2nd International Workshop on Natural Hazards

Pico island, Azores
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HYDROLOGICAL RISKS

The importance of land cover planning on climatic events: evaluation of peatlands' buffer impact on Terceira and Flores islands (Azores, Portugal)

Dinis Pereira, Universidade dos Açores – CBA, dinispereira@dinispereira.com

Cândida Mendes, Universidade dos Açores – CBA, candida.m.mendes@uac.pt

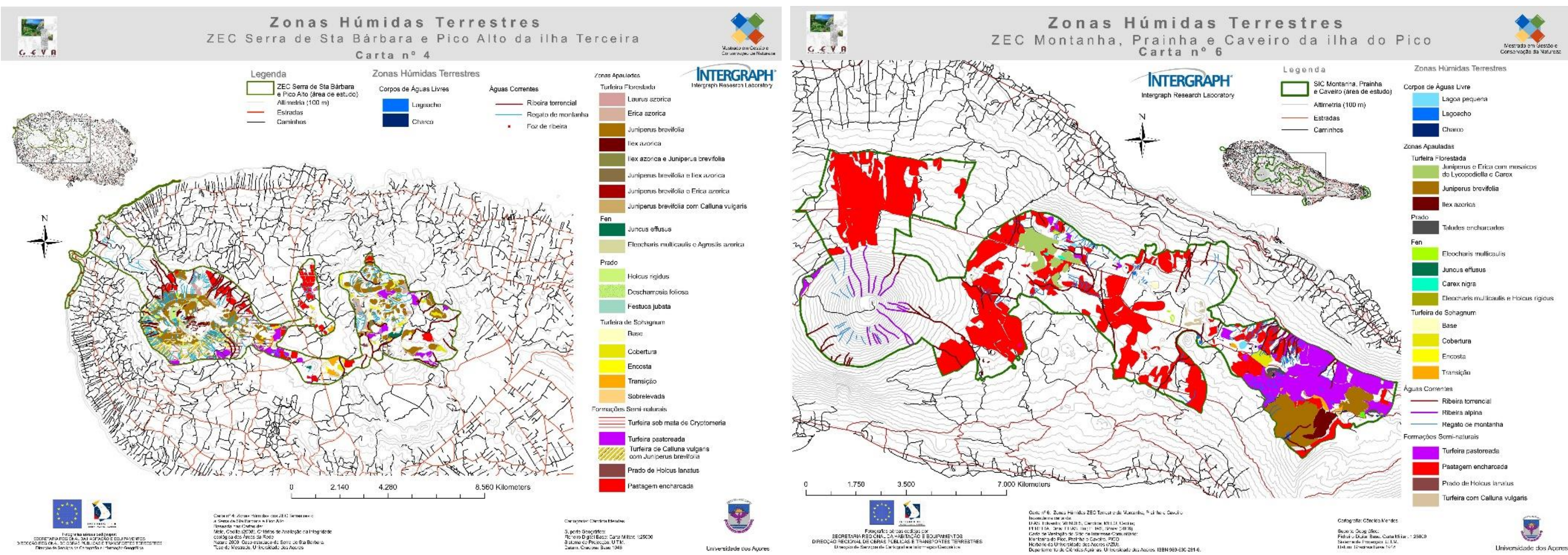
Eduardo Dias, Universidade dos Açores – CBA, eduardo.mf.dias@uac.pt

Organizing:

INTRODUCTION

- There are several natural types of peatlands in the Azores, being the most extended type forest dominated, but a considerable area is now occupied by *Sphagnum*-dominated types.

- The main threat faced by the peatlands in the Azores is their use as pasture for livestock.



Peatlands in Protected areas of Terceira and Pico Islands (Mendes, 2010)

INTRODUCTION

The peatlands are extremely important in the regulation of the water cycle:

- releasing water gradually, acting as buffers
- minimizing the effects of climate events
- promoting landscape equilibrium
- minimizing the impact of extreme events, such as landslides or floods
- supporting biodiversity.

However, owing to peatland depletion and degradation, their natural functions have become narrowed.

