LIFE Project Number

<LIFE15 ENV/IT/000641>

Deliverable "Report on project transferability to others sectors"

Sub-action B4.5 "Evaluation of project transferability to others sectors "

LIFE+ PROJECT Soil4Wine

Table of contents

1. Introduction: Project overview

Soil4Wine project "*Innovative approach to soil management in viticultural landscape*" aims at achieving a better soil management in the whole viticultural ecosystem developing and testing an innovative Decision tool and management solutions tested in farm in Project area and Europe. Moreover, soil ecosystem services have been assessed and financial opportunities have been explored.

This deliverable presents the structure and main outcomes of sub-action B4.5 related to Soil4Wine project Action B.4 "Economic, social and policy evaluation" from M30 (01.07.2019) until M35 (30.11.2019).

ART-ER is the responsible for this action, while other partner involved is UCSC.

Aim of this sub-action is to assess, on the basis of previous demonstrative actions, the possibility to extend to other fruit tree orchards the tools developed in the project.

The transfer potential from vineyards to other orchard systems have been related to the following items:

- tackled soil threats
- cultivation techniques and soil management practices
- ecosystem services (ES) descending from cultivation techniques
- applicable payments for ecosystem services (PES).

A matrix has been elaborated to define transferability among wine industry and other sectors, tackling the above mentioned items. Moreover, some maps have been created to describe the transfer potential considering a regional scale. A focus on carbon sequestration has been developed, leading to scenarios linked to the application of sustainable agricultural techniques.

2. Transferability matrix

The transfer potential has been analyzed considering the following crops:

- Peach
- Apple
- Hazelnut
- Olive
- Citrus.

In the next page a matrix expressing the transferability of some items applied in the pilot vineyards is shown.

For each cell a color scale defines the applicability of the item:

	Applicable item
	Conditioned applicability of item
	Not applicable item

A qualitative evaluation of the potential accompanies the applicability:

+ item more effective or relevant in comparison to grape

- item less effective or relevant in comparison to grape

= change not relevant or not valuable

		PEACH	APPLE	HAZELNUT	OLIVE	CITRUS
soil threats	Erosion	-	+	+	++	=
	low/limited soil organic matter content	+	+	++	++	++
	compaction	+	+	++	=	=
	hard pan	=	+	-	=	=
	drought	+	+	+	++	+
	water logging	++	-	-	=	=
	loss of biodiversity	=	=	=	=	=
agronomical practices	spontaneous permanent grass	+	+	-	--	=
	non-permanent grass	=	=	+	++	+
	artificial permanent grass	-	-	-	-	--
	green manure	+	=	+	++	+
	underground drainage	+	=	=	=	=
	surface water drainage	+	=	=	=	=
ecosystem services	erosion protection	-	+	-	=	=
	water regulation	=	=	-	-	=
	carbon sequestration	+	=	+	+	=
	biodiversity preservation	=	=	=	=	=
	landscape quality	-	-	-	=	=
PES	reclamation fee	-	+	=	=	-
	eco-label	=	=	=	=	=
	carbon credit market	+	=	+	+	=
	museum ticket	=	=	=	=	=
	tourist tax	-	-	-	=	=

In the following tables, a brief comment of the matrix is reported.

STONE FRUITS: PEACH

SOIL THREATS	
Erosion	The ES is not applicable as peach orchards are mainly located in plain areas where erosion risk is very low or absent.
Low/limited soil organic matter content	Loss of organic matter is a common problem in soil in which peach orchard are located.
Compaction	Due to repeated tillage often carried out with heavy machines thi is common soil threat. Threfore ES is applicable
Hard pan	Reiterated tillage can cause the problem, so ES is applicable
Drought	Water scarcity can be a threat in areas for peach tree cultivation.
Water logging	Strong attention has to be paid to water logging because Peach tree has high susceptibility to root anoxia. Plain areas in which orchards are located areprove to such a threat.
Loss of biodiversity	Biodiversity is strongly related to soil quality, so it could be threatened by mechanical operation and loss of organic matter.

AGRONOMICAL PRACTICES	
Spontaneous permanent grass	Spontaneous grass is frequently used to reduce water logging and increase infiltration rates. Conversely ita can increase water deficit.
Non-permanent grass	It should be used in presence of water scarcity.
Artificial permanent grass	As to economical and practical concerns, artificial grass is not used to cover soil in peach orchards. Spontaneous grass is preferred.
Green manure	It is advised to increase soil organic matter and to improve soil water retention capacity.
Underground drainage	Useful to reduce the risk of root anoxia.
Water drainage	Some as above.

ECOSYSTEM SERVICES	
Erosion protection	In consideration of the low/absent risk due to location of peach orchards, the ES is not applicable.
Water regulation	Neutral in comparison to grape.
Carbon sequestration	ES is applicable and potentially more relevant than grape because the woody mass is greater and green manure is more effective.
Biodiversity preservation	Neutral in comparison to grape.
Landscape quality	ES is applicable (see for instance aestetic effects related to the beautiful flowering) but potentially less relevant of grape because the vineyard has a higher perception in citizens and is more linked to local heritage.

PES	
Reclamation fee	If the ES is not applicable, so is the PES.
Eco-label	Neutral in comparison to grape.
Carbon credit market	PES is applicable and potentially more relevant than grape because the carbon stock in woody mass is greater.
Museum ticket	The applicability is the same as the grape, but the presence of a park museum is a not guaranteed condition.
Tourist tax	The PES is applicable but the perception of the link between the orchards and the landscape attractiveness is weaker than grapes.

POME FRUITS: APPLE

SOIL THREATS	
Erosion	Apple orchards are highly affected by erosion as they are often estabilished in hilly or sub-mountains areas.
Low/limited soil organic matter content	Loss of organic matter is a common problem in soil in which orchard are located..
Compaction	Due to mechanical operation compaction is a common problem in soil in which orchard are located, so ES is applicable.
Hard pan	Reiterated tillage can cause the problem, so ES is applicable.
Drought	Water scarcity can be a threat in areas for apple tree cultivation.
Water logging	Apple tree has a high tolerance to water logging that should not be considered a threat.
Loss of biodiversity	Biodiversity is strongly related to soil quality, so it could be threatened by mechanical operation and loss of organic matter.

