

# Apports, intérêts, limites de la télédétection pour mieux connaître la biodiversité

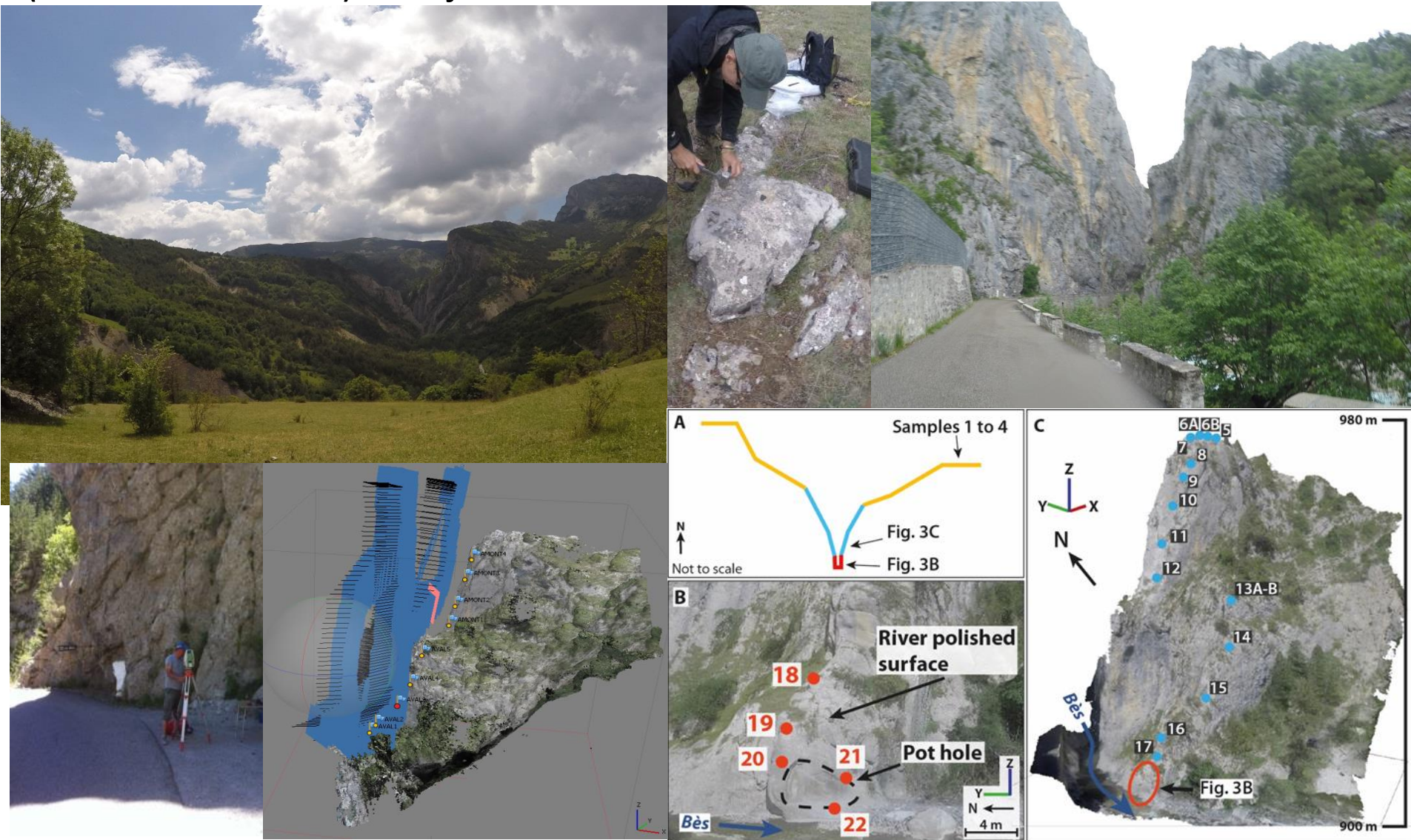
Utilisation de la THRS – application aux espèces exotiques envahissantes

**Laurent Borgniet**

**LESSEM** Laboratoire **EcoSystèmes et Sociétés En Montagne**

laurent.borgniet@inrae.fr

# Vitesses d'incision de la rivière Bès par reconstruction 3D et datations Cl36 (Clue de Barles 04) - Projet Labex OSUG –Isterre - Irstea



Cardinal T. et al. 2021. Interplay of fluvial incision and rockfalls in shaping periglacial mountain gorges in the SW Alps, *Geomorphology*, Volume 381, 107665, ISSN 0169-555X, <https://doi.org/10.1016/j.geomorph.2021.107665>.

# Evaluation des hauteurs de neige dans et hors des peuplements forestiers (SNOUF - Irstea Météofrance CNRS-Labex OSUG -UGA)



<https://doi.org/10.5194/essd-2023-174>  
Preprint. Discussion started: 1 June 2023  
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Earth System  
Science  
Data  
DISCUSSIONS  
OPEN ACCESS

## 1 Snow accumulation and ablation measurements in a mid-latitude 2 mountain coniferous forest (Col de Porte, France, 1325 m alt.): The 3 Snow Under Forest field campaigns dataset

4 Jean Emmanuel Sicart<sup>1</sup>, Victor Ramseyer<sup>1</sup>, Ghislain Picard<sup>1</sup>, Laurent Arnaud<sup>1</sup>, Catherine Coulaud<sup>1</sup>,  
5 Guilhem Freche<sup>1</sup>, Damien Soubeyrand<sup>1</sup>, Yves Lejeune<sup>2</sup>, Marie Dumont<sup>2</sup>, Isabelle Gouttevin<sup>2</sup>, Erwan Le  
6 Gac<sup>2</sup>, Frederic Berger<sup>3</sup>, Jean Matthieu Monnet<sup>3</sup>, Laurent Borgniet<sup>3</sup>, Eric Mermin<sup>3</sup>, Nick Rutter<sup>4</sup>, Clare  
7 Webster<sup>5,6</sup>, Richard Essery<sup>7</sup>.

8 <sup>1</sup> Univ. Grenoble Alpes, IRD, CNRS, Grenoble INP, IGE, 38000 Grenoble, France.

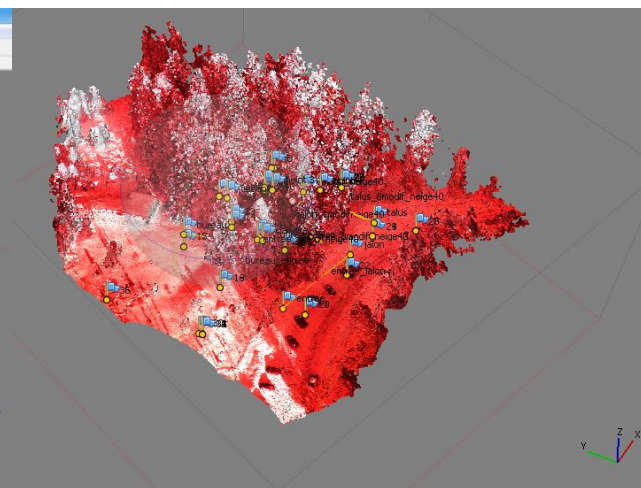
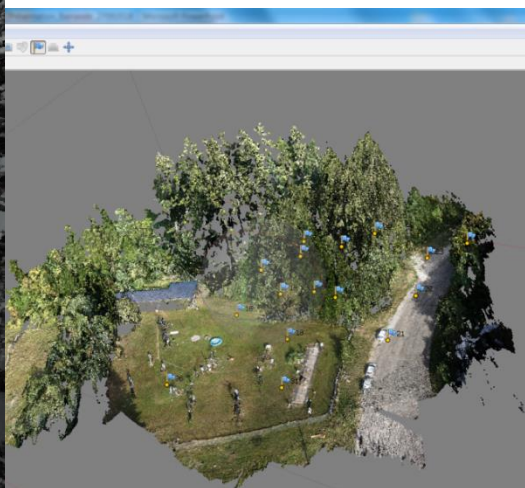
9 <sup>2</sup> CNRM UMR 3589, Météo-France/CNRS, Centre d'Études de la Neige, Grenoble, France

10 <sup>3</sup> Univ. Grenoble Alpes, INRAE, LESSEM, 2 rue de la Papeterie-BP 76, St-Martin-d'Hères, F-38402, France.

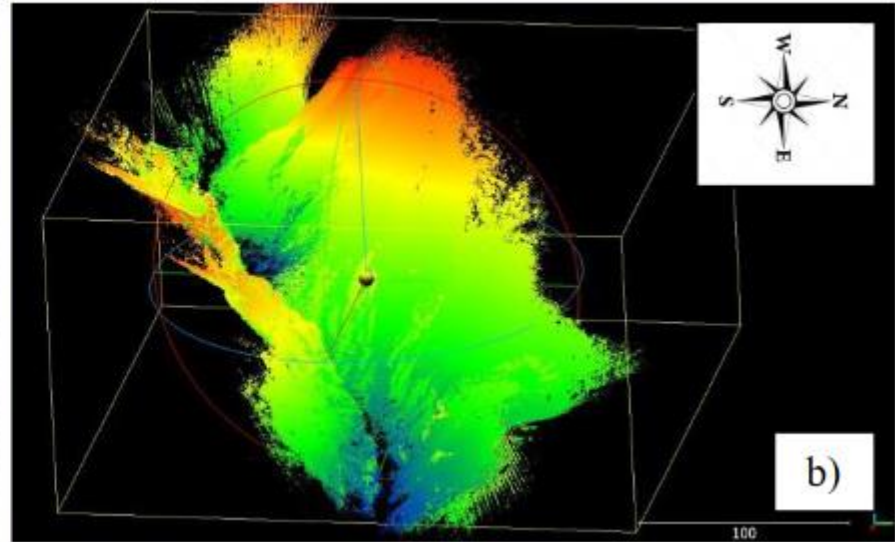
11 <sup>4</sup> Department of Geography and Environmental Sciences, Northumbria University, Newcastle upon Tyne, NE1 8ST, UK

12 <sup>5</sup> WSL Swiss Federal Institute for Snow and Avalanche Research SLF, Davos, Switzerland

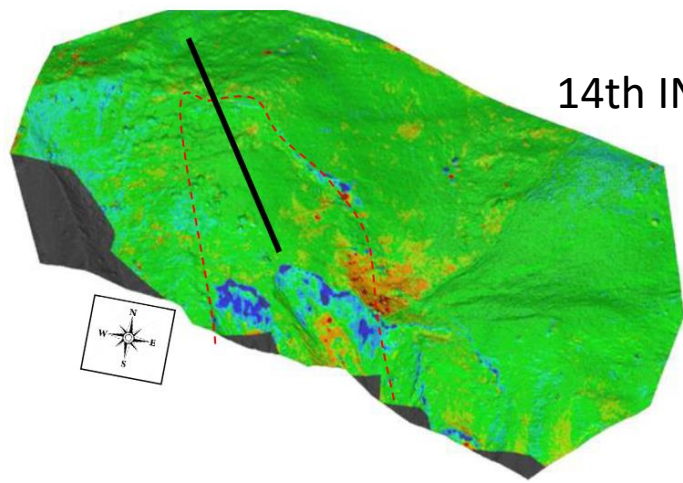
13 <sup>6</sup> Department of Geosciences, University of Oslo, Norway



Mise au point d'un Système d'Instrumentation de MOuvements de TERrain pour l'aide à la décision dans les territoires de montagne – (SIMOTER) programme CIMA-POIA  
 Suivi de Glissements de terrain de Valloire (73)



Implementation of an Integrated Management Strategy to Deal with Landslide Triggered Debris Flows: The Valloire Case Study (Savoie, France). 7<sup>th</sup> International Conference on Debris-Flow Hazards Mitigation.



14th INTERPRAEVENT Congress 2020



Figure 2: Difference between the DEMs of November 2015 and July 2018. Red: accumulation. Blue: erosion. The maximum motion is 1.5 m and the moved volume is estimated to 230 m<sup>3</sup>. The landslide approximate delineation is given by the red dashed line. The black line gives the position of the cross-topography profile (see § 3.2.2).



