

Evaluation of the productive, economic, and ecosystem potential of fruit species in urban settings

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Abstract

In the following paper, the possibility of using fruit tree species, including minor fruit trees, in an urban area of Perugia (Italy), was represented, considering their possible productive, ecosystem and economic contribution. The simulated food forest, created through the use of a web app, can be regarded as an "organic green area" in which different fruit trees grow without resorting to the use of synthetic chemicals, respecting the ecosystem and minimizing soil exploitation. Among the four chosen species (*Arbutus unedo*, *Morus nigra*, *Prunus avium*, *Ficus carica*), both *Ficus carica* and *Morus nigra* showed good potential fruit production and storage of CO₂ from the environment, in particular, the species *Morus nigra* had the highest potential economic value, considering fruit selling in a 50-year time frame.

1. Introduction

The "Urban Food Forest" is described by Clark and Nicholas (2013) as "an emerging multifunctional and interdisciplinary approach that is used to increase sustainability and urban resilience as it relates to food security," to restore unproductive ecosystems in cities, and to enable multiple goals (Park et al. 2018); its creation involves choosing tree species that have the ability to improve air quality, reduce air pollution, control soil erosion, provide food by making it an accessible resource for all, and improve human health and well-being. Edible landscaping is as old as gardening itself, already within ancient Persian gardens, around the 2nd millennium B.C., edible plants and ornamental plants were juxtaposed. In the Middle Ages, monastic gardens had ample space dedicated to fruit trees and vegetable gardens in which they grew vegetables and medicinal herbs (Beck and Quigley 2001). The use of edible gardens, both as a place of pleasure and as a source of sustenance, is also present in the Renaissance period, very common within them were fruit trees, such as the fig and pear, and vegetables such as cabbage, leeks, onions, fava beans, peas, zucchinis, and pumpkins, all the way to the gardens of 19th-century English suburbia, which often included edible fruits and berries. Over the centuries, however, the edible components of urban landscapes have largely been lost to shade trees. The past two decades, however, have seen a resurgence of interest in the edible landscape (Celik), which has been partly reintroduced within cities, called the "edible urban forest". The forest possesses a significant role in making cities more livable and better adapted to a situation of continuous climate-driven change. An important factor to consider before planting trees is to identify edible tree species responsible for possible adverse effects such as, for example, allergic reactions brought about by pollen, which involves an increasing portion of the urban population (Clark and Nicholas 2013). Economic benefits may also be possible from an urban forest, as was highlighted by a study by Clinton et al (2017) in which they estimated the value of four ecosystem services provided by urban area vegetation to be on the order of \$33 billion per year, globally. Potential annual food production of 100 to 180 million tons, energy savings ranging from 14 to 15 billion kilowatt-hours, nitrogen sequestration between 100,000 and 170,000 tons, avoidance of stormwater runoff between 45 and 57 billion cubic meters per year are expected. In addition, it is estimated that food production, nitrogen fixation, energy conservation, pollination, climate regulation, soil formation, and biological pest control could be valued at up to \$160 billion per year (Clinton et al. 2017). Results from

over work showed significant country-to-country variability, developed countries provide profitable agricultural production, contribute to reduced warming or cooling in temperate areas, and mitigate storm runoff in tropical locations. In developing regions, urban agriculture can be fundamental to survival or to necessary adaptation to climate change. In developed and temperate countries, agriculture increases access to the recommended daily consumption of fresh fruits and vegetables (McCormack et al. 2010). The recommended consumption of vegetables for the urban population can be met almost entirely through urban agriculture (Martellozzo et al. 2014), leading to a reduction in emissions from transportation of agricultural products (Weber & Matthews 2008) and a decrease in food waste. Among the ecosystem services assessed, food production provides the most returns (Clinton et al. 2018). As urban populations grow and climate change progresses, it becomes increasingly complicated to ensure food security for all people. Food security or "Food safety" refers to physical and economic access to sufficient safe and nutritious food that meets people's dietary needs (FAO 2008). This need has become one of the greatest challenges of the 21st century. One of the main advantages of growing fruit trees in cities is the presence of many volunteers, people, businesses, schools, food banks, supermarkets, hospitals and other congregations willing to help by taking care of the area and harvesting the fruits. Planting urban food trees on public land could greatly increase local fruit production and may be able to theoretically provide the entire recommended fruit requirement for the population. Large-scale production of fruits in the city will require appropriate planning, staffing, and funding for maintenance, harvesting, storage, processing, and redistribution, by citizens, in this way it will be possible to create a healthy and productive food forest (Clark and Nicholas 2013). An example of an edible urban forest is City Fruit (2011), a project started in Seattle in 2008, within which the great value of fruit trees in cities is emphasized, and which aims to promote fruit growing in urban landscapes, build community and protect cities from climate change. The project also works by preserving urban tree canopies, encouraging proper tree management, and involving more city neighborhoods to harvest fruit. City Fruit also sponsors pruning courses and has produced a series of quick guides on topics such as fruit tree care, identification and control of common fruit tree pests, and fruit drying. (McLaina et al. 2012). In 2016, the City Fruit initiative collected 25,000 kilograms of unused fruit from Seattle's urban fruit trees and donated 13,600 kilograms to food banks and community organizations, with an estimated value of \$60,000 (City Fruit 2016).

