The Interreg Alpine Space project NEWFOR: results and recommendations

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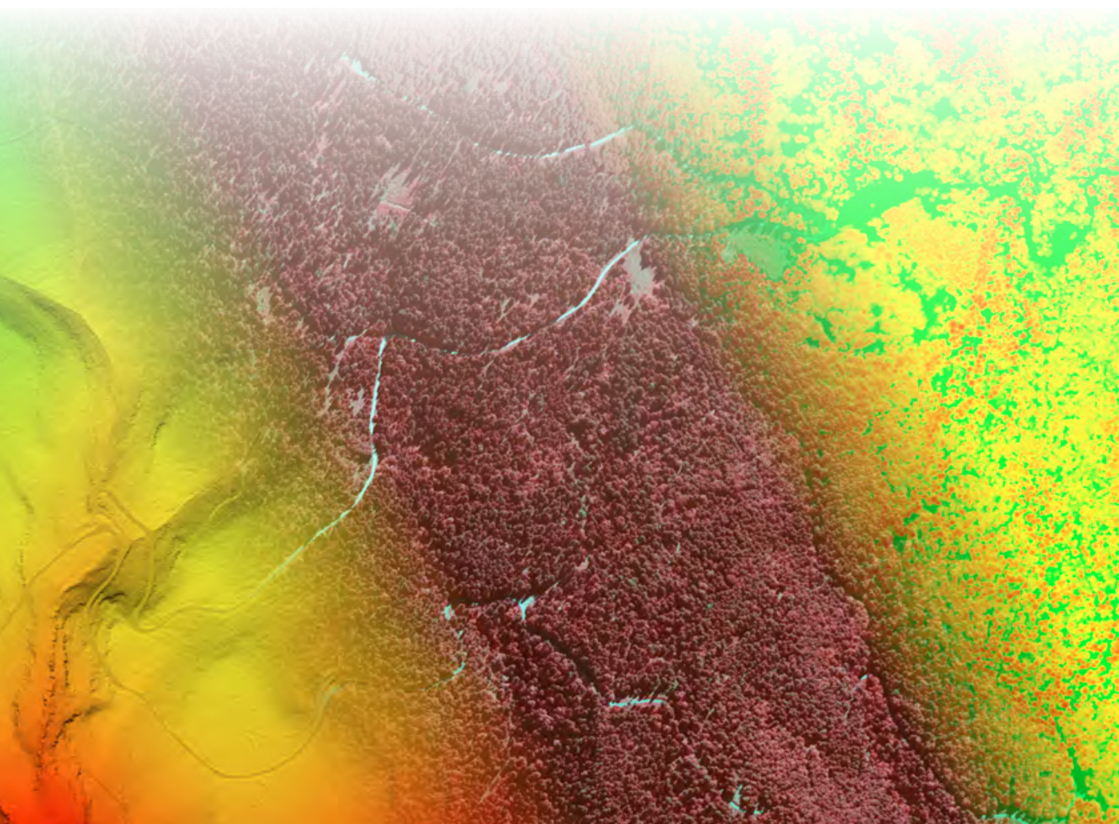
Interreg Alpine Space project - NEWFOR
Project number 2-3-2-FR
NEW technologies for a better mountain FORest timber mobilization
Priority axis 2 - Accessibility and Connectivity

This project has been co-funded by the European Regional Development Funds, and achieved under the third call of the European Territorial Cooperation Alpine Space Programme 2007-2013.



Mountainous forests comprise some of Europe's most stunning, yet inaccessible landscape. Although forests represent a key resource of mountain environments, their valorisation is hampered by accessibility constraints. A comprehensive understanding of such remote terrain via an efficient mapping, management, harvesting and transport of wood products, is thus integral to their exploitation as timber resources.

Forests fulfil multiple functions in mountainous areas. They have an ecological function as host of many habitats and species. They also are a leisure area for social activities such as hiking, skiing… From the economical perspective, the production of renewable resources like timber and fuelwood has positive effects both at global scale, with climate change mitigation, and at a local scale with rural employment and the development of a regional value chain. The objective of preserving and improving the development of mountain forests is a point of public interest.

However, managing forests in mountain territories is a difficult task as topography and climate set strong constraints inside a complex socio-economical framework. In particular, a precise mapping of forest biomass characteristics and mobilization conditions (harvesting and accessibility) is a prerequisite for the implementation of an efficient supply chain for the wood industry. Usually, the available information is currently insufficient to provide, at reasonable costs, the required guarantees on the wood supply and on its sustainability. With the recent development of new remote sensing technologies, such as Light Detection And Ranging (LiDAR), and modelling tools based on the use of Digital Terrain Model (DTM) and implemented in Geographical Information Systems (GIS), major improvements regarding the evaluation of the forest growing stock and accessibility are now possible.

Upon this highly valuable information, decision-making tools must be built to optimize the investments in forest infrastructures required for a cost-effective wood supply while securing the sustainable management of forests, and to support the implementation of an efficient European policy for mountain forest management. This is one of the Alpine Space Programme's aims, which seeks "*to overcome the disadvantages of location factors and to promote the Alpine Space as a dynamic economic region in Europe*".

In order to propose adapted, efficient and pragmatic responses to this technical and economical context, the project NEWFOR (NEW technologies for a better mountain FORest timber mobilization) has been built up by a consortium including researchers and managers from the 6 alpine space countries. The NEWFOR consortium was composed of 14 institutes. The key aim of this project was the improvement of mountain forest accessibility for a better efficiency of wood harvesting and transport in a context of sustainable forest management and wood industry in changing climate. This general objective has been fulfilled by creating, testing and transferring adaptable, robust decision support tools dedicated to mountain forests management.

Four operational objectives have been fixed and reached after the 3 years duration of the project NEWFOR :

1. Sharing of knowledge and development of tools regarding the use of an innovative remote sensing technology (LiDAR: aerial and terrestrial laser scanning) for forest growing stock location, characterization and evaluation of mobilization conditions.