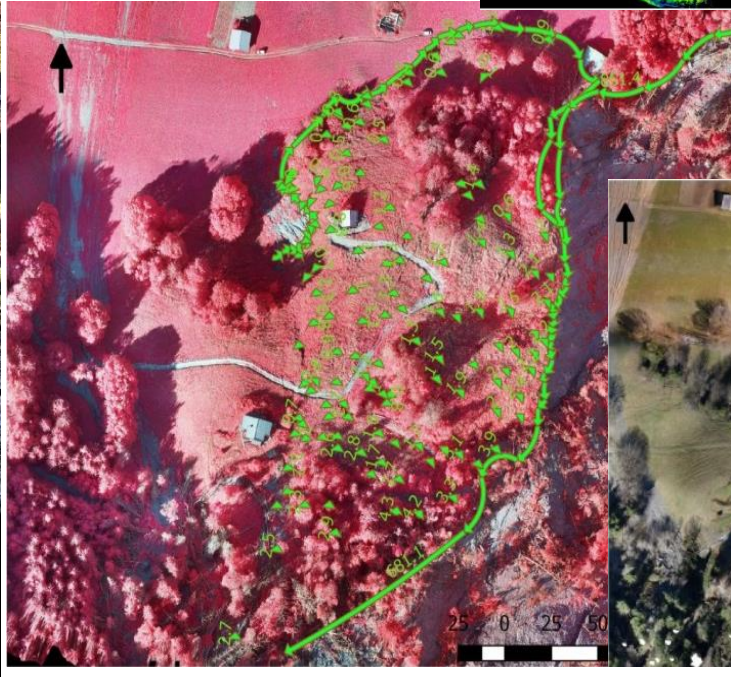
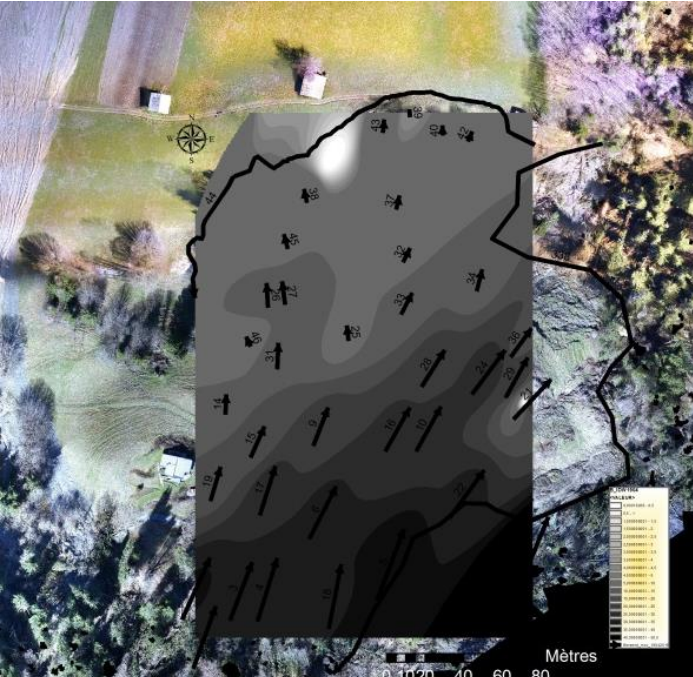
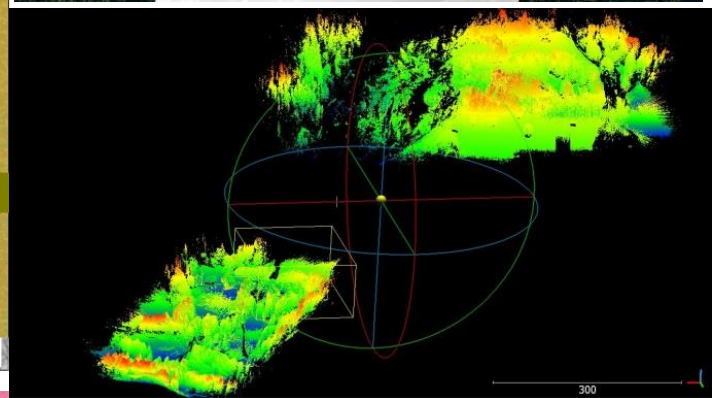
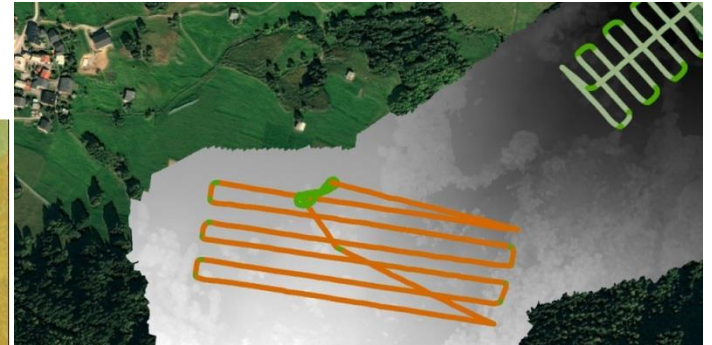
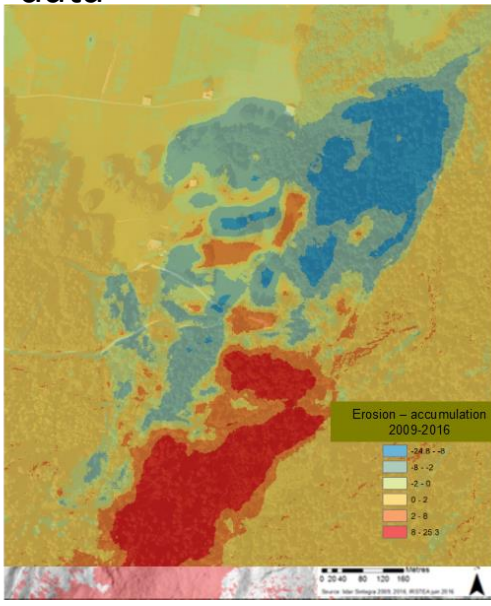
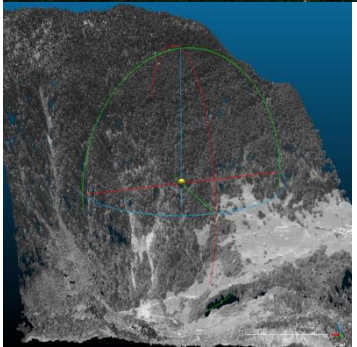
© L. Borgniet - Irstea



Fiolleau, S., Jongmans, D., Bièvre, G., Chambon, G., Michel, O. & Borgniet, L., 2022. Study of clay degradation in an earthslide combining OBIA and roughness analysis of UAV-based optical images. *Earth Surface Processes and Landforms*, 47(15), 3465– 3480. <https://doi.org/10.1002/esp.5468>.

# Beaufort (73): projet DGPR – Labex OSUG Isterre – Irstea

## LIDAR and UAV data

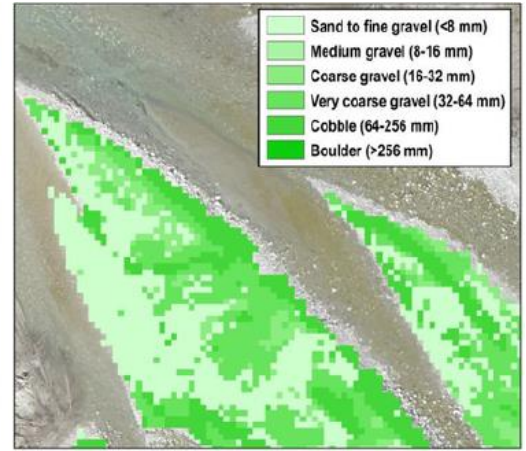
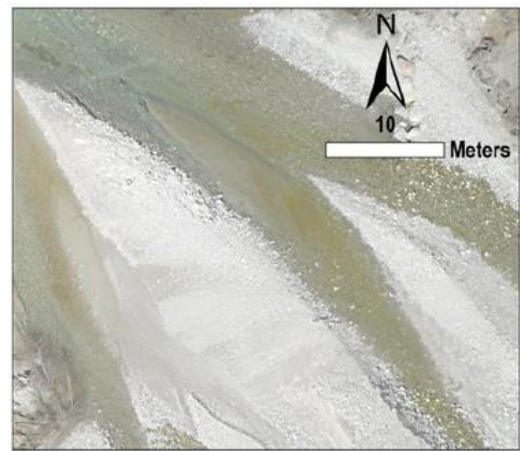


## Landslide Cinematic



# Alpine rivers Morphodynamics

## Buech River (38)



Surface GSD chart derived from UAS-SfM point clouds (right). Left, the ortophotograph (2-cm pixel size). Visual inspection shows correspondence between GSD chart

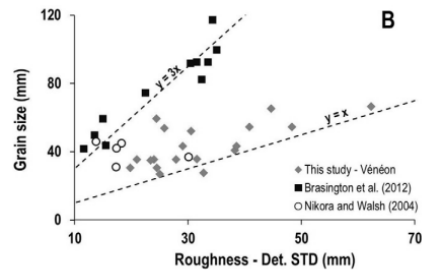
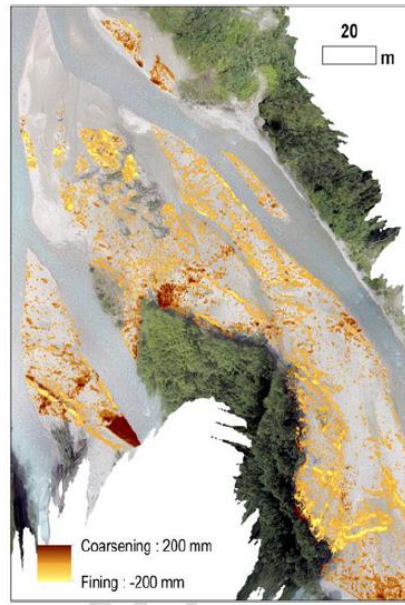
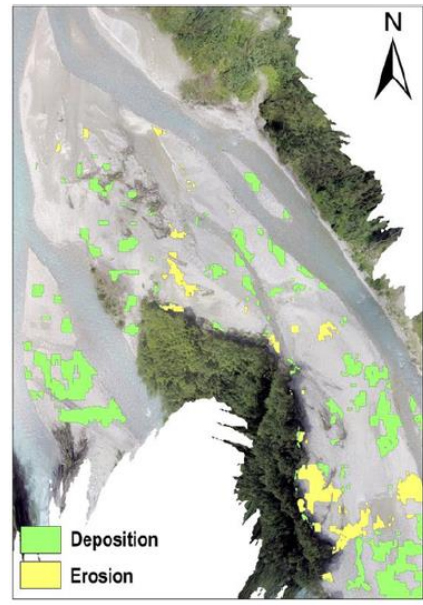
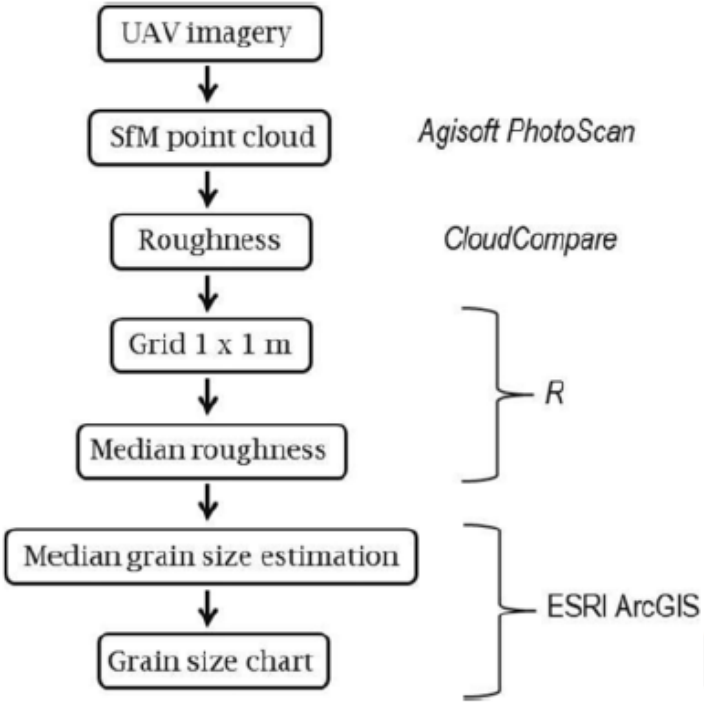


Fig. 15. Roughness and grain size data obtained in the present study are compared to TLS data compiled from the scientific literature. (A) Comparison with studies that used the standard deviation of elevation as the roughness descriptor; (B) comparison with data sets that used the detrended standard deviation.

ght) and model of roughness changes (left) udy site

Workflow for extracting the grain size maps from the UAS-SfM



# HydroMorphological assessment and management at basin scale for the Conservation of Alpine Rivers and related Ecosystem Services

Interreg  
Alpine Space



EUROPEAN UNION  
HyMo  
CARES

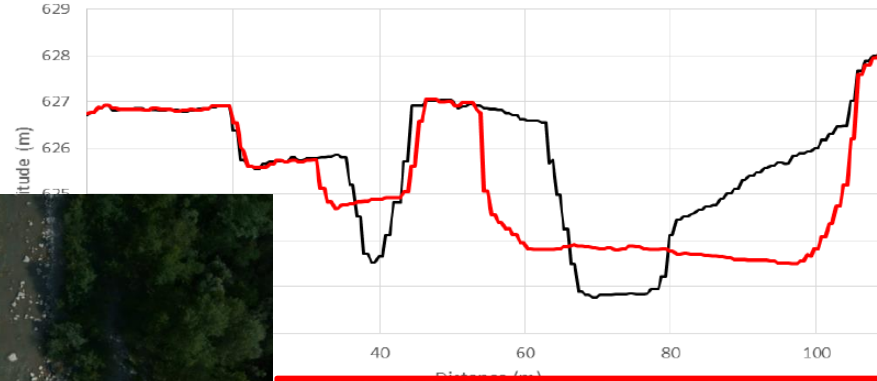
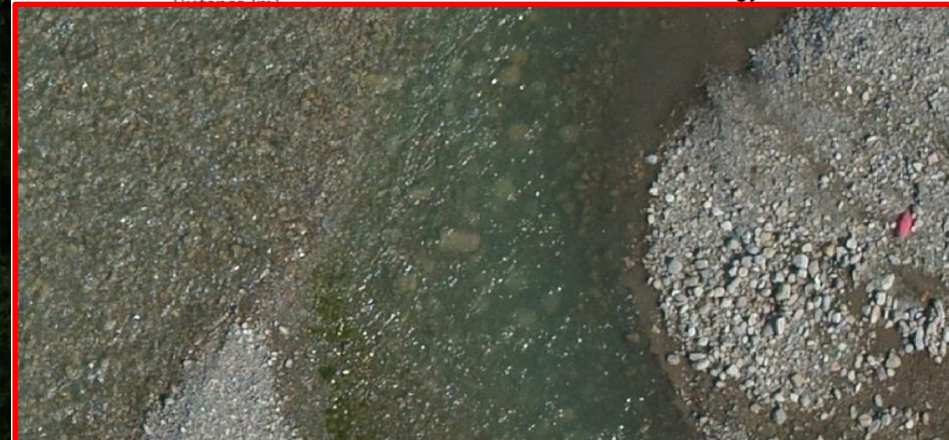


Figure 2: Eroded cross section after  $Q_{10}$  flood.

This graph is obtained by DEM differencing (after restoration in black and after flood in red). See the right and central erosion of artificial berms. Left berm was not really eroded because of not flooded surface and low energy in the trench.





