Deliverable A1: Technical report on Tree-Crop Categorization

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LIFE CLIMATREE (LIFE14 CCM/GR/000635)

A novel approach for accounting and monitoring carbon sequestration of tree crops and their potential as carbon sink areas

The **LIFE CLIMATREE** project "A novel approach for accounting and monitoring carbon sequestration of tree crops and their potential as carbon sink areas" (LIFE14 CCM/GR/000635) is co-funded by the EU Environmental Funding Programme **LIFE Climate Change Mitigation**.

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ΓΕΩΠΟΝΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
AGRICULTURAL UNIVERSITY OF ATHENS

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terra nova

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The current report presents the methodology followed for the implementation of Action A.1: “Selection and analysis of tree-crop categories in S. Europe”, of the LIFE CLIMATREE project and consequently the results obtained in the course of action’s implementation.

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V. *Cydonia* Mill.

1. *C. oblonga* Mill., (Engl: Quince), EL-IT-ES.

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C. Musaceae Family

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D. Fabaceae Family

I. *Ceratonia* L.

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H. Moraceae Family

I. *Ficus* L.

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Summary

BACKGROUND: provides a rationale for the study (understandable to a broad audience) and states the main aim(s).

Ecosystems Services consist a contemporary concept developed during the last decade of the 20th century, which was globally established through the Millennium Assessment report in 2005. A total of 19 ESs functions were grouped in 4 major clusters, namely Regulating, Supporting (often co-considered with previous cluster), Provision, and Cultural services. Great efforts have been taken towards their accounting the most important of which was the "*Stern Review*" (1998), which though preceded the establishment of ESs concept laid the foundation for the development of land use assessment protocols. Since then the significance of ESs has been recognized globally and the necessity for their incorporation in strategic plans and policy measures has driven scientific research towards the development of numerous approaches for their accounting and/or evaluation. In this line of work the relevant returns on a *scopus* search account to almost 4,200 (4,178) papers of which the vast majority (4,080) was published within the 21st century.

As it was expected the agricultural land use, which dominates the human made environment covering almost 40% of landlocked areas globally, has attracted significant scientific attention and comprises the subject of more than 1,600 (1,624) studies. Among those studies only a small fragment, accounting to 53 papers, has focused on the orchards ESs, though tree crops consist a significant portion of the agricultural land with a well established profile that is defined as intermediate between crop land and natural forests, with respect to their ESs.

Within this context CLIMATREE first preparatory action targeted the identification of homogenous clusters of orchard types, with respect to both their biological and cultivation characteristics, and consequently the review of the so far developed knowledge base on their ESs provision, in order to complement the project's initial design and provide a solid and integrated evaluation framework for the pursuit of CLIMATREE's objectives.

RESULTS: describes the main findings, including important numerical values.

The Tree Crop categorization was expanded over three northern Mediterranean countries and proved efficient by the deliverance of four distinct tree crop clusters encompassing homogeneity in both Cultivation and Biological characteristics of the considered orchards. In the course of this study it was also surveyed the availability of complementary data, which could be further utilized in the course of CLIMATREE's implementation. As such data were identified the ecological area of TCs plantations, defined as Coastal, Midland and Upland, the average crop yield per TC and Cultivation methodology, and the prospective life span of each TC.

More over there has been identified a representative tree crop for each category that will be utilized as a case study in the context of CLIMATREE's core actions implementation. Those representative *taxa* reflect both the groups' general profile, but also are indicative with relation to each category's total area coverage. The results of this study are summarized in the following table, which presents the aggregative results on the categorization of almost the 8% of the three countries total land cover.

Biological category	**Cultivation Method**	**Representative Crop**	**Area of Cultivation (ha)**			
			Spain	**Greece**	**Italy**	**Total**
Evergreen	Intensive	Orange	891.004	19.935	31.819	942.758
	Extensive	Olive	1.849.188	1.615.924	981.392	4.456.713
Total			2.740.192	1.635.859	1.013.211	5.399.471
Deciduous	Intensive	Apple/Peach	42.348	17.188	42.767	102.303
	Extensive	Almond	1.253.583	89.355	101.188	1.444.126
Total			1.295.931	106.542	143.955	1.546.428
Total			4.036.123	1.742.401	1.157.166	6.945.899

Consequently, was performed an elaborated review of the prevailing methodologies for the Orchards ESs assessment. This review outlined a study that recognized and attributed synergies and trade-offs between the variable ESs functions, which formed the foundation for the development of the CLIMATREE's ESs assessment methodology. The fundamental principle below this methodology is the consideration of synergies and trade-offs between ESs functions that enables the grouping of homologous functions and their consequent cumulative evaluation separately for each of the four tree crop categories.

Before the detailed review on the assessment of each ESs function we performed a study on the potentials for the cumulative integration of each tree-crop category with respect to their ESs provision. This study was based on existing literature data and concluded to the definition of two coefficients:

A. Everegreen vs Deciduous TCs: Considering as baseline the Deciduous TC, the Evergreen TC present a Regulation ESs coefficient of 2, and Provision ESs coefficient of 0,5.

B. Intensive vs Extensive Cultivation Method: The Integrated ESs coefficient for intensive TCs, considering as baseline the relevant extensive (Traditional, Organic, etc), was defined to 0,25.

Consequently, for each of the homologous groups of ESs functions was performed a detailed review on the respective assessment protocols, and a preliminary set of indicators was chosen in order to validate the proposed methodology as follows:

A. Provision TC Services: As cumulative indicator was chosen the average yield in tonnes per hectare, which can provide substantial evidence for the contribution of TC in Food and Biomass Provision Services.

B. Regulation TC Services:
    a. Biotic Support: For this function was chosen the number of birds per Hectare, which was calculated by Rodríguez-Entrena et al. (2012), for olive groves to present averages of 10 *taxa* ha^{-1}.
    b. Abiotic Support: as indicator was chosen the Soil Erosion respectively. This indicator was calculated by Rodríguez-Entrena et al. (2012), for olive groves to present an average 10 t soil $ha^{-1}year^{-1}$
    c. Flows Support: as indicator was chosen the Soil Carbon Sequestration. These indicators was calculated by Rodríguez-Entrena et al. (2012), for olive groves to present an average of 2,5 tCO_2 $ha^{-1}year^{-1}$.

C. Cultural TC Services: The proposed indicator is the total area of Orchards in hectares.

The cumulative results of TCs ESs assessment according to the developed methodology are summarized in the following table:

Ecosystems Services	ES Function	Grade	Performance
Regulation	Biotic support	13,13	5,14
	Abiotic support	18,75	7,35
	Flows support	4,69	1,60
Provision	Nutrition	11,25	2,69
	Biomass		
Cultural	Stewardship/ Diversity	8.356.337,63	1,12

The performance indicator was constructed in order to integrate the grade per hectare indicator to the sum of the TCs area and is defined by the following equation:

P= Grade per Hectare* (TC category hectares/TC total hectares).

CONCLUSION: provides the main conclusions, including why the results are significant and advance the field.

Previous results concerning TC categorization provided an innovative and inclusive framework for both the continuation of CLIMATREE's implementation but also for the Assessment of their respective ESs.

In the same manner the methodology developed for the ESs assessment congregated the available knowledge of the field while simultaneously recognized crucial knowledge gaps that must be addressed in the course of CLIMATREE's implementation.

Both results are significant for project implementation because they provide a uniform and scientifically sound background for the cumulative interpretation of project's results into Policy priorities and measures, while they are also expected to enhance the project's results transferability and replicability in different environments and geographical scales.

1. Introduction

Ecosystem services are the bridge between nature and society, and are essential elements for the community’s well being. Ecosystem Services (ES) are generally considered as a cumulative figure enabling humanity to access both the tangible and intangible value of Nature. Several classifications of ESs are available, but the most comprehensive work has been done by the Millennium Ecosystem Assessment (MEA), which classifies ESs in four categories:

1. provisioning services: include all the biomass produced by ecosystems and directly used by human such as food, water, timber, and fiber;
2. regulating services: sustain the functioning of the ecosystems, regulating important elements like climate, floods, diseases, wastes, and water quality;
3. supporting services: are necessary to support all other ESs, such as soil formation, photosynthesis, and nutrient or water cycling;
4. cultural services: provide recreational, aesthetic, and spiritual benefits, and affect all intangible values derived from the contact with nature.

This classification, despite is clarity, does not provide guidance to an efficient economic evaluation of ESs which needs to pinpoint the “final good” enjoyed by the people that directly affects their well-being. The attention to “final good” was originally proposed by Fisher et al. and implies that all the intermediate processes and services (like supporting services) that constitute the “back-office” provider of the overall ESs cannot be considered in the economic analysis. An attempt to improve the economic evaluation of ESs has been done by the UK government, which in 2011, published the first UK National Ecosystem Assessment. This classification disentangles ecosystem process/intermediate services and final services to improve the economic evaluation of ESs (Pedone et al., 2014).

However the significance of ESs is of high priority for the integrated impact assessment (IA) of policies in the European Commission takes place in an environmentof competing problem frames, contested policy objectives and a multitude of interested actors. Diehl et al. (2016) elaborated on the potential value of integrating the ecosystem services concept for improving the consideration of environmental benefits and values during framing and appraisal of new policies at European level. This approach was based on a workshop conducted with experts encompassing their disciplinary fields to the science–policy interface. A review of recent literature and impact assessment reports from policy science and ecosystem services research allowed for a two-way contemplation. The potential integration of concepts was analysed for conceptual, technical, ethical and pragmatic aspects. It was found that indicator sets applied in the impact assessment reports follow a much less formalised structure than the reports or the procedure. An integration of the ecosystem services concept would enhance the requisite variety of indicators used, and thus contribute to the overall goal for sustainable development. Potentials for improving IA lie particularly in the up- and downscaling of benefits and values, policy relevant comparative studies and the prospective possibilities for innovation in indicator development. Based on this rationale of improving requisite variety for future decision making, the emphasis lies on a further development of the ESS concept along two pathways of operationalisation: the translation of the concept for a comprehensive approach at a higher level of abstraction (soft application),and the application of the concept for providing aggregated, quantitative and unit-based information at different steps of an IA (hard application).

Sornoyi (2016) framing the quantification of environmental sustainability recognised that recent concepts have mostly focused on narrative economic and societal aspects rather than quantitative ones. Many key sustainability indicators also lack a consistent definition of sustainability, have perspectives that are too short-term, and are unable to model the dynamics of complex environmental utilization which can then result in inappropriate projection of long-term sustainability and/or sustainability indication. The proposed generalized quantitative framework of environmental sustainability requires that

1. environmental capacities and utilization rates are identified,
2. their complex temporal dynamics are:
   a. quantitatively modelled or estimated
   b. while also adjusting for uncertainties, and finally,
3. using one of three options, determining which cumulative utilization pathways can be sustained for a (usually well-defined) period of time.

On the other hand decision-making on resource managements received worldwide attention in the past decades given the urgent need to preserve ecosystems and find a sustainable balance between long-term and short-term benefit and costs of human activities. However, a management decision can cause undesirable consequences if it lacks understanding of the complex nature of ecosystems, which lead to the multi-functionality of land systems. A land system does not provide only one function but combinations of a variety of overlapping functions, each of which provides different ecosystem goods and services to society (Lee and Lautebach, 2016).

Land systems thus have a potential to provide multiple ecosystem services. Due to functional trade-offs and synergies among the different components of this multi-functionality within the land, a decision potentially influences which services people can get or lose at the same time. Therefore, a comprehensive understanding of the multi-functional land system and of the different ES derived from it is crucial in natural resource management to avoid undesired and often unaware trade-offs and to enhance synergies among ES (ibid.).

Croplands and pastures occupy approximately 40% of the Earth's terrestrial surface, making them the largest land use types on the planet. Agricultural expansion and intensification result in loss of biodiversity and reduction of the variety and levels of ecosystem services (Barral et al., 2015), which are benefits that people obtain from ecosystems (MEA, 2005). Converting land for agricultural use leaves some provisioning ES unaffected and improves other provisioning ES (e.g., food and fiber), while at the same time it is considered as a factor reducing land available to supply other supporting, regulating and cultural ES.

A significantly different character though was recently proved for orchards, which represent a rather unique category of cropland with respect in the ESs deliverance. The example establishing this differentiation is developed around the city of Aksu, situated at the northern fringe of the Taklimakan Desert in northwest China, which is exposed to severe periodic dust and sand storms. In 1986, local authorities decided to establish a peri-urban shelterbelt plantation, the so-called Kökyar Protection Forest, with the aim of reducing dust and sand storm impacts on Aksu City by the regulating ecosystem services provided by the plantation. It was realised as a patchwork of poplar shelterbelts and orchards. The total area of the plantation reached 3800 ha in 2005. The Kökyar Protection Forest since then has been used as a case study to answer the following question: *under which institutional frameworks and to which financial conditions can peri-urban shelterbelts be established and maintained?* While the endeavour of planting the shelterbelt was made possible by the annual mass mobilisation of Aksu citizens, based on the Chinese regulation of the "National Compulsory Afforestation Campaigns", the task of the shelterbelt permanent maintenance, is facilitated by leasing orchard plots to private fruit farmers. From the perspective of the local economy, annual farming net benefits generated by Kökyar fruit farmers more than compensate for annual government grants for maintenance, resulting in an average overall monetary net benefit (Missall et al. 2015).

Another aspect of world scale importance concerns the tropics, where large areas are transformed into simplified ecosystems characterised by altered tree species composition and diversity. Human activities in these landscapes have a strong effect on the land cover and exert a selective force on tree species and functional traits, hereby potentially shaping the distribution of ecosystem services in the landscape. Koen et al. (2015) assessed how the land use determines tree species assemblages, their associated traits and potential ecosystem services, which was studied for 589 systematically sampled locations in the Afromontane highlands of Taita Hills (SE Kenya). Several tree traits were non-random distributed in the human-dominated landscape. For instance, on croplands (70% of the sampled locations) belonged 66.5% of the observed species to the exotic tree species group. This group was characterised by significantly larger seeds and fruits, corresponding with the abundance of many fruit trees. Also three functional traits (i.e. economic function, nitrogen fixation and agroforestry potential) were clearly associated with this group. The cloud forest tree species group and small-leaved indigenous group were significantly more present on woodes sites and homesteads (~42%). However, no functional traits were unique for both indigenous groups, implying that farmers may exchange them by exotics, which could be catalysed by the loss of local knowledge about indigenous tree resources and benefits.

A few years earlier Almagir et al. (2009) provided crucial proofs for the conformity of ESs provision through different land uses, which included orchards and rain forest in Australia. The Wet Tropics Australia, is environmentally and biologically diverse, and supplies numerous ecosystem services. It contributes to the community well-being of this region, Australian nationaleconomy and global climate change mitigation efforts. However, the ecosystem services in the regionhave rarely been assessed undermining strategic landscape planning to sustain their future flow. In thisstudy, we attempted to: (i) assess the quantity of five regulating ecosystem services – global climateregulation, air quality regulation, erosion regulation, nutrient regulation, and cyclone protection, andthree provisioning ecosystem services – habitat provision, energy provision and timber provision acrossrainforests, sclerophyll forests and rehabilitated plantation forests; (ii) evaluate the variation of supplyof those regulating and provisioning ecosystem services across environmental gradients, such as rain-fall, temperature, and elevation; (iii) show the relationships among those ecosystem services; and (iv)identify the hotspots of single and multiple ecosystem services supply across the landscape. The resultsshowed that rainforests possess a very high capacity to supply single and multiple ecosystem services,and the hotspots for most of the regulating and provisioning ecosystem services are found in upland rain-forest followed by lowland rainforest, and upland sclerophyll forest. Elevation, rainfall and temperaturegradients along with forest structure are the main determinant factors for the quantity of ecosystem ser-vices supplied across the three forest types. The correlation among ecosystem services may be positive ornegative depending on the ecosystem service category and vegetation type. The rehabilitated plantationforests may provide some ecosystem services comparable to the rainforest.

Even though orchards are considered as valuable potential natural assets their contribution to ESs provision has not yet be approached in general. The presented in the previous chapter framework for the categorisation of Tree-Crops (TC) is utilized in follow in order to provide safe estimates on the ESs provided by each TC category. Each category is built to consist by groupings of TC with similar botanical, biological, and cultivation characters, increasing thus the homogeneity of each group with the respective indicative TC. Present endeavour aspires to partly unveil the potentials of the Mediterranean orchards as ESs providers. This formidable targeting is escalated through a detailed review of the methodologies and the indicators implied previously for the enumeration of a distinct ES covering all 19 ESs considered in the MEA. Consequently are reviewed separately the case studies for the indicative TC from each one of the 4 TC categories and the cumulative assessment is presented and discussed accordingly.

2. Methods

2.1. Ecosystems Services Assessment of Tree Crops

2.1.1. Methological Approach

Within the previously developed context lies a key challenge that CLIMATREE projects faces now: considering simultaneously multiple ES and their potential con-sequences rather than focusing only on a few services in isolation. The concept of multi-functionality has been originally developed at the landscape scale (Bolliger et al., 2011; Mastrangelo et al.,2014). However, it can be transferred to larger scales at which parts of the multi-functionality present at the landscape scale might be hidden due to aggregation effects. Likewise, the concept can be applied at smaller scales but one has to keep in mind that some functions might diminish at small scales such as functions that lead to:

- water regulation,
- seed dispersal,
- pollination and
- pest control that connect different parts of the landscape.

Therefore, interactions across multiple scales are important to be considered in decision-making (Willemen et al., 2012; Dick et al., 2014). The global research community endeavours to elaborate the concept of ES both in theory and practice to preserve multiple ES (MA,2005; Carpenter et al., 2009). The Millennium Ecosystem Assess-ment (MA, 2005) has raised the awareness of the importance of identifying multiple ES and their interactions (Raudsepp-Hearneet al., 2010; Willemen et al., 2012). The number of publication has risen rapidly in last decades on this issue (Bennett et al., 2009).Bennett et al. (2009) stressed the importance of understanding direct and indirect relationships among multiple ES. Recent studies focusing on multiple ES have taken several perspectives using various methodological approaches. The concept of “bundles” of ES has been commonly applied in the assessment of provisioning multiple ES in a landscape (e.g. Raudsepp-Hearne et al., 2010;Martín-López et al., 2013).

This approach tries to identify groups of ES that co-occur repeatedly in landscapes showing patterns of the provision of ES derived from the different land use and land cover types

(Raudsepp-Hearne et al., 2010; Turner et al., 2014). It is frequently based on a GIS analysis at the landscape or the regional scale (O'Farrell et al., 2010; Nemec and Raudsepp-Hearne, 2012). Often complementary statistical or descriptive analyses have been used to identify the bundles. Another research line tends to focus on ecosystem processes and functions that underpin ES (Dickie et al.,2011; Lavorel et al., 2011).