INTRODUCTION

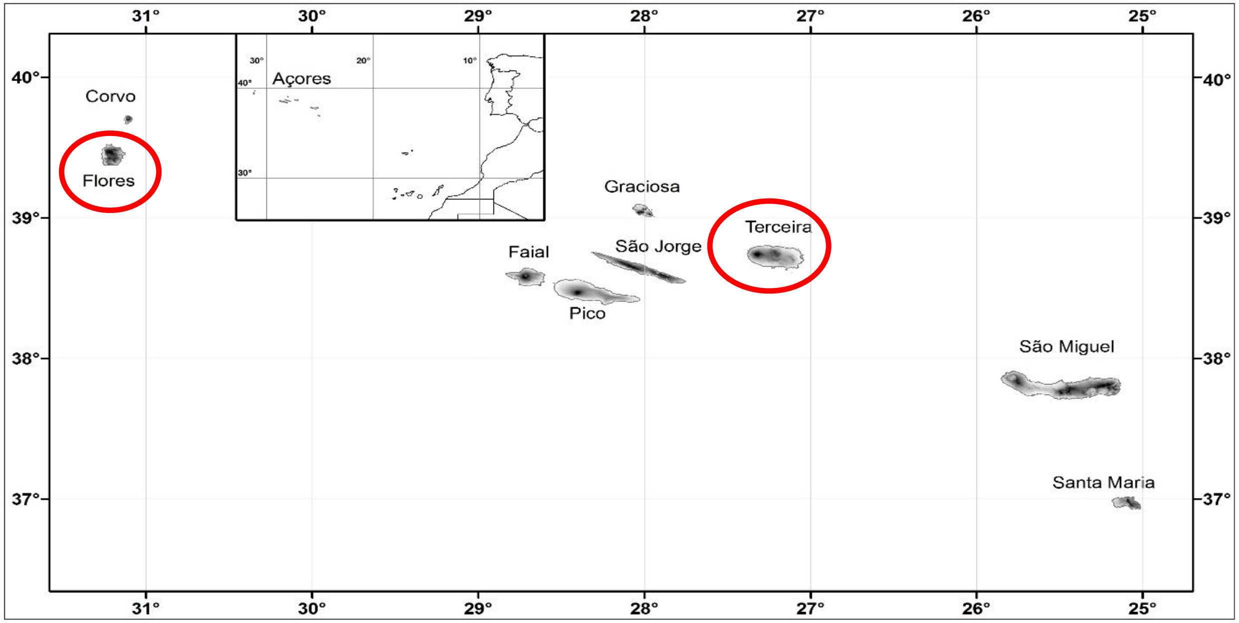
The goal of this study:

- Calculate hydrological services from the current distribution of peatlands in Flores and Terceira Landscape.

- Compare with equal parameters estimation, considering the potential distribution of peatland in those islands.

Methods – Study area

The Azores are located at about 1 400 km W from Europe in the middle of Atlantic Ocean. The islands selected for this study are Flores and Terceira, as these have the largest areas of peatlands.



METHODS – STUDY AREA

Examples of Peatlands in Terceira island © Dinis Pereira

METHODS – STUDY AREA

Examples of Peatlands in Flores island © Cândida Mendes

METHODS - DATA COLLECTION AND ANALYSIS

Actual distribution of peatlands

For the *Sphagnum* distribution was used:

- The modulation was done in ArcGIS with a supervised classification with maximum likelihood using 25% and 50% Reject Fraction (RF).
- For ground truth, ecological field work was done (classification of peatlands, inventories for flora characterization and communities' description).
- For peatland and forested peatland, data from the ATLANTIDA©GEVA database, cartographic distribution data from Mendes (2010) and Dias et al. (2017) and photointerpretation of Planet Scope Images.
- Sentinel-2, and Rapideye images with 2 800 Terceira and 7 500 Flores Ground Truths.

Methods - Data collection and analysis

Field and Drone surveys

ATLANTIDA©GEVA

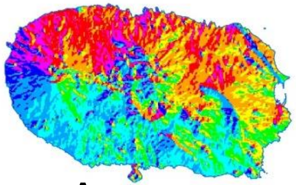
Satellite imagery

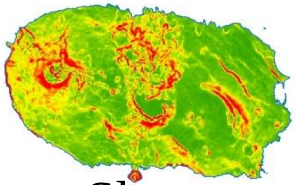
Methods - Data collection and analysis

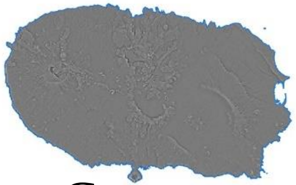
Model of Potential distribution of peatlands parameters:

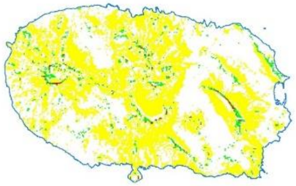
- Rasters (100x100 m) of Aspect E and W orientation, slope (>9º), curvature (<-0.55), TOPEX (Wilson, 1984);
- Endorheic basins;
- Geomorphology (recent lavas as a excluded areas of the model in Terceira).