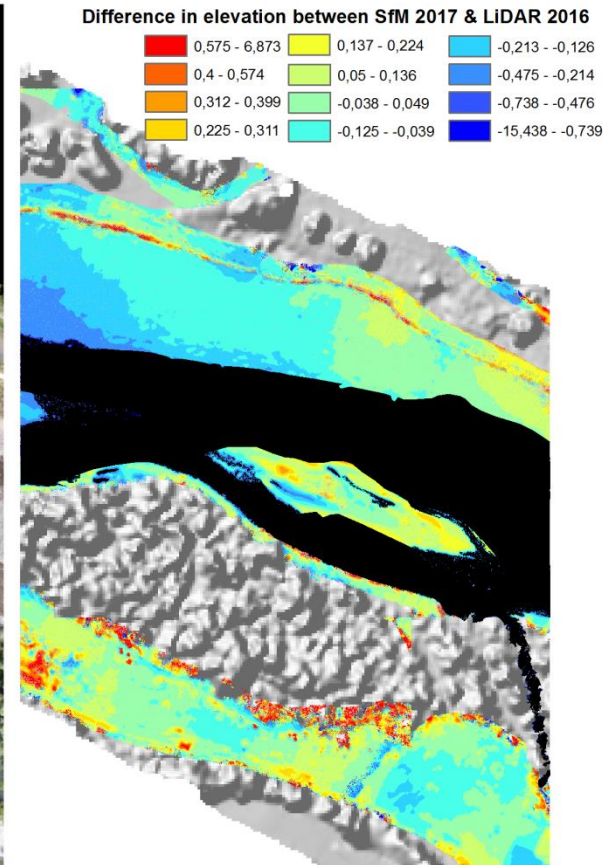
# Methodological work

Identification of stable areas

Alignment of past Lidar dataset on SfM dense cloud

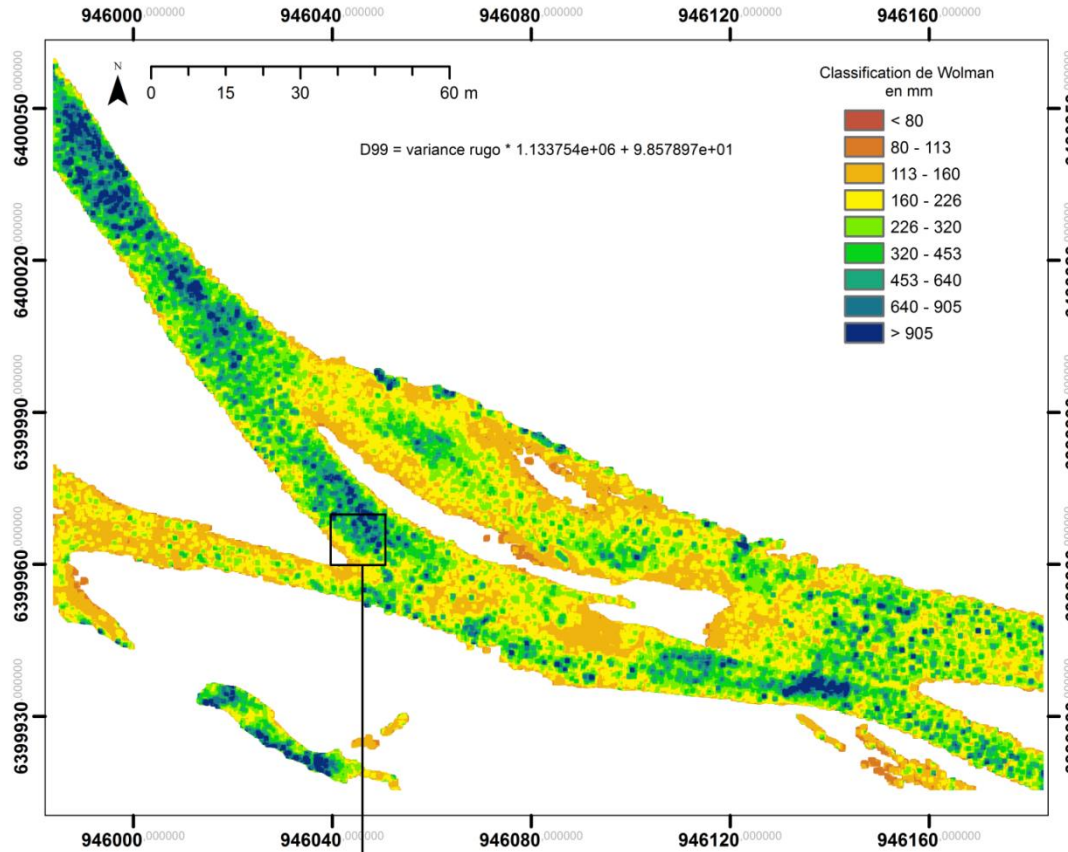
Compute signed distances between the 2 aligned clouds

Rasterize results

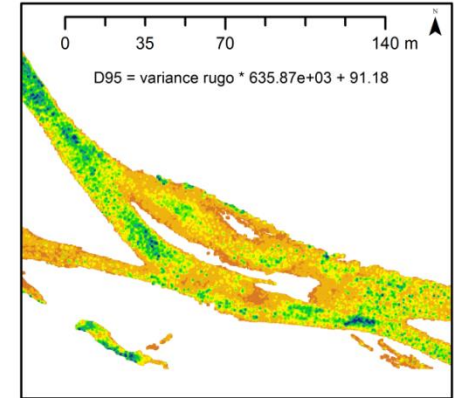


# Granulométrie

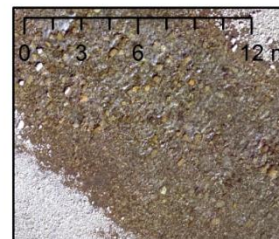
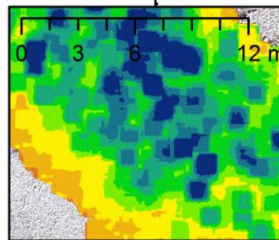
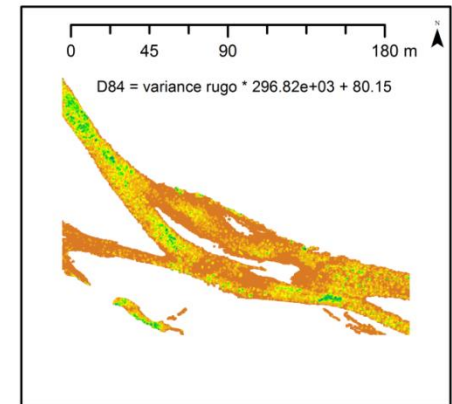
**Prédiction bathymétrique du D99 d'après la variance de la rugosité**  
Zones immergées d'un tronçon du Haut-Drac (05) - France

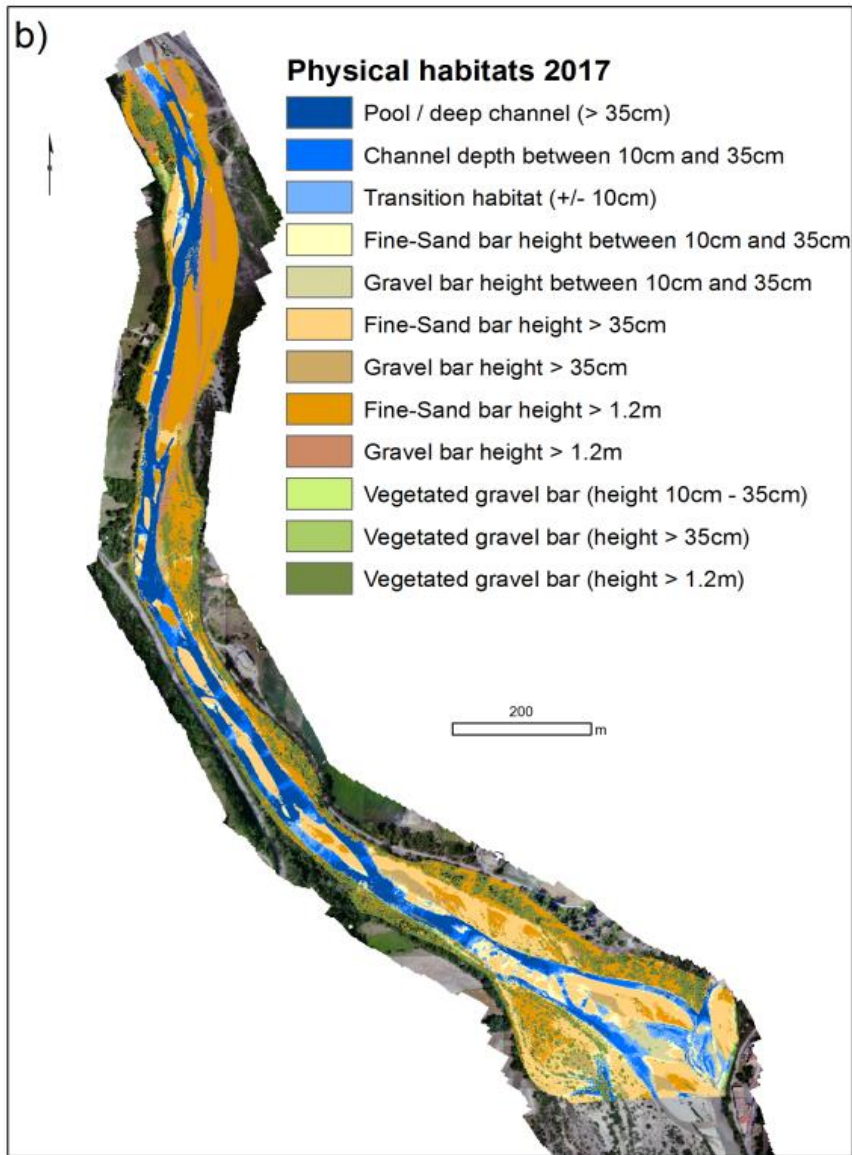


**Prédiction du D95**



**Prédiction du D84**





Drone view of the restored reach of the Upper Drac in 2018, showing the spontaneous recovery of the braided channel morphology (@SIGosphere)

Sciences Eaux & Territoires  
INRAE

<https://doi.org/10.20870/Revue-SET.2023.42.7267>

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### Granulométrie de surface des lits en tresses à partir d'images drone

Frédéric LIÉBAULT<sup>1</sup>, Michaël DESCHÂTRES<sup>1</sup>, Laurent BORGNIET<sup>2</sup>, Gabriel MELUN<sup>3</sup>

<sup>1</sup> Université Grenoble Alpes, INRAE, UR ETNA, Grenoble, France.

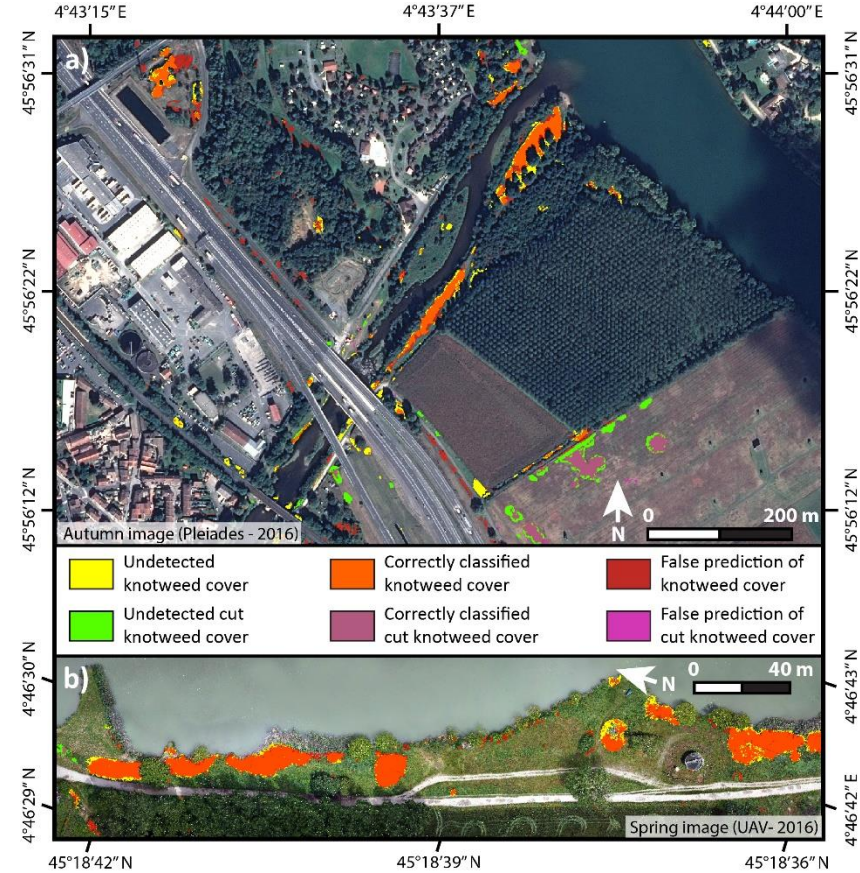
<sup>2</sup> Université Grenoble Alpes, INRAE, UR LESSEM, Grenoble, France.

<sup>3</sup> Office français de la biodiversité (OFB), Direction de la recherche et de l'appui scientifique, Vincennes Cedex, France.

Misset C., Recking A., Legout C., Bakker M., Bodereau N., Borgniet L., Cassel M., Geay T., Gimbert F., Navratil O., Piegay H., Valsangkar N., Cazilhac M., Poirel A., Zanker S., 2020. **Combining multi-physical measurements to quantify bedload transport and morphodynamics interactions in an Alpine braiding river reach**, *Geomorphology*, Volume 351, ISSN 0169-555X, <https://doi.org/10.1016/j.geomorph.2019.106877>.

Shannon index	2017	2018
All habitats	2.97	3.04
Aquatic habitats	0.87	0.77
Terrestrial habitats	2.32	2.62

Evolution of the diversity of habitat types between 2017 and 2018 assessed with the Shannon index calculated for aquatic and terrestrial habitat types



Classification Name	Image Being Classified	Data Used to Derive "Additional Variable"	Type of "Additional Variable"
<b>Pleiades imagery</b>			
<i>Summer-alone</i>	Summer		-
<i>Summer-spring</i>	Summer	+	Spring
<i>Summer-fall</i>	Summer	+	Fall
<i>Summer-all-dates</i>	Summer	+	Spring + Fall
<i>Fall-alone</i>	Fall		-
<i>Fall-spring</i>	Fall	+	Spring
<i>Fall-summer</i>	Fall	+	Summer
<i>Fall-all-dates</i>	Fall	+	Spring + Summer
<b>UAV imagery</b>			
<i>Spring-alone</i>	Spring		-
<i>Spring-phenology</i>	Spring	+	Fall
<i>Spring-CHM</i>	Spring	+	Spring CHM
<i>Spring-biCHM</i>	Spring	+	Spring CHM + Fall CHM
<i>Spring-all-dates</i>	Spring	+	Spring CHM + Fall + Fall CHM
<i>Fall-alone</i>	Fall		-
<i>Fall-phenology</i>	Fall	+	Spring
<i>Fall-CHM</i>	Fall	+	Fall CHM
<i>Fall-biCHM</i>	Fall	+	Fall CHM + Spring CHM
<i>Fall-all-dates</i>	Fall	+	Fall CHM + Spring + Spring CHM



François-Marie Martin, Jana Müllerová, Laurent Borgniet, Fanny Dommaget, Vincent Breton and André Evette. 2018. **Using Single and Multi-Date UAV and Satellite Imagery to Accurately Monitor Invasive Knotweed Species**, *Remote Sens.*, 10, 1662; doi:10.3390/rs10101662

Ombres portées sur les images prises en saison d'hiver, commune de Serrières (07)

