# Introduction to Forest Carbon Sequestration and the Forest Carbon Tool

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# Topics

- Forest sequestration and forest carbon pools
- Mitigation pathways
- Introduction to the Forest Carbon Tool
  - Modelling framework
  - Examples
- Current and future developments

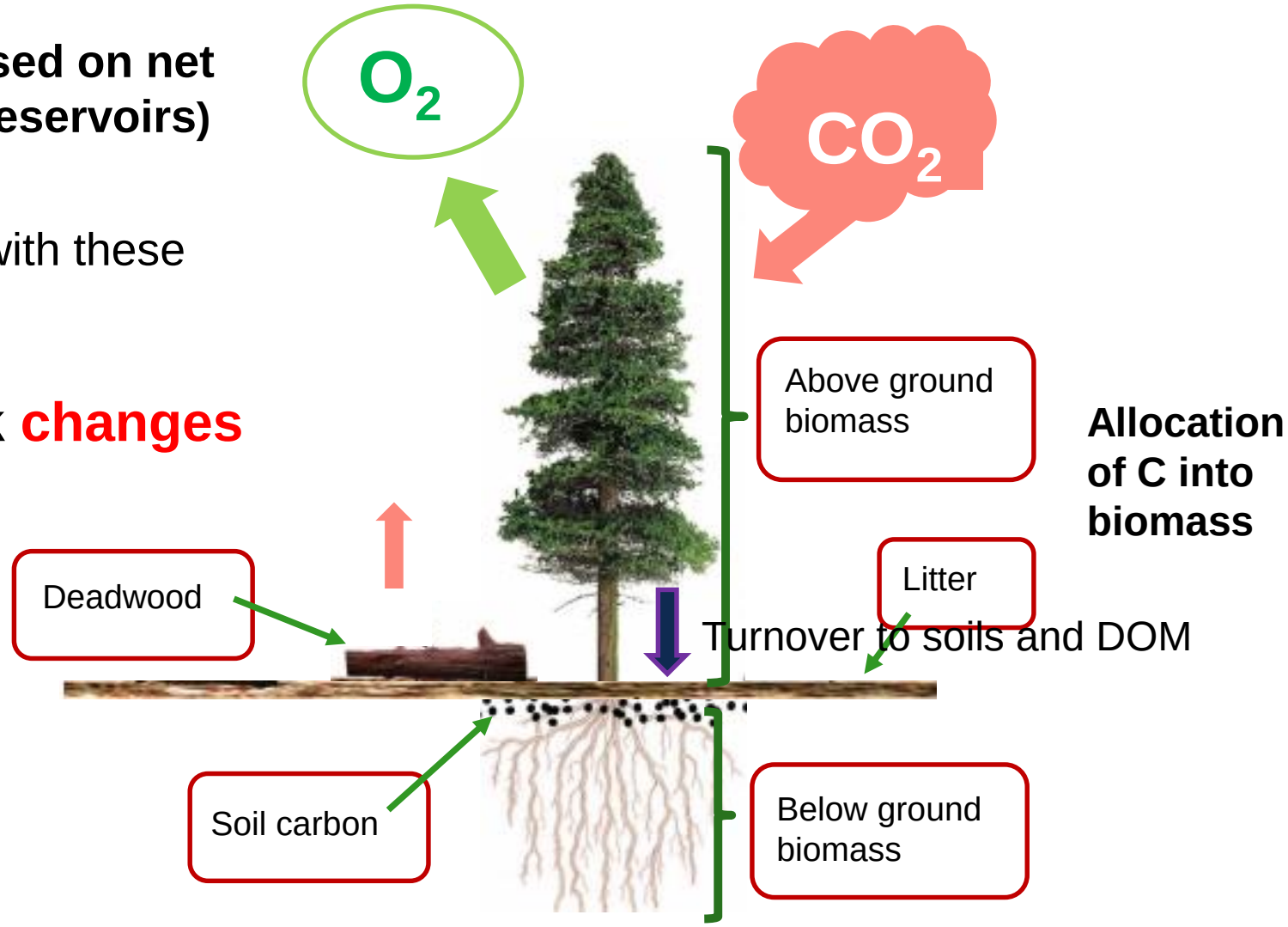
# Forest Carbon (C) Pools

- **At forest level, Carbon balances based on net emissions/removals from 5 pools (reservoirs)**

- Carbon transfers (fluxes) associated with these C pools

- **Final output = sum of C stock changes**

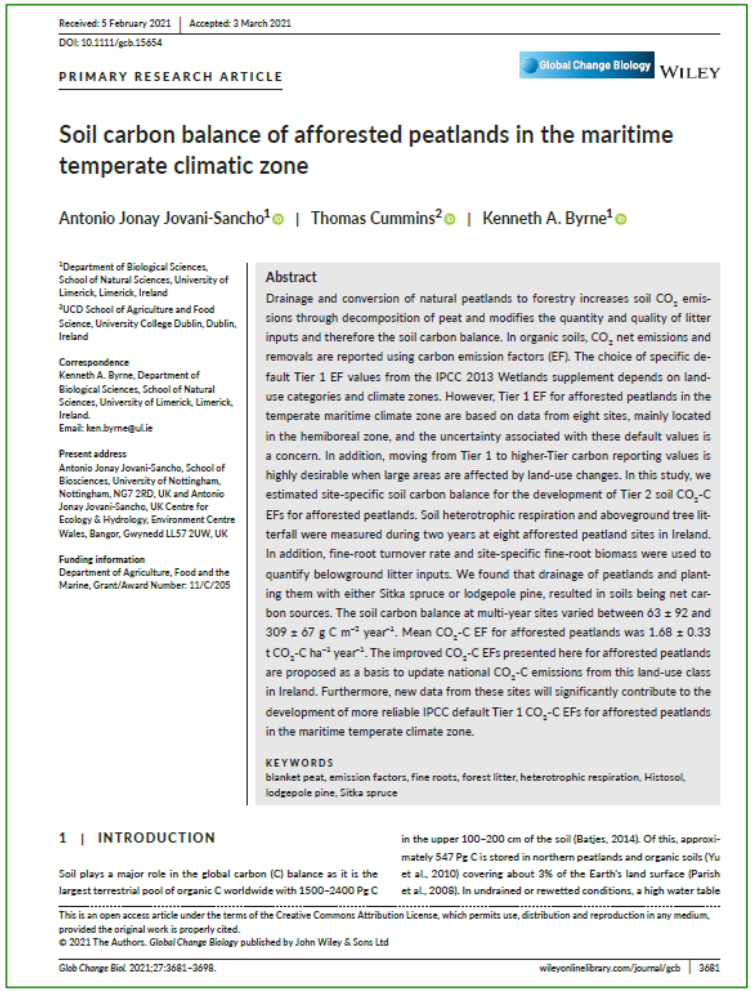
**C loss**
- respiration trees
- oxidation of soil organic matter