The purpose of us work is to study the potential placing of fruit woody species in the urban environment, focusing on fruit yield, potential economic value and CO₂ sequestration during a 50-year time period through a dynamic evaluation considering specific plant growth equations.

2. Materials And Methods

2.1. Virtual planning of an urban green area

Fruit trees, belonging to the species *Prunus avium*, *Ficus carica*, *Morus nigra* and *Arbutus unedo*, were virtually placed in an urban green area, more specifically within the Chico Mendez Park in Perugia,

Umbria, through the use of an online platform called "Lifeclivuttreedb." The open-source software environment (named "Lifeclivuttreedb") is based on a fully web-based architecture and can be used on the Internet network from any device, whether stationary or mobile. The management software "Lifeclivuttreedb" was implemented as part of the Life Clivut project "Climate value of urban trees" operating in four cities in the Mediterranean area such as Perugia and Bologna in Italy, Thessaloniki in Greece, and Cascais in Portugal (<https://www.lifeclivut.eu/>). The project was created with the aim of planning and managing urban greenery and natural spaces to increase resilience to climate change, having as its basis the knowledge of the tree stock in the four cities and its evaluation in terms of climate and ecosystem performance (Orlandi et al. 2022a). The dendrometric data considered by the Web app are DBH (tree diameter at 1.30m), tree height, height at first branch stage, size, shape and transparency of the crown. The species of the tree as well as its phytosanitary status is also recorded, which are useful in identifying any issues for its management. Within the Web app, the "planting" of nursery plants belonging to the considered fruit species was simulated, 4 plants for each species. Plants have arbitrarily defined morphological characteristics considering representative average values derived from technical/scientific literature.

In selecting fruit species for planting in the city, the tree diameter speed of growth, the maximum and minimum temperatures the plant can withstand, hardiness, ability to adapt to climate change, potential production yields, and the allergological risk from the dispersal of their pollen were considered.

2.2. Evaluation of urban tree growth curves

Within rural forests, relatively uniform growth conditions allow foresters to generate growth equations specific to each tree species; this is more difficult for trees in "urban forests," however, because of their heterogeneity. A series of allometric equations were used in the Life-Clivut project to interpret plant growth of tree species derived from the analysis of empirical observations made by the U.S. Forest Service (McPherson et al. 2016). Various equations realized by the "U.S. Forest Service," have been considered but in particular those developed in Mediterranean-like climate zones such as the Central Florida zone (CenFla), Northern and Southern California Coast (NoCalC-SoCalC). The equations most closely matching the characteristics of the plants involved in the study were then chosen where different allometric equations included four polynomial models (linear, quadratic, cubic, and quartic), as well as logarithmic and exponential equations. Then, the selected equations were applied to the considered fruit tree species using common morphological parameters (DBH, H, Crown Diam).