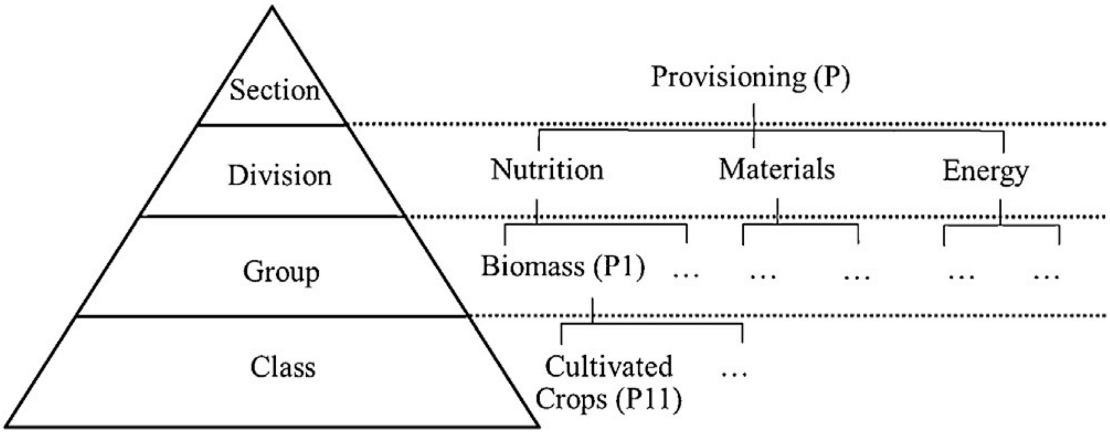


Fig. 1. The CICES nested hierarchy structure (left) and example of provisioningsection and ES code in brackets (adapted from Haines-Young and Potschin (2013)).

The relationships among multiple ES are either identified by statistical analysis of field data or by the analysis of the output process models such as the Lund-Potsdam-Jena General Ecosystem Simulator (LPJ-GUESS) (Smith et al., 2001) or the Soil Water Assessment Tool (SWAT) (Arnold et al., 1999). Lautenbach et al. (2013) for example analyzed the relationships between bio-energy crop and food production, water regulation and water quality regulation using SWAT together with an optimization approach. Relationships of ES pairs can be categorized into 'trade-off', 'synergy', and 'no-effect'. The term 'trade-off' in ES research has been used when one service responds negatively to a change of another service (MA, 2005). An attempt to maximize the provision of a single service will lead to sub-optimal results if the increase of one service happens directly or indirectly at the cost of another service (Holling, 1996; Rodríguez et al., 2006; Haase et al., 2012). When both services change positively in the same direction, the relationship between two ES is defined as synergistic (Haase et al., 2012); this is also called a 'win–win' relationship (Howe et al., 2014). When there is no interaction or no influence between two ES, this is defined as a 'no-effect' relationship. The relationship between a pair of ES can differ across different scales and across different socio-ecological systems (Kremen,2005; Hein et al., 2006; Bennett et al., 2009). An example for this is the "externality" of a decision on a certain service as pointed out by Rodríguez et al. (2006): a decision that seems to influence ES positively for a specific region might cause substantial trade-offs in areas nearby or faraway (e.g. ‘off-site effects’ (Seppelt et al.,2011) and ‘telecoupling’ (Liu et al., 2013; Liu and Yang, 2013)).

If the effects of this decision are viewed at a larger scale including all those negatively influenced areas, the relationship between ES might be characterized by a trade-off. Cimon-Morin et al. (2013) showed in their review study that the relationship between biodiversity and ES changes with scale and region. The relationship between carbon storage and habitat was, for example, described mainly as synergistic at the global scale, but at a finer scale regions of high biodiversity and high carbon storage might be disjunct leading to a trade-off relationship. Furthermore, the relationship can change in different land systems. Land systems are defined by the terrestrial components of environmental systems such as vegetation and soil type, as well as human-environment interactions such as land use intensity, socio-economic factors (Oliver et al., 2004; Dearing et al., 2010;Václavík et al., 2013; Verburg et al., 2013). A decision on increasing a service can affect the other services differently in different land systems. For example, West et al. (2010) showed differences in a trade-off relationship between carbon sequestration and food provisioning among regions with different land systems. Given the increasing interests on relationships between ES in literature, two recent review studies (Mouchet et al., 2014;Howe et al., 2014) addressed aspects of relationships between ES. Mouchet et al. (2014) provided a methodological guideline for assessing trade-offs between ES, whereas Howe et al. (2014) analyzed relationships between ES with a focus of beneficiaries and users.

However, neither of the two studies analyzed pair-wise relationships between ES, which is a first step to investigate relationships among multiple ES (Chan et al., 2006; Raudsepp-Hearneet al., 2010; Jopke et al., 2014). Kandziora et al. (2013) provided a matrix of pair-wise relationships between ES on a conceptual level, but the relationships between ES have not been studied so far based on case study results. In this study, we aim at quantifying pair-wise relationships based on a quantitative review of relationships between ES based on the published literature. As the aforementioned literature showed, the relationship between ES has been studied at various scales, indifferent land systems using various methodological approaches, which complicates the synthesis. We, therefore, addressed threekey hypotheses to investigate the relationships between ES: first, a dominant relationship between ES exists for each ES pair; second, this relationship is influenced by the scale at which the relationship had been studied as well as by the land system the case study took place; and third, this relationship is further affected by the method applied to characterize the relationship.

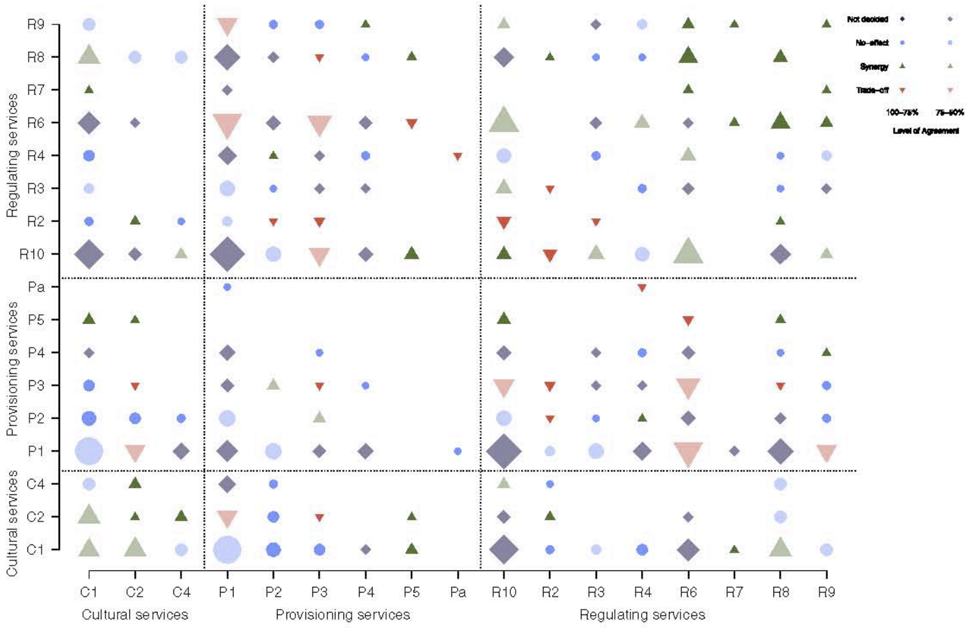


Fig. 2. Result from analysis of 67 case studies with 476 pairs of ecosystem services, showing the empirical pattern of relationships between them. X and Y axes represent theES classification code used in the analysis (See Table ST1). The size of the symbol indicates the square root scaled number of studies. The color intensity represents the level ofagreement. C: Cultural services, P: Provisioning services, R: Regulating services. C1: Physical and experiential interactions, C2: Intellectual and representative interactions, C4:Other cultural outputs, P1: Nutrition biomass, P2: Nutrition water (i.e. drinking purpose), P3: Materials biomass (e.g. for production and agricultural uses), P4: Material water(i.e. non-drinking purpose), P5: Biomass-based energy sources, Pa: Renewable abiotic energy source, R10: Atmospheric composition and climate regulation, R2: Mediation byecosystems, R3: Mass flows, R4: Liquid flows, R6: Life cycle maintenance, habitat and gene pool protection, R7: Pest and disease control, R8: Soil formation and composition,R9: Water conditions. (Lee and Lautenbach, 2016)

Within the studied pairs and groups Cultural Services comprise a well-defined synergistic group while Regulating Services also present significant synergistic character among the distinct functions, and Provisioning Services correspond to the most diverse group with significant discrepancies. In detail:

- C: Cultural services, while all of them provide in general a No-Effect profile with other ESs they are recognised as synergistic between them. In precise:
  - C1: Physical and experiential interactions are identified as synergistic with Soil formation and composition (R8), Pest and disease control (R7), and Biomass-based energy sources (P5).
  - C2: Intellectual and representative interactions are identified as synergistic with Biomass-based energy sources (P5), and Mass flows (R3), and antagonistic to Nutrition biomass (P1), and Materials biomass (P3).
  - C4:Other cultural outputs, which have been identified to positively, interact only with Atmospheric composition and climate regulation (R10).

In conclusion Cultural Services will be considered as a Unit for the present ESs assessment.

- P: Provisioning services present in general a rather independent profile among them, which is replicated in their relationships with Cultural Services, and is considerably diversified when they are considered against the Regulating Services, with which present a mostly antagonistic character. In precise:
    - P1: Nutrition biomass provision is considered antagonistic with Atmospheric composition and climate regulation (R10), Life cycle maintenance, habitat and gene pool protection (R6), and Intellectual and representative interactions (C2).
    - P2: Nutrition water (i.e. drinking purpose) provision is antagonistic to Mediation by ecosystems (R2), but synergistic with Liquid flows (R4), and Materials biomass (P3)
    - P3: Materials biomass (e.g. for production and agricultural uses) provision is antagonistic to Intellectual and representative interactions (C2), Soil formation and composition (R8), Life cycle maintenance, habitat and gene pool protection (R6), Mediation by ecosystems (R2), and Atmospheric composition and climate regulation (R10).
    - P4: Material water (i.e. non-drinking purpose) provision is considered synergistic only with Water conditions (R9).
    - P5: Biomass-based energy sources provision on the other hand are considered antagonistic to Life cycle maintenance, habitat and gene pool protection (R6) but synergistic with Soil formation and composition (R8), Atmospheric composition and climate regulation (R10), and Cultural Services (C2, C3).
    - Pa: Renewable abiotic energy source provision is considered antagonistic to Liquid flows (R4).

  In conclusion for the here considered ESs will be constructed two major evaluation units these of Nutrition (Food and Water-P1 & P2) and Biomass (for raw materials and fuels-P3-P5 & Pa).

- R: Regulating services, which also include the supporting services of the MA (2005), consist a more or less homogenized group with significant synergistic effects among the here included ESs, as also with the Cultural Services. On the contrary, mostly antagonistic effects characterize the relation of the here-considered Regulating ESs, with the Provisioning Services.
    - R2: Mediation by ecosystems source provision is considered antagonistic to Atmospheric composition and climate regulation (R10), Mass flows (R3), Materials biomass (P3), and Nutrition water (P2), while synergistic character is established for the relations with Soil formation and composition (R8), and Intellectual and representative interactions (C2).
    - R3: Mass flows provision is considered synergistic to Atmospheric composition and climate regulation (R10, while antagonistic character is established for the relation with Mediation by Ecosystem Sources (R2).
    - R4: Liquid flows provision presents synergies with Nutrition water (P2), and Life cycle maintenance, habitat and gene pool protection (R6), and antagonism with Renewable abiotic energy source (Pa).
    - R6: Life cycle maintenance, habitat and gene pool protection is consider synergistic with almost all of the Regulation Services Functions, while

presents a significantly antagonistic character with most of the Provisioning Services, and a neutral for the Cultural.

- R7: Pest and disease control provision presents synergies with Water conditions (R9), Life cycle maintenance, habitat and gene pool protection (R6), and Other cultural outputs (C4).
- R8: Soil formation and composition provision presents mostly synergies with a plethora of Functions such as Life cycle maintenance, habitat and gene pool protection (R6), Mediation by Ecosystem Sources (R2), Biomass-based energy sources (P5) and Other cultural outputs (C4), and only one Trade-off with Materials biomass (P3).
- R9: Water conditions provision presents mostly synergies with a plethora of Functions such as Life cycle maintenance, habitat and gene pool protection (R6), Pest and disease control (R7), Biomass-based energy sources (P5), and only one Trade-off with Nutrition biomass (P1).
- R10: Atmospheric composition and climate regulation provision presents mostly synergies with a plethora of Functions such as Life cycle maintenance, habitat and gene pool protection (R6), Water conditions (R9), Mass flows (R3), Biomass-based energy sources (P5), and Physical and experiential interactions (C1), and only two Trade-offs with Mediation by ecosystems sources (R2) and Material biomass (P3).

In conclusion from the 8 ESs functions considered herein three major groups will be structured for further evaluation:

A. Biodiversity Biotic Support (including R6, R7, and R8)
B. Environmental Support (Including R2, R9, and R10)
C. Flows Support (Including R3 and R4)

2.1.2. Geographical Scale

The previously described TC ESs Assessment methodology eventually comprises a tool that will focus on a distinct Land-Use, characterized as "*Orchard Land*", which comprises a significant percent of the Northern Mediterranean EU countries, as depicted in Table 1:

Table 1: Land Coverage by Tree Crops in CLIMATREE's implementation area

Country	**Area (Ha)**		
	Total	**Tree Crops**	**%**
Greece	13.195.700	1.812.178	13,73%
Italy	30.133.800	1.258.169	4,18%
Spain	50.599.000	4.397.967	8,69%
Total	**93.928.500**	**7.468.314**	**7,95%**

The three countries, Italy, Greece, and Spain, consist a virtual arch on the Northern Mediterranean area, depicted in Map 1, which includes the 3 from the four major peninsulas of the Mediterranean Sea.

Map 1: Geographical location of the CLIMATREE's implementation area.

All three countries share a common Climatological background and present the same distribution of their *Orchard Land*, which occupies mostly slopped marginal agricultural land, and partially to a lesser extend levelled high productivity agricultural land.

2.2. Tree Crop Categorization

Present document aims to develop a common operating framework among the three national environments, for the successful implementation of present action.

As basic criteria implied for the selection of the representative tree-crops are proposed the following:

1. Total Area of Cultivation, in Hectares
2. Average Tree-Crop Life-Span, in Years
3. Annual Crop Yield, in Tones per Hectare

In the action's description is indicated the generic cladogram of tree-crop categories, which includes two biological categories as the two first ranks:

1. Evergreen Trees
2. Deciduous Trees

In order for the assessment of these two primary categories is required a short description of the biological cycle for each tree.

The next level of categorization regards the cultivation methodology; this level can be duplicated, as it is possible for a given tree-crop to be cultivated with multiple and diverse cultivation methodologies within even the same Region. These two categories are of course artificial and will consist by assumptions on the overage inputs among the various tree-crops:

1. Intensive Cultivation;
2. Extensive Cultivation

A tree-crop will have to conform to certain elements of discrimination in order to be included in either category. The following proposed criteria should be further defined and thresholds to be set for this attribution:

a. Plantation Density and Tree Growth in Trees per Hectare, as depicted in the ACI Growth Indicator.
b. Years of prospective productive life of the Plantation, as depicted in the ACI Year Indicator.
c. Soil Cultivation Frequency and form of application, in implementation number per year and depth of tillage respectively, which participates in the formation of CII indicator.
d. Irrigation Frequency and Volume, in implementation number per year and tones per hectare respectively, which participates in the formation of CII indicator.
e. Agrochemicals Usage, in Kg per year and hectare, which participates in the formation of CII indicator.

The third level of the dendrogram of tree-crop categories regards the ecological area that each crop occupies. This categorization includes three options:

1. Coastal Zone
2. Midland Zone
3. Mountain Zone

These three categories were include in order to provide a more solid framework for Italy and Spain, as in Greece the first Categories are merged due to the proximity of the Sea to the high Mountains. Attribution of crops in those categories will be pursued through the implementation of two basic Criteria:

a. Elevation, in Meters can distinguish cases for all three categories; e.g. above 500 m of altitude: Mountain Zone, in between 500 and 100 m of altitude: Midland Zone, and below 100 m of altitude: Coastal Zone

Distance from the sea, in Km may distinguish crops of low elevation but with significant differentiation from the coastal zone. In the same manner this criterion could be utilized for tree-crops of higher elevation but with direct proximity to the sea.

2.2.1. Cultivation Intensity Analysis of Tree-Crops

The methodology implicated for the attribution of each crop cultivation intensity degree was established upon two main considerations. The first one regarded the analysis of the numan-oriented inputs in the form of cultivation measures. The second provides an additional criterium, depicting the impacts of cultivation measures upon the natural form of the tree.

Main objective of this two fold approach is to include all aspects of tree cultivation in the evaluation procedure, providing thus an integrated approach considering both the human inputs and the state of difference between the cultivated and natural tree. The ecological signifficance of each tree-crop with respect to the Ecosystems Sevices Approach conforms the cosequent step of tree-crop consideration and closes the loop of tree-crop cultivation total appraoch.

In both cases will be followed the same methodological approach, which will enumarate the degree of intensity for each and every one of the relevant cultivation measure and/or forms of growth. Consequently and based upon the previous enumaration a Cultivation Intensity Indicator (CII) will be generated for each cultivation measure, while a Agronomical Characters Indicator (ACI) will enumerate the deviation of each Tree-Crop plantation characters from the natural characters of the relevant Tree.

