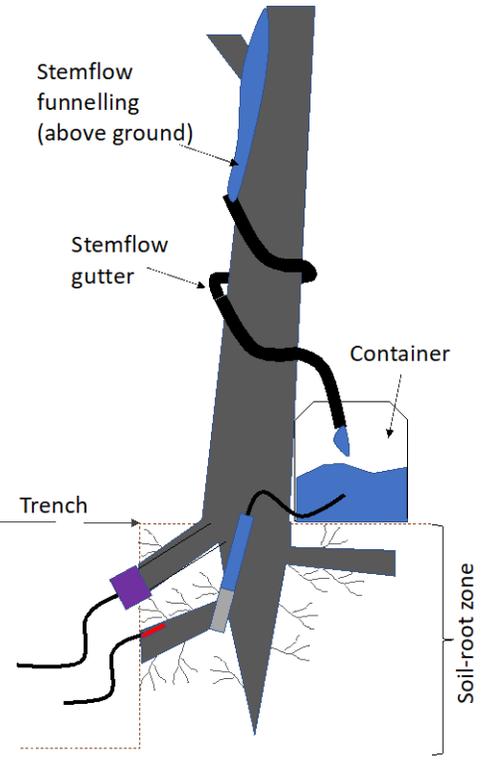
<sup>a</sup> The BEAM Research Centre, School of Computing, Engineering and Built Environment, Glasgow Caledonian University, G4 0BA Glasgow, UK  
<sup>b</sup> INRAE, AMAP, CIRAD, IRD, CRS, University of Montpellier, 34398 Montpellier Cedex 5, France

