**THEME [ENV.2012.6.3-&]**
**Innovative resource efficient technologies, processes and services**

*This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No 308313*

ZEPHYR project – Deliverable D7.2

# Market Analysis

Funding scheme: **Collaborative Project**

Project Acronym: **ZEPHYR**

Project Coordinator: **TUSCIA UNIVERSITY**

Proposal full title: **Zero-impact innovative technology in forest plant production**

Grant Agreement n°: **308313**

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Summary: **Market analysis finalized to the exploitation of the Zephyr project results**

Status: **Final**

Distribution: **Public**

Document ID: ***ZR-Veltha-WP7-D7.2-Market Analysis***

Date: **October 2015**

**Project start: October 2012** **Duration: 36 Months**

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# 1. Executive summary

The Zephyr project has developed a new, zero-impact growth chamber for forest regeneration material: a sustainable controlled environment where forest plants can grow, starting from the seeds, in a robotized nursery assistant. The continuous movement of trays with “mini-plugs” (Very small container plants in containers less than 37 cm3 in volume) guarantees an average environment (light, temperature and humidity) equal for each plant almost impossible to be obtained with ordinary growth chambers.

The controlled environment inside the new growth chamber allows an optimal growth without fertilizers and pesticides, while special LED lamps provide specific spectra for forest seedlings. Another innovation of the Zephyr project is the design and development of the new sensor for soil parameters and new sensors for shoot portions by optical detection measuring the shoot height (stereoscopic optical analysis) and ‘greenness’ (digital image analysis).

A robotic arm is able to position the stereoscopic camera on each of the more than 2000 seedlings the unit can handle in one cycle, and the embedded gripper may perform some simple operations. These innovations allow a full automated monitoring and control, also by remote, with an average power request of only 1,45 Kw.

Finally, the seedlings produced by the Zephyr unit are of better quality, have an higher survival rate after transplanting and can be easily certificated.

In order to show all the innovative solutions of the Zephyr technology in several fairs and exhibitions, the growth unit has been placed in a standard TEU container and fully powered with 20 photovoltaic panels placed in a foldable system on the roof of the container. The system allows an ordinary transportation via truck complying with the road transport rules.

Three different types of Zephyr technology's potential customers are considered:

1) First level customers: forest nurseries.

2) Second level customers: forest owners; in case of public bodies, they may coincide with the first level ones.

3) Universities and research centres (niche market)

With reference to the *first level customers*, there are noticeable advantages of the Zephyr system respect to the ordinary greenhouses :

- Surface saving up to 495%
- Energy saving 85% (
- Time saving 74%
- Water saving given by recovery and re-use of the exceeding water
- Herbicides, pesticides saving 100%
- Up to 11 growth cycles per year

Such advantages are a relevant “market asset” for the new product and the *second level customers* should be adequately informed about this issue through a specific market campaign.

The energy consumption of the Zephyr unit per space unit is very low (up to twenty times!!) respect to the growth chambers currently on the market and used by *universities and research centres*; however, such a parameter does not seem to be interesting to these potential customers.

For this niche market, the main competitive advantages of the Zephyr unit are:

- actual uniformity of the average growth conditions;

- possibility of adding several high-tech actuators for a complete automatic growth cycle, fully monitored and controlled by remote;
- automatic analysis of the green mass in the trays;
- high production capacity.

The most promising market for the Zephyr unit is the one referring to forest nurseries: the prototype built by the project is equivalent to a nursery using 3000 m2 of land (annual production of 50.000 seedlings) and can reduce by around 40% the total production costs. For bigger productions (200,000 up to one million), the modularity of the system may allow further relevant economies.

For low-medium production rates (up to 200.000 seedlings per year) the low energy and water consumption and the zero need of fertilizers/pesticides has an “image to the market” value that seem higher than the actual money savings

The flexibility of the system, allowing several units working in parallel is another asset of the system; however the optimal dimension of the unit, as well as the design of models having different production capacities has to be analysed in the scaling-up phase.

The advantages of the mobile and energy independent system (like the one built within the Zephyr project) have not been taken into consideration yet: it will be approached during the industrial implementation phase.

The analysis of the forest plants market in section 4 shows the trend of natural regeneration slightly increasing, however the market of forest plant production is still promising and the most recent *conservative* estimation indicates a production in Europe of around 2,8 billion plants per year.

The foresight demand for 2030 indicates a strong interest for urban forest, green cities and green architecture: fields where a small, movable and high capacity production unit like the Zephyr one has a competitive advantage.

The preliminary and prudential indications for the scaling up phase estimate a slow market penetration equal to 0,1% of the EU market in 5 years, with a consequent production of 56 Zephyr units in the concerned period.

Overseas market is not considered in the preliminary scaling-up phase, even if seems extremely promising; however, the industrial implementation plan should foresee a “basic unit” in at least two versions (capacity of 20 or 30 standard trays). Such a “basic unit” should be designed and built in a way that allows an easy addition of one or more actuators, either in construction phase, or after the machine has been sold, in order to reach a wide range of potential customers.

The economic analysis of a nursery having a production equivalent to the Zephyr unit and a survey of the growth chambers currently on the market gave a first convergent indication of the possible “price to the market”, that should be considered as a first rough input for the scaling-up phase.

The Industrial implementation Plan will involve the project partners having the ownership of the Zephyr’s IPR and foresee the organization of the “distributed company” (light Consortium) for the commercialization of the innovative growth chamber.

**Reference documents**
This work has been carried out taking as reference the following documents:

Zephyr project: technical deliverables (public ones available at www.zephyr-project.eu ):

| | |
|---|---|
| D3.3 | Final report on growth tests and biological validation |
| D4.1 | Final design of the Growth Chamber (mechanics and water) |
| D4.2 | New LED lamps built and tested |
| D4.3 | New sensors built and tested |
| D4.4 | Control, communication and monitoring system |
| D4.5 | Robotic devices |
| D4.6 | Power system with solar panels |
| D4.7 | Report on completed development of technical components |
| D5.1 | New growth chamber assembled with all the devices integrated |
| D7.5 | Proceedings from Workshop 3 |

ZEPHYR project: Internal Report - Data for market analyses **(in the Appendix )**

1) UNECE - FAO: State of Europe's Forests 2011 Report-Status & Trends in Sustainable Forest Management in Europe
http://www.foresteurope.org/documentos/State_of_Europes_Forests_2011_Report_Revised_November_2011.pdf

2) UK Forestry Commission -Nursery Survey 2015 edition
http://www.forestry.gov.uk/pdf/nursery2015.pdf/$FILE/nursery2015.pdf

3) UK Forestry statistics 2015
http://www.forestry.gov.uk/pdf/ForestryStatistics2015.pdf/$FILE/ForestryStatistics2015.pdf

4) UNECE - FAO: The European Forest Sector Outlook Study II - 2010-2030
http://www.unece.org/fileadmin/DAM/timber/publications/sp-28.pdf

5) PRODUCING PLANTING STOCK IN FOREST NURSERIES. Krasowski, M.J.. Faculty of Forestry and Environmental Management, University of New Brunswick
http://www.eolss.net/sample-chapters/c10/e5-03-05-07.pdf

6) Proceedings of "Foresight on Future Demand for Forest-based Products and Services: Setting the Scene - Vienna/Austria 07 - 08 September 2010"
http://www.cost.eu/events/Forestry-Foresight-Setting-the-Scene

7) EFI Technical Report No 93. 2014 Forest Products Market Transparency: A Report of the International Workshop on Forest Products Price Information - Ibrahim Favada and Ed Pepke (editors)
http://www.efi.int/files/attachments/publications/efi_tr_93_favada_and_pepke_2014.pdf

8)EFI Technical Report 94- 2014 - Guide to Economic Appraisal of Forestry Investments and Programmes in Europe -Pat Snowdon and Patrice Harou
http://www.efi.int/files/attachments/publications/efi_tr_94_snowdon_and_harou_2014.pdf

9) FAO - State of the World's Forests 2014 - http://www.fao.org/forestry/sofo/en/

10) Forest Nurseries in Europe : an overview - presentation of Dr Andy Gordon - Secretary of the European Forest Nursery Association at the Zephyr final conference in Milan on 21/10/2015.
http://www.zephyr-project.eu/sites/default/files/conference/11%20GORDON.pdf

11) A comparison of costs incurred in the nursery production of improved and regular southern pine seedlings - Mason C. Cloud Texas Forest Service, College Station, Texas
http://www.rngr.net/publications/proceedings/1972/comparison-of-cost-incurred-in-the-nursery-production-of-improved-and-regular-southern-pine-seedlings/at_download/file

12) Modelling production cost and financial return of forest reproduction materials in relation to nursery size - Steve Harrison, Nestor Gregorio and John Herbohn - ACIAR seedling enhancement project - https://espace.library.uq.edu.au/view/UQ:242942/SH16.pdf

13) Listino prezzi 2015 delle piante forestali della Regione Lombardia (price list of forest seedlings 2015) - http://www.ersaf.lombardia.it/servizi/moduli/moduli_fase02.aspx?ID=605

# 2. Outcome of the Zephyr project

## 2.1 The zephyr innovative growth chamber

The Zephyr project has developed a new, zero-impact growth chamber for forest regeneration material: a sustainable controlled environment <u>where forest plants can grow, starting from the seeds</u>, in a robotized nursery assistant. The continuous movement of trays with “mini-plugs” (*Very small container plants in containers less than 37 cm$^3$ in volume)* guarantees an average environment (light, temperature and humidity) equal for each plant almost impossible to be obtained with ordinary growth chambers.

Key components of the new system include a rotating set of trays under an array of LED lamps, a robotic arm equipped with a camera, and wireless micro-sensors that keep tabs on the plants.

Forest plants need very specific conditions for ensuring seed germination and then an adequate growth with strong roots: <u>providing these conditions is the only way to preserve biodiversity, as plants produced from cuttings are essentially clones</u>.

The growth chamber is composed by:

- 10 shelves in continuous rotation; each shelve can contain 2 plastic trays of size 53 x 31.5 cm.
- An air conditioning system,
- An irrigation system,
- a track for the horizontal movement of the robotic arm carrying stereoscopic cameras.

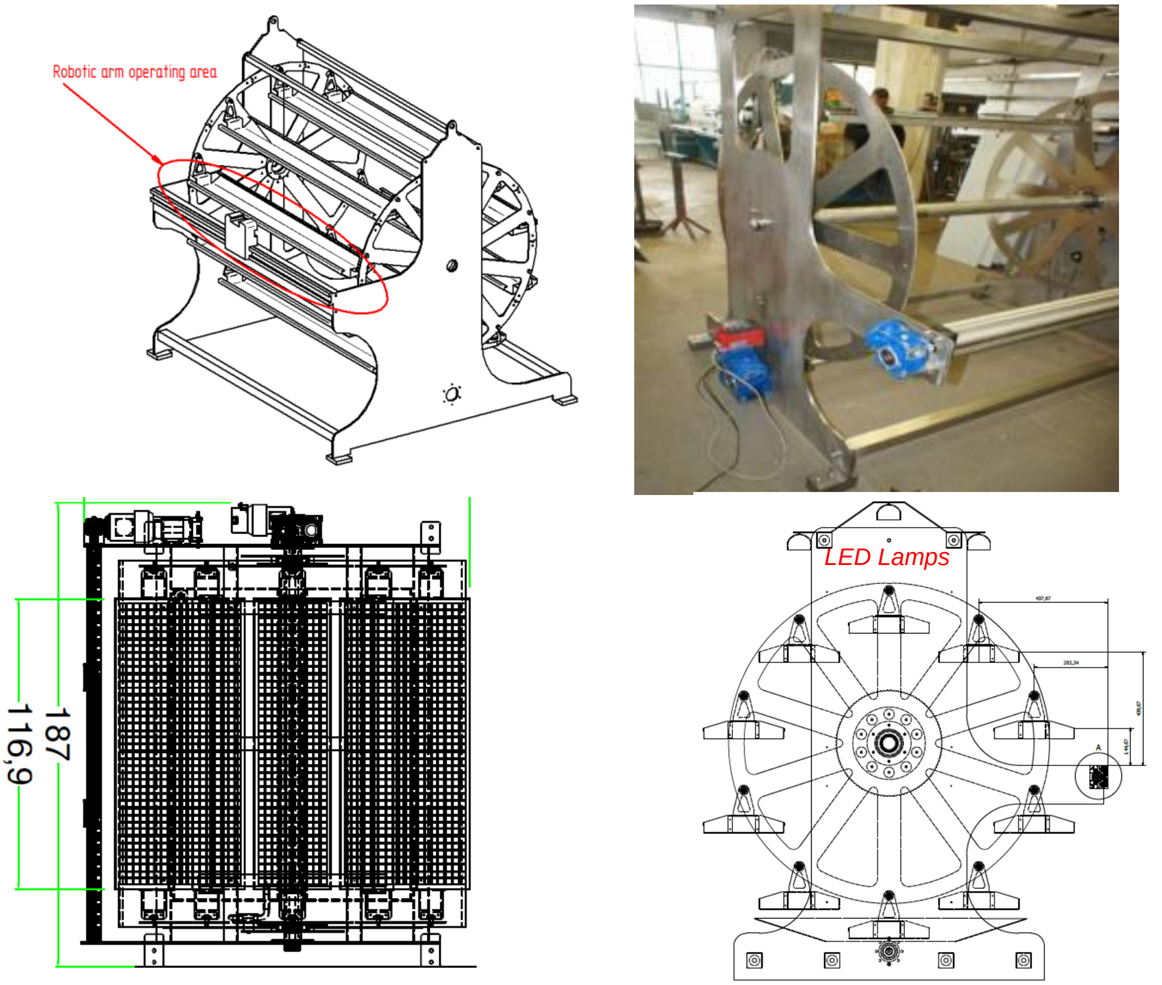



**Figure I- General view of the rotating system**

One of the Zephyr growth chamber's particular strengths is that **it provides uniform conditions**. In the current, "static" chambers and greenhouses, seedlings remain in the same spot for large stretches of time, and some are thus nearer to key components, such as lamps and coolers, than others.

In the prototype unit, all seedlings benefit from the same amounts of light, moisture and warmth. Seedlings are placed on revolving trays, taking turns in the best spots.

<u>The system thus produces plantlets of consistent quality, with the strong roots they will need to survive after being transplanted</u>.

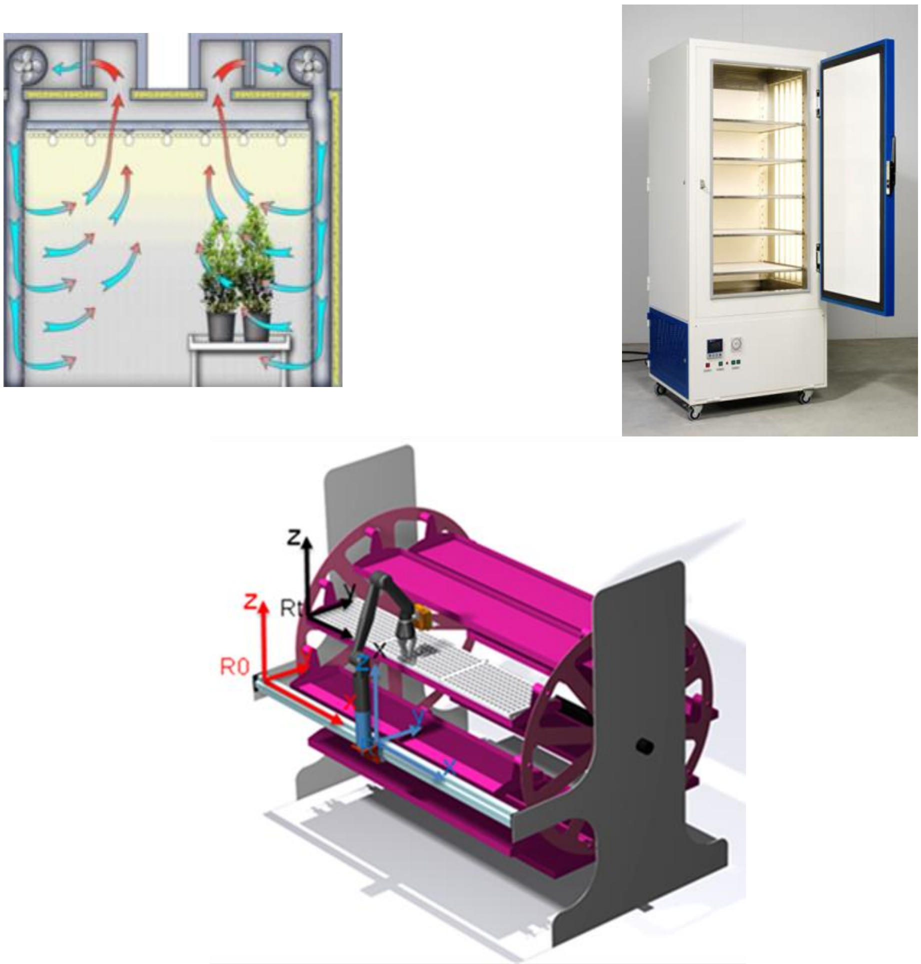



**Figure II: Top: ordinary static growth chamber with the air flow; down: scheme of the Zephyr unit**

The figure above clearly shows how in an "ordinary growth chamber the seedlings closer to the air flow outcome are subjected to a lower temperature than the ones in the centre of the tray; the same is for the light.