2.2.2. Cultivation Measures Intensity Analysis

Grading of the cultivation measure impacts intensity will be performed after carefull consideration of the following parameters:

- Number
- Frequency

- Intensity

For the enumaration of the Number (N) is utilized the 0 to 3 scale were 0 means the relevant cultivation measure is not applied, and 3 the maximum number of repetitions per year observed for the given measure:

N Indicator	***Number of cultivation measure annual repetitions.***
0	*Cultivation measure not applied*
1	*Total numbers of repeptitions (N) ≤ 33% of maximum observed*
2	*Total numbers of repeption (N): 33% < N ≤ 66% of maximum observed.*
3	*Total numbers of repeption (N) > 66% of maximum observed.*

The enumaration of Frequency (F) is similarly structured upon the following evaluation scale:

F Indicator	***Frequency of cultivation measure annual repetitions.***
0	*Cultivation measure not applied*
1	*Total weeks between repeptitions (F) > 66% of maximum observed*
2	*Total weeks between repeption (F): 33% < F ≤ 66% of maximum observed.*
3	*Total weeks between repeption (F) ≤ 33 % of maximum observed.*

Intensity (I) of each cultivation measure is also calculated within the same numerical range according to the folowing scale:

I Indicator	***Intesnity of cultivation measure.***
0	*Cultivation measure not applied*
1	*Average Intensity of repeption (I) ≤ 33% of maximum observed*
2	*Average Intensity of repeption (I): 33% < I ≤ 66% of maximum observed.*
3	*Average Intensity of repeption (I) > 66% of maximum observed.*

The three previous indicator will be enumaretd for each tree crop and will be combined in order to provide the relevant Tree-Crop CIS, according to the following formulas:

Cultivation Measure Intensity:

Tree-Crop Cultivation Intensity:

$$\boxed{CII = (CMI_1 + CMI_2 + \ldots + CMI_v)^{-v}}$$

The final evaluation matrix is structured upon an xls spreadsheet that incorporates the fundmanetal algorithms of CII calculation and presents the following image:

Tree-Crop	**Irrigation**				**Tillage**				**Fertilization**				**Crop Protect.**				**CII**	
	N	**F**	**I**	**CMI_I**	**N**	**F**	**I**	**CMI_T**	**N**	**F**	**I**	**CMI_F**	**N**	**F**	**I**	**CMI_P**		
T-C min	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	**0**	min
T-C max	3	3	3	**27**	3	3	3	**27**	3	3	3	**27**	3	3	3	**27**	**27**	max
T-C 1	3	3	2	**18**	2	2	2	**8**	2	2	2	**8**	2	2	2	**8**	**10,5**	39%
T-C 2	1	1	1	**1**	1	1	1	**1**	1	1	1	**1**	1	1	1	**1**	**1**	4%
T-C 3	3	2	1	**6**	3	2	1	**6**	3	2	1	**6**	3	2	1	**6**	**6**	22%
T-C 4	2	2	2	**8**	2	2	2	**8**	3	3	3	**27**	3	3	3	**27**	**17,5**	65%
T-C 5	3	3	3	**27**	3	3	3	**27**	1	1	1	**1**	0	0	0	**0**	**13,75**	51%

2.2.3. Agronomical Characters Intensity Analysis

Grading of the agonomical characteristic intensity variation will be performed after carefull consideration of the following parameters:

- Form of Growth
- Prospective Age

For the enumaration of the Growth (G) is utilized the 0 to 3 scale were 0 means that tree growth under cultivation is equal or bigger than in Nature, and 3 corresponds to the maximum observed decrease in meters for the given crop:

G Indicator	***Height and Area Coverage of each Tree.***
0	*Height and coverage (G) ≥ Nature*
1	*Height and coverage (G) ≤ 33% of maximum observed decrease.*
2	*Height and coverage (G): 33% < G ≤ 66% of maximum observed decrease.*
3	*Height and coverage (G) > 66% of maximum observed decrease.*

Prospective Age is reflected through the Years indicator (Y) of each tree-crop, which is also calculated within the same numerical range according to the folowing scale:

Y Indicator	***Prospectice productive years of tree-crop.***
0	*Number of Years (Y) ≥ Nature*
1	*Number of Years (Y) ≤ 33% of maximum observed decrease.*
2	*Number of Years (Y): 33% < Y ≤ 66% of maximum observed decrease.*
3	*Number of Years (Y) > 66% of maximum observed decrease.*

The three previous indicator will be enumaretd for each tree crop and will be combined in order to provide the relevant Tree-Crop CIS, according to the following formulas:

Agronomical Intensity:

$$\boxed{AI = G*Y}$$

Tree-Crop ACI:

$$\boxed{ACI = (AI_1 + AI_2)^{-2}}$$

The final evaluation matrix is structured upon an xls spreadsheet that incorporates the fundmanetal algorithms of ACI calculation and presents the following image:

Tree-Crop	**Growth**			**Years**			**ACI**	
	N	**F**	**AI_G**	**N**	**F**	**AI_Y**		
T-C min	0	0	**0**	0	0	**0**	**0**	min
T-C max	3	3	**9**	3	3	**9**	**9**	max
T-C 1	3	3	**9**	2	2	**4**	**6,5**	72%
T-C 2	1	1	**1**	1	1	**1**	**1**	11%
T-C 3	3	2	**6**	3	2	**6**	**6**	67%
T-C 4	2	2	**4**	2	2	**4**	**4**	44%
T-C 5	3	3	**9**	0	0	**0**	**4,5**	50%

2.2.4. Tree-Crop Cultivation Intensity Analysis

The final evaluation on tree-crop cultivation categorization (TCC) will be performed with the application of the following formula, enumerating the TCC indicator:

TCC Indicator:

TCC = CII*CAI

Finally, the TCC indicator is utilized for the attribution of each crop in one of the two respective categories, according to the following scale:

TCC value	**Category**
$TCC \geq 60$	Intensive
$TCC < 60$	Extensive

3. Results and Discussion

3.1.Ecosystems Services Assessment

The previously described TC ESs Assessment methodology, is shortly summarized in the following Table 1 where are presented and described all of the variables under consideration.

Previews quantitative assessments of relationships between ES based on the published literature proved that: Dominance is an expressed character of the relationship between coupled ESs; This relationship is not influenced by the scale at which the relationship had been studied as well as by the land system; This relationship is further affected by the method applied to characterize the relationship.

Considering the later fact we concluded that the descriptive method selected for the present study present's a higher probability to identify more trade-off relationships, in contrast with multi-variate statistics, which is more likely to identify 'no-effect' relationships. More over the selected methodology circumnavigates the lack of comprehensive information, which is required for well-informed policy decisions that do not ignore side-effects in multi-functional land-systems.

On the weighting of the TC ESs we utilized a conception developed originally by Vackar et al. (2016) for the comparison of protected and unprotected areas with natural baselines. Their results show that humans appropriate a considerable share of natural ecosystem productivity and carbon stocks, and significantly reduce natural biodiversity and ecosystem services. Human appropriation of net primary production reached more than 60% in total, humans reduced original biodiversity levels by 69%, and net carbon storage was considerably decreased by intensive types of land use. All three indicators significantly differed between protected areas and unprotected areas, suggesting that protected areas maintain higher biodiversity levels, store more carbon and are in total less influenced by human exploitation than average non-protected landscape. Furthermore, they delivered evidence that human appropriation of net primary production is negatively related both to biodiversity and ecosystem services indicated by mean species abundance and net carbon storage at the national level. In present study, this last conclusion was elaborated as indicator of anthropogenic pressures on ecosystems and biodiversity to compare the level of human influence within TC functional groups and natural areas. The actual state of TCs ecosystems is compared to a natural baseline that is intact with the prevailing natural habitat in the area of consideration. Our results contribute to the quantitative evidence of the impacts of anthropogenic transformation of natural ecosystems on the ecosystem condition based on the indicative yield per hectare transition rate between intensive and extensive crop systems.

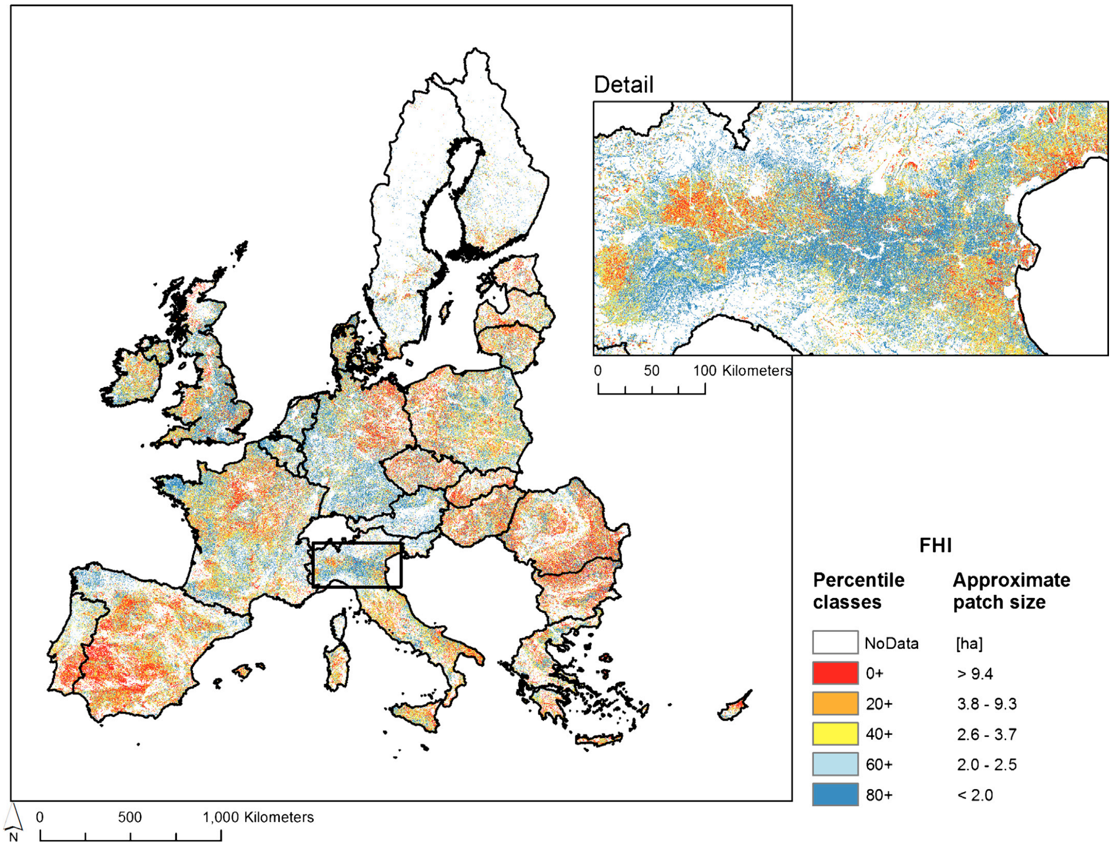
Table 1: Ecosytems Services Functions Vs the respective providers and functional units according to Petrosillo et al. (2010).

Ecosystems Service/Function		**Direct and intermediate ecosystem service providers (ESPs)/organization level**	**Functional units**
Regulation	Biotic support	Insects, birds, mammals and supporting landscape land use/land cover	Species, populations, communities, habitats, landscapes
	Abiotic support	Biogeochemical cycles, plants, micro-organisms, supporting landscape land use/cover	Biogeochemical cycles, populations, species, functional groups, landscapes
	Flows support	Leaf litter and soil invertebrates; soil micro-organisms; nitrogen-fixing plants; plant and animal production and supporting landscape land use/cover	Species, populations, functional groups, communities, habitats, landscapes
Provision	Nutrition	Plants and supporting landscape land use/land cover	Species, landscapes.
	Biomass	Plants, Landscape land use/cover, Leaf litter and soil invertebrates, soil micro-organisms, aquatic micro-organisms, aquatic invertebrates and supporting landscape land use/cover	Species, functional groups, habitats, landscapes
Cultural	Aesthetic	All biodiversity, landscape land use/cover	Species, populations, communities, habitats, landscapes

In the following lines are presented in abstract the fundamental assumptions for the deliverance of the respective results presented consequently in Chapters 3.3.1-4. In specific:

3.1.1. Everegreen vs Deciduous TCs

Mapping and assessment of ecosystem services in agricultural landscapes as required by the EU biodiversity policy need a better characterization of the given landscape typology according to its ecological and cultural values. Such need should be accommodated by a better discrimination of the landscape characteristics linked to the capacity of providing ecosystem services and socio-cultural benefits. Often, these key variables depend on the degree of farmland heterogeneity and landscape patterns. Weisteinner et al. (2016) employed segmentation and landscape metrics (edge density and image texture respectively), derived from a pan-European multi-temporal and multi-spectral remote sensing dataset, to generate a consistent European indicator of farmland heterogeneity, the Farmland Heterogeneity Indicator (FHI). In this study were mapped five degrees of FHI on a wall-to-wall basis (250 m spatial resolution) over European agricultural landscapes including natural grasslands. Image texture led to a clear improvement of the indicator compared to the pure application of Edge Density, in particular to a better detection of small patches. In addition to deriving a qualitative indicator this study attributed an approximate patch size to each class, allowing an indicative assessment of European field sizes. Based on CORINE land cover, was also identified pastures and heterogeneous land-cover classes as classes with the highest degree of FHI, while agro-forestry, olive groves and Fruit trees and berry plantations appeared less heterogeneous on average, which are depicted in Map 2. Further clarification on the typology of is established on the fundamental ecology of each TC, which affects crucial characters for the ESs expression. In specific Evergreen TCs present a yearly respiration and photosynthesis cycle with also year round land cover that enhances the provision of wildlife shelter services as also the provision of micro-climate regulation and hazard prevention services against threats like Soil Erosion and floods. On the other hand material flows in evergreen TCs are integrated within a two-year cycle while in deciduous TCs this task is performed in a yearly manner. In general and according to the previous fundamental assumptions Evergreen TCs present almost double the potential provision of Regulating ES of Deciduous TCs, while in respect to the Provisioning ESs this analogy is reversed especially with regard to the materials provision, and nutrient cycles, which accelerate as a result of the semester long vegetative cycle. Therefore considering as baseline the Deciduous TC, the Evergreen TC present a Regulation ESs coefficient of 2, and Provision ESs coefficient of 0,5.



Map 2: Farmland Heterogeneity Indicator (FHI) for Europe (EU27), Alternative AB. The detail shows the FHI for the agricultural area around the Po River in Northern Italy; Weisteinner et al. (2016).

3.1.2. Intensive vs Extensive Cultivation Method

The study of traditional agrarian systems can provide useful knowledge for improving the sustainability of present-day agriculture. Nonetheless, with the loss of traditional agro-ecosystems and the rationale that guides them, as has happened in Europe, an historical research approach can have a decisive role to play in recapturing this knowledge. The study of the evolution of a typical Mediterranean agro-ecosystem during the last 250 years by Casado and de Molina, (2009), is supporting the claim that high diversity and the internalization of energy flows and nutrient cycles found in traditional agriculture, are not only characteristics of the greatest sustainability of such systems, but are based in the need for additional land in production.

During the past and up to the middle of the 20th century, the territorial dependency of the agricultural metabolism based on solar energy obliged farmers to maintain very strict land use equilibrium, to begin with on a local scale and later on a regional scale A considerable amount of land had to remain "uncultivated" or be devoted to feed livestock. Over that time the system conserved wide spatial heterogeneity and great biological diversity. However, both small-scale and large-scale farmers shifted their focus towards growing crops with the highest market value and increasing the yield for each unit of surface area. This production focus required ever-increasing amounts of space for farming, shorter rotations, fewer varieties and types of crop and, of course, more water. Their productive efforts upset the balance of energy and nutrients in the agro-ecosystem, particularly with the introduction of fertilizers and labour from outside the system.

This process was further intensified over the course of the 20th century, forming an agricultural metabolism of a typically industrial character, highly dependent on external resources for its functioning and reproduction. The expansion of agriculture and of crops with the highest commercial value has lead to an increase in relationships of physical exchange, through the market and the importation of ever increasing quantities of materials and energy.

All this has shaped an ever more homogenous landscape with less biological diversity. Basic functions performed by the land in the past (production of fuels, food for livestock, basic foodstuffs etc). Production ("domestic extraction") in energy terms was 4.3 times greater, whilst the real amount of land appropriated just to provide the nutrients also increased by a factor of 4.2. So the increase in physical production of the agro-ecosystem over intensification has taken place at the same rate as land has been "imported" from elsewhere, simplifying the landscape and its biodiversity. This analogy is utilized for the calculation of the Integrated ESs coefficient for intensive TCs, considering as baseline the relevant extensive (Traditional, Organic, etc), which is 0,25.

3.1.3. Provision TC Services

TCs as a source of food has a substantial spill over that affects the Earth's ecosystems. This results in an 'ecological footprint' of food: negative environmental impacts per capita. The footprint depends on the dietary choice of types and amounts of food, on the non-consumed part of product flows and its fate ('waste' or 'reused'), on transport and processing along the value chain, on the environmental impacts of production per unit area, and on the area needed per unit product. Yield gaps indicate inefficiency in this last aspect: resource-use efficiency gaps for water and nutrients indicate that environmental impacts per unit area are higher than desirable. Ecological intensification aimed at simultaneously closing these two gaps requires process-level understanding and system-level quantification of current efficiency of the use of land and other production factors at multiple scales (field, farm, landscape, regional and global economy). Contrary to common opinion, yield and efficiency gaps are partially independent in the empirical evidence. Synergy in gap closure is possible in many contexts where efforts are made but are not automatic. With Good Agricultural Practice (GAP), enforceable in world trade to control hidden subsidies, there is scope for incremental improvement towards food systems that are efficient at global, yet sustainable at local, scales (Van Noordwijk & Brussaard 2014). Within this context the total yield per hectare incorporates most of the substantial information on the provision of the relative services by TC, and therefore an average yield in tonnes per hectare could provide substantial evidence for the contribution of TC in Food and Biomass Provision Services.

3.1.4. Regulation TC Services

Soil ecosystem functions are derived from plant, animal and microorganism communities and the nonliving environment interacting as a unit. Human activities have affected soil ecosystem functions and in many cases caused soil ecosystem collapse. Nikolaidis (2011) provided a synthesis of current knowledge of human impacts on soil ecosystems, with a special focus on knowledge gaps regarding soil ecosystem shifts and tipping points, using the island of Crete, Greece as an example. Soil ecosystem shifts are abrupt changes that occur at ''tipping points'' and have long-lasting effects on the landscape and both the biotic and abiotic structure of the soil. These shifts can occur due to climate change, land use change, fertilization, or above-ground biodiversity decline. The environmental pressures in the agricultural land of Crete, place the island very close to tipping points, and make it an ''ideal'' area for soil ecosystem shifts. Reversing the trend of the shift while using the soil ecosystem services, means that significantly more organic matter needs to be added to the soil compared to the amount added under set-aside conditions. Soil physical and chemical characteristics were studied explicitly by Miralles et al. (2009) with respect to the climatic and geomorphological factors in 68 sites of a mountain calcimorphic ecosystem in Southeastern Spain. Land use and vegetation were natural pine forest, evergreen oak forest, reforested pine forest of different ages, bush, juniper forest, and olive, almond and cereal crops under conventional tillage. This study utilized multivariate data treatments, and 17 soil variables were processed. Most characteristics were significantly correlated with total organic C (mean=28.5±4.6 g kg−1), which demonstrates the central role of the organic matter in the functioning of the whole ecosystem. New soil quality descriptors consisting of ratios to soil organic carbon were obtained, informing about the specific activity (per C unit) or performance of the organic matter, independently of its total content. When soil data are directly processed by using principal component analysis, we found a set of high quality soils under natural and old reforested forests, where environmental services provided by soil depend on the high levels of quality descriptors related to organic carbon, e.g. cation exchange capacity (CEC), total porosity, or aggregate stability. When variables such as CEC, porosity and aggregate stability are calculated as ratios to the total organic carbon, a new classification pattern is obtained, allowing to detect soils with organic matter of high maturity which in general do not coincide with soils with high organic matter content. The results suggest the assessment of soil quality based on ratios informing on the organic matter performance should be emphasized as an alternative to direct descriptors based on the total organic carbon content. Based on those two fundamental conceptions as indicator for assessing both the TCs contribution to Flows and Abiotic Support was chosen the Soil Carbon Sequestration and the Soil Erosion respectively. These indicators were calculated by Rodríguez-Entrena et al. (2012), for olive groves to present averages of 2,5 tCO_2 $ha^{-1}year^{-1}$, and 10 t soil $ha^{-1}year^{-1}$.