Sphagnum and forested peatland water services values, from Dias *et al*. (2016) and Pereira (2015) were applied to the peatlands.


Aspect


Slope


Curvature


TOPEX


Endorheic basins


Geomorphology

METHODS - DATA COLLECTION AND ANALYSIS

Two types of *Sphagnum* peatlands were assumed:

(1) Mixed *Sphagnum* peatlands that include basin, raised and transition types;

(2) Hillside *Sphagnum* peatlands that include hillside and blanket types, and one type of forested and shrubland peatland.

Considering naturalness, (1) and (2) were separated into:

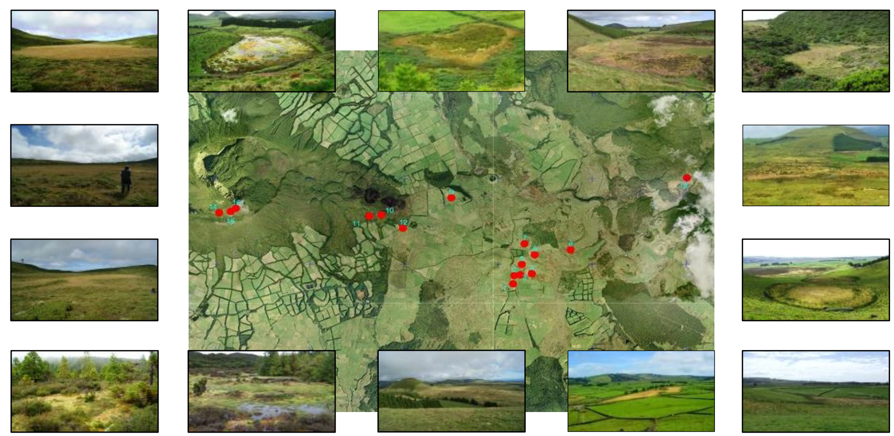
- natural (no disturbance),
- degraded (frequent use as pasture, *Sphagnum* present),
- peat soil pasture (corresponding to wet implanted pastures, no *Sphagnum*);
- forested peatlands were separated in natural and peat soil forested areas (corresponding to forest production).

METHODS - DATA COLLECTION AND ANALYSIS

Hydrological services evaluation:

- Peatlands surveyed with Ground Penetrating Radar for the tri-dimensional modelling of peatlands' internal deep and layer structures.
- Field coring was done with peat collected by layer for bulk density, water retention capacity and water efflux determination.

Georadar and Coring

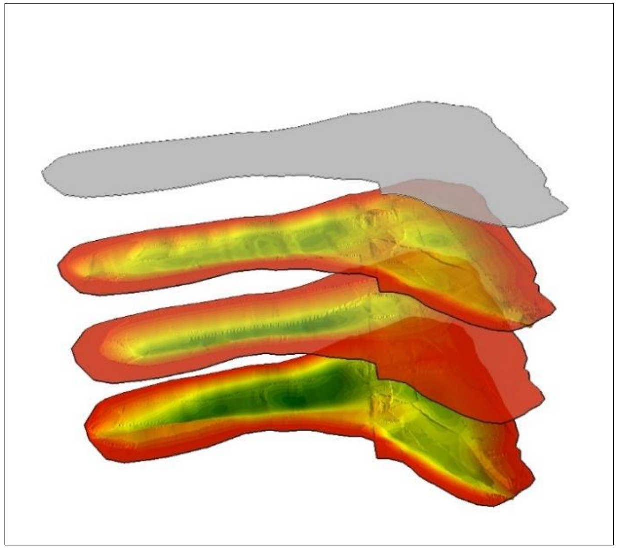


Peatlands studied in Terceira island

METHODS - DATA COLLECTION AND ANALYSIS

Hydrological services evaluation:

- The obtained reference values were estimated for water retention capacity as well as time efflux, by Pereira (2015), for peatlands' various internal layers and various peatland tipologies.
- Applied to the different typologies defined in actual and potential peatlands.