In the ZEPHYR system both light and fresh air come from the top and the rotating system guarantee average uniform conditions

**A further strength of the Zephyr unit is the replacement of the conventional light sources with use of specific Light Emitting Diodes (LEDs)**, due to its considerably lower energy consumption, reduced heat emission and extended lifetime of the light source.

In the concept of intense cultivation the possibility of using LEDs instead of other artificial light contributes to major economic and environmental benefits. It is more cost efficient, improves the sustainable management of forest production and contributes to the environmental protection through a noticeable energy saving. It will also reduce the greenhouse gas emissions and, since the LED lamps do not produce additional warming, there will be further energy saving by reducing the air conditioning costs.

**Figure III: three rows of special LED lamps inside the Zephyr growth chamber**

Furthermore, the specific spectrum selected for the ZEPHYR unit reduces the typical red-blue peaks present in the traditional LED lamps and allows an optimal distribution of the frequencies, as shown in Fig 4

Several tests have been made in a previous research project to identify the best suitable LED light spectrum for different European forest species: the Zephyr lamps chosen have a robust design and special attention has been given to the thermal management to ensure high performance, without producing "waste-light" and thus saving electricity

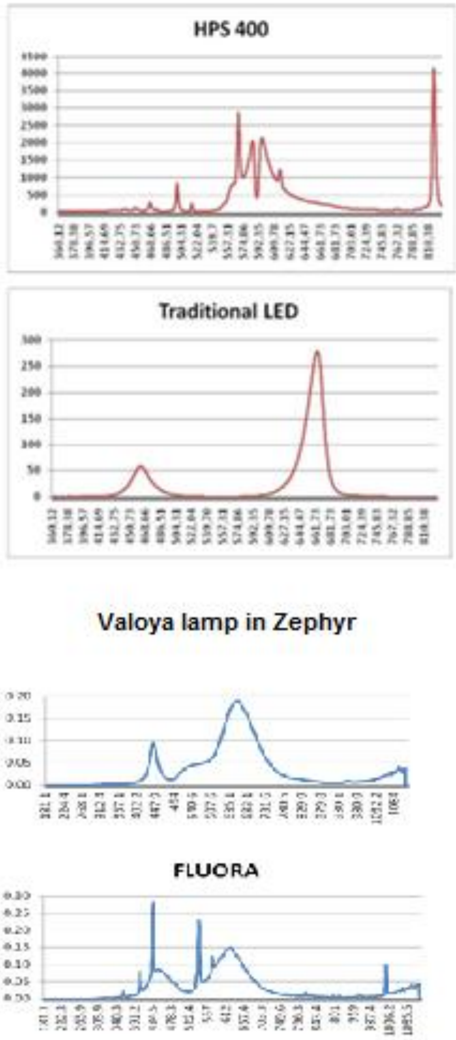



**Figure IV: Scheme of the light spectra used in greenhouses and growth chambers compared with the Zephyr one: Sodium , Traditional LED, Zephyr LED and Fluorescent tube**

The Zephyr unit is space and energy saving , with a daily average electricity consumption of 1,45 Kw (total max load 1,9 Kw) for the simultaneous pre-cultivation in 20 trays (10 shelves carrying 2 trays each).

In order to show such a low consumption in several fairs and exhibitions, **the growth unit has been placed in a standard TEU container and fully powered with 20 photovoltaic panels** placed in a foldable system on the roof of the container. The system allows an ordinary transportation via truck complying with the road transport rules.

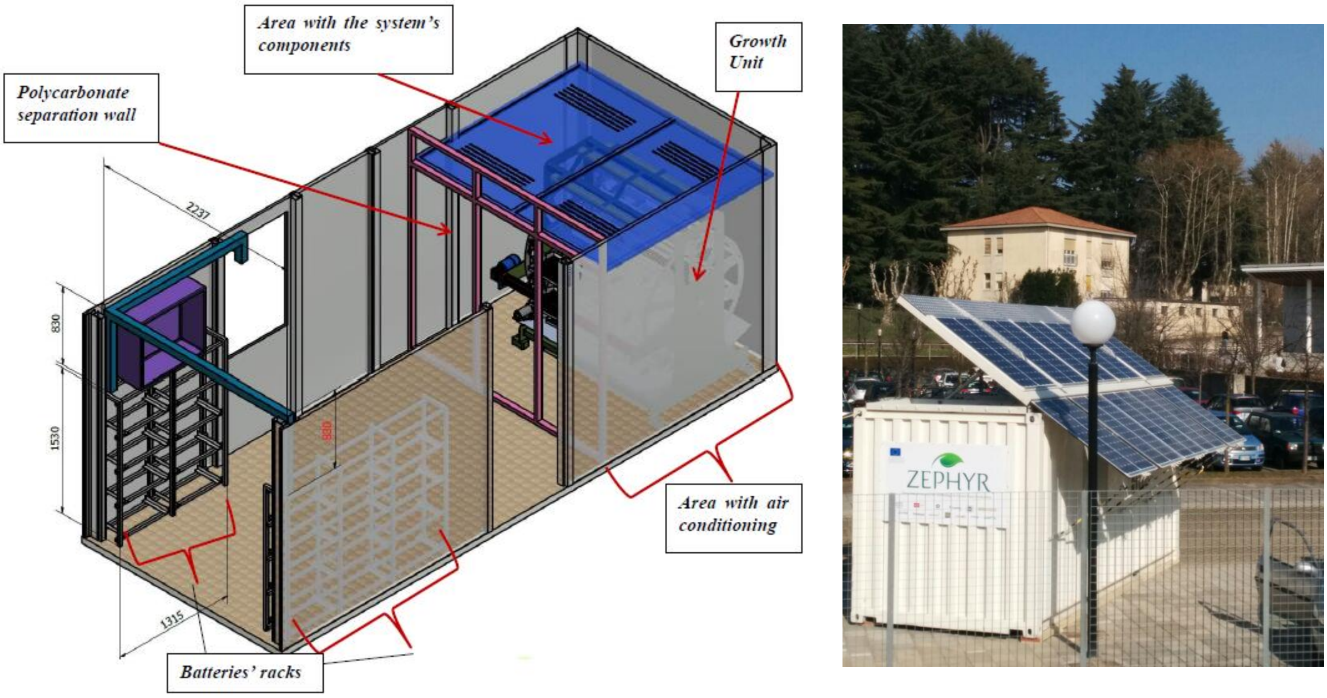



**Figure V Left: The Zephyr unit fully operating with solar energy**

Another innovation of the Zephyr project is **the design and development of the new sensor for soil parameters and new sensors for shoot portions by optical detection** measuring the shoot height (stereoscopic optical analysis) and 'greenness' (digital image analysis). This development deals with soil parameters by 'stick' sensor and shoot portion by optical sensors.

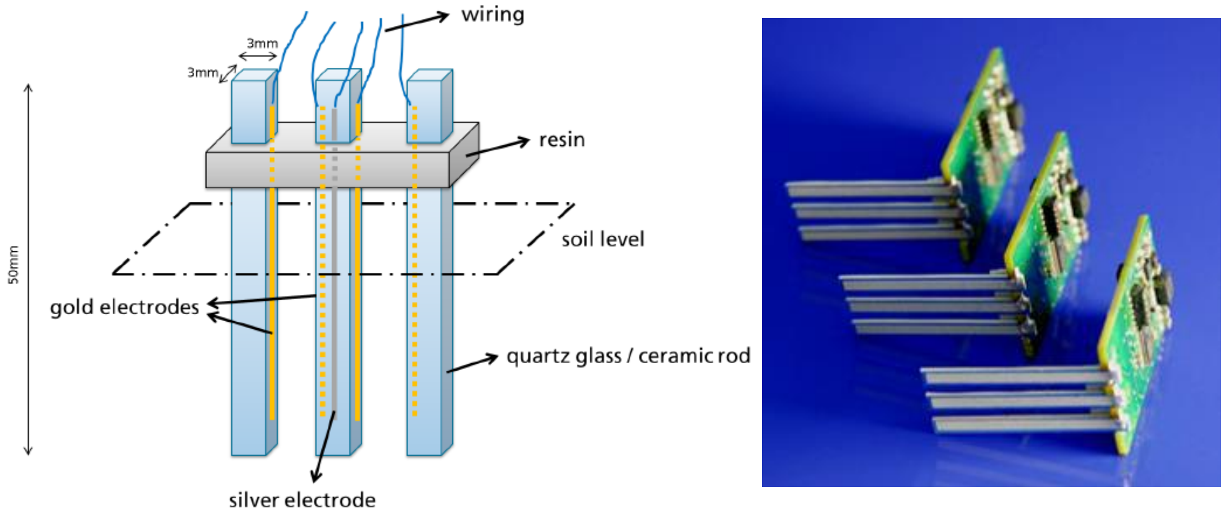



**Figure VI The Zephyr new soils sensors; design details and picture**

A production route for electrodes with high-throughput manufacturing methods for cost-efficiency was established: printing technologies like screen-printing play an important role for the production of sensor electrodes. To automate the process of fabricating printed sensor electrodes a robot-assisted production line was set-up, which allows different printing methods to be combined in a single run.

**Figure VII: Soils sensor (together with the wireless transmission unit and a test battery) placed in the tray with plantlets**

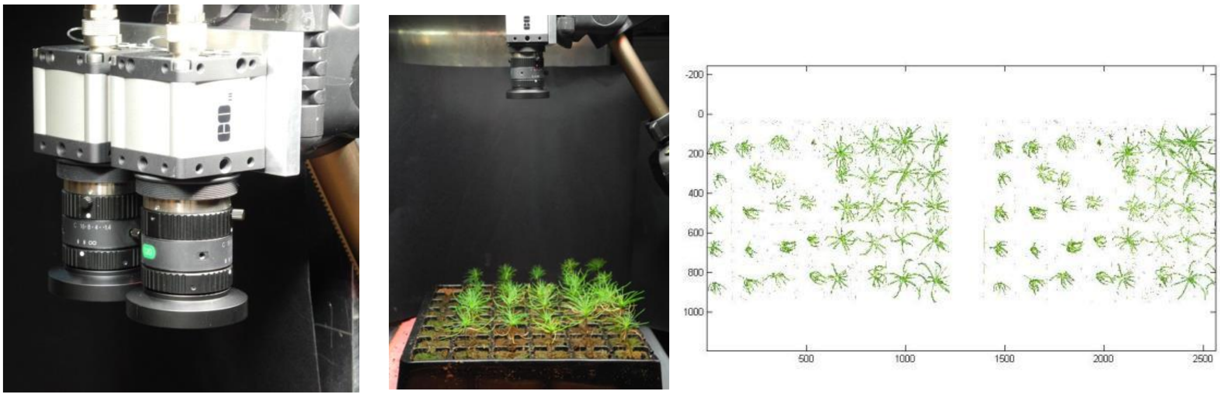



**Figure VIII: Photos of the optical sensors for measuring the shoot height and 'greenness'. From the left: zoom-in showing the dual cameras for stereoscopic imaging; typical position of optical cameras on top of seedlings; (b) optical cameras; green pixels achieved by a stereographic view**

The stereo camera has been mounted on a robotic arm able to take pictures of every plantlet in the system, by using the grid of the mini-pots as reference, together with the number of the shelf. The arm has also a gripper that will conduct some tests (not originally foreseen in the DoW) targeted to a future embedding in a fully automated production unit. The future goal is to develop a robotic arm capable to assist users for:

- Position the camera on the top of the right tray to take picture for further analysis,
- Intervention of eventual replacements of a single plant in the tray inside the unit, in order to ensure that at the end of each growth cycle all the trays will be ready for their delivery

- transplant in pots at the end of each cycle (for the plants that will continue their growth cycle in the nursery)
- place an eventual additional wireless sensor in each tray (for the storage or transport environment)
- put the trays in stacks, pack the stacks for their delivery or storage at low temperatures

**Figure IX: The robotic arm with the stereo camera and the gripper**

A very short video showing the prototype running is available at: https://www.youtube.com/watch?v=zcHGu9KKSWc ;

more videos and pictures are available on the project web site www.zephyr-project.eu

A **central control system** allows to control all the actuators according to the growth protocol inserted, as well as to monitor the system by remote

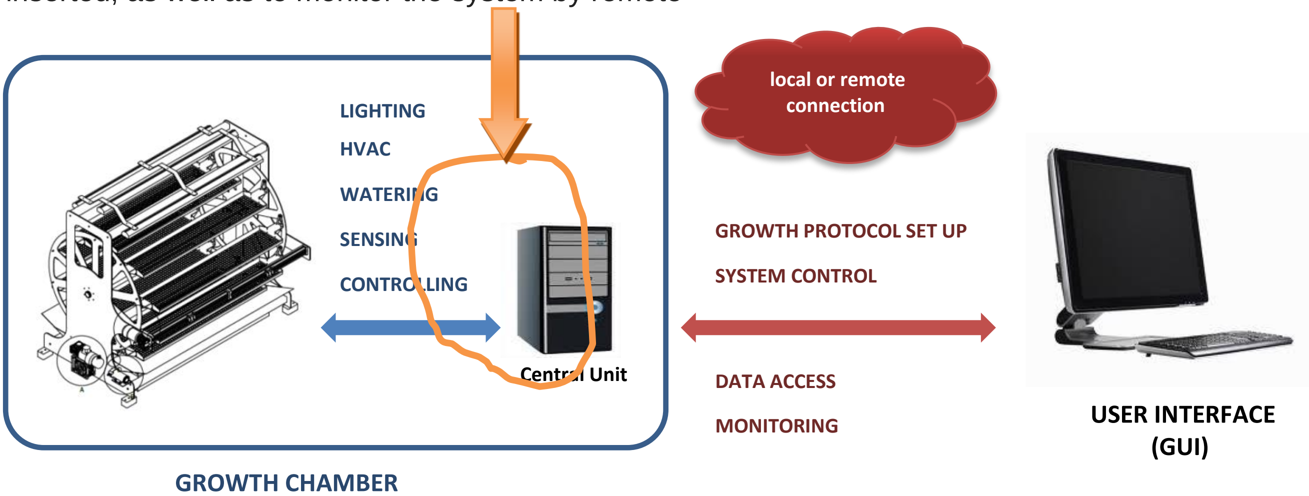



**Figure X: The control unit**

The control unit developed deals with the following architecture offering dedicated hardware interfaces to connect all Zephyr components and also software interfaces to exchange data from the different modules.


**Figure XI –Architecture of Zephyr system, the growth unit inside the container and a screenshot of the control software**

## 2.2 Competitive advantages of the new product

Tests performed during the project have demonstrated that:

- Seedlings of almost all the tested species show good growth performances when cultivated under Valoya LEDs lights, better than under the fluorescent ones.
- LED lights strongly speed up phenological stages of seedlings, reducing the time for seedlings emergence and apical bud closing.
- The ZEPHYR rotating system allows the production of a high amount of seedlings, in a real short time, ready to be used for reforestation programmes, green infrastructures and valuable species production.

The competitive advantages of the Zephyr system are analysed in the following sections, compared with ordinary nurseries and greenhouses with cultivation in pots and with other growth chambers.

**3 different types of customers are considered:**

1) <u>First level customers</u>: forest nurseries, that are the main target in the market

2) <u>Second level customers</u>:

   *2a) forest owners (clients of the forest nurseries), given the large influence they have on the nurseries; in case of public bodies, these two types of customers often coincide;*

   *2b) small nurseries acting as a re-sellers: they buy pre-cultivated material from large nurseries;*

   *2c) Landscapers and urban planners, given the foresight on future demand for urban forests, green cities and green architecture (source [6])*

3) <u>Universities and research centres</u>

### 2.2.1 Bulk production of forest plantlets, compared with an ordinary greenhouse with cultivation in pots

The advantages of the Zephyr system respect to greenhouses are:

- Surface saving up to 495%;
- Energy saving 85%;
- Time saving 74%;
- Water saving given by recovery and re-use of the exceeding water;
- Herbicides, pesticides saving 100% in the pre-cultivation phase; given the increased robustness of the seedlings, the amount of such chemicals will be reduced also in the further growth phases;
- Up to 11 growth cycles per year;

#### *2.2.1.1 Surface saving*

According to the following scheme of the Zephyr unit, the surface of the system containing 10 shelves with 20 trays is 1,562m x 1,169m = 1,826 $m^2$.