AGRONOMICAL PRACTICES	
Spontaneous permanent grass	This solution is commonly used in apple tree orchards to enhance soil accessibility for mechanical operations
Non-permanent grass	It is advised in presence of water scarcity.
Artificial permanent grass	As to economical and practical concerns, artificial grass is not used to cover soil in apple orchards. Spontaneous grass is preferred.
Green manure	It could be use but effects on soil threats are neutral in comparison to grape.
Underground drainage	It could be use even if apple tree are less sensible to water logging and root anoxya as compared to other species.
Water drainage	It could be used to reduce erosion, woater logging and related problems but effects on soil threats are neutral in comparison to grape.

ECOSYSTEM SERVICES	
Erosion protection	The ES is applicable and more relevant in comparison with grape because apple orchards are mainly planted in sloping areas.
Water regulation	Neutral in comparison to grape.
Carbon sequestration	ES is applicable although exploitation occurs in the case of artificial grassing application, with a focused seed selection.
Biodiversity preservation	Neutral in comparison to grape.
Landscape quality	ES is applicable but potentially less relevant of grape because the vineyard has a higher perception in citizens and is more linked to local heritage.

PES	
Reclamation fee	The PES is applicable and potentially more relevant in comparison of grape because apple orchards are mainly planted in mountains.
Eco-label	Neutral in comparison to grape.
Carbon credit market	PES is applicable but it depends to the quality of grassing.
Museum ticket	The applicability is the same of the grape, but the presence of a park museum is a condition not guaranteed.
Tourist tax	The PES is applicable but the perception of the link between the orchards and the landscape attractiveness is weaker.

DRIED FRUIT: HAZELNUT

SOIL THREATS	
Erosion	Soil erosion in Hazelnut orchards could be a strong problem in
Low/limited soil organic matter content	Loss of organic matter is a common problem in soil in which orchard are located.
Compaction	Nuts harvest is made on the floor. Soil is never ploughed to avoid surface irregularity and transit of harvest machinery could cause compaction.
Hard pan	Soil is never ploughed to avoid problems during harvest operations, so deeply compaction is considered as minor problem.
Drought	Water scarcity could be a threat in areas for hazelnut cultivation.
Water logging	Water logging could be a threat in hazelnut orchards.
Loss of biodiversity	Biodiversity is strongly related to soil quality, so it could be threatened by mechanical operation and loss of organic matter.

AGRONOMICAL PRACTICES	
Spontaneous permanent grass	This practice is not applicable due to obstacle to grass growth caused by shading. Moreover nuts harvest require the absence of live material on the ground floor.
Non-permanent grass	Grass cover of soil during winter should be an interesting solution avoiding potential erosion risk.
Artificial permanent grass	Solution is not applicable due to need of bare soil during harvest
Green manure	Covering of soil during winter should be an interesting solution avoiding potential erosion risk and soil incorporation of biomass should enhance organic matter quality. Sowing and trimming period have to be considered with attention
Underground drainage	Solution applicable but effects are not significant.
Water drainage	Solution applicable but effects are not significant.

ECOSYSTEM SERVICES	
Erosion protection	Neutral in comparison to grape.
Water regulation	ES is not applicable because the grassing has a low use for hazelnut.
Carbon sequestration	ES is applicable and potentially more relevant of grape because the woody mass is greater and green manure is more effective.
Biodiversity preservation	Neutral in comparison to grape.
Landscape quality	ES is applicable but potentially less relevant of grape because the vineyard has a higher perception in citizens and is more linked to local heritage.

PES	
Reclamation fee	Neutral in comparison to grape.
Eco-label	Neutral in comparison to grape.
Carbon credit market	PES is applicable but it depends to the quality of grassing.
Museum ticket	The applicability is the same as the grape, but the presence of a park museum is a not guaranteed condition.
Tourist tax	The PES is applicable but the perception of the link between the orchards and the landscape attractiveness is weaker.

OLIVE TREE

SOIL THREATS	
Erosion	Usually soils in Olive groves, when terrain is accessible, are ploughed with high risk of water erosion.
Low/limited soil organic matter content	Olive groves are mainly planted in poor soils, usually rocky and in arid climate. Those factors enhance the lack of organic matter in soils.
Compaction	Soils in which olive trees are planted are usually rocky and so susceptibility to compaction is limited.In olive groves usually ploughed compaction could be considered a threat.
Hard pan	In ploughed soils hard pan could be a threat.
Drought	Olive groves are planted in poor soils and dry climate that is conducive to water scarcity.
Water logging	Olive tree is susceptible to water logging that can, in turn, cause problems of drought sensibility during summer due to shallow growth of root systems.
Loss of biodiversity	Biodiversity is strongly related to soil quality, so it could be threatened by mechanical operation and loss of organic matter.

AGRONOMICAL PRACTICES	
Spontaneous permanent grass	This practice is discouraged due to potential competition with olive trees for water. It should be possible only in case of presence of irrigation system. Usually only inter-row space is grassed.
Non-permanent grass	Temporary grass should be used in winter to avoid erosion risk and it has to be removed before olive trees flowering with trowel.
Artificial permanent grass	This practice should be use only in case of accurate selection of species, choosing ones with less water and nutrient demand and in presence of irrigation system. It is also important to consider the vegetative cycle of choosen species in order to reduce competition during olive reproductive phases. Usually only inter-row space is grassed and sowing is advised after 3-4 year after planting.
Green manure	Temporary grass should be used in winter to avoid erosion risk and it has to be buried before olive trees flowering.

Underground drainage	Practice applicable with positive effects on soil and plant
Water drainage	Practice applicable with positive effects on soil and plant

ECOSYSTEM SERVICES	
Erosion protection	ES is applicable but less relevant in comparison of grape because grassing is little used.
Water regulation	ES is applicable but less relevant in comparison of grape because grassing is little used.
Carbon sequestration	ES is applicable and potentially more relevant of grape because the woody mass is greater and green manure is more effective.
Biodiversity preservation	Neutral in comparison to grape.
Landscape quality	Neutral in comparison to grape.

PES	
reclamation fee	Neutral in comparison to grape.
eco-label	Neutral in comparison to grape.
carbon credit market	PES is applicable and the carbon stock could be greater than for grape.
museum ticket	The applicability is the same of the grape, but the presence of a park museum is a condition not guaranteed.
tourist tax	Neutral in comparison to grape.