*Source: Hendrick and Black, 2009*

# What can affect the rate of sequestration

- Species
- Soil type
- Productivity / growth rate
- Forest management approaches



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PRIMARY RESEARCH ARTICLE

Global Change Biology WILEY

## Soil carbon balance of afforested peatlands in the maritime temperate climatic zone

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**Abstract**

Drainage and conversion of natural peatlands to forestry increases soil $CO_2$ emissions through decomposition of peat and modifies the quantity and quality of litter inputs and therefore the soil carbon balance. In organic soils, $CO_2$ net emissions and removals are reported using carbon emission factors (EF). The choice of specific default Tier 1 EF values from the IPCC 2013 Wetlands supplement depends on land-use categories and climate zones. However, Tier 1 EF for afforested peatlands in the temperate maritime climate zone are based on data from eight sites, mainly located in the hemiboreal zone, and the uncertainty associated with these default values is a concern. In addition, moving from Tier 1 to higher-Tier carbon reporting values is highly desirable when large areas are affected by land-use changes. In this study, we estimated site-specific soil carbon balance for the development of Tier 2 soil $CO_2$-C EFs for afforested peatlands. Soil heterotrophic respiration and aboveground tree litterfall were measured during two years at eight afforested peatland sites in Ireland. In addition, fine-root turnover rate and site-specific fine-root biomass were used to quantify belowground litter inputs. We found that drainage of peatlands and planting them with either Sitka spruce or lodgepole pine, resulted in soils being net carbon sources. The soil carbon balance at multi-year sites varied between 63 ± 92 and 309 ± 67 g C $m^{-2}$ $year^{-1}$. Mean $CO_2$-C EF for afforested peatlands was 1.68 ± 0.33 t $CO_2$-C $ha^{-1}$ $year^{-1}$. The improved $CO_2$-C EFs presented here for afforested peatlands are proposed as a basis to update national $CO_2$-C emissions from this land-use class in Ireland. Furthermore, new data from these sites will significantly contribute to the development of more reliable IPCC default Tier 1 $CO_2$-C EFs for afforested peatlands in the maritime temperate climate zone.

KEYWORDS
blanket peat, emission factors, fine roots, forest litter, heterotrophic respiration, Histosol, lodgepole pine, Sitka spruce

1 | INTRODUCTION

Soil plays a major role in the global carbon (C) balance as it is the largest terrestrial pool of organic C worldwide with 1500–2400 Pg C in the upper 100–200 cm of the soil (Batjes, 2014). Of this, approximately 547 Pg C is stored in northern peatlands and organic soils (Yu et al., 2010) covering about 3% of the Earth's land surface (Parish et al., 2008). In undrained or rewetted conditions, a high water table





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# Sequestration Pathways

**1. C - Sequestration in growing forest -pools**

**2. C - Storage in harvested wood products - HWP**

**3. Substitution of fossil fuels with wood energy**

**4. Substitution of energy intensive materials (not in system boundaries)**

*Source: www.moelvin.com*

# Carbon Budget Model (CBM-CFS3) Outline

**Timber volume increment curves**

- Existing growth models
- National Forest Inventory data
- Developed curves

**Growth -- Net Biomass C Stock Change**

- **C transfer** from biomass to litter, deadwood, soil
- **C decomposition within pools** – $CO_2$ release
- **Disturbances**

**Carbon Allocation**

Target harvest

Harvested wood product and fuelwood pools

**Simulation of uptake and release of carbon**

**Forest Ecosystem**

**Outside of ecosystem**

**Sequestration curves / outputs**

Validation e.g.

- Eddy Covariance Flux
- COFORD research data

# Forest Carbon Tool - assumptions and caveats

- Based on fixed management assumptions and timber flows for different species
- Higher uncertainties for some establshment categories (e.g. Agroforestry, Native Woodland Scheme)
- Afforestation is assumed to be permanent (no deforestation and same management in perpetuity)

**Table 2: Species, yield class, forest management and wood use assumptions applied to the species/species group options in the Forest Carbon Tool**

| Species groups | CODE | YC range | Management | Rotation length | Wood use |
|---|---|---|---|---|---|
| Spruce | SS | 12#, 14#, 16, 18, 20, 24 | Thinned | MMAI*** - 20% | Energy wood*, WBP**, palletwood and sawlog |
| Pine | LP | 8,12 | Unthinned | MMAI | WBP, palletwood |
| Other Conifers | OC | 16 | Thinned | MMAI | Energy wood, WBP*, palletwood and sawlog |
| Fast growing broadleaves (Sycamore, alder, birch) | FGB | 6##, 8 | Thinned | Grow to diameter of 40-50cm### | Energy wood (early thinnings) and sawlog |
| Slow growing broadleaves (Oak) | SGB | 4, 6 | Thinned | Grow to diameter of 50cm (120-150 years) | Energy wood (early thinnings) and sawlog |