# Stemflow

Stemflow-free conditions



Stemflow-suppression conditions



A. Gonzalez-Ollauri, et al.

Journal of Hydrology 582 (2020) 124448

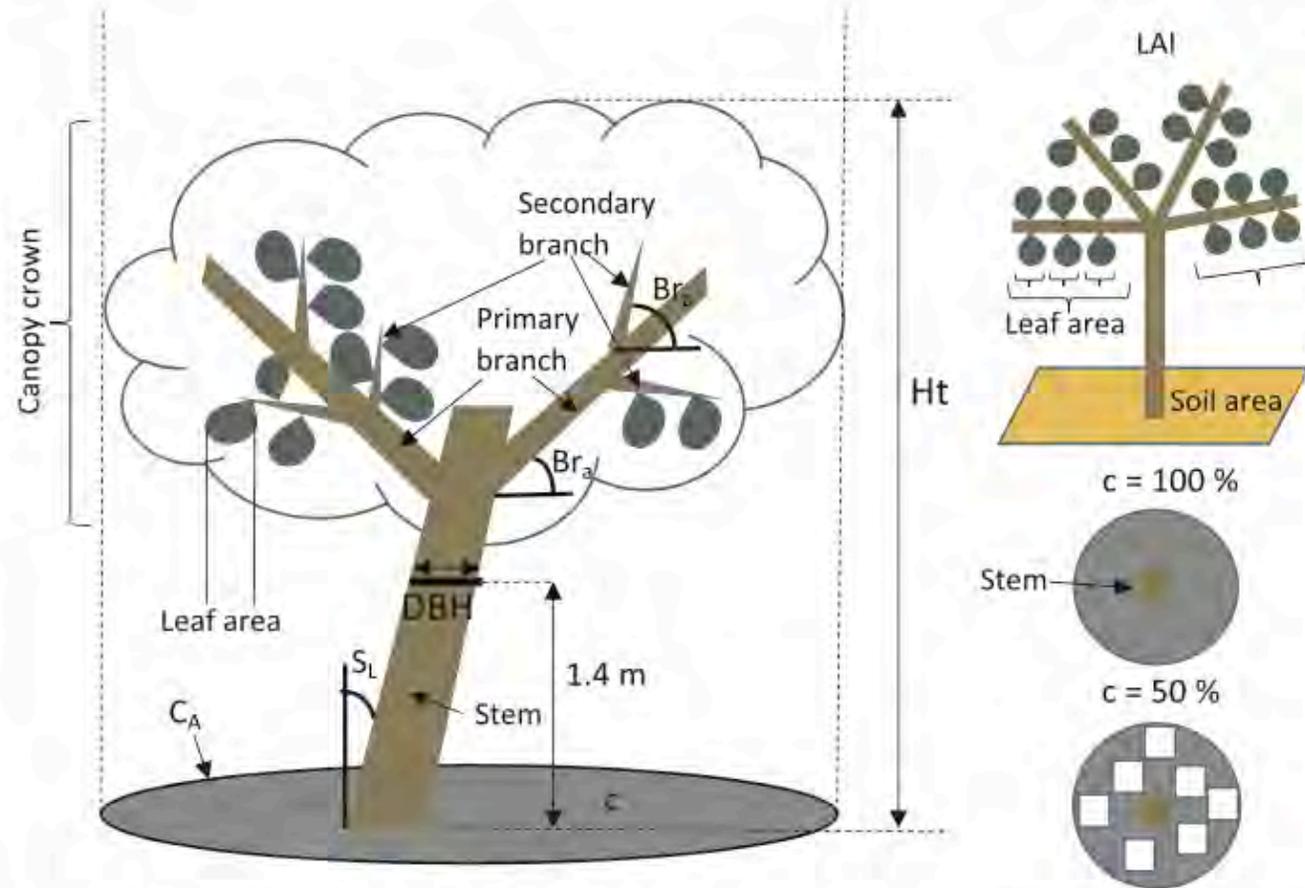
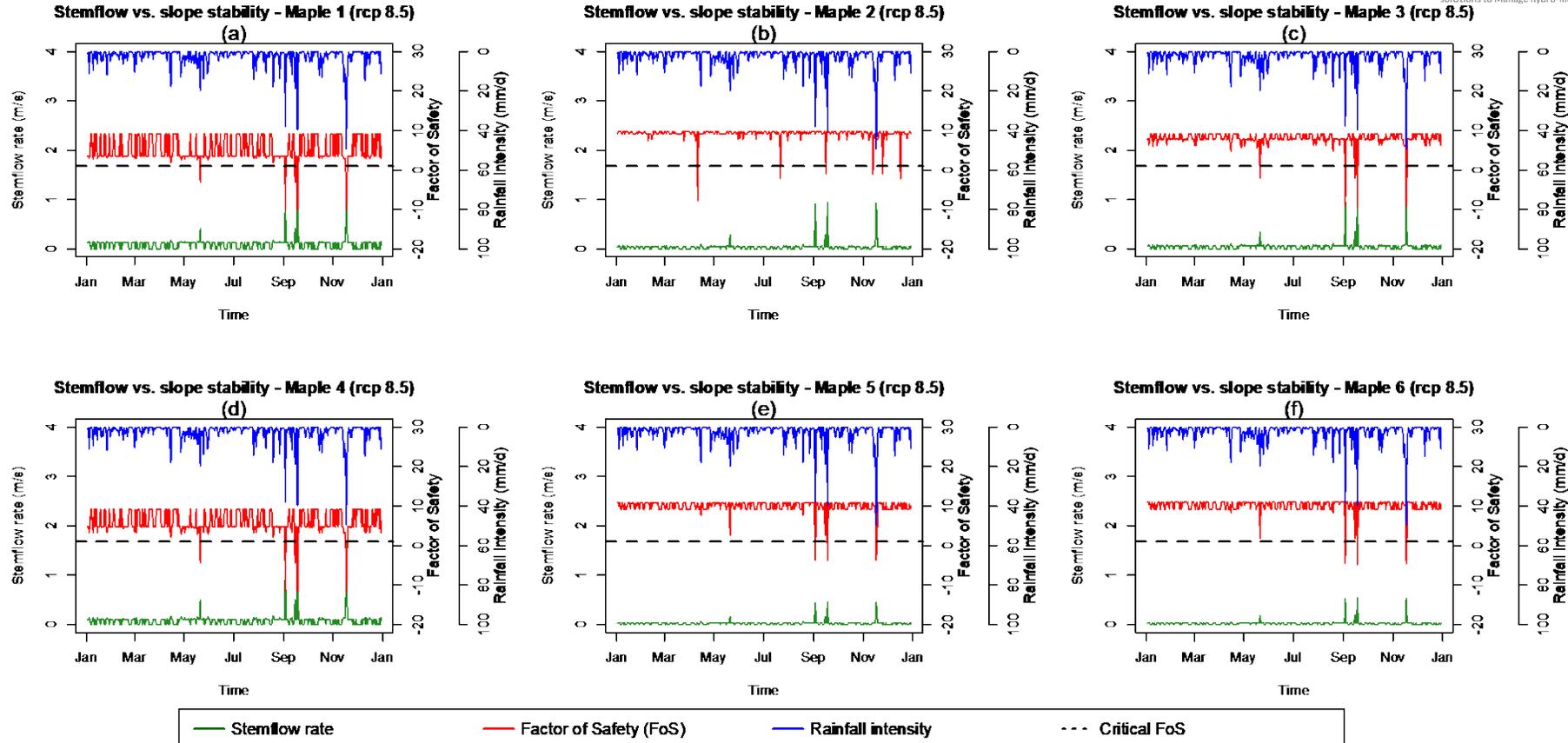


Fig. 1. Illustration showing tree architectural traits measured in this study. *DBH*: diameter at breast height;  $C_A$ : projected canopy-crown area;  $c$ : canopy cover fraction; *Ht*: tree height; *LAI*: leaf area index;  $S_L$ : stem lean;  $Br_a$ : branch insertion angle. On the right-hand side, the concept of *LAI* and two  $c$  examples are illustrated, i.e. dense canopy crown with  $c = 100\%$  and sparse canopy crown with  $c = 50\%$ , where the white squares portray the penetration of sunlight through the canopy.