3D of internal layers

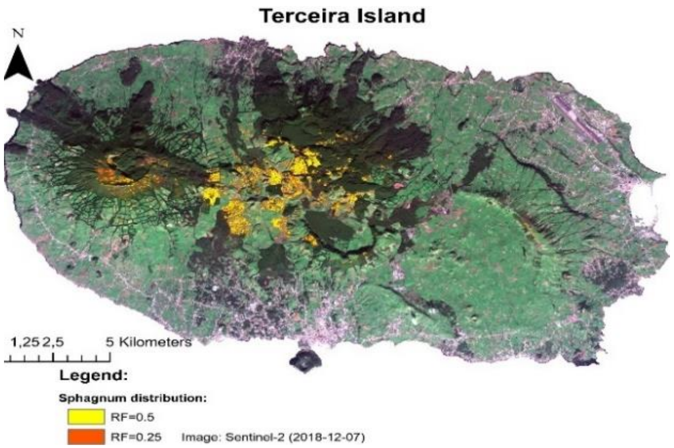
Laboratory analysis

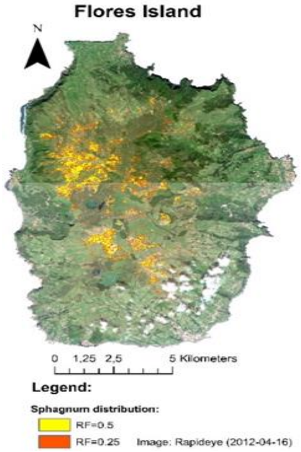
RESULTS - ACTUAL DISTRIBUTION OF PEATLANDS

The *Sphagnum* distribution obtained by:

- Remote Sensing with a supervised classification with maximum likelihood
- Spectral signature of *Sphagnum* and *Juniperis brevifolia*
- Use of Sattelite imagery Rapideye, PlanetScope and Sentinel-2.

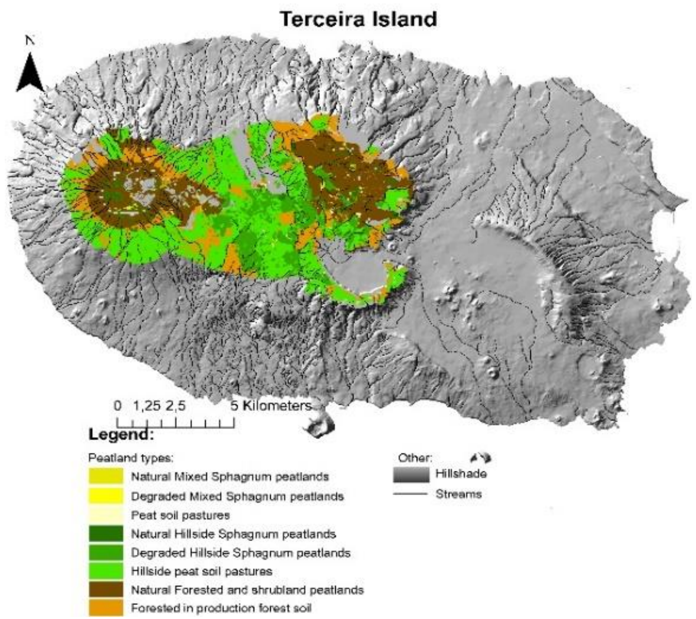
- In Terceira island, the area obtained is 909 ha.
- In Flores island is 648 ha.