CITRUS

SOIL THREATS	
Erosion	Citrus groves, if located in steep areas, are mainly arranged in terraces that avoid erosion risk.
Low/limited soil organic matter content	Loss of organic matter is a common problem in soil in which citrus orchard are located.
Compaction	Soils of Citrus orchards are usually not ploughed so this threat is not present
Hard pan	Same as above.
Drought	Citrus groves are traditionally irrigated so, even if in case of water scarcity, this problem it has already resolved.
Water logging	Not applicable
Loss of biodiversity	Biodiversity is strongly related to soil quality, so it could be threatened by mechanical operation and loss of organic matter.

AGRONOMICAL PRACTICES	
Spontaneous permanent grass	Grassing should be useful in orchards to enhance soil mechanical features and reduce erosion. Problems in case of water scarcity.
Non-permanent grass	Winter grass should be helpful for fruits harvest (Dec-Feb) as it enhance soil mechanical features.
Artificial permanent grass	Grassing should be useful in orchards selecting species with low water demand.
Green manure	Winter grass with early sowing should be helpful for fruits harvest (Dec-Feb) as it enhance soil mechanical features.
Underground drainage	Applicable with neutral effect
Water drainage	Applicable with neutral effect

ECOSYSTEM SERVICES	
Erosion protection	ES is applicable but less relevant in comparison of grape because grassing requires a specific expertise in seed species selection.
Water regulation	ES is not applicable because citrus are generally irrigated and because grassing is little used.
Carbon sequestration	Neutral in comparison to grape.

Biodiversity preservation	Neutral in comparison to grape.
Landscape quality	Neutral in comparison to grape.

PES	
Reclamation fee	PES is applicable but is conditioned by the quality of grassing and terraces.
Eco-label	Neutral in comparison to grape.
Carbon credit market	PES is applicable but is conditioned by the entity of temporary grassing and green manure.
Museum ticket	The applicability is the same of the grape, but the presence of a park museum is a condition not guaranteed.
Tourist tax	Neutral in comparison to grape.

3. Mapping ecosystem services at regional scale

In this chapter some maps have been elaborated regarding the soil ecosystem services at regional scale. A focus on carbon sequestration has been developed, considering different scenarios.

The scope is to make an estimation of the climate change related benefits considering the transferability to other orchards and a growth of sustainable techniques adoption by farmers.

A distribution of cultivation of grape, olive and fruits in Emilia-Romagna Region has been elaborated. In consideration of involved surfaces, the carbon sequestration and other ecosystem services have been calculated for the different orchards.

Finally, some scenarios of carbon stock improvement have been estimated, considering the adoption of sustainable agronomical techniques for different percentage of farmers.

Steps and assumptions of the mapping are the following:

1. Spatial data at regional scale for the different fruit orchards (peach, apple, hazelnut and citrus) are not available, so a generic "fruits" class has been considered. The maps have been elaborated with ARCGIS software.
2. The values of the carbon stock at regional scale has been calculated with InVEST software.
3. The scenarios have been built through a qualitative estimation of the potential transfer of sustainable techniques tested in pilot vineyards, so the results have to be considered as a rough indication.

Carbon storage, Biodiversity and Landscape numerical analysis has been carried out with ESRI ArcGIS software platform and python programming language. The official land use dataset of the Emilia-Romagna region has been used as starting point to retrieve land use information at regional scale. Provided in UTM 32N coordinate reference system and Shapefile file format, the dataset is yearly updated at 1:10.000 scale with 0.5 meters pixel resolution and detecting areas as small as 0.16 Ha. These specifications lead to a great accuracy in obtained results since overall the dataset covers more than 400.000 polygons classified in 90 class. Carbon Storage, Biodiversity and Landscape analysis has been elaborated on three classes according with categories derived from the Corine Land Cover and corresponding in the Emilia-Romagna land use dataset with no modifications. In details:

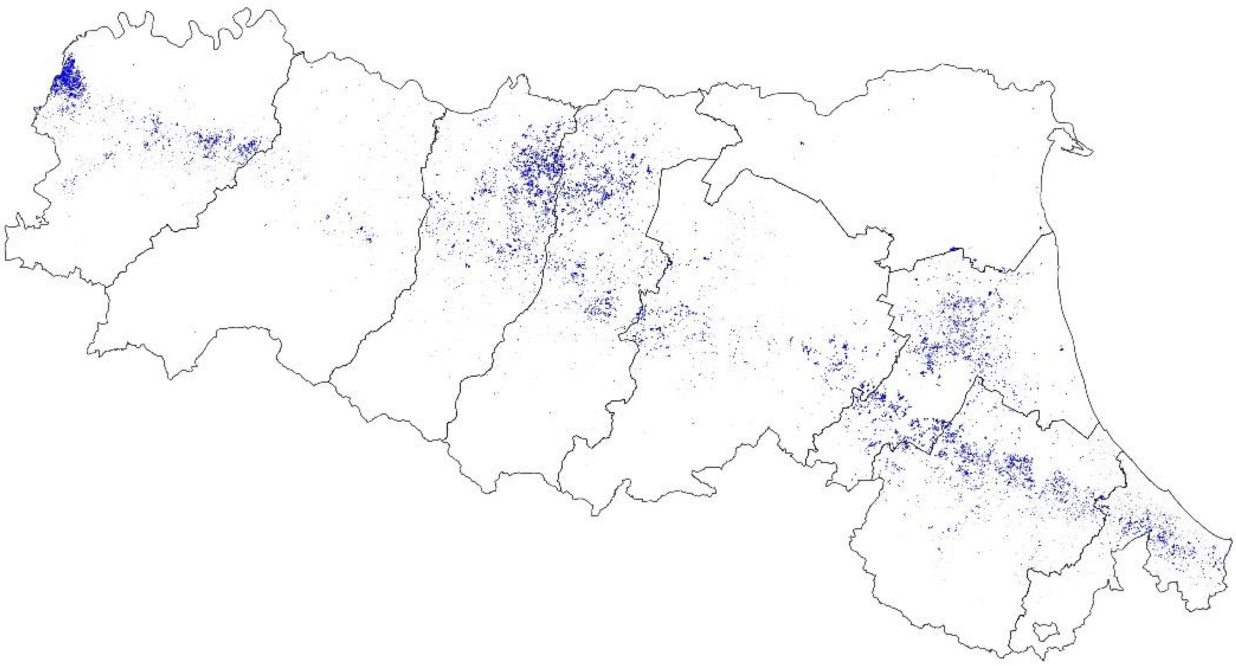
- LULC Class 2.2.1.0 for Vineyards areas;
- LULC Class 2.2.2.0 for Fruits and Citrus areas;
- LULC Class 2.2.3.0 for Olive areas.