2.3. CO₂ stock assessment

The online platform "Lifeclivuttreedb" made it possible to estimate the potential CO₂ stock that trees would attain in 50 years, using allometric equations in which 2 parameters, DBH and plant height (H), are essential. A series of allometric equations derived from the analysis of empirical observations made by the "U.S. Forest Service" (McPherson et al. 2016) were used to interpret plant growth of tree species. The equations most responsive to the characteristics of the plants involved in the study were chosen. The "Life Clivuttreedb" platform, based on the species identification and DBH sampling, evaluated the height

and age of each tree, providing carbon storage estimates expressed in tons of CO₂ equivalent. First, this is done by calculating the volume of fresh tree biomass, then this is converted to dry weight biomass using the densities of the different woods, then the carbon present is estimated and converted to stored carbon dioxide equivalent (Ventura et al. 2021). The main experience on which the model is based comes from that of "I-Tree," which calculates the total carbon storage of the urban forest and individual trees from the allometric biomass equations of forest-grown trees and adapting it to urban environment (Nowak 1994; Nowak and Crane 2000; Nowak 2020). In LifeClivuttreedb the formulas have been adapted to plants typically found in the Mediterranean area, as equations are not available for a full range of tree species and for different climate areas. In order to improve the estimation of the biomass and carbon stock of tree species in the Mediterranean area, the results of an Italian research program (ri.selv.Italia) funded by the Department of Agriculture and Forestry of the Italian government were also taken into account using the equations created (Bianchi 2004). Dry weight biomass and stored carbon are calculated by applying biomass density factors (reported in the scientific literature) and incorporating belowground biomass by multiplying epigeal biomass by 1.28 (Tritton and Hornbeck 1982; Sinacore et al. 2017). Biomass then converted to kilograms of carbon (C) by multiplying by the constant 0.50 (Lamloom and Savidge 2003), while stored carbon was converted to stored carbon dioxide (CO₂ in tons) by multiplying by the constant 3.67 (molecular weight of CO₂).

2.4. Production yields and potential economic value

Productivity of fruit trees can be defined by the following basic variables: High yield (in tons per hectare or equivalent); Precocity (minimum young period, i.e., reaching reproductive maturity at an early age); and Regular, long-term, non-altering productivity (Goldschmidt 2013). However, most fruit trees show some degree of fluctuation and alternation, particularly under suboptimal conditions and biotic or abiotic stress (Monselice and Goldschmidt 1982). This is determined by the fact that the flowering and fruiting of trees in their wild and natural habitats is dominated by the environment: the surrounding wild vegetation, the availability of sunlight, water and mineral nutrients, and biotic and abiotic stresses, all of which interfere with and limit fruit production. As a result, under wild conditions, the sexual reproduction of tree species fluctuates greatly, and the full expression of fruiting potential is rarely obtained. Domestication has gradually alleviated environmental and biological stresses, reducing annual fluctuations and increasing yield. Agricultural practices such as pruning or fruit thinning may optimize the ratio between reproductive activity and ground-level vegetative growth (Goldschmidt 2013). For the chosen species in the following study, the fruit yield, during tree development, was approximated arbitrarily in order to achieve a simplified representation of reality. Production values per plant were conservatively considered to be low because these are individuals placed in urban settings, subjected to specific environmental stresses that limit reproductive activity, resulting in low and irregular productivity. Therefore, reduction coefficients were applied to the assumed yields in kilograms of fruit. In this regard, 2 potential production scenarios were imagined based on methodologies available in literature, where S1 represents 50% of fruit trees yield commercially cultivated, S2 represents 30% of these "benchmark" yield. (Vannozzi Brito and Borelli 2020). According to scientific literature, the fig tree (*Ficus carica* L.) appears to be one of the few fruit trees with well-balanced, regular, and constant production (Neusner 1991), capable of producing about 30

kg/year of fresh fruit (Feliks 1979). Suitable for the purpose of this paper, to obtain a rough production estimate of the "Edible Forest," is the work of Boulestreau et al. 2016, on fruit yield of certain species in urban settings.

After estimating an average production for each species, its potential economic value was calculated considering a time frame of 50 years. To calculate it, the estimated production (kg fruit/plant) of each species was multiplied by the current average price (€/kg) in the fruit market. Average prices of the most common fruits were taken from the Institute of Services for the Agricultural and Food market (ISMEA - <https://www.ismeamercati.it/analisi-e-studio-filiere-agroalimentari>), while the average prices of minor fruits were reconstructed based on empirical knowledge of both farmers and agri-food technicians.

