

# Cymru Fyw - Yn Fyw



Mae prosiect *Cymru Fyw* wedi datblygu adnodd unigryw i alluogi Cymru i fynd i'r afael â heriau lleol a byd-eang drwy arsylwadau'r Ddaear.

- Cyflwyniad i *Cymru Fyw*
- Arsylwadau lloeren ac o'r awyr
- Disgrifwyr amgylcheddol
- Categoriâu tiroedd Cymru
- Perthnasedd i gynefinoedd
- Newidiadau i'r tirwedd ar sail tystiolaeth
- *Cymru Fyw* ar y ddaear
- Ymgysylltu byd-eang
- Adfer ecosystemau a thirweddau'r dyfodol
- Cysylltiadau â pholisi, yr economi, llesiant a rheoli tir
- Addysg ac allgymorth
- Gyrru ac ymateb i uchelgeisiau cenedlaethol a rhyngwladol



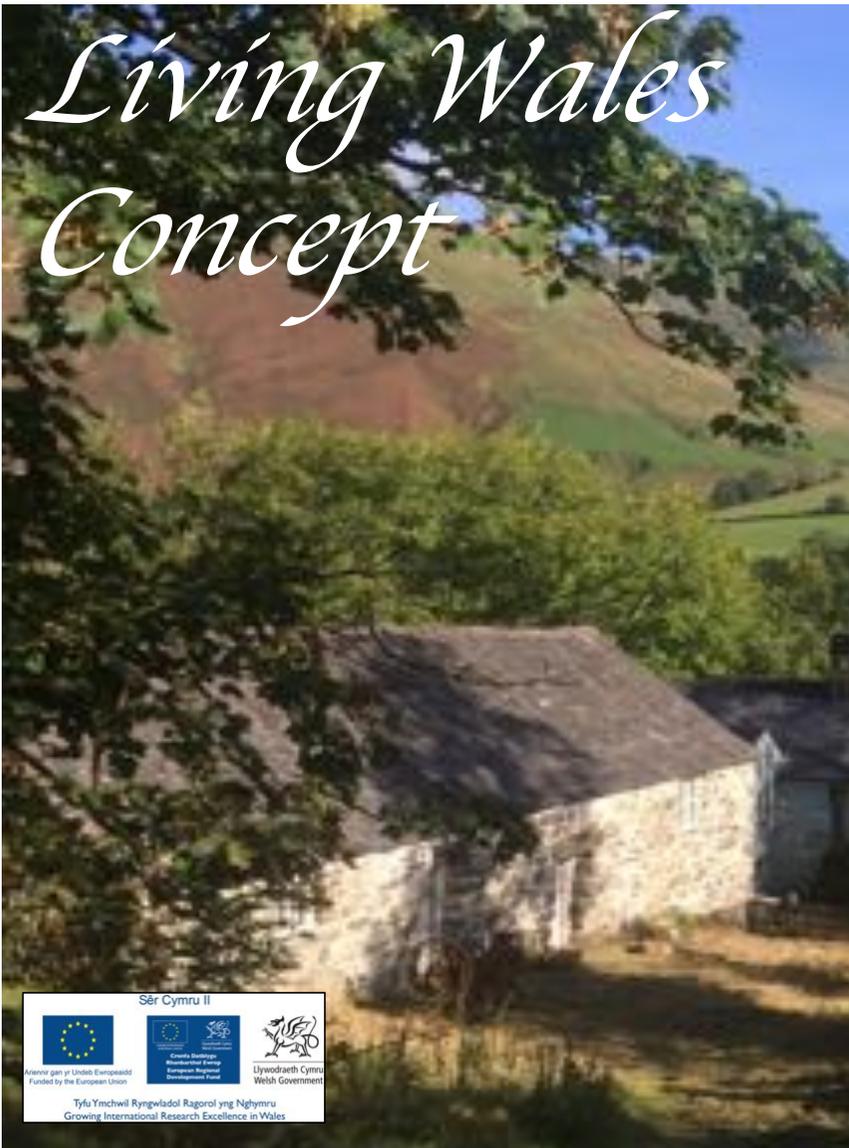
# Living Wales - Live



*Living Wales* has developed unique capacity for Wales to address local to global challenges through Earth observations.

- Introducing Living Wales
- Satellite and airborne observations
- Environmental descriptors
- Land cover classifications for Wales
- Translation to habitats
- Evidence-based land cover change
- Living Wales on the ground
- Global engagement
- Ecosystem restoration and future landscapes
- Links to policy, economy, well-being and land management
- Education and outreach
- Driving and responding to national and international ambitions





- *Living Wales* is first and foremost a research project that aims to significantly advance the use of Earth Observation (EO) data in Wales, but also internationally.
- *Living Wales* is not an operational program but aims to provide operational capability towards the end of or following the project close.
- *Living Wales* is being developed as an open system that encourages collaboration and engagement from all sectors and across a multitude of users.
- A pro-active approach that emphasizes the use of remote sensing for sustainably managing and utilizing, conserving/protecting and restoring landscapes rather than simply observing and reporting on environmental states and change.

# Living Wales



Suvarna Punalekar



Carole Planque



Sebastien Chognard



Christopher Owers



Richard Lucas

Plus many other contributors and collaborators from Wales, the UK and internationally

We would like to thank you all and also the European Regional Development Fund (ERDF) Sêr Cymru, the Welsh European Funding Office (WFO) and Welsh Government



Patryk Poslajko



# Strategic Plans for Living Wales

## Living Wales



A Strategic Plan for Earth Observation in Wales

Long term (50 years)

*Promoting and building national capability in earth observation and economic success whilst ensuring long-term care and maintenance of the environment and resources*

### Prosperity for Wales

Providing new opportunities for economic development in all sectors by providing open access and usable earth observation and derived products to the population.



### Sustainability for Wales

Providing a long-term system for understanding, monitoring and planning landscape change that is applicable at a national level and based on historical and near real time earth observations.



### Resilience for Wales

Ensuring maintenance and promoting enhancement of the state and function of Welsh landscapes and their ability to respond to adverse environmental change through integration of earth observation data.



AIMS

INITIATIVES

INDICATORS

# A Contribution to Wales



**Natural Resources**  
Sustainably and responsibly utilized through wise use and planning



**New technologies**  
Strategic investments and targeted exploration and exploitation



**Biodiversity**  
Conserved, restored and thriving



**Business**  
New and existing ventures supported to increase productivity and employment



**Carbon stores and sinks**  
Maximized and emissions reduced



**Productivity and yields**  
Strategically increased for agriculture, forestry and fisheries



**Environment and climate**  
Resilient to change events and processes including disease and disasters.



**Space sector**  
Earth observation technology use significantly increased and future investment encouraged.



**Clean and safe environments**  
Improved well-being and health of the Welsh people and Wales' flora and fauna



**Science base**  
Greater investment in scientific research and increased impact on the world stage



**Education**  
Skills and knowledge in earth observation and environment substantially increased

CUBESATS



RADAR



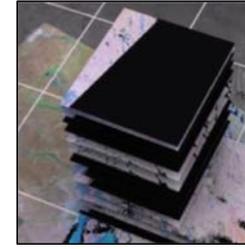
LIDAR



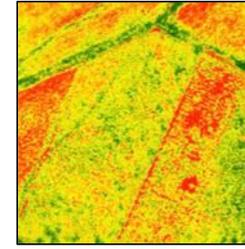
LAND COVER & CHANGE



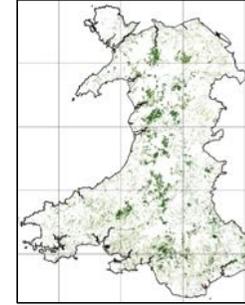
TIME-SERIES



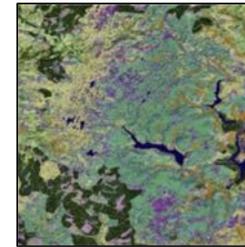
DRONES



VARIABLES



HABITATS



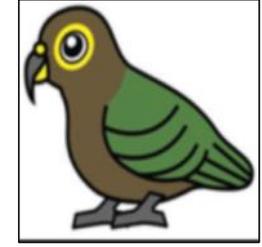
HPC



STORAGE



SOFTWARE



MOBILE APP



# *Living Wales*



*Satellites and airborne observations*

# Satellite and airborne observations



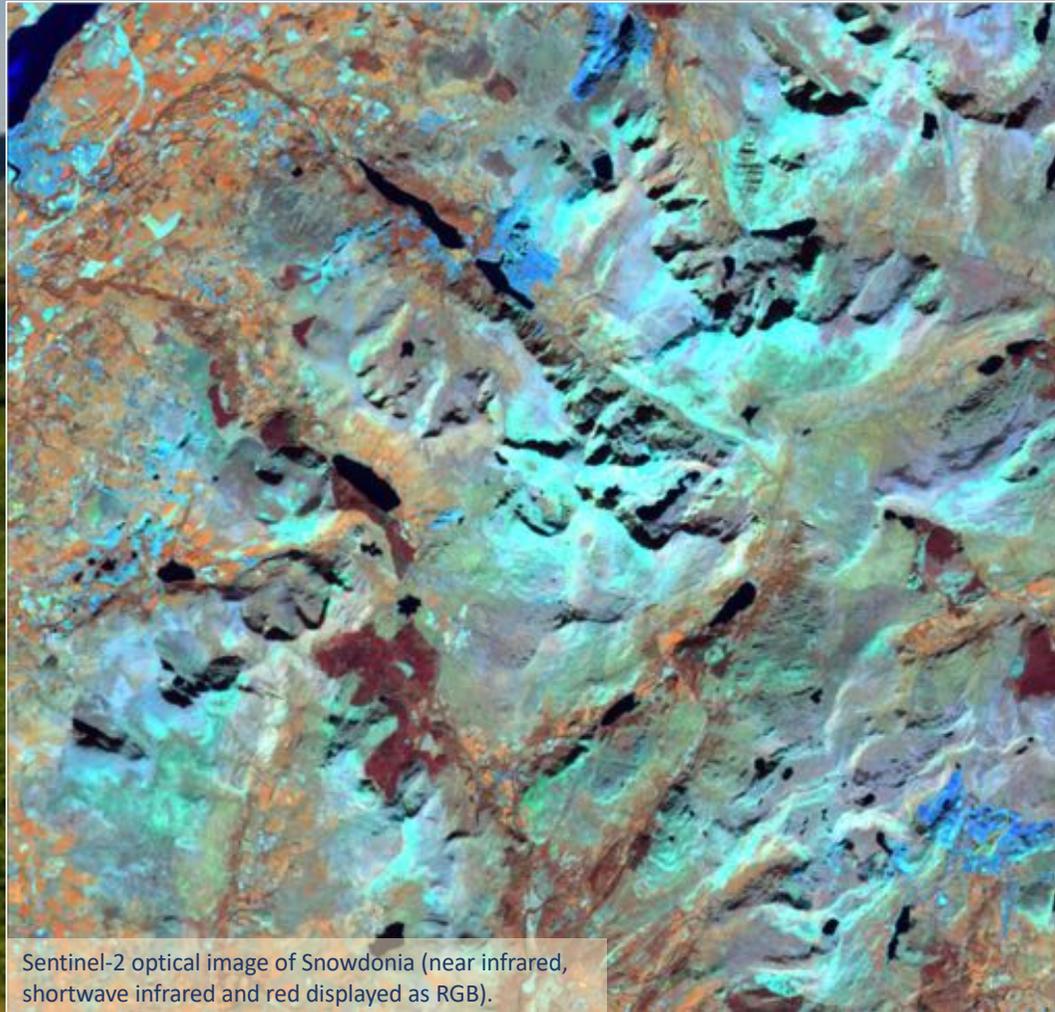
The European Space Agency's (ESA) Sentinel 1 is a radar satellite that transmits microwaves ( $\sim 6$  cm wavelength; termed C-band) to the Earth's surface and records those that return, both in terms of intensity but also polarization.

The main advantage is that the microwaves penetrate cloud and haze and can be acquired regardless of illumination conditions.

Over Wales, C-band radar are acquired every 6 days at 10 m resolution through the combination of two satellites.

The interaction of microwaves varies depending upon the size, orientation and moisture content of materials. These data are particularly useful for mapping woody vegetation, water and moisture amounts and crop types.

# Satellite and airborne observations



Sentinel-2 optical image of Snowdonia (near infrared, shortwave infrared and red displayed as RGB).

The European Space Agency's (ESA) Sentinel 2 is an optical satellite that measures reflected solar energy from the Earth's surface.

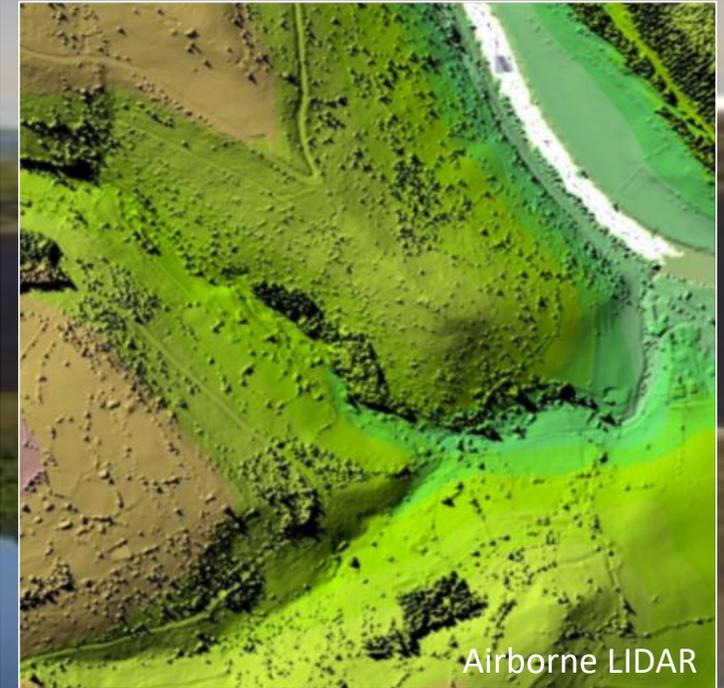
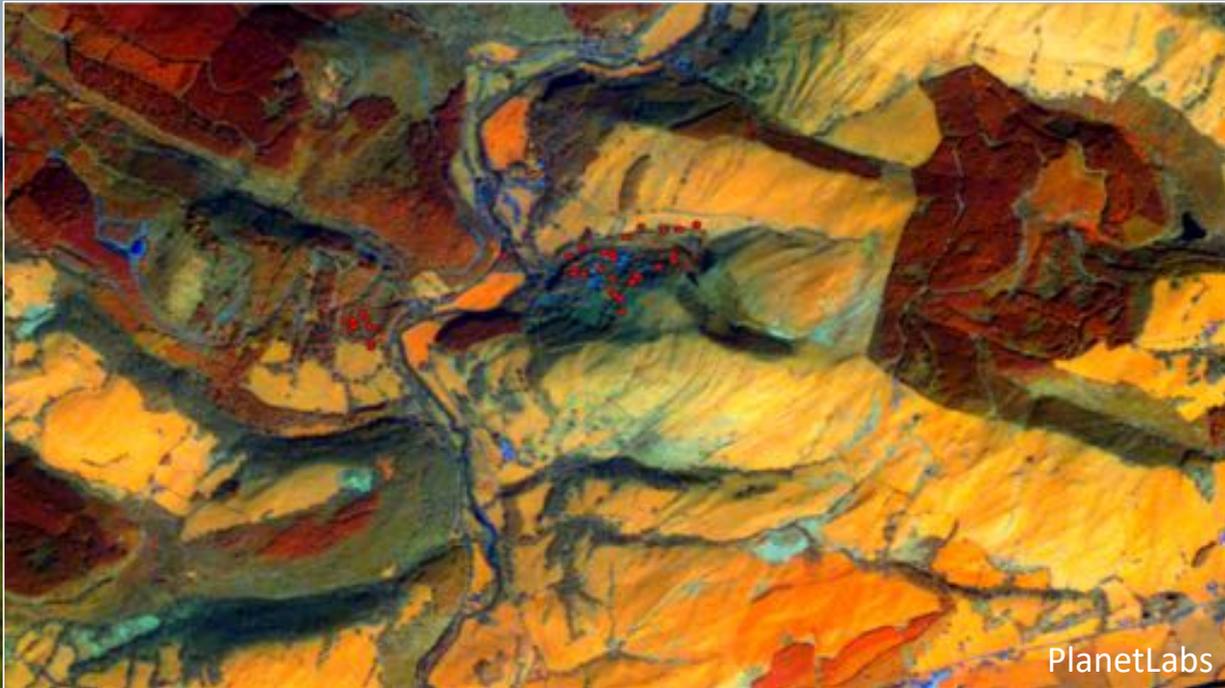
Over Wales, two Sentinel-2 satellite sensors are acquiring visible (blue, green and red), near infrared and shortwave infrared reflectance data every 5 days at 10 m resolution.

As clouds obscure views of the surface, useable data are only acquired under clear conditions and hence the number of observations can be reduced.

The surface reflectance measures obtained from these sensors provides capacity to retrieve information such as vegetation canopy cover and the seasonal variations in leaf cover and classify land cover components (e.g., plant species).



