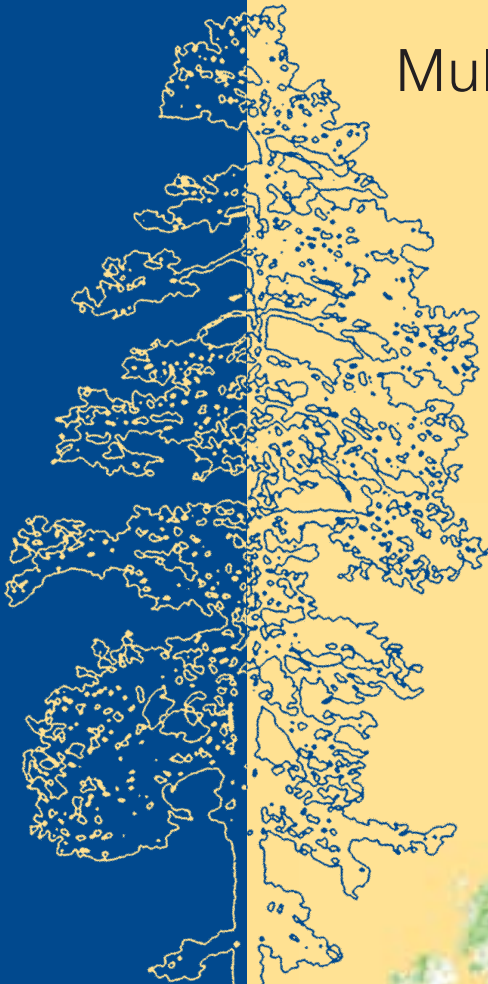


CarboInvent

Multi-Source Inventory Methods for
Quantifying Carbon Stocks
and Stock Changes in
European Forests



CarboInvent

is part of

CARBOEUROPE



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Rationale behind CarboInvent

- The United Nations Framework Convention on Climate Change (UNFCCC) aims at stabilizing the concentration of greenhouse gases (GHG) in the atmosphere. The Kyoto Protocol (KP) to the UNFCCC sets targets for limiting GHG emissions and requires the implementation of national systems for monitoring them. Forests play an important role in achieving these targets because they can be net emitters to, or removers of carbon from, the atmosphere.

- The IPCC has prepared Guidelines for Parties to the UNFCCC to compile inventories of GHG emissions and removals, including in agriculture, forestry and other land-use activities.

- When preparing these inventories, Parties should have in place a “national system” for GHG reporting which is based on sound science and follows the principles of transparency, consistency, and verifiability; while at the same time being “state-of-the-art”, as accurate as possible, and cost-effective.

- Currently, the GHG emissions and removals related to forestry activities are reported using information from National Forest Inventories (NFI), which were not designed to accurately assess the GHG budget of forests, but typically only focus on stemwood. The situation in Europe is further complicated by the heterogeneity of both NFI methods and approaches to extend NFI results to meet GHG inventory needs.

- Improving the completeness of GHG reporting at the EU level, as well as at the level of member states, requires integration of existing multi-source data and creation of new links between NFIs and the GHG reporting needs; for example through improved use of biomass expansion factors (BEFs) or regression techniques, integration of soil carbon monitoring systems, and through the use of remote sensing techniques.



Land cover changes surrounding the La Castanya field station (mediterranean forest) between 1890 (top) and 1990 (bottom)

CarboInvent Approach

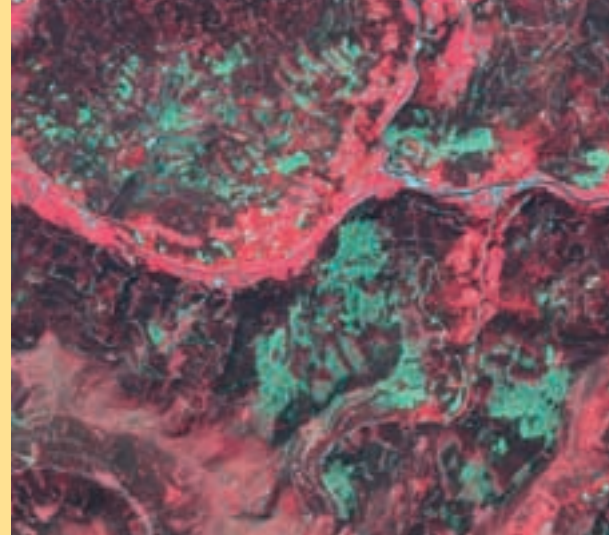
CarboInvent focuses on an improvement in the following areas:

Estimation of forest biomass

- Biomass expansion factors (BEFs) are used to calculate whole tree biomass (including tree tops, branches, foliage, and root biomass). CarboInvent will develop new BEFs and allometric functions. A database of these will be established for different species, species groups, forest types and regions. The integration with forest inventory will be demonstrated and sources of uncertainties will be assessed.