**Stemflow is important, and it can be regulated through managing tree's architecture**

2020

# Plant-Best

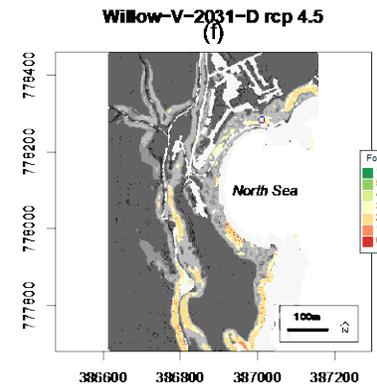
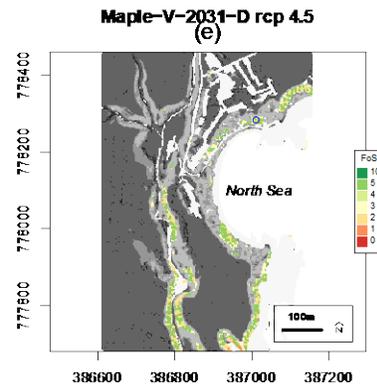
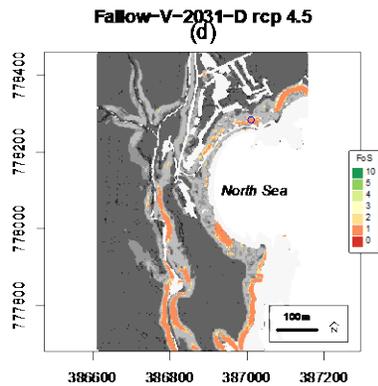
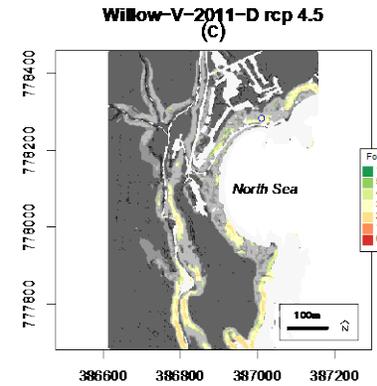
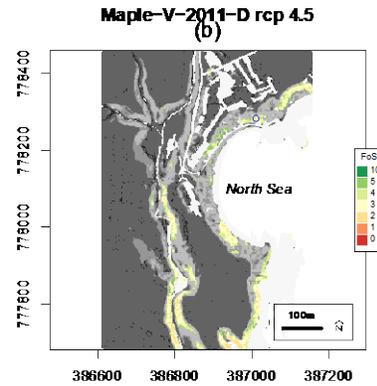
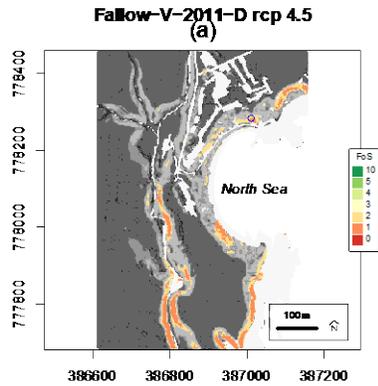
Gonzalez-Ollauri, A. & Mickovski, 2017. *Ecological Engineering*, 106: 154-173



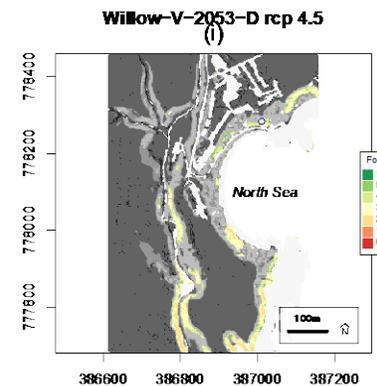
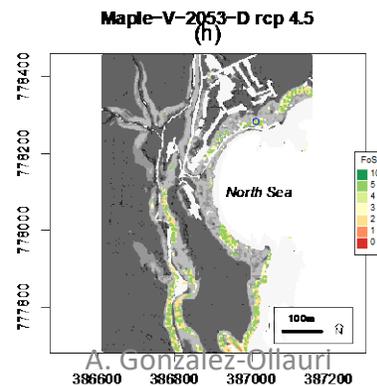
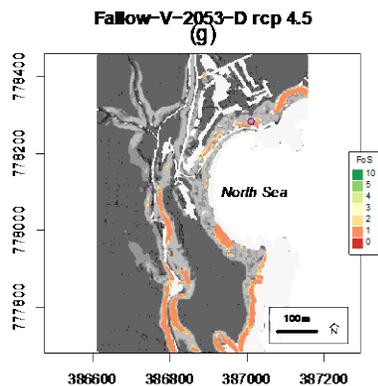
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Factor of Safety:  
**Red** – landslide  
**Green** – no landslide



**Tress are effective against  
landslides, maple better  
than willow**

Gonzalez-Ollauri, A. (Unpublished)