Since the dimension of a single tray is 310x530 mm, it has a total surface of 0,1643 $m^2$. The same surface allows only 11,11 trays "on the floor" in an ordinary greenhouse, meaning a surface saving of 45%. Since the growth in the machine is independent from the outdoor climate and conditions, <u>the machine allows up to 11 cycles per year[1], meaning up to 11 times more than in the ordinary season-depending nursery;</u> **the total surface saving is consequently up to 11 x 45% = 495%**

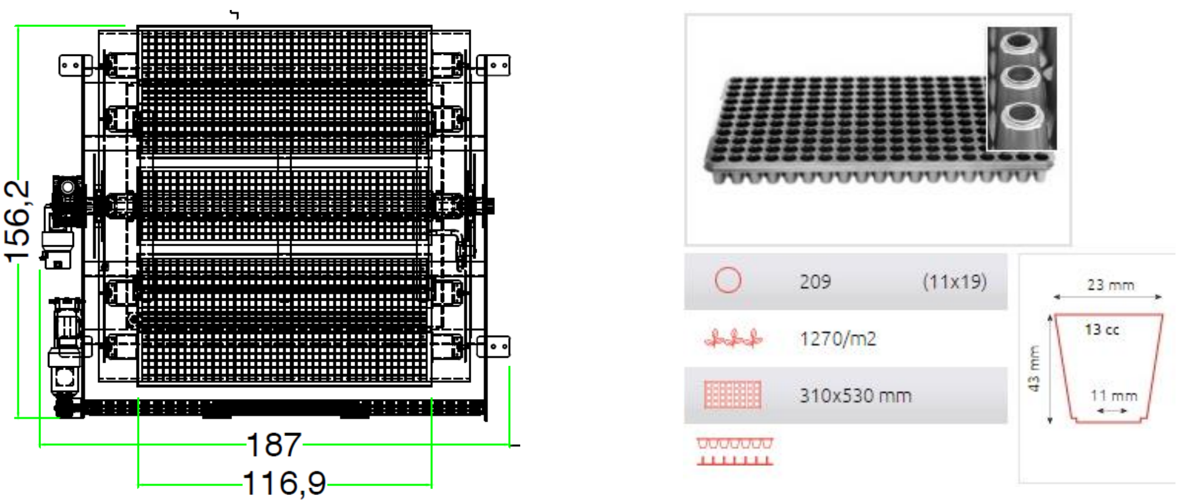



**Figure XII – Plant of Zephyr system, the growth unit inside the container and a screenshot of the control software**

It is to be underlined that the standard dimension chosen for the trays (310 x 530 mm) allows a different number of seedlings per $m^2$ (from 870/ $m^2$ to 3500/$m^2$ , depending on the dimension of the mini-pots), more details at:

<u>http://www.herkuplast.com/en/program/QuickPot/Danish.html</u> ;

***Further calculations in the following section will use the most common dimension of 209 pots per tray, equal to 1270 seedlings per $m^2$, as shown in the picture above***

[1] By considering an average cycle duration of 30 days, plus 2 days preliminary operations per cycle , plus 14 days of maintenance between different cycles, as explained in 2.2.1.3

#### 2.2.1.2 Energy saving

The energy saving is:50% by using LED lamps instead of ordinary/fluorescent lamps, AND

Further 70% by using the rotation system, allowing only 3 rows of lamps for10 rows of trays, instead of one lamp for each row, as usually adopted .

**Total energy saving 85%**

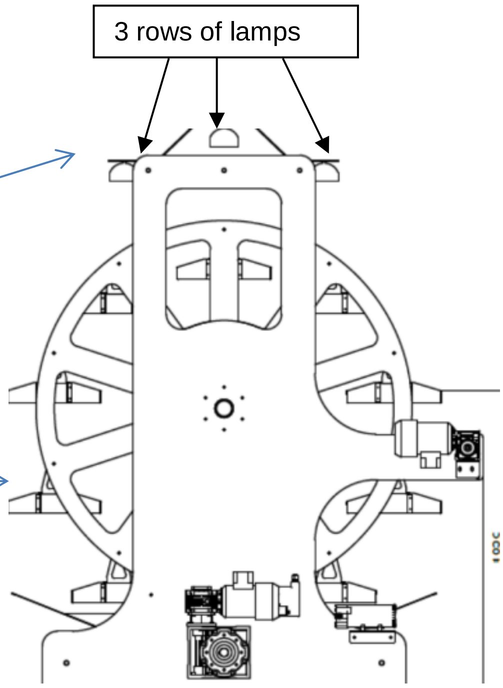
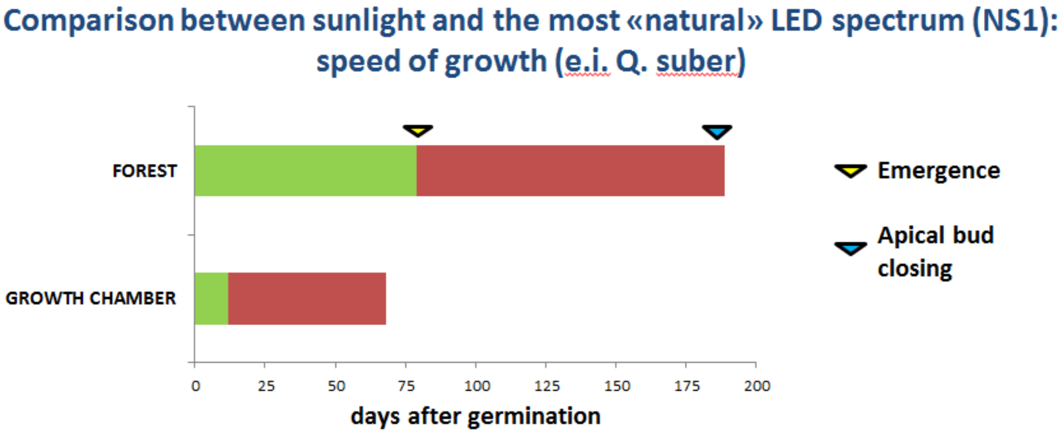



**Figure XIII – Led lamps and their position in the Zephyr unit**

#### 2.2.1.3 Time saving

LED lights strongly speed up phenological stages of seedlings, reducing the time for seedlings emergence and apical bud closing, with an **average time saving of 74%**




| | Forest | Growth chamber | Time reduction (%) |
|---|---|---|---|
| Days between germination and emergence | 79 | 12 | 84% |
| Days between germination and apical bud closing | 189 | 68 | 64% |

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**Figure XIV – Germination time reduction by using LED lamps**

This average time saving, jointly to the independence from the outdoor conditions allows the Zephyr unit to run up to 11 cycles per year, assuming an average cycle duration of 30 days, plus 2 days preliminary operations per cycle , plus 14 days of maintenance between several different cycles

#### 2.2.1.4 Water saving, given by recovery and re-use of the exceeding water

The Water Application Efficiency (WAE) of the Zephyr system is close to 100%, due to:

- Water stored in a closed tank below the rotating system, avoiding any evaporation or dispersion;
- Irrigation is made only when needed, according to the data provided by the sensors;
- Only during the irrigation time, the immersion tub is filled and each shelf is immerged for a pre-defined time; when the next shelf is immerged, the shape of the tub allows the recovering of the dripping water;
- At the end of the irrigation cycle, the water remaining in the tub is recovered and sent to the tank;
- The condensation water coming from the HVAC system is recovered, too.

Micro-irrigation of container crops involves the use of emitters that deliver water directly to containers using a low pressure irrigation system; the WAE Water application efficiency of micro-irrigation systems has been reported to range from 44% to 72%[2].

**Assuming a prudential value for the Zephyr system equal to 90% the water saving in term of increasing of WAE is between 46% and 18%, with an average of 32%**

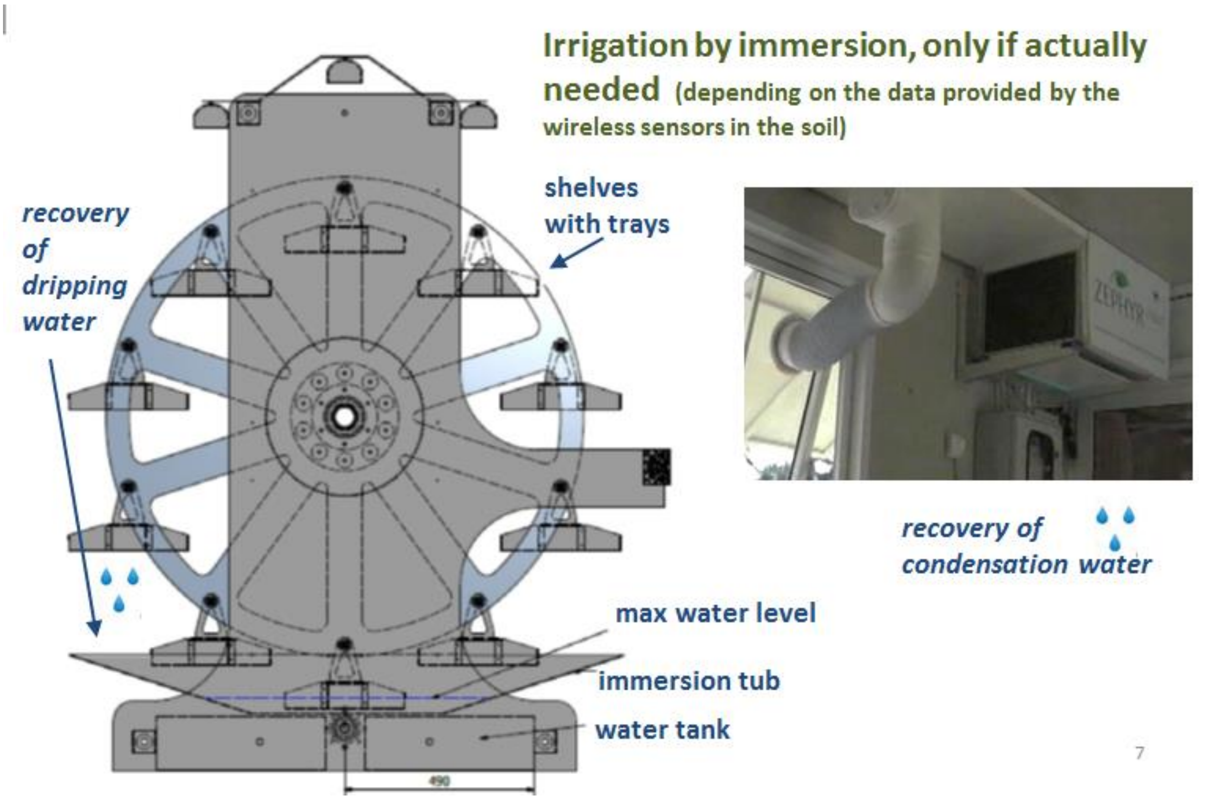
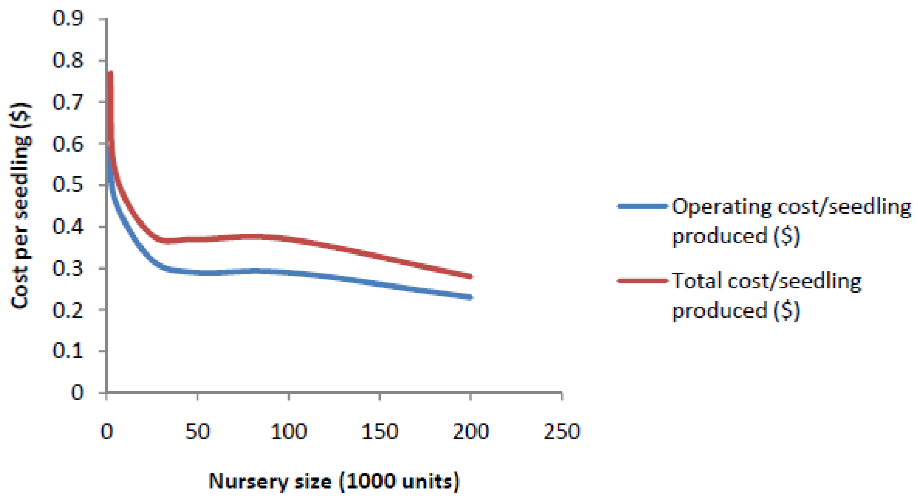



**Figure XV – Irrigation system and water recovery**

[2] *A. Franklin - Increasing Water Application Efficiency in Greenhouse Crop Production - 2013* *https://etd.ohiolink.edu/!etd.send_file?accession=osu1366376123&disposition=inline*

### 2.2.1.5 Comparison of operating costs

A 2011 study (Ref. [12]) demonstrated how operating costs in forest nursery vary with their size: they are very high for small nurseries and become approximately constant for nurseries producing 25,000 seedlings a year or more, up to 200.000.




Source: [12]

| Performance indicator | Nursery size (1000 seedlings per year) | | | | | |
|---|---|---|---|---|---|---|
| | 2 | 5 | 25 | 50 | 100 | 200 |
| Initial capital outlay ($) | 4144 | 4313 | 17136 | 41631 | 87501 | 123247 |
| NPV with no capital subsidy ($) | -5500 | -4510 | -1514 | -2829 | -17407 | 76949 |
| NPV with 100% capital subsidy ($) | -1356 | -197 | 15623 | 38802 | 70093 | 200196 |
| Breakeven capital subsidy (% of cap. outlay) | 133% | 105% | 9% | 7% | 20% | 0% |
| IRR with no capital subsidy (%) | Negative | Negative | 13.0% | 13.5% | 10.4% | 27.3% |
| Number of full-time labour equivalents (FLU) | 0.6 | 1.54 | 4.2 | 6.4 | 10.8 | 16.6 |
| Labour/capital ratio (% of present values) | 108.3% | 216.7% | 181.6% | 135.1% | 109.7% | 117.0% |
| Labour cost as share of annual operating cost (%) | 76.8% | 81.9% | 77.1% | 76.6% | 65.4% | 63.7% |
| Operating cost/seedling produced ($) | 0.59 | 0.46 | 0.32 | 0.29 | 0.29 | 0.23 |
| Total cost/seedling produced ($) | 0.77 | 0.53 | 0.38 | 0.37 | 0.37 | 0.28 |

The table above, coming from such a study, shows the principal indicators[3] for forest nurseries of different sizes, including the 50.000 seedlings/year one, highlighted in red.

**Since the Zephyr unit has the same yearly production capacity (20 trays with 209 seedlings/tray[4] x 11 yearly cycles = 45.980 seedlings per year) the indicators can be compared**

[3] US $ 2010

[4] As explained in the previous section 2.2.1.1

Annual production comparable with the Zephyr's one

| Capital outlays by nursery size | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nursery size (1000 seedlings/year) | 2 | 2 | 5 | 5 | 25 | 25 | 50 | 50 | 100 | 100 | 200 | 200 |
| | Size | Cost ($) | Size | Cost ($) | Size | Cost ($) | Size | Cost ($) | Size | Cost ($) | Size | Cost ($) |
| Nursery vehicle - one small truck | (m) | Not incl. | (m) | Not incl. | (m) | Not incl. | (m) | Not incl | (m) | 20000 | (m) | 20000 |
| land area ($m^2$) (cost of $8/$m^2$) | 100 | | 100 | | 1000 | | 3000 | | 4500 | | 6000 | |
| Nursery perimenter fence, 2 barb | 50 | 50 | 50 | 50 | 125 | 100 | 250 | 175 | 500 | 375 | 800 | 600 |
| Office, bunkhouse and storage area | Not incl. | | Not incl. | | 3.2 x 3.2 | 800 | 3.2 x 3.2 | 800 | 6.5 x 6.5 | 1250 | 6.5 x 6.5 | 1250 |
| Seed store, potting shed, fridge | 4 x 4 | 2091 | 4 x 4 | 2091 | 6 x 6 | 2500 | 10 x 10 | 4800 | 10 x 20 | 6000 | 20 x 20 | 7500 |
| Germination beds (concrete) and shed | 1 x 2.6 | 100 | 1.5 x 2.6 | 120 | 8 x 2.6 | 500 | 16 x 2.6 | 1000 | 32 x 2.6 | 2000 | 64 x 2.6 | 4000 |
| Transplant shed (encloses hardening beds) | 2 x 3.2 | 100 | 5 x 3.2 | 300 | 15 x 3.2 | 1300 | 30 x 3.2 | 2600 | 100 x 3.2 | 5200 | 200 x 3.2 | 10400 |
| Recovery chambers | 1 x 3.2 | 50 | 4 x 3.2 | 200 | 12 x 3.2 | 600 | 25 x 3.2 | 1200 | 50 x 3.2 | 2400 | 100 x 3.2 | 4800 |
| Hardening beds, steel with mesh screens | 2 x 3.2 | 110 | 5 x 3.2 | 275 | 25 x 3.2 | 1375 | 50 x 3.2 | 2750 | 100 x 3.2 | 5500 | 200 x 3.2 | 11000 |
| Cement blocks for hardening beds, @ $5 | | 40 | | 100 | | 200 | | 400 | | 800 | | 1600 |
| Water supply and hoses ($) | | 50 | | 50 | | 250 | | 1500 | | 2000 | | 2500 |
| Hand or knapsack sprayer, @ $5 or $30 | | 5 | | 5 | | 90 | | 150 | | 300 | | 300 |
| Shovels @ $7 ($) | | 7 | | 14 | | 28 | | 28 | | 42 | | 70 |
| Sterilizing pans, @ $15 ($) | | 15 | | 15 | | 30 | | 45 | | 60 | | 90 |
| Allowance for working capital (% of capital outlays) | | | | | | | | 2% | | 2% | | 2% |
| Nursery staff training duration, first year (days) | | 2 | | 2 | | 4 | | 6 | | 10 | | 15 |
| Nursery staff training duration, second year (days) | | 1 | | 1 | | 2 | | 2 | | 2 | | 4 |

Source: [12]

The first datum to be considered is the need of land, estimated in 3000 $m^2$ that gives a first rough indication for the industrial implementation plan:

***1) If the cost of the unit is comparable with the cost of 3000 $m^2$ of land in the area of the customer, all the other competitive advantages will be achieved at a lower cost, given by the avoidance of the operations linked with the land (fences, etc.)***

The first table coming from [12] shows labour costs accounting for 76,6% of the annual operating costs: such a labour is estimated as 6 full time staff[5];

Since cultivation tests occurred during the Zephyr project shown a need of max. 2 full time staff, meaning one third of the ordinary cultivation

Assuming the same amount of the remaining operating costs the difference is given by the difference between:

| |
|---|
| Operating costs in an ordinary nursery: 76,6 % labour costs + 23,4% other costs =100% |
| and |
| Zephyr operating costs = 1/3 x 76.6% + 23,4% = 49% → **51% saving in operating costs** |

| |
|---|
| Since the operating costs accounts for 0,29/0,37 = 78% of the total costs, the above saving implies a reduction of the total costs equal to 0,51 x 0,78 = **39% saving in total production costs** |

The business model in [12] assumes a margin (difference between total production cost and selling price) of 5%: since the study is done in US $ in 2010, a more recent indicator is given by [13], showing the 2015 price list of forest seedling of a public nursery owned by the government of Lombardia region (Italy): forest seedlings in plastic container with a height between 20 and 50 cm; are sold at € 1.20 each.