Mediterranean landscapes comprise a complex mosaic of different habitats that vary in the diversity of their floral communities, pollinator communities and pollination services. Using the Greek Island of Lesvos as a model system, we assess the biodiversity value of six common habitats and measure ecosystemic ‘health’ using pollen grain deposition in three core flowering plants as a measure of pollination services. Three fire-driven habitats were assessed: freshly burnt areas, fully regenerated pine forests and intermediate age scrub; in addition we examined oak woodlands, actively managed olive groves and groves that had been abandoned from agriculture. Oak woodlands, pine forests and managed olive groves had the highest diversity of bees. The habitat characteristics responsible for structuring bee communities were: floral diversity, floral abundance, nectar energy availability and the variety of nectar resources present. Pollination services in two of our plant species, which were pollinated by a limited sub-set of the pollinator community, indicated that pollination levels were highest in the burnt and mature pine habitats. The third species, which was open to all flower visitors, indicated that oak woodlands had the highest levels of pollination from generalist species. Pollination was always more effective in managed olive groves than in abandoned groves. However, the two most common species of bee, the honeybee and a bumblebee, were not the primary pollinators within these habitats. We conclude that the three habitats of greatest overall value for plant-pollinator communities and provision of the healthiest pollination services are pine forests, oak woodland and managed olive groves. We indicate how the highest value habitats may be maintained in a complex landscape to safeguard and enhance pollination function within these habitats and potentially in adjoining agricultural areas. (Potts et al. 2006). Nevertheless pollination is a valuable service cannot be considered as a safe biodiversity indicator. For this function was chosen the number of birds per Hectare, which was calculated by Rodríguez-Entrena et al. (2012), for olive groves to present averages of 10 *taxa* ha^{-1}.

3.1.5. Cultural TC Services

Assessing the ways in which rural agrarian areas provide Cultural Ecosystem Services (CES) is proving difficult to achieve. Carvalho-Ribeiro et al. (2016) developed an innovative methodological approach named as Multi-Scale Indicator Framework (MSIF) for capturing the CES embedded into the rural agrarian areas. This framework reconciled a literature review with a trans disciplinary participatory workshop. Both of these sources revealed that societal preferences diverge upon judgemental criteria, which in turn relate to different visual concepts that can be drawn from analyzing attributes, elements, features and characteristics of rural areas. It concluded that it is possible to list a group of possible multi scale indicators for stewardship, diversity and aesthetics. This research carries major implications for policy at different levels of governance, as it makes possible to target and monitor policy instruments to the physical rural settings so that cultural dimensions are adequately considered.

Within this context the following set of indicators were promoted as more solid and of wide acceptance among the local populations:

Stewardship: Refers to the sense of order and care present in the landscape reflecting active and careful management (Ode Sang and Tveit, 2013). The proposed indicator is Number of man-made structures with a function, which translates to total area of Orchards in hectares.

Diversity: Is defined as the richness and diversity of landscape elements and features noted for their proximity and location, as well as the grain size of the landscape (Tveit et al., 2006). The proposed indicator relates to Edges between agriculture and other land uses, which translates also to total area of Orchards in hectares as TCs in the Mediterranean region usually occupy either marginal land or comprise distinct thickets within arable land, contributing thus to the landscape diversification.

Aesthetics: Relates to landscape characteristics or features which are able to promote a feeling of liking or disliking (adapted from Gobster et al., 2007). No dominant indicator was favoured over this value enumeration; instead numerous subjective indicators were proposed: Sublime features e.g., mountains; Viewpoints; Variety of colors/smell; Landscape features providing coherence; Listed trees classified as monuments; Topographic variability; Time depth, time origin “old landscapes”. Therefore present category will be omitted from further evaluation.

Orchard Type	**Area (Ha)**	**Representative Taxon**	**Ecosystems Services**	**ES Function**	**Grade per He**	Grade Total
Deciduous Intensive	631651,86	*Malus sylvestris / Prunus persica*	Regulation	Biotic support	0,88	0,07
				Abiotic support	1,25	0,11
				Flows support	0,31	0,03
			Provision	Nutrition	1,50	0,13
				Biomass		
			Cultural		557.089,18	0,07
Deciduous Extensive	1444125,87	*Amygdalus communis*	Regulation	Biotic support	3,50	0,68
				Abiotic support	5,00	0,97
				Flows support	1,25	0,00
			Provision	Nutrition	6,00	0,68
				Biomass		
			Cultural		2.228.356,70	0,30
Evergreen Intensive	942757,68	*Citrus sinensis*	Regulation	Biotic support	1,75	0,22
				Abiotic support	2,50	0,32
				Flows support	0,63	0,08
			Provision	Nutrition	0,75	0,09
				Biomass		
			Cultural		1.114.178,35	0,15
Evergreen Extensive	4456713,4	*Olea europaea*	Regulation	Biotic support	7,00	4,17

Orchard Type	**Area (Ha)**	**Representative Taxon**	**Ecosystems Services**	**ES Function**	**Grade per He**	Grade Total
				Abiotic support	10,00	5,96
				Flows support	2,50	1,49
			Provision	Nutrition	3,00	1,79
				Biomass		
			Cultural		4.456.713,40	0,60
	7475248,81					

Ecosystems Services	**ES Function**	**Grade**	**Performance**
Regulation	Biotic support	13,13	5,14
	Abiotic support	18,75	7,35
	Flows support	4,69	1,60
Provision	Nutrition	11,25	2,69
	Biomass		
Cultural	Stewardship/ Diversity	8.356.337,63	1,12

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3.2. Tree Crop Categorization

3.2.1. **Biological Characters**

A. Rosaceae Family

I. *Prunus* L.

The genus *Prunus* is native to northern temperate regions and includes more than 400 (±430) species of flowering shrubs and trees. *Prunus taxa* can be deciduous or evergreen. A few species have spiny stems. The leaves are simple, alternate, usually lanceolate, unlobed, and often with nectaries on the leaf stalk. The flowers are usually white to pink, sometimes red, with five petals and five sepals. There are numerous stamens. Flowers are borne singly, or in umbels of two to six or sometimes more on racemes. The fruit is a fleshy drupe (a "prune") with a single relatively large, hard-coated seed (a "stone").

According to contemporary systematic classification in *Prunus* L. are included six subgenera that are described as follows:

> Subgenus *Amygdalus*, almonds and peaches: axillary buds in threes (vegetative bud central, two flower buds to sides); flowers in early spring, sessile or nearly so, not on leafed shoots; fruit with a groove along one side; stone deeply grooved; type species: Prunus dulcis (almond).
>
> Subgenus *Prunus*, plums and apricots: axillary buds solitary; flowers in early spring stalked, not on leafed shoots; fruit with a groove along one side, stone rough; type species: Prunus domestica (plum)
>
> Subgenus *Cerasus*, cherries: axillary buds single; flowers in early spring in corymbs, long-stalked, not on leafed shoots; fruit not grooved, stone smooth; type species: Prunus cerasus (sour cherry)
>
> Subgenus *Lithocerasus*: axillary buds in threes; flowers in early spring in corymbs, long-stalked, not on leafed shoots; fruit not grooved, stone smooth; type species: Prunus pumila (sand cherry)

Subgenus *Padus*, bird cherries: axillary buds single; flowers in late spring in racemes on leafy shoots, short-stalked; fruit not grooved, stone smooth; type species: Prunus padus (European bird cherry)

Subgenus *Laurocerasus*, cherry-laurels: mostly evergreen (all the other subgenera are deciduous); axillary buds single; flowers in early spring in racemes, not on leafed shoots, short-stalked; fruit not grooved, stone smooth; type species: Prunus laurocerasus (European cherry-laurel)

This genus has a number of economically important members, including the cultivated almond, peach, plum, cherry, and apricot. In addition, many species flower prolifically and are grown as ornamentals or fence plants because of their thorny stems. Herein are discussed the species occurring in cultivation as Tree-Crops in Greece (EL), Italy (IT) and Spain (ES).

1. *P. dulcis* (Mill.) D.A.Webb, (Engl: Almond). EL-IT-ES.

The almond (syn. Prunus amygdalus, Amygdalus communis, Amygdalus dulcis) is a species of tree native to the Middle East and South Asia. It is a deciduous tree, growing 4–10 m in height, with a trunk of up to 30 cm in diameter. The young twigs are green at first, becoming purplish where exposed to sunlight, then grey in their second year. The leaves are 3–5 inches long, with a serrated margin and a 2.5 cm petiole. The flowers are white to pale pink, 3–5 cm diameter with five petals, produced singly or in pairs and appearing before the leaves in early spring. Almond grows best in Mediterranean climates with warm, dry summers and mild, wet winters. The optimal temperature for their growth is between 15 and 30 °C and the tree buds have a chilling requirement of 300 to 600 hours below 7.2 °C to break dormancy.

Almonds begin bearing an economic crop in the third year after planting. Trees reach full bearing five to six years after planting. The fruit matures in the autumn, 7–8 months after flowering.

2. *P. armeniaca* L., (Engl: Apricot). EL-IT-ES.

P. armeniaca is a small tree, 8–12 m tall, with a trunk up to 40 cm in diameter and a dense, spreading canopy. The leaves are ovate, 5–9 cm long and 4–8 cm wide, with a rounded base, a pointed tip and a finely serrated margin. The flowers are 2–4.5 cm in diameter, with five white to pinkish petals; they are produced singly or in pairs in early spring before the leaves. The fruit is a drupe similar to a small peach, 1.5–2.5 cm diameter (larger in some modern cultivars), from yellow to orange, often tinged red on the side most exposed to the sun; its surface can be smooth (botanically described as: glabrous) or velvety with very short hairs (botanically: pubescent). The flesh is usually firm and not very juicy. Its taste can range from sweet to tart. The single seed is enclosed in a hard, stony shell, often called a "stone", with a grainy, smooth texture except for three ridges running down one side.

3. *P. cocomilia* Ten., (Engl: Italian plum). EL-IT-?.

Italian plum is a small evergreen tree native to Albania, Croatia, Greece, southern Italy (including Sicily), Macedonia, Montenegro, Serbia, and western Turkey.

4. *P. avium* (L.) L., (Engl: Cherry). EL-IT-ES.

FÅGELBÄR, PRUNUS AVIUM L.

P. avium is a deciduous tree growing to 15–32 m tall, with a trunk up to 1.5 m in diameter. Young trees show strong apical dominance with a straight trunk and symmetrical conical crown, becoming rounded to irregular on old trees. The bark is smooth purplish-brown with prominent horizontal grey-brown lenticels on young trees, becoming thick dark blackish-brown and fissured on old trees. The leaves are alternate, simple ovoid-acute, 7–14 cm long and 4–7 cm broad, glabrous matt or sub-shiny green above, variably finely downy beneath, with a serrated margin and an acuminate tip, with a green or reddish petiole 2–3.5 cm long bearing two to five small red glands. The tip of each serrated edge of the leaves also bear small red glands. In autumn, the leaves turn orange, pink or red before falling. The flowers are produced in early spring at the same time as the new leaves, borne in corymbs of two to six together, each flower pendent on a 2–5 cm peduncle, 2.5–3.5 cm in diameter, with five pure white petals, yellowish stamens, and a superior ovary; they are hermaphroditic, and pollinated by bees. The ovary contains two ovules, only one of the becomes the seed. The fruit is a drupe 1–2 cm in diameter (larger in some cultivated selections), bright red to dark purple when mature in midsummer, edible, variably sweet to somewhat astringent and bitter to eat fresh. Each fruit contains a single hard-shelled stone 8–12 mm long, 7–10 mm wide and 6–8 mm thick, grooved along the flattest edge; the seed (kernel) inside the stone is 6–8 mm long.

The fruit are readily eaten by numerous kinds of birds and mammals, which digest the fruit flesh and disperse the seeds in their droppings. Some rodents, and a few birds (notably the hawfinch), also crack open the stones to eat the kernel inside. All parts of the plant except for the ripe fruit are slightly toxic, containing cyanogenic glycosides.

5. *P. persica* (L.) Batsch, (Engl: Peach). EL-IT-ES.

The peach is a deciduous tree native to the region of Northwest China between the Tarim Basin and the north slopes of the Kunlun Shan mountains, where it was first domesticated and cultivated. It bears an edible juicy fruit called a peach or a nectarine. The peach-tree grows to 4–10 m tall and 16 cm in diameter. The leaves are lanceolate, 7–16 cm long, 2–3 cm broad, pinnately veined. The flowers are produced in early spring before the leaves; they are solitary or paired, 2.5–3 cm diameter, pink, with five petals. The fruit has yellow or whitish flesh, a delicate aroma, and a skin that is either velvety (peaches) or smooth (nectarines) in different cultivars. The flesh is very delicate and easily bruised in some cultivars, but is fairly firm in some commercial varieties, especially when green. The single, large seed is red-brown, oval shaped, approximately 1.3–2 cm long, and is surrounded by a wood-like husk. Peaches, along with cherries, plums and apricots, are stone fruits (drupes).

Cultivated peaches are divided into clingstones and freestones, depending on whether the flesh sticks to the stone or not; both can have either white or yellow flesh. Peaches with white flesh typically are very sweet with little acidity, while yellow-fleshed peaches typically have an acidic tang coupled with sweetness, though this also varies greatly. Both colors often have some red on their skin. Peaches grow in a fairly limited range in dry, continental or temperate climates, since the trees have a chilling requirement that tropical or subtropical areas generally cannot satisfy except at high altitudes. Most cultivars require 500 hours of chilling around 0 to 10 °C. Once the chilling period is fulfilled, the plant enters a second type of dormancy, the quiescence period. During quiescence, buds break and grow when sufficient warm weather favorable to growth is accumulated. The trees themselves can usually tolerate temperatures to around −26 to −30 °C, although the following season's flower buds are usually killed at these temperatures, preventing a crop that summer. Flower bud death begins to occur between −15 and −25 °C, depending on the cultivar and on the timing of the cold, with the buds becoming less cold tolerant in late winter. Another climate constraint is spring frost. The trees flower fairly early and the blossom is damaged or killed if temperatures drop below about −4 °C. However, if the flowers are not fully open, they can tolerate a few degrees colder. Climates with significant winter rainfall at temperatures below 16 °C are also unsuitable for peach cultivation as the rain promotes peach leaf curl, which is the most serious fungal disease for peaches. In practice, fungicides are extensively used for peach cultivation in such climates, with >1% of European peaches exceeding legal pesticide limits in 2013. Finally, summer heat is required to mature the crop, with mean temperatures of the hottest month between 20 and 30 °C. Typical peach cultivars begin bearing fruit in their third year. Their lifespan varies by region; from 7 to 15 years.

6. *P. domestica* L., (Engl: Plum). EL-IT-ES.

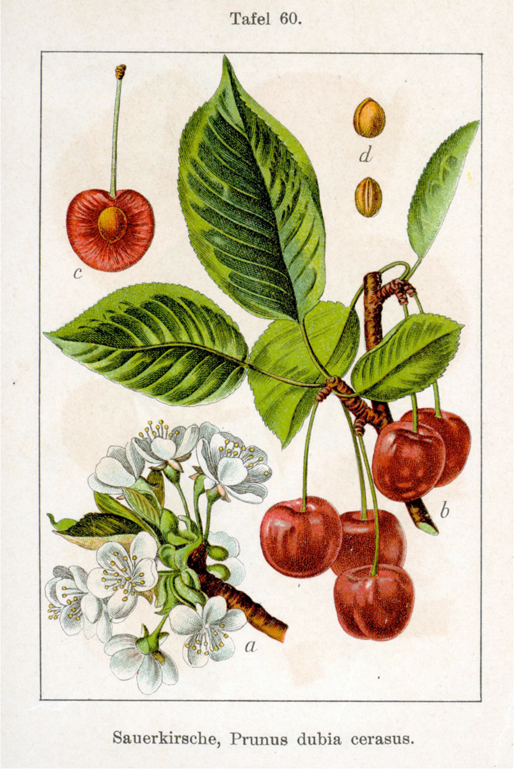
P. domestica (sometimes referred to as *Prunus* × *domestica*) is a deciduous tree, it includes many varieties of the fruit trees known as plums in English, though not all plums belong to this species. Its hybrid parentage is believed to be *P. spinosa* and *P. cerasifera*. This is the most commonly grown plum at least in Europe, and most prunes (dried plums) are made from fruits of this species. Typically it forms a large shrub or a small tree. It may be somewhat thorny, with white blossom, borne in early spring. The oval or spherical fruit varies in size, but can be up to 8 cm across, and is usually sweet (dessert plum), though some varieties are sour.

Plums are grown commercially in orchards, but modern rootstocks, together with self-fertile strains, training and pruning methods, allow single plums to be grown in relatively small spaces. Their early flowering and fruiting means that they require a sheltered spot away from frosts and cold winds.

7. *P. cerasus* L., (Engl: Sour cherry). EL-IT-ES.

P. cerasus is thought to have originated as a natural hybrid between *P. avium* and *P. fruticosa* in the Iranian Plateau or Eastern Europe where the two species come into contact. *P. fruticosa* is believed to have provided its smaller size and sour tasting fruit. The hybrids then stabilised and interbred to form a new, distinct species. Sour cherry tree is smaller than the sweet cherry (growing to a height of 4–10 m), has twiggy branches, and its crimson-to-near-black cherries are borne upon shorter stalks.

There are several varieties of the sour cherry.


Tafel 60.

Sauerkirsche, Prunus dubia cerasus.

II. *Eriobotrya* Lindl.

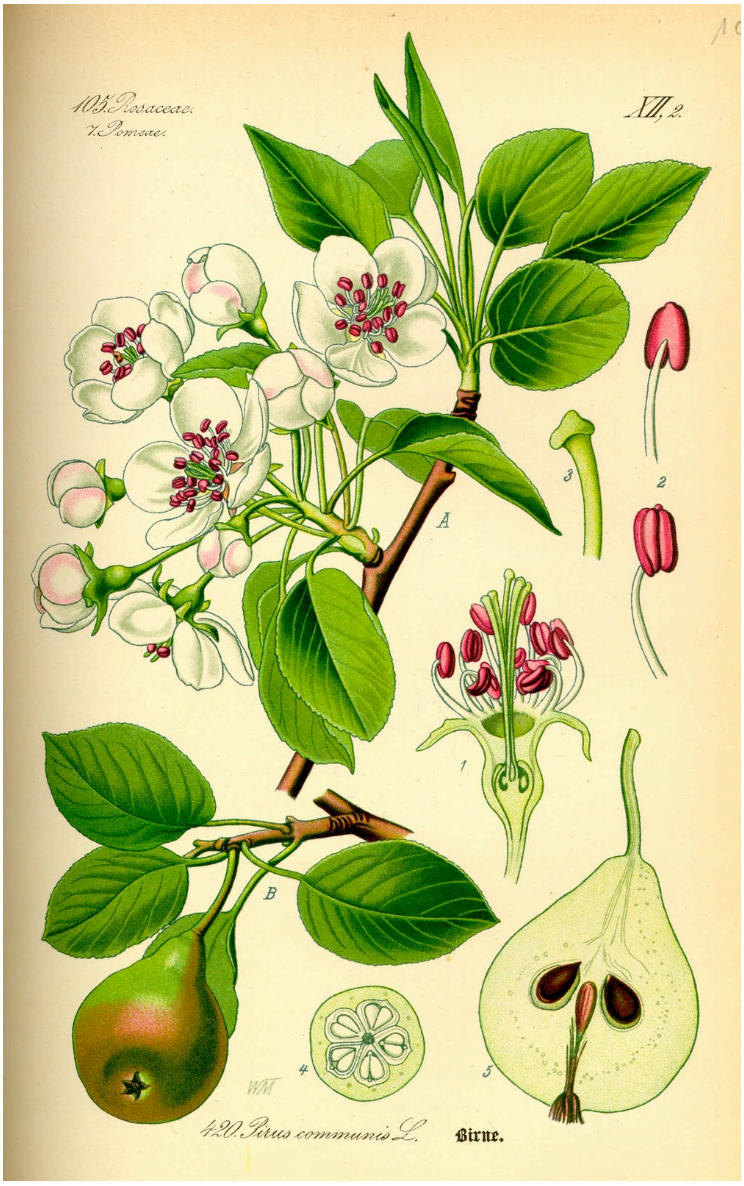
1. *E. japonica* (Thunb.) Lindl., (Engl: Loquat), EL-IT-ES.