2. Sharing of knowledge and development of tools for the optimization of timber harvesting and transport from the technical and economical points of view.

3. Identification of actions and tools requirements at regional and local level

4. Development of methodology and tools, in cooperation with political decision makers at regional level, dedicated to improve the connectivity between forest resources and wood industries.

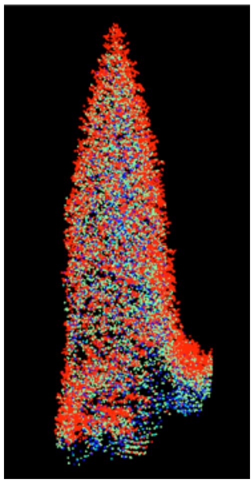
The project has targeted a broad range of end-users: local authorities, public administrations, forest administrations, road and transportation administrations, forest owners, forest practitioners, forest industry managers, NGOs, political decision makers and policy-makers, and also forestry students. The target groups of end users have been involved as part of the partnership network and/or members of the reference panels.

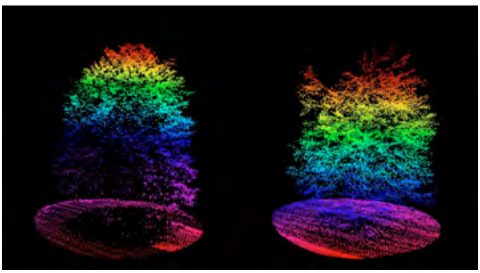
The practice oriented outputs of the project (state of the arts, tools, maps, manuals) have been designed for broad distribution and dissemination via transnational workshops, conferences, training course, one summer school on sustainable mobilisation of wood in Europe. All these deliverables are freely available on the project website. This brochure presents only some key results of each of the 5 workpackages. For more information on the project please visit its website :

www.newfor.net

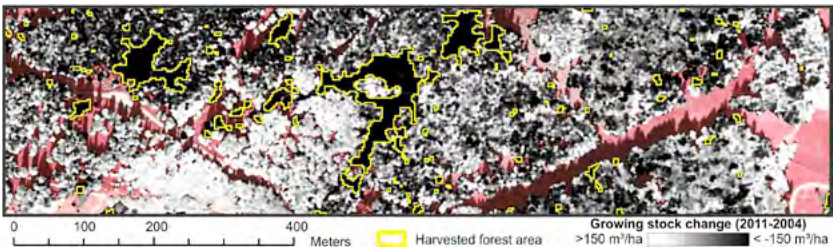
Workpackage: Forest resources and LiDAR (WP4)

Airborne laserscanning (ALS) data, combined with other available data sources (i.e. aerial photographs, aerial photo series by UAVs) allows a precise and fine mountain forest resource quantification, qualification and mapping. The operationalization of these technologies provides an innovative response to the challenges of a precise and robust knowledge on the available growing stocks. The actions of this WP have the overall objectives to test (e.g. benchmark for single tree detection algorithms), to optimize (e.g for forest area delineation, growing stock assessment) and to develop new tools (e.g growing stock change assessment, forest structure estimation) using data which are acquired by these new remote sensing technologies.

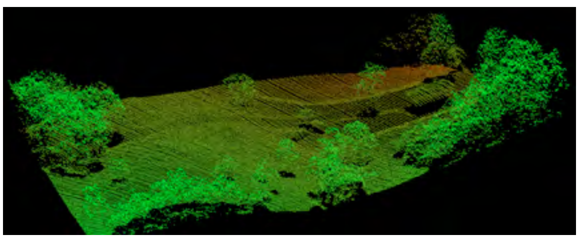




Within NEWFOR a forest area delineation method [1] was applied to several pilot areas characterized with different forest structures and growing conditions. The method relies on four clearly defined geometrical criterions (min. area, min. height, min. width and min. crown coverage), which leads to robust, repeatable and comprehensible delineation results. This is significant when the results are used for obligatory reporting or change detection based on multi-temporal data. For forest structure assessments different structurally relevant parameters [2] can be derived from ALS data. These parameters describe the vertical and horizontal distribution of vegetation and how different patches of vegetation are inter-connected in terms of vertical structure of the plants building the patches. For estimating the growing stock the method described in [3] is applied. This method assumes a linear relationship between the growing stock and the ALS derived canopy volume, stratified according to four canopy height classes to account for height dependent differences in canopy structure. A further stratification can be done considering e.g. tree species groups or canopy closure. Furthermore, the capability of multi-temporal ALS data for operational monitoring of forest growing stock change [4] was analysed in the pilot area Montafon (AUT). Based on in-situ forest inventory data the growing stock increased from 2002 to 2011 of 43.0 m³/ha in average in comparison to 42.5 m³/ha estimated from the ALS data.



The goal of the single tree detection benchmark was to show the potential and limitations of existing methods related to tree detection and extraction of single tree parameters. The methods were analysed in 21 study areas in five countries in the alpine space region. This benchmark gives a unique overview of the performance of the applied methods for different Alpine forest types characterized by varying tree species, tree ages and heights as well as forest structures.



Unmanned Aerial Vehicles (UAVs) are a rapidly upcoming method for remote sensing data acquisition, mostly aerial images and derived products. By now, the systems are light-weight and cost-effective, the development and miniaturization of the sensors and their reliability enable a relative safe operation with good chance of success. UAVs are quickly ready for operation almost everywhere and every time. Therefore UAVs have a high potential to provide high temporal resolution in small areas of interest.

The results of WP4 are building the background for the setting up of specific models dedicated to an adapted logistic planning strategy taking into account the accessibly and availability of growing stocks, the economical conditions and the mountain forest ecosystems services.