Since the max height of the seedlings produced by the Zephyr unit is 25 cm., we assume a selling price of €1,00. The 5% margin in an "ordinary" production means a production cost of 95 cents.

The reduction of the production costs by using the Zephyr unit is 0,39 x 95 = 37 cents, so the production costs become 58 cents and the theoretical margin is 42 cents

Assuming a prudential value of the new margin equal to 35 cents, a pay-back period of the Zephyr unit of 5 years and a prudential production of 175.000 seedlings during such a period (average production of 35.000 seedlings/year), we have:

| |
|---|
| **2) 175.000 x 0,35 = €61.250 that indicates the max selling price of the Zephyr unit in the specific case of a Nursery wiling to increase his production up to 50.000 seedlings per year.** |

The above cost is just a second rough indication for the industrial implementation plan and does not consider all the advanced actuators (robotic arm, stereo camera, wireless sensors, placed in the prototype developed by the project. Their value has to be considered in a separate discussion.

#### *2.2.1.6 Second level customers (end users)*

We see in [12] that in nurseries producing up to 200.000 seedlings per year, energy and water costs are not considered (placed in general costs), being very low[6] respect to the main costs; costs of fertilizers and pesticides are marginal, too.

These advantages should be therefore treated as an "added value" towards the **second level customers** (forest managers, small nurseries, urban planners and landscapers), being the environmental sensibility a focal point also in marketing operations.

[5] Ref [12] Attachment 16-A, page 149

[6] Only in particular areas with water scarcity, this aspect can have an economic value

However, from the point of view of these “end users”, the quality of the seedlings should be expressed in their “resistance” after the final transplantation: several growth have demonstrated the clear advantage of using specific LED lamps are shown in the following picture and the details can be found on the specific deliverables of the Zephyr project.


**Figure XVI – Comparison between growth test with LED lamps (left) and fluorescent tubes (right)**

The relevant further advantage of coupling the use of LED Lamps with the use of mini-plugs (like in the Zephyr system) is shown by the presentation of Prof. K. Radoglou at the Zephyr final conference[7].


**Figure XVII – Presentation of Prof. K. Radoglou**

7 available at http://www.zephyr-project.eu/sites/default/files/conference/8%20Radoglou%20-%20Expo-2015%20voice.pdf

In very large productions (up to dozens millions seedlings per year) like in North European countries the importance of the energy costs assumes a noticeable importance and will be taken into consideration in the industrial implementation plan (deliverable D7.7)

#### *2.2.1.7 Preliminary conclusions*

- There are noticeable advantages of the Zephyr system respect to the ordinary greenhouses, mainly given by the reduction of both surface and operating costs, as well as a better final product
- Water and energy saving, as well as the avoidance of fertilizers and pesticides do not seem to have relevance in small-medium nurseries[8], while assume importance in large production in northern countries. Such advantages are in any case a good "market asset" for the new product.
- The results of the above analyses gave two rough indicators about the "price to market" of a "basic" Zephyr unit, without the advanced actuators developed by the project; such a price should be however adequately investigated during the industrialization phase, in order to reach a wide range of potential customers: from small medium nurseries to the largest ones.
- The flexibility of the system, allowing several units working in parallel is another asset of the system; however the optimal dimension of the unit, as well as the production of models having different production capacities has to be analysed in the scaling up phase
- The advantages of the mobile system have not been taken into consideration yet, because the prototype was built to be shown at different international fairs after the end of the project

**The above issues will be discussed in the Deliverable D7.7 "Industrial Implementation Plan"**

[8] Excluding those areas with water scarcity

### 2.2.2 Production of forest plantlets, compared with current growth chambers in research centres

The Zephyr unit has been conceived for a bulk production of forest plantlets, while plant growth chambers currently on the market are produced in many places around the world and come in a variety of standard sizes.

The "ordinary" models have the control of light, temperature, humidity; and sometimes CO2; specific sophisticated models for researchers are produced by only a dozen of companies in Europe, USA and Canada, with system features like Nutrient injection, sampling, and control; Photosynthesis and respiration measurement; Real-time pH measurement and control, Transpiration rate measurement, Leaf/canopy temperature measurement and control, etc.

In this case the competitive advantage of the Zephyr system is given by the uniformity of the average conditions, as already explained in the previous section 2.1, the better quality of the plantlets obtained (thanks to the specific spectra and the related growth protocols) and the less energy needed per surface/volume unit.

In facts the overall daily energy needed by the Zephyr system is, according to the loads

Table of Loads (AC)

| Main Loads | Unit Power (W) | Quantity | Total Power (W) | Average daily hours of usage (h) | Daily Energy (Wh) |
|---|---|---|---|---|---|
| LED Lamps | 165 | 3 | 495 | 16 | 7920 |
| HVAC System | 800 | 1 | 800 | 24 | 19200 |
| Motor (rotation) | 170 | 1 | 170 | 24 | 4080 |
| Motor (X-axis) | 170 | 1 | 170 | 1.5 | 255 |
| Irrigation System | 60 | 1 | 60 | 1 | 60 |
| Additional Loads | 150 | 1 | 150 | 12 | 1800 |
| Control System | 60 | 1 | 60 | 24 | 1440 |
| Total | | | 1905 | | 34755 |

Table of Loads (DC)

| Main Loads | Unit Power (W) | Quantity | Total Power (W) | Average daily hours of usage (h) | Daily Energy (Wh) |
|---|---|---|---|---|---|
| Robotic Arm | 40 | 1 | 40 | 1.5 | 60 |
| Total | | | 40 | | 60 |

table, 34.775+60 = 34.835 W x hour, meaning an average of 34.835/24 of 1.451 Watt

Such a power is related to a total plantlets surface of 3,29 square meters, according to the data reported in the previous section *2.2.1.1* and a total volume of 2,00 x 1,70 x 2,00 =6,8 cubic meters. The power needed for $m^2$ of plantlets or $m^3$ of volume is therefore:

1451/3.29 = **441W per 1 square meter of plantlets**, and

1451/6.8 = **213 W per 1 cubic meter of growth chamber**

In the following pages there is a comparison with some growth chambers currently on the market[9], with emphasis on the ratio Power/Volume

[9] *data have been kept the same also for comparisons with growth chambers without complex actuators like the Zephyr ones*

Producer: **BINDER** www.binder-world.com **Model KBWF 720**

Dimension 1250x1925x890 mm Surface and volume: Interior volume 720 litres

| Consumption / power: Nominal power 3500 W **Ratio 4861 Watt/m$^3$ (Zephyr 213)** |
|---|

LED □ NO Lamp 10 FLUORA®

Description:
Plant biotechnology, agriculture Industrial, Chemical and Pharmaceutical, Basic Research,

---

Producer: **Photon** http://psi.cz **Model: Reach-In FytoScope FS-SI 3400**

Internal dimension: 130 x 110 x 210 cm (W x D x H) Inside capacity: 3000 l

| Consumption / power: Power:6500 W **Ratio 2166 Watt/m$^3$ (Zephyr 213)** |
|---|


LED ☒YES

**Step-in FytoScopes FS-SI** are plant growth chambers that utilize Light Emitting Diodes (LEDs) as a sole light source. Thus excellent spectral quality with high irradiance is provided for plant physiology applications. Due to versatile construction, these FytoScopes may be used for growing of diverse plants:.

Producer: **Qubitsystems** http://qubitsystems.com/category/product_list/cultivators-growth-chambers

Model Z130 Fytoscope Chamber

Dimension, Surface and volume: volume FS130 version – Outside dimensions: 100 x 55 x 62 cm (H x W x D). FS130 version inside dimensions: 69 x 42 x 40 cm (H x W x D).

**Volume 124 l; Consumption / power: n/a**

LED ☒ YES Offered are two standard colour versions: WIR (white + infra-red LEDs), RGBIR (red + green + blue + infra-red LEDs).

Description: High irradiance – 1500 µmol(photons)/m².s, optional 2000 µmol(photons)/m².s.Rapid modulation of irradiance simulating light flecks as well as precise adjustment of the light intensity in the range of 1 % to 100 %.other colours LEDs available 9inlcuding UVA as an option. Independently programmable light composition and dynamics in UVA, VIS and near IR.

---

Producer: **Conviron** www.conviron.com Model A 1000
Dimension: n/a
Surface and volume: Internal Capacity 35ft3 (1000l)
Consumption / power : Electrical Service 120-1Ø-60Hz (220/240-1Ø-50Hz) **No power declared**
LED ☐NO

Description : With its unique ability to adapt to four different research applications, the Adaptis A1000 offers an economical and flexible equipment platform. The base chamber itself can be fitted with one of four specially configured kits, and each kit is specifically designed for a particular application including: Plant Growth, Arabidopsis, Tissue Culture, and Incubation. By varying the configuration of the airflow, light, and shelving, each kit defines one of the four applications. The A1000 is also available with several options such as phenolic coated coils and network communication. The phenolic coated coils enable the A1000 to be used for entomology research while the communications option facilitates connection to a facility's local area network

Producer: **Percival** www.percival-scientific.com **Model LED 41L2**

Interior Space Volume: 37.2 ft3 (1.1 m3)

Total Shelving Floor Area: 10.8 ft2 (1.0 m2)

Maximum Growing Height: 20.6 in. (52.4 cm)

Exterior Dimensions: inches(cm) Height: 77.2 (196.1)

Width: 41.0 (104.1)

Depth: 33.6 (85.4)

LED ☒YES

**Consumption / power: Not declared**

LED Series - Designed to set the standard for plant growth, the Percival LED Series offers research chambers that allow for specific control over the one research variable that has eluded precision – light!

---

Producer: **Weiss Technik UK** http://weiss-uk.com /

**Model SGC 120 LED Light Production Chamber**

Interior dimensions (w x d x h)

1310mm x 675mm x 1410mm

Exterior dimensions (w x d x h)

1440mm x 810mm x 1975mm

Surface and volume: 1200 litres

**Consumption / power: Not declared**

LED ☒YES

- LED temperature range:

-2°C to +35°C (lights off)

+5°C to +35°C (lights on)

- Temperature stability of ±0.3°C
- Two illuminated LED production shelves with Philips LED lighting
- Production area of 1.36m$^2$
- 3.5" colour touch panel
- S!MPAC 32-bit control and monitoring system
- 1200 litre capacity
- User-settable high/low temperature alarms with remote contact
- Audible and visual alarm indicators
- USB and Ethernet interfaces
- Lockable door and castors
- Corrosion-resistant stainless steel chamber interior
- Chamber manufactured in the United Kingdom

Producer : **Panasonic** www.panasonic-biomedical.co.uk

**Model MLR-352-PE Plant Growth Chamber**

Dimension : Internal 520 x 490 x 1135 (mm) / 20.5 x 19.3 x 44.7 (inch

Surface and volume: Plant Growth Chamber capacity 294Liters

Consumption / power: 230V, 50Hz (CE) heater 334 W , compressor 250 W

Assuming the only consumption of the compressor (no data available regarding the fluorescent lamps, there is a ratio of 250W/0,294M$^3$ meaning **850W/ M$^3$** **(Zephyr 213**)

LED ☐NO

Description: Panasonic Plant Growth Cabinets / Plant Growth Chambers / Plant Growth Incubators provided a wide variety of temperatures and lighting patterns that are essential for plant growth research. Plant Growth Chamber environmental conditions can be accurately reproduced and controlled with the new MLR-352 . If your plant growth requires optional humidity control then the MLR-352H Plant Growth Chamber is the model to choose.

### *2.2.2.1 Preliminary conclusions*

The energy consumption of the Zephyr unit per space unit is very low (up to twenty times!!) respect to the models on the market; however, this parameter does not seem to be interesting to the customers (mainly universities and research centres) and several producers do not show it in their product data sheets, clearly not considering it as an asset.

The cost of the above described growth chambers is not public and is subjected to negotiation with the local re-sellers: it may vary from €10.000 to more than €70.000, depending on the models and add-ons

For this kind of market, the "appeal" of the Zephyr unit are:

- actual uniformity of the average growth conditions
- possibility of adding several high-tech actuators for a complete automatic growth cycle, fully monitored and controlled by remote[10]
- automated greenness analysis
- high production capacity

For this specific market sector, every client may have different specific needs and any unit is expected to be actually "customized", so the indication for the industrial implementation is:

3) the "basic" unit should be designed and built in a way that allows an easy addition of one or more actuators, either in construction phase, or after the machine has been sold.

However, *this specific market has already several incumbent players* and the launch of the new technology should be accompanied by a relevant marketing action.

[10] This option, together with the greennes analysis one, is of course available also for forest nurseries

# 3. Purpose of the product and services

On the basis of the results shown by the previous analyses, it is clear that the actual promising market for the zephyr unit is related to a bulk production of forest plantlets: a smaller unit for research purposes may be produced for those customers interested in uniform growth conditions and High-Tech actuators.

The bulk production sector should be divided in two parts having different customers that are conventionally divided in first level and second level ones:

1) Product: innovative growth chamber – **first level customers:**[11]
2) Service: seedlings production **– second level customers**

The **product** competitive advantages are, as explained in section 2.1,

- Surface saving 495%
- Energy saving 85%
- Time saving 74%
- No pesticides or fertilizers needed
- Water saving given by recovery and re-use of the exceeding water
- Scalability: several units can work jointly, so the Zephyr system can be adapted to a small nursery up to a large one
- Flexibility: the growth system can be composed by a simple rotating unit up to a fully robotized one, according to the needs of the different customers.

The competitive advantages of the **services** are:

- Better plantlets, with stronger roots and higher survival rate after trans-plantation on site
- Growth and delivery of the plantlets independently from the season and the outdoor conditions

Even though significant progresses have been done in certain European forest nurseries, it is well recognised that the standard of European production technology regarding all types of forest regeneration materials has still to be elevated. First, this is necessary for the implementation of EU forest policy, aimed at supporting and further developing the principles of sustainable forest management, and re-vegetating and expanding the forest area for production, environmental, socio-cultural reasons.

The cost and environmental benefits of the Zephyr system will open a substantial market for pre-grown forest regeneration materials in Europe and the rest of the world. Besides the benefits for local nurseries when using pre-grown forest regeneration materials, the proposed technology will also be beneficial for the end-users. Due to the improved cost efficiency and quality in the production, private landowners and forest companies will make financial gains when using these materials. Since environmental issues are more and more discussed in forest operations the new technology will also give the end users, using pre-grown regeneration materials, a better image compared to landowners using conventional planting stock.

**In conclusion, the current market of the forest seedlings need to be analysed in order to understand how the Zephyr technology can be successfully introduced and exploited. The following chapter is fully dedicated to such analysis.**

[11] In this section Research centers are not considered as potential customers

# 4. Market analysis

## 4.1 Method and sources

The data search has been conducted in the following way:

- a specific task assigned to the project partner AZORINA, who delivered a report attached as an appendix to this deliverable.
- analysis the major sources of information, listed from 1 to 10 in the section 1.1 “Reference documents”, together with the internet link to the full document;
- by buying documents from a market data reseller;

The *“UNECE - FAO: State of Europe's Forests 2011 Report-Status & Trends in Sustainable Forest Management in Europe*” (ref [1]) gives a very good general overview of the forest sectors and relative trends: endangered species, medicinal plants and valuable species. This report also shows trends in natural regeneration methods that, even if increasing respect to the plantation ones in central Europe, still has a relevant area of potential interest for the Zephyr technology. Data has been integrated and crossed with other sources (namely ref. 2,3,4,5,and 9) to confirm and/or correct some information.