# YC 12 & 14 SS are unthinned

##Maximum diameter (DBH) for YC 6 is 35cm

###Huss et al., 2016

* Wood fuel options e.g. wood chips and firewood

** Wood-based panels

*** MMAI is the age of maximum mean annual increment

# Assumptions - GPC categories

**Table 1: Grant and premium category (GPC) description, yield class, forest management and wood use assumptions applied to GPC options in the Forest Carbon Tool**

| GPC Category | Description | Species/Species Group | Mix | % Open area | Yield Class (YC) | Wood Use |
|---|---|---|---|---|---|---|
| GPC 1 | Unenclosed | SS | 100 | 15.0 | YC 16 and YC 18 | Energy wood*, WBP**, palletwood and sawlog |
| GPC 2 | Sitka spruce/Lodgepole pine | SS/LP | 50:50 | 15.0 | SS YC 12/LP YC 8 | WBP for LP, WBP, palletwood and sawlog for SS, no thinning |
| GPC 3 | 10% Diverse Conifer/Broadleaf | SS/FGB^ | 90:10 | 15.0 | Conifer YC 20/BL YC 6 | Energy wood, WBP, palletwood and sawlog /FGB retention |
| GPC 3 | 10% Diverse Conifer/Broadleaf | SS/FGB | 90:10 | 15.0 | Conifer YC 24/BL YC 8 | Energy wood, WBP, palletwood and sawlog / FGB retention |
| GPC 4 | Diverse Conifer | Other conifers | 100 | 15.0 | YC 16 | Energy wood, WBP, palletwood and sawlog |
| GPC 5 | Broadleaf | FGB | 100 | 15.0 | YC 6 | Energy wood (early thinnings) and sawlog |
| GPC 5 | Broadleaf | FGB | 100 | 15.0 | YC 8 | Energy wood (early thinnings) and sawlog |
| GPC 6 | Oak | SGB^^ | 100 | 15.0 | YC 4 | Energy wood (early thinnings) and sawlog |
| GPC 6 | Oak | SGB | 100 | 15.0 | YC 6 | Energy wood (early thinnings) and sawlog |
| GPC 7 | Beech | SGB | 100 | 15.0 | YC 4 | Energy wood (early thinnings) and sawlog |
| GPC 7 | Beech | SGB | 100 | 15.0 | YC 6 | Energy wood (early thinnings) and sawlog |
| GPC 8 | Alder/Birch | FGB | 100 | 15.0 | YC 6 | Energy wood (early thinnings) and sawlog |
| GPC 8 | Alder/Birch | FGB | 100 | 15.0 | YC 8 | Energy wood (early thinnings) and sawlog |
| GPC 9 | Native Woodland Est. Scenario 1^^^ | SGB | 100 | 15.0 | YC 4 | Long term retention (some timber removal e.g. sawlog, energy wood) |
| GPC 10 | Native Woodland Est. Scenario 5^^^ | SGB/FGB | 50:50 | 15.0 | YC 4 | Long term retention (some timber removal e.g. sawlog, energy wood) |
| GPC 11 | Agroforestry (5m spacing) | SGB/FGB | 100 | 0 | | Initial stocking of 400 reduced to 70 stems over the rotation (all sawn to HWP) |
| GPC 12 | Forestry for Fibre | *Eucalyptus nitens* | 100 | 15.0 | YC 30 | Energy wood |

^ Fast growing broadleaves (e.g. Sycamore, alder, birch)

^^ Slow growing broadleaves (e.g. oak)

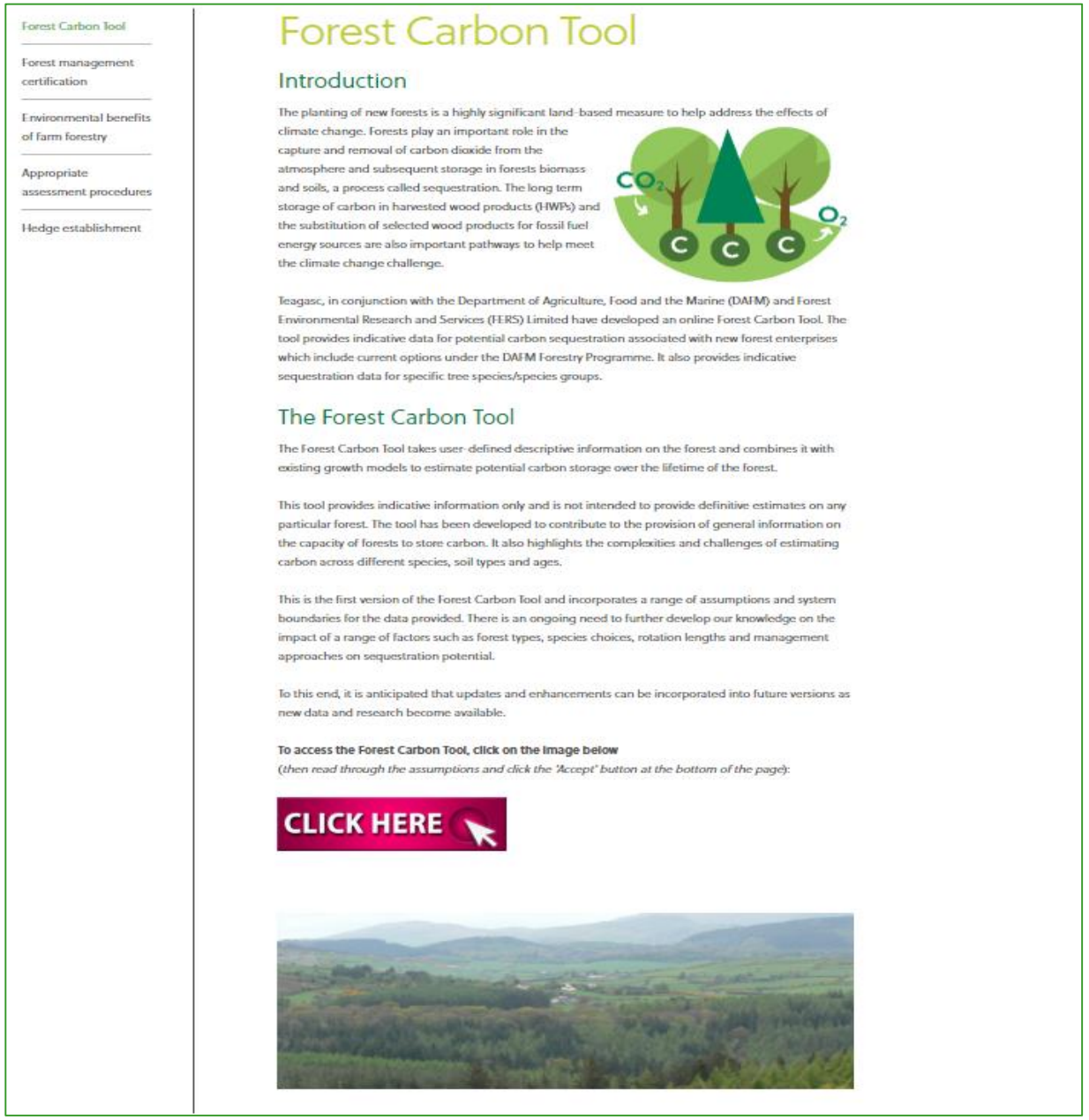
^^^ Values will be available subject to further data analysis and validation