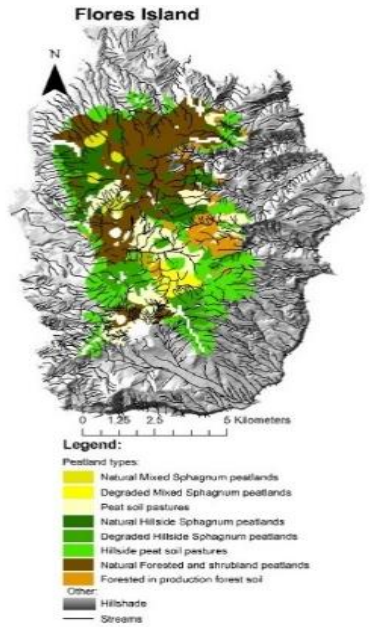




RESULTS - ACTUAL DISTRIBUTION OF PEATLANDS

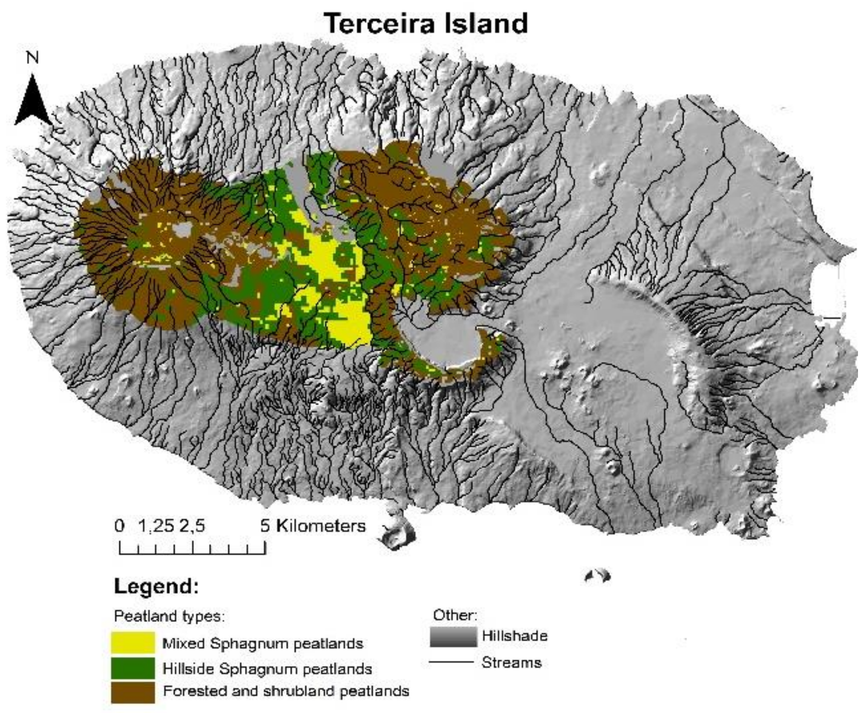
- There is a big area of *Sphagnum* peatland.
- Indeed, a considerable actual area of *Sphagnum* peatlands resulted from the progressive degradation of forested types of peatlands.
- However, in potential terms, it would be the forested formations that have become the commonest form of Azorean peatlands.

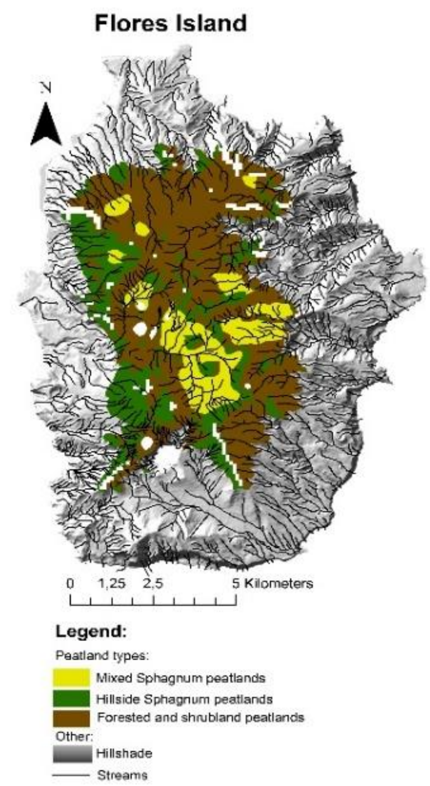




RESULTS - POTENTIAL DISTRIBUTION OF PEATLANDS

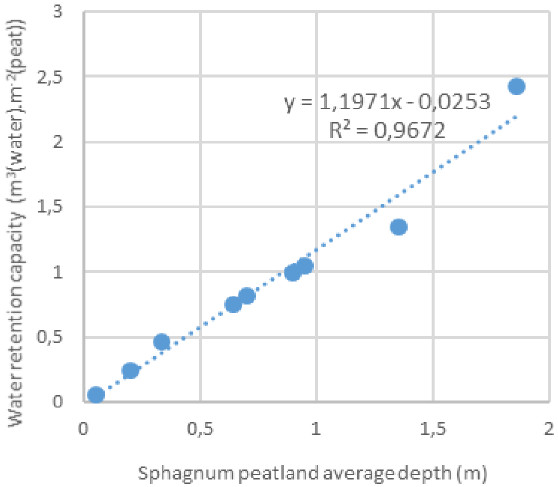
Both in Flores and Terceira, the dominant potential types of peatlands are forested and shrubland. Basin *Sphagnum* types prevail in endorheic valleys, and *Sphagnum* hillside types monopolise extreme wind sloping areas.