Soil carbon

- Soil carbon has so far received much less attention than carbon in above-ground biomass. The project will compile (and extend for test areas) existing European soil carbon inventory data, review soil models to estimate soil carbon pools for given depths and assess the cross-national and regional distribution of soil carbon.
- CarboInvent will develop a methodology for assessing soil carbon that can be combined with forest inventories and applied to countries lacking representative soil data (Soil Carbon Reference Database). It will also develop monitoring standards to detect soil carbon stock changes due to land-use changes (such as afforestation, reforestation or deforestation), natural disturbances, and forest management.



SPOT5-satellite image showing storm damage (Austrian test area – damaged forests in green)

Remote sensing

- CarboInvent will provide methods for monitoring carbon in forested areas by assessing woody biomass through combined field and remote sensing methods. The main objectives are to reduce cost, to increase the accuracy of field measurements, and to interpolate/extrapolate existing forest inventories for GHG inventory years not covered by the NFI.
- Remote sensing methods will be developed for monitoring afforestation, reforestation, deforestation (ARD) activities, and forest disturbances. The methods will be based on the assessment of multi-temporal remote sensing imagery. Special consideration will be given to the applicability of the methods at regional and national levels.

Disturbances and forest management

- Disturbances and forest management activities are important factors influencing the carbon budget of forests. CarboInvent will review the state of knowledge on carbon dynamics following large-scale disturbances (e. g. wildfire, storm damage) in European forests and improve methods for monitoring the effects of disturbances and forest management on carbon stock changes using data from NFI and other forest monitoring systems. In a case study, the carbon losses following a storm disturbance over the course of 20 years, and the effects of different management activities hereon, will be assessed in a temperate spruce forest.



CarboInvent Approach

Integration of Methods

■ The **top-down integration** builds on aggregated forest inventory data at the national or regional level, such as NFIs or the European Forest Resource Database. These data are combined with biomass expansion factors to account for whole-tree biomass, and with soil carbon estimates from soil surveys in order to calculate carbon stocks and stock changes at regional and national levels, including an estimate of uncertainties. This will be done for six countries: Austria, Finland, Germany, Ireland, Spain and Sweden. Further, the effects of afforestation, reforestation, forest management and disturbances on carbon stocks in these countries will be estimated.

■ The **bottom-up integration** builds on forest inventory data at the plot level, such as tree diameter, height, or volume. These data will be used to obtain estimates of whole-tree biomass, and integrated with measurements of soil carbon. Remote sensing is used to interpolate between inventory plots, thus enhancing accuracy. With this method, the biomass-soil integration occurs at the local level, which allows full coverage of plot-level uncertainties and provides local estimates of carbon stocks and stock changes. The bottom-up integration will be done in test sites representative of the major forest regions of Europe (boreal – Finland, temperate – Germany, alpine – Austria, mediterranean – Spain). The integration methods must allow upscaling to the national level. Upscaling techniques will be investigated and their feasibility demonstrated in this project. The results will include improved and demonstrated methods for setting up GHG inventories of forest land, including an estimate of uncertainties.

■ The Kyoto Protocol (KP) requires integrated reporting on afforestation, reforestation, deforestation, and forest management activities, as well as for “Joint Implementation” projects under the KP. To facilitate meeting this requirement, data-needs and methodologies for monitoring of these activities will be assessed with a view of improving their efficiency and feasibility. The methodologies for estimation of “Kyoto carbon budgets” and associated uncertainties will be tested at sites in Ireland and Hungary.



Advanced computer-aided system are used in field data collection and mapping of boreal forest



Biomass data collection in temperate forest: significant human effort is needed for collection of data on tree components not covered by forest inventories.