* Wood fuel options e.g. firewood and wood chips

**Wood-based panels (WBP) from pulpwood

# Forest Carbon Tool: www.teagasc.ie/forestcarbontool

- Raise awareness of the importance of climate mitigation through afforestation options
- Provide up-to-date information on carbon sequestration trends for a range of afforestation options on a user friendly interface
- Allow comparisons of the relative merits of varying afforestation scenarios from a carbon sequestration perspective
- **NB: This tool is for the above purposes and not intended to provide absolute data on any particular forest carbon valuation or potential trading platforms.**



# Selection of inputs

The Forest Carbon Tool provides indicative carbon sequestration values associated with forest planting options. Users can select from a dropdown list of Grant and Premium Categories which include eligible conifers, broadleaf species, agroforestry and forestry for fibre options (click here for more details).
Alternatively, a range of approved species/species groups may be selected.

Link to Table 1 (Grant & Premium Categories)

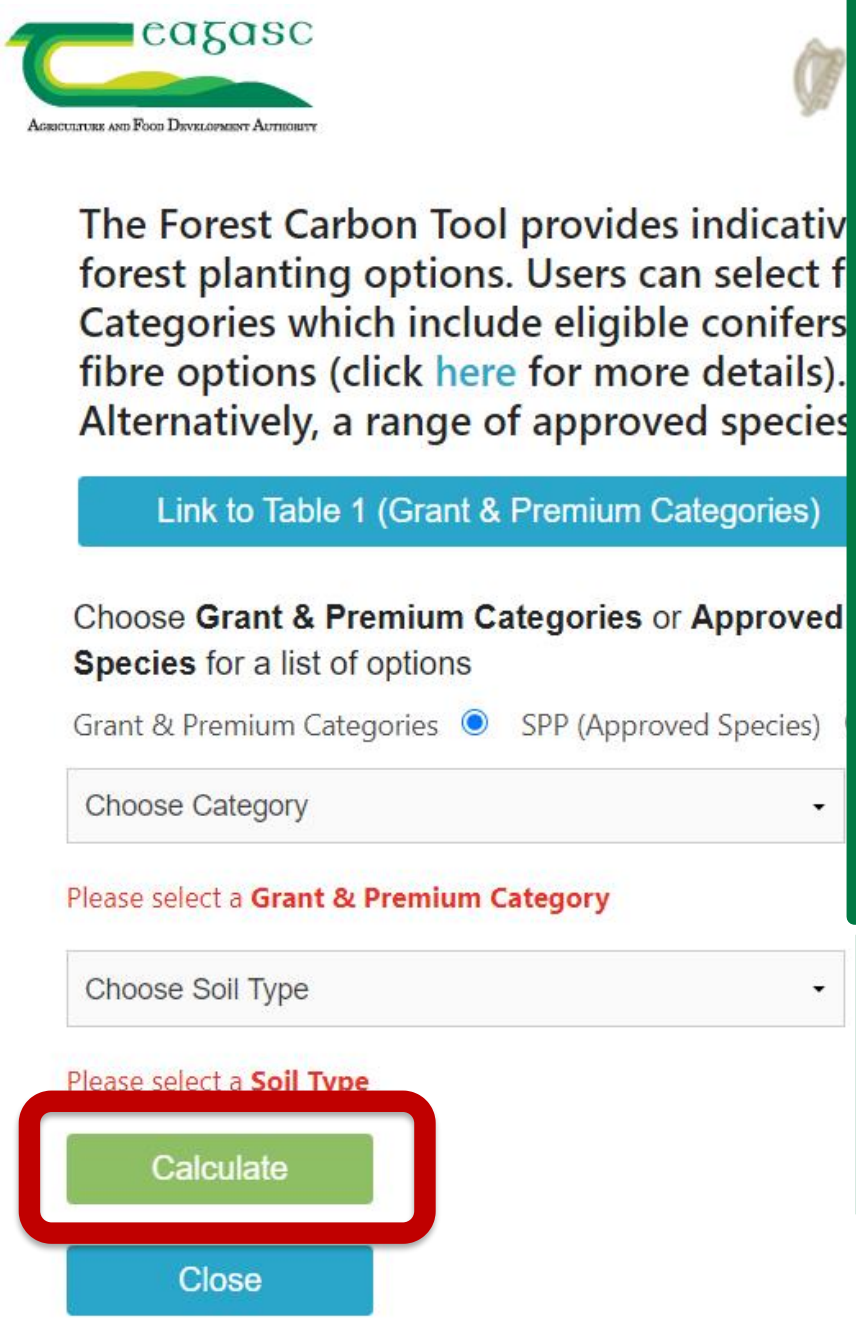
Link to Table 2 (Approved Species)