The Loquat is a large evergreen shrub or small tree, with a rounded crown, short trunk and woolly new twigs. The tree can grow to 5–10 metres tall, but is often smaller, about 3–4 metres. The leaves are alternate, simple, 10–25 centimetres long, dark green, tough and leathery in texture, with a serrated margin, and densely velvety-hairy below with thick yellow-brown pubescence; the young leaves are also densely pubescent above, but this soon rubs off. Loquats are unusual among fruit trees in that the flowers appear in the autumn or early winter, and the fruits are ripe in late winter or early spring. The flowers are 2 cm in diameter, white, with five petals, and produced in stiff panicles of three to ten flowers. The flowers have a sweet, heady aroma that can be smelled from a distance. Loquat fruits, growing in clusters, are oval, rounded or pear-shaped, 3–5 centimetres long, with a smooth or downy, yellow or orange, sometimes red-blushed skin. The succulent, tangy flesh is white, yellow or orange and sweet to subacid or acid, depending on the cultivar. Each fruit contains from one to ten ovules, with three to five being most common. A variable number of the ovules mature into large brown seeds. The skin, though thin, can be peeled off manually if the fruit is ripe. In Egypt varieties with sweeter fruits and fewer seeds are often grafted on inferior quality specimens.

Over 800 loquat cultivars exist worldwide. The loquat is easy to grow in subtropical to mild temperate climates where it is often primarily grown as an ornamental plant, especially for its sweet-scented flowers, and secondarily for its delicious fruit.

III. *Pyrus* L.

1. *P. communis* L., (Engl: Apple), EL-IT-ES.



The pear is native to coastal and mildly temperate regions of the Old World, from western Europe and north Africa east right across Asia. It is a medium-sized tree, reaching 10–17 metres tall, often with a tall, narrow crown; a few species are shrubby. The leaves are alternately arranged, simple, 2–12 centimetres long, glossy green on some species, densely silvery-hairy in some others; leaf shape varies from broad oval to narrow lanceolate. Most pears are deciduous, but one or two species in southeast Asia are evergreen. Most are cold-hardy, withstanding temperatures between −25 °C and −40 °C in winter, except for the evergreen species, which only tolerate temperatures down to about −15 °C. The flowers are white, rarely tinted yellow or pink, 2–4 centimetres diameter, and have five petals. Like that of the related apple, the pear fruit is a pome, in most wild species 1–4 centimetres diameter, but in some cultivated forms up to 18 centimetres long and 8 centimetres broad; the shape varies in most species from oblate or globose, to the classic pyriform 'pear-shape' of the European pear with an elongated basal portion and a bulbous end. The fruit is composed of the receptacle or upper end of the flower-stalk (the so-called calyx tube) greatly dilated. Enclosed within its cellular flesh is the true fruit: five cartilaginous carpels, known colloquially as the "core". From the upper rim of the receptacle are given off the five sepals, the five petals, and the very numerous stamens.

About 3000 known varieties of pears are grown worldwide. The pear is normally propagated by grafting a selected variety onto a rootstock, which may be of a pear variety or quince. Quince rootstocks produce smaller trees, which is often desirable in commercial orchards or domestic gardens. The fruit of the pear is produced on spurs, which appear on shoots more than one year old. Three species account for the vast majority of edible fruit production, the European pear Pyrus communis subsp. communis cultivated mainly in Europe and North America, the Chinese white pear (bai li) Pyrus ×bretschneideri, and the Nashi pear Pyrus pyrifolia (also known as Asian pear or apple pear), both grown mainly in eastern Asia. There are thousands of cultivars of these three species.

IV. *Malus* Mill.

1. *M. sylvestris* (L.) Mill., (Engl: Apple), EL-IT-ES.

The apple is a deciduous tree, generally standing 1.8 to 4.6 m tall in cultivation and up to 12 m in the wild. When cultivated, the size, shape and branch density are determined by rootstock selection and trimming method. The leaves are alternately arranged dark green-colored simple ovals with serrated margins and slightly downy undersides. Blossoms are produced in spring simultaneously with the budding of the leaves, and are produced on spurs and some long shoots. The 3 to 4 cm flowers are white with a pink tinge that gradually fades, five petaled, with an inflorescence consisting of a cyme with 4–6 flowers. The central flower of the inflorescence is called the "king bloom"; it opens first, and can develop a larger fruit. The fruit matures in late summer or autumn, and varieties exist with a wide range of sizes. The skin of ripe apples is generally red, yellow, green, pink, or russetted although many bi- or tri-colored varieties may be found. The skin may also be wholly or partly russeted i.e. rough and brown. The skin is covered in a protective layer of epicuticular wax. The flesh is generally pale yellowish-white, though pink or yellow flesh is also known.

Commercial growers aim to produce an apple that is 7.0 to 8.3 cm in diameter, due to market preference. Some consumers, especially those in Japan, prefer a larger apple, while apples below 5.7 cm are generally used for making juice and have little fresh market value. There are more than 7,500 known cultivars of apples. Cultivars vary in their yield and the ultimate size of the tree, even when grown on the same rootstock. Different cultivars are available for temperate and subtropical climates.

V. *Cydonia* Mill.

1. *C. oblonga* Mill., (Engl: Quince), EL-IT-ES.

The quince is the sole member of the genus *Cydonia*. It is a small deciduous tree that bears a pome fruit, similar in appearance to a pear, and bright golden-yellow when mature. Throughout history the cooked fruit has been used as food, but the tree is also grown for its attractive pale pink blossom and other ornamental qualities. The tree grows 5 to 8 metres high and 4 to 6 metres wide. The leaves are alternately arranged, simple, 6–11 cm long, with an entire margin and densely pubescent with fine white hairs. The flowers, produced in spring after the leaves, are white or pink, 5 cm across, with five petals. The fruit is 7 to 12 centimetres long and 6 to 9 centimetres across. It is native to rocky slopes and woodland margins in South-west Asia, Turkey and Iran although it can be grown successfully at latitudes as far north as Scotland. The immature fruit is green with dense grey-white pubescence, most of which rubs off before maturity in late autumn when the fruit changes colour to yellow with hard, strongly perfumed flesh.

Quince is resistant to frost and requires a cold period below 7 °C to flower properly (yarovization). The tree is self-fertile; however, its yield can benefit from cross-fertilization. The fruit can be left on the tree to ripen further, which softens the fruit to the point where it can be eaten raw in warmer climates, but should be picked before the first frosts.

B. Lauraceae Family

I. *Persea* Mill.

1. *P. americana* Mill., (Engl: Avocado), EL-IT-ES.

The avocado is a tree native to Mexico and Central America. The tree grows to 20 m, with alternately arranged leaves 12–25 cm long. The flowers are inconspicuous, greenish-yellow, 5–10 mm wide. The pear-shaped fruit is 7–20 cm long, weighs between 100 and 1,000 g, and has a large central seed, 5–6.4 cm.

Avocados are commercially valuable and are cultivated in tropical and Mediterranean climates throughout the world. They have a green-skinned, fleshy body that may be pear-shaped, egg-shaped, or spherical. Avocado trees are partially self-pollinating and often are propagated through grafting to maintain a predictable quality and quantity of the fruit. The subtropical species needs a climate without frost and with little wind. High winds reduce the humidity, dehydrate the flowers, and affect pollination. When even a mild frost occurs, premature fruit drop may occur. The trees also need well-aerated soils, ideally more than 1 m deep. Yield is reduced when the irrigation water is highly saline. Commercial orchards produce an average of seven tonnes per hectare each year, with some orchards achieving 20 tonnes per hectare. Biennial bearing can be a problem, with heavy crops in one year being followed by poor yields the next. The avocado tree does not tolerate freezing temperatures, and can be grown only in subtropical or tropical climates. Cold-hardy varieties can survive temperatures as low as −6.5 °C with only minor leaf damage.

Like the banana, the avocado is a climacteric fruit, which matures on the tree, but ripens off the tree. Avocados used in commerce are picked hard and green and kept in coolers at 3.3 to 5.6 °C until they reach their final destination. Avocados must be mature to ripen properly. Avocados that fall off the tree ripen on the ground. Generally, the fruit is picked once it reaches maturity; when they have more than 23% dry matter. Once picked, avocados ripen in one to two weeks (depending on the cultivar) at room temperature (faster if stored with other fruits such as apples or bananas, because of the influence of ethylene gas). In some cases, avocados can be left on the tree for several months, which is an advantage to commercial growers who seek the greatest return for their crop; but if the fruit remains unpicked for too long, it falls to the ground.

C. Musaceae Family

I. *Musa* L.

The genus *Musa* was created by Carl Linnaeus in 1753. The name may be derived from Antonius Musa, physician to the Emperor Augustus, or Linnaeus may have adapted the Arabic word for banana, mauz.[28] Musa is in the family Musaceae. The APG III system assigns Musaceae to the order Zingiberales, part of the commelinid clade of the monocotyledonous flowering plants. Some 70 species of Musa were recognized by the World Checklist of Selected Plant Families as of January 2013; several produce edible fruit, while others are cultivated as ornamentals.

1. *M. x paradisiaca* L., (Engl: Banana), EL-IT-ES.

The currently accepted scientific names for most groups of cultivated bananas are *M. acuminata* Colla and *M. balbisiana* Colla for the ancestral species, and *Musa* × *paradisiaca* L. for the hybrid *M. acuminata* × *M. balbisiana*.

The banana plant is the largest herbaceous flowering plant. All the above-ground parts of a banana plant grow from a structure usually called a "corm". Plants are normally tall and fairly sturdy, and are often mistaken for trees, but what appears to be a trunk is actually a "false stem" or pseudostem. The leaves of banana plants are composed of a "stalk" (petiole) and a blade (lamina). The base of the petiole widens to form a sheath; the tightly packed sheaths make up the pseudostem, which is all that supports the plant. The edges of the sheath meet when it is first produced, making it tubular. As new growth occurs in the centre of the pseudostem the edges are forced apart. Cultivated banana plants vary in height depending on the variety and growing conditions. Most are around 5 m tall, with a range from around 3 m to 7 m or more. Leaves are spirally arranged and may grow 2.7

metres long and 60 cm wide. When a banana plant is mature, the corm stops producing new leaves and begins to form a flower spike or inflorescence. A stem develops which grows up inside the pseudostem, carrying the immature inflorescence until eventually it emerges at the top. Each pseudostem normally produces a single inflorescence, also known as the "banana heart". After fruiting, the pseudostem dies, but offshoots will normally have developed from the base, so that the plant as a whole is perennial. The inflorescence contains many bracts (sometimes incorrectly referred to as petals) between rows of flowers. The female flowers (which can develop into fruit) appear in rows further up the stem (closer to the leaves) from the rows of male flowers. The ovary is inferior, meaning that the tiny petals and other flower parts appear at the tip of the ovary. The banana fruits develop from the banana heart, in a large hanging cluster, made up of tiers (called "hands"), with up to 20 fruit to a tier. The hanging cluster is known as a bunch, comprising 3–20 tiers, or commercially as a "banana stem", and can weigh 30–50 kilograms. Individual banana fruits (commonly known as a banana or "finger") average 125 grams, of which approximately 75% is water and 25% dry matter. The fruit has been described as a "leathery berry". There is a protective outer layer (a peel or skin) with numerous long, thin strings (the phloem bundles), which run lengthwise between the skin and the edible inner portion. The inner part of the common yellow dessert variety can be split lengthwise into three sections that correspond to the inner portions of the three carpels by manually deforming the unopened fruit. In cultivated varieties, the seeds are diminished nearly to non-existence; their remnants are tiny black specks in the interior of the fruit.

D. Fabaceae Family

I. *Ceratonia* L.

1. *C. siliqua* L., (Engl: Carob), EL-IT-ES.

The carob tree is native to the Mediterranean region, including Southern Europe, Northern Africa, the larger Mediterranean islands; to the Levant and Middle-East of Western Asia into Iran; and to the Canary Islands and Macaronesia. The word carat, a unit of mass for gemstones and a unit of purity for gold alloys, was possibly derived from the Greek word kerátion literally meaning a small horn, and refers to the carob seed as a unit of weight.

The carob tree grows up to 15 metres tall. The crown is broad and semi-spherical, supported by a thick trunk with brown rough bark and sturdy branches. Leaves are 10 to 20 centimetres) long, alternate, pinnate, and may or may not have a terminal leaflet. It is frost-tolerant. Most carob trees are dioecious, some are hermaphrodite. The male trees don't produce fruit. The trees blossom in autumn. The flowers are small and numerous, spirally arranged along the inflorescence axis in catkin-like racemes borne on spurs from old wood and even on the trunk (cauliflory); they are pollinated by both wind and insects. The fruit is a legume (also known less accurately as a pod) that can be elongated, compressed, straight or curved, and thickened at the sutures. The pods take a full year to develop and ripen. The ripe pods eventually fall to the ground and are eaten by various mammals, thereby dispersing the seed. The seeds contain leucodelphinidin, a colourless chemical compound.

E. Fagaceae Family

I. *Castanea* L.

1. *C. sativa* Mill., (Engl: Chestnut), EL-IT-ES.

Chestnut tree is a long-living deciduous tree, native to Europe and Asia Minor, and widely cultivated throughout the temperate world, for its edible seed and wood.

Chestnut tree attains a height of 20–35 m with a trunk often 2 m in diameter. The bark often has a net-shaped (retiform) pattern with deep furrows or fissures running spirally in both directions up the trunk. The oblong-lanceolate, boldly toothed leaves are 16–28 cm long and 5–9 cm broad. The flowers of both sexes are borne in 10–20 cm long, upright catkins, the male flowers in the upper part and female flowers in the lower part. In the northern hemisphere, they appear in late June to July, and by autumn, the female flowers develop into spiny cupules containing 3-7 brownish nuts that are shed during October. The female flowers eventually form a spiky sheath that deters predators from the seed.

The tree requires a mild climate and adequate moisture for good growth and a good nut harvest. Its year-growth (but not the rest of the tree) is sensitive to late spring and early autumn frosts, and is intolerant of lime. Under forest conditions, it will tolerate moderate shade well.

F. Anacardiaceae Family

I. *Pistacia* L.

1. *P. vera L.* L., (Engl: Pistachio), EL-IT-?.

The pistachio is a small tree originating from Central Asia and the Middle East. The tree grows up to 10 m tall. It has deciduous pinnate leaves 10–20 centimeters long. The plants are dioecious, with separate male and female trees. The flowers are apetalous and unisexual, and borne in panicles. The fruit is a drupe, containing an elongated seed, which is the edible portion. The seed, commonly thought of as a nut, is a culinary nut, not a botanical nut. The fruit has a hard, creamish exterior shell. The seed has a mauvish skin and light green flesh, with a distinctive flavor. When the fruit ripens, the shell changes from green to an autumnal yellow/red, and abruptly splits part way open. The splitting open is a trait that has been selected by humans. Commercial cultivars vary in how consistently they split open.

Pistachio is a desert plant, and is highly tolerant of saline soil. It has been reported to grow well when irrigated with water having 3,000–4,000 ppm of soluble salts. Pistachio trees are fairly hardy in the right conditions, and can survive temperatures ranging between −10 °C) in winter and 48 °C in summer. They need a sunny position and well-drained soil. Pistachio trees do poorly in conditions of high humidity, and are susceptible to root rot in winter if they get too much water and the soil is not sufficiently free-draining. Long, hot summers are required for proper ripening of the fruit. They have been known to thrive in warm moist environments. Like other members of the Anacardiaceae family (which includes poison ivy, sumac, mango, and cashew), pistachios contain urushiol, an irritant that can cause allergic reactions.

G. Juglandaceae Family

I. *Juglans* L.

1. *J. regia* L., (Engl: Walnut), EL-IT-ES.

Walnut is an Old World walnut tree species native to the region stretching from the Balkans eastward to the Himalayas and southwest China. The largest forests are in Kyrgyzstan, where trees occur in extensive, nearly pure walnut forests at 1,000–2,000 m altitude. It is widely cultivated across Europe.

Walnut is a large, deciduous tree attaining heights of 25–35 m, and a trunk up to 2 m diameter, commonly with a short trunk and broad crown, though taller and narrower in dense forest competition. It is a light-demanding species, requiring full sun to grow well. The bark is smooth, olive-brown when young and silvery-grey on older branches, and features scattered broad fissures with a rougher texture. Like all walnuts, the pith of the twigs contains air spaces; this chambered pith is brownish in color. The leaves are alternately arranged, 25–40 cm long, odd-pinnate with 5–9 leaflets, paired alternately with one terminal leaflet. The largest leaflets are the three at the apex, 10–18 cm long and 6–8 cm broad; the basal pair of leaflets are much smaller, 5–8 cm long, with the margins of the leaflets entire. The male flowers are in drooping catkins 5–10 cm long, and the female flowers are terminal, in clusters of two to five, ripening in the autumn into a fruit with a green, semifleshy husk and a brown, corrugated nut. The whole fruit, including the husk, falls in autumn; the seed is large, with a relatively thin shell, and edible, with a rich flavour.

H. Moraceae Family

I. *Ficus* L.

1. *F. carica* L., (Engl: Fig), EL-IT-ES.