# Satellite and airborne observations



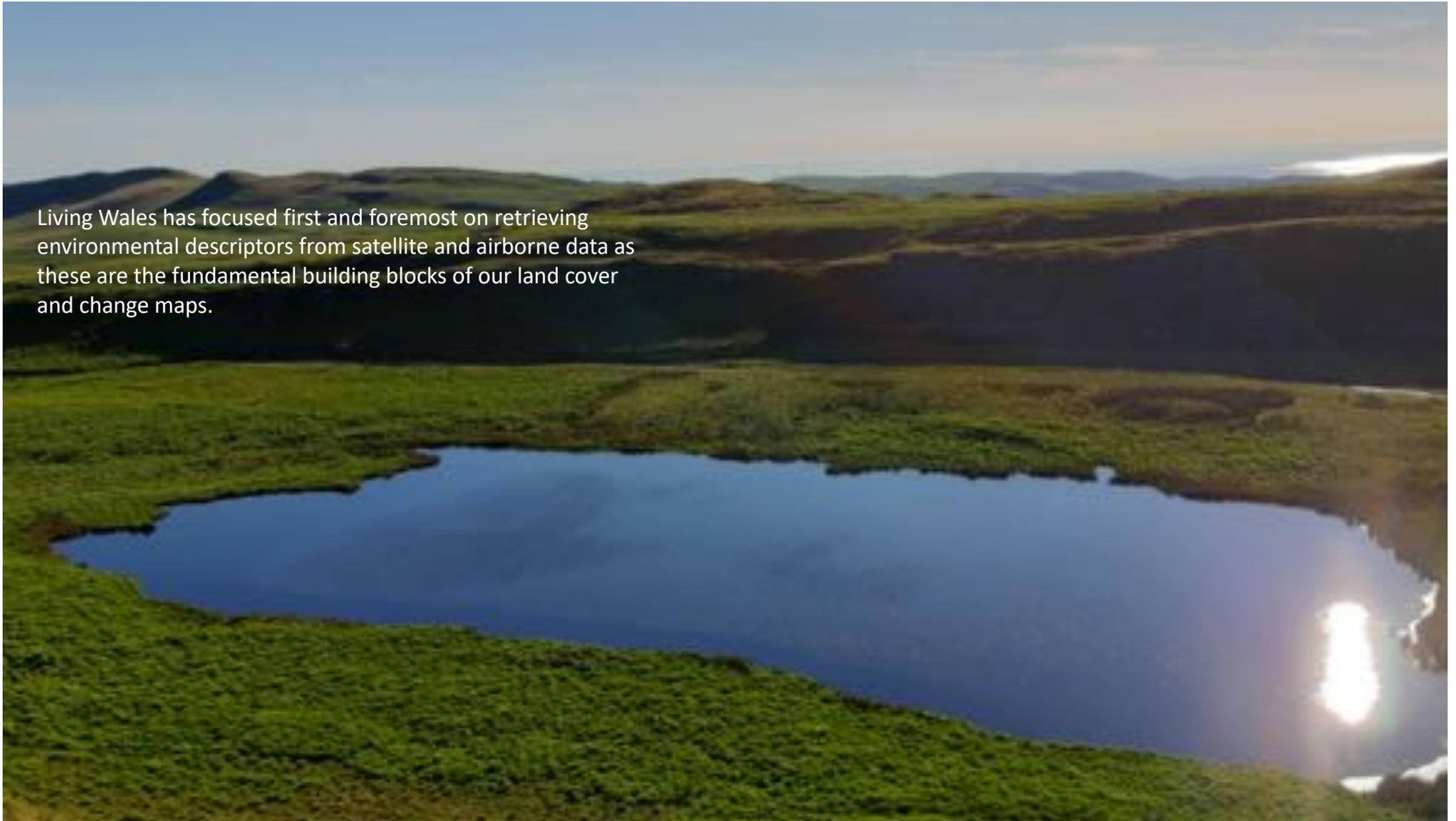
An increasing amount and diversity of satellite and airborne sensor data are being acquired over Wales, and we want to make maximum use of these to support ongoing descriptions and mapping of the national landscape and to inform future directions.

# *Living Wales*



*Environmental Descriptors*

Living Wales has focused first and foremost on retrieving environmental descriptors from satellite and airborne data as these are the fundamental building blocks of our land cover and change maps.



By combining a range of descriptors, we can generate a detailed classification of a landscape on the ground and remotely



Trees with a closed canopy (>70-60 %) that are tall (14-30 m), broadleaved, deciduous, with a 2nd layer supporting an open (20-40 %) canopy 7-3 m in height.

In addition, the forest is also dominated by European Birch, has an above ground biomass of 60 tonnes per hectare, a Leaf Area Index of 2.3, 50 % moisture content and some senescent material in the canopy.

# The Living Wales Website

The Living Wales website provides a comprehensive list of these environmental descriptors and is being updated as and when new datasets are released

The idea is to inform people in Wales on the information and data that are currently available for the country

The majority of the datasets are openly available and so do let us know if you would like us to include any you have produced or which we have not yet included

Information is also available on how these descriptors might be measured or categorized on the ground and also on methods for retrieving these from satellite and airborne sensors

For more information, visit [wales.livingearth.online](http://wales.livingearth.online)



## ENVIRONMENTAL DESCRIPTORS

View the wide range of environmental descriptors describing the land, marine and atmosphere at multiple spatial and temporal scales for Wales, many of which have been provided through Earth observations.

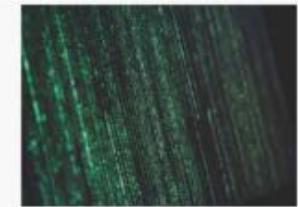
[READ MORE](#)



## GROUND MEASUREMENTS

Ground measurements are essential for developing algorithms for retrieving environmental variables from Earth observation data and for validating land cover and change classifications. Find out how to collect ground measurements but also view and download some of our current collections, which include those in near real time. If you would like to contribute ground data,...

[READ MORE](#)



## REMOTE SENSING ALGORITHMS

A range of satellite data based products are available globally and/or regionally. The products provide valuable spatiotemporal information for a range of environmental descriptors, including Leaf Area Index (LAI), canopy height (m), Net Primary Productivity (NPP) and phenology. The following details algorithms that are existing or have been developed through Living Wales to retrieve...

[READ MORE](#)



## WOODY BIOMASS

Woody biomass is defined as the total mass of living plant material per woody area. Aboveground biomass plays a key role in the carbon cycle and climate processes. It can be measured through direct or indirect in situ sampling (see here) or estimated through satellite/airborne sensors. Typically, biomass in woody areas ranges between 0 (poorly...

[READ MORE](#)



## LEAF AREA INDEX

The Leaf Area Index (LAI) is defined as the total area of on-sided leaves per ground surface area. It is a fundamental property of the plant canopy as it plays a key role in the absorption of solar radiation, through photosynthesis, and thus on the vegetation growth. LAI can be estimated by ground measurements...

[READ MORE](#)



## ALBEDO

Albedo is defined as the ratio of total upwelling to total downwelling solar radiation at the surface. It represents the energy balance at the soil-vegetation-atmosphere interface. The albedo allows to quantify the part of the energy that is absorbed by Earth surface and then transformed to heat. The albedo is a unitless variable ranging from...

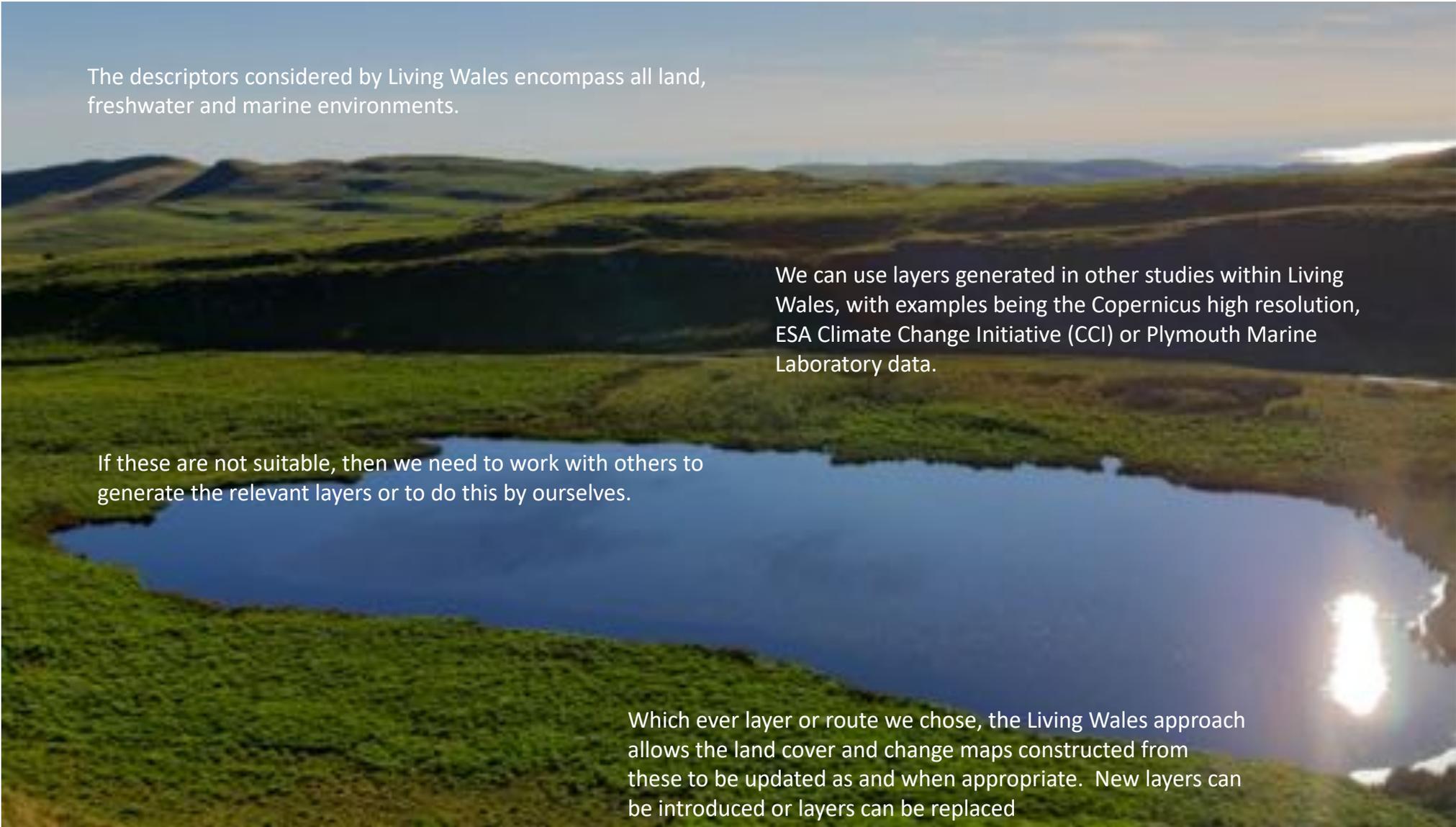
[READ MORE](#)



## HERBACEOUS BIOMASS

Herbaceous biomass is defined as the total mass of living plants, that have a non-woody stem, per area. Aboveground biomass plays a key role in the carbon cycle and climate processes and is of major importance in various fields such as agronomy, biodiversity, climate, energy production, etc. Herbaceous biomass can be measured through destructive or...

[READ MORE](#)

A landscape photograph showing rolling green hills under a clear sky. In the foreground, a calm lake reflects the sky and the surrounding greenery. The sun is visible on the right side of the image, creating a bright reflection on the water.

The descriptors considered by Living Wales encompass all land, freshwater and marine environments.

We can use layers generated in other studies within Living Wales, with examples being the Copernicus high resolution, ESA Climate Change Initiative (CCI) or Plymouth Marine Laboratory data.

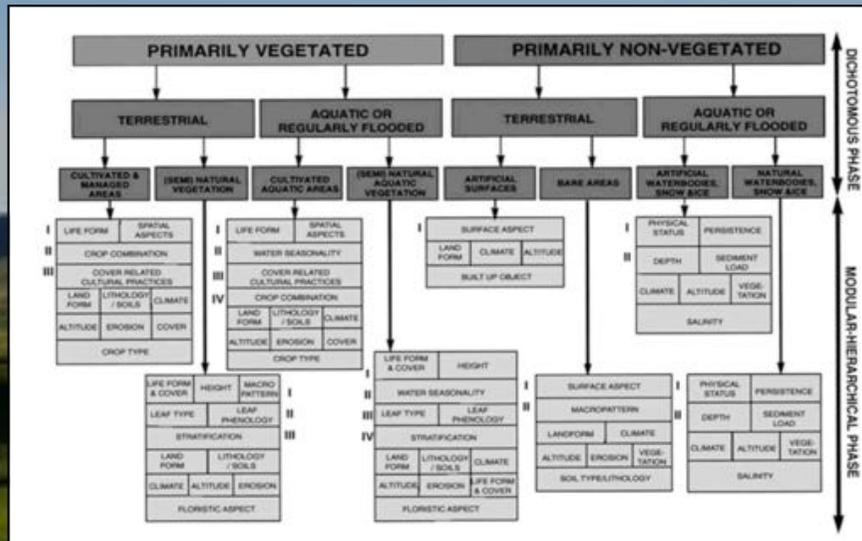
If these are not suitable, then we need to work with others to generate the relevant layers or to do this by ourselves.

Which ever layer or route we chose, the Living Wales approach allows the land cover and change maps constructed from these to be updated as and when appropriate. New layers can be introduced or layers can be replaced

# *Living Wales*



*Land cover classifications*



We focus first on finding five main categories in the landscape; vegetation, water, agricultural (cultivated) land, artificial surfaces and man-made waterbodies such as reservoirs.

We then take their opposites

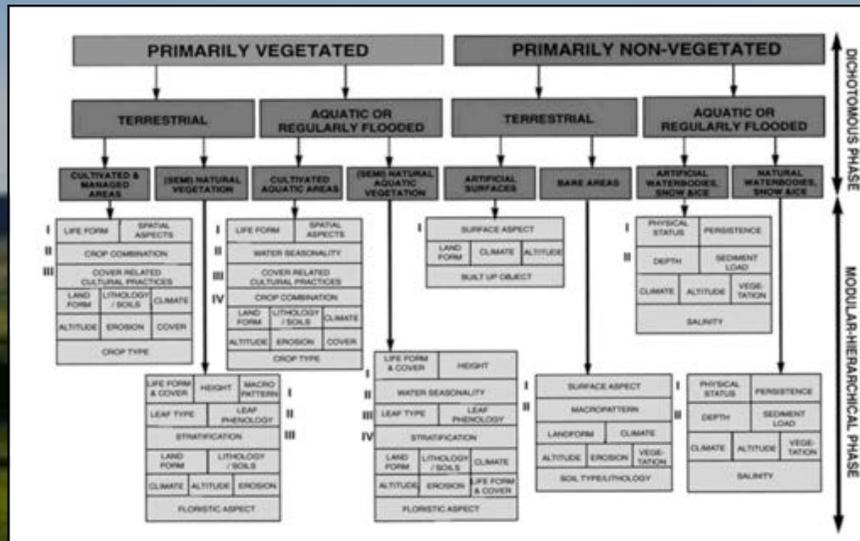
These are non-vegetated, terrestrial, semi-natural/natural vegetation and naturally bare surfaces and natural water

Through this approach, we classify the landscape according to the dichotomous phase (often referred to as Level 3)

The land cover classification for Wales is based on the globally applicable Food and Agriculture Organisation's (FAO) Land Cover Classification System (LCCS).

The classification consists of a dichotomous phase, which considers eight main categories

- Cultivated and managed land
- Natural and semi natural terrestrial vegetation
- Natural and semi natural aquatic vegetation
- Cultivated aquatic areas
- Artificial surfaces and ass. areas
- Bare areas
- Artificial waterbodies
- Inland waterbodies snow and ice
- Non classified



The modular hierarchical phase provides more detail on each of the eight land cover categories

For these, we reference environmental descriptors retrieved primarily from EO data and considered **essential** to the LCCS, with these allowing classification of semi-natural and natural vegetation, agricultural areas, artificial and bare surfaces and water.

We can then further describe each land cover class by referencing **additional** descriptors external to the FAO LCCS. Examples are land surface temperature ( $^{\circ}\text{C}$ ) and above ground biomass ( $\text{Mg ha}^{-1}$ )

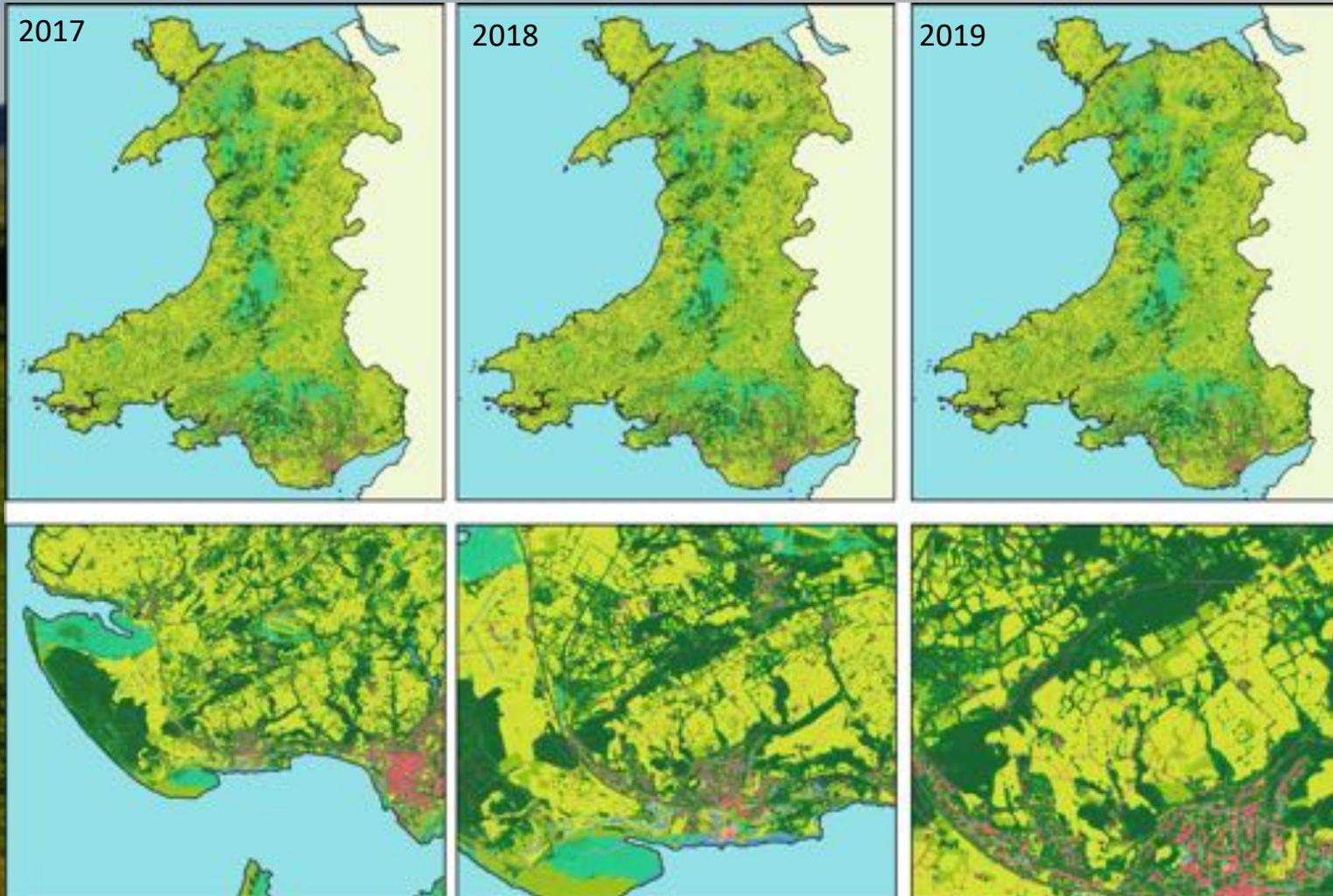
### Essential Environmental Descriptors

- Canopy cover (%)
- Lifeform
- Leaf type
- Phenology
- Water hydroperiod (time)
- Canopy height (m)

### Additional Environmental Descriptors

- Above ground biomass ( $\text{Mg ha}^{-1}$ )
- Plymouth Marine Laboratory Marine layers

# Land cover classifications for Wales



The land cover classifications for Wales using this approach are for 2017, 2018 and 2019 and are at 10 m spatial resolution.