3. Results

3.1. Species selection

Fruit trees chosen for planting in urban areas include: the *Arbutus unedo* L., known by the common name Strawberry which possesses good resistance to cold, down to -17°C, can tolerate pollutants, has the peculiarity of reacting to fire with a high emission of suckers and recolonizing surfaces destroyed by fire; the dispersal period of its pollen is from October to January. *Ficus carica* L., common name Common fig, is a very drought-resistant fruiting species and can adapt well to all types of soil; in April and August it disperses its pollen into the air. *Morus nigra* L. known by the common name Black mulberry is a hardy plant that is adapted to poor soils, resistant to cold and tolerant to periods of drought. Finally, the fruiting species *Prunus avium* L., common name Sweet cherry, was chosen, which is also very hardy, resistant to cold down to -20°C and has high vigor. Both *Morus nigra* and *Prunus avium* disperse their pollen from the months of April and May. All of the fruit trees were also evaluated according to the allergological risk that dispersing their pollen in an urban environment would cause. No scientific evidence has been found to state that pollen from *Arbutus unedo*, *Ficus carica*, and *Prunus avium* can be responsible in any way for allergic sensitization with or without clinical significance; therefore, urban planting of this species does not appear to pose a risk for respiratory allergies. There is moderate evidence, on the other hand, that *Morus nigra* pollen may be responsible for possible allergies with clinical relevance; therefore, planting of this species in cities should be limited to a few specimens and/or avoiding sensitive locations (Papia et al 2020).

3.2. Growth curves of the tree species considered

A maximum age of 70 years was considered to better visualize the growth curves although this period is certainly "optimistic" given the species evaluated through the application. With a realistic approach, in fact for later evaluations a maximum age of growth and production of a fruit tree based on 50 years will be considered. Figure 1 shows the potential growth of the diameter of the trunk of the trees examined, expressed in centimeters, over a 70-year period. Growth was evaluated every 5 years. The value of the trunk diameter is shown in the y-axis, while the age of the various species, expressed in years, is shown in the abscissa axis. The species that reaches a larger trunk diameter among all is *Ficus carica* reaching 70

years of age with a maximum diameter of about 74 cm, in contrast to that of *Prunus avium*, which only reaches about 42 cm. The growth conditions of all the species were considered without particular constraints as small tree pit, poorly permeable ground and limited soil, tree topping or tree suffering conditions being allowed to grow spontaneously.

Figure 2 depicts the potential height growth of trees, expressed in meters, up to the age of 70 years. Height values are shown every 5 years and indicated on the y-axis, while the age of the various species, expressed in years, is shown on the x-axis. The growth of all species decreases over time, after the age of 40 years for most species they remain the same height except *Morus nigra* which increases growth even beyond 40 years reaching maximum heights of about 14 meters. The lowest height results from *Prunus avium*, which reaches only about 8 meters.

Estimates of average CO₂ accumulation of the considered species from the time of edible forest establishment to 70 years are presented in Fig. 3. The average CO₂ accumulation per species at the time of planting is very small, amounting to 0.07 ton. Over the years, the CO₂ storage potential of trees rises as DBH and age increase. In fact, according to the developed models *Morus nigra* sequesters 1.27 tons of CO₂ at 30 years and goes up to 2.40 at 50 years. Among all the species considered, *Ficus carica* is the one that gets to store the largest amount of CO₂ at 50 years, which is 2.93 tons. The least amount of CO₂ that is stored over 70 years is 1.19 ton, referring to the tree species *Prunus avium* and *Arbutus unedo*, shown in curve 3.