Fig tree is native to the Middle East and western Asia, and has been sought out and cultivated since ancient times; now is widely grown throughout the temperate world, both for its fruit and as an ornamental plant. Fig tree is a dioecious, deciduous tree or large shrub, growing to a height of 7–10 metres, with smooth white bark. Its fragrant leaves are 12–25 centimetres long and 10–18 centimetres across, and deeply lobed with three or five lobes. The complex inflorescence consists of a hollow fleshy structure called the syconium, which is lined with numerous unisexual flowers. The flower itself is not visible from outside the syconium, as it blooms inside the infructescence. Although commonly referred to as a fruit, the fig is actually the infructescence or scion of the tree, known as a false fruit or multiple fruit, in which the flowers and seeds are borne. It is a hollow-ended stem containing many flowers. The small orifice (ostiole) visible on the middle of the fruit is a narrow passage, which allows the specialized fig wasp *Blastophaga psenes* to enter the fruit and pollinate the flower, whereafter the fruit grows seeds. The edible fruit consists of the mature syconium containing numerous one-seeded fruits (druplets). The fruit is 3–5 centimetres long, with a green skin, sometimes ripening towards purple or brown. Ficus carica has milky sap (laticifer). The sap of the fig's green parts is an irritant to human skin.

The fig tree grows wild in dry and sunny areas, with deep and fresh soil; also in rocky areas, from sea level to 1,700 meters. It prefers light and medium soils, requires well-drained soil, and can grow in nutritionally poor soil. The plant can tolerate seasonal drought, and the Mediterranean climate is especially suitable for the plant. Situated in a favorable habitat, old specimens can reach a considerable size and form a large dense shade tree. Its aggressive root system precludes its use in many urban areas of cities, but in nature helps the plant to take root in the most inhospitable areas. The fig tree is mostly a phreatophyte that lives in areas with standing or running water. The fig tree cools the environment in hot places, creating a fresh and pleasant habitat for many animals that take shelter in its shade in the times of intense heat.

I. Actinidiaceae Family

I. *Actinidia* Lindl.

1. *Actinidia deliciosa* (A.Chev.) C.F.Liang & A.R.Ferguson, (Engl: Kiwi), EL-IT-ES.

Kiwi is a vigorous, woody, twining vine or climbing shrub reaching 9 m; it is native to southern China, were grows naturally at altitudes between 600 and 2,000 m. Its leaves are alternate, long-petioled, deciduous, oval to nearly circular, cordate at the base, and 7.5–12.5 cm long. Young leaves are coated with red hairs; mature leaves are dark-green and hairless on the upper surface, and downy-white with prominent, light-colored veins beneath. The flowers are fragrant, dioecious or unisexual, borne singly or in threes in the leaf axils, are five- to six-petalled, white at first, changing to buff-yellow, 2.5–5 cm broad, and both sexes have central tufts of many stamens, though those of the female flowers with no viable pollen. The flowers also lack nectar. Male and female flowers appear on different plants (dioecious), and both sexes have to be planted in close proximity for fruit set. Bees are normally used by commercial orchards, although the more labour-intensive hand pollination is sometimes employed. Male flowers are gathered and processed to extract their pollen. This is then sprayed back on to the female flowers. The oblong fruits are up to 6.25 cm long. The russet-brown skin of the fruits is densely covered with short, stiff, brown hairs. The flesh is firm until fully ripened; it is glistening, juicy and luscious. The color of the flesh is bright-green, or sometimes yellow, brownish or off-white, except for the white, succulent center from which radiate many fine, pale lines.

J. Ebenaceae Family

I. *Diospyros* L.

1. *D. kaki* L., (Engl: Persimmon), EL-IT-ES.

Persimmon is a widely cultivated deciduous tree, native to subtropical southwest Asia and southeast Europe. It is among the oldest plants in cultivation. This is a tree height of 15–30 m with sloughing of aging bark. The leaves are shiny, leathery, oval shape with pointed ends, 5–15 cm long and 3–6 cm in width. The flowers are small, greenish, appearing in June to July. Fruits are berries with juicy flesh, yellow when ripe, 1–2 cm in diameter. Seeds with thin skin and a very hard endosperm.

DIOSPYROS KAKI, VAR. COSTATA (Carrière).
JAPON. PLEIN AIR.
J. Linden publ.

The tree grows in the lower and middle mountain zones in the Caucasus. They usually grow up to 600 m above sea level. In Central Asia, it rises higher—up to 2000 m. They rarely grow in stands but often grows with the frame, ash, maple and other deciduous species. It is not demanding on the soil and can grow on rocky slopes but requires a well lit environment.

K. Lythraceae Family

I. *Punica* L.

1. *P. granatum* L., (Engl: Pomegranate), EL-IT-ES.

The pomegranate is a fruit-bearing deciduous shrub or small tree originated in the region of modern-day Iran and has been cultivated since ancient times throughout the Mediterranean region and northern India.

The pomegranate is a shrub or small tree growing 6 to 10 m high. The pomegranate has multiple spiny branches, and is extremely long-lived, with some specimens in France surviving for 200 years. *P. granatum* leaves are opposite or subopposite, glossy, narrow oblong, entire, 3–7 cm long and 2 cm broad. The flowers are bright red and 3 cm in diameter, with three to seven petals. Some fruitless varieties are grown for the flowers alone. The edible fruit is a berry, intermediate in size between a lemon and a grapefruit, 5–12 cm in diameter with a rounded shape and thick, reddish skin. The number of seeds in a pomegranate can vary from 200 to about 1400. Each seed has a surrounding water-laden pulp — the edible sarcotesta that forms from the seed coat — ranging in color from white to deep red or purple. The seeds are "exarillate". The sarcotesta of pomegranate seeds consists of epidermis cells derived from the integument. The seeds are embedded in a white, spongy, astringent membrane.

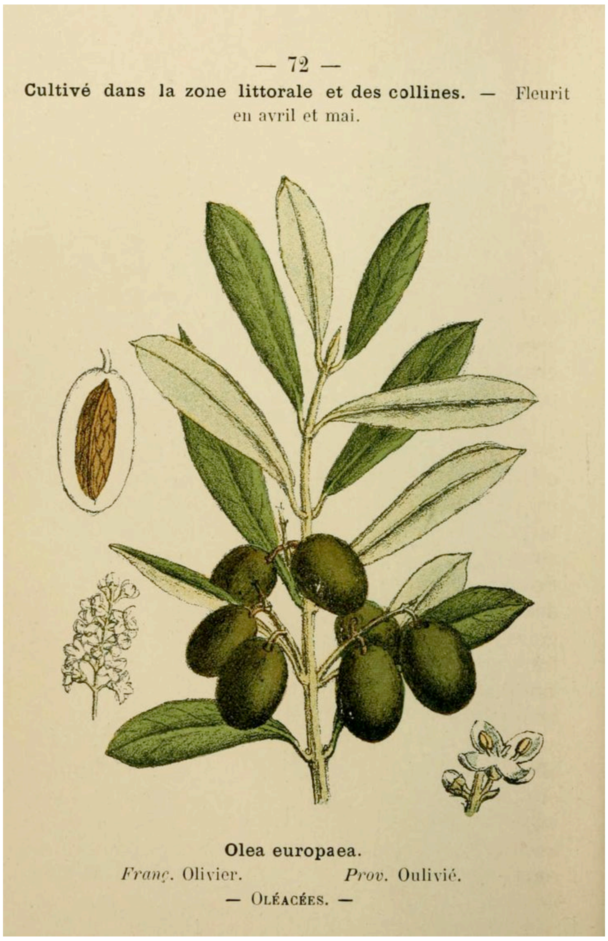
Pomegranate has more than 500 named cultivars, but evidently has considerable synonymy in which the same genotype is named differently across regions of the world. Pomegranates are drought-tolerant, and can be grown in dry areas with either a Mediterranean winter rainfall climate or in summer rainfall climates. In wetter areas, they can be prone to root decay from fungal diseases. They can be tolerant of moderate frost, down to about −12 °C.

L. Oleaceae Family

I. *Olea* L.

1. *O. europaea* L., (Engl: Olive), EL-IT-ES.

The olive tree is an evergreen tree or shrub native to the Mediterranean, Asia and Africa. It is short and squat, and rarely exceeds 8–15 m in height. The silvery green leaves are oblong, measuring 4–10 cm long and 1–3 cm wide. The trunk is typically gnarled and twisted. The small white, feathery flowers, with ten-cleft calyx and corolla, two stamens and bifid stigma, are borne generally on the previous year's wood, in racemes springing from the axils of the leaves. The fruit is a small drupe 1–2.5 cm long, thinner-fleshed and smaller in wild plants than in orchard cultivars. Olives are harvested in the green to purple stage. Olea europaea contains a seed commonly referred to in American English as a pit or a rock, and in British English as a stone.



— 72 —

Cultivé dans la zone littorale et des collines. — Fleurit en avril et mai.

Olea europaea.

Franç. Olivier. *Prov.* Oulivié.

— OLÉACÉES. —

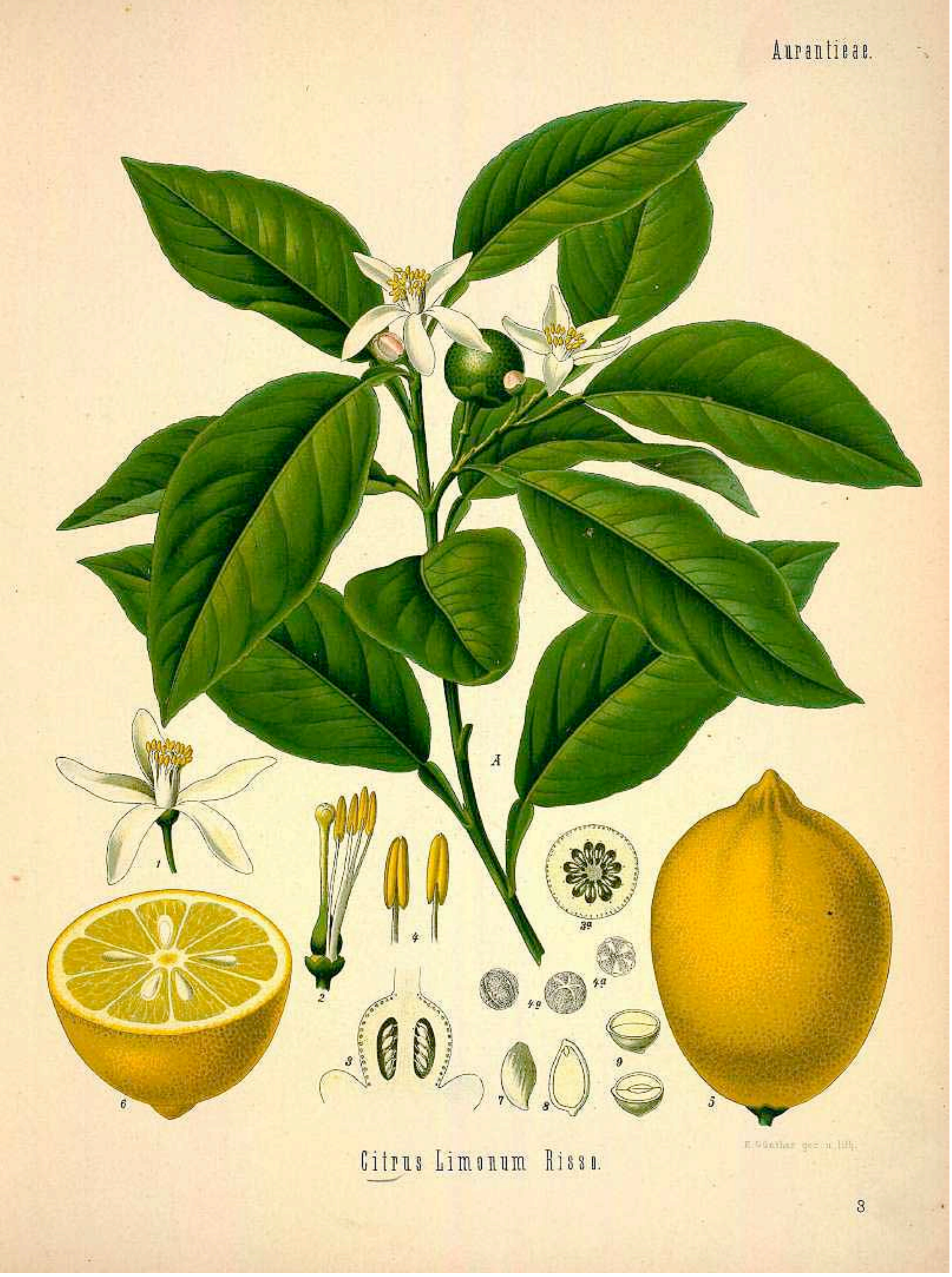
Olive trees show a marked preference for calcareous soils, flourishing best on limestone slopes and crags, and coastal climate conditions. They grow in any light soil, even on clay if well drained, but in rich soils they are predisposed to disease and produce poorer oil than in poorer soil. Olives like hot weather and sunny positions without any shade while temperatures below −10 °C may injure even a mature tree. They tolerate drought well, thanks to their sturdy and extensive root system. Olive trees can live for several centuries and can remain productive for as long if they are pruned correctly and regularly. In situations where extreme cold has damaged or killed the olive tree the rootstock can survive and produce new shoots, which in turn become new trees. In this way olive trees can regenerate themselves. Olives grow very slowly, and over many years the trunk can attain a considerable diameter. The trees rarely exceed 15 m in height, and are generally confined to much more limited dimensions by frequent pruning.

M. Rutaceae Family

I. *Citrus* L.

Citrus is a common term and genus of flowering plants in the rue family, Rutaceae. The most recent research indicates an origin in Australia, New Caledonia and New Guinea. Citrus fruit has been cultivated in an ever-widening area since ancient times; the best-known examples are the oranges, lemons, grapefruit, and limes. These plants are large shrubs or small to moderate-sized trees, reaching 5–15 m tall, with spiny shoots and alternately arranged evergreen leaves with an entire margin. The flowers are solitary or in small corymbs, each flower 2–4 cm diameter, with five (rarely four) white petals and numerous stamens; they are often very strongly scented. The fruit is a hesperidium, a specialised berry, globose to elongated, 4–30 cm long and 4–20 cm diameter, with a leathery rind or "peel" called a pericarp. The outermost layer of the pericarp is an "exocarp" called the flavedo, commonly referred to as the zest. The middle layer of the pericarp is the mesocarp, which in citrus fruits consists of the white, spongy "albedo", or "pith". The innermost layer of the pericarp is the endocarp. The segments are also called "liths", and the space inside each lith is a locule filled with juice vesicles, or "pulp". From the endocarp, string-like "hairs" extend into the locules, which provide nourishment to the fruit as it develops.

1. *C. limon* (L.) Osbeck, (Engl: Lemon), EL-IT-ES.



2. *C. sinensis* (L.) Osbeck, (Engl: Orange), EL-IT-ES.

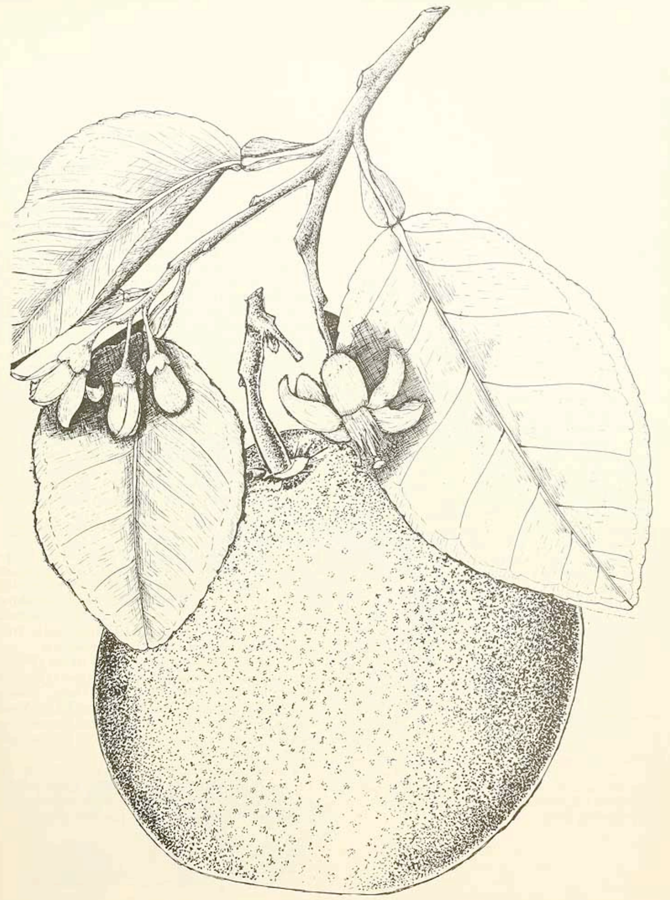
The orange tree is an evergreen, flowering tree, with an average height of 9 to 10 m, although some very old specimens can reach 15 m. Its oval leaves, alternately arranged, are 4 to 10 cm long and have crenulate margins. Although the sweet orange presents different sizes and shapes varying from spherical to oblong, it generally has ten segments (carpels) inside, and contains up to six seeds (or pips). When unripe, the fruit is green. The grainy irregular rind of the ripe fruit can range from bright orange to yellow-orange, but frequently retains green patches or, under warm climate conditions, remains entirely green. Like all other citrus fruits, the sweet orange is non-climacteric. The *C. sinensis* is subdivided into four classes with distinct characteristics: common oranges, blood or pigmented oranges, navel oranges, and acidless oranges.

3. *C. maxima* (Burm.) Merr., (Engl: Pomelo), EL-IT-ES.

4. *C. reticulata* Blanco, (Engl: Tangerine), EL-IT-ES.

5. *C. paradisi* Macfad, (Engl: Grapefruit), EL-IT-ES.

The evergreen grapefruit trees usually grow to around 5–6 meters tall, although they can reach 13–15 m. The leaves are glossy dark green, long up to 15 centimeters and thin. It produces 5 cm white four-petaled flowers. The fruit is yellow-orange skinned and generally an oblate spheroid in shape; it ranges in diameter from 10–15 cm. The flesh is segmented and acidic, varying in color depending on the cultivars, which include white, pink and red pulps of varying sweetness.



99. Toronja, grapefruit

Natural size.

Citrus paradisi Macfadyen

3.2.2. **Cultivation Characters**

A. Rosaceae Family

I. *Prunus* L.

The genus *Prunus* is native to northern temperate regions and includes more than 400 (±430) species of flowering shrubs and trees. *Prunus taxa* can be deciduous or evergreen. A few species have spiny stems. The leaves are simple, alternate, usually lanceolate, unlobed, and often with nectaries on the leaf stalk. The flowers are usually white to pink, sometimes red, with five petals and five sepals. There are numerous stamens. Flowers are borne singly, or in umbels of two to six or sometimes more on racemes. The fruit is a fleshy drupe (a "prune") with a single relatively large, hard-coated seed (a "stone").