The following table shows the surface data of the analyzed orchards in Emilia-Romagna Region.

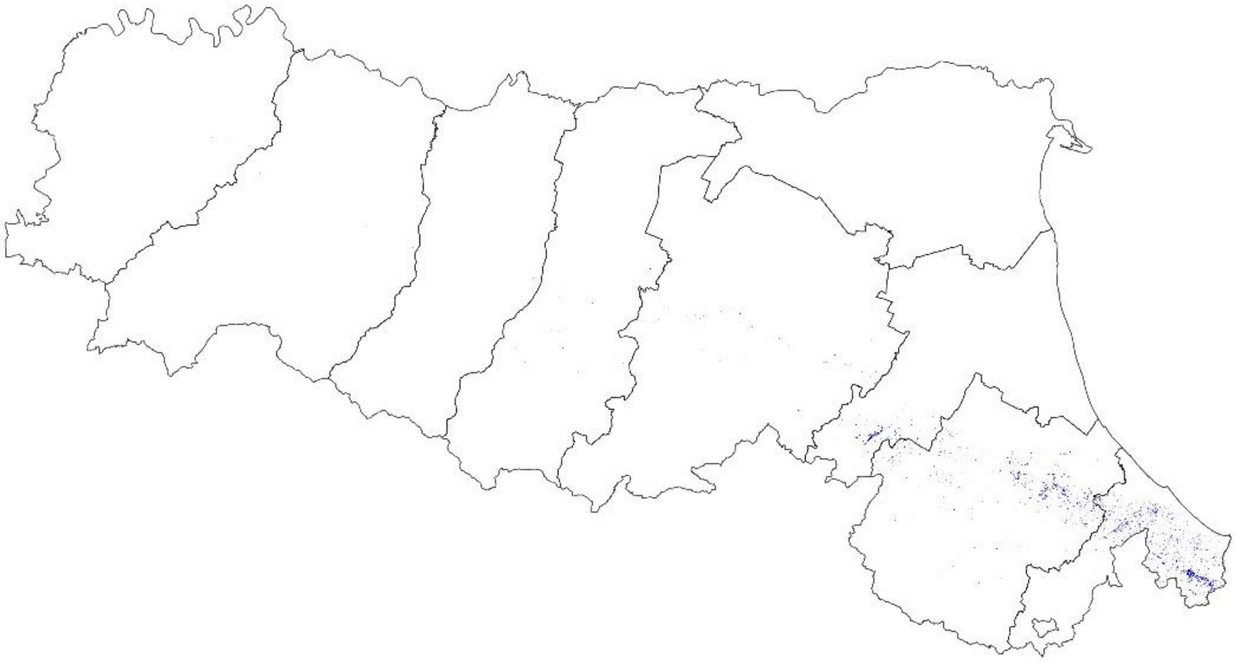
Orchards type	Cultivated surface (Ha)	% of regional surface
Grapevine	43.844,53	1,95%
Fruits	84.847,23	3,78%
Olive	3.984,38	0,18%

Some maps have been elaborated, for grape, fruits and olive.