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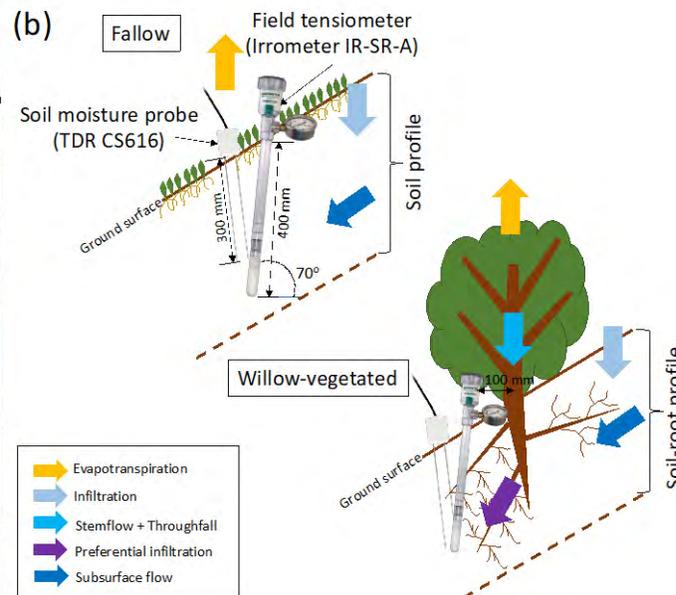
Article

# The Effect of Willow (*Salix* sp.) on Soil Moisture and Matric Suction at a Slope Scale

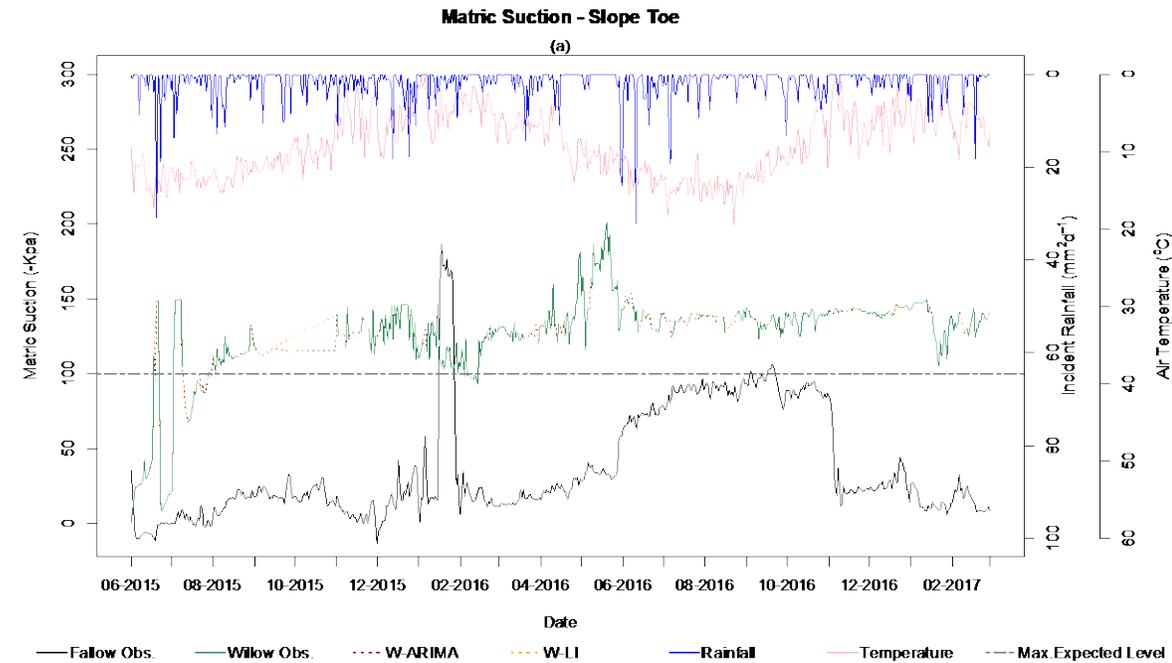
Alejandro Gonzalez-Ollauri \* and Slobodan B. Mickovski

The BEAM Research Centre, School of Computing, Engineering and Built Environment, Glasgow Caledonian University, Glasgow G4 0BA, UK; slobodan.mickovski@gcu.ac.uk