[1] Eysn, L., Hollaus, M., Schadauer, K. and Pfeifer, N., 2012: Forest Delineation Based on Airborne LIDAR Data. Remote Sensing 4 (3), 762-783.

[2] Mücke, W., Hollaus, M. and Prinz, M., 2010. Derivation of 3D landscape metrics from airborne laser scanning data, SilviLaser 2010, Freiburg, Germany, 11 p.

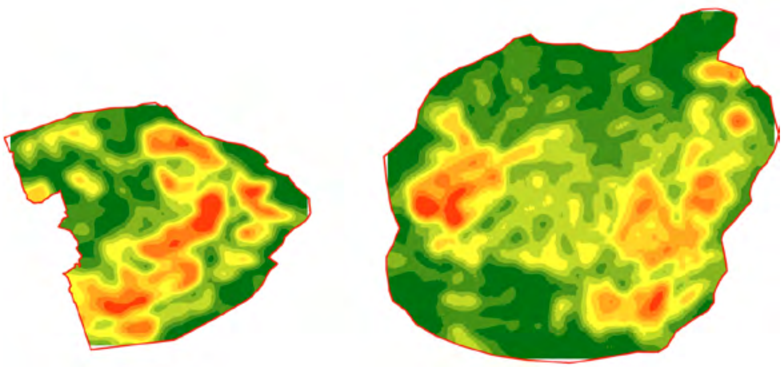
[3] Hollaus, M., Wagner, W., Schadauer, K., Maier, B. and Gabler, K., 2009: Growing stock estimation for alpine forests in Austria: a robust lidar-based approach. Canadian Journal of Forest Research 39 (7), 1387-1400.

[4] Hollaus, M., Eysn, L., Karel, W., Pfeifer, N., 2013: Growing stock change estimation using Airborne Laser Scanning data, SiliLaser 2013, Peking, China.

Workpackage: Forest accessibility (WP5)

GIS-based procedure for working out a proposal to define corridors for road construction planning in high mountain forest areas

The different forest functions were weighted according to their significance for the living space of the people. As a whole forty five different categories of forest functions were classified and weighted. Because there are no objective facts, which allow to distill an objective weighted impact, we used a subjective weighting done by experts. In the figure presenting an example of the map provided with this methodology, the dark green areas have the most favorable conditions for the forest road construction planning. The red areas are "classified", at worst.

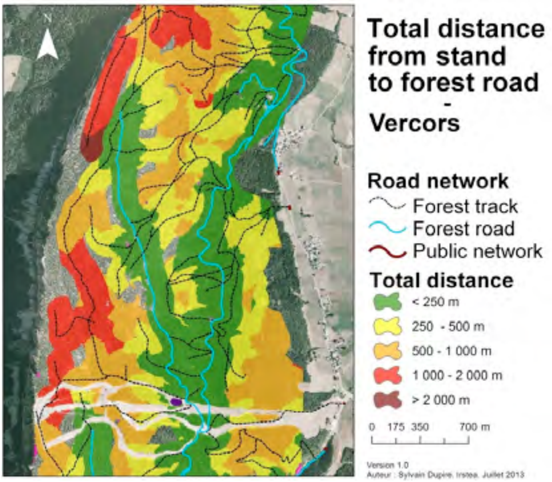


Potential development corridors (green color: advantageous; red color avoid if possible)

GIS-based decision support systems for ground-based harvesting optimization

Sylvaccess – Skidder

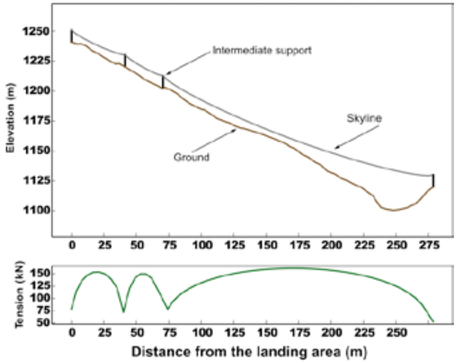
Starting from spatial data (forest road network, forest areas, topography and obstacles) and different parameters filled by the user the model identifies the accessible areas with a skidder from the forest tracks and the forest roads. Some others outputs of the model allow quantifying the difficulty of the operation: total distance from the tree to the forest road, detail of the distances (skidding distance in forest, skidding distance on track, winching distance). Finally, the model identifies the optimal forest areas that have the same connection to the public road.



Example of one of the Sylvaccess outputs

Sylvaccess – Cable

The model uses spatial data and different parameters related to the cable yarding equipment. The model tests all the possible cable lines in the test area. For each of them it calculates the load trajectory and the cable tensile forces taking into account cable elasticity and deflection. The model optimizes the layout of each line and returns the best location for intermediate supports. All the results are gathered in a database. The best locations for covering a forest with cable crane can be generated from this database according to different scenarios.

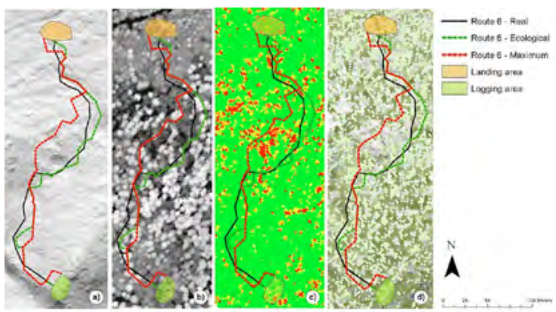


Optimization of a cable line

FPI (Forest Path Identifier): a GIS-tool to predict forest machinery extraction routes using Aerial Laser Scanned derived data

The final output of FPI tool is the feasible route layout with the lowest cost index from the forest to the landing.