3.3. Potential production yields

In Table 1 the potential yields for the considered fruit tree species were reported on the base of the scientific and technical literature. It can be shown that during the first 4 years of rooting, all the species examined are in a non-productive stage. From the fourth year onward they all enter the production phase (indicated in grey), producing an average of 1 kg of fruit each in the first few years. Over time the quantity increases. *Arbutus unedo* is the species with the lowest productivity, averaging 10 kg of fruit per year, at 40 years of age it needs replanting, and after 50 years it reaches a total of 395 kg of fruit produced. According to the considerations made in terms of production, replanting would also be advisable for *Prunus avium* trees after 40 years. Instead, *Ficus carica* would seem to be the species with the greatest productive potential, on average producing 36 kg of fruit during the peak production years (shown in gold color) for a total of 1299 kg over 50 years. The species of fruit trees whose potential use in urban areas was evaluated will not necessarily be managed and cultivated for production purposes but may predominantly grow wild without the use of specific care and subjected to various environmental stresses. So new potential fruit productions, on the base of the considered reduction coefficients (30–50% of the commercial yields), were calculated (Fig. 4). As an example, the productivity of *Arbutus unedo* (Strawberry) in non-urban areas ranges from 7 to 10 kg/plant/year. Therefore, the assumed productivity values for Strawberry trees under urban conditions were 5 kg/plant/year (S1) and 3 kg/plant/year (S2).

3.4. Potential economic value

The potential economic value, resulting from the sale of all fruits produced by the four chosen species, was calculated considering the best possible production scenario (commercial yield), as shown in Table 1. Based on the production and average price of fruit in the reference market, it was found that *Arbutus unedo* trees, potentially producing very small amounts of fruit in 50 years, about 395 kg in total, allow for a total economic value of only 2,000 \$, which can be derived by considering an average price of 5 \$/kg. The species *Ficus carica* and *Prunus avium* could yield up to 2,598 \$ the former, respectively, considering an average fruit price of 2\$/kg and up to 4,110 \$ the latter, finding its fruits at an average market price of 5\$/kg. In contrast, the fruit species with the highest potential economic value is *Morus nigra*, with a potential economic value of about 6,000 \$, with an average price of 7\$/kg. The possible total profit that could be obtained from marketing all the fruits produced by the 4 species considered is around 14,794 \$ total in 50 years.

4. Discussion

The realization of an edible landscape within cities allows urban areas to be improved in many ways by an environmental point of view that considering practical benefits for citizenship. The present study focused on assessing the productive, economic and ecosystem potential of specific tree species planted virtually in urban settings. Data obtained using a web app allowed to analyze woody fruit species on the basis of a range of ecosystem services such as CO₂ storage and to calculate their potential production yield and economic value from the sale of the fruit.

In various studies, the ability of some orchards to absorb atmospheric CO₂ has been determined; in particular, in an orchard in China, the results showed the great potential of an apple orchard as a sink for atmospheric CO₂ absorption. Trees reached the maximum capacity of C sequestration at the age of 18 years, over the years this capacity has been decreasing. Net C uptake in apple orchards in China ranged from 14 to 32 tons and C storage in biomass from 230 to 475 tons between 1990 and 2010 (Wu et al, 2012). In another work, however, the potential carbon sequestration in 15-year-old Mango (*Mangifera indica* Linn.) and 12-year-old Rambutan (*Nephelium lappaceum* L.) and 32-year-old Santol (*Sandoricum koetjape* Merr.) in the Philippines was evaluated (Janiola and Marin, 2016). The results revealed that among the three plantations, the 32-year-old santol plantation had the highest value of total stored carbon with 203.62 tons/ha, followed by the 15-year-old mango plantation with 122.34 tons/ha and the 12-year-old rambutan plantation with only 112.18 tons/ha of stored carbon. These agrosystems behave like some forests, fixing a significant amount of carbon per ha per year, becoming relevant in climate change mitigation (Janiola and Marin 2016). In the urban area of Perugia, the most frequent ornamental tree species are Horse chestnut (*Aesculus hippocastanum*), Holm oak (*Quercus ilex*), and Lime tree (*Tilia cordata*); these are able to store an average of 2 tons of CO₂ at 30 years of age while at 50 years of age an average of 5/6 tons of CO₂ (Orlandi et al. 2022b). The fruit trees in the present work stock proportionally 20% over the reference ornamentals at 30 years and 25% at 50 years. In fact, according to the developed models *Morus nigra* sequesters 1.27 tons of CO₂ at 30 years and goes up to 2.40 tons at 50 years, *Ficus carica* 2.93 tons at 50 years and *Prunus avium* and *Arbutus unedo* the smallest ones even

at 70 years stored only 1.19 tons of CO₂. These differences are due to the fact that CO₂ uptake varies both with changing environmental conditions and with species and individual characteristics. Understanding how and to what extent the species and type of canopy conditions exchanges with the surrounding atmosphere is of great importance both for the development of productivity models and for characterizing the extent of mitigation operated by different crop areas against greenhouse gases, which are responsible for climate change.