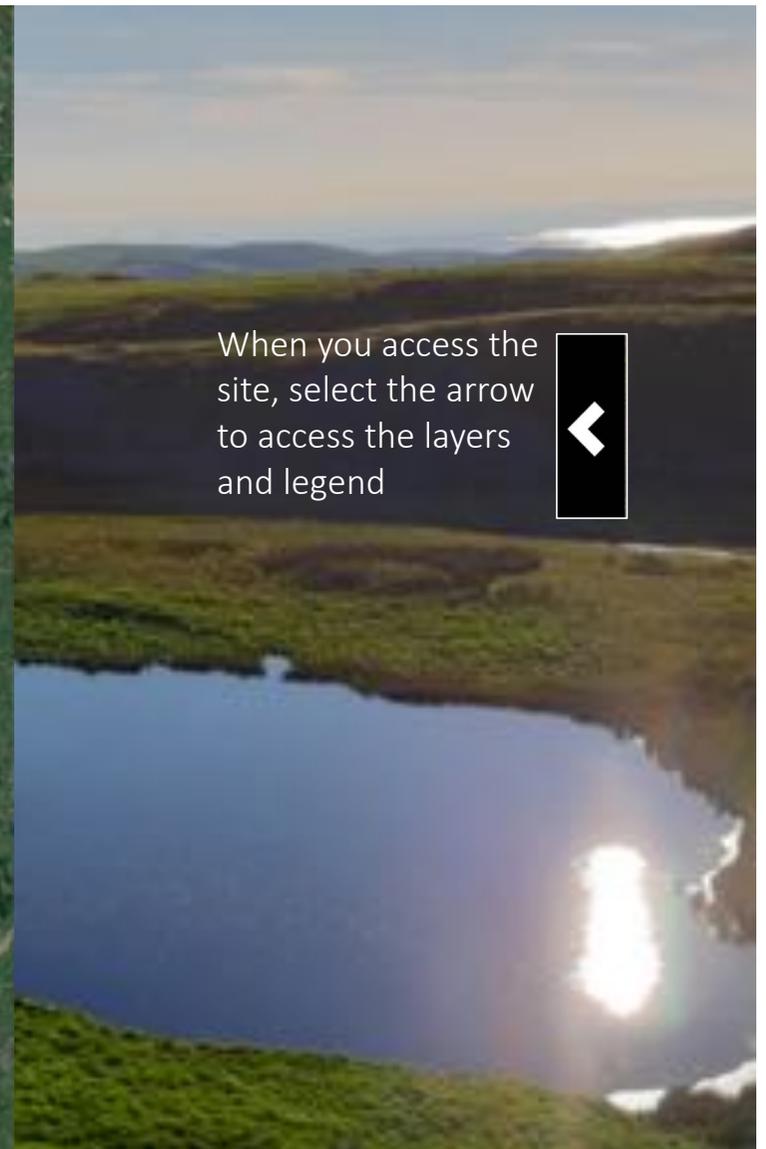
Each pixel contains information on the FAO LCCS land cover classes but also the categorical and continuous layers used for their construction and further description.



The land cover maps for Wales can be accessed through the Living Wales geo-portal

(wales.livingearth.online)

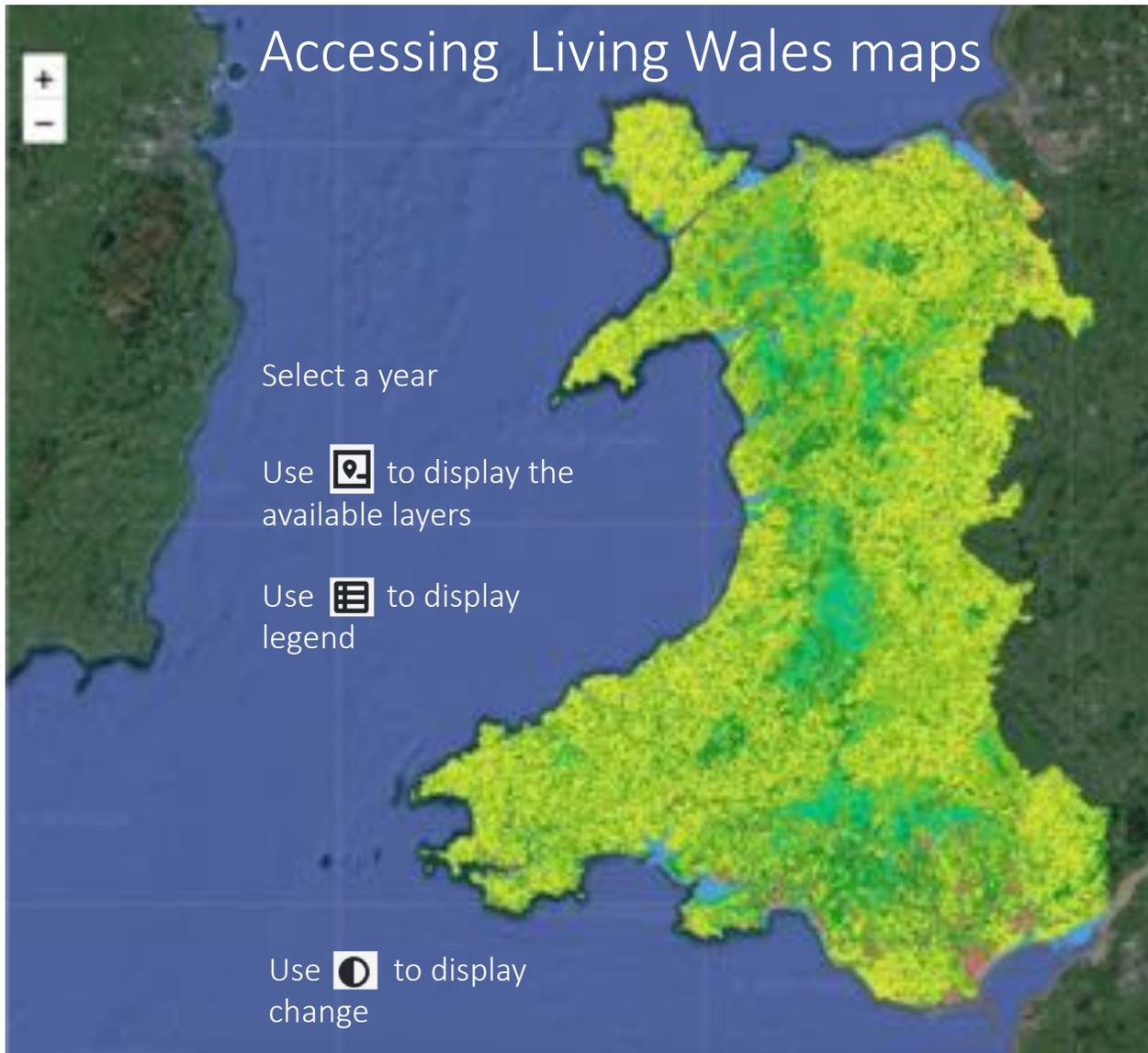
You can load onto your mobile phone if you are in wifi access.



When you access the site, select the arrow to access the layers and legend



# Accessing Living Wales maps



Select a year

Use  to display the available layers

Use  to display legend

Use  to display change

 Land Cover

 Change

 Legend

Select a year

2017

Select a basemap

- L3 land cover 2017
- L3 plus land cover 2017
- No basemap

Select an additional layer

- Canopy cover 2017   
- Canopy cover (continuous) 2017   
- Lifeform 2017   
- Leaf type / phenology 2017   
- Non-trees semi-natural communities 2017   
- Water persistence (semi-natural) 2017   
- Water persistence (continuous - all vegetation types) 2017   
- Water persistence >3 months (continuous - all vegetation types) 2017   
- Above ground biomass 2017 

# Accessing Living Wales maps

Select a year

Use  to display the available layers

Use  to display legend

Use  to display each legend

For further information, select 

 Land Cover

 Change

 Legend

Select a year

Select a basemap

- L3 land cover 2017
- L3 plus land cover 2017
- No basemap

Select an additional layer

- Canopy cover 2017 
- Canopy cover (continuous) 2017 
- Lifeform 2017 
- Leaf type / phenology 2017 
- Non-trees semi-natural communities 2017 
- Water persistence (semi-natural) 2017 
- Water persistence (continuous - all vegetation types) 2017 
- Water persistence >3 months (continuous - all vegetation types) 2017 
- Above ground biomass 2017 

Further information on each layer is available.

Link to the Living Wales website for layer information

### Leaftype / phenology 2017

**The map** Merge of the leaftype and phenology map produced by the Living Wales project.

**The product** There are many types of leaves. Leaf type is defined as the type of leaf morphology. It is mainly linked to the botanical group of plants (Angiosperm and Gymnosperm). Phenology is the study of the timing of vegetation life-cycle events, such as budburst, flowering, leaf colouring, leaf fall, ect.

- The classes**
- Broadleaf Deciduous
  - Broadleaf Evergreen
  - Needle-leaved Deciduous
  - Needle-leaved Evergreen

**More info** More information on our website: [here](#)

Land Cover

Change

Legend

Select a year

2017

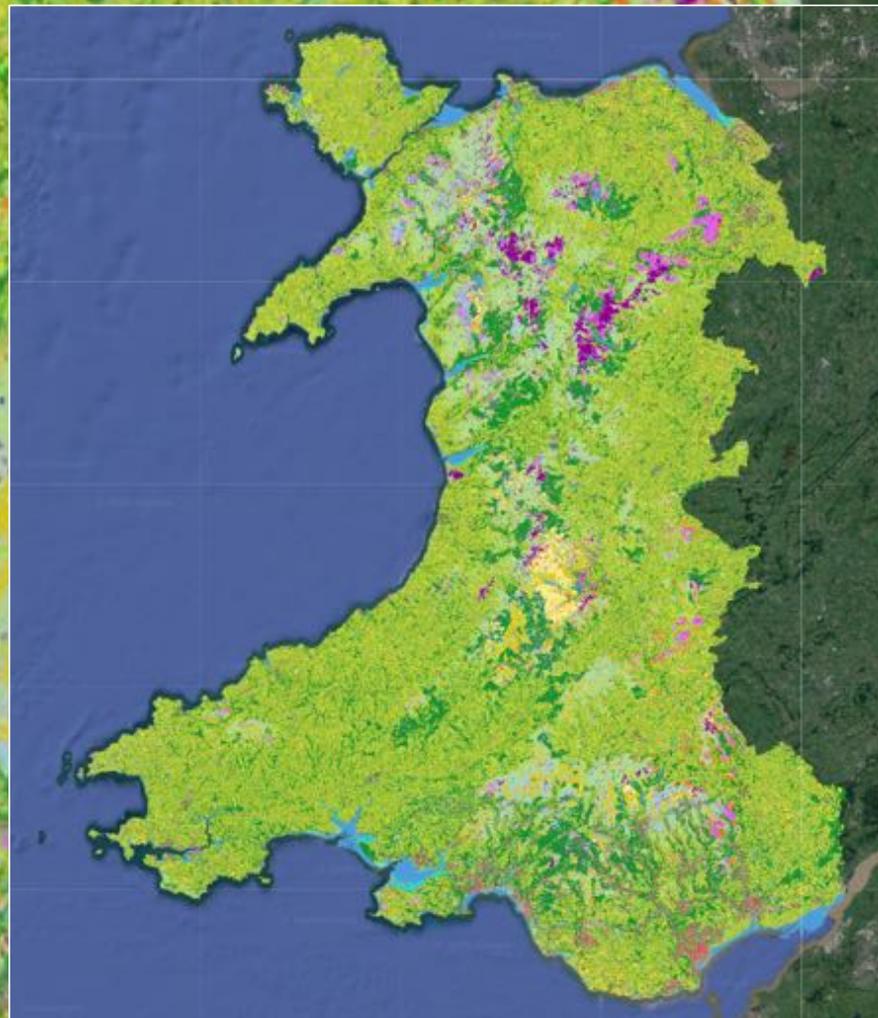
Select a basemap

- L3 land cover 2017
- L3 plus land cover 2017
- No basemap

Select an additional layer

- Canopy cover 2017
- Canopy cover (continuous) 2017
- Lifeform 2017
- Leaftype / phenology 2017
- Non-trees semi-natural communities 2017
- Water persitence (semi-natural) 2017
- Water persitence (continuous - all vegetation types) 2017
- Water persitence >3 months (continuous - all vegetation types) 2017
- Above ground biomass 2017

*Dominant  
species, genera  
or communities*



Living Wales

Land Cover

Change

Legend

#### Basemap

- Cultivated Terrestrial Vegetation
- Semi-natural Terrestrial woody vegetation
- Semi-natural Terrestrial herbaceous vegetation
- Cultivated Aquatic Vegetation
- Natural Aquatic Vegetation
- Artificial Surface
- Bare Surface
- Water

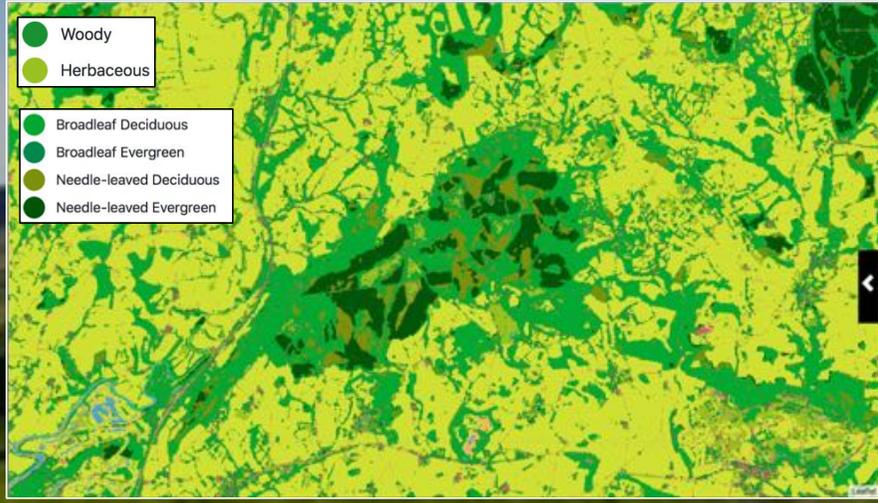
#### Crop 2018

- Winter barley
- Oilseed rape/rapeseed
- Winter wheat
- Maize
- Potatoes
- Beetroot
- Spring barley
- Spring wheat
- Other vegetables
- Spring crops
- Grass

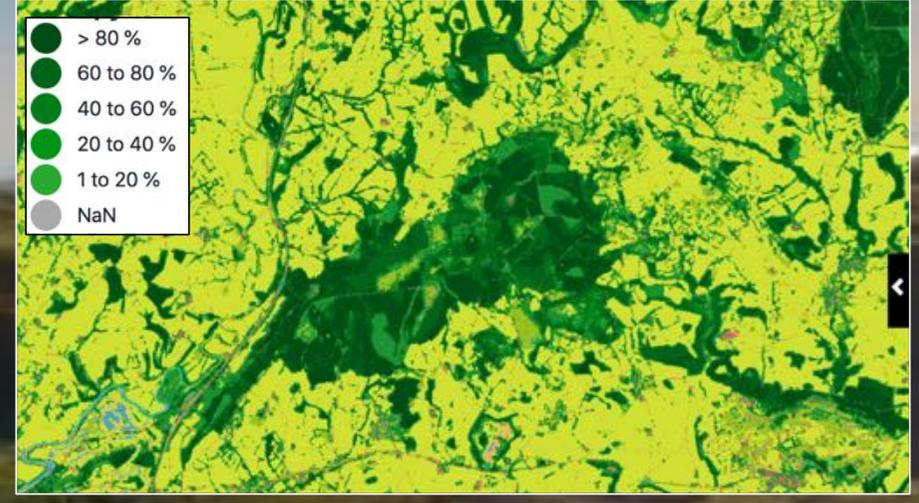
#### Non-trees semi-natural communities 2018

- Bracken
- Wet modified bog dominated by Molinia
- Marshy grassland dominated by Molinia
- Raised or sphagnum bog
- Other wet communities (similar to bog but not on the peat layer)
- Heathland (Ericoides dominated)
- Grassland
- Saltmarshes

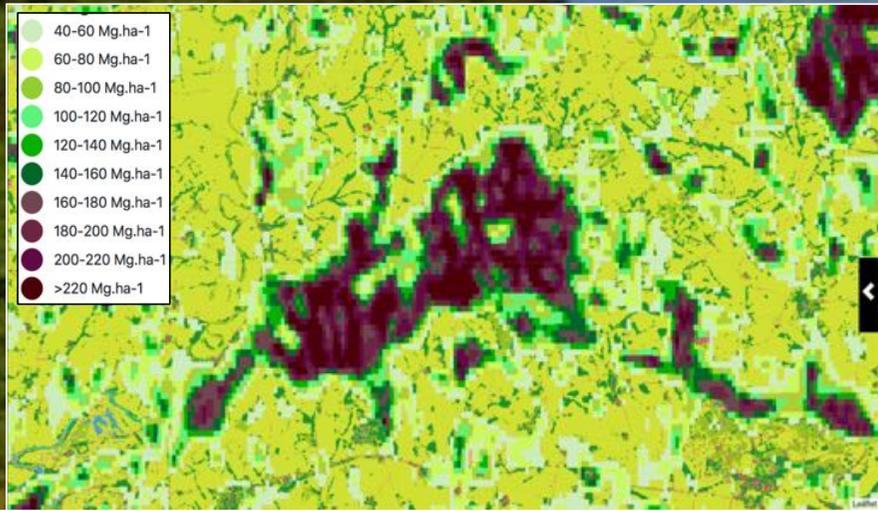
Lifeform, leaf type and phenology



Canopy cover (categorical; %)

