CARBON CALCULATION PROTOCOL

WP 4 Pilot project implementation

Activity 4.2 Pilot project preliminary actions

GECO2 – Green Economy and CO2

Safety and resilience | SO 2.1

Work Package:	**4. Pilot project implementation**
Activity:	**4.2 Pilot project preliminary actions**
Phase Leader:	**ARPAE**
Deliverable:	**Carbon calculation protocol**

Version:	**Final**	**Date:**	**February 25, 2021**
Availability:	Public		
Responsible Partner:	**ARPAE**		
Editor:	Antonio Cinti, Antonio Volta		
Contributors:	Leonardo Marotta		

Table of contents

GeCO2 Carbon Calculation System

1. Introduction

GECO2 Carbon calculation system consists in a set of tools made in order to support the calculation of carbon stocks (credits) and emissions (debts or carbon footprint).

Protocol explains the principles on which carbon farm balance (limited to the project selected fields), carbon credits and carbon debts (carbon footprint for credit buyers) are estimated.

This protocol is one of the 3 GECO2 project operational documents:

a. Farm cultivation;

b. Calculation system;

c. Market (including farms contract and plan).

GECO2 carbon calculation system has been set up with reference to three different goals:

a. definition of carbon experimental field(s) budget chosen by the farmers;

b. estimation of seller's carbon balance (including farmer's field emissions and removals) based on presumptive impact of the project selected practices. The calculation will take into account specific buffers in order to reduce errors and uncertainties.

c. evaluation of the amount of carbon credits produced per each field (and per each farm), deriving from the application of GECO2 agricultural carbon sinking practices;

d. estimation of buyer's carbon footprint in order to offset a selected part of his organization/activity. The carbon offsetting can be defined by the buyer according to a single product or service, to a production line or the entire company. Carbon emissions are offset by purchasing carbon credits.

Carbon calculation scheme takes into account objectives, available resources and limits of GECO2 Project.

The concept of additionality[1] is used within the time limits of the project[2], the duration of the project and the subsequent implementation of the carbon local market. Additionality principle is based on the presumption and on the application of a forecasting model of carbon stock. This approach overcomes the time limits and it is in line with GECO2 main objective, i.e. the experimentation of a voluntary market in the agricultural system.

In order to properly apply the calculation principles and to develop speed and ease calculation procedures for all the involved actors, GECO2 has developed an *ad hoc* informatic on-line tool, a carbon calculator. This tool has been prepared in two different versions: the first for farmers (CAFÉ, CArbon Fixing Elaborator), in order to calculate both, their CO2e sequestration potential balance and the number of credits produced; the second (COFFEE, Carbon Offsetting Emissions Elaborator), for credits buyers, with the aim to estimate quantity of CO2e debts to be offset[3].

---

[1] Additionality is an essential criterion for credits in all standards and schemes, with the follow definition: A credit is considered additional if the emissions reduction that underpins the credit would not have occurred in the absence of the activity that generates the credit.

[2] World Bank. 2016. "Carbon Credits and Additionality: Past, Present, and Future." PMR Technical Note 13. Partnership for Market Readiness, World Bank, Washington, DC. License: Creative Commons Attribution CC BY 3.0 IGO. Available at:
https://openknowledge.worldbank.org/bitstream/handle/10986/24295/K8835.pdf?sequence=2%26isAllowed=y

[3] Carbon market instruments fall essentially into two categories: cap-and-trade (C-T) and baseline-and- credit (B-C) instruments. Under the former, units are issued to installations or entities included under the cap by an administrator, and entities are meant to surrender a specified quantity of units to offset/ compensate their emissions. Units represent therefore an "allowance" to emit that is usually denominated in metric tons of CO2e. In a B-C scheme, units are earned from a calculation of the difference of emissions between a baseline scenario (that is, that which would have occurred in the absence of the scheme itself) and the actual prevailing (or "project") scenario. If that calculation yields a reduction between baseline scenario emissions and project emissions, these emission reductions accrue to the entity responsible for the action. They represent therefore a "credit."

It is important to understand that "offset" refers to a particular use of either "allowances" or "credits." If an allowance is used to offset emissions elsewhere in a cap-and-trade scheme, it becomes effectively an "offset." If a "credit" coming from a B-C scheme is used to demonstrate achievement of emission reductions under a payment-for-results scheme, emissions credited may indeed end up failing to offset any emission increase elsewhere. Instead, most professionals tend refer to "offsets," which are effectively the products of baseline-and-credit schemes.