According to contemporary systematic classification in *Prunus* L. are included six 1subgenera that are described as follows:

> Subgenus *Amygdalus*, almonds and peaches: axillary buds in threes (vegetative bud central, two flower buds to sides); flowers in early spring, sessile or nearly so, not on leafed shoots; fruit with a groove along one side; stone deeply grooved; type species: Prunus dulcis (almond).
>
> Subgenus *Prunus*, plums and apricots: axillary buds solitary; flowers in early spring stalked, not on leafed shoots; fruit with a groove along one side, stone rough; type species: Prunus domestica (plum)
>
> Subgenus *Cerasus*, cherries: axillary buds single; flowers in early spring in corymbs, long-stalked, not on leafed shoots; fruit not grooved, stone smooth; type species: Prunus cerasus (sour cherry)
>
> Subgenus *Lithocerasus*: axillary buds in threes; flowers in early spring in corymbs, long-stalked, not on leafed shoots; fruit not grooved, stone smooth; type species: Prunus pumila (sand cherry)
>
> Subgenus *Padus*, bird cherries: axillary buds single; flowers in late spring in racemes on leafy shoots, short-stalked; fruit not grooved, stone smooth; type species: Prunus padus (European bird cherry)

Subgenus *Laurocerasus*, cherry-laurels: mostly evergreen (all the other subgenera are deciduous); axillary buds single; flowers in early spring in racemes, not on leafed shoots, short-stalked; fruit not grooved, stone smooth; type species: Prunus laurocerasus (European cherry-laurel)

This genus has a number of economically important members, including the cultivated almond, peach, plum, cherry, and apricot. In addition, many species flower prolifically and are grown as ornamentals or fence plants because of their thorny stems. Herein are discussed the species occurring in cultivation as Tree-Crops in Greece (EL), Italy (IT) and Spain (ES).

8. *P. dulcis* (Mill.) D.A.Webb, (Engl: Almond). EL-IT-ES.

Almond is cultivated mainly in relatively hot and dry environments. Although almond is considered to be one of the most tolerant fruit species to drought stress, irrigation, especially during the summer months, results in higher yields and better kernel quality. Almond responds quite well to nitrogen supply as well as to potassium. Phosphorus seems to have minor role, while zinc and boron are the most important among micronutrients.

Almond is a medium lived tree (50 or more years) which may reach as high as 5-6m tall depending on the rootstock used. Trees are planted at distances ranging from 4-6 x 5-6m, thus resulting in approximately 330-500 trees per hectare. The average production is approximately 5 tn/hectare.

Almond requires low to medium amounts of water in order to produce high yields, which ranges from 150-200 m3/1000 m2 additionally to rainfall (in Mediterranean type climate) distributed into 6-8 irrigation events.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. Many farmers choose to apply herbicide on the planting rows and plough between rows and some others the application of herbicide on the entire orchard. This stands for most of the species described below. The fertilization strategy applied consists of 100-150 Kg/ha nitrogen, while every two to three years 50-80 Kg/ha potassium and 50-60 Kg/ha phosphorus. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied during early spring and late spring to early summer and if needed during the mid summer period. The phytosanitary program includes spray applications which may reach a total of 4-8 per year.

9. *P. armeniaca* L., (Engl: Apricot). EL-IT-ES.

Apricot is cultivated in sites characterized by mild climate. Apricot responds well to nitrogen addition to the soils, but care should be taken to avoid over-fertilization with nitrogen which will lead to vigorous shoots, shading and low bud differentiation. Potassium is a major nutrient for apricot, which improves tree growth and productivity. Among micronutrients, the most common deficiencies are those of iron, especially in calcareous soils, zinc and boron, which are easily treated by yearly (for iron and zinc) addition of the suitable fertilizers. Apricot responds well to irrigation, which is an important cultivation practice in order to improve yield and fruit quality and to ensure production of the next year.

Apricot is a short lived tree (20-30 years) which may reach as high as 5-6m tall. Trees are planted at distances ranging from 4-8 x 4-8m, thus resulting in approximately 150-620 trees per hectare. The average production is approximately 30-50 tn/hectare.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. Herbicides are also applied to control weeds on the row and/or between rows two.

The fertilization strategy applied consists of 100-150 Kg/ha nitrogen, and every 2-3 years 200-220 Kg/ha potassium and 50-100 Kg/ha phosphorus. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied during early spring and late spring to early summer and if needed during the mid summer period. Irrigation is applied at a range of approximately 200-400 m3/1000m2 distributed into 6-10 irrigation events within the growing season. The phytosanitary program includes spray applications which may reach a total of 4-6 per year.

10. *P. cocomilia* Ten., (Engl: Italian plum). EL-IT-?.

11. *P. avium* (L.) L., (Engl: Cherry). EL-IT-ES.

Cherry trees are grown well in areas characterized by cold winters and cool summers. Cherry trees respond well to nitrogen supply, but care is needed to avoid over application, which will result in vigorous non-fruiting branches. Potassium application can improve fruit characteristics while the most common micronutrient efficiency is that of iron which can be easily treated with iron chelate products. Irrigation is necessary during spring when the fruit is growing, especially in early maturing cultivars as well as during the summer months.

Cherry is a short-medium lived tree (15-50 years) which may reach as high as 3-10m tall depending on the rootstock used and the cultural practices employed, with the farmers seeking lower tree heights, in order to reduce cultural costs. Trees are planted at distances ranging from 1.0-6 x 4.5-8m, thus resulting in approximately 200-2000 trees per hectare. The average production is approximately 4-6.5 tn/hectare.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. Herbicides are also applied to control weeds on the row and/or between rows two.

The fertilization strategy applied consists of 50-150 Kg/ha nitrogen, while every two to three years 100 Kg/ha potassium and 50-100 Kg/ha phosphorus. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied during early spring and late spring to early summer and if needed during the mid summer period. Irrigation is applied at a range of approximately 300-400 m3/1000m2 distributed into 6-10 irrigation events within the growing season. The phytosanitary program includes spray applications which may reach a total of 4-9 per year.

12. *P. persica* (L.) Batsch, (Engl: Peach). EL-IT-ES.

Peach and nectarine trees are cultivated in a variety of climates, excluding areas characterized by early spring frosts which can damage flower buds. As in all trees, nutritional requirements for peach trees vary through their lifetimes and are influenced by the rootstock chosen, crop load, soil type etc. In addition to nitrogen, phosphorus, and potassium, peach trees need adequate levels of calcium, boron, copper, and zinc to maintain the health of the tree and produce quality fruit. Peach demands high amounts of irrigation water during the entire growing period, being most important from the pit hardening to fruit maturation.

Peach is a short lived tree (15-20 years) which may reach as high as 5-6m tall depending on the rootstock used. Trees are planted at distances ranging from 2.0-6 x 4-6m, thus resulting in approximately 300-1250 trees per hectare. The average production is approximately 20-30 tn/hectare.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. Herbicides are also applied to control weeds on the row and/or between rows two.

The fertilization strategy applied consists of 100-200 Kg/ha nitrogen, while every two to three years 150-200 Kg/ha potassium and 100-150 Kg/ha phosphorus. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied during early spring and late spring to early summer and if needed during the mid summer period. Irrigation is applied at a range of approximately 300-500 m3/1000m2 distributed into 6-10 irrigation events within the growing season. The phytosanitary program includes spray applications which may reach a total of 4-9 per year.

13. *P. domestica* L., (Engl: Plum). EL-IT-ES.

P. domestica (European plum) is most cold tolerant than P. salicina (Japanese plum) so it can be grown in colder areas. Nitrogen and potassium are the main macronutrients needed for a good yield, with European plum responding well to nitrogen and Japanese plum to potassium fertilization. Plums respond well to irrigation by achieving good fruit size and quality. Irrigation is specially needed during the summer months when the fruit is growing and bud differentiation occurs.

Plum is a medium lived tree (30-50 years) which may reach as high as 5-6m tall depending on the rootstock used. Trees are planted at distances ranging from 1.5-5 x 4-6m, thus resulting in approximately 300-800 trees per hectare. The average production is approximately 25-30 tn/hectare.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. Herbicides are also applied to control weeds on the row and/or between rows two.

The fertilization strategy applied consists of 100-200 Kg/ha nitrogen, while every two to three years 150-200 Kg/ha potassium and 100-150 Kg/ha phosphorus. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied during early spring and late spring to early summer and if needed during the mid summer period. Irrigation is applied at a range of approximately 300-500 m3/1000m2 distributed into 4-8 irrigation events within the growing season. The phytosanitary program includes spray applications which may reach a total of 4-7 per year.

are sour.

Plums are grown commercially in orchards, but modern rootstocks, together with self-fertile strains, training and pruning methods, allow single plums to be grown in relatively small spaces. Their early flowering and fruiting means that they require a sheltered spot away from frosts and cold winds.

14. *P. cerasus* L., (Engl: Sour cherry). EL-IT-ES.

Sour cherry grows well in areas characterized by cold winter and relatively hot summer. It can withstand cold and hot better than cherry. It prefers deep, fertile soils which are well drained.

Sour cherry is not a major fruit species in Greece so the acreage and information is limited. Sour cherry is a medium lived tree (30-40 years) which may reach as high as 5-6m tall. The number of trees is approximately 400-1600 trees per hectare, this depending on the rootstock used, soil fertility, cultural practices etc. The average production is approximately 1-4 tn/hectare.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. Herbicides are also applied to control weeds on the row and/or between rows two.

The fertilization strategy applied is similar to that of cherry i.e. 50-150 Kg/ha nitrogen, while every two to three years 100 Kg/ha potassium and 50-100 Kg/ha phosphorus. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied during early spring and late spring to early summer and if needed during the mid summer period. The phytosanitary program includes spray applications which may reach a total of 3-5 per year.

II. *Eriobotrya* Lindl.

1. *E. japonica* (Thunb.) Lindl., (Engl: Loquat), EL-IT-ES.

Loquat grows well in areas characterized by mild climate with high average rainfall. It requires high amounts of water in order to produce high quality yield, especially in areas where rainfall does not cover its needs throughout the growing season.

As loquat currently is not a major fruit species in Greece the data provided are based on information from limited number of farmers. Loquat is a medium lived tree (40-50 years) which may reach as high as 5-6m tall depending on the rootstock used. Trees are planted at distances ranging from 6-7 x 6-7m, thus resulting in approximately 200-280 trees per hectare. The average production is approximately 30-40 Kg per tree.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. The fertilization strategy applied consists of 100-150 Kg/ha nitrogen, 180-200 Kg/ha potassium and 100-120 Kg/ha phosphorus. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied during early spring and late spring to early summer. Irrigation is distributed into 4-8 irrigation events within the growing season, ensuring constant soil moisture. The phytosanitary program includes spray applications which may reach a total of 3-5 per year.

III. *Pyrus* L.

1. *P. communis* L., (Engl: Apple), EL-IT-ES.

Pear grows well in areas characterized by cold winter and cool summers. Pear responds quite well to nitrogen and potassium supply, while iron, zinc and magnesium deficiencies occur on calcareous soils in trees grafted in quince rootstocks. Irrigation practice is necessary when growing pear trees, especially from late spring to late summer, in order to support new shoot growing and ensure good fruit quality characteristics.

Pear is a medium lived tree (30-50 years) which may reach as high as 5-6m tall depending on the rootstock used. Trees are planted at distances ranging from 2.0-5 x 3-5m, thus resulting in approximately 400-1600 trees per hectare. The average production is approximately 30-50 tn/hectare.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. Herbicides are also applied to control weeds on the row and/or between rows two.

The fertilization strategy applied consists of 100-150 Kg/ha nitrogen, while every two to three years 50-80 Kg/ha potassium and 50 Kg/ha phosphorus. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied during early spring and late spring to early summer and if needed during the mid summer period. Irrigation is applied at a range of approximately 400-700 m3/1000m2 distributed into 6-10 irrigation events within the growing season. The phytosanitary program includes spray applications which may reach a total of 9-12 per year.

IV. *Malus* Mill.

1. *M. sylvestris* (L.) Mill., (Engl: Apple), EL-IT-ES.

Apple tree grows well in cold, relatively wet areas, where it can satisfy the chilling requirements for bud dormancy release. Selection of rootstocks is mainly based on the cultivation system which will be applied, i.e. intensive or semi-intensive, as there is a variety of rootstocks, classified based on their dwarfism. For intensive cultivation systems, dwarf and semi-dwarf rootstocks are preferred. Trees are trained as open vase, central leader, palmette, Y trellis, super spindle, slender pyramid etc. Apple trees respond well to nitrogen and potassium supply while calcium is the major element affecting fruit firmness and storability. Magnesium is also important as well as boron. Fertilization takes place early in spring and before fruit set, while additional nutrients can be applied as fertigation or foliar spray when needed. Dormant nutrient sprays are applied sometimes, in order to cure deficiencies observed late in the season and ensure adequate supply for the spring shoot growth. Since modern apple orchards are intensive tree cultivation, soil coverage is achieved early and higher quantities of water are needed to cover foliage and overall tree demands. Apple trees require adequate supply of water during the early stages of fruit set and during fruit development, a time when bud differentiation takes place too. Apples are harvested by hand and stored for long time (months) in the freezer or under controlled environment.

Apple has moderately long productive life (30-50 years) which may reach as high as 5-6m tall depending on the rootstock used. Trees are planted at distances ranging from 1.0-5 x 3-5m, thus resulting in approximately 200-3000 trees per hectare. The average production is approximately 60-70 tn/hectare.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. Herbicides are also applied to control weeds on the row and/or between rows two.

The fertilization strategy applied consists of 200-300 Kg/ha nitrogen, 150-300 Kg/ha potassium and 50-80 Kg/ha phosphorus. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied during early spring and late spring to early summer and if needed during the mid summer period. Irrigation is applied at a range of approximately 250-400mm per year (thus approximately 400 m3/1000m2) distributed into 6-10 irrigation events within the growing season. The phytosanitary program includes spray applications which may reach a total of 15 per year.

V. *Cydonia* Mill.

1. *C. oblonga* Mill., (Engl: Quince), EL-IT-ES.

Quince can be grown under various pedoclimatic conditions, although it grows better under mild winters and hot summers. It cannot withstand calcareous soils as well as water stress, under which it produces hard, low juice fruits. It requires irrigation more often than pear but with lower water quantities. It also responds well to nitrogen and potassium supply, but in less quantities that those for pear trees.

Quince is not a major fruit species in Greece so the acreage and information is limited. Quince is a short lived tree which may reach as high as 5-6m tall. Trees are planted at distances ranging from 3-5 x 3-5m, thus resulting in approximately 400-1000 trees per hectare. The average production is approximately 25-35 tn/hectare.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. The fertilization strategy applied is that of pear, but with almost half the quantities applied, due to the smaller size of the tree, thus 100-200 Kg/ha nitrogen and every two years 50-70 Kg/ha potassium and phosphorus. Iron is also applied when needed, in quantities based on the form of iron used. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied during early spring and late spring to early summer and if needed during the mid summer period. The phytosanitary program includes spray applications which may reach a total of 5-6 per year.

B. Lauraceae Family

I. *Persea* Mill.

1. *P. americana* Mill., (Engl: Avocado), EL-IT-ES.

Avocado is a medium lived tree (30-40 productive years) which may reach as high as 8-20m tall. Trees are planted at distances ranging from 5-10 x 8-12m, thus resulting in approximately 100-200 trees per hectare. The average production is approximately 10-20 tn/hectare.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. The fertilization strategy applied is that of pear, but with almost half the quantities applied, due to the smaller size of the tree, thus 200-300 Kg/ha nitrogen and every two years 200-300 Kg/ha potassium and 50-60 Kg/ha phosphorus. Iron is also applied when needed, in quantities based on the form of iron used. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied during early spring and late spring to early summer and if needed during the mid summer period. It has high needs of irrigation which is applied in 6-8 irrigation events.

C. Musaceae Family

I. *Musa* L.

1. *M. x paradisiaca* L., (Engl: Banana), EL-IT-ES.

Banana grows in tropical and subtropical areas, where the temperature does not fall below 20 oC. In Greece there is a limited area in Crete where banana is grown as well as sporadically in some other areas. It is usually planted in density between 1000-3000 plants/ha. The height ranges from 3-5 m depending on the cultivar etc. It needs a constant of about 125mm water per month. The fertilization strategy is based on an annual supply of 120-140 Kg/ha nitrogen, 13-15 Kg/ha phosphorus and 350-400 Kg/ha potassium, with nitrogen supply being distributed in several applications. Mean production is approximately 60 tn/ha under greenhouse conditions. There are not any registered phytosanitary products in banana in Greece, so the protection of the crop is based on either cultural measurements or release of predators etc.

D. Fabaceae Family

I. *Ceratonia* L.

1. *C. siliqua* L., (Engl: Carob), EL-IT-ES.

Carob is cultivated in warm, dry areas.. It responds well to nitrogen. It is trained as open vase or free standing tree, while bearing trees are usually pruned lightly.

Carob is not a major fruit species in Greece so the acreage and information is limited. Carob is a long lived tree which may reach as high as 15m. Trees are planted at various distances ranging from 8-10 x 8-10 m, thus resulting in approximately 100-150 trees per hectare. The average production is approximately 45-90 Kg per tree.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. Carob does not require large amounts of water in order to produce high yields, which ranges from 100-200 L/tree additionally to rainfall (in Mediterranean type climate) applying 2-3 times in the growing season, under very arid conditions. A good scheme of fertilization is the annual addition of 90-100 Kg/ha nitrogen, 90-100 Kg/ha potassium and 50-60 Kg/ha phosphorus. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied during early spring and late spring to early summer and if needed during the mid summer period. There are not any registered phytosanitary products for application in carob trees. The average production life of carob tree extends beyond that of 100 years when properly managed.

E. Fagaceae Family

I. *Castanea* L.

1. *C. sativa* Mill., (Engl: Chestnut), EL-IT-ES.

Chestnut grows well in areas with relatively high altitude, characterized by slightly cold, wet weather. It responds very well to nitrogen application and it needs quite high amounts of water in order to get high quality yield.

Chestnut is a long lived tree which may reach as high as 30m but growers tend to train the tree to reach a height from 5-10 meters. Trees are planted at various distances, this depending on the rootstock and species growth habit. In general an average distance ranges from 6-10 x 6-10 m, thus resulting in approximately 100-200 trees per hectare. The average production is approximately 3-5 tn/hectare.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. Chestnut does not require large amounts of water in order to produce high yields, which ranges from 200-350 m3/1000 m2 additionally to rainfall (in Mediterranean type climate) distributed into 6-8 irrigation events. A good scheme of fertilization is the annual addition of 90-120 Kg/ha nitrogen, 100-150 Kg/ha potassium and 60-90 Kg/ha phosphorus (applied as needed, even every 2-3 years). Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied during early spring and late spring to early summer and if needed during the mid summer period. The phytosanitary program includes spray applications which may reach a total of 5-6 per year. The average production life of chestnut tree extends beyond that of 100 years when properly managed.

F. Anacardiaceae Family

I. *Pistacia* L.

1. *P. vera L.* L., (Engl: Pistachio), EL-IT-?.

Pistachio is considered as a xerophytic species, which can withstand drought and at some extend soil salinity. Pistachio trees respond well to nitrogen supply while application of potassium is necessary for the nuts to split. While its requirements in irrigation are low, it benefits from the application of water, as it supports kernel growth and new shoots formation.

Pistachio is a long lived tree which may reach a height of 5-8m or more. In general an average planting distance ranges from 6-7 x 6-7 m, thus resulting in approximately 200-300 trees per hectare. The average production is approximately 3-4 tn/hectare.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. Herbicides are also applied to control weeds on the row and/or between rows two.