Proceedings of "*Foresight on Future Demand for Forest-based Products and Services: Setting the Scene - Vienna/Austria 07 - 08 September 2010"* (ref [6]) shows that plantation and urban forests and green cities are increasing trends in the 2030 scenario, while the monocultural plantation and biodiversity hotspots are prevalent in the 2050 scenario. all the above mentioned items are relevant for the potential market of the Zephyr technology

The EFI (European Forest Institute) “*Technical Report 94- 2014 - Guide to Economic Appraisal of Forestry Investments and Programmes in Europe”* (ref.[8]) confirms the increasing importance of the green infrastructures in the next future

All the above mentioned sources clearly indicate a lack of data, both in quantity and quality: this is confirmed also by EFI technical report n° 93/2014 (ref.[7]) and from the recent search done by the European Forest Nursery Association (EFNA)

Data bought from data resellers were almost useless: despite appealing titles such as the ones shown in the following screenshot, the reports were only composed by a series of documents issued by the European Commission , European Parliament and other institutions dealing with policy issues , but without any relevant figure.

www.reportlinker.com/ci02005/Forestry-Plantation.html/since/2014

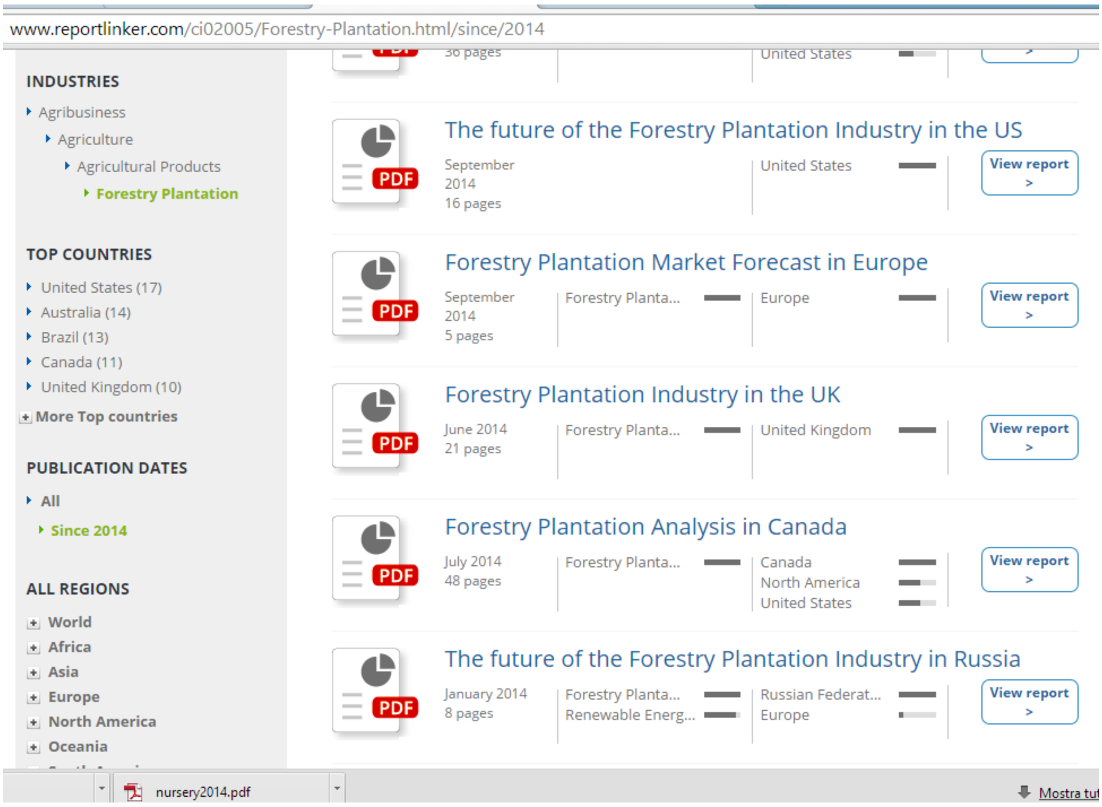


**Figure XVIII – Screenshot of the data reseller web page**

The Zephyr internal report provided by the project partner Azorina underlined again the lack of data and made an rough estimation of the value of plantlets sold in 2012 around 500 Euro million.

The Presentation given at the Zephyr final conference by the Secretary of the European Forest Nursery Association (EFNA), shows an estimation of the missing data and assumes an overall EU nursery production of 2,8 billion seedlings..

## 4.2 Data and analysis

The following sections maintain the original numbering of tables, graphs and schemes, in order to facilitate their reference to the source documents.

### 4.2.1 General data

The following figures show the forest area and share by country and region (source [1])

Figure 1: Forest area (million ha) and share (percent) of land area by country, 2010

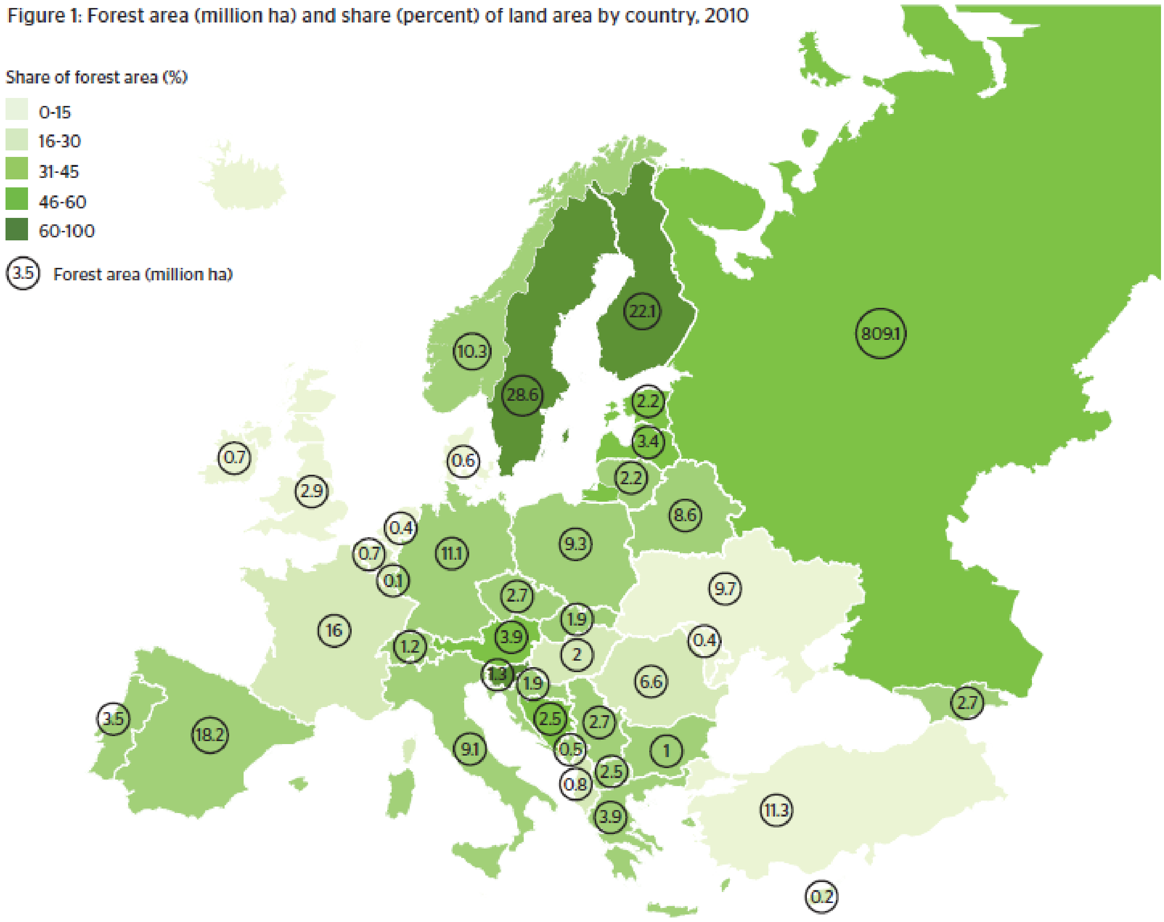
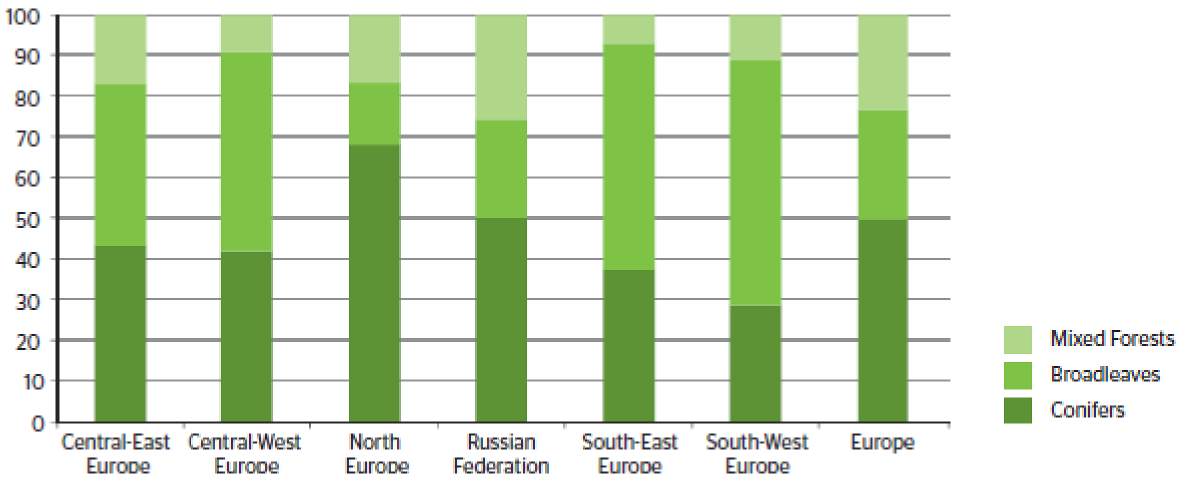



Figure 2: Proportion of forest area by forest composition, by region, 2010 (percent)




The annual rate of change and the overall damage trends give a first rough idea of the potential market related to reforestation activities (source [1])

Figure 4: Annual rate of change in forest area by region, 1990-2010 (percent of forest area/year)

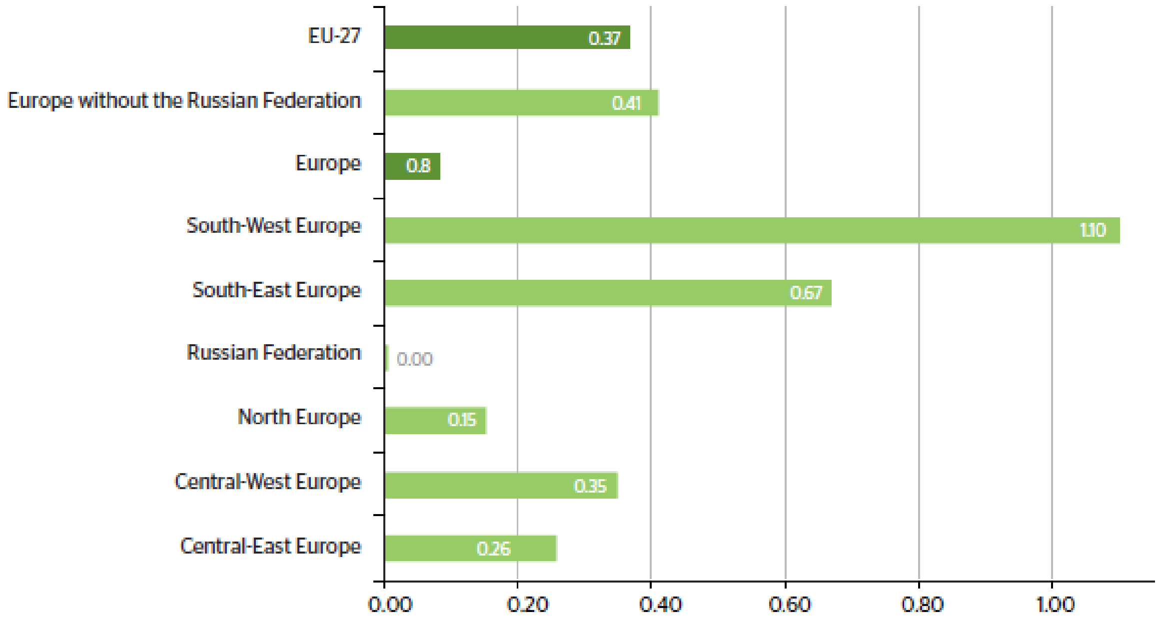



Table 14: Overall forest damage trends 1990-2005 (1000 ha)

| | | Insects & disease | | | Wildlife & grazing | | | Storm, wind & snow | | | Fires | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Country | 1990 | 2000 | 2005 | 1990 | 2000 | 2005 | 1990 | 2000 | 2005 | 1990 | 2000 | 2005 |
| Europe | Forest area with damage (million ha) | 5.2 | 10.3 | 7.9 | 1.0 | 1.0 | 2.4 | 1.2 | 2.4 | 4.0 | 1.0 | 1.5 | 1.4 |
| | Represented forest area (million ha) | 928.1 | 968.4 | 968.9 | 93.7 | 107.8 | 127.0 | 944.8 | 978.9 | 985.8 | 987.4 | 1 019.4 | 979.1 |
| | Represented forest area (%) | 91.0 | 94.9 | 95.0 | 9.2 | 10.6 | 12.5 | 92.6 | 96.0 | 96.7 | 96.8 | 99.9 | 96.0 |
| | Forest area with damage (%) | 0.6 | 1.1 | 0.8 | 1.1 | 0.9 | 1.9 | 0.1 | 0.2 | 0.4 | 0.1 | 0.2 | 0.1 |
| Europe without the Russian Federation | Forest area with damage (million ha) | 3.4 | 4.4 | 5.1 | 1.0 | 1.0 | 2.4 | 1.0 | 1.9 | 2.6 | 0.3 | 0.3 | 0.3 |
| | Represented forest area (million ha) | 119.0 | 159.3 | 159.9 | 93.7 | 107.8 | 127.0 | 135.7 | 169.9 | 176.7 | 178.3 | 210.3 | 170.0 |
| | Represented forest area (%) | 56.4 | 75.6 | 75.8 | 44.5 | 51.1 | 60.2 | 64.3 | 80.6 | 83.8 | 84.6 | 99.8 | 80.6 |
| | Forest area with damage (%) | 2.8 | 2.8 | 3.2 | 1.1 | 0.9 | 1.9 | 0.8 | 1.1 | 1.5 | 0.2 | 0.1 | 0.2 |

The following table shows in particular (fifth column) the value of resins, medicinal and aromatic plants in Europe (without Russian Federation): 16,6 million Euro (source [1])

Table 23: Quantity and value of marketed NWGs: marketed plant products

| Region | Christmas trees | | Mushrooms and truffles | | Fruits, berries and edible nuts | | Cork | | Resins, raw material - medicine, aromatic products, colorants, dyes | | Decorative foliage, incl. ornamental plants (mosses,...) | | Other plant products |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Quantity | Value | Quantity | Value | Quantity | Value | Quantity | Value | Quantity | Value | Quantity | Value | Value |
| | 1 000 pcs | 1 000 € | tonnes | 1 000 € | tonnes | 1 000 € | tonnes | 1 000 € | tonnes | 1 000 € | tonnes | 1 000 € | 1 000 € |
| Russian Federation | 6 | 4 | 9 332 | 21 006 | 49 053 | 105 501 | - | - | 5 059 | 7 861 | - | 2 240 | 3 |
| North Europe | 17 162 | 132 104 | 4 428 | 12 493 | 52 231 | 15 107 | - | - | 882 | 182 | 400 | 58 824 | - |
| Central-West Europe | 38 850 | 733 900 | 732 | 14 550 | 239 | 883 | 1 550 | 775 | 145 | 32 | 1 581 | 7 202 | 55231 |
| Central-East Europe | 1542 | 2 830 | 29 935 | 10 587 | 61 362 | 28 132 | - | - | 957 | 1 621 | 350 | 1 802 | 106 |
| South-West Europe | - | 110 828 | 366 873 | 124 161 | 208 236 | 299 574 | 167 665 | 323 850 | 7 351 | 2 364 | - | - | 7997 |
| South-East Europe | 631 | 377 | 17 398 | 11 283 | 5 056 | 10 296 | - | - | 17 368 | 12 476 | 37 | 921 | 408 |
| Europe | 58 193 | 980 043 | 428 699 | 194 081 | 376 178 | 459 494 | 169 215 | 324 625 | 31 762 | 24 536 | 2 368 | 70 989 | 63745 |
| Europe without the Russian Federation | 58 187 | 980 039 | 419 367 | 173 075 | 327 125 | 353 993 | 169 215 | 324 625 | 26 703 | 16 675 | 2 368 | 68 749 | 63742 |

### 4.2.2 Regeneration Trends 1990–2010

(source [1])

*Thirty-three European countries have provided the complete data set on regeneration for 1990, 2000, 2005 and 2010. A comparison between 1990 and 2010 in all of Europe, excluding the Russian Federation, indicates that the forest area regenerated by both main regeneration types has increased: natural regeneration and expansion (4 million hectares), and regeneration by planting and seeding (6 million hectares).*

*No clear difference in trends between these two regeneration types can be distinguished, but these trends seem to be connected to the increase in new forest area in Europe between 1990 and 2010.*

*A detailed analysis by European regions and countries shows that natural regeneration and natural expansion as regeneration types have increased in all regions except North Europe. In Sweden and Finland the shares of natural regeneration and planting/seeding have remained nearly stable during the last 20 years.*

*From the annual regeneration methods it can be assumed that natural regeneration has increased in Central-East Europe, whereas in South-East and South-West Europe the natural expansion shows an increased trend during the last 20 years.*

The forest regeneration in Europe (without Russian Federation) is made through afforestation and reforestation for the 31% of the surface (source [1])

Table 25: Share (percent and 1 000 hectares) of forest area (uneven-aged and even-aged) by regeneration types, European regions, 2010

| Region | Natural regeneration and natural expansion | | Afforestation and regeneration by planting and seeding | | Coppice | |
|---|---|---|---|---|---|---|
| | 1 000 hectares | Percent of forest area | 1 000 hectares | Percent of forest area | 1 000 hectares | Percent of forest area |
| Russian Federation | 792 099 | 98 | 16 991 | 2 | n.s. | n.s. |
| North Europe | 48 912 | 71 | 20 358 | 29 | 1 | n.s. |
| Central-West Europe | 19 623 | 57 | 12 594 | 37 | 2 001 | 6 |
| Central-East Europe | 21 291 | 54 | 17 972 | 46 | 23 | n.s. |
| South-West Europe | 11 135 | 88 | 1 470 | 12 | 777 | 6 |
| South-East Europe | 23 578 | 80 | 5 887 | 20 | 77 | n.s. |
| Europe | 916 639 | 92 | 75 272 | 8 | 2 879 | n.s. |
| Europe without the Russian Federation | 124 539 | 67 | 58 281 | 31 | 2 879 | 2 |
| EU-27 | 84 803 | 64 | 44 851 | 34 | 2 848 | 2 |