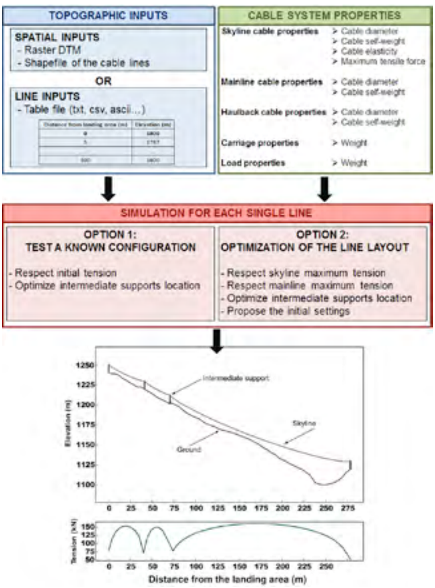
The result of the application of FPI tool shows that many improvements can be gained for in the estimation of extraction distances as linear distances from harvesting site to landing site, differ in average by -26% from the real extraction distance along the skid road while the extraction distances estimated by model FPI differ in average only by +5.5%. Furthermore the inclusion of terrain micro-topography and the presence of obstacles on the ground allow to evaluate more precisely the local possibility to use a harvesting technology.



Example of model output for Route 6 (Site 4), with respect to Hill-shading of DTM (a), CHM (b), terrain roughness (c) and cost surface considering all previous factors (d)

CableHelp and NEWFOR Cable Way: numerical tools for optimizing the set-up of cable yarding operations

In the steep Alpine terrain, wood production with the use of cable yarders is the prevalent timber extraction technology. Planning of pilot tracks of cable lines (skylines) is crucial for optimal functioning and rationalization of costs. With known procedures, we shall be able to calculate suspension cable sags, assume the number and places of intermediate supports and ascertain the possible load that the system will safely bring from working site in the stand to the standing place of the yarder on the forest road. The aim of these two freeware is to provide a reliable and user-friendly tool able to optimize the cable layout, the location of intermediate support and the safety of operators. The outputs of CableHelp are the optimal positioning of intermediate supports, the load path and the evolution of skyline and mainline tension according to load position. CableHelp relies on the mechanical approach proposed in Irvine. Irvine equations have been adapted to cable yarding specificities and programmed in the open source language Python 2.7. The model has been validated with both small scale and real scale field experiments. The average error observed during the validation is less than 1% for the load path and less than 3% for the tension.

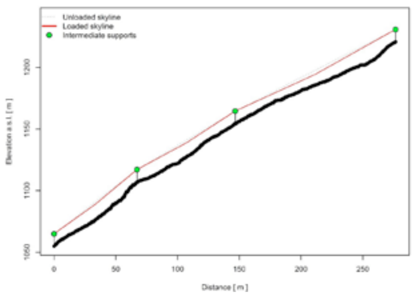


Procedure and sequence of CableHelp, input and result

It is important that the user visualizes the line and is able to tune certain parameters (such as heights of intermediate supports) and optimizes the envisaged costs or effects, independently from the chosen method of detailed cable line planning. Such interactive visualization is possible with the NEWFOR Cableway (NCW) tool. Based on Java programming language, this tool enables 3D visualization of cable line and of optionally selecting snapshot of the terrain. The parameters of the machine and cables are also predefined, and the user can insert some options regarding such parameters. The final purpose of the programme is the presentation of the selected line in space, with the optimization of intermediate supports, as well as a visualization of dangerous zones.

Library(NewForCC) – a R package for forest cable crane planning

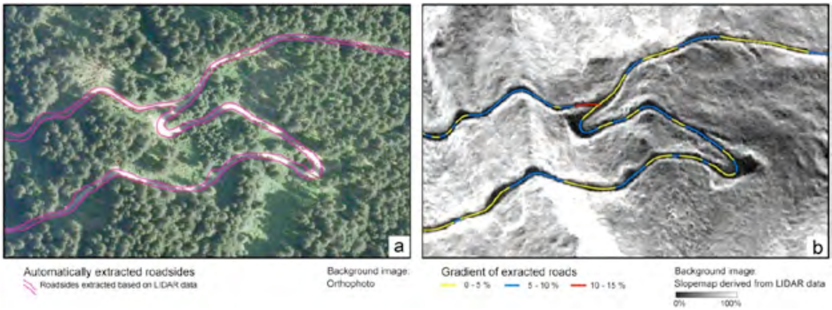
Library(NewForCC) is a package for cable crane planning, especially for finding optimal location for intermediate support(s). LiDAR derived Digital Elevation Model (DEM) represents a source data for ground profile extraction, while canopy height model (CHM) can be used for (dominant) single tree detection, suitable for intermediate support(s).



Example of single cable crane layout with intermediate supports

Remote sensed data for forest road planning support

It is a semi-automatically method for extracting forest roads from LiDAR data. The developed algorithm relies on a weighted graph, automatically extracted from LiDAR data using watershed methods and slope information of the terrain. Additionally information from orthophotos is used. Based on this graph the forest roads are extracted as follows. A human interpreter defines starting and ending points of road sections. Between these points the shortest, best voted path within the weighted graph is automatically found. Using this method the forest roads network is sequentially extracted by the interpreter in a very efficient way. Based on the extracted geometry additional attributes are automatically derived and assigned to road sections.



An example for extracted forest roads. a) Automatically delineated roadsides b) Extracted road network. The road segments are colour coded by gradient

Critical nodes and future opportunities

The analysis of the forest operations in the Alpine Space currently shows big differences among the different nations. The biggest difference regards the organization of the forest operation enterprises in terms of size and type of used machine. Big differences are present in some cases (Italy) also among the single regional administrations. The common trends regard the shifting towards a high level of mechanization, that in some countries is already established, but in others still represents an issue.

The main issue concerning this trend regards the type of infrastructures that should have the standards to allow the bigger machine to operate safely.

The use of the Decision Support Tools developed within the project shows a big potential in helping the planning of forest operation, even at the operational level.