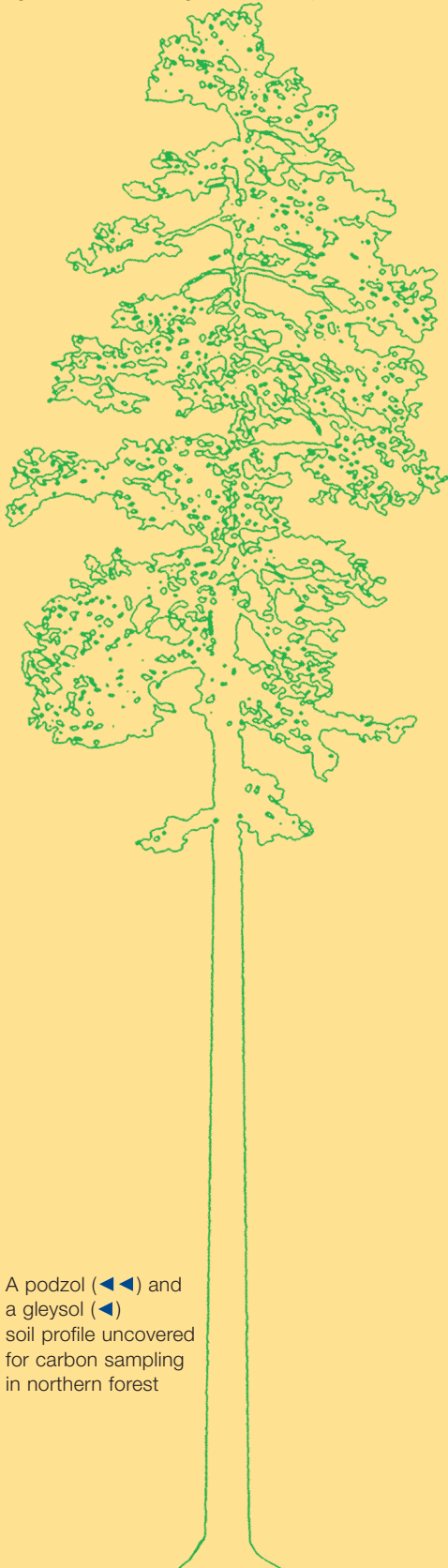




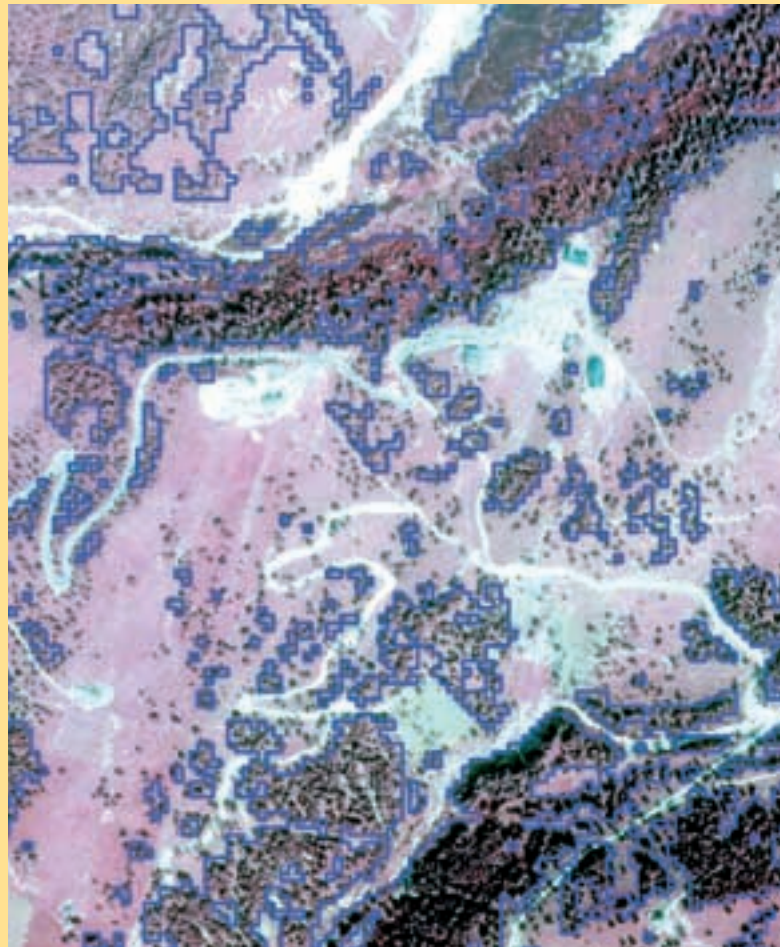
Regeneration following harvest in Alpine forest