2. Project principles included in the calculation system

Principles adopted for the calculation system imply a set of assumptions.

These assumptions, in line with objectives and time limits of the project, were built on scientific guidelines and literature.

Literature data, previously developed, are used in order to overpass the time and budget limits of the project.

The principal goal is to set up and test an agriculture-based carbon market in a limited time.

In this experimental market frame, GECO2 has created a simple tool to calculate the carbon uptake due to agricultural practices and the carbon emission due to production emitting subjects (which have not already calculated their carbon footprint).

For the purpose of the project, carbon uptake in soil and biomass is transformed into carbon dioxide equivalent, and this into carbon credit/offset.

The principles on which GECO2 schemes are based on the main international offset's standards.

Geco2 standard comprehends the following characteristics[4]:

a. Additionality.

Carbon reduction would not have happened without the offset.

b. Permanence.

Reduction will continue for the entire certification period of the offset.

c. Absence of Leakage.

4 Richard Kim and Benjamin C Pierce, 2018. Carbon Offsets, An Overview for Scientific Societies, UPenn CIS, June 24, https://www.cis.upenn.edu/~bcpierce/papers/carbon-offsets.pdf

Implementing an offset policy in one place must not lead to a relocation of those emissions in another place (e.g., wood is protected in one location, and lumber companies cut a forest down elsewhere).

d. Verification.

The above characteristics will be verified by Geco2 Project Management.

Furthermore, the GECO2 calculation mechanisms are based on the following construction principles:

- Conservation and prudence.

The data used for the calculation are based on the minimum values of carbon storage. A buffer is used in order to reduce the error. The criterion of prudence is expressed in the carbon stocks and sinks chosen calculation methods and through the definition of buffers in calculating credits from agricultural systems. Conservativeness principles imply the use of conservative assumptions and the use of values and procedures able to ensure that a specified emission/reduction/sequestration would not be overstated.

- Use of buffers

In order to apply the above mentioned principles of conservation and prudence is foreseen the implementation of two different types of buffers related to the accumulation of carbon in soil and biomass.

Both have a sigmoid function that grows according to the number of practices implemented, starting from a minimum value and extending to an asymptotic maximum value for infinite practices adopted.

The buffer codes implemented in the calculator are the following:

Soil buffer:

3 Practices: 0.68 (approx. 0.7);

11 practices: 0.94 (approx. 0.9)

Woody biomass buffer:

3 practices: 0.8;

11 practices: 0.9.

- Scientific approach (completeness, use of literature data).

The adopted presumptive criteria model the future carbon storage in the farm ecosystem starting from a baseline and through the calculation of the carbon stored in the field. In the calculation, the local climate trend is assumed.

Completeness and application of environmentally relevant data, including the Life Cycle criteria (carbon footprint is calculated from the cradle to the field) and the inclusion of fertilizers, soil improvers and pesticides, assures a technical systemic fully integrated approach. Calculators have been created in order to make operational calculation of credits easier within a scientific logical framework. The calculation method applied to carbon sinks and sources is based on ISO 14064-1 international standards.

- Use of real farm data**.**

Calculation system is based on soil data and biomass assessment. For each experimental farm field, a base line is computed. Baseline refers to field data.

- Conformity to the environmental context.

The implemented model, applied to the farm calculator, includes farm and field data (history of the cultivation system, erosion, hedge and rows, natural patches, still erosion and watering processes).

3. Structure of the calculation system

Carbon balance is calculated (in a preliminary way and with the addition of practices) through the use of the online carbon calculator.

Carbon balance, following the ISO 14064-1 and ISO 14064-2 includes:

a. direct emissions;

b. indirect emissions;

c. biogenic emissions and removals (only for organizations producing credits, i.e. farms).

3.1 Carbon calculator for farmers (sellers)

CAFÉ has two different aims:

- Calculation of the carbon balance. In particular the tool allows to evaluate and to assess the current carbon budget of the farms, in the selected fields (farm patches) chosen by farmers wishing to participate to GECO2 who meet the basic conditions required by the project;

- Definition of CO2e credits per farm field, and per hectare. Each credit is calculated in tons of equivalent carbon dioxide sequestered. These credits will be registered in the GECO2 database. A specific offset registry is a part of this database. The registry is a system for reporting and tracking offset project information including project status, project documents, credits generated, ownership, sale, and retirement.

The principles of calculation find its application in the calculator structure.

Calculation scheme of the GECO2 calculator (CAFÉ) is based on an algorithms system.