\* Correspondence: alejandro.ollauri@gcu.ac.uk



**Willow keeps the slope dry and stable**



2021



Sloped wet zones are prone to landslides



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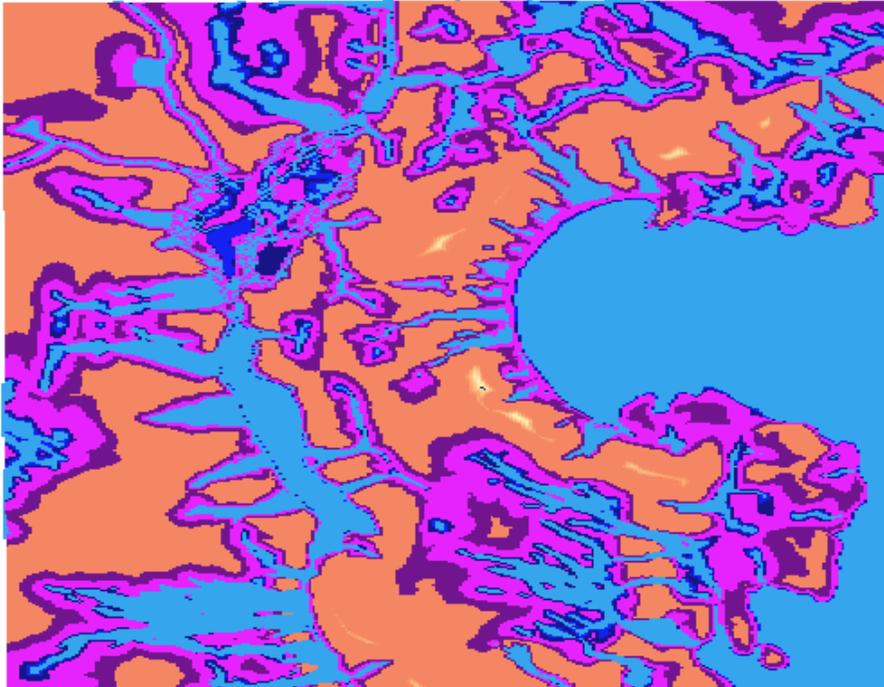


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Article

# A Simple GIS-Based Tool for the Detection of Landslide-Prone Zones on a Coastal Slope in Scotland

Alejandro Gonzalez-Ollauri <sup>1</sup> and Slobodan B. Mickovski <sup>1,\*</sup>



A. Gonzalez-Ollauri

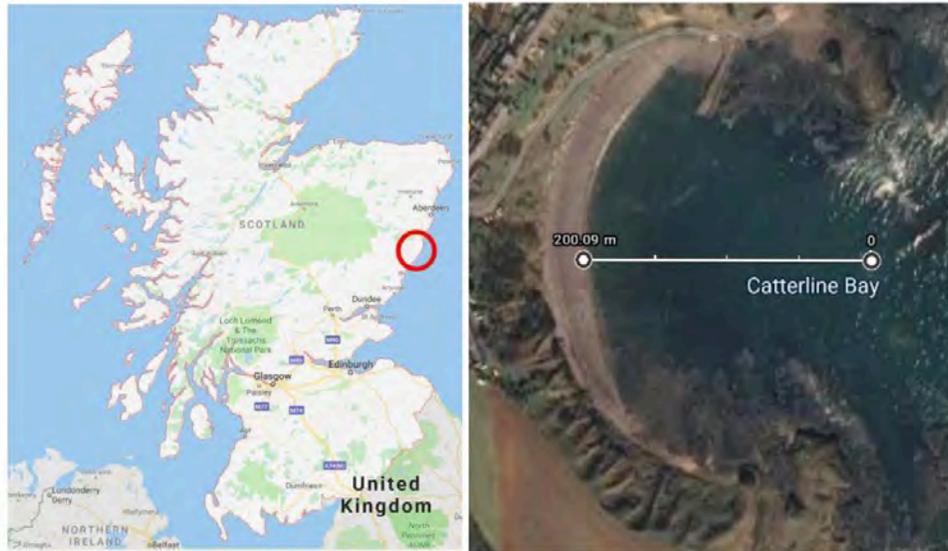


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# Considerations on the design of shellfish reef against coastal erosion

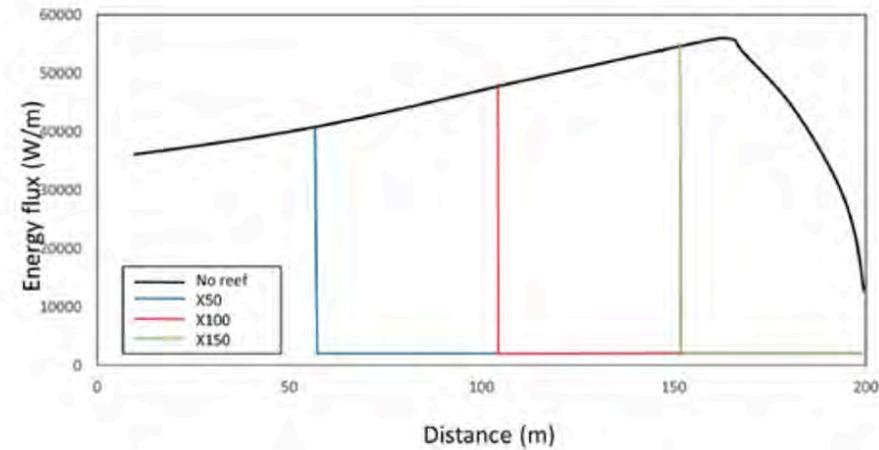
Slobodan B. Mickovski<sup>1</sup>[0000-0002-1792-1258] Alejandro Gonzalez-Ollauri<sup>1</sup>[0000-0001-8894-1662] and Victor Henneton<sup>1</sup>

<sup>1</sup> Glasgow Caledonian University, 70 Cowcaddens Rd, Glasgow G4 0BA, Scotland, UK



**Fig. 1.** Location of Catterline Bay, showing the assumed wave corridor and distances from the bay neck ( $x=0$ ) to the shore ( $x=200$ m). Figure lined up on North.