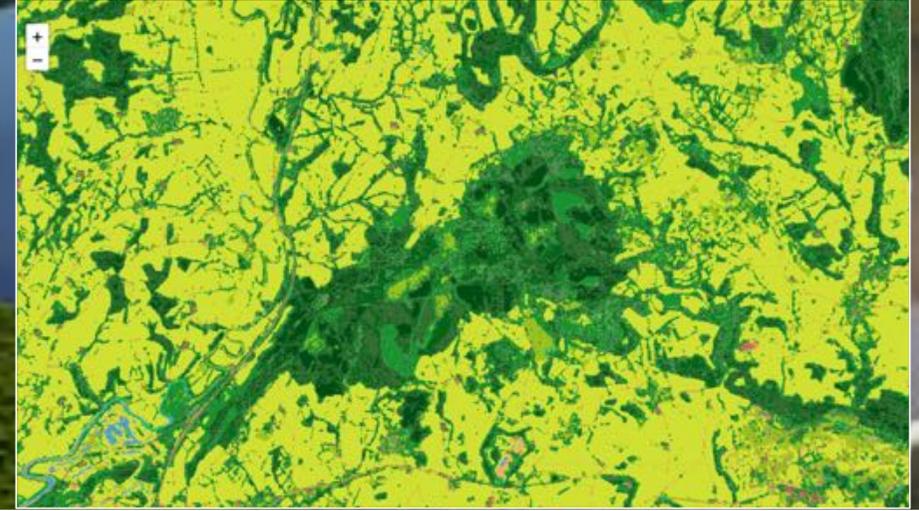


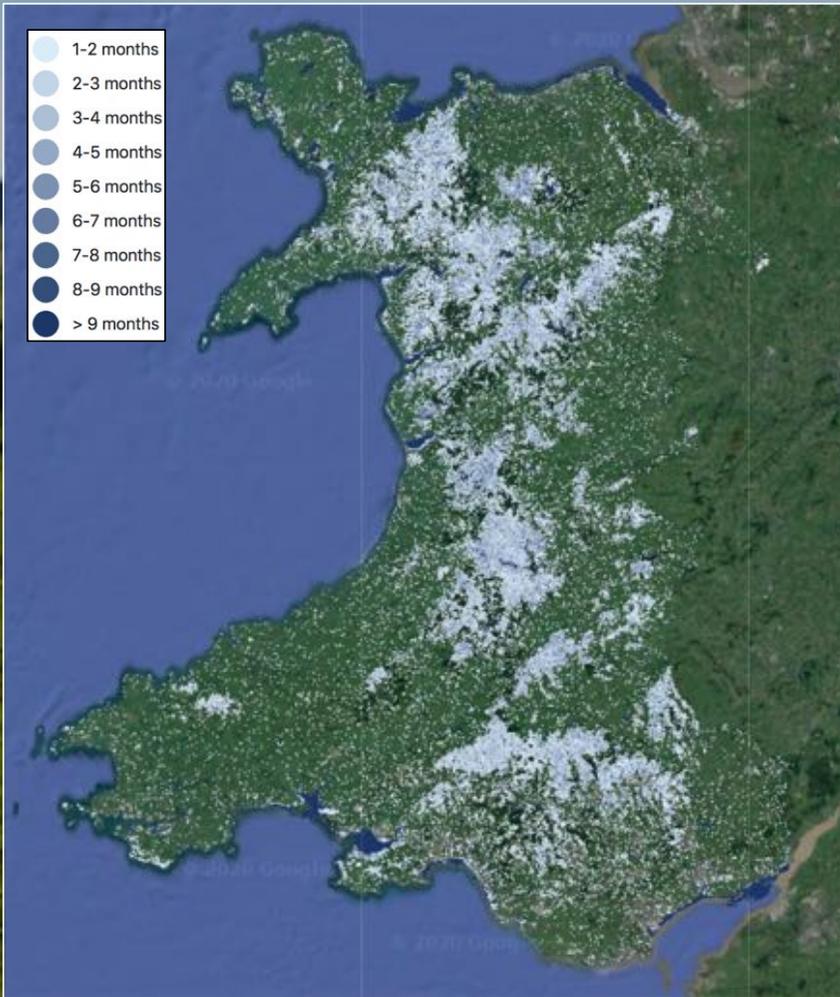
Above ground biomass



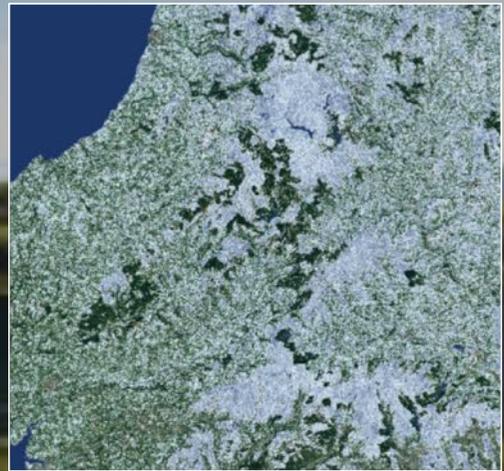
*Forests*

Canopy cover (continuous; %)





> 1 month (semi-natural vegetation)



> 1 month (all vegetation)



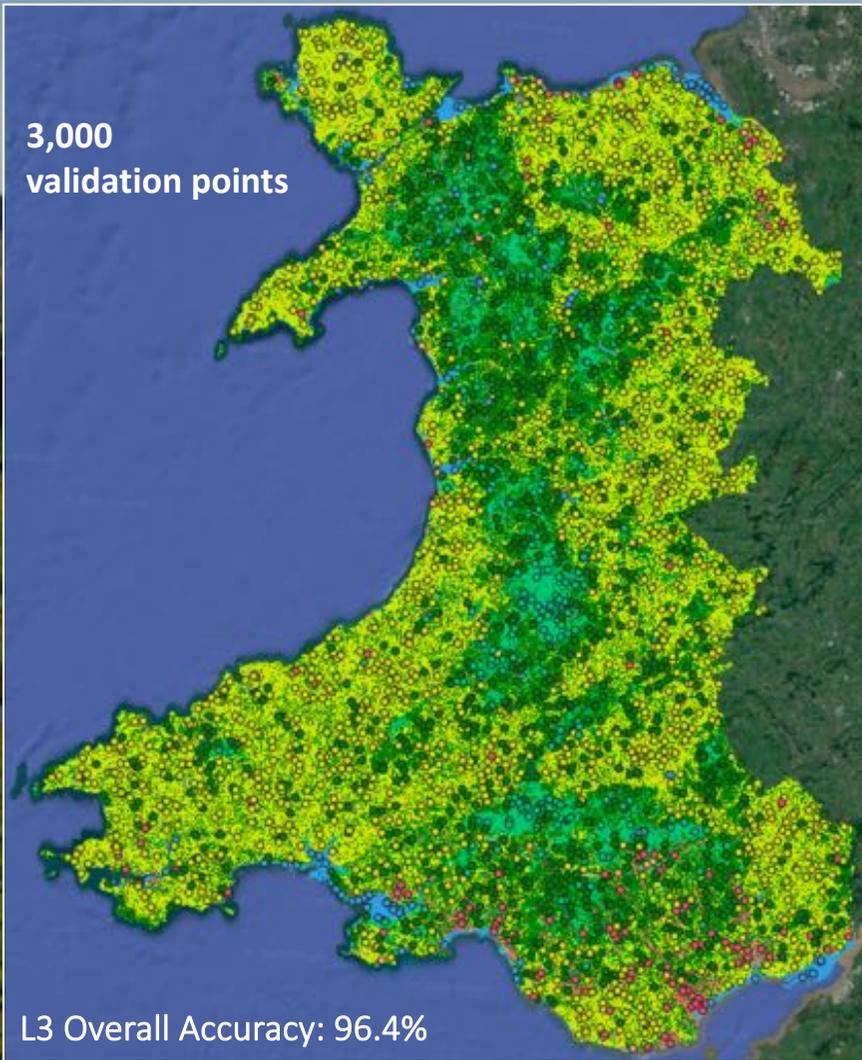
> 3 months (all vegetation)



> 2 months (all vegetation)

*Water/vegetation  
Moisture  
persistence*

3,000  
validation points



L3 Overall Accuracy: 96.4%

The accuracy of the Living Wales maps has been determined for the baseline FAO LCCS classification has been obtained by referencing aerial photography, Google Earth Imagery (time-series) and Planetscope data.

*Class*

The accuracy of each environmental descriptor is assessed separately (e.g., through use of mobile applications or ground data; e.g. ESA CCI Biomass).

The Earthtrack mobile data on land cover and change provides validation historically and in near real time

*Class*

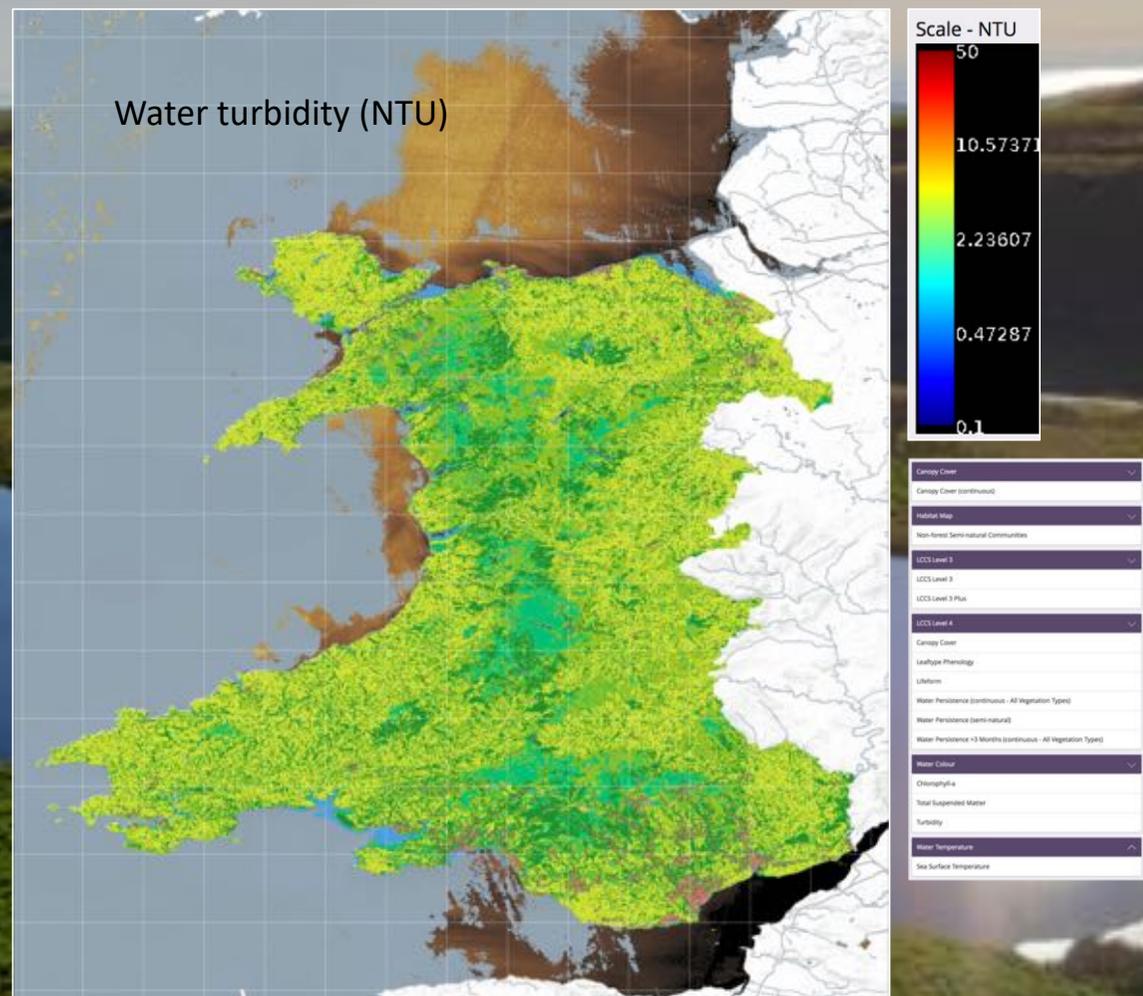
# Living Wales on the NEODAAS

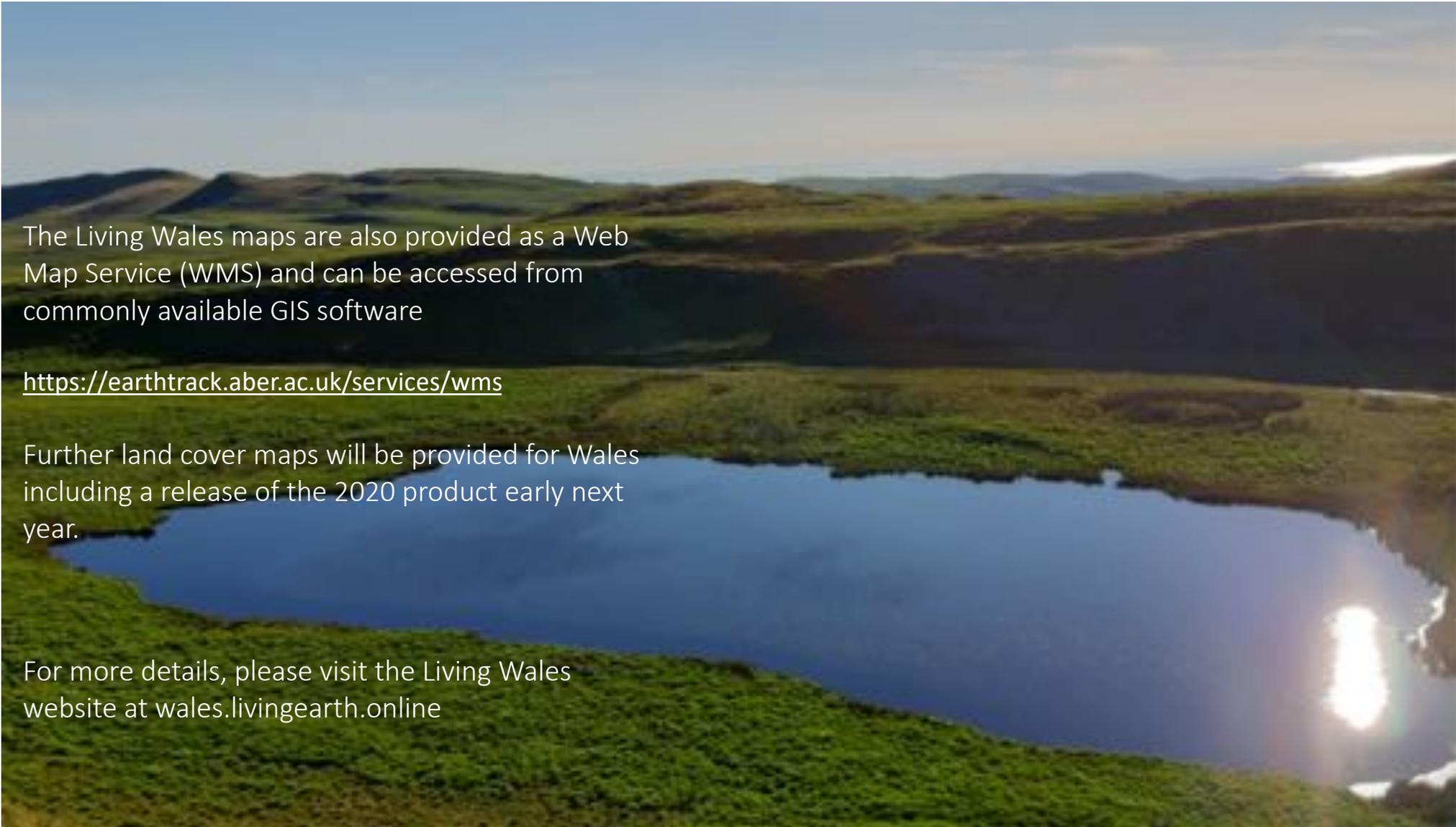
The PML developed portal now allows layers being developed as part of Living Wales to be shown alongside other environmental layers, such as marine layers being produced as part of the NEODAAS and EOMORES projects at PML as well as those produced through Copernicus services.

It provides a mechanism for browsing dense time series and performing simple analysis such as plotting and allows users to easily add new web services

To access the portal, go to:  
<https://visual.pml.ac.uk/livingwales/>

Many thanks to Dan Clewley and the crew at PML





The Living Wales maps are also provided as a Web Map Service (WMS) and can be accessed from commonly available GIS software

<https://earthtrack.aber.ac.uk/services/wms>

Further land cover maps will be provided for Wales including a release of the 2020 product early next year.

For more details, please visit the Living Wales website at [wales.livingearth.online](http://wales.livingearth.online)

# *Living Wales*



*Translation to habitats*

# *Living Wales*



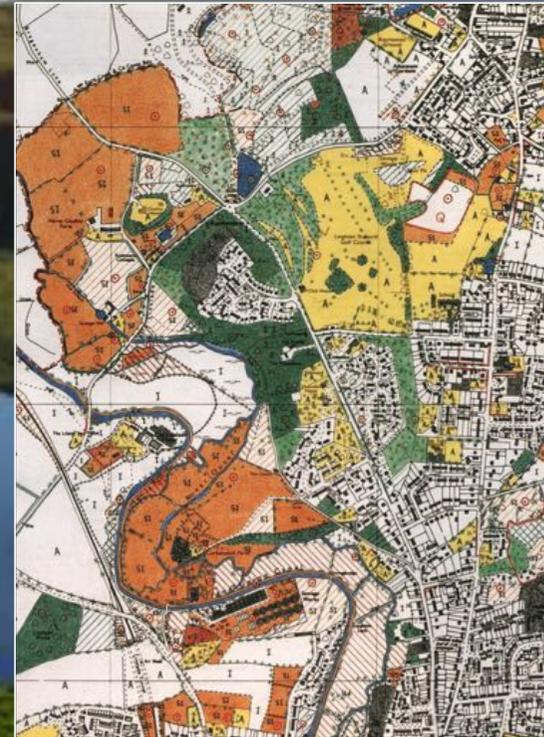
As the land cover maps are constructed from environmental descriptors, these can be more easily translated to other land cover but also habitat taxonomies

This includes the Phase I Habitat Classification for Wales.