The application of the derived maps proves to be a useful tool to orient the execution of forest operation, and the future investments within the project test-sites.

Transport activity from the forest to the timber industries is an important technical and economical step in the process of wood procurement. In mountain areas, hard conditions in terms of topography, seasonality, difficult forest road network (low density and practicability) are increasing significantly the cost of transport in comparison with the costs in flat area.

Specific equipments are used for transportation of long pieces of roundwood (6-16 m) or billets (2 to 6 m). The latest is the most common in the Alpine Space.

Workpackage: Forest and industry connectivity (WP6)

In terms of organization, transport operation is made by small independent enterprises with 1 to 5 trucks and most often, the orders are given by the logging companies or the end-users of the timbers (sawmills, pulpmills and chip board mills). The organization is not favourable to optimization as a great number of enterprises is involved in the process. Indeed, the state of the art reveals that the actors involved in the process of wood procurement do not use decision tool. For the biggest end-users such as pulpmills or board mills, monthly delivery programs are made but it is just consisting in defining the quantity to be delivered at the mill. Transport companies and mills do not use routing system or optimisation tools for improving the rate of utilisation of the trucks.

Nevertheless, hearings of sawmill and transport companies managers show that they are more and more aware that transport must be more efficient in order to decrease the overall cost of this activity and also because there is a need to improve the use of the truck fleet in a context where the transport capacities are too small (at least in some period of the year). Considering the structure of the enterprises, only a common approach and a mutualisation of decision tools are feasible considering that important investments are required.

In all countries, a first "brick" for future optimisation does exist. Forest road data base are present in every country. They have been built in different contexts, with different purposes but this is a first step toward new tools and new processes for the improvement of logistic in the Alpine Space.

Two decision tools have been tested during the project.

- NavLog is a routing system used in Germany and it has been tested in Alpine context. The main test was dealing with the integration of an existing forest road date base and the accuracy of the routing system both on the public network and the private one (forest roads and the other cardinal points such as turning and crossing areas, bridges, hairpin turn, difficult road sections…). The tests have been done in the east of Tyrol in the municipalities of Wildschönau and Kundl. They revealed some weaknesses in terms of connectivity between the public road network and the private one, falsities about the public network, missing legend or absence of vocal response for some cardinal point information.

Tyrolean forest road network, showing pilot area Wildschönau (source: webclient.navlog.de/)

- FLO (Forest Logistic Optimisation) is a North America planning tool for wood haulage. Inputs are the location of the wood piles that are available at road side in the forest and the delivery points (first transformation mills). Some very simple tests have been made to make a comparison between the deliveries made by a transport company and the program proposed by FLO. It appears that extra loads could have been delivered if FLO had been used. But first results should be confirmed by additional tests and deeper analysis.

Perspectives

The utilization of decision tools for wood haulage is ineluctable. Consequently, new organisations are needed to use them and to share the associated gains in the whole wood procurement chain.

The knowledge of the forest road network and its characteristics are very important as a big share of the driving time of trucks in mountainous area is devoted to drive on forest roads. Further works are needed to automatically catch information with Lidar or truck-embarked technologies.

Information and Communication Technologies and GIS based tools (route guidance system…) should greatly improve the efficiency of wood logistic

The second important topic is to adopt an information format that is compatible with routing and other optimisation tools. Works and reflections engaged during NEWFOR project conclude on the necessity to have a single reference graph in order to avoid parallel systems. In that purpose, using existing public frame (GIP in Austria, IGN in France…) seems to be the best solution with advantages in terms of accuracy, coherency and perenniality of the data base.

Workpackage: Costs and benefits evaluation (WP7)

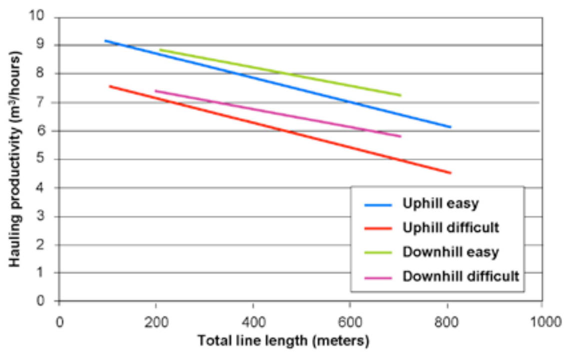
HEPROMO – A productivity estimation tool from WSL

HeProMo is a web-based tool to estimate productivity and costs of different harvesting operations. The tool was created by WSL and is freely available. For the international application, the German manual has been translated into English and Italian and made available in a glossary.

The pre-calculation with HeProMo was compared with the results of several harvest-operations in different test sides in France, Italy and Slovenia. HeProMo works well in CTL harvesting systems. But it is not designed for timber harvesting in whole tree method. As the whole tree method is very common in the Alpine Space, 80 cable crane lines have been followed in order to collect field data to compare the productivity results «in the field» with the forecast results given by HEPROMO and to develop a productivity model for the whole tree harvesting method.

These data were analysed with a statistical approach. The goal was to identify the main parameters that have an impact on the productivity in cable crane logging.

A model has been created and must be integrated in a new tool for calculating the productivity and associated costs for cable crane activities.