**Reef closer to the beach reduces more wave energy**



**Fig. 3.** Wave energy flux ( $P$ ) scenario comparison.

2021



2021

# Live cribwall



# Concrete cribwall



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Horizon 2020

2021

After construction

One year later



2021

## Live slope grating



## Concrete grating

2021

After construction



One year later

2021

# Live pole drain



# Concrete drain



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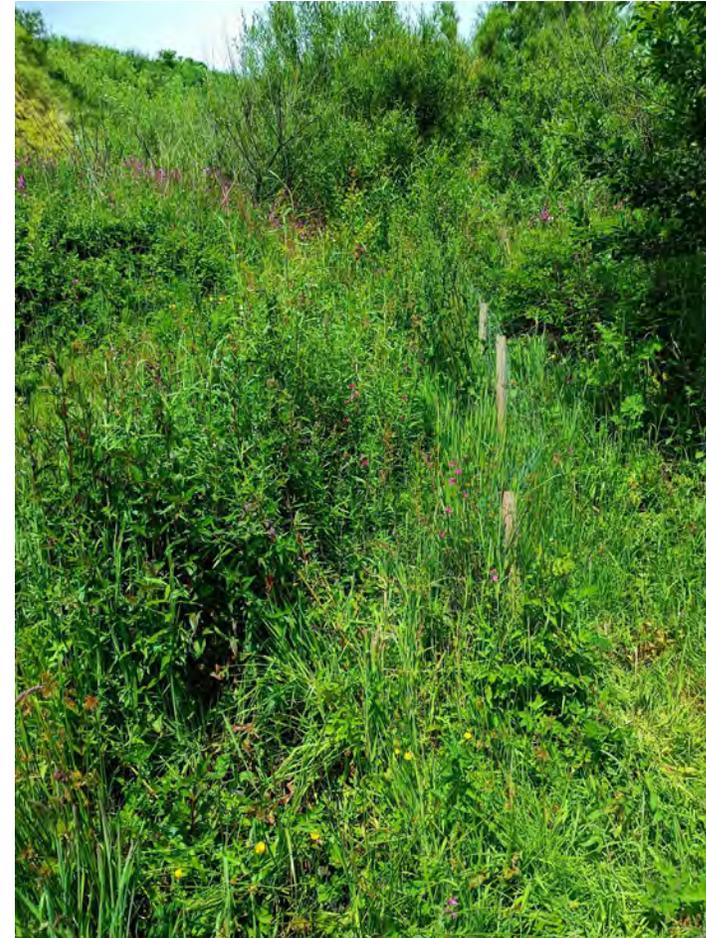
Horizon 2020

2021

After construction



One year later





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Journal of Environmental Management

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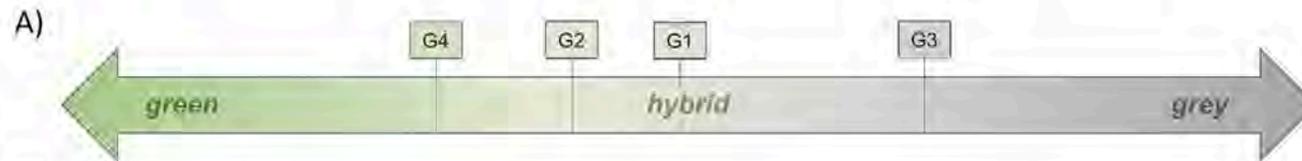


# Green, hybrid, or grey disaster risk reduction measures: What shapes public preferences for nature-based solutions?

Carl C. Anderson <sup>a,\*</sup>, Fabrice G. Renaud <sup>a</sup>, Stuart Hanscomb <sup>a</sup>, Alejandro Gonzalez-Ollauri <sup>b</sup>

<sup>a</sup> School of Interdisciplinary Studies, University of Glasgow, Dumfries, DG1 4ZL, Scotland, UK

<sup>b</sup> The BEAM Research Centre, School of Computing, Engineering and Built Environment, Glasgow Caledonian University, Glasgow, G4 0BA, Scotland, UK



B)

	n	Dominant rationale for group preference
G1	2	Depends on where in the community and for what purpose. Closer to the sea requires greyer measures, on the braes [cliffs] in some places green is adequate, but hybrid is ideal.
G2	3	Hybrid made the most sense with prior work for slope stabilization, but green was used for drains and green is generally preferable. It may be that greyer measures could be implemented at first and then afterwards greener measures.
G3	2	Hybrid is ideal, but some things can and should be done with grey measures. The issue must be broken down into many small problems and many different solutions should be used in different areas, but possibly best to start with grey and then later start to move towards green.
G4	3	Green is the best but only assuming the measure is sufficiently effective, while there are trade-offs to consider with any measure.