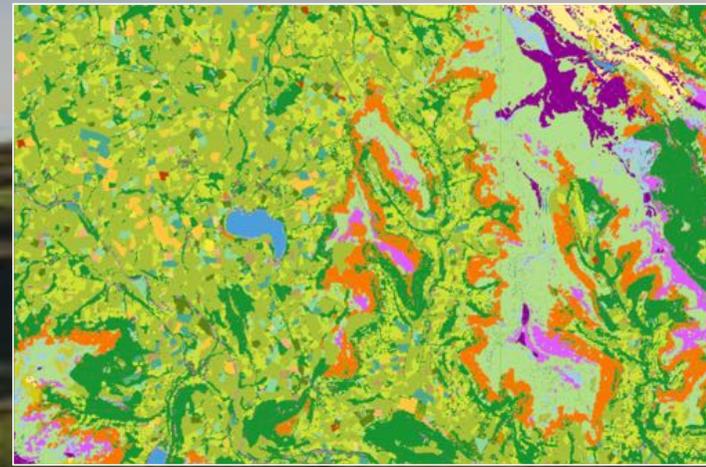
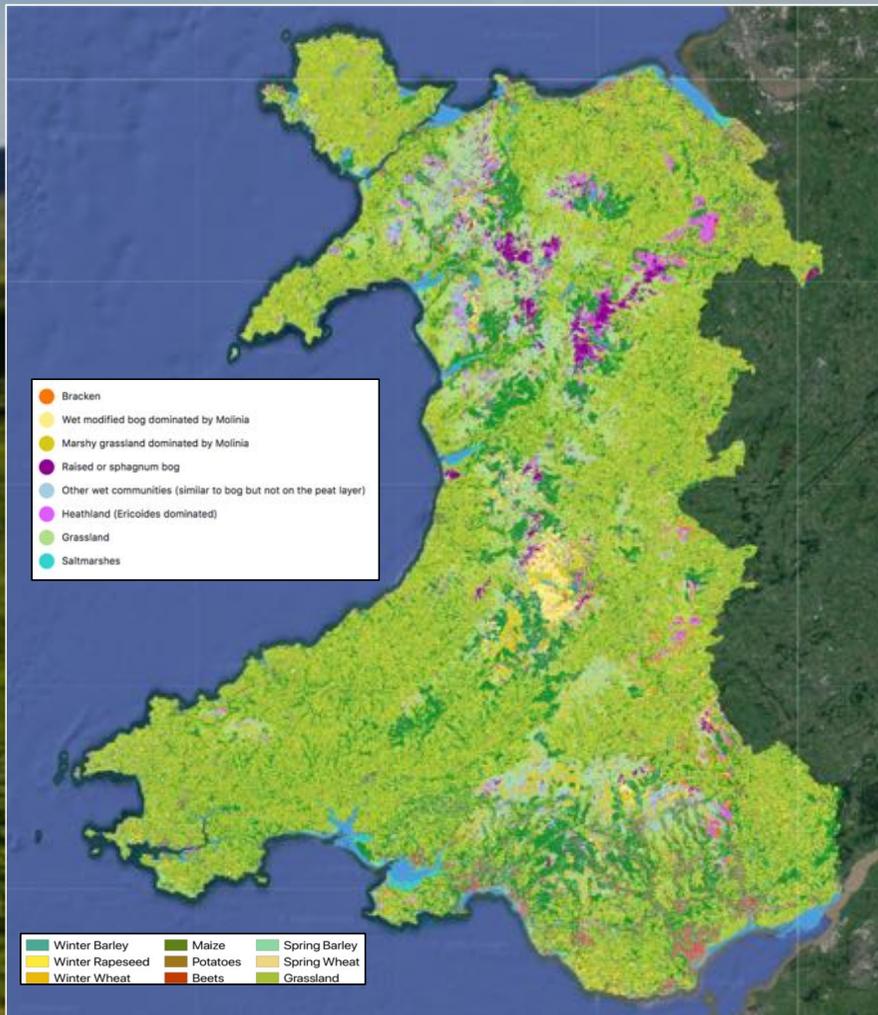
As well as facilitating the mapping of habitat extent, additional information on condition and also be obtained.

Habitat classes such as fens and mires can also be described using environmental descriptors.

Dynamic habitat maps can also be generated.



# Dominant genus/species



Living Wales is aiming to generate an annual map of dominant and, where feasible, co-dominant species, genera or communities for Wales to facilitate monitoring of biodiversity and restoration.

For forest and non-forest semi-natural habitats, machine learning algorithms informed by time-series of spectral reflectance data and derived indices are being used to differentiate non-forest semi-natural habitats (e.g., bracken, heather)

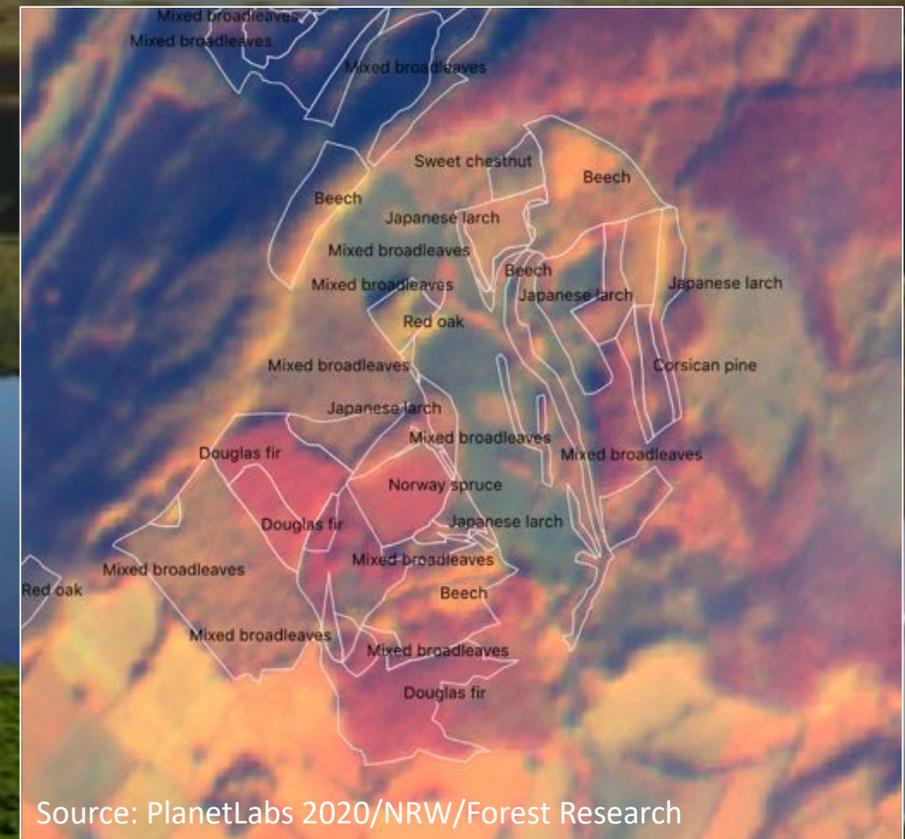
Algorithms for discriminating and mapping different crop types have also been generated from time-series of Sentinel-1 radar imagery.

## Other dominant genera > Translation to habitat taxonomies

Living Wales is working with forest organizations in Wales and the wider UK to advance the discrimination and mapping of dominant tree species.

For this, we have been using the spectral information obtained from time-series of 3 m Planetscope data , which give daily observations (climate permitting) at 3 m spatial resolution and provide information on changes in forest spectral reflectance and other biophysical properties throughout the year.

Recently, additional observations in the red-edge reflectance region have been provided with the new Planetscope superdove imagery, with this being mid way between the red and near infrared wavelength regions and of major benefit for tree species discrimination.



# *Living Wales*



*Evidence-based land cover change*



UNDEB EMBROPEAIDD  
EUROPEAN UNION



Llywodraeth Cymru  
Welsh Government

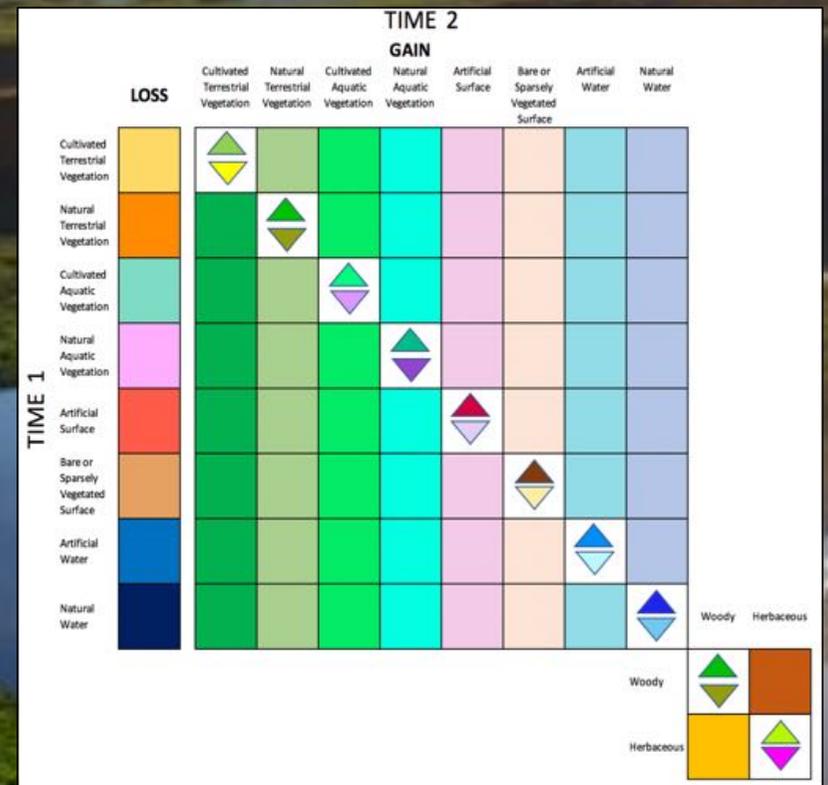
**Cronfa Datblygu  
Rhanbarthol Ewrop  
European Regional  
Development Fund**

Living Wales has developed a new approach to the detection of change in conjunction with our Australian and European collaborators

First, we consider changes in the eight land cover classes generated in the first phase of the FAO LCCS as well as the herbaceous and woody lifeform categories.

Where the land cover class differs, this indicates a change in extent.

Where the land cover class remains the same, only changes in amount, condition or type (e.g., of vegetation or water) can be quantified



Where we compare the LCCS maps between any two time-separated periods, over 70 change classes are automatically mapped

Several changes are unlikely over short time periods (e.g., urban to forest).

In Living Wales, we break the classes down to differentiate 26 **OBSERVED CHANGE** classes representing changes in extent as well as amount/condition or type which can be further described and differentiated based on evidence.

Change layers are being progressively added following validation



Land Cover Change Legend

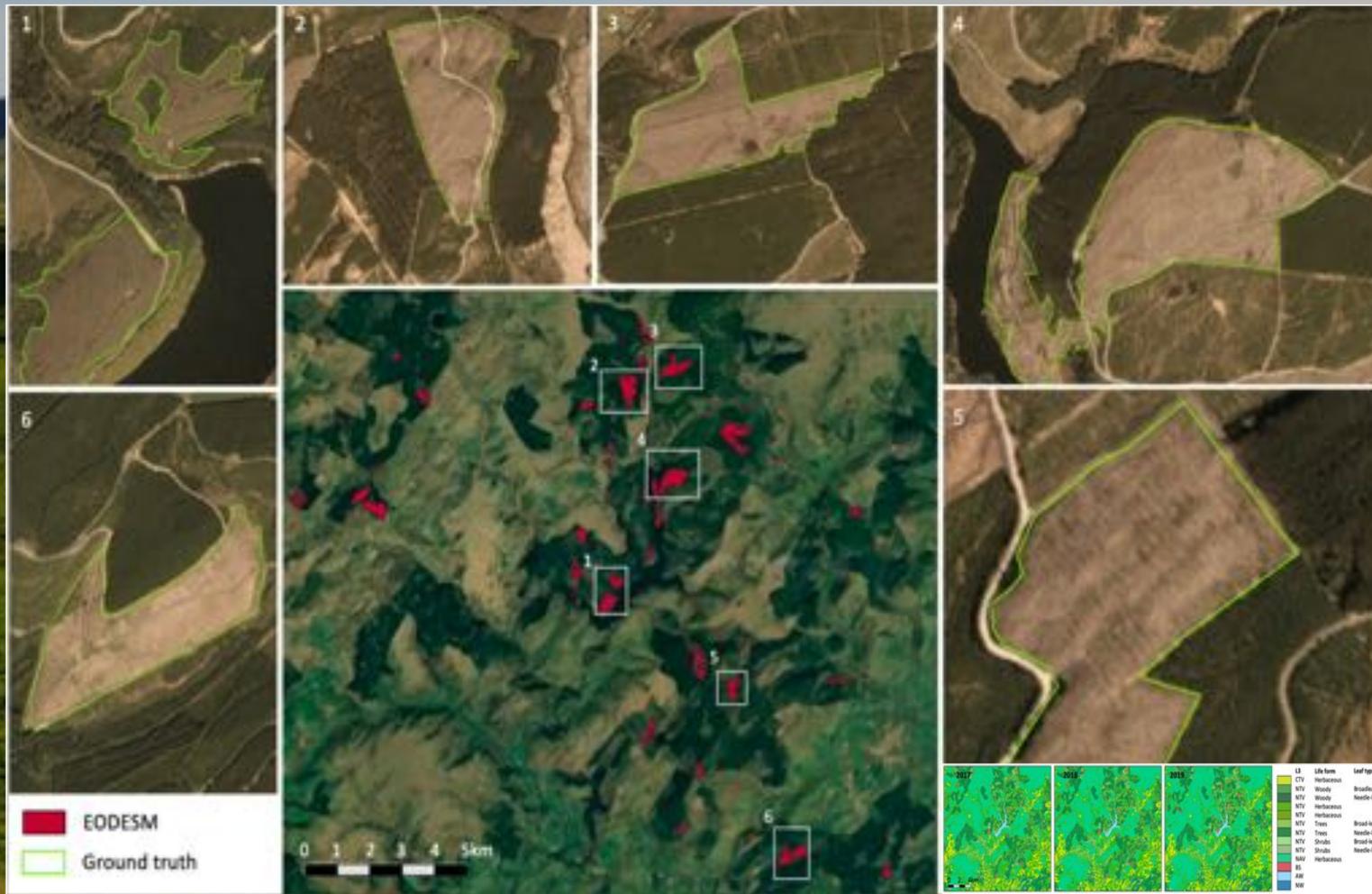
Select a year 1 2017

Select a year 2 2019

Select a change layer

Woody loss 2017/2019

# Evidence-based change: Annual (e.g., forestry)



Clear cuts, for example, are identified as a change from natural terrestrial vegetation to a bare surface, which is an extent change.

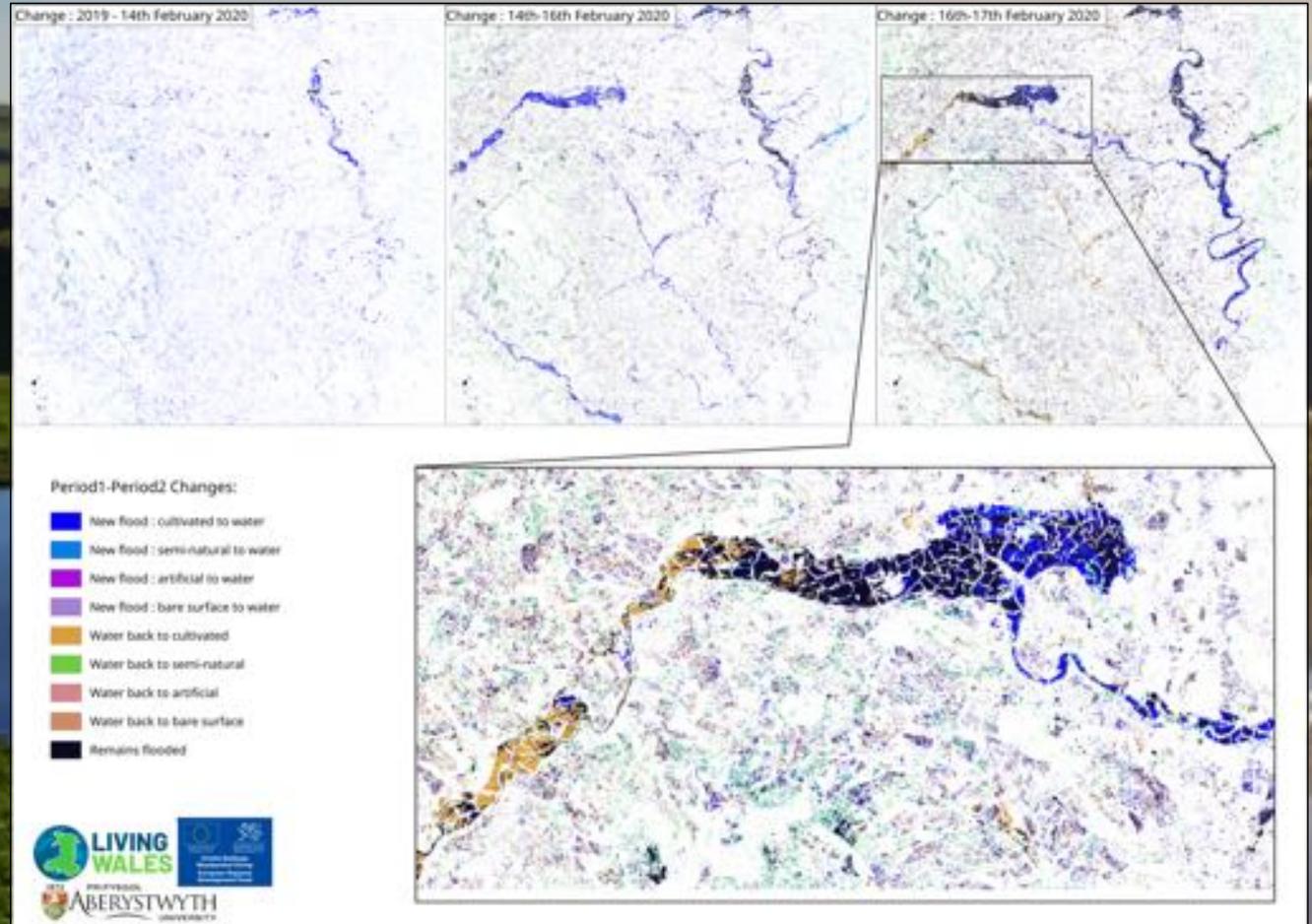
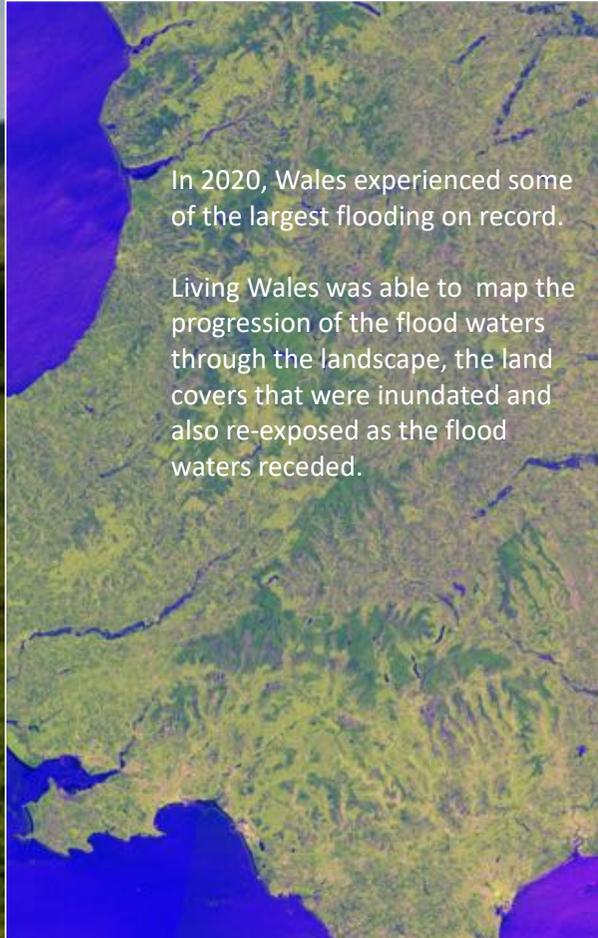
However, the area may remain as vegetation but the woody trees are replaced by herbaceous grasslands, which is a change in type (i.e., lifeform)

These two extent and type changes are combined to allow initial detection and mapping of clear cut areas.