Considering practical benefits for citizenship for example, urban food forestry provides a source of local food that can increase household food security. Preserving the food security of rapidly growing urban populations is one of the greatest challenges of the 21st century (Camhis 2006; Clark 2007; Easterling 2007; Tanumihardjo et al. 2007; FAO 2008; Godfray et al. 2010). The condition in which all people, at all times, have sufficient safe and nutritious food available to meet their dietary needs and food preferences for an active and healthy, healthy life (FAO 2008), could be aggravated by climate change, transportation failures, and a host of other unexpected factors. (Fraser et al. 2005; Schmidhuber and Tubiello 2007; Cluff and Jones 2011). An urban food forest is able to make a certain amount of fruit available and accessible to every citizen. Market data by the webnet indicate per capita consumption of cherries is about 2 kg/year; for figs about 0.2 kg/year (<https://www.indexbox.io/store>). Based on estimated production calculations, a *Ficus carica* tree could produce 36 kg/year in maximum production, meeting the annual consumption of figs for about 180 citizens; in contrast, *Prunus avium* with its 24 kg/year can meet the annual consumption of cherries for about 12 people.

Moreover, an urban food forest strengthens community ties bringing physical and psychological health benefit. Several studies have shown that people living in neighborhoods with a higher density of trees have lower risks of incurring cardio-metabolic conditions and mental illness, in fact, exposure to green spaces can promote mental health (Richardson et al. 2013), reduce blood pressure and stress levels (Pretty et al. 2005), promote outdoor activities (Kaczynski et al. 2007), have beneficial effects on individuals' memory and attention (Berto 2005) increase children's attention capacity and consequently has a central role in improving school performance (Mancuso et al. 2006), finally, can reduce crime and aggression (Kuo and Sullivan 2001) by encouraging healthy behaviors (Kardan et al. 2015). The effects of viewing cherry blossoms in urban parks have been studied in Japan, and it has been shown that observing the flowers and fresh vegetation leads to lower blood pressure, decreased tension and anxiety levels (Pratiwi et al. 2019). The purpose of these studies and projects involving edible forests is to promote practices that are as sustainable as possible by reducing the use of chemicals in the landscape, supporting wildlife, and creating eventual energy and economic savings from less use of refrigeration systems in the areas in question by harvesting fruit directly from the trees at the peak of ripeness. Locally grown foods also usually do not require the same intensive amount of processing and packaging as conventionally grown foods and can result in further reductions in air and water pollution, air and water pollution if fruit in urban forests is grown organically, that is, without synthetic fertilizers and pesticides (Frank 2011).

5. Conclusion

To design an "Urban Food Forest," one must consider a variety of environmental and ecological attributes, such as genetic diversity, high species interaction, and tolerance of ecological communities to extreme events (Park et al. 2018). For these reasons, it may be of interest to include minor fruit trees in urban areas, not only to safeguard forgotten fruit species but also because these would be able, with their genetic make-up, to develop strains that are naturally resistant to extreme weather conditions and diseases, grow quickly and achieve good yields without resorting to the use of pesticides, being of particular interest in environmental strategies and in the context of sustainable agriculture. Another positive aspect of edible landscapes is their ability to give rise to an ecosystem and habitat that can attract animals, birds and wildlife, and consequently improve urban biodiversity. Planting fruit trees could be of interest in the creation of ecological corridors for connecting urban and peri-urban areas. Ecological corridors aim to protect animal and vegetation species typical of a specific habitat, allow the migration of fauna and genetic exchange between plant species.

Declarations

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Sitography

<https://www.indexbox.io/store>

<https://www.lifeclivut.eu/>

<https://www.ismeamercati.it/analisi-e-studio-filiere-agroalimentari>

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Table 1

Table 1 is available in the Supplementary Files section.