The algorithm system is built in a modular form to determine, at the field level, the greenhouse gas emissions produced by the farm and its practices, the loss of carbon due to erosion and the accumulation of carbon instead due to the sustainable practices applied.

In addition to that, calculator has the objective of evaluating the carbon credits. Credits are produced by the agricultural organization (farm).

In order to exploit calculator functions, input forms must be filled in by farms. Model (algorithms), on which the calculator was designed, estimates the corporate carbon credits /debts, in connection with the farm data and the answers provided.

At the end of the computation, a budget is determined, specifying which procedural components have the most impact on the final result.

Emissions are calculated considering the following five categories:

1) CO_2 emissions due to energy consumption (fuel and electricity);

2) CO_2 emissions due to the production of pesticides then applied in the field (the emissions of the application are not considered here because they fall within the first point);

3) CO_2 emissions due to the production of the fertilizers used (the emissions of the application are not considered here because they fall within the first point). N_2O, NO and NH_3 emissions due to the application of nitrogen fertilizers in relation to the management and type of soil (texture, pH, drainage, etc.) following the Bowman model;

4) CO_2, N_20, CH_4 emissions due to the management of crop residues;

5) CO_2 emissions due to carbon oxidation in the soil due to field management practices.

Carbon loss is estimated by calculating the amount of soil lost due to erosion with a RUSLE equation (acronym for Revised Universal Soil Loss Equation).

Factors influencing RUSLE are: annual rainfall, field slope, soil texture, land cover and agricultural practices.

Carbon budget is calculated considering two different pools:

The carbon stored in the soil (underground part):

1) Type of soil management (forest, stable meadow, grassy orchard or field with worked land);

2) Type of tillage (conventional, minimum tillage, no tillage);

3) Use of cover crops in the period in which the crop is at rest (cover crops);

4) Application of organic amendments with a non-negligible organic carbon content;

5) Release or not of crop residues in the field (woody, herbaceous);

6) Annual increase of root biomass;

The carbon stored in the topsoil (epigeal part):

1) Calculation of the increase of the woody system following a tabular method for which each species has a specific annual growth of biomass.

2) With this growth, the carbon lost from any pruning or removal of trees from the orchard is reduced.

Appendix A shows in detail the information collected by the farmers calculator (CAFÉ).

The calculation of CO2e absorptions and of the credits produced by the farm, follows these assumptions:

1) The number of conservative practices adopted is calculated. If this number is less than 3, the credit is void. Otherwise the credit is considered eligible and will depend on the stored epigeal and hypogeal carbon.

2) The credit is determined by multiplying each carbon pool by its weight which is calculated on the number of conservative practices adopted and on the age of the plant. The weight is determined with a non-linear (sigmoid) equation.

3.2 Calculator for buyers (offset energy emissions)

COFFEE is a tool that estimates buyer's carbon footprint.

It registers buyers' data and their carbon footprint (for selected activities and /or production of goods and services)[5]. In case that buyer's carbon footprint was not available this tool allows the definition and the assessment of global energy emissions, and in particular the quantity of GHG emissions that buyer can offset. The calculation can be linked to the selected activities to be offset, in compliance with marketing choices made by the buyers.

Calculation system for buyers is structured in an operation tool (COFFEE). The calculator acquires data for calculating carbon debts. If the company holds an LCA / carbon footprint for a product, line, firm it wants to evaluate, then the LCA value is considered as a carbon debt to be covered by the purchase of credits from farms included in the GECO2 project. In order to purchase offsetting credits, buyers must provide the value of their carbon footprint. If a buyer does not have a certified LCA or carbon footprint, GECO2 has introduced an *ad hoc* tool. The calculator evaluates the emissions due to energy consumption of a single product, or of a production line or of the entire company (depending on the choices of the buyer). For the energy part the buyer's algorithm reads the same database used for farmers.

Energy consumption is assessed on the basis of both fuel and electricity consumption.

Each fuel used must be declared with the respective unit of measurement (liters if liquid; kilograms if solid or methane). Each fuel is associated with a conversion factor that transforms consumption into CO_2 equivalent emissions.

As regards electricity, it must be specified whether it is taken from the grid or self-produced through renewable plants. In the case of energy from the grid, it will be necessary to declare the percentage of renewables of the own operator (this data must be present in the bill by law). If this data is not available then the algorithm applies the national average renewable share.

An emission conversion factor is attributed per unit of electricity based on the production method.