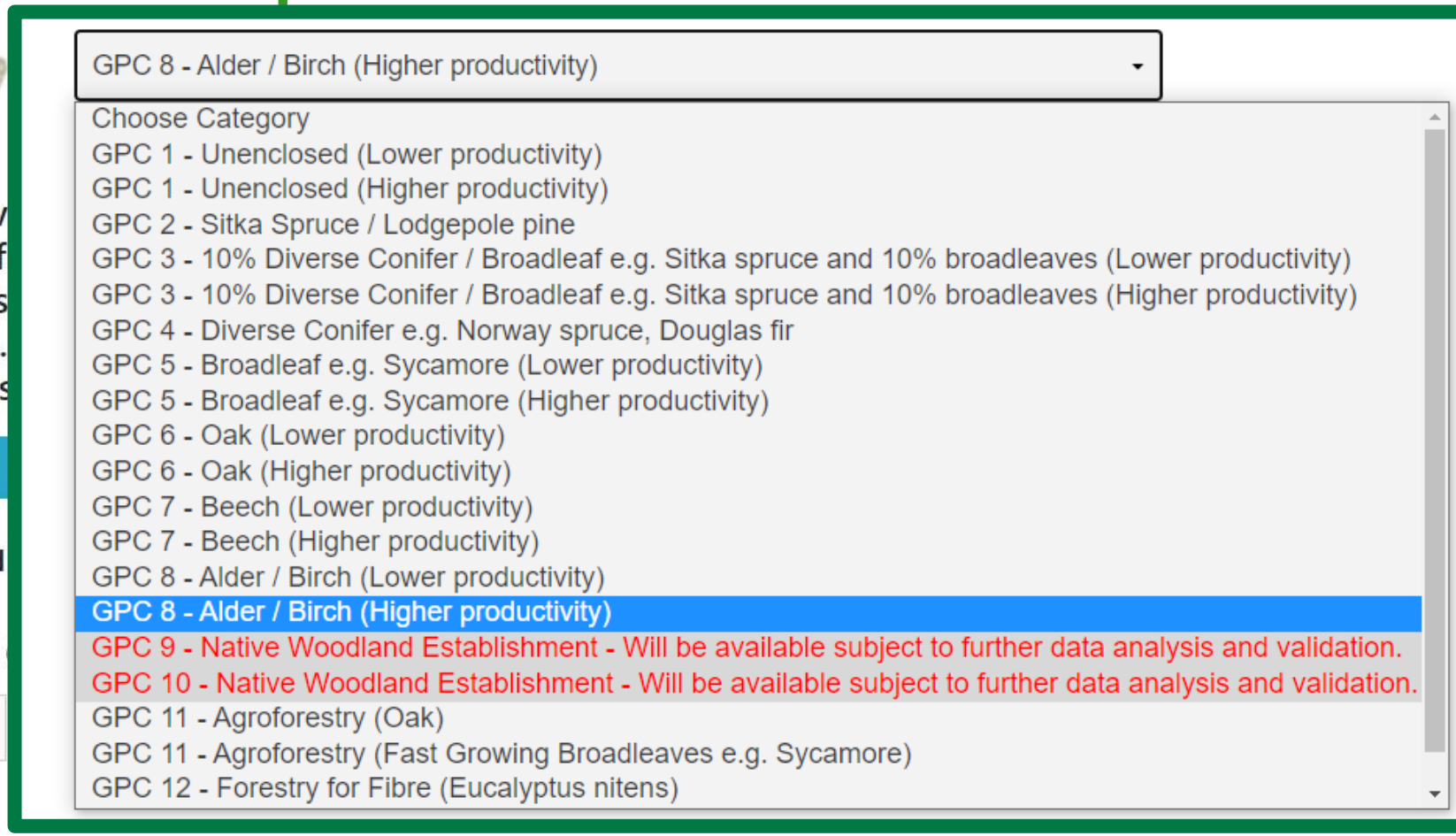
Choose **Grant & Premium Categories** or **Approved Species** for a list of options

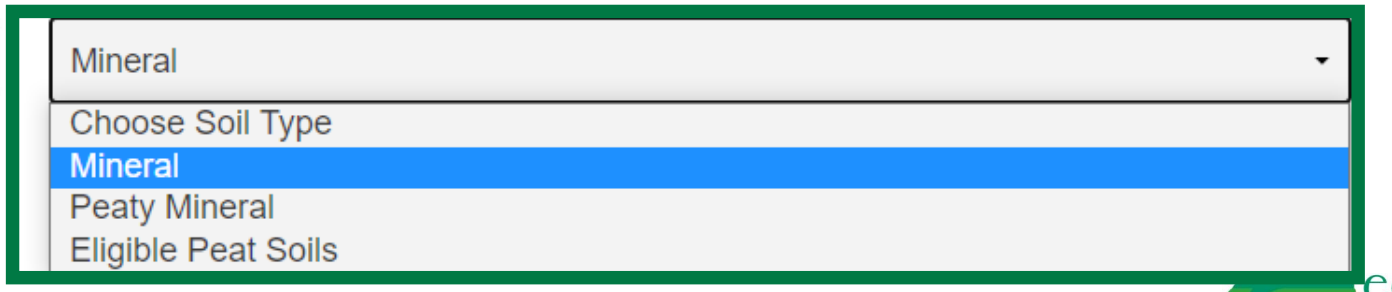
Grant & Premium Categories ○ SPP (Approved Species) ○

Close

# Choose category – grant and premiums



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Choose **Grant & Premium Categories** or **Approved Species** for a list of options

Grant & Premium Categories ◉ SPP (Approved Species) ○

GPC 8 - Alder / Birch (Higher productivity)

Mineral

## GPC 8: Alder/Birch

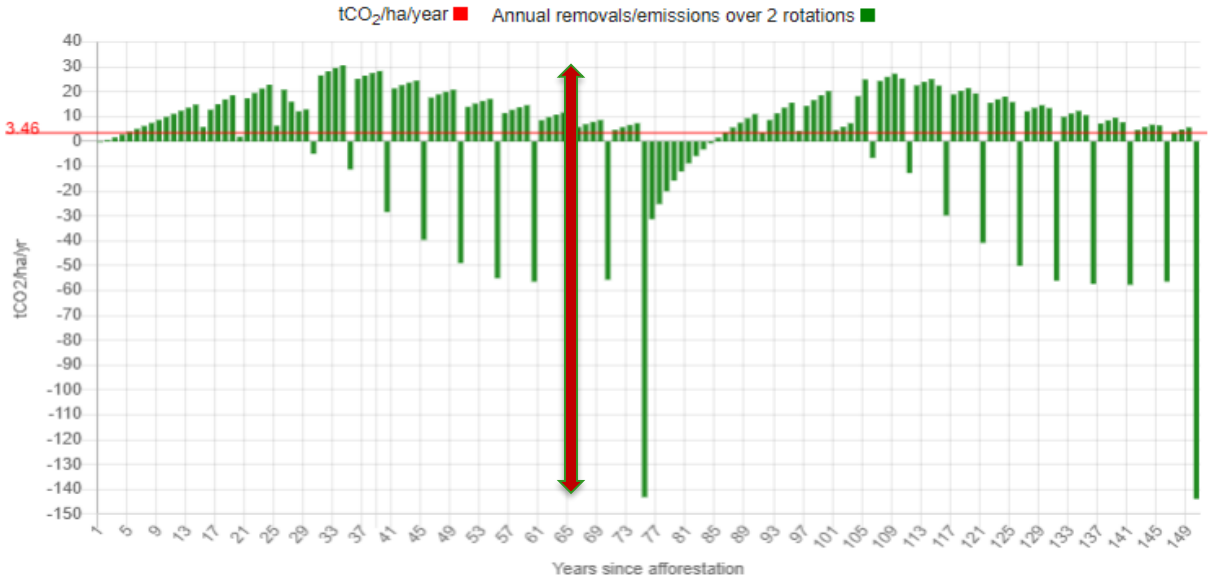
- Mineral soil
- Yield class 8
- Thinned
- Rotation 75 years