Tops and branches (and roots) create a significant part of tree biomass, thus BEFs are needed to account for whole tree biomass when using forest inventory data



A podzol (◀◀) and a gleysol (◀) soil profile uncovered for carbon sampling in northern forest



Forest/non-forest distribution pattern derived from Satellite Imagery

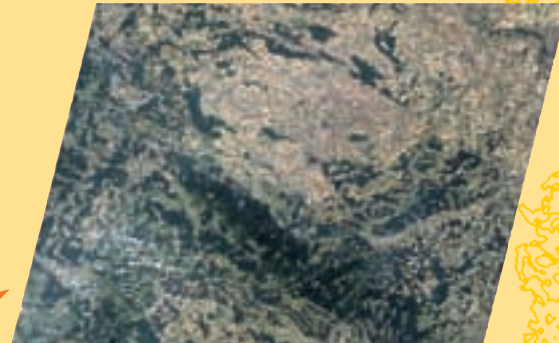
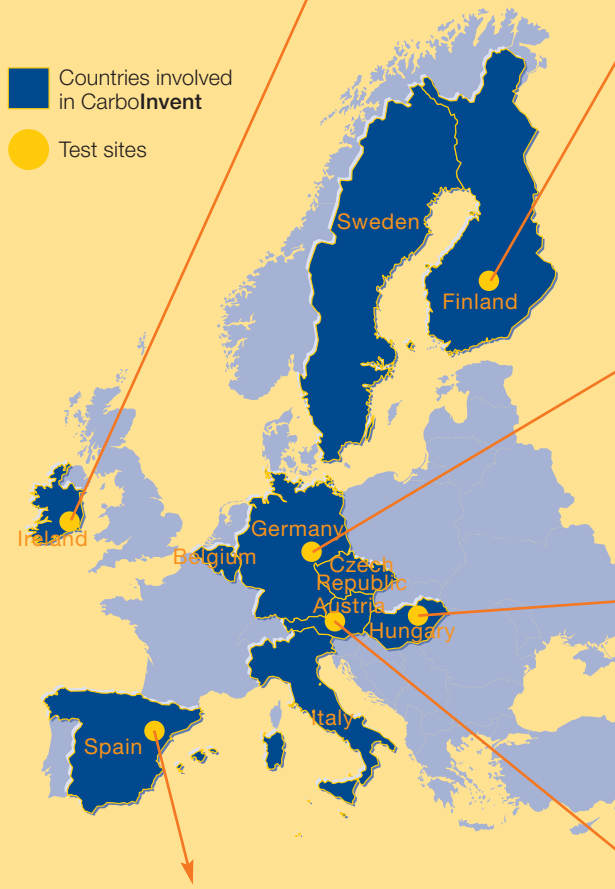
CarboInvent Test Sites



Afforestation of Sitka Spruce on previously agricultural land



Lappeenranta test site representative of boreal forests dominated by Scots Pine, Norway Spruce and birch



Thuringia test site (temperate region), Landsat TM Scene (Data provider: DLR, German Aerospace Center)



Afforestation with Black Locust at test site representative of Great Hungarian Plains



Manipulation experiment on a *Quercus ilex* coppice performed at a test site in Catalonia