Fig. 4. Group preferences for the approximate position of the “ideal measure for Catterline” on a spectrum of green-hybrid-grey (A) and corresponding dominant rationale synthesized from the group discussions (B). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)



2022



2022



Credit: Naturalea

2022

## Brush layers



Credit: Naturalea



## Concrete terraced wall

2022

After construction



Few days later



2022

# Sustainable drainages



Credit: Naturalea

2022



2022

## Live drainage + live fascines



Credit: Naturalea

## Branch mattress



2022



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solutions to manage hydro-meteorological risks



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A. Gonzalez-Ollauri



Horizon 2020

2022



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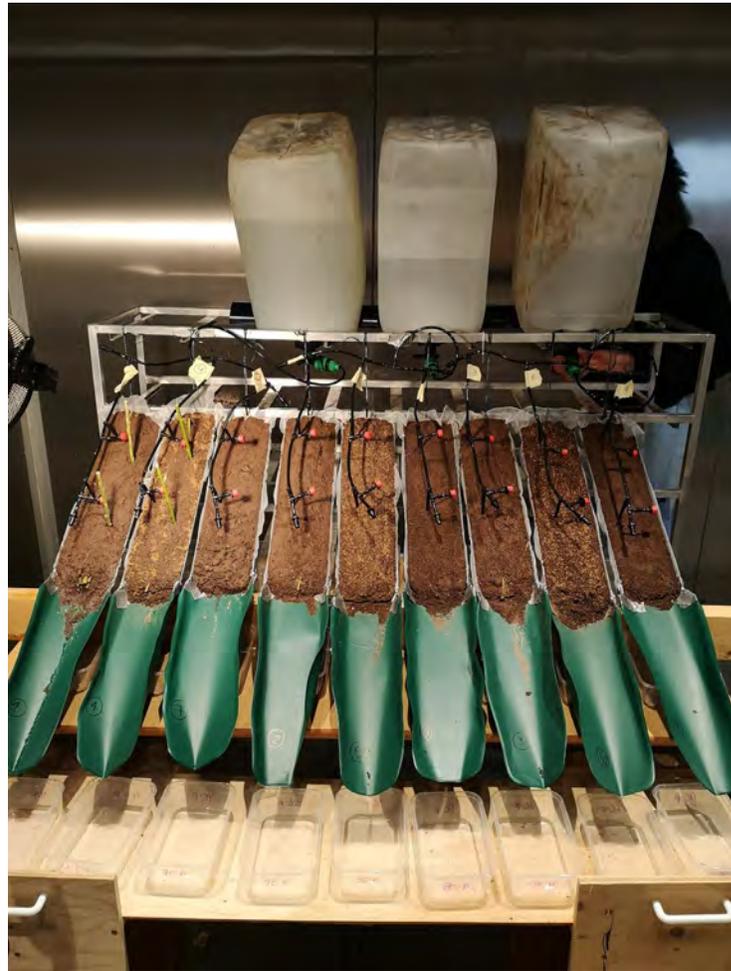
# NbS Performance Monitoring



- Soil-water dynamics
- Plant establishment
- Habitat provision
- Structural integrity

A. Gonzalez-Ollauri

# Experiments



Credit: F. Berlitz et al. (Forthcoming)

# Summer schools & scholars' visits



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# Capacity building



# Dissemination

- European Geosciences Union (EGU) Annual Assemblies 2020 and 2021
- 12<sup>th</sup> ALERT Olek Zienkiewicz School 2021 - 18<sup>th</sup> May 2021
- UNESCO's OAL seminar series – 31<sup>st</sup> July, 2021
- Nature-Based Solutions Workshop for Hazard Mitigation - Territory of American Samoa- April 28, 2022
- UNEP and UN-Habitat
- Nature-Based Solutions for reducing hydro-meteorological hazards - Capacity Building Workshop- June 14, 2022
- Chamber of Civil Engineers of the Republic of N. Macedonia- November 1<sup>st</sup> 2022



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## People & Nature vs Landslides & Erosion

Alejandro Gonzalez-Ollauri, Slobodan B. Mickovski, Rohinton Emmanuel [aol3@gcu.ac.uk](mailto:aol3@gcu.ac.uk)



GA - No 770848



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### The Open-air Lab at Catterline Bay

We set up an OAL in Scotland to build and investigate NbS on a site subject to landslides & erosion.



### Working with the local community

We worked with Catterline's community to co-create NbS, which are already helping build capacity and resilience to climate change hazards such as landslides & erosion.



Credit: CBAG

### Local natural materials

Earth

+

Timber

+

Plants



### Built manually, blended into the landscape

The NBS follow civil and ecological engineering principles, they can be built by hand, and they promote landscape restoration as the vegetation cover develops in the intervention.