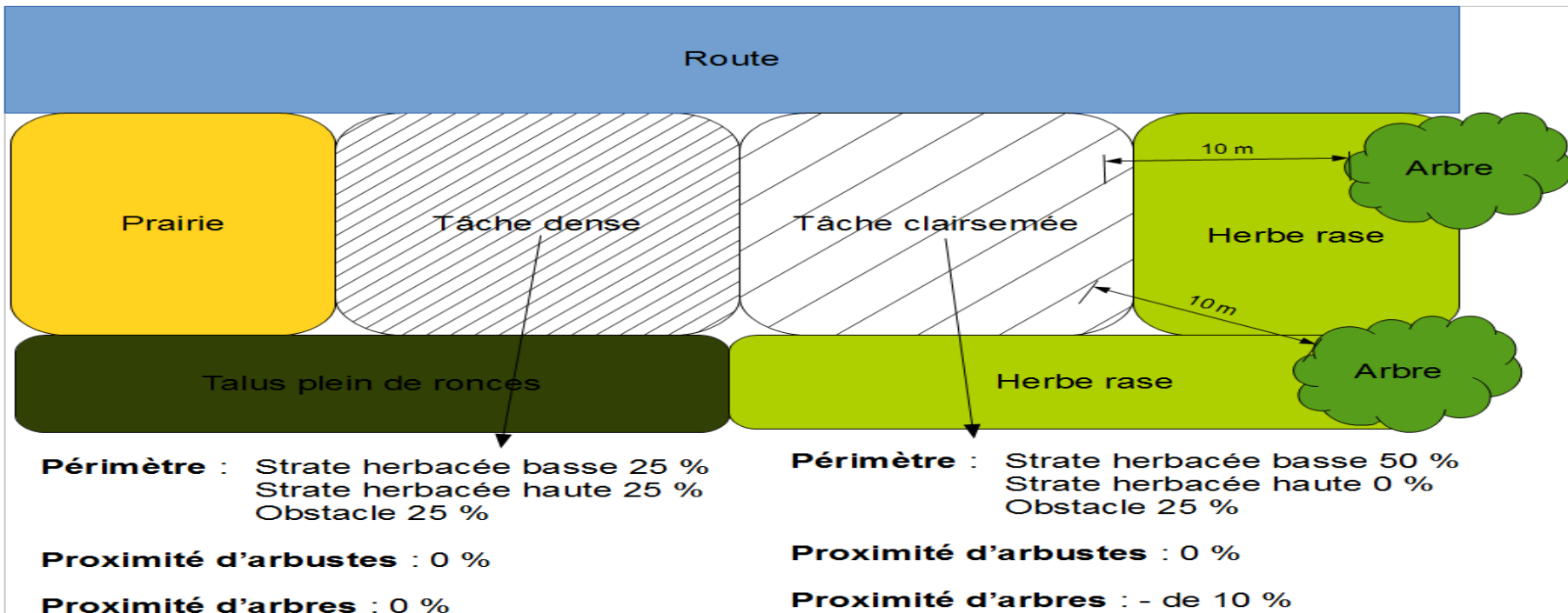


Légende:

taches de renouées asiatiques

0 25 50 100  
m

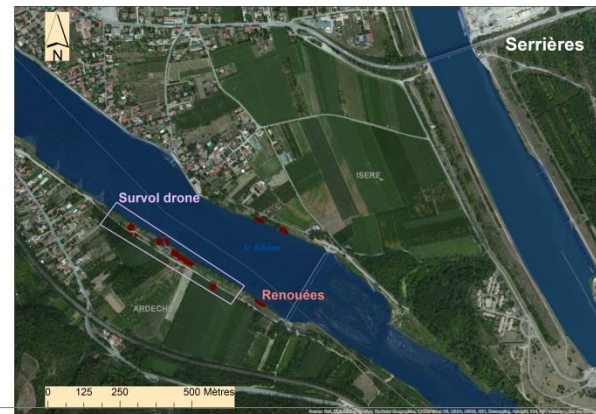
sources: images satellites Pléiades, rés. 0,70m, Lambert93



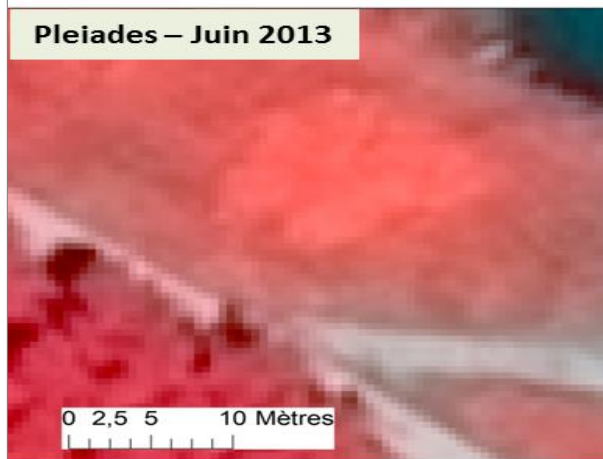
# Dynarp 2015-2018 : Improving management of Asian knotweeds alongside transport axes



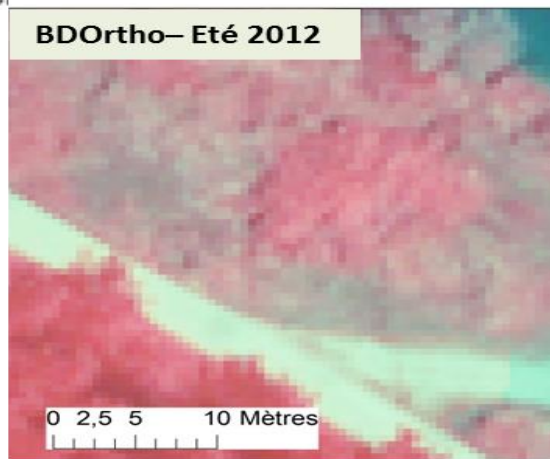
© A. Evette/lrstea



Pleiades – Juin 2013



BDOrtho – Eté 2012

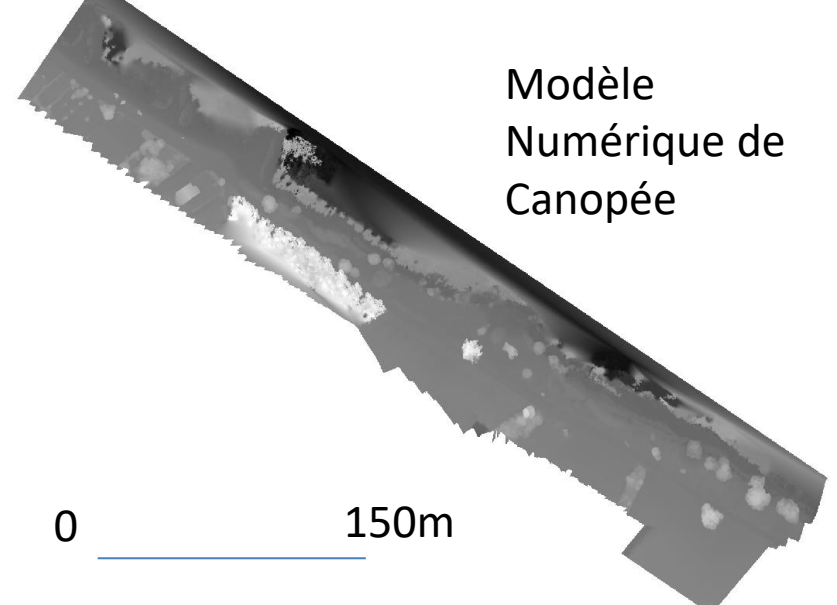
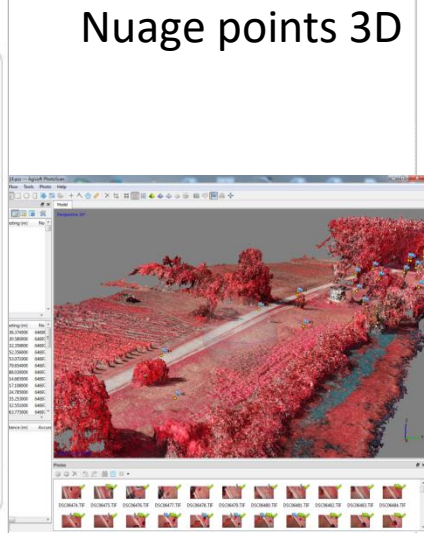
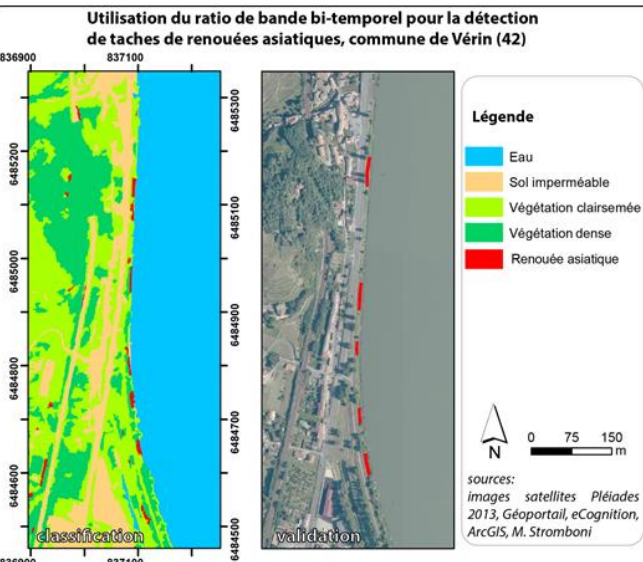
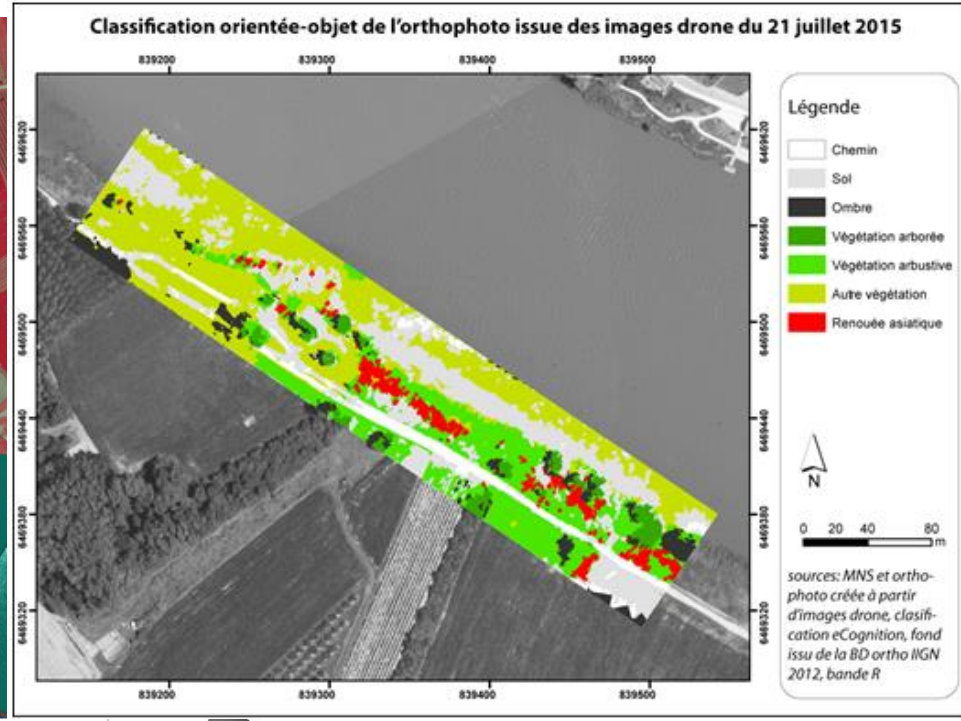
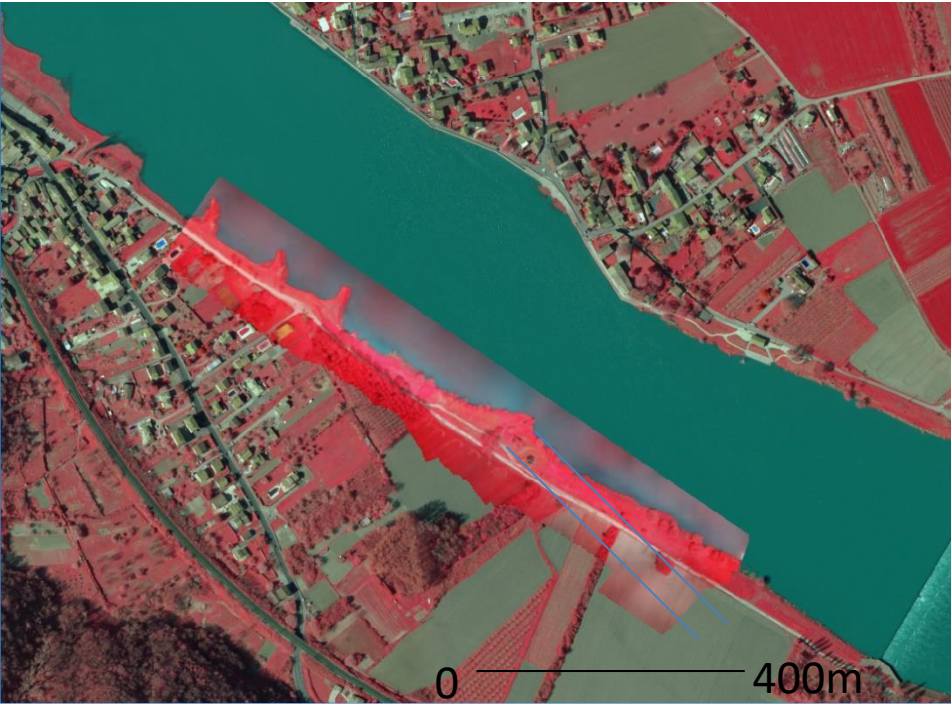


Drone – Juillet 2015



# Acquisition télédétection THRS – Serrières 2016

## Satellite Pleiade - Drone





Méthodes de suivi, d'évaluation et de mise en place des mesures compensatoires et des mesures de réduction d'impact du projet  
Romanche-Gavet





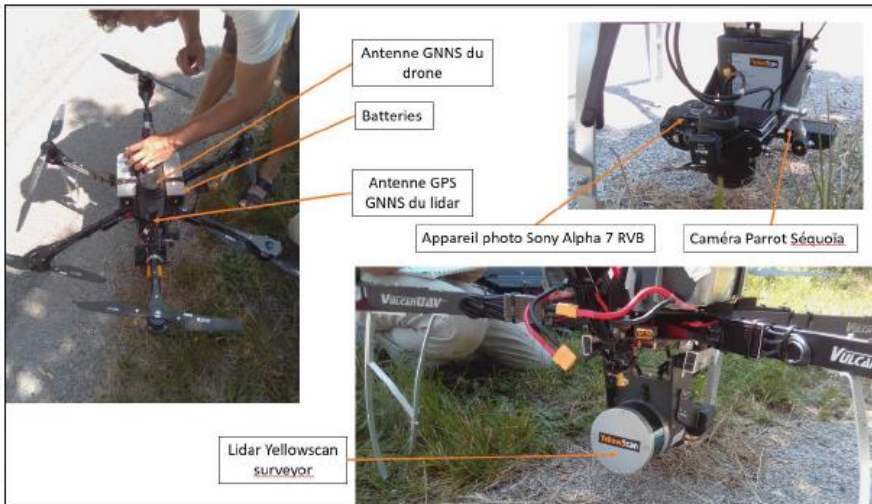
# Suivis d'espaces de compensation écologique