The table below shows the details per country of the previous global figures and therefore the most interesting countries for the Zephyr market  (source [1])

Figure 42: Share (percent) of forest area (even-aged and uneven-aged) by regeneration types for countries in Europe, 2010

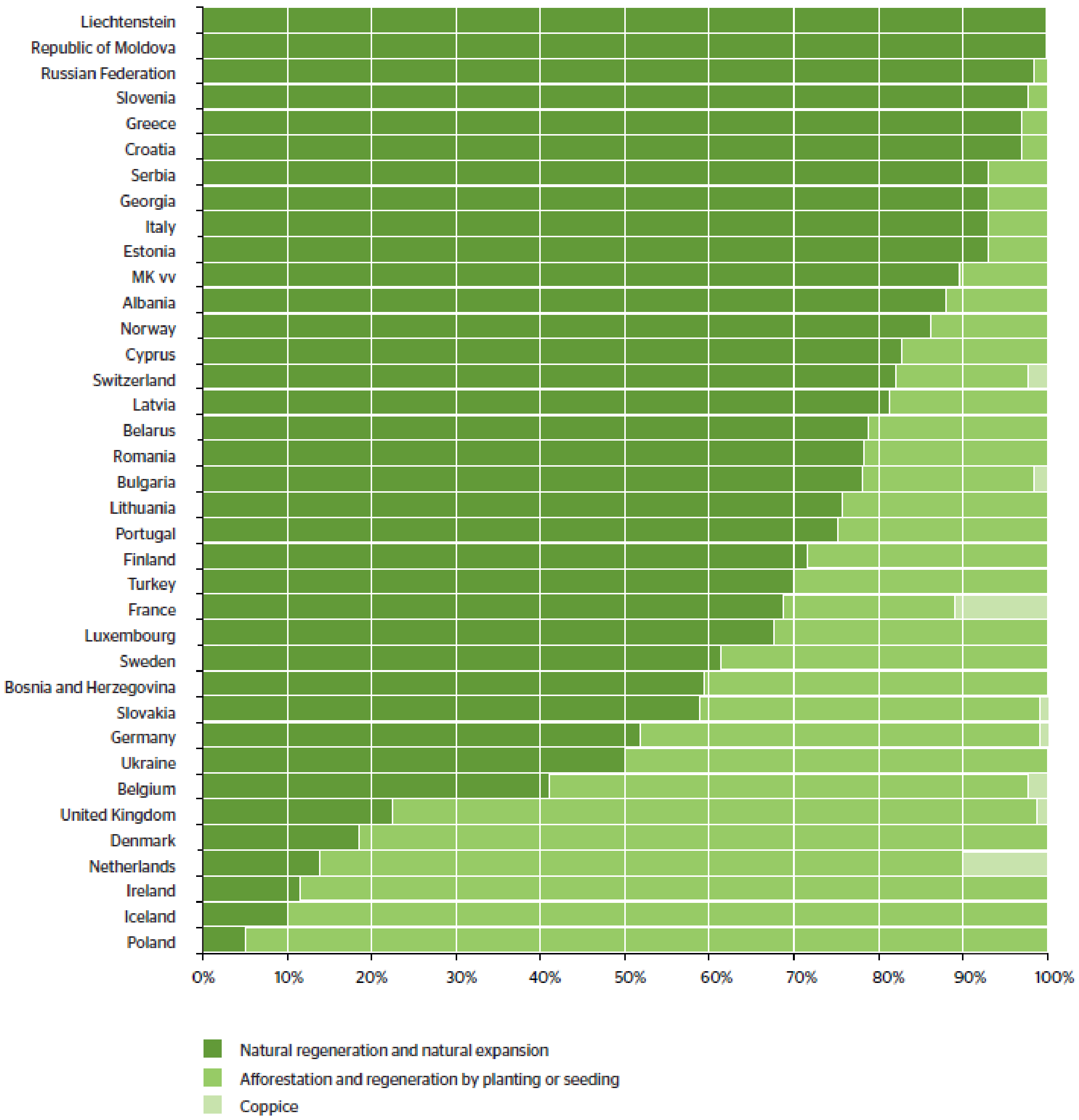


Figure 43: Share (percent) of annual afforestation, natural expansion, natural regeneration, planting and coppice from the total area regenerated in 2005 in European regions and the Russian Federation

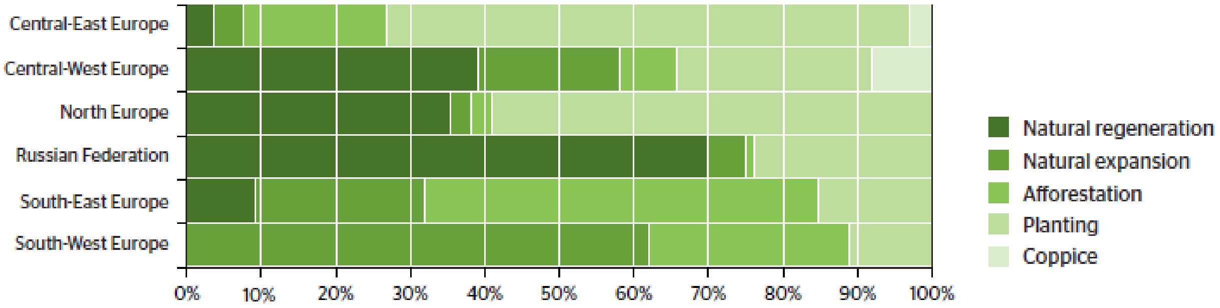
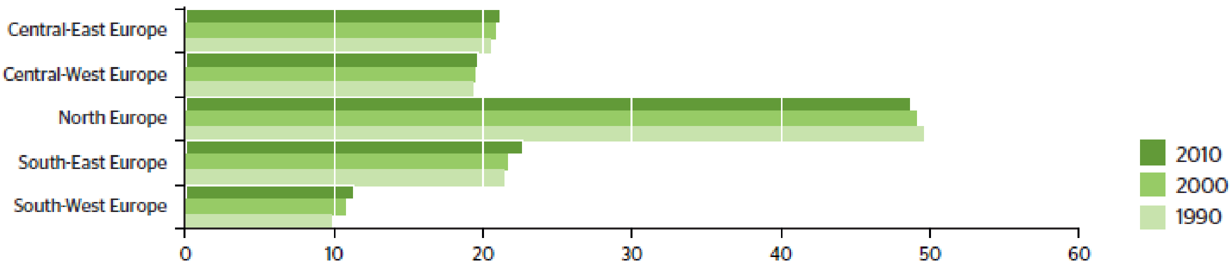



Figure 44: Natural regeneration and natural expansion of forest area (million hectares) in European regions for 1990, 2000 and 2010




### 4.2.3 Status of endangered tree species

This section deals with another potential market sector for the Zephyr technology

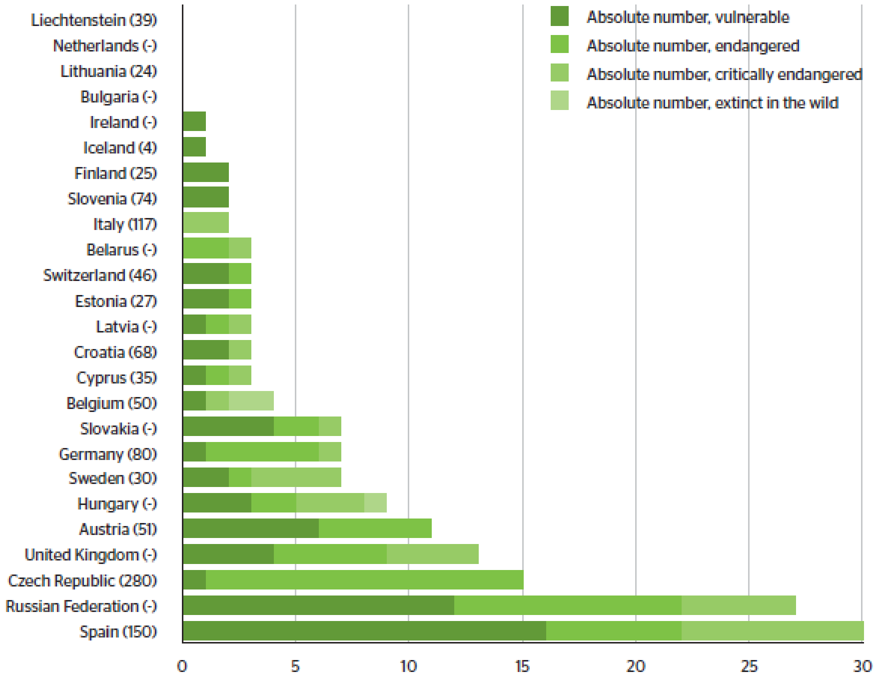
(source [1]) *Five countries (Austria, Czech Republic, Russian Federation, Spain and United Kingdom) reported more than 10 forest-occurring tree species as endangered. The largest number of threatened tree species is found in the Russian Federation (27) and Spain (30).*

*Four countries have indicated that there are no threatened tree species. On average, with some exceptions, the share of threatened tree species of the total forest-occurring tree species ranges in reporting countries from 5 to 10 percent (Figure 59 in the following page).*

*Sweden reported that, for the first time, two widespread tree species, Fraxinus excelsior and Ulmus glabra, are categorized as threatened. Their steep decline was caused by the Ash dieback and the Dutch elm disease, respectively. In total, three tree species have been reported as extinct in the wild, two in Belgium and one in Hungary*

*An overview of the distribution of forest tree species which were classified under the IUCN Red List categories shows that about 40 percent of threatened tree species are assorted as vulnerable, 36 percent are considered endangered, and 20 percent are considered critically endangered. This includes trees growing at the limits of their potential range. Economically important and abundant tree species for wood production are not found amongst threatened tree species.*

Figure 59: Number of threatened forest tree species, classified according to IUCN Red List categories, 2010. Note: The number in brackets after the country name indicates the total number of forest tree species reported by countries




### 4.2.4 Foresight demand for forest-based products and services

The following scheme resumes the conclusions of the workshop "Foresight on Future Demand for Forest-based Products and Services: Setting the Scene3 - Vienna/Austria 07 - 08 September 2010 (source [6])

**Internal development**

**2030**

- Plantations/short-rotation forestry/agroforestry
- Urban forests/Green cities & Green architecture
- Decreasing availability of large-size timber
- Decreasing role of wood production globally
- Regional diversification of forestry – increase in Nordic/Boreal/Russia areas, decrease in CEE
- Regionalisation/localisation and specialisation in wood processing: high-quality products in EU, mass production elsewhere
- Systems in systems (more integrated industries)
- Recycling & better use of waste (refinery)
- Fibers for durability, wood for luxury
- Forest as a commodity

**2050**

- Segregation of forests: monocultural plantations, biodiversity hotspots
- Efficiency: GMO
- Optimal use of resources based on their value
- Utilization of fibers
- Increasing price of real estates

### 4.2.5 Ecosystem Services of Green Infrastructure

From the EFI technical report 94-2014 - (source [8])

*In recent years, research has examined the role of green infrastructure in providing ecosystem services. Green infrastructure is defined as the greenspaces that exist within and between urban areas.*

*Green infrastructure can affect wide-ranging economic, social and environmental factors, including economic growth and investment, land and property values, labour productivity, health and wellbeing, tourism and leisure quality of place, land and biodiversity, flood alleviation, water quality, and climate change adaptation and mitigation. The quality of the green infrastructure will determine the value of these services.*

### 4.2.6 Government expenditure on forest services

*Data coverage and data quality* (source [1])

*In total, 176 figures were provided for this indicator out of a possible total of 736, so **countries were able to provide just under one-quarter (24 percent) of the detailed information requested**. Out of the 46 European countries, four provided this information for all types of service and all four years, another six provided information for all types of service for some of the years (usually the more recent years) and another 21 countries provided partial information. A summary of the responses to this part of the enquiry is given in Table 43 below. In general, there were three main deficiencies in the data:*

- *very few countries provided any information for the year 1990;*
- *many countries provided information for some (but not all) services in any given year; and*
- *15 countries did not supply any information at all.*

*The second problem above was the most important. Excluding countries in such cases would reduce the response rate significantly. Therefore, to take advantage of the large amount of partial data provided, countries were included in the analysis even if they did not include data for all four types of forest service in any given year.*

*Status* (source [1])

*The current status of government expenditure on forest services in Europe is given in Table 44 in the next page. The countries that provided this data reported total expenditure of EUR 3.2 billion, with expenditure of about EUR 2.5 billion in the EU and EUR 0.7 billion in the Russian Federation. Expenditure at the regional level cannot really be interpreted because of the very small number of countries reporting information in each region.*

*However, looking at the expenditure per hectare, the data broadly reflect the different levels of wealth across Europe, showing that this is an important factor affecting expenditure on forest services.*

*The information about expenditure on different types of forest service is given in Table 44. It shows that almost 60 percent of all public expenditure on forest services is spent on supporting ecological and biospheric services. About 3 percent is spent on social and amenity services and the remaining nearly 40 percent is spent on other services.*

***Again, these figures may give a very poor indication of the true levels of expenditure on different types of forest service because of missing data.***

*This high level of variability, both in terms of how much is spent and its focus, makes it very difficult to generalize about the priority given to public expenditure on forestry at the European and regional level and the relative importance of the different forest services.*

Table 44: Government expenditure on forest services in 2010, by type of service and region

| Region | Total expenditure (million EUR) | | | | Expenditure per ha (EUR/ha) |
|---|---|---|---|---|---|
| | Type of service | | | Total | |
| | Ecological and biospheric | Social and amenity | Others | | |
| Russian Federation | 0 | 0 | 672 | 672 | 0.83 |
| North Europe | 496 | 3 | - | 499 | 16.22 |
| Central-West Europe | 267 | 75 | 15 | 357 | 14.45 |
| Central-East Europe | 87 | 1 | - | 87 | 5.47 |
| South-West Europe | 961 | 28 | 568 | 1 557 | 85.66 |
| South-East Europe | 32 | 2 | 3 | 36 | 6.21 |
| Europe | 1 841 | 108 | 1 258 | 3 208 | 3.55 |
| Europe without the Russian Federation | 1 841 | 108 | 586 | 2 536 | 26.59 |
| EU-27 | 1 761 | 108 | 585 | 2 455 | 26.20 |

Moreover, the EFI (European Forest Institute http://www.efi.int/ ) technical report n° 93/2014 (source [7])concluded as follows:

**Needs for price data:**

• Users have many different needs for and means of accessing information. Industry and market participants seem to have most of the data they need whereas forest owners and outsiders do not;

• Long-term series are important for policy setting, e.g. the UNECE/FAO price databases, including for European Forest Sector Outlook Study;

• Policy development requires adequate forest products price information, and understanding how policies affect prices;

• Forests are converted to other land uses in the tropics because of the low profitability of forest products, partly due to the weak knowledge of prices;

• Forest products (including by-products) prices are essential for various industrial projects such as feasibility studies for establishing a sawmill, making business plans, mergers and acquisitions and valuation.

### 4.2.7 An updated overview of forest nurseries' production in Europe

The following figures come from the presentation "*Forest Nurseries in Europe : an overview*" given by Dr Andy Gordon - Secretary of the European Forest Nursery Association (http://efna.co.uk/ ) at the Zephyr final conference in Milan on 21/10/2015 (source [10])

**Production in EFNA members (millions)**

| Country | Total | Private | State |
|---|---|---|---|
| Austria | 46 | 35 | 11 |
| Belgium | 65 | 65 | 0 |
| Czech Rep. | 159 | 139 | 20 |
| Denmark | 56 | 56 | 0 |
| France | 75 | 74 | 1 |
| Germany | 200* | 150 | 50* |
| Hungary | 218 | 153 | 65 |
| Ireland | 47 | 17 | 30 |
| Netherlands | 350 | 350 | 0 |
| Portugal | 50 | 38 | 12 |
| Spain | 35 | 18 | 17 |
| Sweden | 369 | 50 | 319 |
| UK | 98 | 74 | 24 |
| **TOTALS** | **1768** | **1218** | **550** |

*Legenda*

Brown: no official figures

Blue: official figures usually from state body

Red: based upon area of production, no actual figures

Green: (Spain) part official part private figures.

Other notes: Sweden and Ireland State owned companies,

UK includes figures for Forestry Commission

Asterisk: estimated values.