[5] Per each buyer the carbon footprint is defined through a standard. This standard includes protocols/methodologies and guidance documents. These standards provide guidance and/or specifications on GHG (green house gases) quantification, monitoring, reporting. Stand-alone standards typically do not have an associated regulatory body that registers projects and also do not typically have registration and enforcement systems to track and ensure legal ownership of offset credits (e.g., ISO 14064-2).

Appendix B contains the information collected by the buyer's calculator.

Appendix A: Farm data for GeCO2 project

a. general data (carbon calculator questions 1 - 11)

Company data are collected in this section of the input form.

The calculator takes into account the experimental field and its slope in the calculation of soil carbon loss using RUSLE[6] equation[7]. RUSLE equation is used consistently within the European framework[8].

Each different experimental field for each company is labeled and considered through a sorting number. Each field has its own carbon balance and gives rise to the production of carbon credits.

b. climate data (carbon calculator questions 12 - 15)

In this section climate data are collected in order to define the carbon loss by weathering process:

Annual average temperature in C°

Annual rainfall (mm)

Reference Annual Evapotranspiration ET0[9] (mm)

---

[6] Renard, K., Foster, G., Weesies, G., McCool, D., and Yoder, D., 1997. Predicting soil erosion by water: a guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE). Agricultural Handbook No. 703. http://doi.org/DC0-16- 048938-5 65–100.

[7] Panagos, P., Borrelli, P., Meusburger, K., Yu, B., Klik, A., Jae Lim, K., and Ballabio, C. (2017). Global rainfall erosivity assessment based on high-temporal resolution rainfall records. Sci. Rep., 7(1), 4175. https://doi.org/10.1038/s41598-017-04282-8.

[8] https://esdac.jrc.ec.europa.eu/themes/rusle2015, Panagos, P., Borrelli, P., Robinson, D.A. Common Agricultural Policy: Tackling soil loss across Europe. Nature 526, 195 (07 October 2015), doi:10.1038/526195d

[9] Reference crop evapotranspiration or reference evapotranspiration, denoted as ETo. The reference surface is a hypothetical grass reference crop with an assumed crop height of 0.12 m, a fixed surface resistance of 70 s m-1 and

Climatic Water Balance[10] (mm/year)

c. soil data (carbon calculator questions 16 - 24)

In this section soil data are collected in order to define the carbon gain and loss:

Soil depth[11];

Soil drainage properties;

Soil pH[12];

Soil texture[13];

---

an albedo of 0.23. The reference surface closely resembles an extensive surface of green, well-watered grass of uniform height, actively growing and completely shading the ground. The fixed surface resistance of 70 s m-1 implies a moderately dry soil surface resulting from about a weekly irrigation frequency. see also: https://edis.ifas.ufl.edu/pdffiles/ae/ae45900.pdf

[10] The climatic water balance (CWB) is defined as the difference between precipitation depth and the depth of potential evapotranspiration at a given site during a certain time period.

[11] Soil depth is defined as the unconsolidated material immediate the surface of the earth serves as natural medium for the growing plants. Soil depth defines the root space and the volume of soil from where the plants fulfil their water and nutrient demands.

[12] Soil pH is a measure of the acidity or basicity (alkalinity) of a soil. Soil pH is a key characteristic that can be used to make informative analysis both qualitative and quantitatively regarding soil characteristics. Most soils have pH values between 3.5 and 10. In higher rainfall areas the natural pH of soils typically ranges from 5 to 7, while in drier areas the range is 6.5 to 9.

[13] Soil texture (such as sandy, loam, sandy loam or clay) refers to the proportion of sand, silt and clay sized particles that make up the mineral fraction of the soil. Coarse-grained soils (CGS) which contain 50 percent or less of fines; Medium soil (Loam) which contain 50 percent or less of silt and sand; Fine-grained soils (FGS) which contain more than 40% percent clay is more than 40%: i.e. lays feel slightly sticky and dense; they feel smooth (not gritty) when a piece is rubbed between finger and thumb; a moist fragment can be rolled into a ball and then into sausage shape with no cracking. If, after being rolled into a clay sausage the moist surface becomes shiny when rubbed, it is likely that the soil is especially rich in clay and is termed a ‘heavy clay’

Soil organic matter[14];

Soil skeleton[15];

Available Water Capacity (in mm);

Total Nitrogen in soil;

C/N ratio.

d. crop and field management data (carbon calculator questions 25 - 46)

The description of the single field allows the calculator to evaluate the carbon balance considering the presence of crops, other vegetation and field management practices.