NEWFOR – BFW – online-forest-machinery-database: calculating machinery-costs for more than 750 forest machines

The BFW forestry equipment and machinery database contains data from approximately 750 forestry machinery and equipment and allows the calculation of the cost of the equipment and machinery involved in a timber supply chain. At the Research and Training Centre for Forests, Natural Hazards and Landscape, Department of Forest Engineering and Economics a machine and device database was listed, containing a large number of forest machinery and equipment, with device-specific characteristics, production and sales addresses and guide prices. The actual online database is the product of the experience gained from an first online database for energy wood crushing equipment, initially built in 2007, and provides the ability to perform cost calculations for operating hours of machinery and equipment according to three different schemes of the following organizations:

- Federal Research Centre for Forests, Austria (BFW),
- Council for Forest Operations und Forest Technique e.V., Germany (KWF)
- Food and Agriculture Organization of the United Nations (FAO)

Within the Newfor project, this online Database has been updated and translated in English. It is now available in German and English on the link:

http://bfw.ac.at/fmdb or http://www.newfor.net/forest-machinery-database/

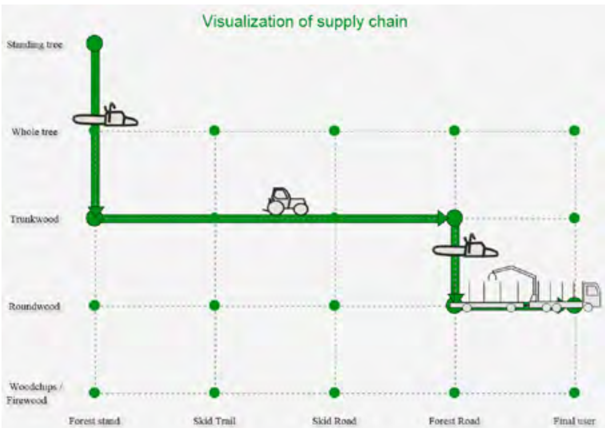
WoodChainManager: an online tool for visualizing and summarizing costs of the forestry-wood supply chain

The WoodChainManager was developed by researchers at the Slovenian Forestry Institute and gives users the ability to visualize and to summarize costs of the forestry-wood supply chain.

Forestry production includes numerous processes in the complex forestry-wood supply chain. From the technological point of view forestry production covers different manufacturing processes where natural resources from forests are transformed into products and services. Costs are an important issue when selecting individual machines and processes in a supply chain. Material costs of individual machines and their mandatory accessories and connections are crucial for optimization of production processes in supply chain. The online application WoodChainManager, enables easy selection of different technological approaches for the production of round wood as well as green wood chips. Selection of machines, and their mandatory accessories and connections along the entire supply chain from harvest to delivery to the final consumer, defines also the cost of supply chain. Visualization of supply chain with representative cost allows optimization and better understanding of otherwise very complex supply chains.

The "WoodChainManager" can be used on this link:

http://www.gozdis.si/



An example of the outputs of the inline tool WCM

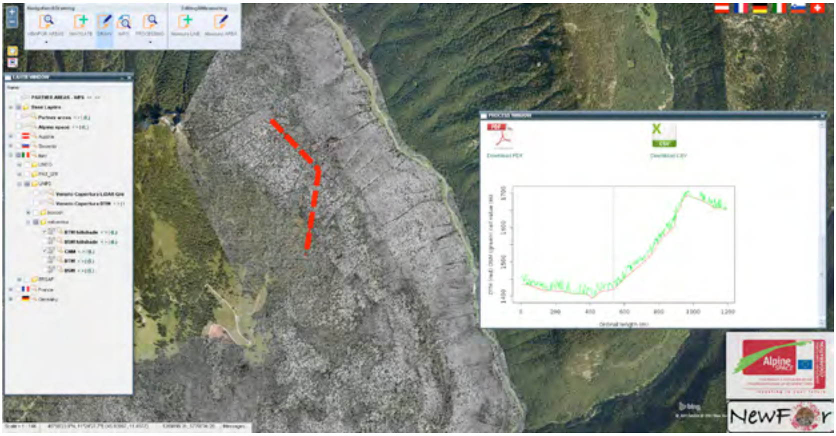
Workpackage: Logistic planning strategy (WP8)

NEWFOR-WebGIS

In the framework of the NEWFOR project several tools have been developed according to each WP goals and activities. It has been evident quite from the early stages of the project that it was impossible to build a single decision support system tool able to catch all the facets of mountain forest management. The choice was thus to create different tools able to use or create data from or for each other. The concatenation of the results of these tools is able to provide a powerful support system, and the modular structure guarantees a high flexibility. This task has been supported by the creation of the NEWFOR-WebGIS.

NEWFOR-WebGIS is a geospatial infrastructure hosting spatial and non-spatial data, as well as modules and tools for representation and processing or the project's data. The functionalities follow a "software as a service" paradigm.

The focus of the NEWFOR-WebGIS implementation covers multiple aspects: (i) to provide tools for accessing the project's very high volume of data remotely without having to move large amounts of data between partners/stakeholders (ii) link together other software developed in the project - and potentially also from others - acting as interoperability bridge between different data formats, standards and requirements (iii) valorize and disseminate results by visually representing them over multiple layers of other information (iv) create a future collaborative interface between users of the project's data in the Alpine Space region.



Dissemination

In order to promote the awareness of new technologies application on mountain forests to potential end-users of project outputs, several events have been organized throughout the three years of the project. Two main dissemination events, held during 2014, animated the final period, arising people's interest, both from the forestry sector and the non-technical public: final conferences and NEWFOR Summer School.

In July 2014, almost 30 people coming from all over Europe (Austria, France, Germany, Italy, Poland, Serbia, Slovakia, Slovenia, Spain and Switzerland) attended the NEWFOR Summer School in the Italian Alps. The students (university students, PhD candidates, public and private forest practitioners) spent a full week with NEWFOR staff to learn about LiDAR and UAV technologies and their applications in the forestry sector.

NEWFOR was present at both BOSTER 2014 events. One of the final workshops for presenting the manual of good practices was held at BOSTER NW (Beaulard, Oulx, Italy) inside a test site of the project. The two weekends gathered approximately 13000 visitors. Inside both events NEWFOR was there with a stand showing the tools developed, results achieved (forest maps, 3D models,...), and technologies used in the project (LiDAR, UAV, laser rangefinder...). Hundreds of people stopped by and were directly informed on NEWFOR activities and achievements. From kids to elderly peoples, from local inhabitants to tourists, forest landowners to forest technicians, different categories showed high interest in the project and acquired new information about the application of new technologies in mountain forests.