Figures

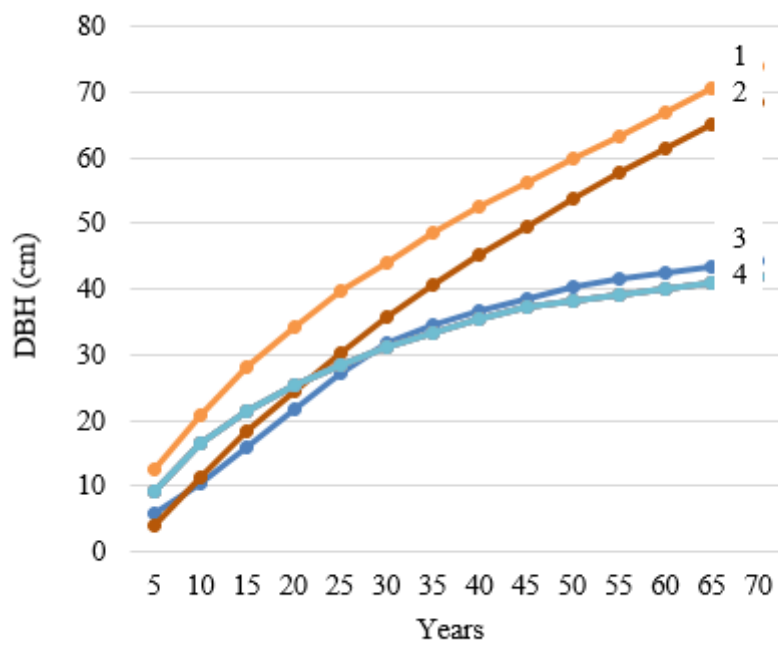


Figure 1

Fruit woody species growth curves. Age (years) predicting DBH.

1=*Ficus carica*L.; 2=*Morus nigra* L.; 3= *Arbutus unedo* L.; 4=*Prunus avium*L.

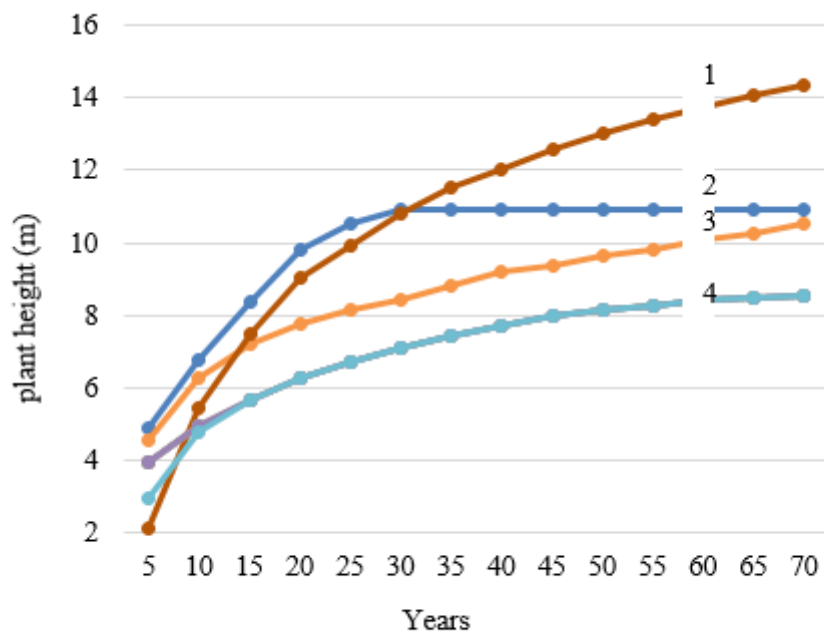


Figure 2

Fruit woody species growth curves. Age (years) predicting height.

1=*Morus nigra*L.; 2=*Arbutus unedo* L.; 3=*Ficus carica* L.; 4= *Prunus avium*L.