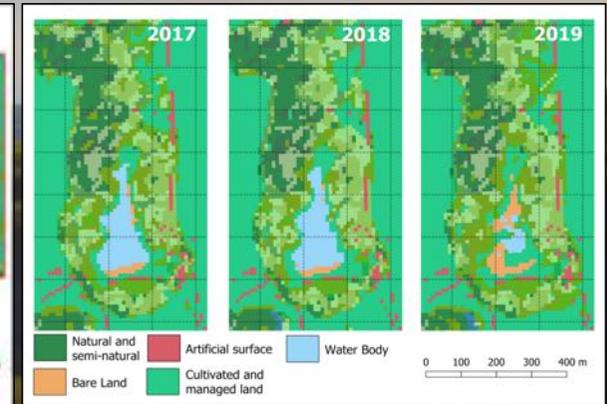
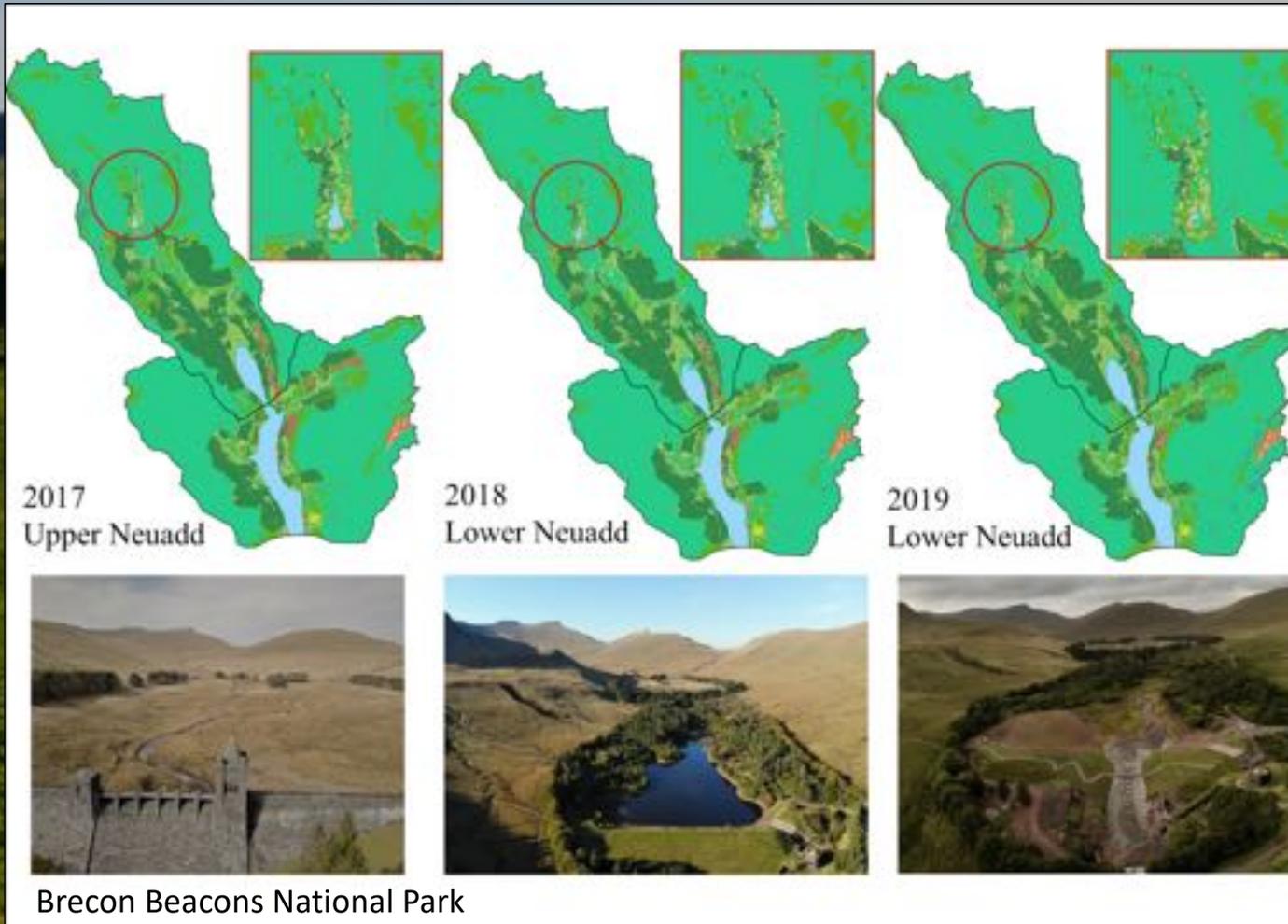
# Evidence-based change - sub-annual (extreme flooding)

In 2020, Wales experienced some of the largest flooding on record.

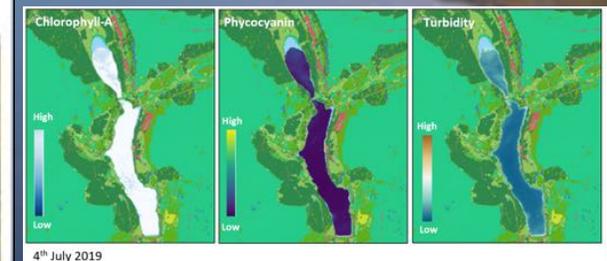
Living Wales was able to map the progression of the flood waters through the landscape, the land covers that were inundated and also re-exposed as the flood waters receded.



# Evidence-based change: dam removal and water quality



In the Brecon Beacons National Park, the Living Wales maps detected the multiple changes in land cover extent associated with removal of a dam



Within the reservoir, more frequent changes in water quality indicators can be quantified (Sentinel-1/PlanetScope)

# Evidence-based change: Impacts and pressures



From the **OBSERVED CHANGES**, Living Wales is able to differentiate a wider range of change categories based on evidence accumulated from satellite and airborne data as well as other sources.

For this, we have developed a new global change taxonomy that considers the **DRIVERS** of change and resulting **PRESSURES**, how these lead to changes in **STATES** (in other words, environmental descriptors) and result in **IMPACTS**. **RESPONSES** are also considered in future planning.

Our change taxonomy is scalable and is based on the combination of **IMPACTS** and **PRESSURES**, each of which have been defined in an online glossary to be released following publication in late 2020.

We can see how this works by simply observing change on the ground.

DIEBACK (PATHOGENS)  
Bosherston



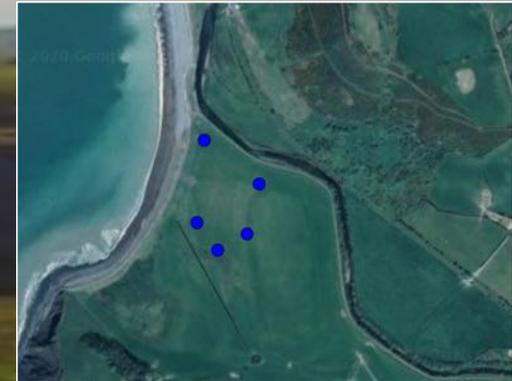
25<sup>TH</sup> MAY 2019

VEGETATION DAMAGE  
(WINDTHROW)  
Trawscoed



2<sup>ND</sup> DEC 2019

FLOODING  
(PRECIPITATION)  
Aberystwyth



16<sup>TH</sup> FEB 2020

New maps using the change taxonomy and supportive information will be available from 2021

# *Living Wales*



*Checks with reality: Ground and near-ground observations*

# The need for ground data

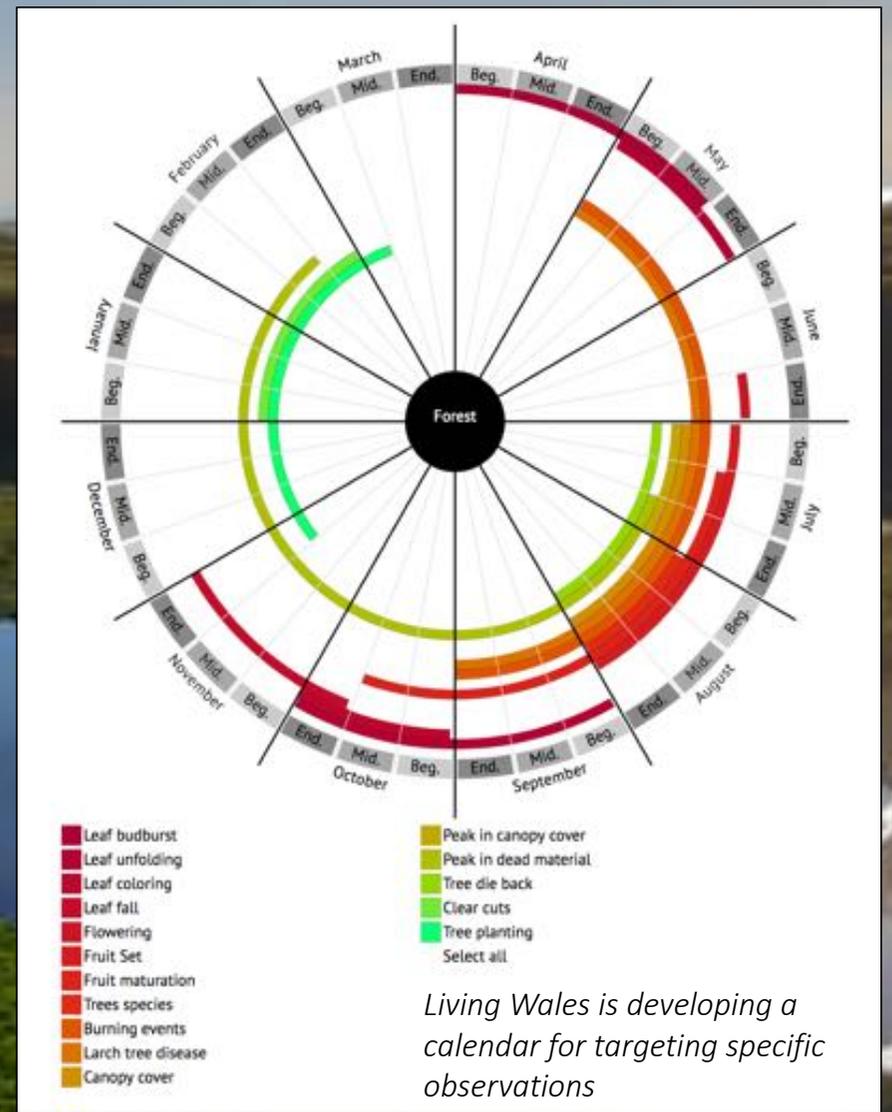
Ground data are essential to support the characterization, mapping, monitoring and future planning of Wales' landscape

A key criteria is that the ground measurements are at the same location and ideally collected near to or at the same time as the image acquisition, particularly where change is concerned.

Data collected on the ground also need to be appropriate, relevant, consistent and robust. Standardization across Wales and ideally other countries or regions is highly desirable if not essential but agreement on methods and effective coordination and collaboration is needed.

Standardisation over time is also essential

The main areas where ground observations are needed are first, to allow development and validation of algorithms for retrieving or classifying environmental descriptors; second, to validate maps of land cover and also evidence-based change generated through Living Wales; and third to support collection of information relevant to applications (e.g., biodiversity assessment)



# EARTHTRACK

The EarthTrack mobile application ([earthtrack.aber.ac.uk](http://earthtrack.aber.ac.uk)) allows the recording of land cover classifications according to the FAO LCCS taxonomy and the new change taxonomy, with this mirroring the approach used to generate the same classes from Earth observation data.

Earthtrack also provides the option to record select woody and herbaceous plant species, with focus on those that are dominant within the landscape and likely to be detected from Earth observation data.

Land cover change categories are also indicated and these are being updated with those that describe both impacts and pressures (e.g., dieback because of pathogens)

Additional (including tailored) modules are also available, with these including biodiversity, plot-based measurements (e.g., of trees) and ash dieback.

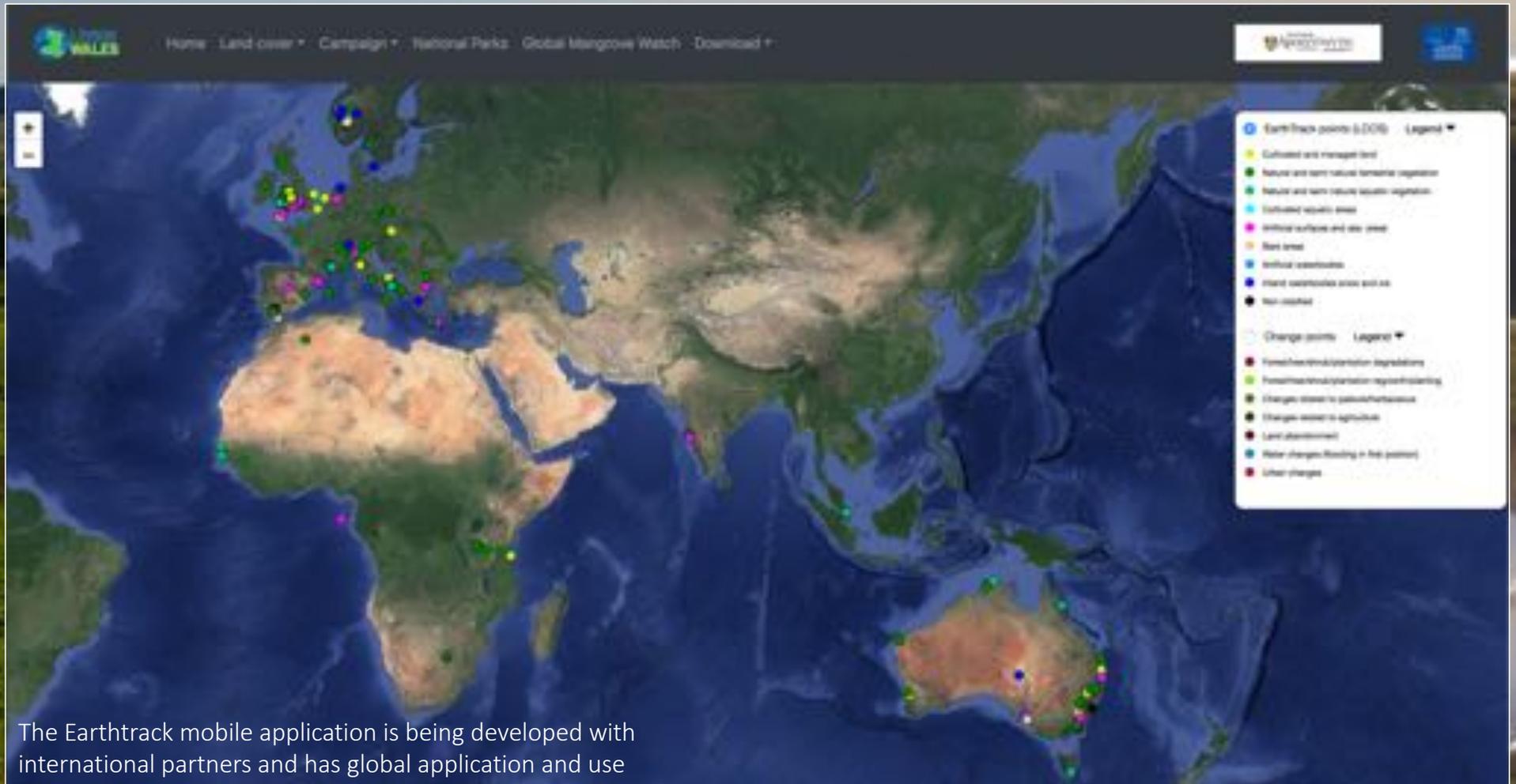
All data (including historical) are freely and openly available all the time and as and when submitted

**LIVING WALES** Home Land cover Campaign National Parks Global Mangrove Watch Download

- Cultivated and managed land
- Natural and semi natural terrestrial vegetation
- Natural and semi natural aquatic vegetation
- Cultivated aquatic areas
- Artificial surfaces and ass. areas
- Bare areas
- Artificial waterbodies
- Inland waterbodies snow and ice
- Non clasified
- Forest/tree/shrub/plantation degradations
- Forest/tree/shrub/plantation regrowth/planting
- Changes related to pasture/herbaceous
- Changes related to agriculture
- Land abandonment
- Water changes (flooding in first position)
- Urban changes

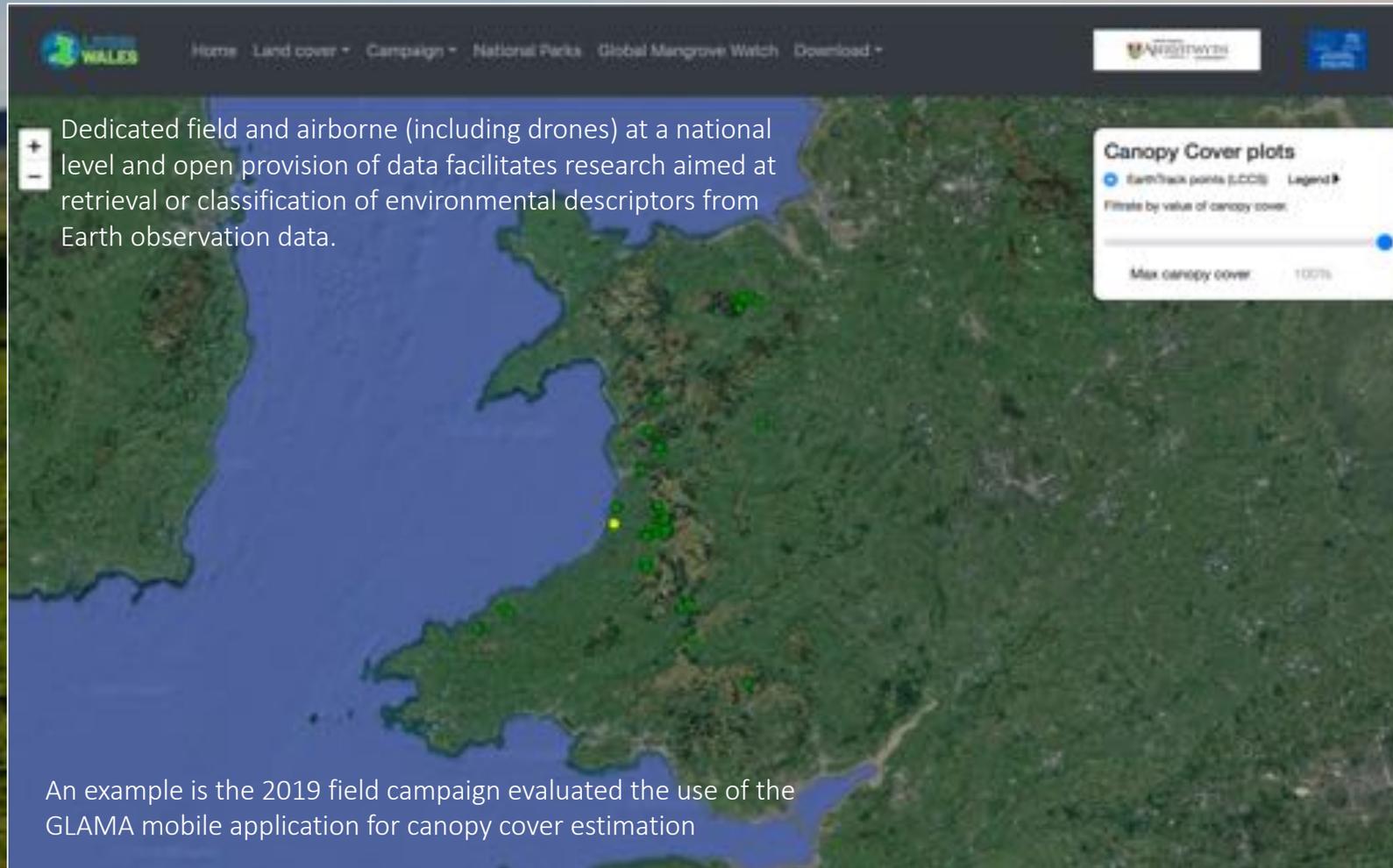
Shapefile format (.shp) CSV format (.csv) KML format (.kml)