NewFor


NEWFOR


Fotogrammetria con UAV e
laser scanner per applicazioni forestali
www.polito.it/geomatics_lab
Alpine Space
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Recommendations for an efficient mountain forests action plan in the Alpine Space

From the beginning of time, man has modified the environment he lived on and therefore the forest has been one of the key point of land management strategy for developing a sustainable liveable space. The simplest definition of a forest is the following one: a plant community dominated by trees and other woody plants growing relatively close to each other. Traditionally, in mountain areas man has assigned three main functions to forest as 1) the production of timber and (or) other forest products (mushrooms, berries, etc.), 2) protection against natural hazards and 3) watershed protection (soil stabilization, water regulation...). Man has then exploited it regularly by entrusting these specific functions (production, protection, etc).

Nowadays, the term "forest functions" has evolved to the one of ecosystem services provided by forests. Due to the evolution of the human society, these services includes also landscape protection, fauna and flora protection, carbon sequestration, the economic sector including the whole wood supply chain.

Their economic value, the functions they must provide and the management required for maintaining and improving these functions state that forests have to be considered as a real heritage. A heritage is all the property, rights and duty of a person or a system. According to all the services provided, mountain forests are the woody ecosystems for whose heritage aspects are the most pronounced. This notion of heritage is one of the expression of the multi-functionality of these forests. So they should be considered not only as primary production units (timber production and investment income) serving particular interests but as heritage and cultural assets for the human society. So, forest ecosystems serve the interests of the community.

All these functions must be taken into account in the development of adapted forest management, forestry actions and forest policy. But according to its natural dynamics, the forest is changing and only certain stages of development meet the various functions that are expected of it. This inventory determines the first baseline that decision and policy makers have to keep in mind for defining a sustainable and adapted mountain forest action plan:

People need the forest, and the forest needs our support

The concepts of sustainable development, biodiversity and multi-functionality, have become essential for the management of natural environments. Management is the art of making decisions guided by the pursuit of goals that vary depending on the systems studied. Forest management is therefore all the means and methods used to manage a forest to ensure its ecological balance and allow it to optimize its various functions. Managing mountain forests is significantly more expensive than managing lowland forests. This is mainly due to the constraints generated by the slope and climatic conditions, but also by the ones coming from human implementations and associated activities (i.e. leisure activities that create new constraints on land uses). The main result of all these constraints is the spatially and time limited access to mountain forest resources. Merely to manage mountain forest according to the general principle of sustained yield (to use no more than the forest can produce), is currently no more efficient to sustain all the mountain forest ecosystem services.

In relation with these statements and according to the results gained by the consortium of the project NEWFOR the following 10 baselines for defining an efficient Alpine Space mountain forests action plan should be considered:

1. Mountain forests are multifunctional ecosystems but an efficient and sustainable forest management and land use strategy have to be based on the definition of priority functions. This could only be done if efficient decision support systems (DSS) are developed in order to identify, qualify, quantify and prioritize the different forest ecosystems services.

2. Such a DSS is only a tool, so it is necessary to develop a real governance policy for its uses:

- **a.** The DSS and the tools associated have to be developed using geographical information systems in order to provide maps that should be used as negotiation support with the different actors.
- **b.** The DSS and the tools associated have to be actors oriented by offering the possibility to each actor to propose is own weighting and set of priorities. The confrontation of each result then will encourage the search for consensus.

3. The prioritization of mountain forest ecosystems services has to be based on the optimization of the natural dynamics of forest stands.

4. If the production function is not sufficient for covering all the management and resources extraction costs then, as preserving and improving the efficiency of mountain forest are key points of public interest, an adapted economic context has to be settle. A specific attention should be paid to the monetisation of ecosystem services.

5. The monetisation of mountain forest ecosystems services can only be done if all the actors are identified and if the public general interest is well defined and displayed. Cost-benefits analysis should be carried on in order to clearly analyse the added value of this "bio-based" land use management. These are the necessary and sufficient conditions for the acceptance by all of this ecosystems services' monetisation. All the users or beneficiaries of these services should be clearly identified and a financial solidarity should be build up in order to help the forest owners and managers to sustainably manage the mountain forest functions of public interest.

6. All the methods and associated tools for defining and prioritizing mountain forest ecosystems services should be harmonized at the Alpine Space scale in order to develop a rational utilisation of forest resources and European funds taking into account the potential benefits and costs of actions. For reaching this goal the development of a global European strategy for providing, producing and disseminating high resolution data consistent with the outcome of the foresters' and more generally users' requirements should be pursued.

7. The access to and mobilization of mountain timber resources should be enhanced in respect to the different mountain forests ecosystems services. This also requires optimising the uses of timber and wood in the local, regional and national economies.

8. According to the specificities of topographic and climate conditions in mountain areas, the preservation and enhancement of the protective role of forest stands against natural risks have to be considered as the key drivers for the development of an efficient action plan for strengthening the liveability of the Alpine Space. This has to be done in consideration to the principle of sustainable production in order to also guarantee the sustainable use of forests as one of the most important reservoir of renewable raw material.

9. The success of all these baselines can only be guaranteed if a public awareness based on an efficient communication strategy is developed. In other terms the forester has to get out of his forest and communicate!

10. The future forest action plan should be build up on the concept that foresters and associated policy have to guarantee and leave a value environmental legacy for future generations.

Specific and technical recommendation

According to the activities conducted during the three years of the NEWFOR project, recommendations are provided in the next sections of the document. These were formulated from the project's experience in (i) applying new technologies, (ii) testing several tools with data from the Alpine Space region and (iii) using several expert hearings and feedback from stakeholders and potential end-users.