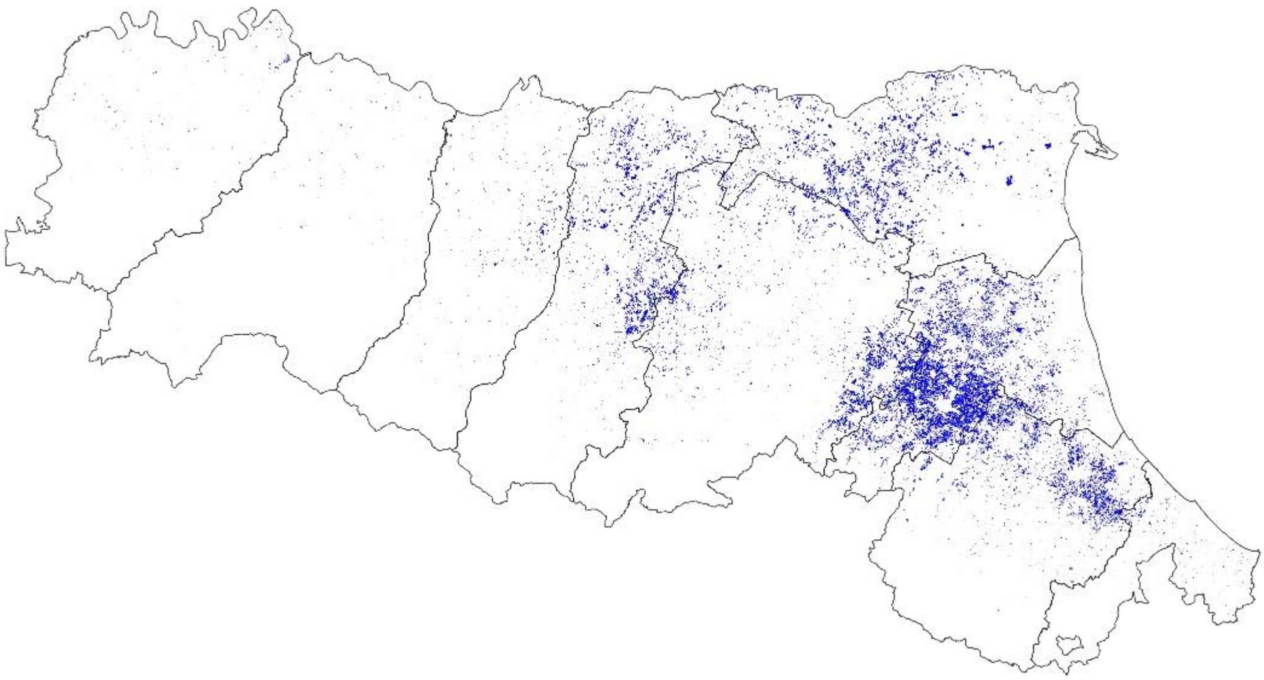
GRAPE

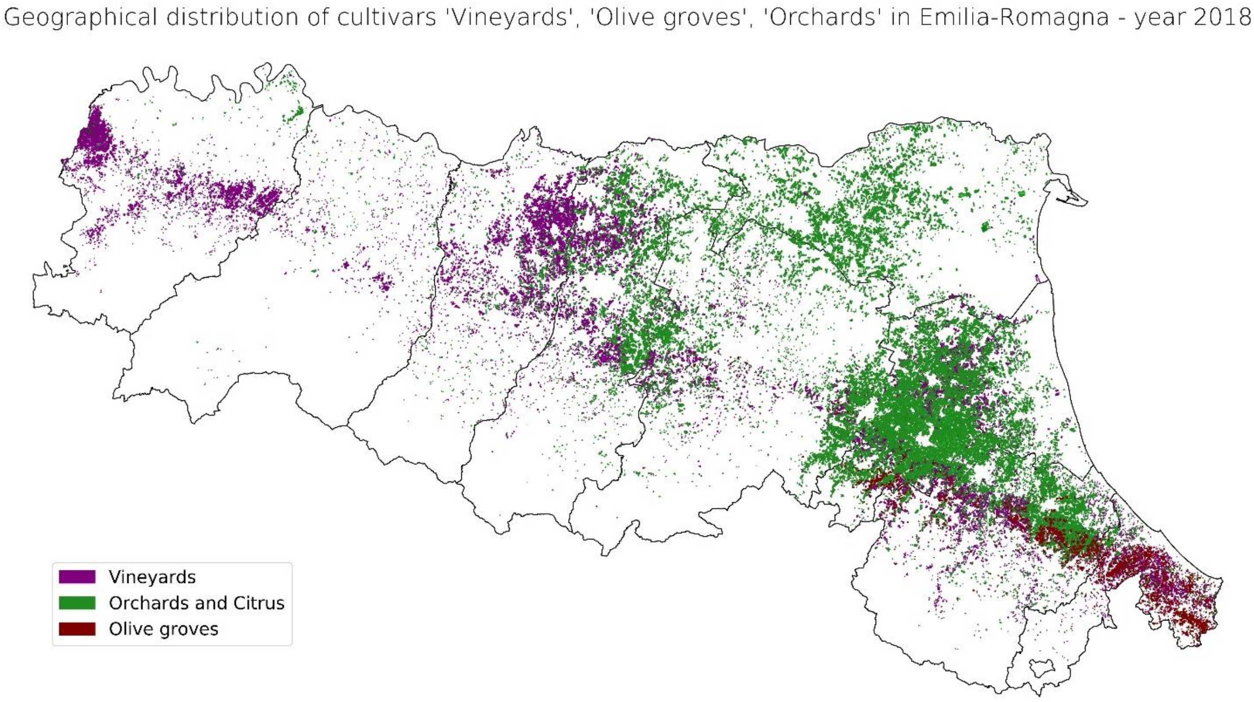


OLIVE



FRUITS





With spatial data elaborated with ARGIS it has been possible to develop ecosystem services analysis with InVEST software.

The InVEST model

Carbon storage on a land parcel largely depends on the sizes of four carbon pools: aboveground biomass, belowground biomass, soil, and dead organic matter. The InVEST Carbon Storage and Sequestration model aggregates the amount of carbon stored in these pools according to land use maps and classifications provided by the user. Aboveground biomass comprises all living plant material above the soil (e.g., bark, trunks, branches, leaves). Belowground biomass encompasses the living root systems of aboveground biomass. Soil organic matter is the organic component of soil, and represents the largest terrestrial carbon pool. Dead organic matter includes litter as well as lying and standing dead wood.

Using maps of land use and land cover types and the amount of carbon stored in carbon pools, this model estimates the net amount of carbon stored in a land parcel over time and the market value of the carbon sequestered in remaining stock. Limitations of the model include an oversimplified carbon cycle, an assumed linear change in carbon sequestration over time, and potentially inaccurate discounting rates. Biophysical conditions important for carbon sequestration such as photosynthesis rates and the presence of active soil organisms are also not included in the model.

Analysis process has been implemented with latest InVEST software version, 3.7.0 at the time of writing, following the Carbon Storage and Sequestration model. The model requires an estimate of the amount of carbon, so carbon pools have been submitted as a table of LULC classes, containing data on carbon stored in each of the four fundamental carbon pools for each LULC class. The model maps carbon storage densities to land cover and for each LULC class to the sum of the carbon pool estimates to produce a total value of carbon storage. The use of local data for all pools has lead to accurate results.

Existing scientific publications have been analyzed to define the value of carbon stock. The amount of carbon stock is defined considering the contribution of sequestration due to above ground tree biomass, below ground tree biomass, litter and soil.

For different crops, the baseline values for Emilia-Romagna are:

Orchards type	**C_above**	**C_below**	**C_dead**	**C_soil**	**C_tot**	**UdM**
Grapevine	7,62	3,54	1,70	56,80	**69,66**	ton C / Ha
Fruits	16,32	11,27	6,70	56,80	**91,09**	ton C / Ha
Olive	17,91	4,62	2,77	56,80	**82,10**	ton C / Ha

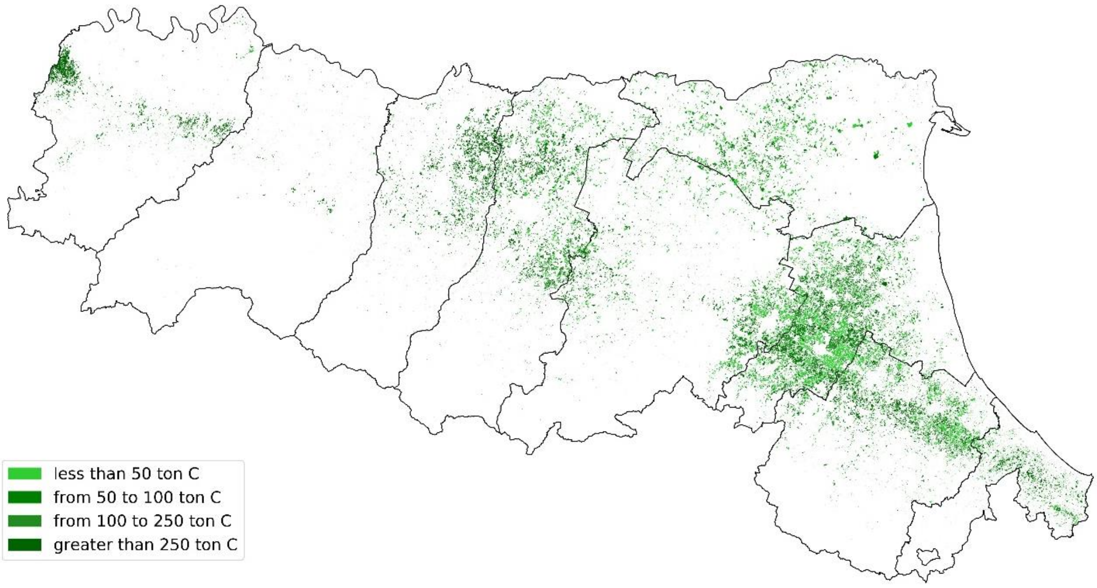
The weight of soil component is always prominent, but for grapevine is the greatest (as considered in the pilot phase).