# EARTHTRACK – A GLOBAL APPLICATION



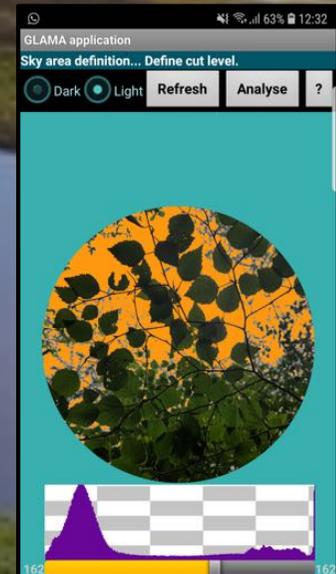
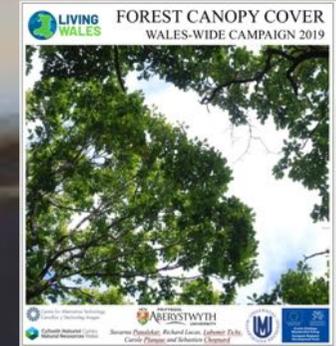
The Earthtrack mobile application is being developed with international partners and has global application and use

# CANOPY COVER CAMPAIGN 2019



Dedicated field and airborne (including drones) at a national level and open provision of data facilitates research aimed at retrieval or classification of environmental descriptors from Earth observation data.

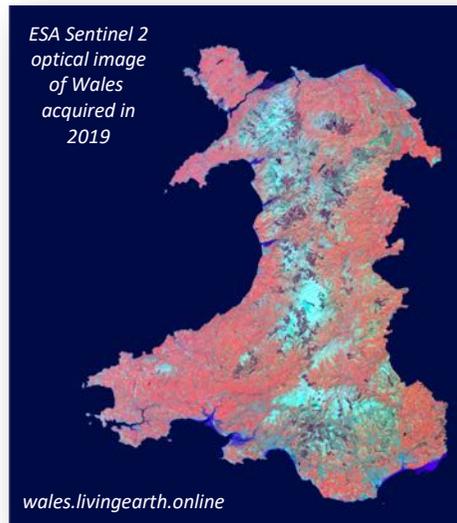
An example is the 2019 field campaign evaluated the use of the GLAMA mobile application for canopy cover estimation



# WHY A FOREST CANOPY COVER CAMPAIGN?

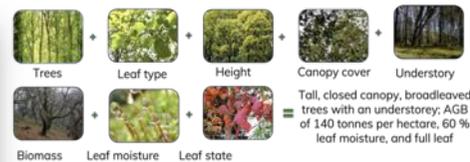
## Satellite Observations

Satellites observing at < 30 m spatial resolution have been continuously passing over Wales since 1985. The Landsat is the best known of these. These archival data acquired provide a unique opportunity to describe the changing state of the Welsh landscape over the past 35 years. The continuation of observations through programs such as the European Space Agency's (ESA) Sentinel-1 and 2 allows monitoring into the future.



## Living Wales

*Living Wales* is a European and Welsh Government-funded research project under the Sêr Cymru programme that is generating detailed maps of land cover for Wales on at least an annual basis. These maps are obtained by simply combining a range of environmental variables retrieved from satellite data, whether archival or recently acquired.



A forest can be described by combining information on lifeform (trees, shrubs), canopy cover and height, leaf type, phenology, number of layers, dominant species, biomass and so on and each of these variables can be retrieved from satellite data.

All map products generated by *Living Wales* are being made available to encourage use across a range of domains and the project is encouraging engagement with people throughout Wales.

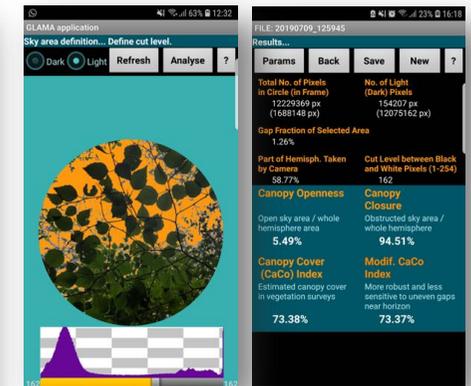
## Earth Track

The *EarthTrack* mobile app has been developed to support near real time collection and provision of field-based measurements of variables to support evaluation of existing products or development of new satellite-based retrieval algorithms and validation of the derived land cover and change maps. The data are available for download and the resource is continually built as and when new data are added.



## Canopy cover

*Canopy cover* (%) is just one of the environmental variables that *Living Wales* is targeting. The ambition is to obtain > 1000 field measurements across the Wales from mid-August to mid-September. To achieve this, *Living Wales* has established that the GLAMA mobile app is optimal for quantifying canopy cover and that only nine vertically orientated photographs are needed to obtain a robust measure.



Canopy cover from the GLAMA Mobile App

The following provides an overview of how to install and use GLAMA and submit and retrieve records through *Living Wales*.



## AusCover Good Practice Guidelines

A technical handbook supporting calibration and validation activities of remotely sensed data products



Version 1.1  
August 2015

[www.auscover.org.au](http://www.auscover.org.au)

Living Wales is proposing a Good Practice Guideline document for Wales that outlines protocols for ground data collection in support of Earth observations and if there is interest in contributing, please let us know.



## FOREST CANOPY COVER WALES-WIDE CAMPAIGN 2019



The canopy cover manual that outlines the use of the GLAMA mobile application developed through Living Wales is already available for reference.

Most recently, the manual has been used to support the collection of canopy cover measurements in Australia

(see [wales.livingearth.online](http://wales.livingearth.online))

# VALIDATION OF LAND COVER AND CHANGE MAPS

Aerial photographs and high resolution spaceborne imagery (e.g., PlanetScope) are a useful source for validating land cover maps.

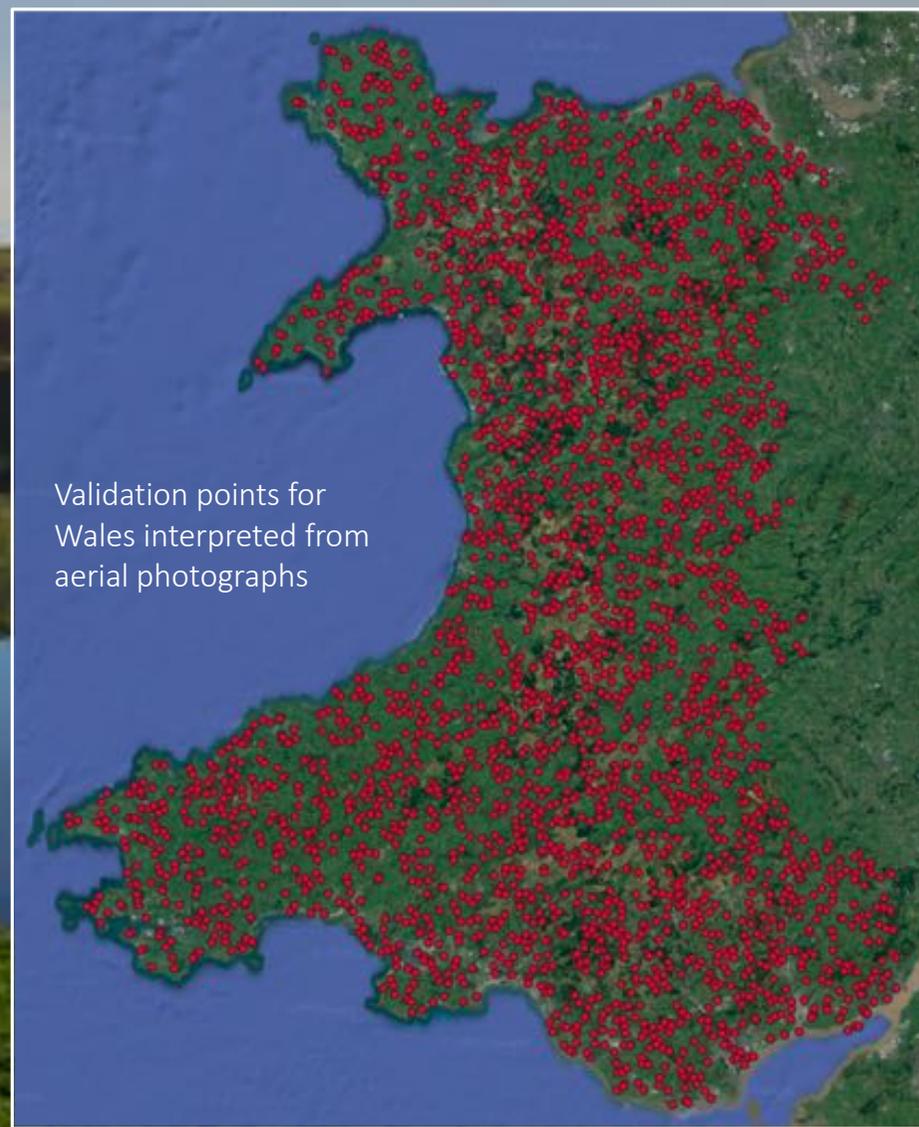
For Wales, over 3000 points have been manually interpreted to provide validation data for the FAO LCCS classification of Wales and these are being made openly available for use in other projects.

A limitation is that many aerial images are collected for specific points in time and, unless the landscape remains the same, the quality of the validation data might be compromised

High resolution and daily (cloud permitting) PlanetScope data, routine and national use of Earthtrack and/or targeted use of drones provide alternatives and are relevant for validating change

Dedicated and coordinated field and/or airborne campaigns are also beneficial

New approaches to generating validation data from aerial imagery are being investigated through Living Wales, including via use of deep learning



# *Living Wales*



*Global Engagement*



# Global Engagement



Living Wales has worked extensively with a wide range of partners, internationally, in the UK and within Wales

This engagement has resulted in open exchange of knowledge, ideas and information

Examples include types of algorithms for retrieving different environmental descriptors, ensuring correct implementation of the land cover classifications using the FAO LCCS, development of the new change taxonomy and glossary, design of the Earthtrack mobile application and formulating and testing ground-truthing methods, and advancement of ecosystem modelling frameworks for Wales.

The Living Wales project has only achieved its ambitions because of this engagement and collaboration and we would like to take this opportunity to thank everyone involved.

# Australia



Earthtrack data collection points



Bushfire recovery, southern NSW



Plymouth Marine Laboratory

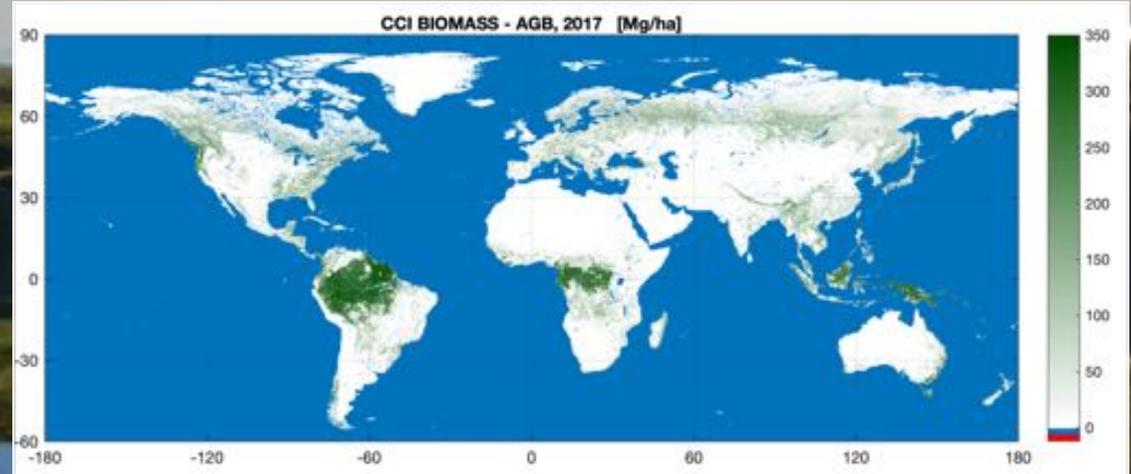
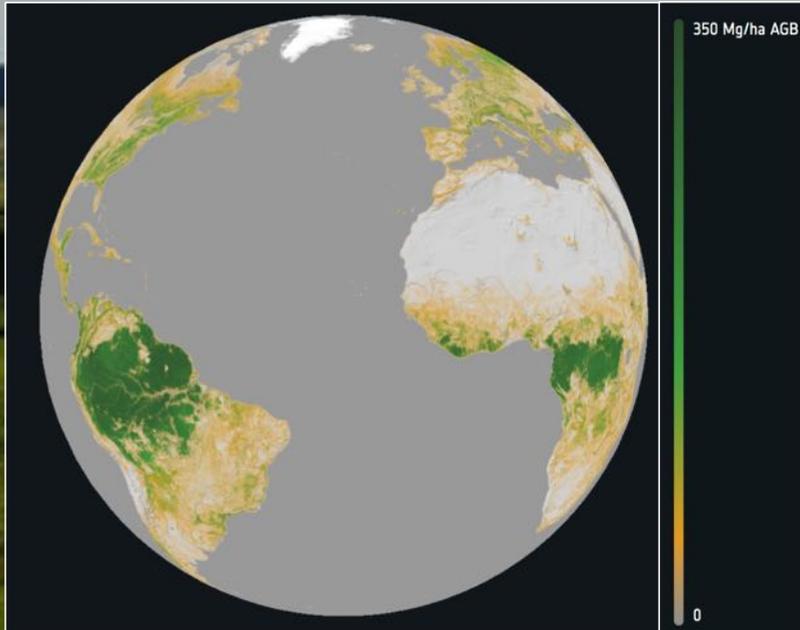


The involvement of Digital Earth Australia and collaborators has led to capacity for large area implementation of the Living Earth approach through the Open Data Cube and its application to the Landsat archive.



UNSW SYDNEY

# The European Space Agency (ESA)



Dataset  
esa ESA Biomass Climate Change Initiative (Biomass\_cci): Global datasets of forest above-ground biomass for the year 2017.



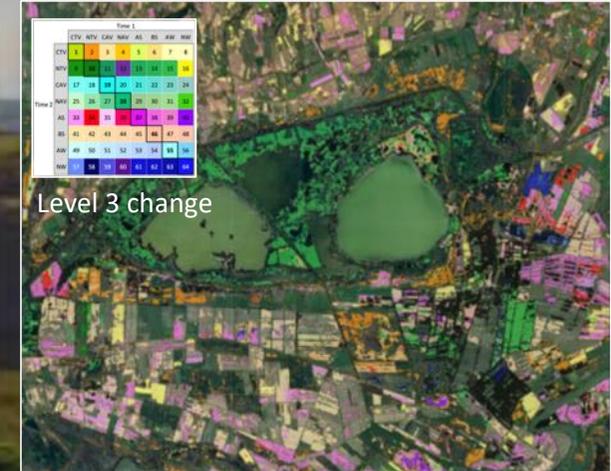
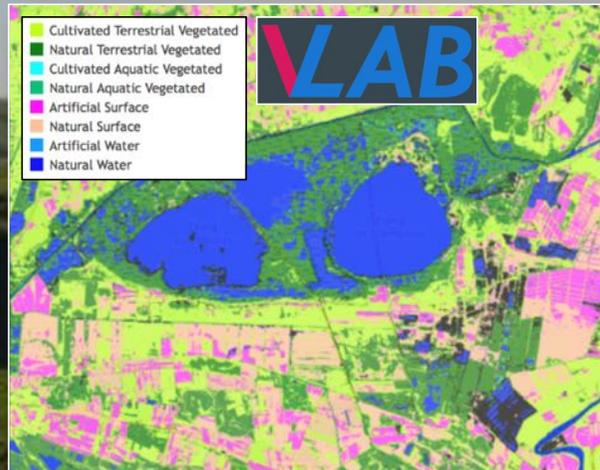
Aberystwyth University is managing ESA's Climate Change Initiative (CCI) Biomass project, which is generating global maps of above ground biomass (tonnes or Mg per hectare) for 2010, 2017 and 2018 at 100 m spatial resolution and associated errors.

These data are available for Wales

ESA have also been active in supporting the Living Wales Exhibition and Training Centre at CAT and Old College Aberystwyth University

# The European Union Ecopotential Project and Vlab

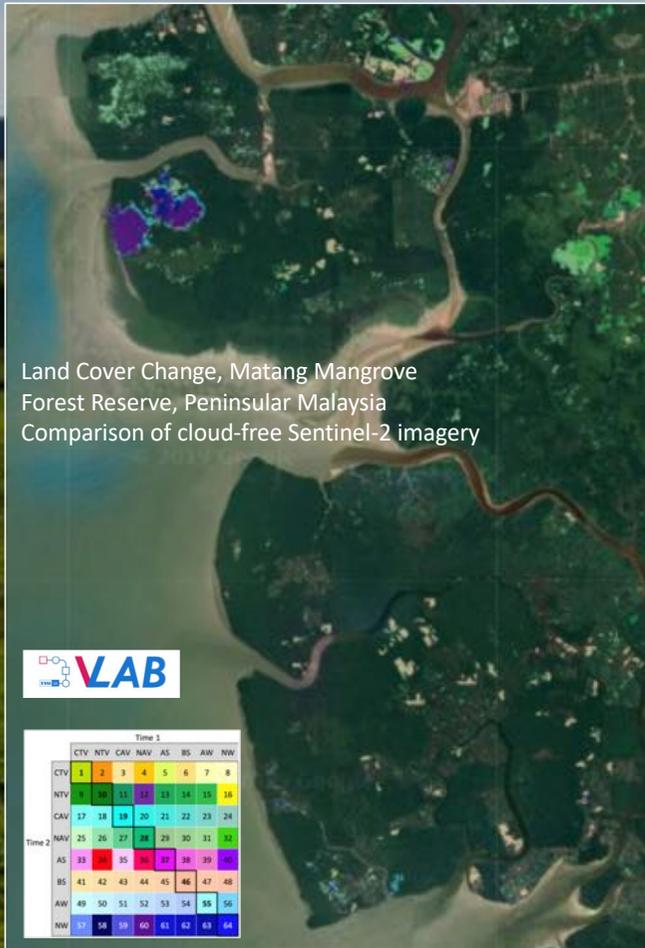
**ECOPOTENTIAL:** improving future ecosystem benefits through earth observations



Living Wales continues to support the development of the EU Ecopotential Virtual Laboratory (VLab), with this allowing global application of the FAO LCCS in near real time from Sentinel-2 imagery only.