Conventions Irstea - EDF 2015-2020



Topography (DGPS – totalstation), photography RGB-PIR, LiDAR)



*Aster spp*



*Solidago Canadensis*

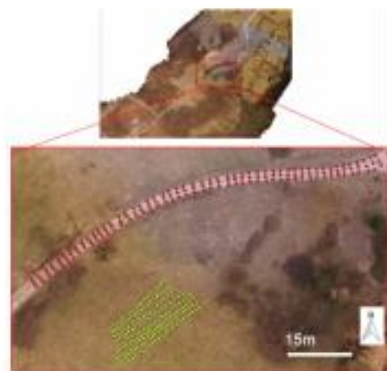
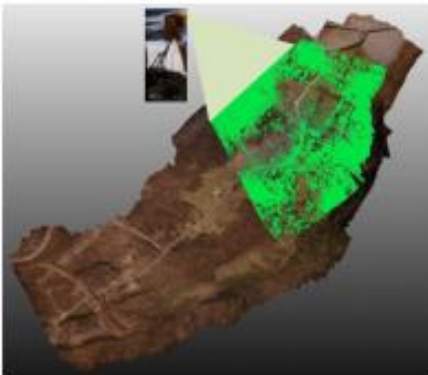


*Falopia Japonica*



*Ruddleia Davidii*

## Terrestrial Laser Scanner



# Evaluation du potentiel de colonisation des zones de compensation par les plantes invasives

Forte présence de plantes invasives sur les deux sites = enjeu majeur

Pourquoi s'intéresser à la banque de graines du sol ?

- Invasives répertoriées = majorité se reproduisent par graines
- Invasives = impacts banque de graines
- « Leg invasif » = quel effet de la gestion ?



Potentiel de colonisation lié à la banque de graines ?

- en fonction de différents milieux
- en fonction de différentes gestions
- en fonction du temps

- Protocole d'échantillonnage
- Prélèvement et mise en culture
- Identification

# Méthode de suivi et de détection de la végétation par télédétection à très haute résolution spatiale

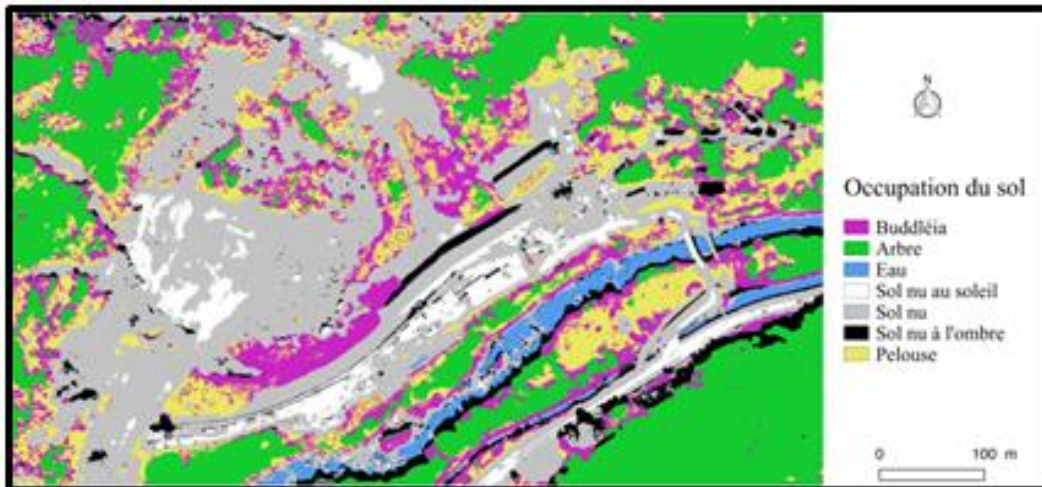
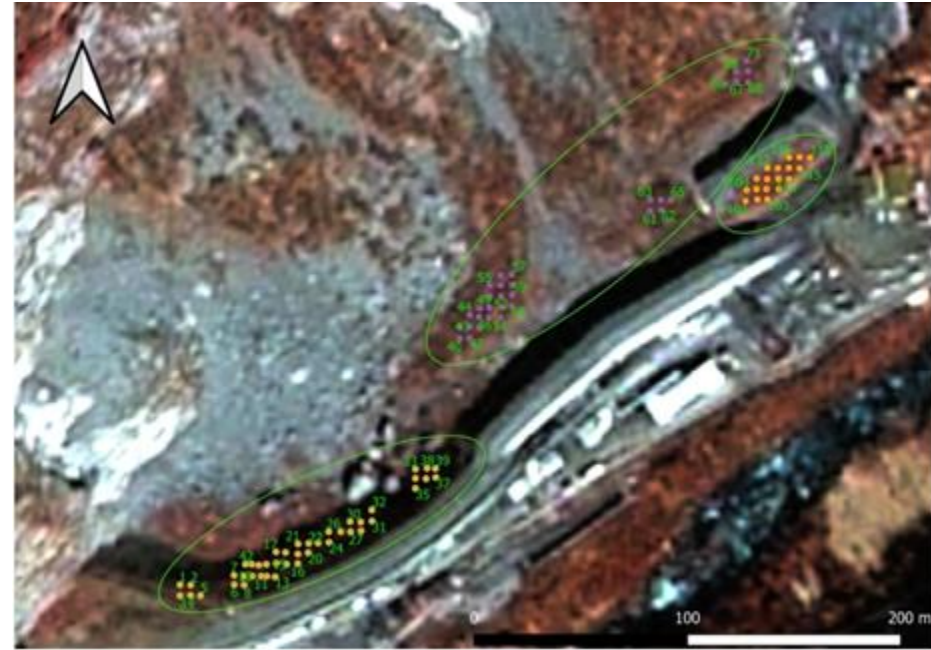
Upscaling passage drone-> Spot6-7 extension à échelle vallée

## Perspectives:

Evaluation travaux de restauration par méthode machine learning

Base de données apprentissage: Images drone résolution >1cm

Base de données terrain transects

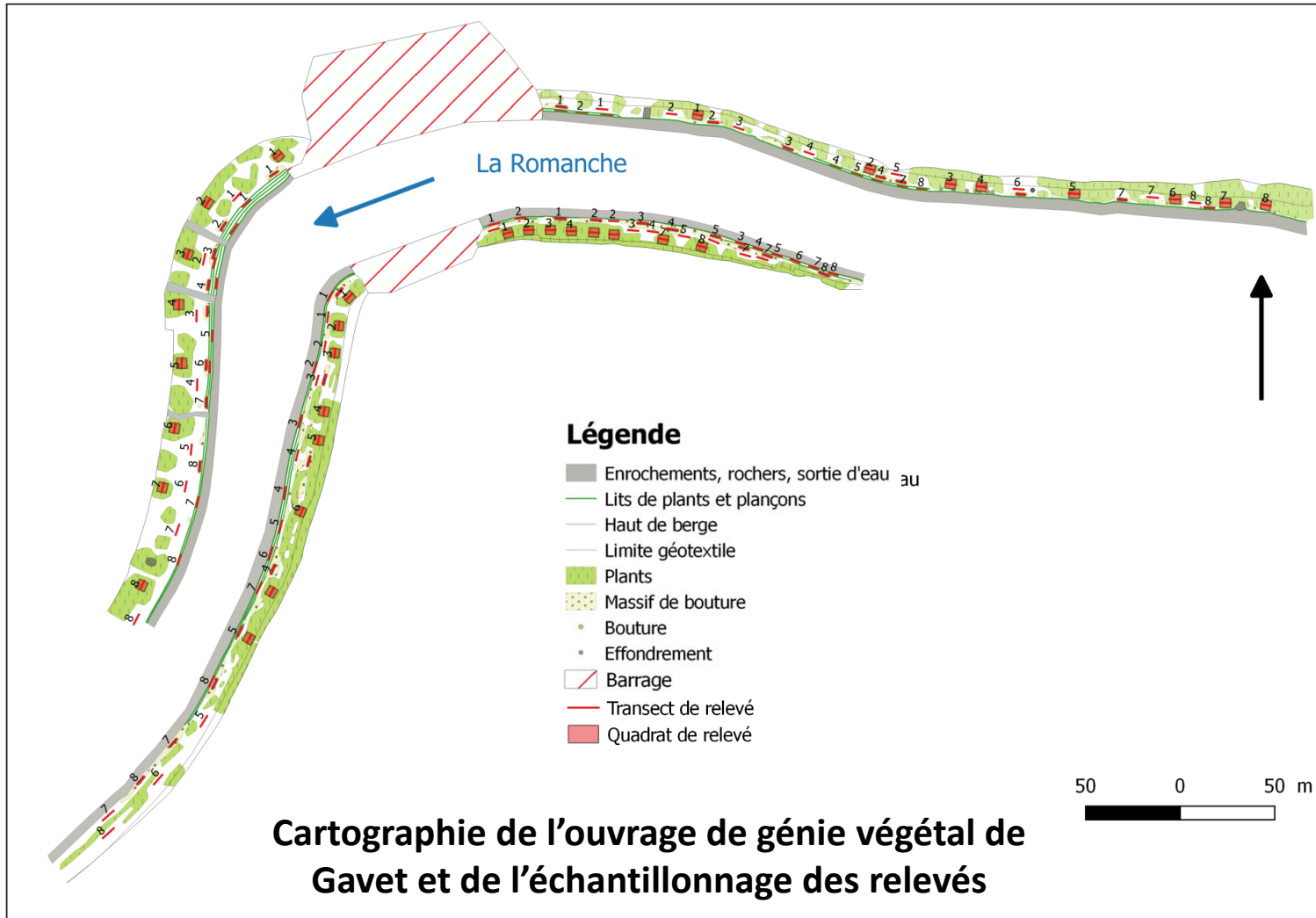


# Evolution de la biodiversité des berges réaménagées

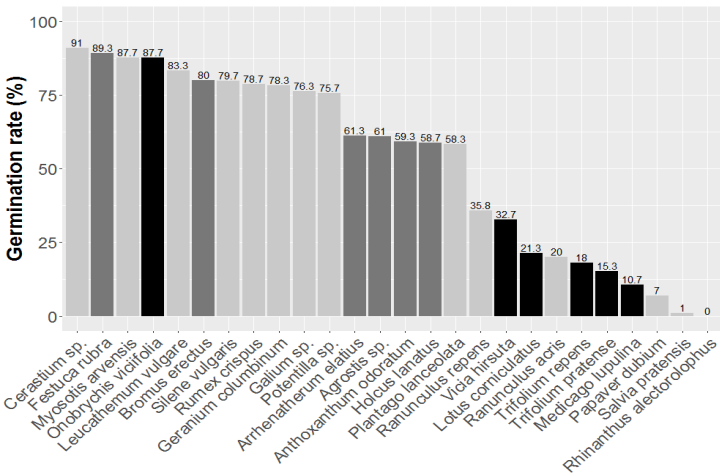
2015 Définition des systèmes de référence

2016 – 2017 Etude du mélange grainier

2016 – 2020 – 2022 – 2024 Suivis de végétation



# Evolution de la biodiversité des berges réaménagés

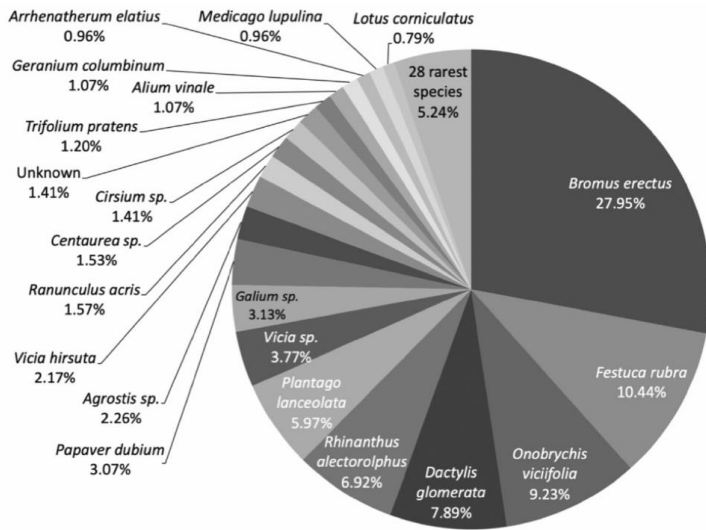


1 – Abondance (Braun Blanquet) des principales espèces relevées en terreau au laboratoire et sur le terrain

Espèces spontanées

Espèces semées

	Laboratoire	Terrain
<i>Solidago gigantea</i>	0	0,5
<i>Epilobium hirsutum</i>	0	1
<i>Agrostis stolonifera</i>	0	1
<i>Tussilago farfara</i>	0	1
<i>Trifolium pratense</i>	0	1
<i>Equisetum arvense</i>	0	1
<i>Centaurea scabiosa</i>	0,5	0,5
<i>Daucus carota</i>	0,5	1
<i>Festuca rubra</i>	1	0
<i>Salvia pratensis</i>	1	0,5
<i>Malva moschata</i>	1	0,5
<i>Prunella vulgaris</i>	1	0,5
<i>Silene vulgaris</i>	1	0,5
<i>Holcus lanatus</i>	1	0,5
<i>Deschampsia cespitosa</i>	1	1
<i>Anthyllis vulneraria</i>	1	1
<i>Onobrychis viciifolia</i>	1	1
<i>Galium mollugo</i>	1	1
<i>Lolium perenne</i>	1	1
<i>Echium vulgare</i>	1	1
<i>Schedonorus arundinaceus</i>	1	1
<i>Ranunculus repens</i>	2	0,5
<i>Brachypodium pinnatum</i>	2	1
<i>Plantago lanceolata</i>	2	2
<i>Bromopsis sp.</i>	2	2
<i>Dactylis glomerata</i>	3	2