Print/PDF

Mean annual/cumulative $CO_2$ removals

| | |
|---|---|
| Forest site sequestration | 1.9 |
| Harvested wood products | 1.25 |
| Energy subsitution | 0.31 |
| **Mean sequestration rate ($tCO_2$/ha/year)** | **3.46** |
| **CAP ($tCO_2$/ha)** | **471.72** |

Annual removals/emissions over 2 rotations




Graph: While the table presents average carbon sequestration, this graph shows how the rate of sequestration varies over the forest cycle/timeline.

Choose **Grant & Premium Categories** or **Approved Species** for a list of options

Grant & Premium Categories ◉ SPP (Approved Species) ○

GPC 3 - 10% Diverse Conifer / Broadleaf e.g. Sitka spruce

Mineral

Calculate

Print/PDF

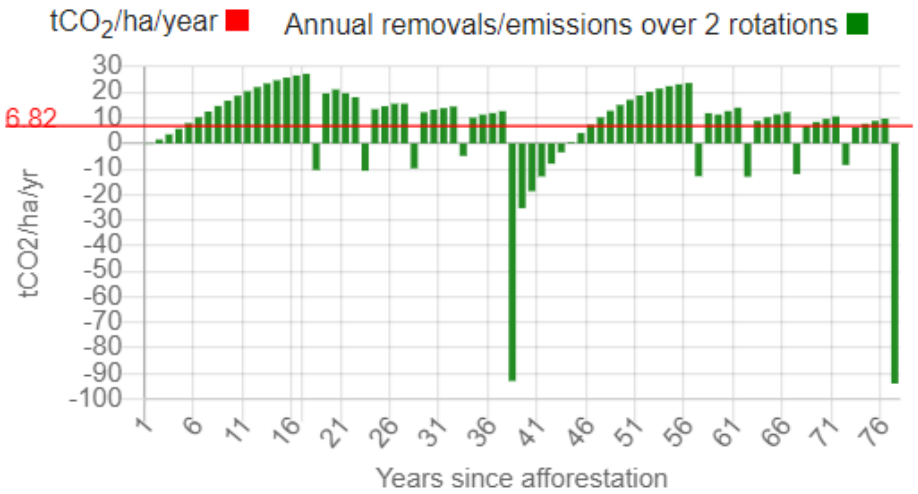
Mean annual/cumulative $CO_2$ removals

| | |
|---|---|
| Forest site sequestration | 3.13 |
| Harvested wood products | 3.26 |
| Energy subsitution | 0.43 |
| **Mean sequestration rate ($tCO_2$/ha/year)** | **6.82** |
| **CAP ($tCO_2$/ha)** | **357** |

**GPC 3: 15% Diverse Conifer/Broadleaf**

- Mineral soil
- Yield class 24
- Thinned
- Rotation 38 years

Annual removals/emissions over 2 rotations

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Choose **Grant & Premium Categories** or **Approved Species** for a list of options

Grant & Premium Categories ◉ SPP (Approved Species) ○

GPC 3 - 10% Diverse Conifer / Broadleaf e.g. Sitka spruce

Mineral

Calculate

Print/PDF

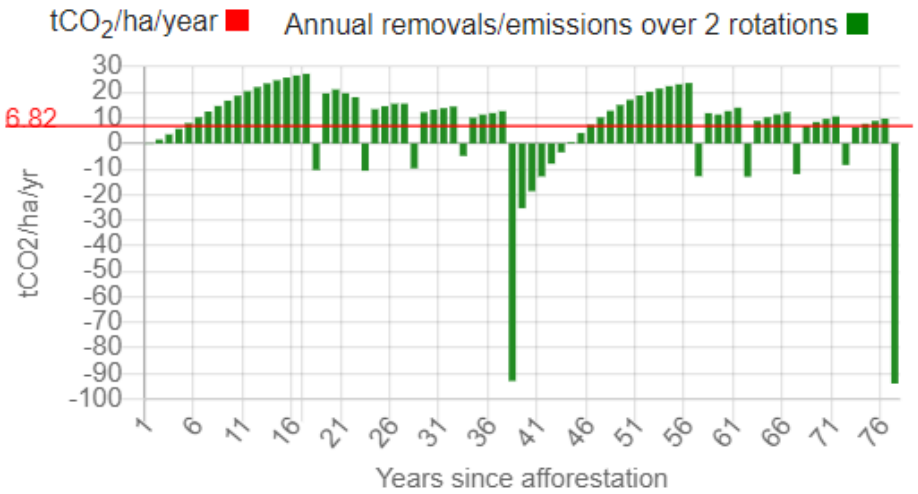
Mean annual/cumulative $CO_2$ removals

| | |
|---|---|
| Forest site sequestration | 3.13 |
| Harvested wood products | 3.26 |
| Energy subsitution | 0.43 |
| **Mean sequestration rate ($tCO_2$/ha/year)** | **6.82** |
| **CAP ($tCO_2$/ha)** | **357** |

**GPC 3: 15% Diverse Conifer/Broadleaf**

- Mineral soil
- Yield class 24
- Thinned
- Rotation 38 years

Annual removals/emissions over 2 rotations




Graph: While the table presents average carbon sequestration, this graph shows how the rate of sequestration varies over the forest cycle/timeline.