### Lessons & Exploitation

- Identify the problem
- Understand the environment
- Map the stakeholders
- Listen and engage
- Look out for existing solutions
- Follow established principles
- Be creative
- Use local resources
- Work along with Nature



### Live structures against landslides & erosion

The NbS that we built are "alive" and they act as:

- gravity walls to stabilise slopes –i.e., **live cribwall**
- slope skins to control surface erosion – i.e., **live slope grating**
- drainages to reduce surface water – i.e., **live pole drain**

Vegetation is the live component of the NBS, which improves the ecological, mechanical, and hydrological properties of the soil, it creates habitats to flora & fauna, and it enhances the aesthetic value of the local landscape

# Dissemination

Anderson, C. C., Renaud, F. G., Hanscomb, S., & Gonzalez-Ollauri, A. (2022). Green, hybrid, or grey disaster risk reduction measures: what shapes public preferences for nature-based solutions? *Journal of Environmental Management*, 310, [114727]

Gonzalez Ollauri, A., & Mickovski, S. B. (2021). A simple GIS-based tool for the detection of landslide-prone zones on a coastal slope in Scotland. *Land*, 10(7), [685].

Mickovski, S. B., Gonzalez-Ollauri, A., & Hennenon, V. (2022). Considerations on the design of shellfish reef against coastal erosion. In D. Vu Khoa Huynh, A. Minh Tang, D. Hong Doan, & P. Watson (Eds.), *Proceedings of the 2nd Vietnam Symposium on Advances in Offshore Engineering* (pp. 222-229). (Lecture Notes in Civil Engineering; Vol. 208). Springer. [https://doi.org/10.1007/978-981-16-7735-9\\_23](https://doi.org/10.1007/978-981-16-7735-9_23)

Gonzalez Ollauri, A., & Mickovski, S. B. (2021). A simple GIS-based tool for the detection of landslide-prone zones on a coastal slope in Scotland. *Land*, 10(7), [685]. <https://doi.org/10.3390/land10070685>

Gallotti, G., Santo, M. A., Apostolidou, I., Alessandri, J., Armigliato, A., Basu, B., Debele, S., Domeneghetti, A., Gonzalez Ollauri, A., Kumar, P., Mentzafou, A., Pilla, F., Pulvirenti, B., Ruggieri, P., Sahani, J., Salmivaara, A., Sarkar Basu, A., Spyrou, C., Pinardi, N., ... Di Sabatino, S. (2021). On the management of nature-based solutions in open-air laboratories: new insights and future perspectives. *Resources*, 10(4), [36]. <https://doi.org/10.3390/resources10040036>

Gonzalez-Ollauri, A., Stokes, A., & Mickovski, S. B. (2020). A novel framework to study the effect of tree architectural traits on stemflow yield and its consequences for soil-water dynamics. *Journal of Hydrology*, 582, [124448].

Anderson, C. C., Renaud, F. G., Hanscomb, S., Munro, K. E., Gonzalez-Ollauri, A., Thomson, C. S., Pouta, E., Soini, K., Loupis, M., Panga, D., & Stefanopoulou, M. (2021). Public acceptance of nature-based solutions for natural hazard risk reduction: Survey findings from three study sites in Europe. *Frontiers in Environmental Science*, 9, [678938]. <https://doi.org/10.3389/fenvs.2021.678938>

Gonzalez-Ollauri, A., & Mickovski, S. B. (2020). The effect of willow (*Salix* sp.) on soil moisture and matric suction at a slope scale. *Sustainability*, 12(23), 1-19. [9789]. <https://doi.org/10.3390/su12239789>

Gonzalez Ollauri, A., & Mickovski, S. B. (2017). Hydrological effect of vegetation against rainfall-induced landslides. *Journal of Hydrology*, 549, 374–387.

Gonzalez-Ollauri, A., & Mickovski, S. B. (2017). Plant-Best: a novel plant selection tool for slope protection. *Ecological Engineering*, 106(A), 154–173.

Gonzalez-Ollauri, A., & Mickovski, S. B. (2017). Plant-soil reinforcement response under different soil hydrological regimes. *Geoderma*, 285, 141-150.

Gonzalez-Ollauri, A., & Mickovski, S. B. (2017). Shallow landslides as drivers for slope ecosystem evolution and biophysical diversity. *Landslides*, 14(5), 1699-1714.

Tardio, G., Gonzalez-Ollauri, A., & Mickovski, S. B. (2016). A non-invasive preferential root distribution analysis methodology from a slope stability approach. *Ecological Engineering*, 97, 46-57. <https://doi.org/10.1016/j.ecoleng.2016.08.005>

Gonzalez-Ollauri, A., & Mickovski, S. B. (2016). Using the root spread information of pioneer plants to quantify their mitigation potential against shallow landslides and erosion in temperate humid climates. *Ecological Engineering*, 95, 302-315. <https://doi.org/10.1016/j.ecoleng.2016.06.028>

# Future plans

# Open-air museum of NbS



LIVE CRIB WALL



## UNESCO-IHP's Ecohydrological Demonstration Site



**unesco**  
Intergovernmental  
Hydrological Programme

### Call for submissions of new Ecohydrology Demonstration Sites

Deadline: 31 October 2022



Putrajaya Corporation, Malaysia.

# Future plans

## Sea monitoring station



Credit: Robert Reglinski

## Future plans

- More NbS monitoring
- Some NbS management
- Summer schools
- Strengthen networks & collaborations
- New research studies and testing
- e.g., health benefits, uptake barriers, performance
- More capacity-building
- More NbS
- Funding?

Thank you  
Gracias