**Figure XIX – Total seedling production in EFNA members**

**Production in EFNA members**

| Country | Total millions | Bare-root % | Container % |
|---|---|---|---|
| Austria | 46 | 95 | 5 |
| Belgium | 65 | 100 | 0 |
| Czech Rep. | 159 | 85 | 15 |
| Denmark | 56 | 95 | 5 |
| France | 75 | 31 | 69 |
| Germany | | 99 | 1 |
| Hungary | 218 | 100 | 0 |
| Ireland | 47 | 95 | 5 |
| Netherlands | 350 | 98 | 2 |
| Portugal | 50 | 5 | 95 |
| Spain | 35 | 5 | 95 |
| Sweden | 369 | 13 | 87 |
| UK | 98 | 79 | 21 |

**Figure XX – Bare-root and container production in EFNA members**

Production in EU countries not members of EFNA (millions)

| Country | Total | Private | State |
|---|---|---|---|
| Finland | 169 | 37 | 123 |
| Slovakia | 138 | 34 | 104 |
| Bulgaria | 60 | | |
| Lithuania | >132 | | |
| Latvia | | yes | 24 |
| Poland | >100 | yes | |
| Estonia | | >12 | |
| Italy | | 0 | yes |
| Luxemburg | 0 | 0 | 0 |
| Croatia | | 0 | yes |
| Romania | | yes | yes |
| Slovenia | | yes | |
| Greece/Cyprus | | | |
| Total | 629 | | |

*Legenda*

Blue: official figures usually from state body

Brown: data from internet

Red: estimation (see the next table)

Green no data

**Figure XXI – Total production in EU countries not members of EFNA**

Production in EU countries not members of EFNA (millions)

| Country | Total | Estimate | |
|---|---|---|---|
| Finland | 169 | | |
| Slovakia | 138 | | |
| Bulgaria | 60 | | |
| Lithuania | >132 | | |
| Latvia | | 50 | |
| Poland | >100 | | |
| Estonia | | 50 | |
| Italy | | 50 | |
| Luxemburg | 0 | 0 | |
| Croatia | | 60 | |
| Romania | | 100 | |
| Slovenia | | 30 | |
| Greece/Cyprus | | 70 | |
| Total | 629 | 410 | |

**Figure XXII – Total production in EU countries not members of EFNA: estimate for countries with no data**

Resuming *(data in million/year):*

- Production by EFNA Member nurseries ..................................... ..1.750
- Production by Non EFNA Member nurseries with some evidence......630
- Conservative Estimate of remaining countries ..................................410

**Grand Total approx. 2.8 billion plants per year**

## 4.3 Conclusions

### 4.3.1 The new product compared with the state of the art

There are noticeable advantages of the Zephyr system respect to the ordinary greenhouses, mainly given by the reduction of both surface and operating costs, as well as a better final product

Water and energy saving, as well as the avoidance of fertilizers and pesticides do not seem to have relevance in small-medium nurseries , while assume importance in large production in northern countries. Such advantages are in any case a good “market asset” for the new product.

The energy consumption of the Zephyr unit per space unit is very low (up to twenty times!!) respect to the growth chambers currently on the market; however, this parameter does not seem to be interesting to the customers (mainly universities and research centres) and several producers do not show it in their product data sheets.

For Universities and research centres, the “appeal” of the Zephyr unit are: actual uniformity of the average growth conditions; possibility of adding several high-tech actuators for a complete automatic growth cycle, fully monitored and controlled by remote; automatic analysis of the green mass in the trays; high production capacity. For this specific market sector, every client may have different specific needs and any unit is expected to be actually “customized”

**It is however clear that the actual promising market for the Zephyr unit is the one referring to forest nursery one, with a production starting from 50.000 seedling per year.**

3 different types of customers are considered:

- First level customers: forest nurseries
- Second level customers: forest owners, small nurseries, urban planners and landscapers
- Universities and research centres (niche market)

The prototype built by the project is equivalent to a nursery using 3000 m2 of land (annual production of 50.000 seedlings) and can reduce by around 40% the total production costs. For bigger productions (200,000 up to one million), the modularity of the system may allow further relevant economies.

For low-medium production rates (up to 200.000 seedlings per year) the low energy and water consumption and the zero need of fertilizers, pesticides has an “image to the market” value that seem higher than the actual money savings

The seedlings produced by the unit are of better quality with an higher survival (after transplanting) rate and can be easily certificated.

The flexibility of the system, allowing several units working in parallel is another asset of the system; however the optimal dimension of the unit, as well as the production of models having different production capacities has to be analysed in the scaling-up phase.

The advantages of the mobile and energy independent system (like the one built within the Zephyr project) have not been taken into consideration yet, because the prototype was built to be shown at different international fairs after the end of the project.

### 4.3.2 Outcome from the market analysis of forest plants

All the sources used for the reforestation market analysis clearly indicate a lack of data, both in quantity and quality.

**Even if the trend of natural regeneration is slightly increasing, the market of forest plant production is still promising and the most recent conservative estimation shows a production in Europe of around 2,8 billion plants per year.**

The foresight demand for 2030 indicate a strong interest for urban forest, green cities and green architecture, all issues where a small, movable and high capacity production unit like the Zephyr one has a competitive advantage.

### 4.3.3 Input for the Industrial Implementation Plan

Assuming a conservative, slow market penetration equal to 0,1% of the EU market in 5 years, this means a production of 0,001 x 2.800.000.000 = 2.800.000 seedlings/year.

Since the Zephyr unit has a capacity of 50.000 seedlings/year the estimated production in 5 years is 56 units

Overseas market is not considered at the beginning, even if seems extremely promising.

The plan should foresee a “basic unit” in at least two versions (capacity of 20 or 30 standard trays)

The “basic unit” should be designed and built in a way that allows an easy addition of one or more actuators, either in construction phase, or after the machine has been sold.

The results of the economic analysis of a nursery having a production of 50.000 seedlings per year gave a rough indicators about the “price to market” close to the higher price of the growth chambers currently on the market; such a price should be however adequately investigated during the industrialization phase, in order to reach a wide range of potential customers.

The Industrial implementation Plan should adequately involve the project partners having the ownership of the Zephyr’s IPR and foresee the organization of the “distributed company” (light Consortium) for the commercialization of the innovative growth chamber.

# 5. Appendix

THEME [ENV.2012.6.3-1]
Innovative resource efficient technologies, processes and services

# ZEPHYR project – Internal Report

# Data for market analyses

Funding scheme: Collaborative Project

Project Acronym: **ZEPHYR**

Project Coordinator: TUSCIA UNIVERSITY

Proposal full title: Zero-impact innovative technology in forest plant production

Grant Agreement n°: **308313**

Author: **Azorina**

## 5.1 Introduction

The Government of the Azores, through Azorina, is a partner in the Zephyr Project - Zero Impact Innovative Technology in Forest Plant Production, a project in the area of Environment, funded by the Seventh Framework Programme of the European Union for Research and Technological Development.
Through its partners from several European Countries - Scientific institutions (Universities and research centres) and companies - the project's main goal is the exchange and development of knowledge, particularly in the area of replication technologies of forestry plants.
In this context, Azorina participation meets the terms with the specific objectives of the project:
- Development of a business model for European nurseries;
- The integration of technologies developed in a functional system for forest plants production on a large scale, ready for transplantation and increased growth forest nurseries throughout Europe.

## 5.2 Objectives

The main goal of this report is to present the findings for the data search and collection about European market for forest nurseries, providing data for the market analysis to be developed in Zephyr project. The topics to be answered in this task are:
1. Classification of European forest nurseries (products and ownership);
2. Number of forest seedlings sold in Europe for reforestation and afforestation purposes (per year);
3. Quantity of requested plants in previous point 2, but not sold, due to unavailability of the product, if any;
4. Kinds of certification in Europe: seeds certification (including the seeds' origin) and seedlings quality certification.
The work presented in this report includes the research methodology and findings, the sources for data acquisition and presentation of alternatives to supplant the shortage of data.

## 5.3 Methodology

To search and acquire the data of the number of forest seedlings sold in Europe for reforestation and afforestation purposes (per year) and the quantity of requested plants in previous point, but not sold, due to unavailability of the product, the following methodology was used:
1. Internet and bibliography research
2. Screening of organizations to be contacted
3. Contact the selected organizations via e-mail
4. Compilation of the data and evaluation of results

The requested data to this task is at European Union’s level; nevertheless, a European Union country was chosen to provide a case study at the country level. Portugal was the selected country and its results are included on this report.

## 5.4 Outcomes

The outcomes from the work concerning the topics of this task are described next:

## 5.5 1. Classification of European forest nurseries (products and ownership);

A research has been conducted to evaluate the possibility of collecting information regarding European Forest nurseries and trade of forest seeds, seedlings and VP material.
The first step was to understand if all European countries were using the same classification systems and how that was reflected on the statistics database.

After the work done to accomplish this assignment it was concluded that there is not one standard classification used in the European Union countries, and that classifications vary between countries. Nevertheless, there are some international classification systems, used worldwide with available statics regarding the seeds, seedling and VP material. The most significant classifications are described below:

- Eurostat
- FAO
- International Standard Industrial Classification of all economic activities, Revision 4.0
- North American Industry Classification System

**Eurostat**
Eurostat produces yearly data using two questionnaires - The Joint Forest Sector Questionnaire (JFSQ) on production and trade in wood and wood products and the Integrated environmental and economic accounting for forests (IEEAF).
The data on forest nurseries activity are included in the Statistical Classification of Economic Activities in the European Community, the nomenclature of economic activities in the European Union (NACE).
NACE is a four-digit classification providing the framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics (e.g. production, employment and national accounts) and in other statistical domains developed within the European statistical system (ESS).

**FAO**
FAO has various databases of agricultural and forestry statistics called the FAOSTAT. The data of these databases is collected every year from governments through questionnaires.
The forestry databases do not contain any information about forest tree seed production or the production of other plant material. However, FAOSTAT does have several databases of agricultural production, one of which includes seed production. Agricultural products in these databases are arranged according to FAO's "Definition and Classification of Commodities" "(Adrian Whiteman, 2005).

**International Standard Industrial Classification of all economic activities, Revision 4.0**

"The International Standard Industrial Classification of All Economic Activities (ISIC) is the international reference classification of productive activities. Its main purpose is to provide a set of activity categories that can be utilized for the collection and reporting of statistics according to such activities.
Since the adoption of the original version of ISIC in 1948, the majority of countries around the world have used ISIC as their national activity classification or have developed national classifications derived from ISIC. ISIC has therefore provided guidance to countries in developing national activity classifications and has become an important tool for comparing

statistical data on economic activities at the international level. Wide use has been made of ISIC, both nationally and internationally, in classifying data according to kind of economic activity in the fields of economic and social statistics, such as for statistics on national accounts, demography of enterprises, employment and others. In addition, ISIC is increasingly used for non-statistical purposes." (Adrian Whiteman, Rome 2005**).**

The ISIC "Section A Agriculture, Forest and Fishing, 02 Forestry and logging" includes the production of round wood for the forest-based manufacturing industries (ISIC divisions 16 and 17) as well as the extraction and gathering of wild growing non-wood forest products. Besides the production of timber, forestry activities result in products that undergo little processing, such as fire wood, charcoal, wood chips and round wood used in an unprocessed form (e.g. pit-props, pulpwood etc.).

021 Silviculture and other forestry activities
0210 Silviculture and other forestry activities This class includes:
- Growing of standing timber: planting, replanting, transplanting, thinning and conserving of forests and timber tracts
- Growing of coppice, pulpwood and fire wood
- Operation of forest tree nurseries

These activities can be carried out in natural or planted forests.
"The production of forest seeds and other forest plant material is included in Class 0200 (operation of forest tree nurseries), but it would not be possible to use any national statistics organised according to ISIC Rev. 3.1 to identify this separately from other forestry activities." (A. Whiteman, 2005).

**North American Industry Classification System**

The North American Industry Classification System (NAICS) is the standard used by the statistical agencies in Canada, Mexico, and United States industries, to classify business establishments for the purpose of collecting, analysing, and publishing statistical data related to the economy. This system facilitates economic analyses that cover the economies of the three North American countries.
At its most detailed industry level, the NAICS system uses a six-digit code. The first two digits designate the largest business sector, the third digit designates the subsector, the fourth digit designates the industry group, the fifth digit designates the NAICS industries, and the sixth digit designates the national industries (NAICS, 2015). For Agriculture, Forestry and Fishing industry the NAICS code is 01-09.

According to Adrian Whiteman (2005), the codes for forest nurseries are:

- 111421 Nursery and Tree Production

This industry includes establishments primarily engaged in (1) growing nursery products, nursery stock, shrubbery, bulbs, fruit stock, sod, and so forth, under cover or in open fields and/or (2) growing short rotation woody trees with a growth and harvest cycle of 10 years or less for pulp or tree stock.

- 444220 Nursery, Garden Centre, and Farm Supply Stores

This industry comprises establishments primarily engaged in retailing nursery and garden products, such as trees, shrubs, plants, seeds, bulbs, and sod, that are predominantly grown elsewhere. These establishments may sell a limited amount of a product they grow themselves. Also included in this industry are establishments primarily engaged in retailing farm supplies, such as animal (non-pet) feed.

- 113210 Forest Nurseries and Gathering of Forest Products

This industry comprises establishments primarily engaged in (1) growing trees for reforestation and/or (2) gathering forest products, such as gums, barks, balsam needles, rhizomes, fibres, Spanish moss, ginseng, and truffles.

## 5.6 2. Number of forest seedlings sold in Europe for reforestation and afforestation purposes (per year);

A preliminary research was made, with the objective of identifying the main organizations and institutions at the transnational level, that collect and organize forest and forestry information. As a case study for the national level, the main institutions and organizations in Portugal were also identified.
The following table (Table 1) lists these organizations, their contact information and their feed-back.

| Institutions and Organizations | Contact (e-mail) | Reply |
|---|---|---|
| EuroStat | eurostat-infodesk@cec.eu.int; Sg-Acc-Doc@ec.europa.eu | DG SANTE does not receive any information on European forest nurseries. |
| United Nations Economic Commission for Europe | support.stat@unece.org | UNECE does not collect this information |
| FAO - Liaison Office with the European Union and Belgium | FAO-LOB@fao.org | FAO Forestry and Timber Section does not have a comprehensive data-set on forest nurseries in Europe |
| EFNA - European Forest Nursery Association | andyg.gordon@btopenworld.com | No data available |
| European Forest Genetic Resources Programme | http://www.euforgen.org/contact-us/ | No data available |
| ICNF - Instituto da Conservação da Natureza e das Florestas | http://www.icnf.pt/portal/icnf/serv/formularios/contactar | No reply up to this date |
| INE - Instituto Nacional de Estatística | http://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_ped_informacao | No data available |
| ANEFA - Associação Nacional de Empresas Florestais, Agrícolas e do Ambiente | mila.anefa@gmail.com; joanafaria.anefa@gmail.com | No data available |

**Table 1:** Contacted organizations and their feedback.

The replies from the contacted organizations, both at the transnational and national level (Portugal case study) reveal that these type of data is not systematically collected by any of these organizations.

**Data findings**
The data sets found for these topics are from Eurostat. The collected data is included in the Statistical Classification of Economic Activities in the European Community.
The data on the economic activity of the forestry and nurseries and marketing of plants - Economic accounts for forestry and logging - (values at current prices), has the code **for_ieeaf_cp** and includes the period from 2004 to 2013. The relevant items in the IEEAF are value of forestry and nursery plants output (O_OPLAN) and the intermediate consumption of plants (C_PLAN).
The last update of the dataset is from 10.04.2015 and holds 19064 records. The oldest data is from 1986 and the most recent from 2013. The dataset is attached as an annex in an excel file (**data_set_for_ieeaf_cp.xls**).

The dataset has several weaknesses: there are breaks in the time series, not all EU countries report this information, and some values are estimates or provisional. The following table (Table 2) summarizes the available data in Eurostat. For clarity purposes, EU member countries and their dates of entry are also shown in the table.

| Country | Year of entry | Data years (O_OPLAN) | Data years (C_PLAN) |
|---|---|---|---|
| Austria | 1995 | 2004-2013 | 2004-2013 |
| Bosnia and Herzegovina | | 2010-2013 | 2010-2013 |
| Belgium | 1958 | | |
| Bulgaria | 2007 | 2005-2012 | 2005-2012 |
| Croatia | 2013 | | |
| Cyprus | 2004 | 2005-2012 | 2005-2012 |
| Czech Republic | 2004 | 2005-2012 | 2005-2012 |
| Denmark | 1973 | | |
| Estonia | 2004 | | |
| Finland | 1995 | 2005 | 2005 |
| France | 1958 | 2004-2012 | 2004-2012 |
| Germany | 1958 | 0 | 2005-2012 |
| Greece | 1981 | 2004-2012 | 2004-2012 |
| Hungary | 2004 | 2005-2009 | 2005-2009 |
| Ireland | 1973 | | |
| Italy | 1958 | 0 | 0 |
| Latvia | 2004 | 2009-2011 | 2009-2011 |
| Lithuania | 2004 | 2005 | 2005 |
| Luxembourg | 1958 | 2006-2012 | 2004-2012 |
| Malta | 2004 | 0 | 0 |
| Netherlands | 1958 | 0 | 2005-2006 |
| Norway | | 2006-2012 | 2005-2012 |
| Poland | 2004 | 2011-2012 | 2011-2012 |
| Portugal | 1986 | 2004-2012 | 2004-2012 |
| Romania | 2007 | 2005; 2008-2012 | 2008-2012 |
| Slovakia | 2004 | 0 | 0 |
| Slovenia | 2004 | 2004-2013 | 2004-2013 |
| Spain | 1986 | 2005-2007 | 2005-2007 |
| Sweden | 1995 | 2007-2010 | 2007-2012 |
| Switzerland | | 2004-2013 | 2004-2013 |
| United Kingdom | 1973 | 2004-2012 | 2004-2012 |

**Table 2: Available data per country. EU member countries in blue shade.**

Table 3 and Table 4 show the data for forestry and nursery plants output and intermediate consumption of plants available from 2004 to 2013. These items are described in the Explanatory notes for the economic accounts for forestry and logging, which is included as a MS Word file in the annex to this report (ESTAT-2011-10042-02-00_EN-TRA-00.doc).