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# Agroforestry

Print/PDF

Mean annual/cumulative $CO_2$ removals

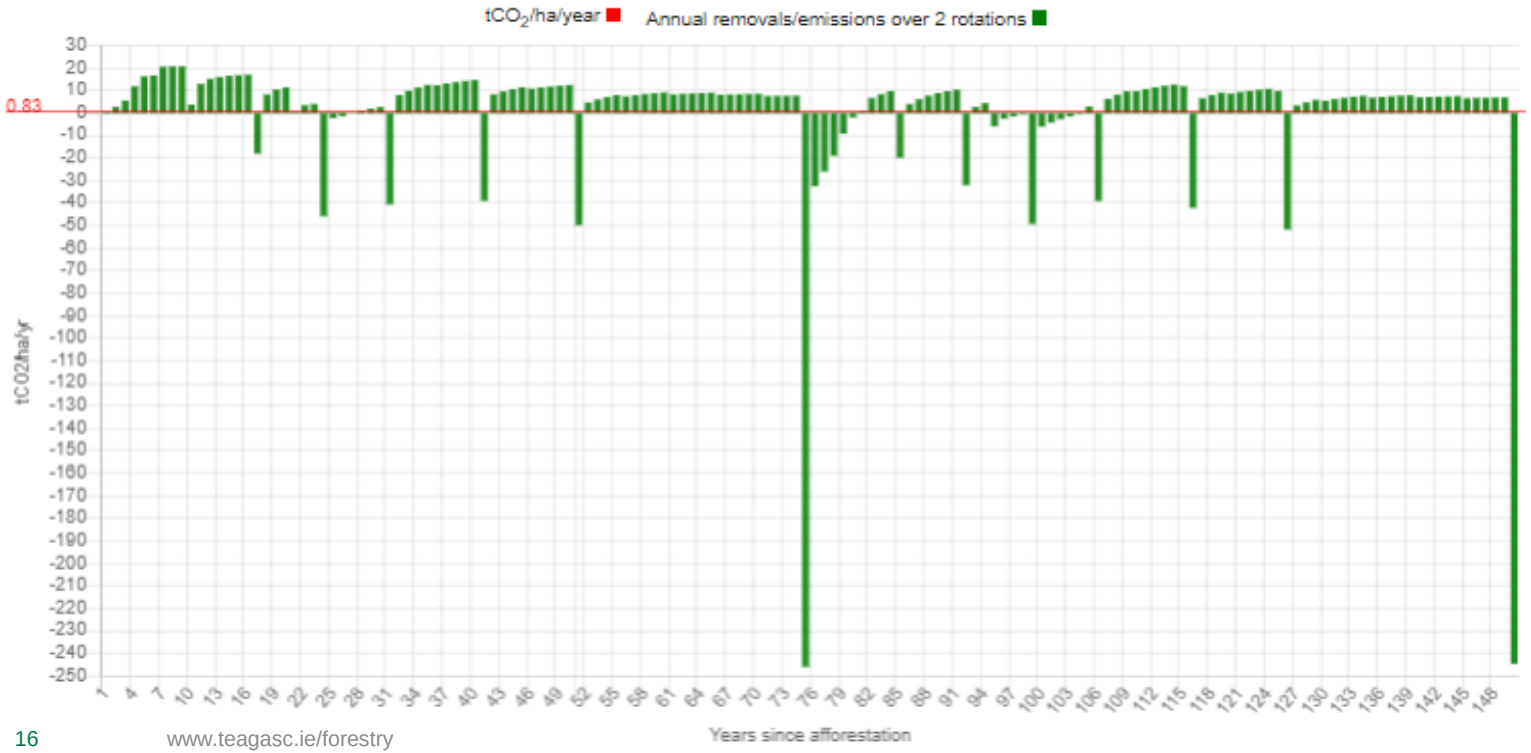
| | |
|---|---|
| Forest site sequestration | 1.94 |
| Harvested wood products | 0.87 |
| Energy subsitution | 0.05 |
| Agriculture emissions | -2.03 |
| **Mean sequestration rate ($tCO_2$/ha/year)** | **0.83** |
| **CAP ($tCO_2$/ha)** | **187.4** |

Forest sequestration 1.94 + 0.87 + 0.05 = 2.86 $tCO_2$-eq/ha/yr

Agricultural emissions - 2.03 tCO2-eq/ha/yr

0.83 $tCO_2$-eq/ha/yr

Annual removals/emissions over 2 rotations

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# Future Tool Updates

- Incorporation of emission factors
- Incorporation of new Forest Types
- Incorporation of enhanced data as it emerges

# Forest Carbon Researcher

**Measure and model impacts of afforestation and forest management on:**

- Carbon sequestration and greenhouse gas emissions
- Carbon accounting and greenhouse gas inventories
- Co-benefits to water quality and biodiversity

- Integrate with ongoing relevant research
- Develop a national and international network of collaborators

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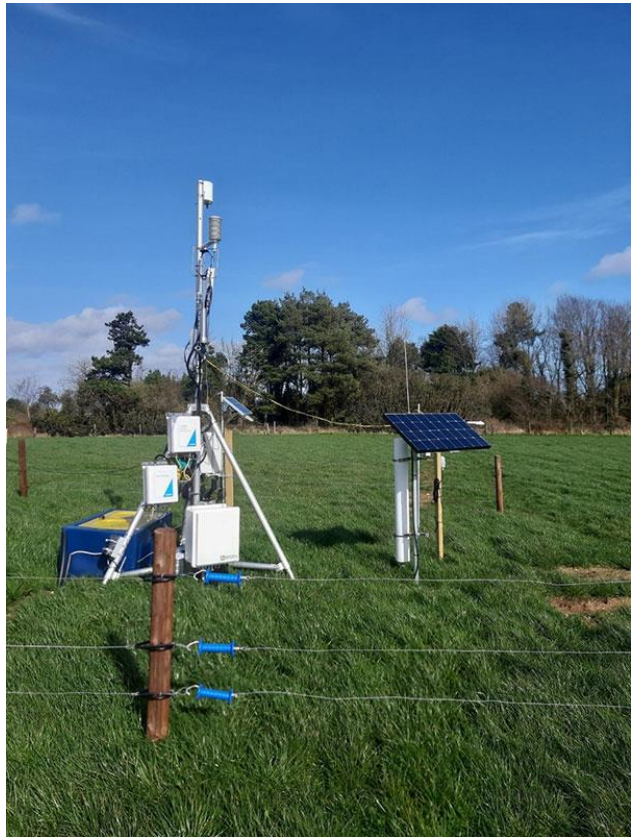
# Agroforestry demonstration plots



# AgNav

Trusted Solutions,

For Everyday Farming

AGNAV

Origin Green IRELAND

Teagasc
Agriculture and Food Development Authority

icbf

# AgNav – What it is..!



- AgNav is a national online farmer-centric portal developed by three partner agencies, i.e**. Bord Bia, the Irish Cattle Breeding Federation (ICBF) and Teagasc**.