Type of crop;

Density of trees in the present year (no./ha)

Density of trees (increase/decrease) ;

Cobbles: particles with a diameter larger than 75 mm;

Gravel: particle sizes from 4.75 to 75 mm;

Sand: particle sizes from 0.075 to 4.75 mm;

Silt: particle sizes between 0.002 mm and 0.063 mm

Clay: particles smaller than 0.063 mm.

see: http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e11.htm

[14] Soil organic matter is any material produced originally by living organisms (plant or animal) that is returned to the soil and goes through the decomposition process. At any given time, it consists of a range of materials from the intact original tissues of plants and animals to the substantially decomposed mixture of materials known as humus.

[15] Soil skeleton, also known as rock fragments is the fraction of soil particles greater than 2 mm.

Orchard/Vineyard age;

Tree/vine DBH (cm DBH= Diameter at Breast Height, namely 130 cm) ;

Organic management;

Area managed through no-tillage;

Area managed through minimum-tillage;

Area where winter cover crops;

Permanent grass or grassed orchard/grassed vineyard;

Forestry crop area;

Sparse vegetation, shrubs, hedges;

Above ground woody residue dry weight treatment;

Woody Residue treatment;

Above ground green residue dry weight treatment;

Green Residue treatment.

e. agronomic input data (carbon calculator questions 47 - 79)

The description of the single field management allows the calculator to evaluate the carbon balance considering agronomic management practices.

Cumulated weight of active principles of applied pesticides;

Fertilizers;

Product application rate for fertilizer;

Application method;

Emissions inhibitors for fertilizer;

Amendment;

Product application rate for amendment;

Application method for amendment;

Emissions inhibitors for amendment;

e. energy data (carbon calculator questions 80 - 94)

The use of energy, which must be evaluated for the single field and not for the whole farm, allows to evaluate the direct and indirect emissions of greenhouse gases.

Use of fuels;

Use of electric energy.

f. farming project (carbon calculator questions 95 - 98)

Number of practices used in farm management in the frame of GECO2, specifying the following conditions:

- which practices are already in use in farm management (before participation in GECO2);
- which management improvements will be implemented for the GECO2 project;
- which management practices and improvements will be continued and implemented after GECO2 conclusion in order to maintain and increase soil organic carbon.

Appendix B: Buyer data for GeCO2 project

a. general data (carbon calculator questions 1 - 11)

Emitting organizations data are collected in this part of the calculator. Offsetting organizations have to provide their carbon footprint, calculated according to the part that would offset, and eventually the energy data (for the carbon footprint of energetic systems, if the carbon footprint were not previously calculated)

b**. energy data**

The use of energy, allows to evaluate the direct and indirect emissions of greenhouse gases.

Use of fuels;

Use of electric energy.

Appendix C: Bibliographical references

● Altieri, M.A. 1987. Agroecology: the scientific basis of alternative agriculture. Westview Press, Boulder, 227 p.

● Dallimer, M. L. C.Stringer, 2018. Informing investments in land degradation neutrality efforts: A triage approach to decision making Environmental Science & Policy, 89, 198-205.

● European Commission, 2020. Carbon Farming Schemes in Europe - Roundtable Background document. https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/events/documents/carbon-farming-schemes-roundtable-background_en.pdf

● European Union, 2011. Soil: the hidden part of the climate cycle. Publications Office of the European Union, Luxembourg, 20 p.
https://ec.europa.eu/clima/sites/clima/files/docs/soil_and_climate_en.pdf

● FAO, 2017. Soil Organic Carbon: the hidden potential. Food and Agriculture Organization of the United Nations Rome, 77 p. http://www.fao.org/3/a-i6937e.pdf

● IPCC, 2005. IPCC Special Report on Carbon Dioxide Capture and Storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change. In: Metz B, Davidson, O., H. C. de Coninck, M. Loos, and L. A. Meyer (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 442 pp, https://www.ipcc.ch/site/assets/uploads/2018/03/srccs_wholereport-1.pdf

● LaCanne, C & Lounger, J. 2018. Regenerative agriculture: Merging farming and natural resource conservation profitably. PeerJ. 6. e4428. 10.7717/peerj.4428.

● Lal, R., 2011a. Soil carbon sequestration, SOLAW Background Thematic Report - TR04B, Fao, Rome, http://www.fao.org/fileadmin/templates/solaw/files/thematic_reports/TR_04b_web.pdf

● Lal, R. 2011b. Sequestering Carbon in Soils of Agroecosystems. Food Policy 36: S33–S39.

● Lengnick, L. 2015. Resilient agriculture: cultivating food systems for a changing climate. Gabriola Island New Society, Gabriola Island, 288 p.