The average value of carbon stock improvement in SOIL4WINE pilot vineyards has been of 15% of C_soil. The same improvement has been used considering the adoption of good practices (as grassing and green manure) in other orchards types. Four scenarios consider the adoption of good practices by 25%, 50%, 75% and 100% of farming surfaces at regional level.

Orchards		**Carbon stock scenario**				**UdM**
		25%	**50%**	**75%**	**100%**	
Grapevine	baseline	763.534	1.527.068	2.290.602	3.054.137	ton C / year
	improvement	93.389	186.778	280.167	373.555	
Fruits	baseline	1.932.131	3.864.261	5.796.392	7.728.522	ton C / year
	improvement	180.725	361.449	542.174	722.898	
Olive	baseline	81.257	162.514	243.771	325.028	ton C / year
	improvement	8.487	16.973	25.460	33.947	

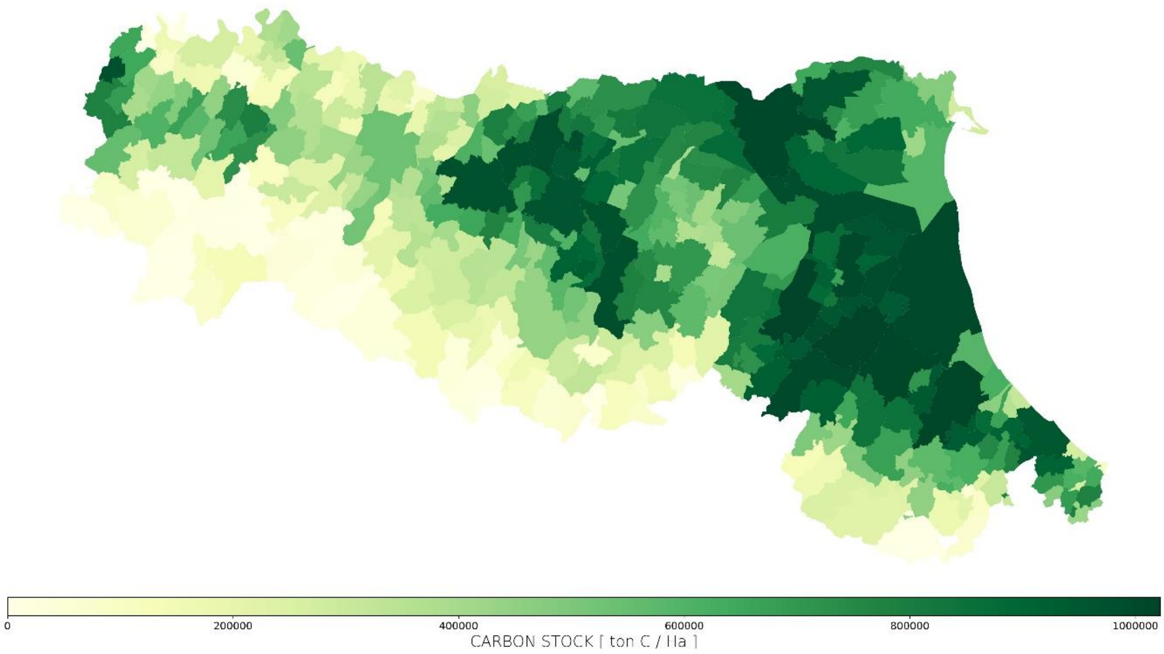
The following map represents the distribution of carbon stock potential of vineyards in Emilia-Romagna.

Carbon Stock of cultivars 'Vineyards', 'Olive groves', 'Orchards' in Emilia-Romagna - geographic distribution year 2018