- AgNav will utilise the three respective agencies' collective knowledge by providing **data**, **decision making support tools** and **guidance** which will be housed within one consolidated online platform.

- A definitive resource to support farm sustainability in Ireland.

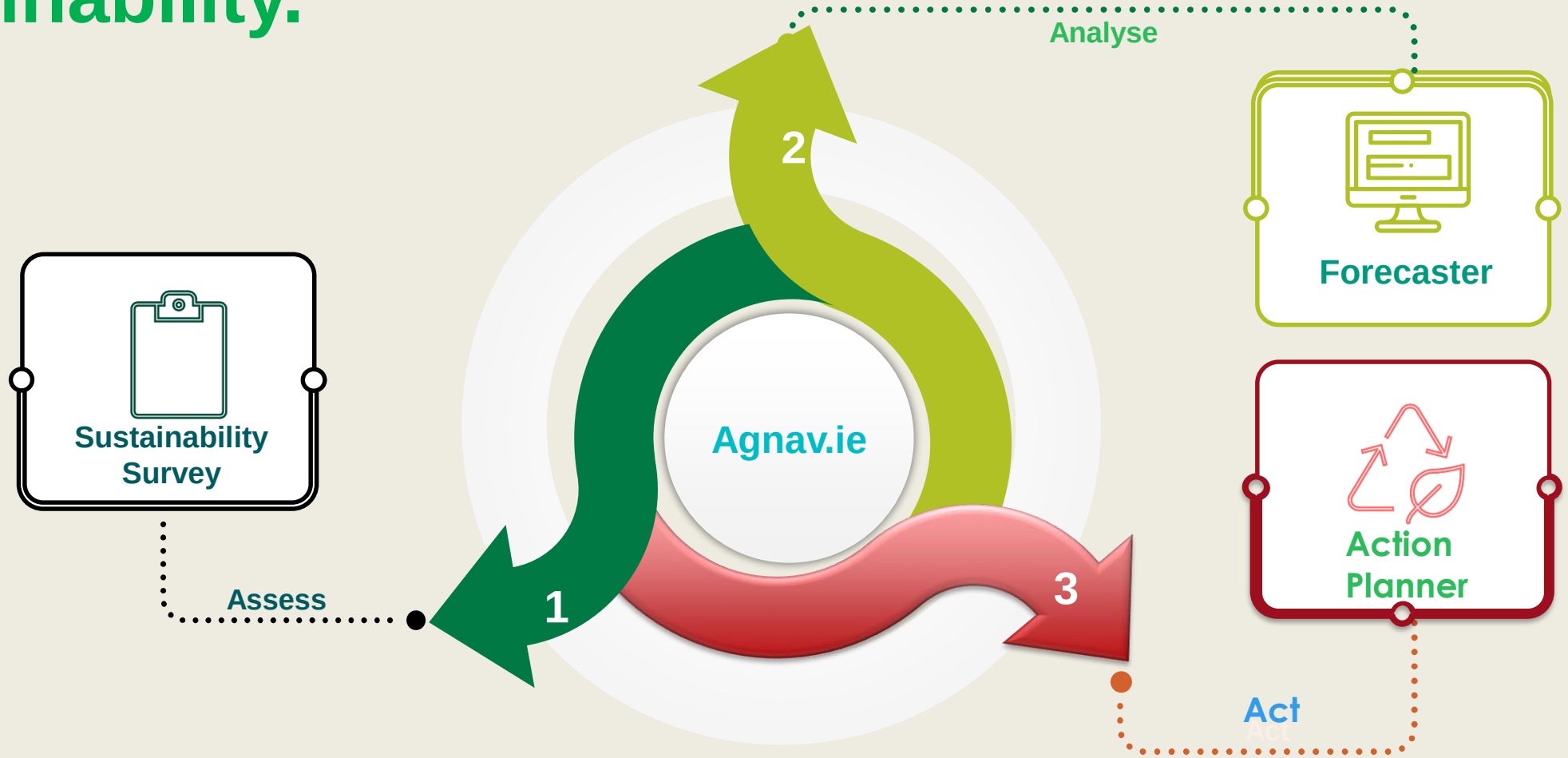
AGNAV

# Key features



- Much-needed and ambitious initiative to **chart a clear path forward** for sustainable farming.
- Accurate and verifiable data to **support decision making** on farm.
- Aims to reduce duplication of effort for a farmer – providing **a one-stop-shop** for farm sustainability management.
- S**upport the work of existing environmental schemes** such as EIPs or processor-led programmes.
- Data will not be shared outside of AgNav, **unless a farmer chooses** to do so.
- The toolkit is **optional for all farmers**. It is not linked to the Bord Bia audit and farmers are not required to be clients / members of Origin Green, Teagasc or ICBF
- In time it is hoped that AgNav will facilitate an ability to **account for all carbon** within each individual farms' system.

# A platform guided by science to assist farmers in achieving on-farm sustainability.



# Future Development – pilot phase in 2023

| | Short Term Pilot phase (12 months) | Medium Term (12 -24 months) | Long term (36 months) |
|---|---|---|---|
| **Development / User experience** | • Enhancing usability<br>• Piloting via Signpost Advisory regional Workshops | • Sheep model<br>• Tillage model<br>• **Forestry model**<br>• Mapping – water | • Pig model<br>• Horticulture model<br>• Poultry model<br>• Egg model<br>• Biodiversity |
| **Functionality** | • Age at slaughter<br>• Concentrate feed<br>• Production systems | • Animal inventory changes<br>• Economic impact | • Carbon models |

AGNAV








# THANK YOU

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