Future collaborative effort with CNR Italy and the VLab is focusing on the generation of more environmental descriptors for Sentinel 1 and 2 and also time-series of these data to allow sub-annual and multi-annual land cover and change mapping and monitoring.

# MAMAFOREST: Managing mangrove forests from the sky



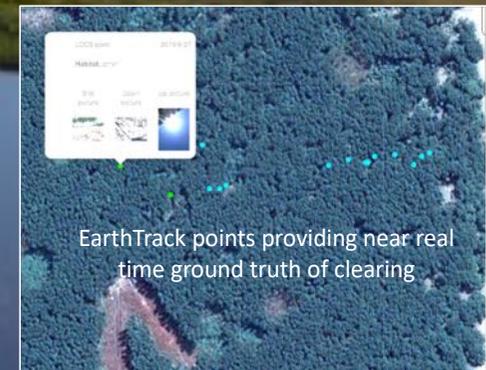
2017-2018

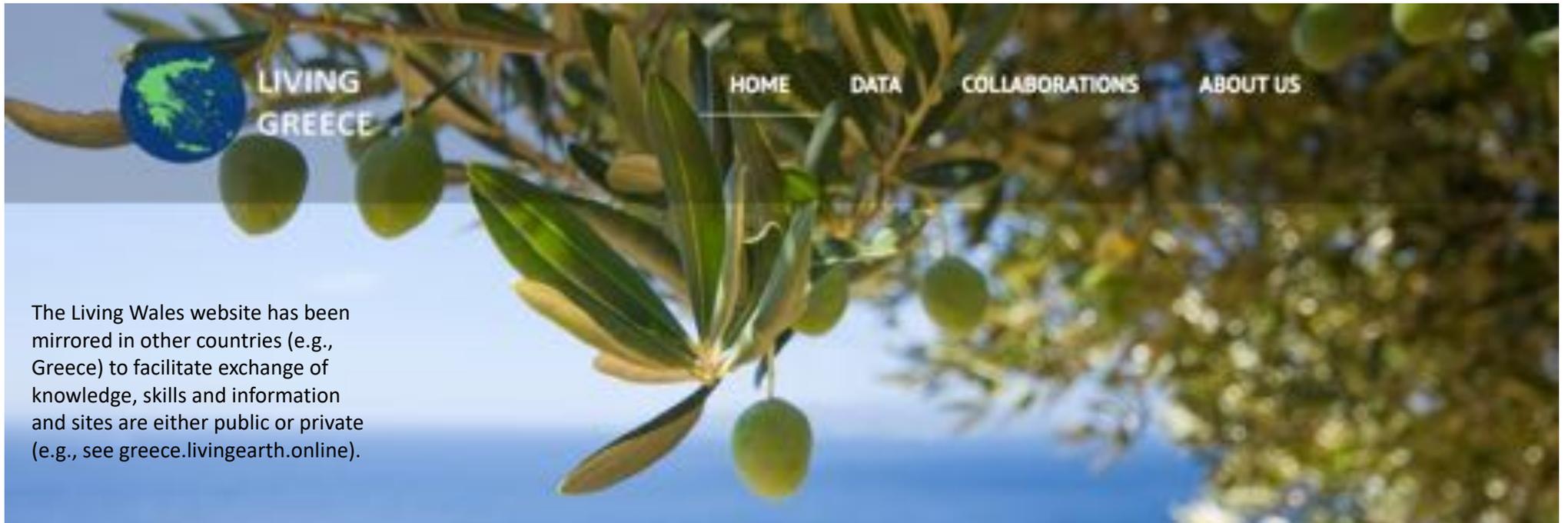


2018-2019



Clearing of mangroves for charcoal production, July 2019





The Living Wales website has been mirrored in other countries (e.g., Greece) to facilitate exchange of knowledge, skills and information and sites are either public or private (e.g., see [greece.livingearth.online](http://greece.livingearth.online)).



LAND



MARINE



ATMOSPHERE

# *Living Wales*



*Ecosystem restoration and biodiversity*



# *Living Wales*



Living Wales has worked with local scientists and organisations in Australia to describe what are termed reference and modified ecosystem states in Wales.

These highlight the natural ecosystems of Wales and give insight into the states that occur naturally and how these have been modified, including through human activities.

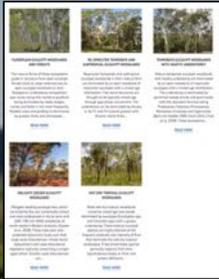
This information has been collated to inform and assist in the planning of future landscapes and is available on the Living Wales website under THEMES

Particular thanks go to Clive Hurford and CSIRO



**WELSH REFERENCE ECOSYSTEMS AND  
MODIFIED STATES**

# Ecosystem restoration and future landscapes



Australian Ecosystem Models



FORESTS AND WOODLAND



SEMI-NATURAL GRASSLANDS



HEATHS AND MIRE



COASTAL DUNES



SESSILE OAK WOODLAND



BEECH FOREST



BRACKEN AND SCRUB



CLIFFS, BOULDER FIELDS AND SCREES



WETLANDS, STANDING WATERS AND WATER COURSES



REFERENCE STATES



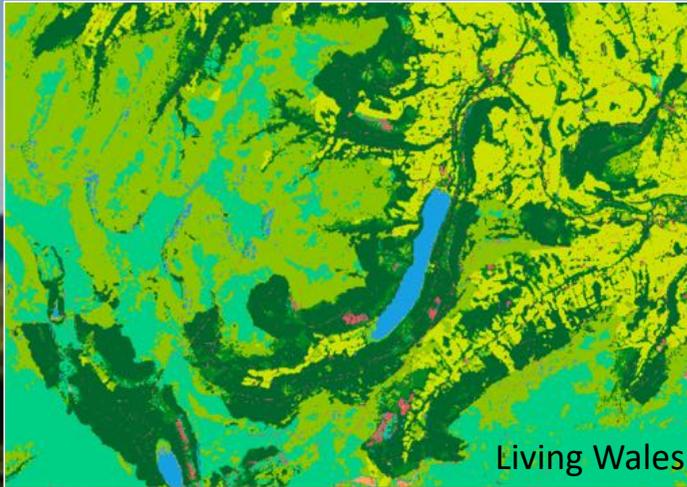
MODIFIED STATES



ESTUARIES



INTERTIDAL



Living Wales



Woodland Opportunity Maps, Wales

The land cover and evidence-based change maps are generated from categorical and continuous environmental descriptors, and these can be predicted (e.g., using process models relating to forest growth, hydrology, climate) and/or species distribution models (e.g., plants).

On this basis, maps of future landscapes and change in Wales can also be generated for different scenarios or according to ambitions or targets

Progress towards these targets can then be monitored using the Living Wales approach.

The land cover and environmental descriptors can be used to inform on the past, current and future distributions of flora and also fauna.



# *Living Wales*



*Links to policy*

# Living Wales



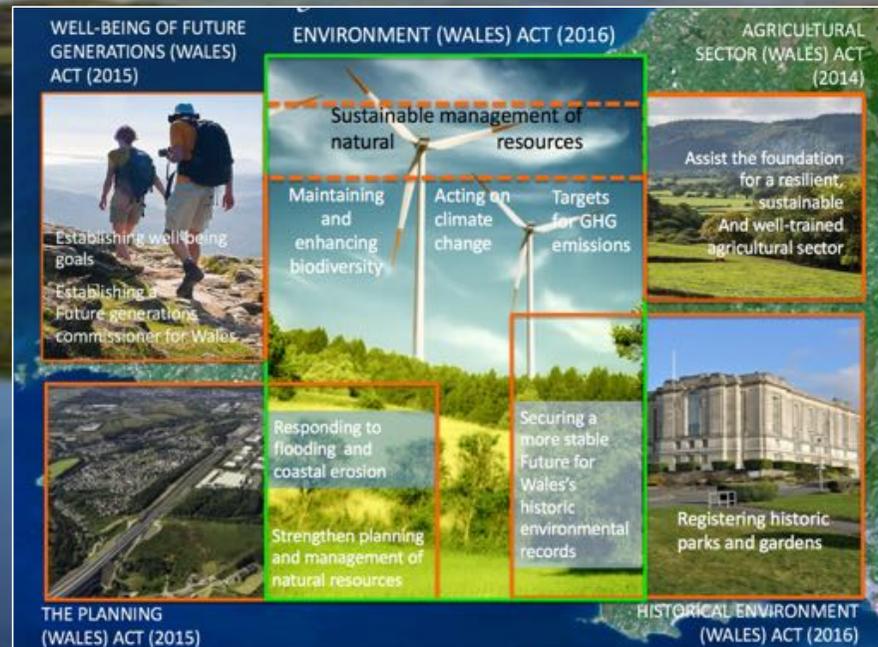
Living Wales has the potential to address multiple policy areas in Wales and to inform land management.

The environmental variables and maps of land cover and evidence-based change are nationally-focused and address multiple domains and dimensions of the Welsh landscape, historically, now and potentially into the future.

We envisage applications and use in forestry, agriculture, fisheries, coastal and marine environments, nature conservation, biodiversity, carbon, urban planning and health and well-being, climate and planning future landscapes, as examples

We very much welcome feedback onto the use of Living Wales in these areas

We also highlight that the Well-being of Future Generations Act requires public bodies in Wales to think about the long-term impact of their decisions, to work better with people, communities and each other, and to prevent persistent problems such as poverty, health inequalities, climate change and biodiversity loss.



# Living Wales



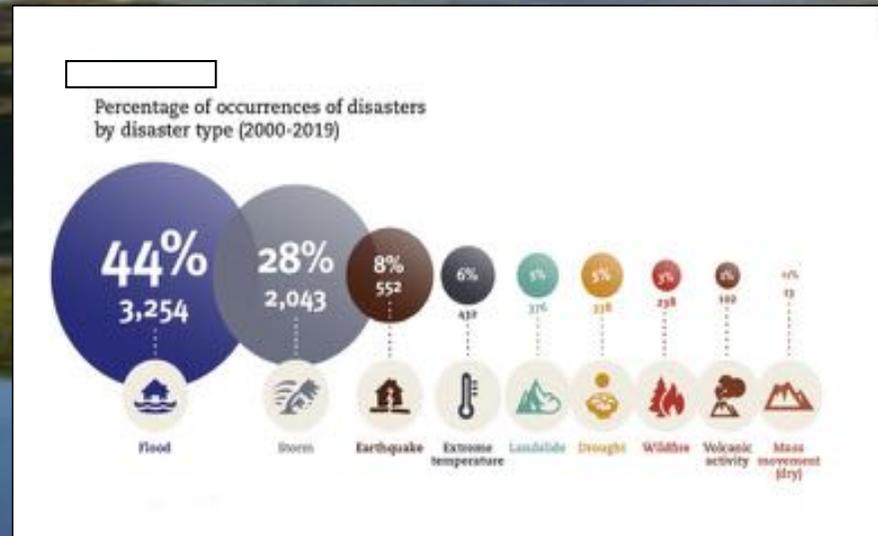
Living Wales has the potential to address multiple policy areas in Wales and to inform land management.

The environmental variables and maps of land cover and evidence-based change are nationally-focused and address multiple domains and dimensions of the Welsh landscape, historically, now and potentially into the future.

We envisage applications and use in forestry, agriculture, fisheries, coastal and marine environments, nature conservation, biodiversity, carbon, urban planning and health and well-being, climate and planning future landscapes, as examples

We very much welcome feedback onto the use of Living Wales in these areas

We also highlight that the Well-being of Future Generations Act requires public bodies in Wales to think about the long-term impact of their decisions, to work better with people, communities and each other, and to prevent persistent problems such as poverty, health inequalities, climate change and biodiversity loss.



# *Living Wales*



*Education and outreach*

Living Wales provides a large and expanding resource that can be used to support education across all ages and levels.



The Living Wales website ([wales.livingearth.online](http://wales.livingearth.online)) provides access to information on:

- Ways to measure and describe the environment
- Spatial datasets
- Methods for measuring/recording environmental descriptors in the field
- Algorithms for retrieving environmental information from satellite sensor and airborne data
- Thematic areas including biodiversity, ecosystems and use of the national landscape
- Partner websites (e.g., in Greece, Australia)

EarthTrack provides a unique way to learn about our environment and establishes a connection with Earth observation



# Aberystwyth University



Aberystwyth University has played a major role in hosting and supporting the development of the Living Wales project.

The research has been conducted through the Department of Geography and Earth Sciences (DGES) and the resources of Living Wales will be widely used in teaching for undergraduates and postgraduates

Visit [www.aber.ac.uk](http://www.aber.ac.uk) for more information

In 2020, Aberystwyth University and the Centre for Alternative Technology (CAT) jointly established the Living Wales Exhibition and Training Centre at CAT near Machynlleth, with support from Living Wales, the Welsh Government and the Joy Welch Foundation.



A mobile exhibition was also developed, which was first housed in the Old College, Aberystwyth University from July 2020





# The Living Wales Exhibition and Training Centre



Llywodraeth Cymru  
Welsh Government

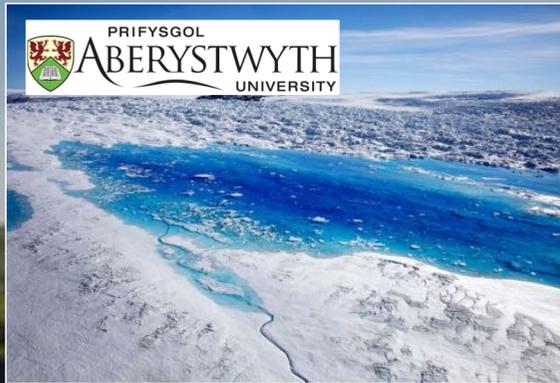


Displaying data and products from Living Wales

# ZERO CARBON BRITAIN

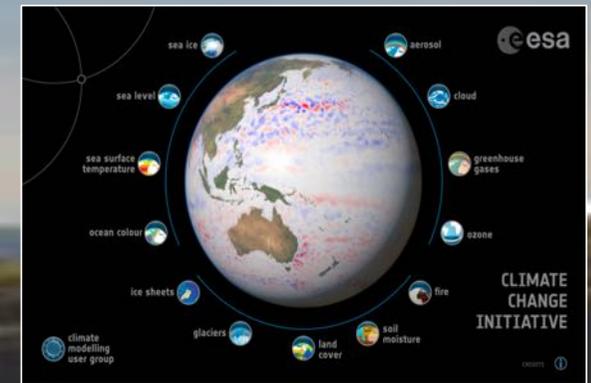
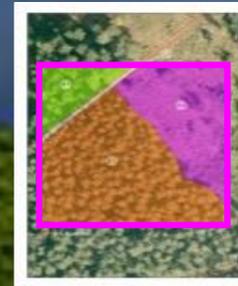
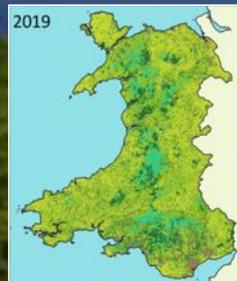
RISING TO THE CLIMATE EMERGENCY

CAT's new Zero Carbon Britain Hub and Innovation Lab helps turn climate emergency declarations into action, sharing zero carbon solutions to help build resilience where you live. CAT provides local authorities, businesses, institutions and community groups with the confidence, skills and understanding to help achieve net zero greenhouse gas emissions by 2040.



Aberystwyth University has been involved in climate change research for many decades and has recently been involved in the European Space Agency's (ESA) Climate Change Initiative (CCI) Biomass project.

In a collaboration between CAT, Aberystwyth University and Forest Research, national forest inventory plots have been established at CAT



ESA's CCI displays are also central to the Living Wales Exhibition, where interactive displays are available to help understanding of climate and how the World has changed over recent decades





CAT provides accommodation, lecture facilities and training spaces.

# Education and outreach



# *Living Wales*



*Driving and responding to national and international ambitions*



# Meeting Future Needs

Without Earth observations, there is no doubt that the global community would be far less aware of the changes that have occurred and the extent of damage inflicted.

However, whilst we should do more of the same, we also need to pursue new directions.

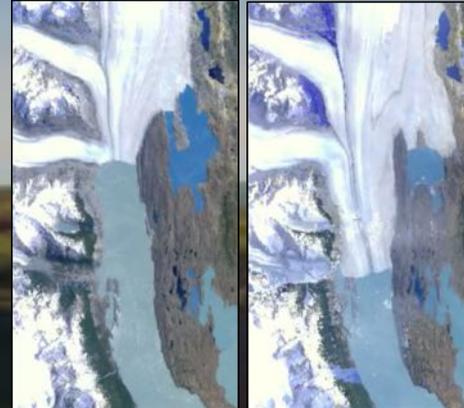
- Take a more proactive stance towards using EO and other approaches (e.g., process models) to prevent further damage and plan conservation and restoration of our global landscapes and all their assets.
- Combine forces (data, investment, knowledge) to ensure EO are used to their fullest potential and that data and knowledge are made available and accessible to everyone.

Build on what we have achieved in the past but use EO to give us all a better future.

- Focus on the well-being of future but also current generations

*THIS IS  
Cymru Fyw  
Living Wales*

## WHAT WE WOULD LIKE TO REPORT



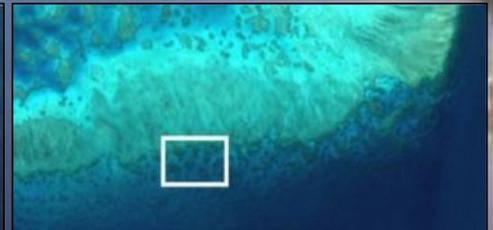
Patagonia Glaciers



Aral Sea



Arctic Ice



Great Barrier Reef