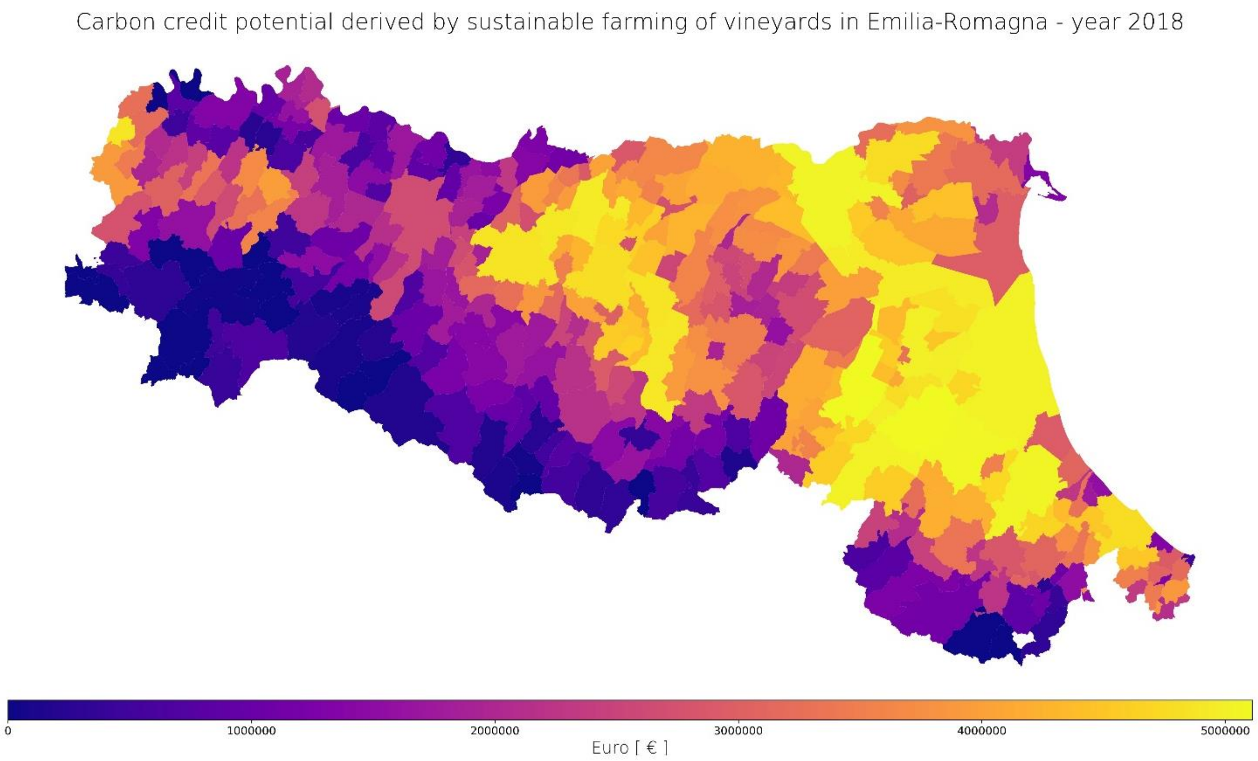


And the other one represents the carbon stock potential of vineyards for the municipalities of Emilia-Romagna..

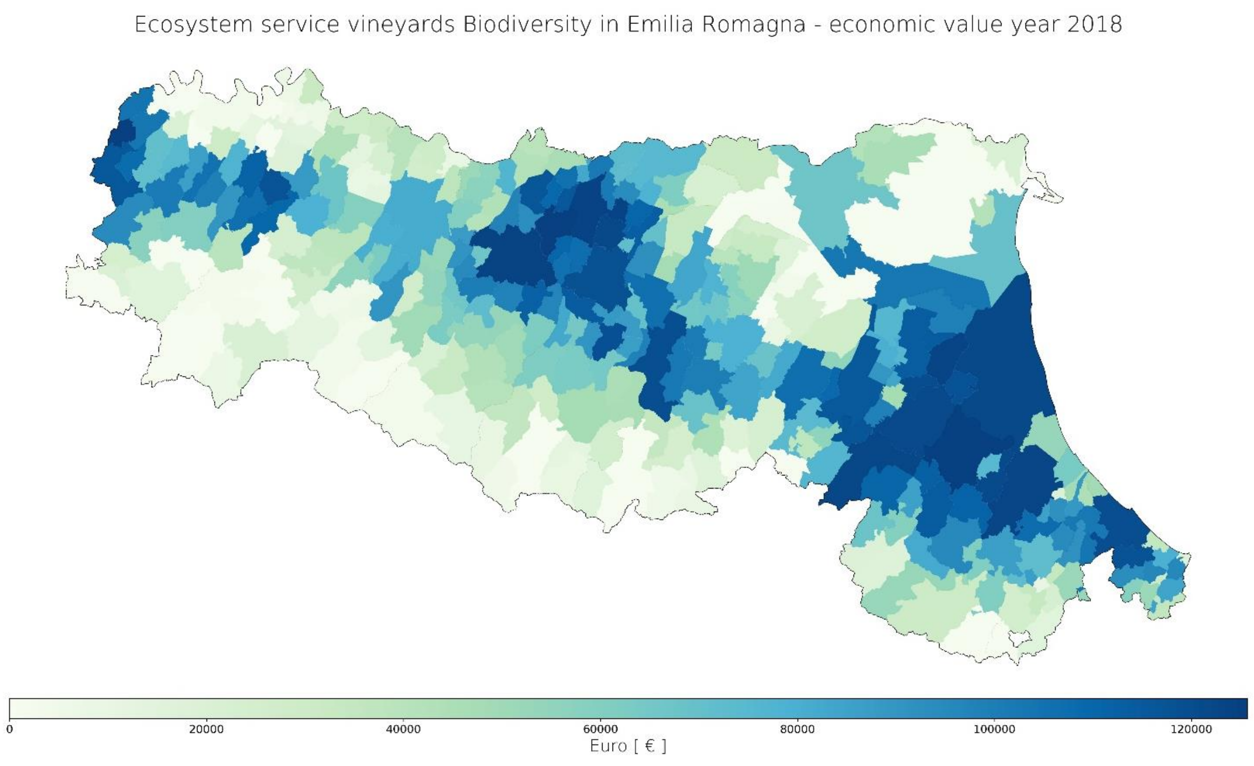
Carbon Stock of cultivars 'Vineyards', 'Olive groves', 'Orchards' in Emilia-Romagna - municipality distribution year 2018