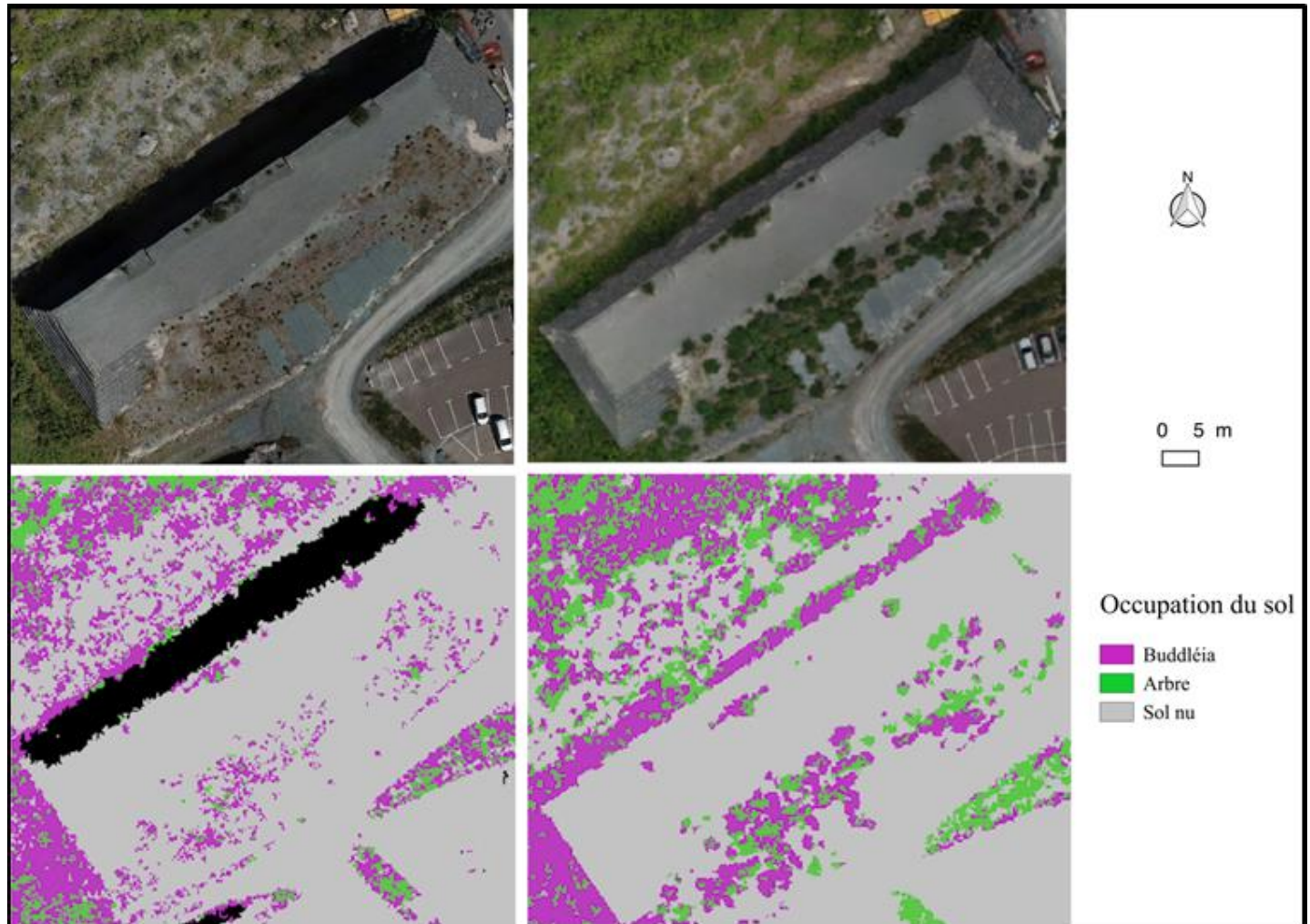


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# Méthode de suivi et de détection de la végétation par télédétection à très haute résolution spatiale

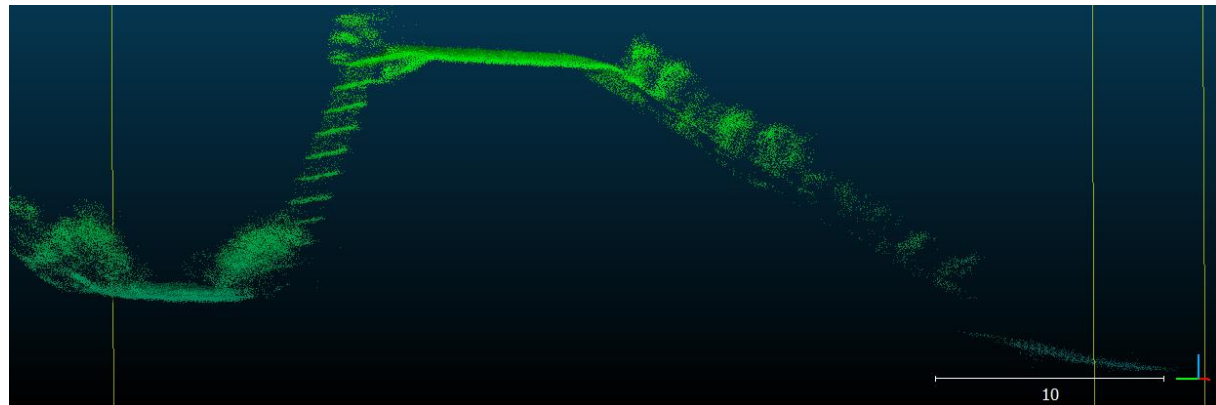
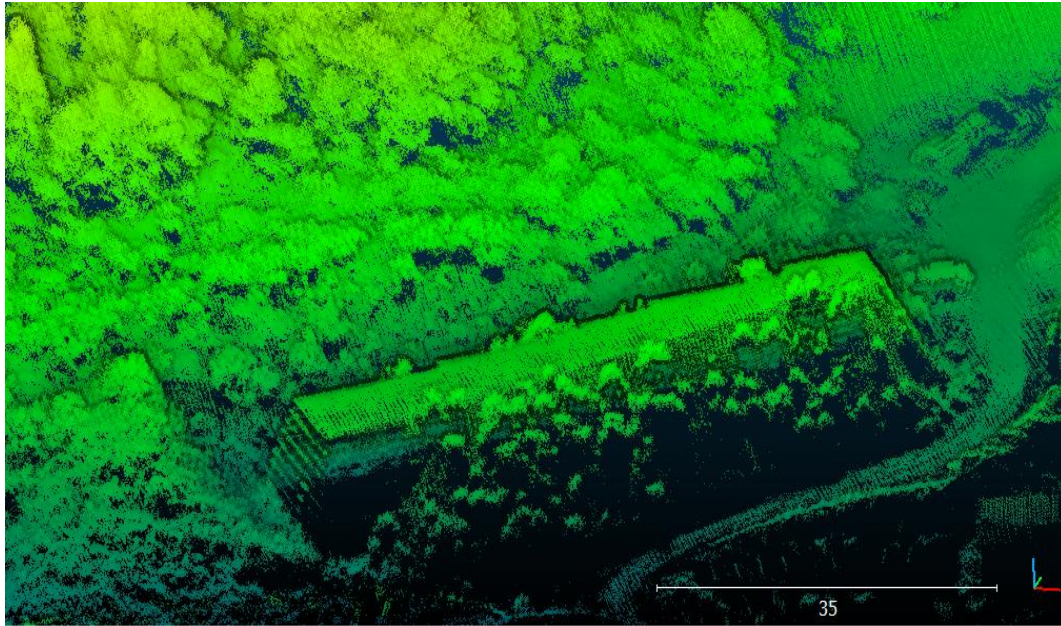
## Résultats

validation hypothèses suivi de chantier Ponants- lutte buddleias recouvrement par matériaux extraction tunneliers-> quantification mesure efficacité



# Méthode de suivi et de détection de la végétation par télédétection à très haute résolution spatiale

Exploitation 3D des nuages de points LiDAR pour l'évaluation biomasses



# Machine learning OTBTF (Cresson R. Tetis)

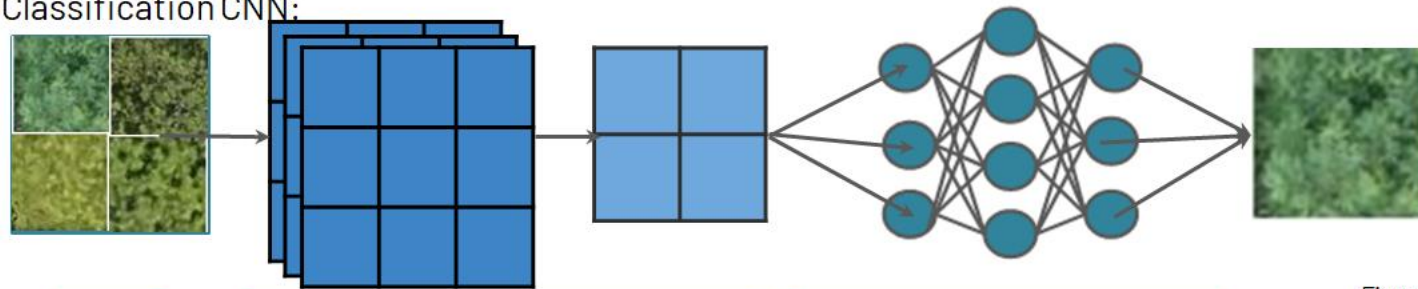
Classification Pixel:



Classification Objet:



Classification CNN:

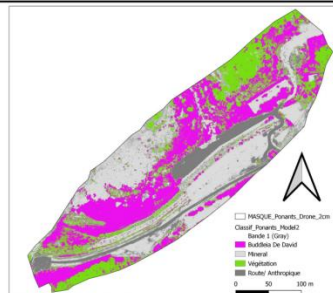


Échelle des communautés

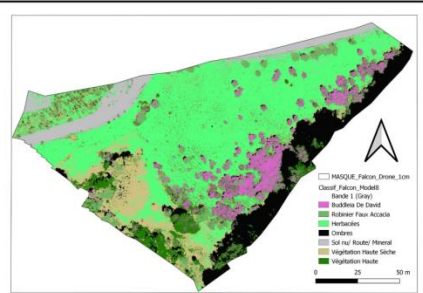
Échelle des individus?

Figure 1 : Schémas de classification: Source : HERRIG Nathan, M2 GAED - GEOIDES.

Classification zone Ponants - 2cm/pixel - Model 2



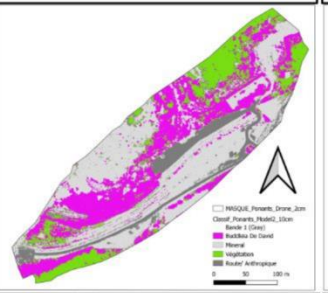
Classification zone Falcon - 1cm/pixel - Model 8



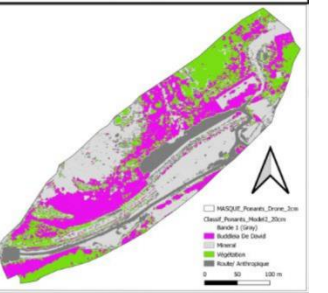
Résolution: 5cm



Résolution: 10cm



Résolution: 20cm



Kappa index: 0.968  
Overall accuracy index: 0.976

Kappa index: 0.798667  
Overall accuracy index: 0.827429

2022-08-24 16:25:21 (INFO) tensorflow:train: Kappa index: 0.95213  
2022-08-24 16:25:21 (INFO) tensorflow:train: Overall accuracy index: 0.968  
2022-08-24 16:25:21 (INFO) tensorflow:train: confusion matrix:  
2022-08-24 16:25:21 (INFO) tensorflow:train: Kappa index: 0.96  
2022-08-24 16:25:21 (INFO) tensorflow:train: Overall accuracy index: 0.965  
2022-08-24 16:25:21 (INFO) tensorflow:train: confusion matrix:  
2022-08-24 16:25:21 (INFO) tensorflow:train: Kappa index: 0.95927  
2022-08-24 16:25:21 (INFO) tensorflow:train: Overall accuracy index: 0.963  
2022-08-24 16:25:21 (INFO) tensorflow:train: confusion matrix:



# Méthode de suivi et de détection de la végétation par télédétection à très haute résolution spatiale

## Perspectives:

Evaluation travaux de restauration par méthode machine learning

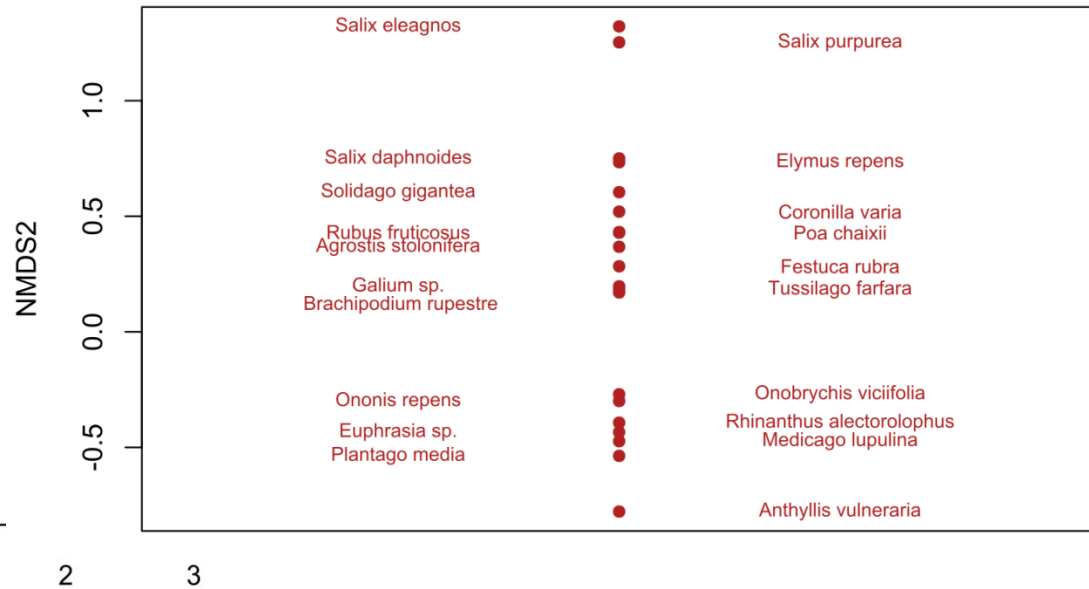
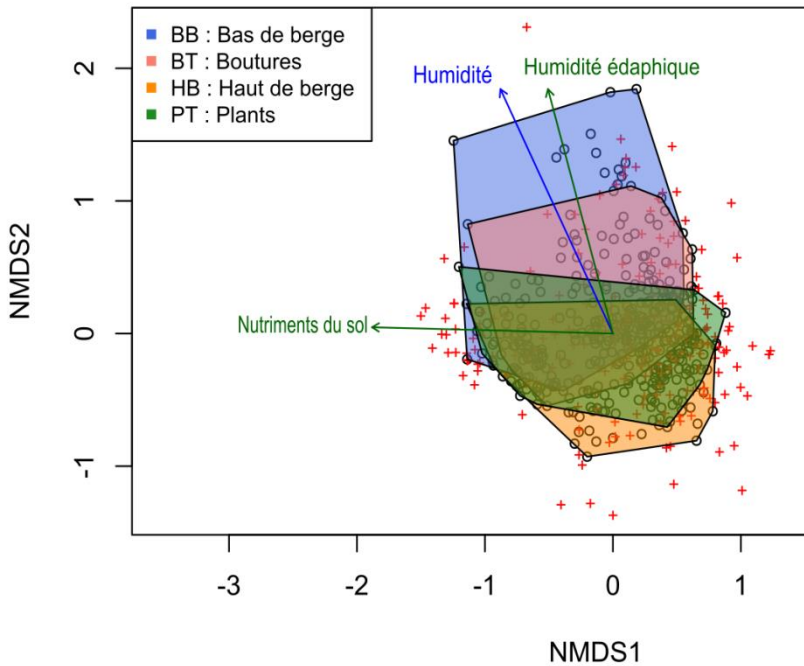
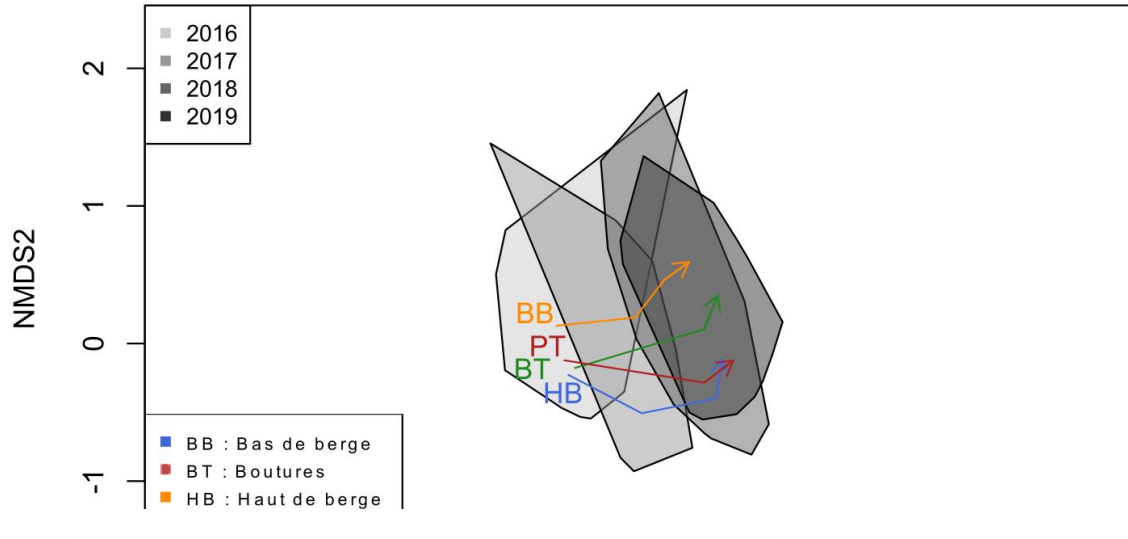
Base de données apprentissage: Images drone résolution >1cm

Base de données terrain transects



# Evolution de la biodiversité des berges réaménagées

## Dynamique des communautés sur les berges



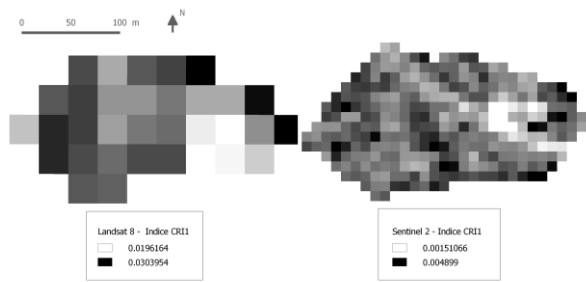
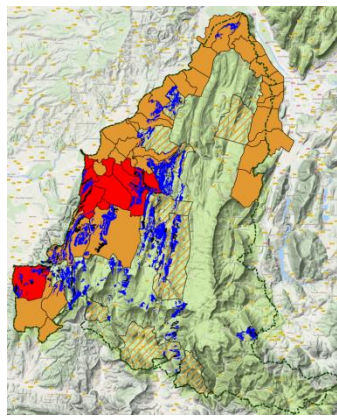
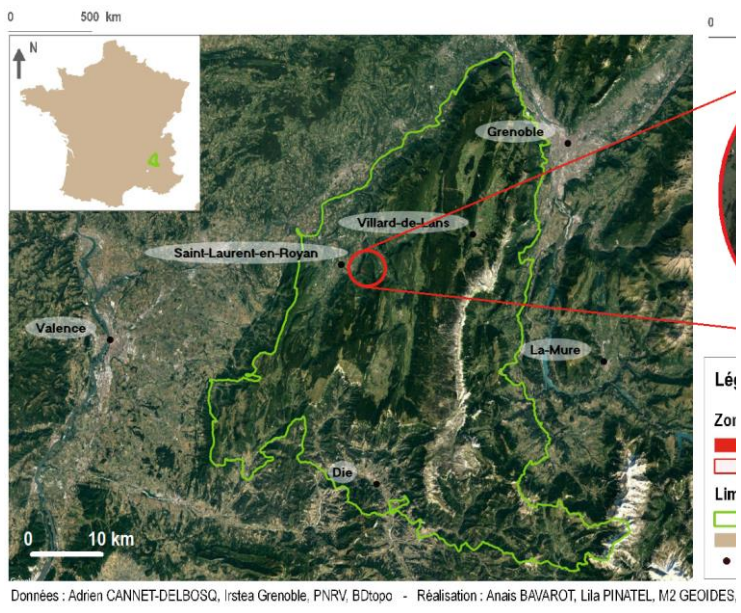
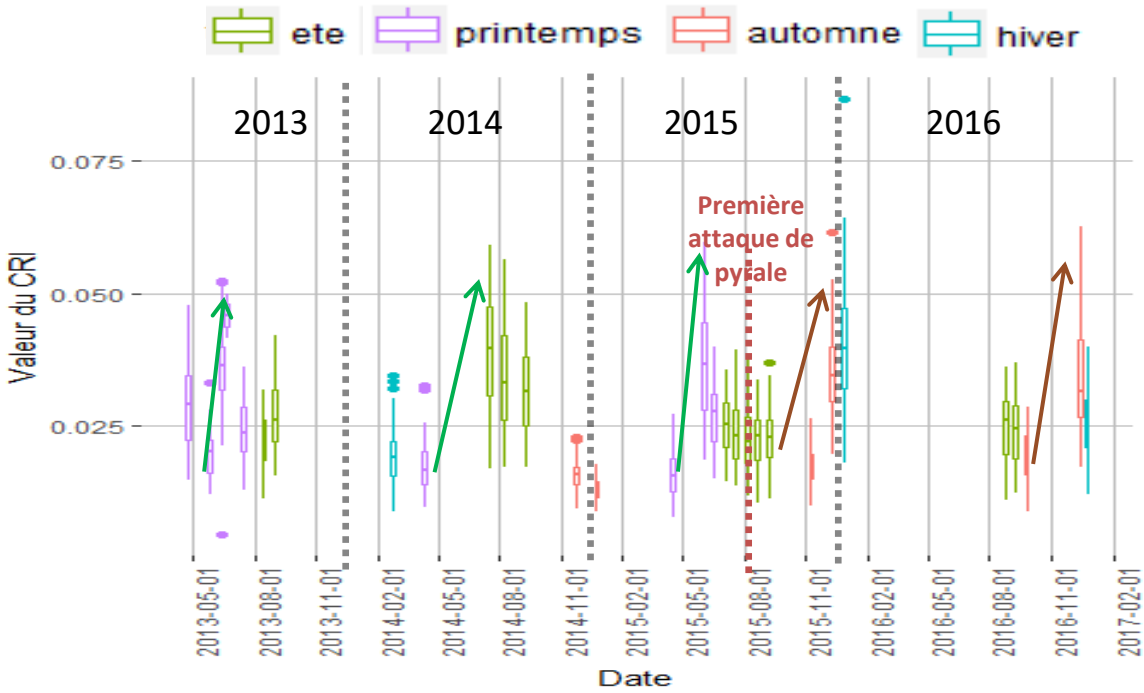


# Remote Sensing for Detection and Monitoring of Boxwood Moth Invasion (*Cydalima perspectalis*) in Vercors Natural Park (poster colloque PNTS june 2018)

Convention Irstea DGPR

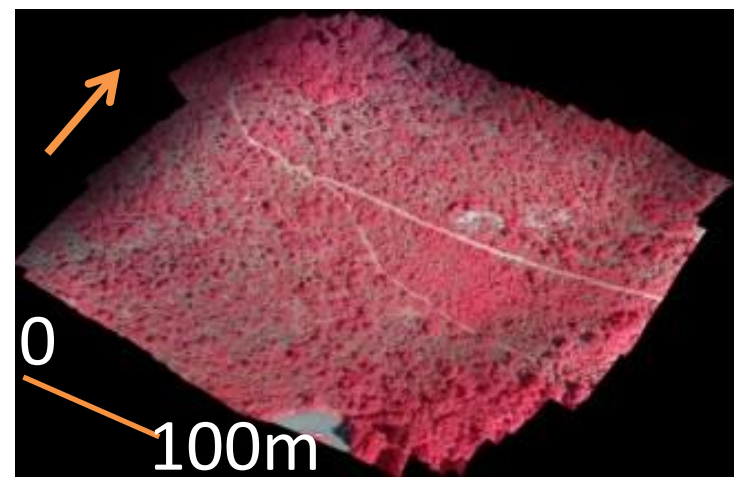


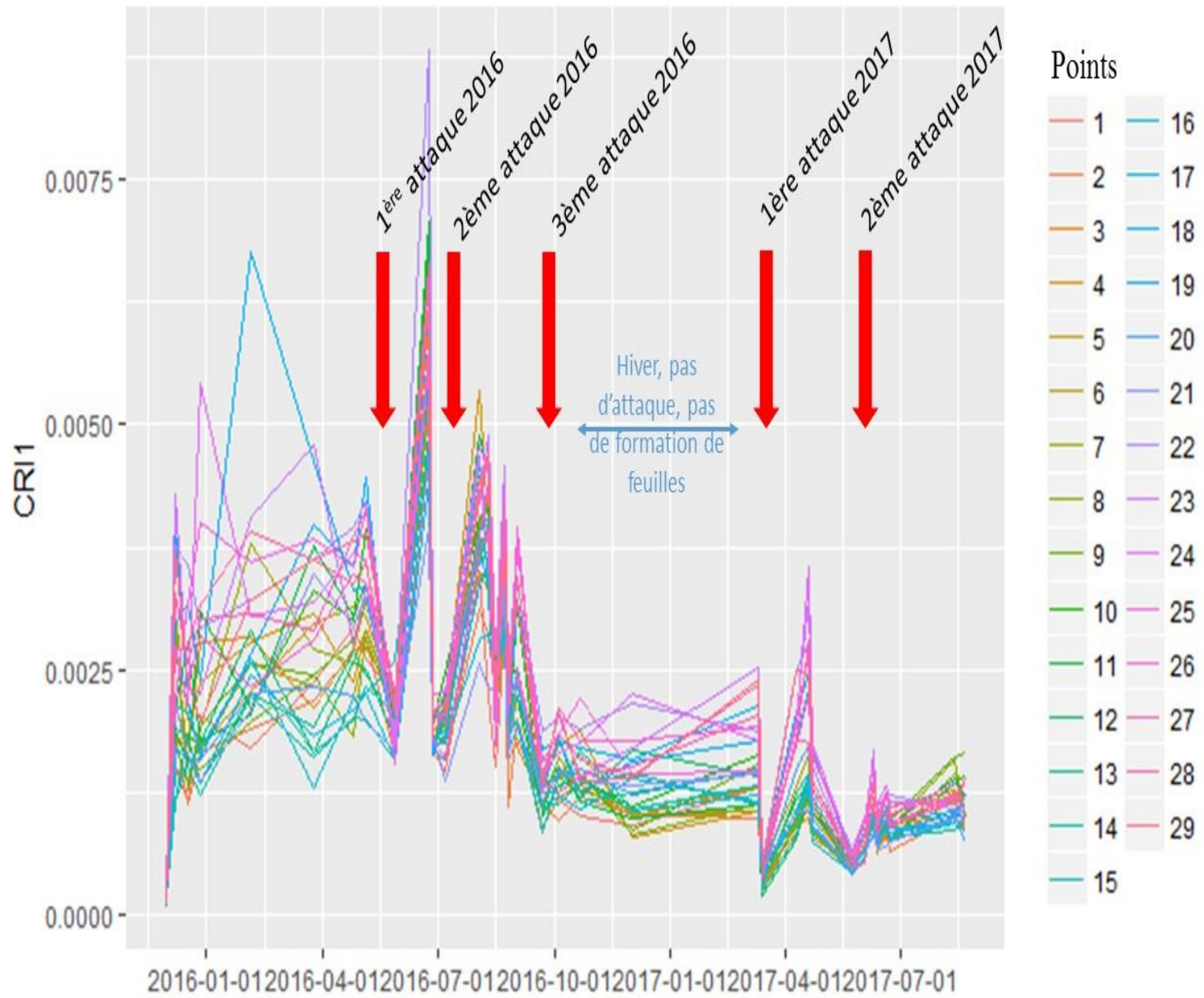
Evolution pluriannuelle du CRI. Images Landsat-8 2A



Source : Sentinel 2, Landsat 8 (Terra) - réalisation : Anais Bavarot, Lila Pinatel M2 GEOIDES, IGA 2018

**Carotenoid Reflectance Index 1**  
 $CRI1 = (Blue-Green)/Blue+Green$





# Knotweed inventory along Herault River at Alluvial bar scale

## Results:

Influence de la géométrie des berges sur la présence de la renouée ...  
 Modèle de préférence d'implantation à l'échelle de la barre alluviale .