Pistachio requires low to medium amounts of water in order to produce high yields, which ranges from 150-200 m3/1000 m2 additionally to rainfall (in Mediterranean type climate) distributed into 6-8 irrigation events. A good scheme of fertilization is the annual addition of 150-300 Kg/ha nitrogen, 150-300 Kg/ha potassium and 30-50 Kg/ha phosphorus based on the biennial bearing habit of the tree. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied in three doses, during early spring and late spring to early summer and if needed during the mid summer period (three nitrogen applications). The phytosanitary program includes spray applications which may reach a total of 6-8 applications per year. The average production life of pistachio tree extends beyond that of 50 years when properly managed.

G. Juglandaceae Family

I. *Juglans* L.

1. *J. regia* L., (Engl: Walnut), EL-IT-ES.

Walnut is usually cultivated in areas characterized by cold winter and mild summer, avoiding extremely low or high temperatures, which damage the tree and nut.

Walnut is a long lived tree which may reach as high as 30m but growers tend to train the tree to reach a height from 5-10 meters. Trees are planted at various distances, this depending on the rootstock and cultivar growth habit. In general an average distance ranges from 6-10 x 6-10 m, thus resulting in approximately 100-300 trees per hectare. The average production is approximately 3-4 tn/hectare.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. Herbicides are also applied to control weeds on the row and/or between rows two.

Walnut requires large amounts of water in order to produce high yields, which ranges from 300-450 m3/1000 m2 additionally to rainfall (in Meditteranean type climate), applied within 4-8 irrigation events). A good scheme of fertilization is the annual addition of 60 Kg/ha nitrogen plus 8 Kg nitrogen for every 10 Kg nuts produced the previous year, 100-160 Kg/ha potassium and 40-60 Kg/ha phosphorus. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied during early spring and late spring to early summer and if needed during the mid summer period. The phytosanitary program includes spray applications which may reach a total of 7-9 applications per year. The average production life of walnut tree extends beyond that of 50 years when properly managed.

H. Moraceae Family

I. *Ficus* L.

1. *F. carica* L., (Engl: Fig), EL-IT-ES.

Fig is a medium lived tree (40-50 or more productive years) which may reach as high as 4-5m tall. Trees are planted at distances ranging from 5-10 x 5-10m, thus resulting in approximately 100-300 trees per hectare. The average production is approximately 6-8 tn/hectare.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. The fertilization strategy applied is approximately 20-40 Kg/ha nitrogen and every two years 20-40 Kg/ha potassium. Potassium is applied during the rainy season, thus from autumn to late winter, while nitrogen is applied in three doses, during early spring and late spring to early summer and if needed during the mid summer period (three nitrogen applications). Irrigation is performed with an average of 3-5 irrigation events with 20-30 m3/1000m2 per time. The phytosanitary program includes spray applications which may reach a total of 1-2 per year.

I. Actinidiaceae Family

I. *Actinidia* Lindl.

1. *Actinidia deliciosa* (A.Chev.) C.F.Liang & A.R.Ferguson, (Engl: Kiwi), EL-IT-ES.

Kiwi is a long lived tree (over 50 years its productive life) of relatively warm climates (mild winters and summers). It is trained as pergola trellis, reaching a height of approximately 3 meters. The number of trees per hectare is approximately 400-500 plants. The mean kiwi production is approximately 20-35 tn/ha.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. Herbicides are also applied to control weeds on the row and/or between rows two. The fertilization strategy applied is approximately 150-200 Kg/ha nitrogen, 60 kg/ha phosphorus and 150-300 Kg/ha potassium plus micronutrients. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied in three doses, during early spring and late spring to early summer and if needed during the mid summer period (three nitrogen applications). Due to high transpiration losses during a hot day in summer, kiwi is frequently irrigated, reaching once per week during the summer months and less frequently during the other months (a total of 10-20 irrigation events). The phytosanitary program includes spray applications which may reach a total of 4-7 per year.

J. Ebenaceae Family

I. *Diospyros* L.

1. *D. kaki* L., (Engl: Persimmon), EL-IT-ES.

Persimmon does not occupy much area in Greece, so the information on the cultivation practices is limited. Persimmon's productive life is estimated to be around 40-50 years. It is a plant growing in subtropical or mild temperate climate.

It is trained mainly as open vase, reaching a height of approximately 3-5 meters. The number of trees per hectare is approximately 400-500 plants. The mean persimmon production is approximately 10-15 tn/ha.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. The fertilization strategy consists of applying 0.4-0.5 kg of a full strength fertilizer (type 4-10-4) per tree for each year of tree age till fully productive age. There are not available data on the irrigation strategy employed, but it is estimated to be around 6-12 irrigation events during the growing season with an average of 30-40 m3/1000m2. The phytosanitary program includes spray applications which may reach a total of 1-4 per year.

K. Lythraceae Family

I. *Punica* L.

1. *P. granatum* L., (Engl: Pomegranate), EL-IT-ES.

During the last decade pomegranate cultivation has started to expand in Greece as in all other South European countries.

Pomegranate’s productive life is estimated to be around 30-40 years. It is trained mainly as open vase, reaching a height of approximately 3-5 meters. The number of trees per hectare is approximately 400-500 plants. The mean pomegranate production is approximately 18-25 tn/ha. Irrigation is applied approximately 2-3 times per month during the growing season (depends on the pedoclimatic conditions)(an average of 6-12 irrigation events) with an average of 20-30 m3/1000m2 each time.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. The fertilization strategy applied is approximately 200 Kg/ha nitrogen, 60 kg/ha phosphorus and 120-200 Kg/ha potassium plus micronutrients. There are not yet any registered pesticides in Greece, but effort is being made to get registrations from other Mediterranean countries. The only use of pesticides permitted are those with biological-organic registration, with an average number of applications ranging between 3-9, depending on the pests and diseases found in the region.

L. Oleaceae Family

I. *Olea* L.

1. *O. europaea* L., (Engl: Olive), EL-IT-ES.

Olive is the main tree cultivation in Greece and generally in Mediterranean countries. It is a long lived tree (there are olive trees of approximately 2000 years old or more in Greece) which may reach as high as more than 10m but growers tend to train the tree to reach a height of 4-6 meters. Trees are planted at various distances, this depending on the cultivar growth habit and vigor. In general an average distance ranges from 6-7 x 6-7 m, thus resulting in approximately 200-300 trees per hectare. New cultivations under the scheme of super high density orchards are planted at densities approximately 1200-1800 trees per hectare. The average production of a modern, semi-intensive and intensive olive orchard is approximately 4-12 tn/hectare while only 0.2-1.5 tn/ha in extensive, traditional olive groves.

As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. Herbicides are also applied to control weeds on the row and/or between rows too.

Olive does not require large amounts of water in order to produce high yields. Typically the irrigation needs are fulfilled by applying 250-300 m3/1000 m2 additionally to rainfall (in Mediterranean type climate) distributed into 4-10 irrigation events. A good scheme of fertilization is the annual addition of 0.5-1 kg nitrogen and 1-2 Kg potassium per tree and the biannual addition of 0.2-0.35 kg of phosphorus per tree. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied during early spring and late spring to early summer and if needed during the mid summer period. Potassium is also applied through the irrigation system in the summer (only in irrigated orchards). Micronutrients are also applied by spraying, combining them with pesticides. Boron may also be applied in orchards with deficiency, either in soil or by spraying, before flowering. The phytosanitary program includes spray applications which may reach a total of 7-9 applications per year.

M. Rutaceae Family

I. *Citrus* L.

1. *C. limon* (L.) Osbeck, (Engl: Lemon), EL-IT-ES.
2. *C. sinensis* (L.) Osbeck, (Engl: Orange), EL-IT-ES.
3. *C. maxima* (Burm.) Merr., (Engl: Pomelo), EL-IT-ES.
4. *C. reticulata* Blanco, (Engl: Tangerine), EL-IT-ES.
5. *C. paradisi* Macfad, (Engl: Grapefruit), EL-IT-ES.

Citrus species are grown well under subtropical conditions or mild temperate ones. The main species cultivated in Greece is orange, mandarin, lemon and grapefruit. Trees are planted at densities ranging from 220-540 trees/ha. Citrus species are expected to be productive for at least 40-50 years. The height depends among others (pedoclimatic conditions and cultural managements) on the species itself, with mandarin trees being less vigorous (3-4m height) than oranges and grapefruit (3-5 m height), with lemon trees (3-6m height) being the most vigorous among citrus species in concern.

Water needs are covered by applying approximately 700-900 m3/ha/year, under Mediterranean conditions, where rainfall is mainly distributed within the winter months. This amount of water is applied in doses with their number ranging from 6-12. As in all other tree crops, soil tillage is performed twice a year (spring and autumn) to reduce weed emergence, at a depth of approximately 20-30 cm. Herbicides are also applied to control weeds on the row and/or between rows too.

A good scheme of fertilization is the annual addition of 120-160 Kg/ha nitrogen for grapefruit, 120-300 Kg/ha for oranges and mandarins and 150-180 Kg/ha nitrogen for lemon trees. Phosphorus is usually applied at rates of 60-90 Kg/ha in grapefruit, oranges and mandarins and 40-100 Kg/ha in lemons, while potassium is applied at rates 50-90 Kg/ha in grapefruit, in oranges and mandarins and 60-120 Kg/ha in lemons. Potassium and phosphorus are applied during the rainy season, thus from autumn to late winter, while nitrogen is applied during early spring and late spring to early summer and if needed during the mid summer period. In case of micronutrient deficiencies, these are either applied as fertigation, foliar application or soil application. Average yield is estimated at 25-55 tn/ha for oranges, 20-30 tn/ha for mandarins, 30-40 tn/ha for lemons and 40-60 tn/ha for grapefruit.

The phytosanitary program includes spray applications which may reach a total of 3-7 applications per year.

3.2.1. Tree Crop Categorization Matrix

Biological categories	Cultivation methodology	Ecological area	Tree-Crop	Area of cultivation (ha in Spain)	Area of cultivation (ha in Greece)	Area of cultivation (ha in Italy)	Area of cultivation (ha inTotal)
Evergreen	Intensive (Irrigated)	Costal zone	Orange	139.931,00	17.297,10	18.604,32	175.832,42
			Lemon	37.089,00	869,56	5.120,00	43.078,56
			Grapefruit	1.648,00	108,14	0,00	1.756,14
			Tangerine clm	74.495,00	50,78	0,00	74.545,78
			Tangerine	29.894,00	538,58	0,00	30.432,58
			Citrus various	813,00	742,54	8.094,32	9.649,86
			Pomelo	0,00	0,40	0,00	0,40
			Banana	9.146,00	143,38	0,00	9.289,38
			Avocado	10.212,00	184,56	0,00	10.396,56
			Date Palm	606,00	0,00	0,00	606,00
			Cactus Pear	56,00	0,00	0,00	56,00
			Loquat	2.478,00	0,00	0,00	2.478,00
			Raspberry	1.433,00	0,00	0,00	1.433,00
			Olive	0,00	0,00	222.140,21	222.140,21
		Total		307.801,00	19.935,04	31.818,64	359.554,68
		Midland zone	Carob	1.323,00	0,00	0,00	1.323,00
			Olive	583.203,00	0,00	0,00	583.203,00
		Total		583.203,00	0,00	0,00	583.203,00
		Mountain zone	-	0,00	0,00	0,00	0,00
		Total		0,00	0,00	0,00	0,00
	Total			891.004,00	19.935,04	31.818,64	942.757,68
	Extensive (Rainfed)	Costal zone	Cactus Pear	217,00	0,00	0,00	217,00
			Avocado	3,00	1.539,52	0,00	1.542,52
			Carob	0,00	2.007,10	0,00	2.007,10
			Loquat	83,00	6,96	0,00	89,96
			Grapefruit	0,00	183,22	0,00	183,22
			Olive (isl)	0,00	168.239,80	888.560,84	1.056.800,64
			Lemon	0,00	1.539,52	10.880,00	12.419,52

Biological categories	Cultivation methodology	Ecological area	Tree-Crop	Area of cultivation (ha in Spain)	Area of cultivation (ha in Greece)	Area of cultivation (ha in Italy)	Area of cultivation (ha inTotal)
			Orange	0,00	39.700,82	58.913,68	98.614,50
			Tangerine	0,00	9.854,40	0,00	9.854,40
			Citrus various	0,00	354,72	23.037,68	23.392,40
		Total		303,00	213.216,94	981.392,20	1.205.121,26
		Midland zone	Carob	36.459,00	0,00	0,00	36.459,00
			Olive	1.848.885,00	1.402.707,14	0,00	3.251.592,14
		Total		1.848.885,00	1.402.707,14	0,00	3.251.592,14
		Mountain zone	-	0,00	0,00	0,00	0,00
		Total		0,00	0,00	0,00	0,00
	Total			1.849.188,00	1.615.924,08	981.392,20	4.456.713,40
Total				2.740.192,00	1.635.859,12	1.013.210,84	5.399.471,08
Deciduous	Intensive (Irrigated)	Costal zone	Fig	1.346,00	4.180,72	0,00	5.526,72
			Kiwi	647,00	9.596,12	12.747,00	22.990,12
			Plum	12.547,00	38,64	0,00	12.585,64
			Persimmon	8.995,00	149,54	0,00	9.144,54
			Nectarin	25.967,00	8.602,72	0,00	34.569,72
			Peach	41.058,00	35.505,04	35.685,64	112.248,68
			Apricot	14.159,00	0,00	5.985,00	20.144,00
			Pear	22.341,00	1.458,02	14.031,00	37.830,02
			Pistachio	911,00	5.844,00	0,00	6.755,00
			Pomegranate	2.343,00	2.915,86	0,00	5.258,86
			Plum Dried	0,00	103,02	0,00	103,02
		Total		130.314,00	68.393,68	68.448,64	267.156,32
		Midland zone	Almond	37.817,00	0,00	0,00	37.817,00
			Tablegrapes	12.178,00	0,00	32.554,00	44.732,00
			Winegrapes	179.644,00	0,00	0,00	179.644,00
		Total		229.639,00	0,00	32.554,00	262.193,00
		Mountain zone	Chestnut	720,00	0,00	0,00	720,00
			Apple	16.629,00	16.787,14	38.783,00	72.199,14
			Quince	879,00	0,00	0,00	879,00

Biological categories	Cultivation methodology	Ecological area	Tree-Crop	Area of cultivation (ha in Spain)	Area of cultivation (ha in Greece)	Area of cultivation (ha in Italy)	Area of cultivation (ha inTotal)
			Custard apple	3.157,00	0,00	0,00	3.157,00
			Walnut	4.216,00	0,00	0,00	4.216,00
			Cherry	8.548,00	0,00	3.984,00	12.532,00
			Hazelnut	8.199,00	400,40	0,00	8.599,40
		Total		42.348,00	17.187,54	42.767,00	102.302,54
	Total			402.301,00	85.581,22	143.769,64	631.651,86
	Extensive (Rainfed)	Costal zone	Fig	9.256,00	1.013,94	0,00	10.269,94
			Kiwi	685,00	0,00	12.070,00	12.755,00
			Apricot	1.856,00	8.773,94	10.605,00	21.234,94
			Pear	1.098,00	5.266,32	16.152,00	22.516,32
			Persimmon	360,00	0,00	0,00	360,00
			Nectarin	786,00	0,00	0,00	786,00
			Peach	2.965,00	0,00	26.418,27	29.383,27
			Pistachio	2.721,00	0,00	0,00	2.721,00
			Pomegranate	55,00	0,00	0,00	55,00
			Plum	2.554,00	2.886,46	0,00	5.440,46
		Total		22.336,00	17.940,66	65.245,27	105.521,93
		Midland zone	Almond	465.253,00	19.753,80	0,00	485.006,80
			Tablegrapes	1.610,00	0,00	3.109,00	4.719,00
			Winegrapes	700.642,00	0,00	0,00	700.642,00
		Total		1.167.505,00	19.753,80	3.109,00	1.190.367,80
		Mountain zone	Chestnut	27.920,00	13.089,20	0,00	41.009,20
			Apple	12.214,00	0,00	13.475,00	25.689,00
			Walnut	2.829,00	17.587,54	0,00	20.416,54
			Quince	334,00	335,84	0,00	669,84
			Hazelnut	5.644,00	0,00	0,00	5.644,00
			Cherry	14.801,00	20.647,56	19.359,00	54.807,56
			Sour Cherry		38,62	0,00	38,62
		Total		63.742,00	51.660,14	32.834,00	148.236,14
	Total			1.253.583,00	89.354,60	101.188,27	1.444.125,87

Biological categories	Cultivation methodology	Ecological area	Tree-Crop	Area of cultivation (ha in Spain)	Area of cultivation (ha in Greece)	Area of cultivation (ha in Italy)	Area of cultivation (ha inTotal)
Total				1.655.884,00	174.935,82	244.957,91	2.075.777,73
Various (pip fruit various)				1.891,00	1.383,04	0,00	3.274,04
Total				4.397.967,00	1.812.177,98	1.258.168,75	7.478.522,85

4. Conclusions

The fundamental challenge in the elaborated study was focused towards the minimization of the inefficient and inappropriate impacts on provisioning of multiple ES by enhancing the understanding of multi-relationships between ES. Making this information more explicit and accessible is more likely to drive at more balanced conditions (Carpenter et al., 2009). In this study, we tried elaborate on relationships between ES by a synthesis of relationships between ES according to the established scientific literature and best available practices. Our results provide an overview of ES homologous groups assessment; those results reflect in a national level for a specific land use – namely orchards - of various biological and cultivation background. Those results equip the project with a practical tool towards the implementation of C.1 Action.

In specific, our results highlighted pairs of ES for which more input is needed from the scientific community. Those results were already utilized in the design of the project's implementation. To be more precise critical knowledge gaps that were identified relate to the availability of primary data on the following subjects of the 5 archetypal crops:

1. *Olea europaea*
2. *Amygdalus communis*
3. *Malus sylvestris*
4. *Citrus sinensis*
5. *Prunus persica*

A. Biomass:

- I. Annual Production per plant
    - α. Foliage
    - β. crop
    - γ. root
- II. Stored in plant tissue

        - α. trank
        - β. root
    - III. Crop by products
        - α. Cuttings
        - β. Crop Residues
- B. Cultivation:
    - I. Machinery
    - II. Human Labour
    - III. Agrochemicals
    - IV. Soil Cultivation
    - V. Irrigation
- C. Biodiversity
    - I. Plants
    - II. Fungi
    - III. Insects
    - IV. Animals

The limited number of case studies and the uneven distribution across ES groups, scales and land system archetypes is a potential explanation for it. Therefore, we encompass those priorities in the course of the project's implementation in order to to come to a more complete picture on relationships between different ES. Being able to predict the direction of a relationship between ES as a function of scale and land system would be an important step for decision support and ecosystem management but it would be by no means the end of the end of the road.

Previous results concerning TC categorization provided an innovative and inclusive framework for both the continuation of CLIMATREE’s implementation but also for the Assessment of their respective ESs.

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