| Country | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|
| Austria | 9.4933 | 10.1783 | 11.1511 | 11.3540 | 13.1282 | 17.1398 | 17.7292 | 17.9437 | 18.5752 | 19.3967 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Bosnia and Herzegovina | : | : | : | : | : | : | 0.1023 | 0.9203 | 0.9510 | 0.9561 |
| Belgium | | | | | | | | | | |
| Bulgaria | : | 1.1417 | 1.3227 | 1.2425 | 1.6377 | 3.0468 | 2.6363 | 0.9551 | 0.9347 | : |
| Croatia | | | | | | | | | | |
| Cyprus | : | 0.2808 | 0.2814 | 0.2622 | 0.2090 | 0.2570 | 0.2293 | 0.1672 | 0.1751 | : |
| Czech Republic | : | 17.5374 | 19.0742 | 21.0113 | 25.1824 | 25.5343 | 27.3968 | 26.2139 | 23.4960 | : |
| Denmark | | | | | | | | | | |
| Estonia | | | | | | | | | | |
| Finland | : | 9.0000 | : | : | : | : | : | : | : | : |
| France | 37.0000 | 37.0000 | 37.0000 | 38.5500 | 54.0000 | 44.0000 | 42.0000 | 40.0000 | 53.0000 | : |
| Germany | : | : | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | : |
| Greece | 2.8400 | 2.1400 | 1.6190 | 1.3800 | 2.0100 | 2.3400 | 2.5300 | 1.6500 | 1.2000 | : |
| Hungary | : | 5.6804 | 5.9960 | 6.4427 | 5.6206 | 5.5634 | : | : | : | : |
| Ireland | | | | | | | | | | |
| Italy | : | 0.0000 | 0.0000 | : | : | : | : | : | : | : |
| Latvia | : | : | : | : | : | 5.6681 | 5.7006 | 7.4168 | : | : |
| Lithuania | : | 1.5639 | : | : | : | : | : | : | : | : |
| Luxembourg | : | : | 0.0474 | 0.0359 | 0.0225 | 0.0182 | 0.0113 | 0.0165 | 0.0062 | : |
| Malta | : | : | : | : | : | 0.0000 | : | : | : | : |
| Netherlands | : | 0.0000 | : | : | : | : | : | : | : | : |
| Norway | : | : | 6.4619 | 6.9856 | 6.8096 | 6.1871 | 6.2466 | 7.4807 | 8.1604 | : |
| Poland | : | : | : | : | : | : | : | 6.4554 | 10.8490 | : |
| Portugal | 5.3200 | 7.3700 | 6.2800 | 5.3400 | 4.4700 | 3.9200 | 4.2200 | 4.6200 | 5.4700 | : |
| Romania | : | 2.2094 | : | : | 8.7710 | 6.1086 | 9.9948 | 18.8483 | 20.3844 | : |
| Slovakia | : | : | : | : | : | : | : | : | : | : |
| Slovenia | 0.5211 | 0.6475 | 0.6997 | 0.6621 | 0.5685 | 0.4890 | 0.5639 | 0.6563 | 0.6441 | 0.6175 |
| Spain | : | 19.0000 | 134.0000 | 27.0000 | : | : | : | : | : | : |
| Sweden | : | : | : | 44.2157 | 41.9128 | 36.0671 | 46.0298 | : | : | : |
| Switzerland | 18.5782 | 17.2565 | 17.3028 | 14.8416 | 14.2932 | 16.3434 | 18.2797 | 17.3163 | 19.9898 | 16.8501 |
| United Kingdom | 32.4168 | 29.2483 | 32.2708 | 32.1478 | 25.1168 | 26.9378 | 30.3087 | 28.8058 | 30.8311 | : |

**Table 3: Output of forestry and nursery plants (O_OPLAN), in million Euro. Data from Eurostat. EU member countries in blue shade.**

| Country | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|
| Austria | 10.7006 | 11.6781 | 12.3848 | 12.4218 | 14.2077 | 19.9864 | 19.6041 | 20.8832 | 21.2925 | 22.4020 |
| Bosnia and Herzegovina | : | : | : | : | : | : | 6.1866 | 6.6468 | 0.9203 | 0.7414 |
| Belgium | | | | | | | | | | |
| Bulgaria | : | 0.3891 | 0.2091 | 0.2454 | 0.5353 | 0.4515 | 0.6422 | 0.3298 | 0.2797 | : |
| Croatia | | | | | | | | | | |
| Cyprus | : | 0.0000 | 0.0000 | 0.0070 | 0.0050 | 0.0080 | 0.0020 | 0.0040 | 0.0018 | : |
| Czech Republic | : | 16.5469 | 17.9769 | 19.8228 | 23.5348 | 23.8623 | 25.6051 | 24.5018 | 22.1639 | : |
| Denmark | | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Estonia | | | | | | | | | | |
| Finland | : | 11.0000 | : | : | : | : | : | : | : | : |
| France | 34.4079 | 35.0000 | 36.0000 | 36.0000 | 36.0000 | 36.0000 | 35.0000 | 40.0000 | 41.0000 | : |
| Germany | : | 47.4310 | 48.9060 | 56.0297 | 62.6774 | 60.5477 | 58.8382 | 69.7641 | 61.1218 | : |
| Greece | 2.8400 | 2.1400 | 1.6190 | 1.3800 | 2.0100 | 2.3400 | 2.5300 | 1.6200 | 1.2000 | : |
| Hungary | : | 5.6804 | 5.9960 | 6.4427 | 5.6206 | 5.5634 | : | : | : | : |
| Ireland | | | | | | | | | | |
| Italy | : | : | : | : | : | : | : | : | : | : |
| Latvia | : | : | : | : | : | 0.0000 | 0.4374 | 0.5270 | : | : |
| Lithuania | : | 1.7377 | : | : | : | : | : | : | : | : |
| Luxembourg | 0.0452 | 0.0686 | 0.9428 | 1.0090 | 0.8943 | 0.6807 | 0.5495 | 0.6376 | 0.9426 | : |
| Malta | : | : | : | : | : | 0.0000 | : | : | : | : |
| Netherlands | : | 3.0000 | 3.0000 | : | : | : | : | : | : | : |
| Norway | : | 4.5947 | 5.4056 | 5.7756 | 6.1529 | 5.3736 | 5.4846 | 7.4807 | 8.1604 | : |
| Poland | : | : | : | : | : | : | : | 1.4804 | 1.6489 | : |
| Portugal | 11.2600 | 12.3400 | 12.3900 | 10.1900 | 10.2100 | 6.1800 | 6.7600 | 5.3400 | 5.7100 | : |
| Romania | : | : | : | : | 8.7710 | 6.1058 | 10.0063 | 18.8483 | 20.3844 | : |
| Slovakia | : | : | : | : | : | : | : | : | : | : |
| Slovenia | 0.5338 | 0.6276 | 0.9032 | 0.6022 | 0.4958 | 0.4619 | 0.2636 | 0.3891 | 0.4412 | 0.3827 |
| Spain | : | 19.0000 | 8.0000 | 8.0000 | : | : | : | : | : | : |
| Sweden | : | : | : | 45.1887 | 35.2567 | 25.2375 | 38.4805 | 54.1540 | 63.0737 | : |
| Switzerland | 7.4385 | 8.7419 | 8.5868 | 4.2349 | 4.0182 | 5.7049 | 6.4634 | 4.8603 | 5.3877 | 3.7382 |
| United Kingdom | 32.4168 | 29.2483 | 32.2708 | 32.1478 | 25.1168 | 26.9378 | 30.3087 | 28.8058 | 30.8311 | : |

**Table 4: Intermediate consumption of Plants (C_PLAN), in million Euro. Data from Eurostat. EU member countries in blue shade.**

## 5.7 3. Quantity of requested plants in previous point 2, but not sold, due to unavailability of the product, if any

The Eurostat dataset assumes that there is a steady balance between the production of forestry nurseries and the sale of plants (see the Explanatory notes for the economic accounts for forestry and logging, annex to this document). To our best knowledge, there is no available data for this topic.

**Suggestions for resolving the need of data**
In order to build statistics on the quantity of requested plants in previous point 2, but not sold, due to unavailability of the product, and simultaneously improve data for point 2, two questionnaires are suggested, one to be addressed to the national forestry authorities and to forest nurseries organizations, and the second to be addressed directly to the nurseries. These two questionnaires are attached to this report as **.pdf files questionnaire01** and **questionnaire02.pdf**.

Useful websites:
- European Forest Nursery Association (EFNA) is an organisation primarily looking after the interests of the private forest nursery and forest seed industries within the European Union.
http://www.efna.eu/index.php
- International Seed Federation (ISF) is an organization that represents the interests of the seed industry at a global level.

http://www.worldseed.org/isf/home.html

## 5.8 4. Kinds of certification in Europe: seeds certification (including the seeds' origin) and seedlings quality certification;

**European Union Certification Scheme**
The document of support for EU certification is the Basic Directive 1999/105/EC - marketing of forest reproductive material. The national law on the marketing of forest reproductive material in European Union countries was revised in order to comply with this Directive, and since 2003 is being gradually implemented. Many non-EU countries also follow the requirements of this Directive.
From the basic Directive come the following implementing measures:

- *2012/90/EU*
  Commission recommendation, of 14 February 2012
  On guidelines for the presentation of the information for the identification of lots of forest reproductive material and the information to be provided on the supplier's label or document
- *2010/680/EU*
  Releasing some EU countries from applying to some species Directives on the marketing of various types of seed, material for the propagation of the vine and forest reproductive material
- *2008/989/EC*
  Authorising EU countries to decide on equivalence of guarantees for forest reproductive material imported from non-EU countries
- *2008/971/EC*
  Equivalence of forest reproductive material produced in non-EU countries
- *2006/665/EC*
  Temporarily allowing Spain to market seed of Pinus radiata and planting its stock imported from New Zealand, not satisfying identification and labelling requirements
- *2005/942/EC*
  Authorising EU countries to decide on assurances for forest reproductive material produced in non-EU countries
- *2005/853/EC*
  Authorising France to ban marketing of reproductive material of Pinus pinaster Ait. of Iberian Peninsula origin to seed or plant it in some regions of France
- *2004/678/EC*
  Authorising EU countries to temporarily permit marketing seed of Cedrus libani, Pinus brutia, and planting its stock
- *Regulation EC 69/2004*
  Derogations from some provisions of Directive 1999/105/EC on marketing forest reproductive material from certain basic material
- *Regulation EC 2301/2002*
  Defining small quantities of seed
- *Regulation EC 1602/2002*
  Authorising EU countries to ban marketing of specified forest reproductive material to the end-user
- *Regulation EC 1597/2002*
  National lists of basic material of forest reproductive material
- *Regulation EC 1598/2002*
  Administrative cooperation

**OECD's Scheme for the Certification**

OECD's Scheme for the Certification of Forest Reproductive Material Moving in International Trade addresses the production and trade of forest tree seeds and plants through its certification scheme.

Currently, the EU scheme and the OECD scheme on forest reproductive material have in practice similar requirements for information that has to follow the marketed material.

**Portuguese Case Study**

Concerning the certification, again the European Union countries follow the Directive 1999/105/CE of 22 December 1999, but with different national implementations. Next is presented the Portuguese example.

- *Decreto-Lei nº 205/2003, de 12 de Setembro*
  Transposing into national law the Directive nº 1999/105 / EC of 22 December, on the marketing of forest reproductive material, it establishes the general rules for the production and marketing of forest reproductive material not covered by this Directive
- *Portaria nº 863/2001, de 27 de Julho*
  Approves the Regulation for certification of Forest Reproductive Material. Revokes the Portaria nº 135/94 of 4 March
- *Portaria nº 862/2001, de 27 de Julho*
  Approves the Regulation of the Producer and Supplier of Forest Reproductive Material. Revokes the Portaria nº 136/94 of 4 March
- *Portaria nº 918/98, de 21 de Outubro*
  Approves the Regulation of Base Material Admission and marketing of Cork Oak Reproductive Material. Revokes the Portaria nº 975/95, of 11 August, and Portaria nº 78/98, of 19 February
- *Portaria nº 809/98, de 24 de Setembro*
  Changes the values of the fees due by the suppliers of nursery material, for the control and certification of forest plants. Revokes Portaria nº 821/97, of 5 September
- *Portaria nº 114/98, de 28 de Fevereiro*
  Approves the Regulation of Base Material Admission and marketing of *Pinus pinea* Reproductive Material. Repealing Ordinance No. 991/95, of 17 August
- *Portaria nº 95/98, de 23 de Fevereiro*
  Amending the Regulation of Base Material Admission and marketing of *Pinus pinaster* Reproductive Material
- *Portaria nº 80/98, de 19 de Fevereiro*
  Amending the Regulation of Base Material Admission and marketing of *Eucalyptus globulus* Reproductive Material
- *Portaria nº 78/98, de 19 de Fevereiro*
  Amending the Regulation of Base Material Admission and marketing of *Quercus suber* Reproductive Material
- *Portaria nº 1011/95, de 19 de Agosto*
  Approves the Regulation of Base Material Admission and marketing of *Pinus pinaster* Reproductive Material
- *Portaria nº 977/95, de 12 de Agosto*
  Approves the Regulation of Base Material Admission and marketing of *Eucalyptus globulus* Reproductive Material
- *Portaria nº 134/94, de 4 de Março*
  Approves the Regulation of marketing of Forest Reproductive Material
- *Decreto-lei nº 33/93 de 12 de Fevereiro*
  Amending Decreto-lei nº 277/91 of 8 August, which regulates the production and marketing of nursery materials
- *Decreto-lei nº 239/92 de 29 de Outubro*
  It states rules on marketing conditions for Forest Reproduction Materials

## 5.9 Conclusion

In conclusion, to complete this task, many difficulties were experienced in finding the desired data and information.
Data is collected at national level, but the approaches used for classifying forest nurseries varies considerably, as in some countries (e.g. Portugal, Hungary) a significant proportion of nurseries produce seedlings for both forestry and other purposes.
There is very little organized information on European countries, none of the contacted organizations has a comprehensive data-set on forest nurseries in Europe.
The best way to obtain such information seems to be the direct contact of the forest administrations in each particular country. For this purpose two questionnaires were developed, that are presented as an annex of this report.
The next phase to access the necessary data for topics 2 and 3 is to distribute the questionnaire 1 to the National Forest Authorities and Forestry nurseries organizations to all European Union Countries, collect the replies and organize the data.
In the case that some countries do not have Forest nurseries organizations, or that these are unable to complete and return the questionnaire in due time, questionnaire 2, addressed to the individual nursery companies should, be distributed.
In parallel, the other partners of the Zephyr project should be directly involved in locating and collecting the national statistics in their countries of origin

## 5.10 Bibliography

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## Annex 1

**Nursery Questionnaire - Forest nurseries organizations**

| | | |
|---|---|---|
| **Operators** | | |
| Number of associated nurseries ____________ | | |
| Type of nursery | Wholesale ___% | Retail ___% |
| Revenue | Wholesale ___% of Revenue | Retail ___% of Revenue |

| **Sales and production volume** | **Certification** |
|---|---|
| Number of plants produced per year: ________ | Number of certified nurseries: ____________ |
| Number of plants sold per year: ________ | Type of certification: ____________ |
| Total sales per year: ________ | Type of certification: ____________ |
| Propagation: | Species produced (more representative): |
| Seedling ______% | 1.____________ |
| Vegetative propagation ______% | 2.____________ |
| Micropropagation ______% | 3.____________ |

**Growing Operation**

| Type | | Grown in Container | Grown in Ground |
|---|---|---|---|
| Trees | ______% | ______% | ______% |
| Shrubs | ______% | ______% | ______% |
| Ornamentals | ______% | ______% | ______% |
| Other | ______% | ______% | ______% |

| **Agreements** | | | |
|---|---|---|---|
| Contract or Selling agreements | Yes | No | N/A |

**Greenhouses**

Total # of Greenhouses per nurserie_____(average)

| **Greenhouse Construction** | **Coverings** | **Heat** |
|---|---|---|
| Type | Type | Type |
| Wood Frame ______% | Corrugated Polycarbonate________% | Gas________% |
| Metal Frame_____% | Polycarbonate Sheets________% | Boiler________% |

# Annex 2

**Nursery Questionnaire - Forest nurseries**

**Operators**

Type of nursery Wholesale ________ Retail ________

Revenue ________/Year

| **Sales and production volume** | **Certification** |
|---|---|
| Number of plants produced per year: ______________ | Type of ____________________ |
| Number of plants sold per year: ______________ | Species produced:<br>1.<br>2.<br>3.<br>4.<br>Others: ______________________________ |
| Total sales per year: ______________ Euros | |
| Type of propagation:<br>Micropropagation ☐<br>Seedling ☐<br>Vegetative propagation ☐ | |

**Growing Operation**

| **Type** | **Grown in Container** | **Grown in Ground** |
|---|---|---|
| Trees | ☐ | ☐ |
| Shrubs | ☐ | ☐ |
| Ornamentals | ☐ | ☐ |
| Other ______________ | ☐ | ☐ |

| **Agreements** | Yes | No | N/A |
|---|---|---|---|
| Contract or Selling<br>If yes, provision indicating who is responsible for planting and growing of purchased | Yes | No | N/A |
| **Greenhouses** | Yes | No | N/A |
| Total # of Greenhouses: ______________ | | | |

| **Greenhouse** | **Coverings** | | **Heat** | |
|---|---|---|---|---|
| **Wood Frame**<br>How many? _____ | **Type** | **Number of Greenhouses** | **Type** | **Number of Greenhouses** |
| | Corrugated Polycarbonate | ☐ | Gas | ☐ |
| **Metal Frame**<br>How Many? _____ | Polycarbonate Sheets | ☐ | Boiler | ☐ |