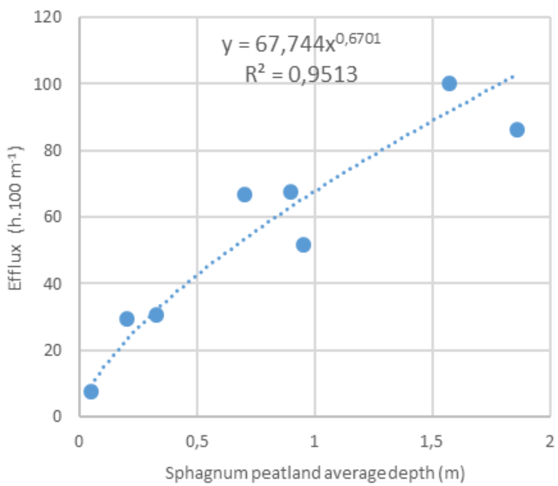


Results - Hydrological services

Considering the study of the eight reference peatlands, the results showed that hydrologic services, such as water retention as well as water efflux, varied with peatland type. However, we found a more relevant relation of these services associated with peat depth.



Relation between *Sphagnum* peatland's depth and water retention capacity (Pereira, 2015).

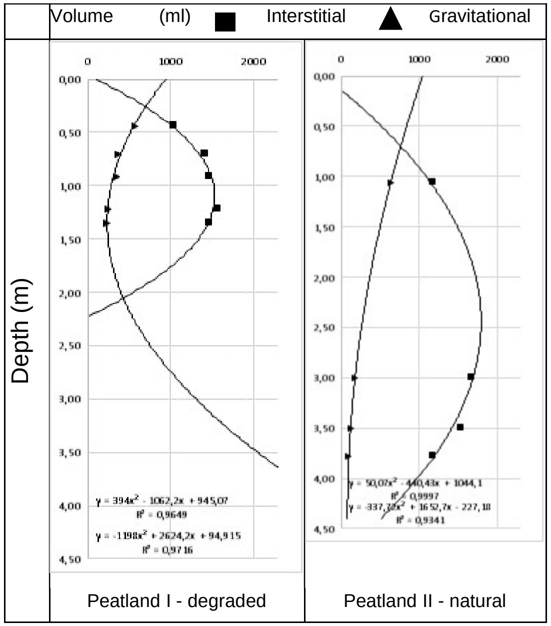


Relation between *Sphagnum* peatland's depth and water efflux (Pereira, 2015).

RESULTS - HYDROLOGICAL SERVICES

- More degraded peatlands tend to have lower peat depth, diminishing peatland water services provided.

- Peatlands with lower naturalness degree reveal different water retention curves along the depth profile of the peat, compared to the natural ones.



Trends of gravitational and interstitial water retention at the midpoint of each layer, considering the maximum depth of each *Sphagnum* peatlands (I-degraded, II - natural). Interstitial water associated with retention capacity, gravitational water is associated to efflux delay.

RESULTS - HYDROLOGICAL SERVICES

- Mixed peatlands show a greater capacity to retain water by area (m3/m2), working as accumulation structures. Hillside peatlands show a greater capacity of volumetric water retention (m3/m3)

- Mixed *Sphagnum* reveals the greatest capacity for the temporal restraint of water (efflux), being more important for buffering torrential regimes after large rainfall events.

	Nat. Mixed Sphag.	Nat. Hillside Sphag.	Nat. For./shrubland	Deg. Mixed Sphag.	Deg. Hillside Sphag.	For. in production forest soil	Peat soil pastures	Hillside peat soil pastures
Peatland depth (m)	1.65	1.10	0.33	1.15	0.20	0.15	0.10	0.10
Vol. Water retention (m^3(water).m^{-3} (peat))	1.10	1.38	0.70	1.18	1.18	0.47	0.45	0.45
Water retention by area (m^3 (water).m^{-2} (peat))	1.82	1.53	0.23	1.35	0.24	0.07	0.05	0.05
Efflux (h.100 m^{-1})	67.74	30.59	10.26	37.21	29.25	7.00	7.80	7.80
Perlocation velocity ($m.h^{-1}$)	0.11	0.08	0.10	0.18	0.02	0.07	0.08	0.08

RESULTS - HYDROLOGICAL SERVICES

- The results show an actual distribution of natural peatlands of 2 766 ha and 2 414 ha, for Terceira and Flores, respectively, which is even so quite lower than the potential area estimated as 8 079 ha and 5 268 ha, correspondingly.