● Leno, N., 2020. Soil Carbon Sequestration: Basis & Basics. Tarakeswar, London, 52 p. 10.9734/bpi/mono/978-93-89816-36-5.

● Machmuller, M. B., Kramer, M. G., Cyle, T. K., Hill, N., Hancock, D. & Thompson, A. 2015. Emerging land use practices rapidly increase soil organic matter. Nature Communications, 6, 6995. https://www.nature.com/articles/ncomms7995 DOI:10.1038/ncomms7995

● Melvani, K., 2012. Handbook for Regenerative Agriculture http://www.silc.com.au/wp-content/uploads/2012/11/NSRC-ENG-Complete-Handbook-with-covers-smaller1.pdf

● Merfield, C. N. 2019. An Analysis and Overview of Regenerative Agriculture. The Biological Husbandry Unit Organics Trust, Report number 2-2019. The BHU Future Farming Centre, Lincoln. http://www.bhu.org.nz/future-farming- centre/ffc/information/misc/an-analysis-and-overview-of-regenerative-agriculture-2019-ffc- merfield.pdf

● Minasny, B., Malone, B. P., McBratney, A. B., Angers, D. A., Arrouays, D., Chambers, A., Chaplot, V., Chen, Z.-S., Cheng, K., Das, B. S., Field, D. J., Gimona, A., Hedley, C. B., Hong, S. Y., Mandal, B., Marchant, B. P., Martin, M., McConkey, B. G., Mulder, V. L., O'Rourke, S., Richer-de-Forges, A. C., Odeh, I., Padarian, J., Paustian, K., Pan, G., Poggio, L., Savin, I., Stolbovoy, V., Stockmann, U., Sulaeman, Y., Tsui, C.-C., Vågen, T.-G., van Wesemael, B. & Winowiecki, L. 2017. Soil carbon 4 per mille. Geoderma, 292(Supplement C), 59-86.

● Muñoz, Pablo., 2018. Investing in Land Degradation Neutrality: Making the Case. An Overview of Indicators and Assessments. Bonn, Germany. ttps://www.researchgate.net/publication/328461280_Investing_in_Land_Degradation_Neutrality_Making_the_Case_An_Overview_of_Indicators_and_Assessments_Bonn_Germany

● Rhodes, C. 2012. Feeding and healing the world: Through regenerative agriculture and permaculture. Science progress. 95. 345-446. 10.3184/003685012X13504990668392.

● Soussana, J.-F., Lutfalla, S., Ehrhardt, F., Rosenstock, T., Lamanna, C., Havlík, P., Richards, M., Wollenberg, E., Chotte, J.-L., Torquebiau, E., Ciais, P., Smith, P. & Lal, R., 2019. Matching policy and science: Rationale for the ‘4 per 1000 - soils for food security and climate’ initiative. Soil and Tillage Research, 188, 3-15.

● The World Bank. 2012. Carbon sequestration in Agricoltural Soils. Report n.: 67395-GLB, The World Bank. Washington, D.C., 84 p. http://documents1.worldbank.org/curated/en/751961468336701332/pdf/673950REVISED000CarbonSeq0Web0final.pdf

● Wezel, A., Soldat, V. , 2009. A quantitative and qualitative historical analysis of the scientific discipline agroecology. International Journal of Agricultural Sustainability 7 (1): 3-18.

● Wojtkowski, P. A. 2002. Agroecological Perspectives in Agronomy, Forestry and Agroforestry. Science Publishers Inc., Enfield, New Hampshire, 356p.

● Zhu, Zhiliang, ed., Bergamaschi, Brian, Bernknopf, Richard, Clow, David, Dye, Dennis, Faulkner, Stephen, Forney, Wil- liam, Gleason, Robert, Hawbaker, Todd, Liu, Jinxun, Liu, Shuguang, Prisley, Stephen, Reed, Bradley, Reeves, Matthew, Rollins, Matthew, Sleeter, Benjamin, Sohl, Terry, Stackpoole, Sarah, Stehman, Stephen, Striegl, Robert, Wein, Anne, and Zhu, Zhiliang, 2010, A method for assessing carbon stocks, carbon sequestration, and greenhouse-gas fluxes in ecosystems of the United States under present conditions and future scenarios: U.S. Geological Survey Scientific Investigations Report 2010–5233, 188 p. (Also available at http://pubs.usgs.gov/sir/2010/5233/.) (Supersedes U.S. Geological Survey Open-File Report 2010–1144.)