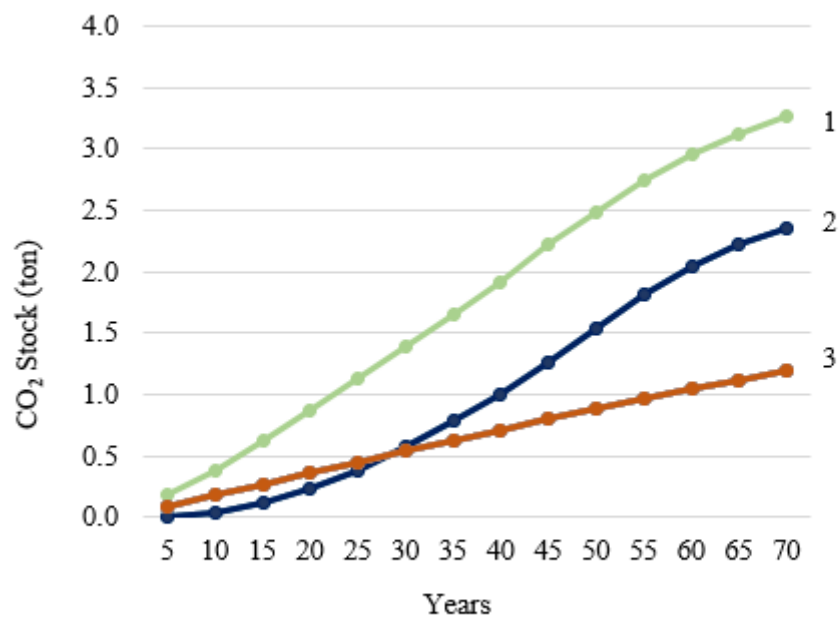


Figure 3

Fruit woody species growth curves. Age (years) predicting CO₂ storage.

1= *Ficus carica* L.; 2=*Morus nigra* L.; 3=*Arbutus unedo* L.; *Prunus avium* L.

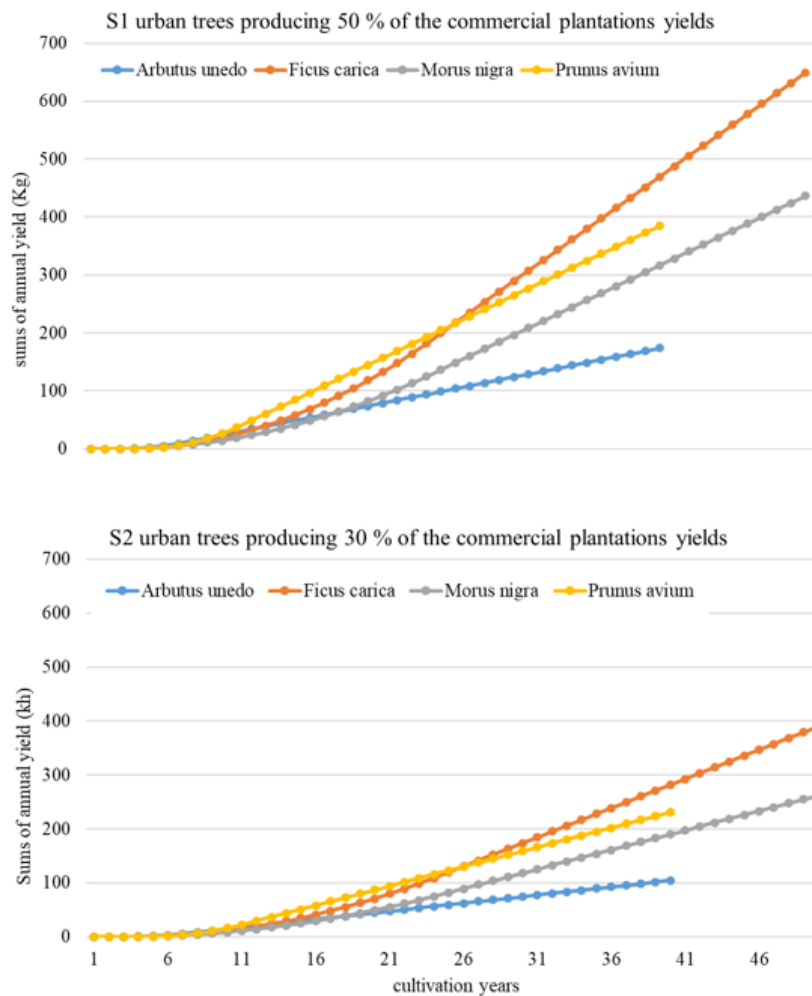


Figure 4

Potential production scenarios S1 represents 50% of commercially cultivated fruit trees yield, S2 represents 30% of the yield.

Supplementary Files

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- [Table1.docx](#)