- These peatlands currently have the ability to retain 72 438 317 m3 of water. Theoretically, if all peatlands were in a natural state, this capacity would **increase to 300% of the retained water.**

	TERCEIRA				FLORES			
	Area (ha)		Water storage (m^3)		Area (ha)		Water storage (m^3)	
	Actual	Potential	Actual	Potential	Actual	Potential	Actual	Potential
Nat. Mixed Sphag.	71	763	1300615	13841653	123	799	2240017	14505886
Nat. Hillside Sphag.	197	2166	3037997	47404912	769	1327	11875007	29031787
Nat. For./shrub.	2497	5150	5775013	11844863	1523	3142	3526759	7226076
Deg. Mixed Sphag.	379		5137043		148		2002912	
Deg. Hillside Sphag.	825		1990130		463		1119573	
For. in production forest soil	1864		843477		376		170264	
Peat soil pastures	1050		738909		684		482185	
Hillside peat soil pastures	1151		520931		1146		519303	
Total	8035	8079	19344115	73091429	5231	5268	21936020	50763749

DISCUSSION

The Regional Programme for Climate Change in the Azores (PRAC in Costa et al. 2017) presented for the Azores climate:

- Slight upward trend of precipitation in winter (10%) and a decrease in summer.

- Extreme wind and storm events can occur with higher frequency and intensity.

Nowadays, floods accompanied by landslides are quite frequent in the Azores.

<u>In these scenarios peatlands are extremely important landscape regulators due to their water retention capacity, which are far below their potential capacity, due to high disturbance.</u>

DISCUSSION

Environmental imbalances:

1) Differences between natural and potential hydrological services varies within the territory:

Terceira

- Large natural areas as Santa Barbara Mountain and Pico Alto Mountain with a potential increase of 285% and 237%.
- Pasture-dominated mosaic with a potential increase of 1418% in water retention.

Flores

- Large natural areas (north central plateau) with a potential increase of 132%
- Pasture-dominated mosaic with a potential increase of 432%.

2) Irregularity of Azorean streams flow:

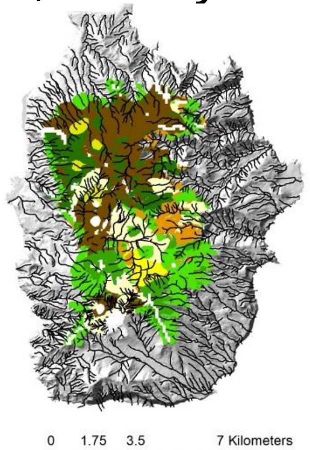
The application of the differences between actual and potential water services to Ribeira Grande waterline catchment area (in Flores) showed a potential increase of 313% in retained water.

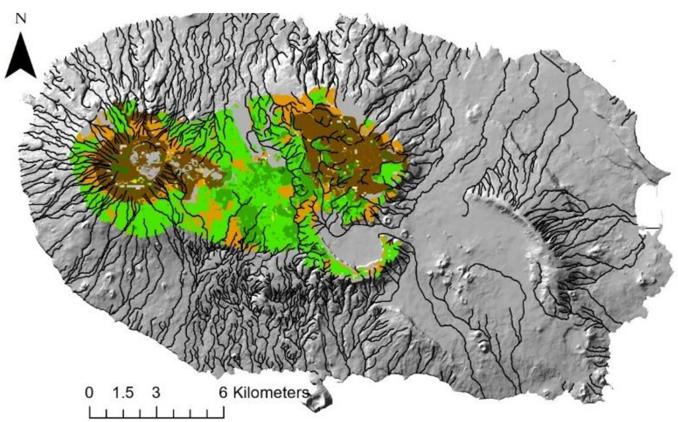
CONCLUDING REMARKS

- Terceira and Flores islands possess a relevant area of peatlands; however, disturbance diminishes their intervention in the hydrologic cycle control of the landscape.

- Restoration implementation would significantly increase the buffering capacities of peatlands in a scenario of climate change.

- It is essential that the future land use and planning of peatlands incorporate the principles and practices of wise use to promote sustainable management, especially concerning biodiversity, carbon retention, and hydrology.





Spatial location of waterlines in the peatland areas

ACKNOWLEDGEMENTS

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