Forest structure evaluation

UAV flight planning and law limitations

Many developments in national and European legislation, related to restrictions and permission for UAV surveys, have occurred mainly during the concluding year of the project, through all the Alpine Space region. Some issues are likely to cause confusion or even be a source of problematics in handling data collection through UAV surveys. Detailed information on legislation concerning UAV are provided by the national aviation authorities and mostly also local model aircraft associations. On the website of the European Aviation Safety Agency – EASA – useful links to national UAV regulations can be found (http://easa.europa.eu/unmanned-aircraft-systems-uas-and-remotely-piloted-aircraft-systems-rpas). See also the homepage of the "German Speaking Association for Unmanned Aerial Vehicles" (www.uavdach.org) for news concerning legislation, certification, technologies and actual research in Austria, Switzerland, Germany, Italy and the Netherlands.

Recommendations for a safe and proper data acquisition:

- Follow the national legislation and certification regulations;
- Select the appropriate aircraft for the application purpose (multicopter or fixed wing aircraft). Remember to consider flight time, flight range and visibility of and to the UAV;

- Find an area close to the test-site for starting, piloting and landing. Carefully take into account that the UAV has to be ALWAYS visible from the pilot´s position;
- Care for wind and position of the sun which may cause reflection hampering visibility (blinding);
- Use automatic mode only in case you receive enough GNSS-related signals and thus proper positioning at all times;
- Preparing an intelligent flight plan saves battery, flight time and processing time. Try to hold a constant height above ground and follow a regular flight pattern. Plan a high image overlap in all directions;

For forestry applications it is better to avoid extreme wide-angle lenses due to strong radial distortions.

LiDAR data acquisition

For forestry related LiDAR data acquisitions the following recommendations are formulated:

- Minimum point density: 4 laser pulses per m^2;
- At least first and last echoes, beneficial are intermediate echoes or even full-waveforms, even if the latter require skilled personnel for post-processing;
- High positional accuracy: strip differences less than 5 cm; accuracy in XY less than the footprint size;
- Delivering the 3D point clouds and not only derived raster models;
- In addition to the 3D point clouds also the trajectory information should be delivered;
- Detailed information about the coordinate system used as well as other metadata (e.g. date and time of flight, company etc…).

Forest roads planning and industry connectivity

Nomenclature and definition parameters

The definition of a common nomenclature and standard technical parameters is definitely the most important goal to achieve within the alpine territory. Indeed, the movement of forest companies among the different countries in the Alpine Space in the last years have become more and more frequent. It is then often necessary to be able to offer to a foreign company a proper planning overview, both for harvesting and later mobilisation.

Forest road data bases

- Data must be compatible or easily convertible for integration in route guidance system because in the future transport companies will use route guidance systems for navigation and optimization/planning of wood transport.
- Upgrading the data must be done in a collaborative way by the end-users, not only forest management organizations but also transport enterprises and logging companies. Specific procedures must be defined to control the proposed upgrading (new forest roads, temporary obstacles, unpractical section both on public and forest roads).
- The qualification of forest roads should be uniform and consistent and based on European harmonized criteria.
- A good connection between the public road and forest road network need particular attention and post processing data is necessary to make sure that this connection is well established.
- According to the fact that classical field survey (men + GNSS) for forest roads mapping are highly time consuming for a low accuracy results, the research and development action on how to use automatic acquisition of data for forest road qualification (Lidar, embarked equipment in trucks….) should be followed up in order to provide a new and cheaper conventional methods. Public organizations responsible for Geographic Information have also to provide “first level” data and could provide the general frame housing the forest road data.

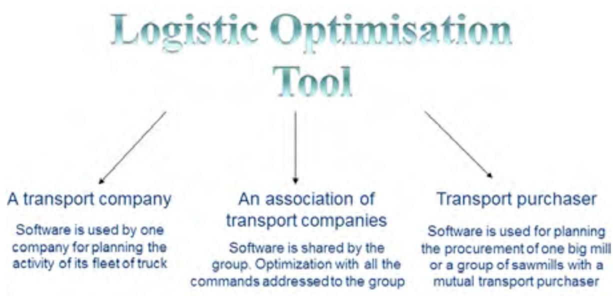
Transport planning tools

- The specific national regulations must be easily integrated and taken into account in the algorithm used for timber transportation optimization from the forest to the users (e.g. public road network with specific regulations in terms of allowable payload or with particular tax). This research of optimization should of course consider the utilization rate of the trucks fleet but also the cost of transportation, including toll and taxes.

- The softwares which will be developed in the future should be high speed calculator in order than they can quickly propose new options in case of unexpected perturbations and changes (climatic hazards, engine failure on truck or harvesting material in the forest, difficulties on forest roads, and changes in the delivery program of the mills…).
- Transport companies must work in a common way. Optimization is more efficient when possibilities of allocation are higher.
- Back haulage strategy should be taken into account in the optimization tools as it is an important lever to decrease the cost of transport when using non forest-specific truck such as tractor + semi-trailer.
- Transport planning tools must be considered in a global logistic optimization with data exchanges (Electronic Data Interchange) between all the enterprises involved in the supply chain (transport companies, logging companies, sawmills, pulp mills and chipboards mills. The objectives are to have up-to-date data for planning and a good knowledge of the wood stocks all along the supply chain: in the forest, at the roadside, in the factories.

Organisation

- New organisations must be found for an improved efficiency.
- Transport companies must work in collaboration. Sawmills should also collaborate because optimisation is more efficient when possibilities of allocation are higher.



- Transport planning tools must integrate new organisation frameworks.

Irstea
Lead partner

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Tyrolean Forest Service

Austrian Research Center for Forests

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Regional Agency for Development of Agriculture and Forestry

Autonomous Province of Trento
Flora and Fauna Department

Technological Institute for Forestry, Cellulose, Construction Timber and Furniture

Slovenian Forestry Institute

Bavarian Forest Institute
Department of Forest Management

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