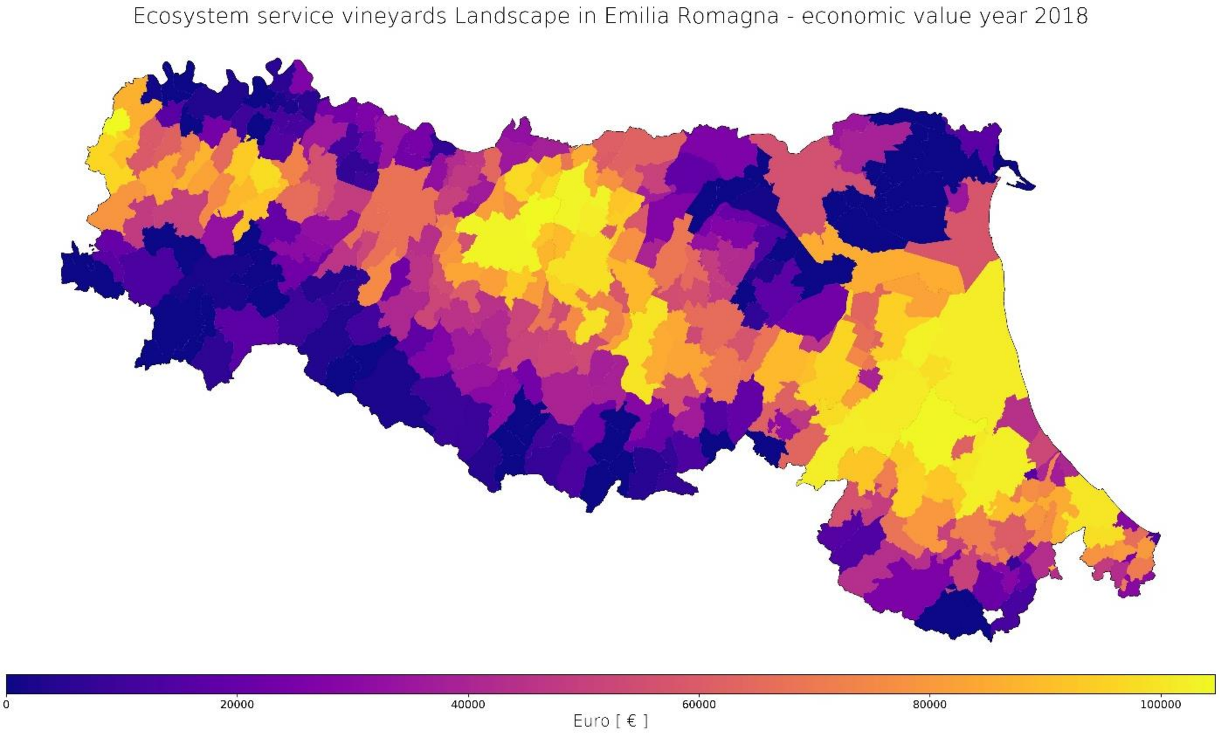


The following map represents the potential carbon credit market if all the regional vineyards would adopt the Soil4wine techniques (scenario n. 4).



An economic representation is possible also for other ecosystem services, as biodiversity preservation and landscape quality, based on results of the survey carried out in sub-action B.4.4.





This is only a simulation, based on spatial data and qualitative evaluations on transferability potential of agronomical practices, but is a useful exercise to have an estimation of potential benefits in terms of carbon sequestration and other ecosystem services related to the diffusion of sustainable cultural techniques.

4. Conclusions

The transfer potential from vineyards to other orchard systems have been related to the following items:

- tackled soil threats
- cultivation techniques and soil management practices
- ecosystem services (ES) descending from cultivation techniques
- applicable payments for ecosystem services (PES).

Considered orchards are: peach, apple, hazelnut, olive and citrus.

In terms of soil threats, comparison with grape has showed that reduction of soil organic matter content is a shared problem between considered fruit typologies, with higher magnitude for olive and citrus. Erosion problem is strongly related to orchards located in steep fields (as apple, olive and citrus) but traditional techniques, as terraced, reduce negative effects on this threat and facilitate agronomical practices. In this context maintenance of terrace become the focus point during the assessment of erosion impact on these crops. Drought affects all the considered crops and effects are more pronounced than in vineyards.

Peach is strongly vulnerable to water logging so technique that reduce impacts of this threat are more effective as compared to grapes. In terms of agronomical practices green manure or non permanent grass could be interesting and effective innovative techniques especially for hazelnut and olive as they cover soil during rainy periods and they are removed before harvesting operations. Artificial permanent grassing could be used only after an accurate selection of species mixtures to avoid competition, as advise also for grape. In absence of water competition and drought, the use of spontaneous grass could be effective for peach and apple as it enhances water holding and bearing soil capacity and reduces compaction.

Considering the ecosystem services, the transferability of biodiversity preservation and landscape quality is the easiest. Very limited differences in comparison with grape have been highlighted. The erosion protection, as intuitive, is not relevant for crops not located in hilly territories or mountains, for peach. Water regulation favored by infiltration is difficult for crops that have low use of grassing, as hazelnut or citrus.

Finally, for PES transferability, the reclamation fee is strongly related to the erosion and hydrogeological issues, instead the carbon credit voluntary market offers the same opportunity for each crop.

The tourist tax transferability is high only for the crops that have real influence on landscape attractiveness, as olive and citrus.

The eco-label is an interesting opportunity for every orchards to communicate their performances in terms of ecosystem services maintenance or development.

5. Bibliography

- Caddeo, A., Marras, S., Sallustio, L., Spano, D., & Sirca, C. (2019). **Soil organic carbon in Italian forests and agroecosystems: Estimating current stock and future changes with a spatial modelling approach**. Agricultural and forest meteorology, 278, doi: 10.1016/j.agrformet.2019.107654
- FAO and ITPS. 2018. **Global Soil Organic Carbon Map (GSOCmap)** Technical Report. Rome. 162 pp.
- Chiti, Pellis, Perugini, De Angelis, Manso, Canaveira, Scarascia. (2018). **Nuovi fattori di emissione per la biomassa epigea nei sistemi arborei perenni.**
- Morandé, J.A., Stockert, C.M., Liles, G.C., Williams, J.N., Smart, D., & Viers, J.H. (2017**). From berries to blocks: carbon stock quantification of a California vineyard**. Carbon Balance and Management. doi: 10.1186/s13021-017-0071-3
- Scandellari, Caruso, Liguori, Meggio, Assunta, Zanotelli, Celano, Gucci, Inglese, Pitacco, Tagliavini. (2016). **A survey of carbon sequestration potential of orchards and vineyards in Italy.** European Journal of Horticultural Science. 81. 106-114. doi: 10.17660/eJHS.2016/81.2.4.
- Brunori, Farina, Biasi. (2016). **Sustainable viticulture: The carbon-sink function of the vineyard agro-ecosystem.** Agriculture, Ecosystems & Environment, 223, 10-21. doi: 10.1016/j.agee.2016.02.012
- Proietti, Sdringola, Desideri, Zepparelli, Brunori, Ilarioni, Nasini, Regni, Proietti. (2014). **Carbon footprint of an olive tree grove**. Applied Energy. 127. 115–124. doi: 10.1016/j.apenergy.2014.04.019.
- Parras-Alcántara, L. & Lozano-García, B. (2013). **Conventional tillage vs. organic farming in relation to soil organic carbon stock in olive groves in Mediterranean rangelands (Southern Spain).** Solid Earth Discussions. 6. doi: 10.5194/sed-6-35-2014.
- Wu, Wang, Yu, Chiarawipa, Zhang, Han, Wu. (2012). **Carbon Sequestration by Fruit Trees - Chinese Apple Orchards as an Example.** PloS one. 7. e38883. doi: 10.1371/journal.pone.0038883.
- Ungaro, F. , Staffilani, F. and Tarocco, P. (2010), **Assessing and mapping topsoil organic carbon stock at regional scale: A scorpan kriging approach conditional on soil map delineations and land use.** Land Degrad. Dev., 21: 565-581. doi: 10.1002/ldr.998
- Sofo, Nuzzo, Palese, Xiloyannis, Celano, Zukowskyj, Dichio. (2005). **Net CO_2 storage in Mediterranean olive and peach groves.** Scientia Horticulturae. 107. 17-24. doi: 10.1016/j.scienta.2005.06.001.