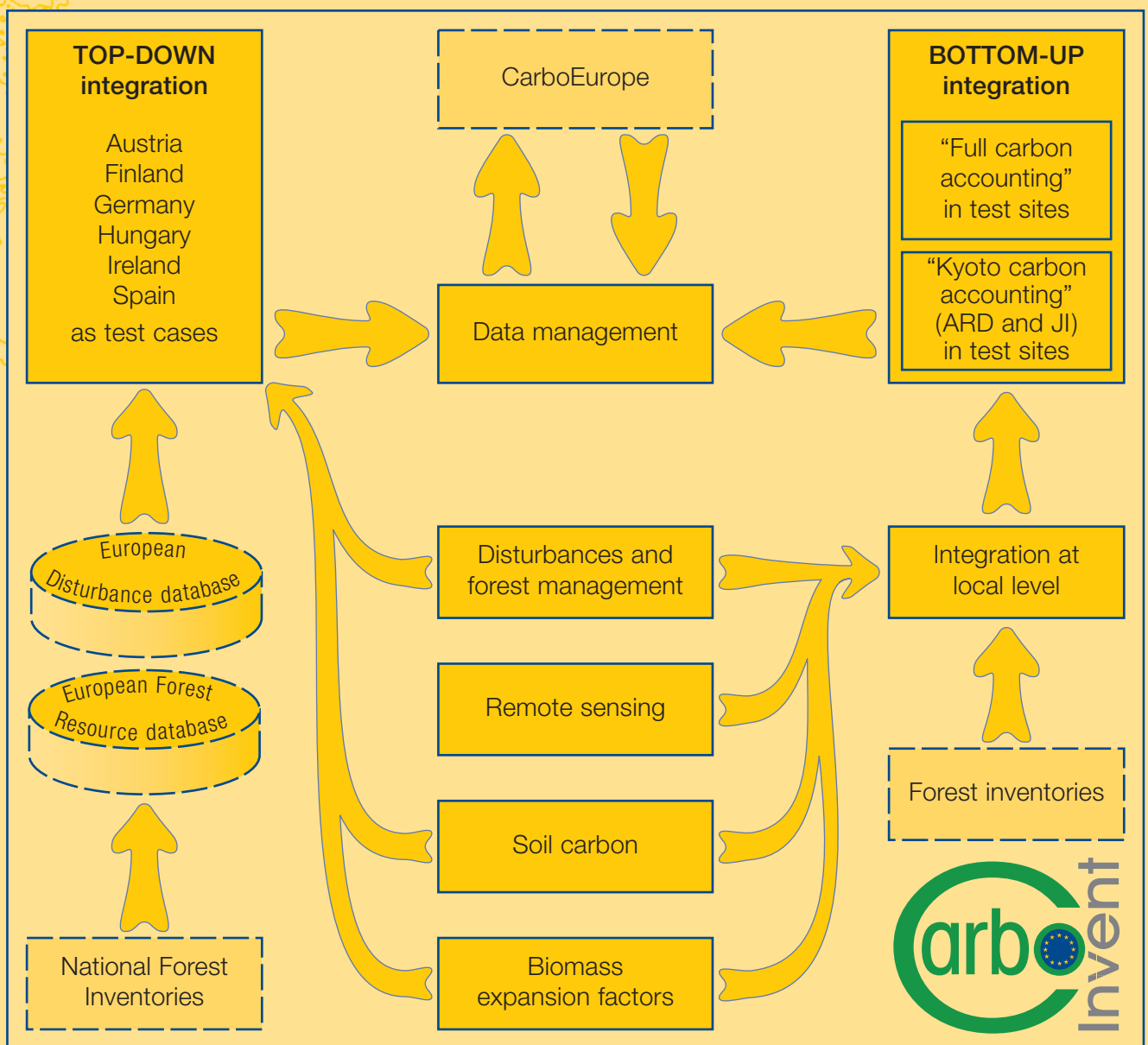
"Sengengebirge" test site in Upper Austria representative of central European mountainous area

Innovative methods of integrating multi-source inventory data for forest lands are applied in test sites representative of different climatic zones, including lands that are subject to "Kyoto activities" in Europe. The test sites are used for:

- (1) developing and applying trials of remote sensing and inventory based methods for monitoring carbon budgets in forests, taking into account disturbances as well as forest management, afforestation, reforestation, and deforestation activities;
- (2) demonstrating that the developed approaches can be upscaled to the national level.



CarboInvent Components



Solid boxes correspond to Work Packages in the internal structure of CarboInvent. Dotted boxes correspond to structures external to CarboInvent.

CarboInvent provides methodologies for combining different data sources and methods towards an improved estimation of carbon stock changes in forests at the national and European levels, for the purposes of the United Nations Framework Convention on Climate Change, and the Kyoto Protocol. The methodologies obtained within CarboInvent will be useful to national inventory agencies, allowing an improved quality of national/EU level GHG reporting.

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