Réchauffement climatique -> probable expansion populations de renouées asiatiques (Groeneveld et al., 2014)  
 -> menace majeure pour les cours d'eau.  
 - Améliorer notre compréhension des interactions entre les processus hydrogéomorphologiques et invasions de renouées  
 - Etape importante -> répondre aux questions opérationnelles des gestionnaires.  
 Souligne nécessité de prendre en compte davantage de variables hydrogéomorphologiques dans une approche plus globale de la gestion de l'eau et de l'environnement.

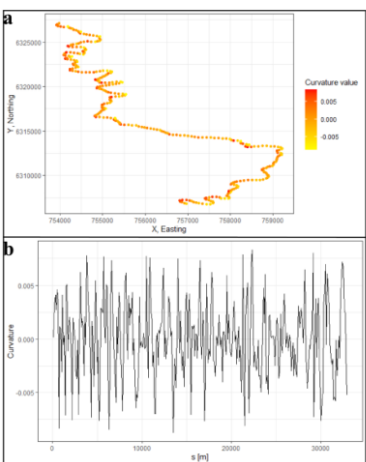


Fig. 3. (a) Channel axis configuration of the l'Hérault and (b) the corresponding curvature. s is the distance to the most upstream invaded point.

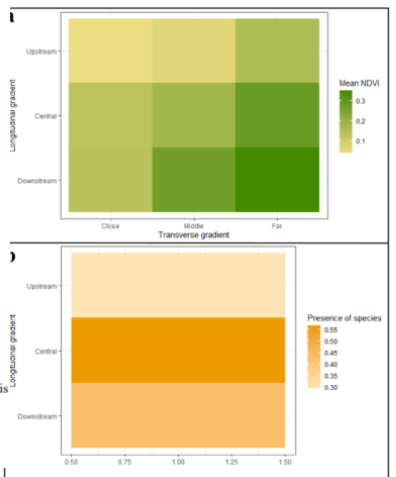


Fig. 5. (a) Average NDVI according to the longitudinal and transverse gradient, calculated on 7 banks on the Hérault (63 observations). / Wilcoxon-Mann-Whitney test was performed to test the difference between the 9 locations, showing no significant difference. (b) Probability of presence of species predicted along the longitudinal gradient.

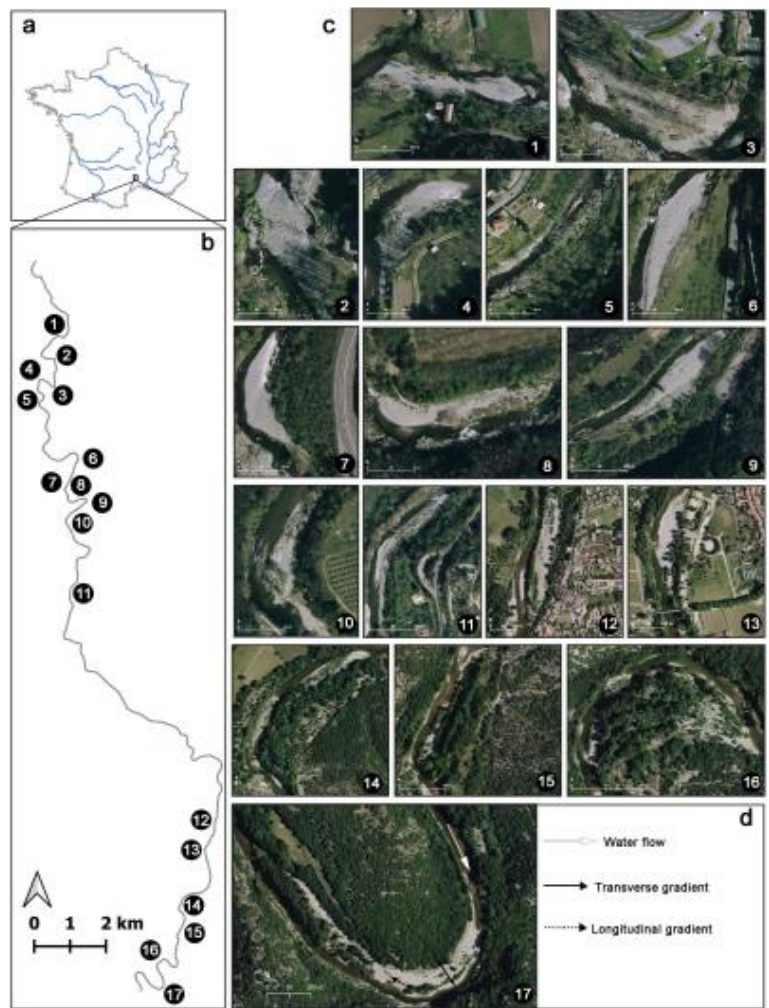
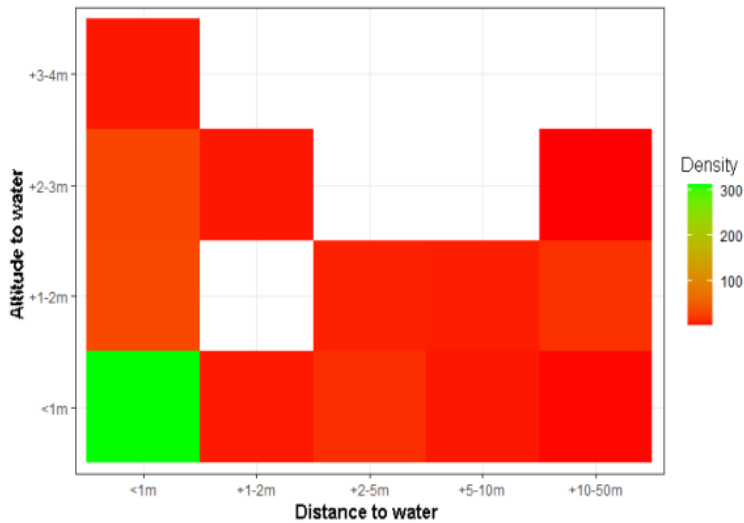


Fig. 1. The study reach of the Hérault and the 17 alluvial bars studied.

**Table 2.** Evolution of the invasion by the Asian knotweed on the Hérault

	Date	Linear invaded (km)	Total number of stations	Total area invaded (m <sup>2</sup> )	Number of stations < 1m <sup>2</sup>	Number of stations between 1 and 50 m <sup>2</sup>	Number of stations > 50 m <sup>2</sup>
Hérault	2007	14	91	500	52	37	2
	2015	26	611	21 500	145	408	58



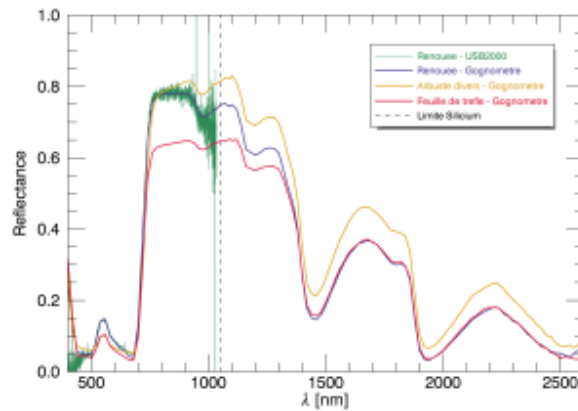
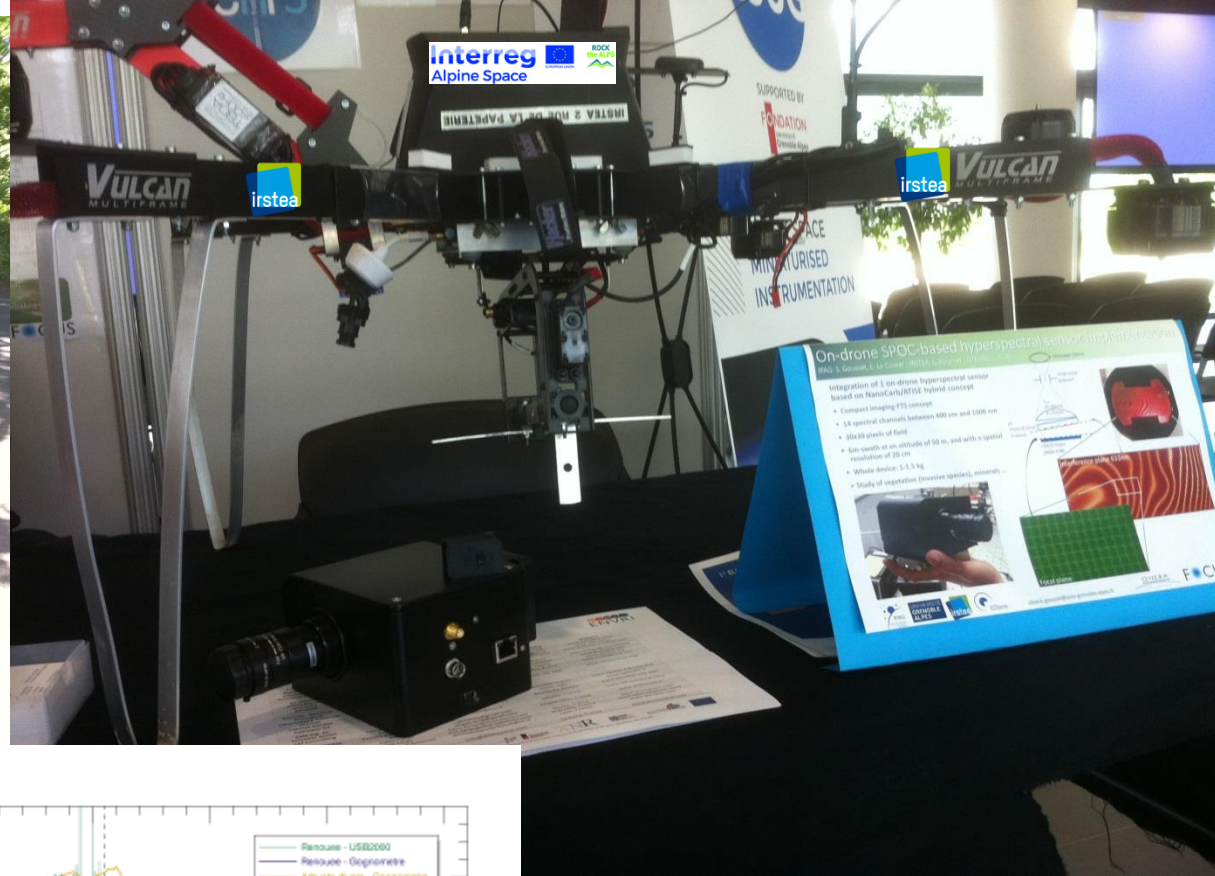
**Fig. 1.** Position of knotweeds on the banks: elevation and distance to water based on 611 observations in 2015.



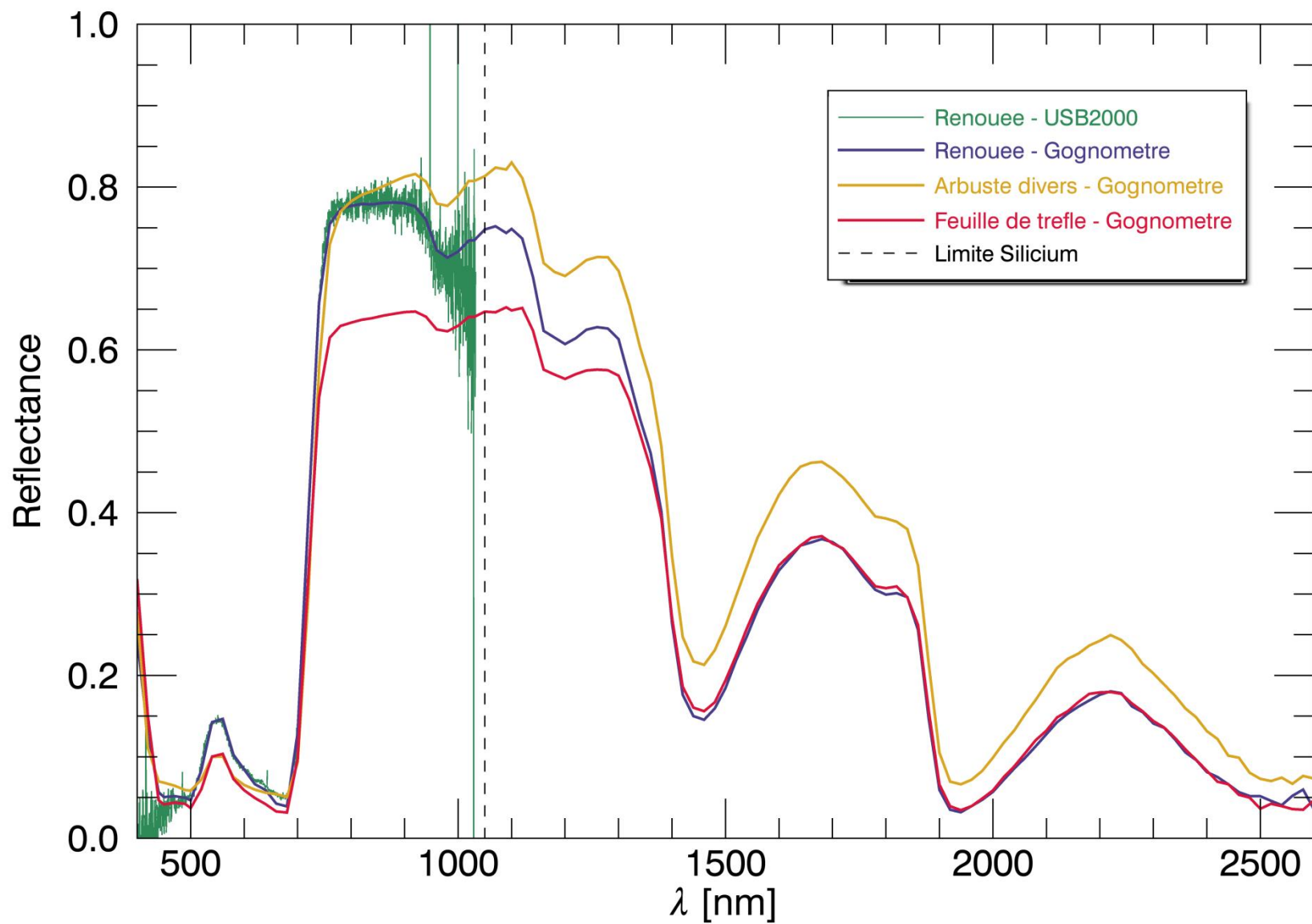
**Fig. 2.** Examples of the effects of recent floods and propagules found along the Hérault River

# Développement capteur Hyperspectral embarqué sur drone.

## Applications à la végétation (EEE) - Labex OSUG – IPAG-Irstea-Isterre- Leca







Merci de votre attention