Annual project report

Surge-Pro

The past development, present status and likely futures of Norway spruce in Western Ukraine, Northwest Russia and Southwest Germany - A scenario-based projection of forest resources and wood supply to support transition to green economies

Reporting for year 2021 (01.02.2021 – 31.12.2021).

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1. Scientific results

[short summary of the scientific results]

WP 1: Forest inventory data base (WP leader: SPSFTU)

For all partner institutions, three uniform templates for inventory data collection were developed. The first template is designed to collect data about Norway spruce area and growing stock per age class groups, total mean wood increment and mean age. The second template is intended for information on allowable and real harvest of Norway spruce wood and the third one asks for the impact of damaging factors on Norway spruce tree stands such as forest fires, unfavorable weather conditions (wind storm, snow break, drought, water logging), insects, diseases as well as manmade damages (air pollution, garbage dump, etc.). The time period to be covered by data was agreed to be from 1988 up to 2018 (2020 if possible).

By September 2021 the respective inventory data was collected for North West Russia (Leningrad, Novgorod and Pskov regions), for Western Ukraine (Transcarpathian, Lviv, Chernivtsi and Ivano-Frankivsk regions) as well as for South West Germany (Baden-Württemberg). As a data source mainly official forest statistic reports on country or regional levels, regional forest management plans, forest authority reports were used. Quality control, validation and verification of data were successfully done.

The acquired data was analyzed with respect to the development of Norway spruce total area and growing stock over time on regional and country levels, but also between country comparisons were conducted. Allowable and real harvest of wood and effects of damaging factors on Norway spruce tree stands were also examined. Finally, the “normal forest model” was applied to simulate the sustainable harvest level under different rotation periods.

The dynamics of Norway spruce forests (stands with >=80% stand area of Norway spruce) of the three countries appear to be different: In Western Ukraine total growing stock remains the same despite a decline in total area of 31,4%. Norway spruce forests in Northwest Russia elevate both in total area and growing stock by 34,3 % and 18,3 % respectively. In Southwest Germany (Baden Württemberg) there is evidence of decline both in total area and total growing stock by 31,6 % and 24,8 % respectively.

Allowable as well as actual harvest of Norway spruce wood is largest in absolute numbers in Northwest Russia, followed by Southwest Germany and Western Ukraine. In Western Ukraine and Northwest Russia actual harvest does on average not exceed allowable cut and make up only 81,9 % and 65,3 % of allowable cut, respectively. In Southwest Germany, actual Norway spruce wood harvest exceeds allowable cut by 27,9 % (period 2003-2018). Reasons are the plans to adapt forests to climate change and therefore to reduce the share of Norway spruce on unsuited sites aiming at more mixed-species forests in general.

Norway spruce forests suffer from damaging factors in diverse ways. The first and second important damaging factors are:

- Western Ukraine – diseases, unfavorable weather conditions (droughts)
- Northwest Russia – unfavorable weather conditions (wind storm), diseases
- Southwest Germany – unfavorable weather conditions (wind storm), insect attacks

The total absolute area of Norway spruce forests damaged by all analyzed factors is approximately the same in Northwest Russia and Southwest Germany. In Western Ukraine, the damaged area is twice as high as in the other two countries.

The application of the "normal forest model", despite of distinct differences in the productivity of Norway spruce forests such as in mean growing stock and mean annual increment per hectare, results in normal rotation ages comparable for all three countries and it appears to be in between 70-90 years and may be estimated at around 80 years of age.

WP 2: Growth data base (WP leader: VL, UNFU)

A sampling design for taking increment cores from spruce trees for the analysis of the influence of climatic factors on radial growth was developed. It was agreed to take increment cores – in close alignment to the other working packages – in spruce stands with Norway spruce share of 80% at least. Forms for taxation of sample plots have been developed.

In Ukraine, data on silvicultural and stand parameters of spruce stands were collected and processed (tree species composition, stand age, stand height, stand diameter, stand basal area, standing volume, forest type, altitude, exposure and slope) for different forestry enterprises in the territory of Transcarpathian, Ivano-Frankivsk, Lviv and Chernivtsi regions.

A reconnaissance survey of spruce stands in the territory of the eight State Enterprises and the "Synevyr National Nature Park" was carried out. 52 sample plots were selected in different forest types stratified according to age, altitude, exposure and slope. In-house data processing was carried out to determine silvicultural and taxonomic indicators of spruce stands on the sample plots. On each sample plot, increment cores were taken from the five thickest trees to study the growth dynamics of the Norway spruce stands. In total, 260 increment cores were taken.

During the 2021 field season in North-west Russia, 10 sample plots were selected along a north-south gradient in the Novgorod and Pskov regions. The description of the sample areas was done according to the developed form. On each sample plot, increment cores were taken from 10 sample trees to study the dynamics of the growth of stands of Norway spruce; the total number of cores is 100. Currently, the tree-ring width are measured by two students of the final year of the bachelor's degree in forestry.

In Germany, already existing increment data which have been collected in other research projects during recent years will be used for the comparative study. Samples taken along several altitudinal transects in South West Germany have been selected. Increment data from 84 sample trees are available and ready to be used for the analyses.

WP 3: Satellite data base (WP leader: SH, UNFU)

On the USGS Earth Explorer Hub (https://earthexplorer.usgs.gov/) we examined the possibilities to receive satellite images from different sensors for the areas of interest for all partners of the project. Because the images have considerable data volume it was decided (c.f. minutes of meeting June 16th, 2021) to use only images from Landsat and Sentinel satellites in the first step. Areas of interest were defined for all partners to be covered by satellite images.

Landsat images are available from 1980 up to now from different generations of the Landsat program (Landsat-1 to Landsat-8). It is possible to select images according to different criteria (e.g., cloud cover), hence, the limits for searching were "no cloud cover" and recording should have taken place during vegetation period (from May to October) within 5-years periods. For coverage of areas of interest for all partners, 2 scenes were required for Germany, 5 scenes for Russia, and 3 scenes for Ukraine for a one-time period. In total, we downloaded 88 scenes of Landsat images for every 5-years-time period starting from 1980 to 2020 (in 1980 no scenes available for two Ukrainian plots).

Landsat images show some disadvantages with respect to the planned usage:

1. Due to the flight trajectory and weather conditions during recording, it was not always and not for all partners possible to receive images for the same date in a given year. In consequence, there will be scenes of different days for the same time period (year), and this will have an influence on the comparability of the calculated NDVI-indexes. This is most typical for the first Landsat satellites, where the number of possible images is limited and the images have a poor resolution.
2. Landsat-7 satellite images have been defected since May 31, 2003, when the SLC (scan-line corrector) failed. With this problem, the images have wedge-shaped gaps that range from a single pixel in width near the nadir point, to about 12 pixels towards the edges of the scene. So, for some points, it could be impossible to have spectral characteristics.

Sentinel-2 images were also acquired from USGS Earth Explorer Hub for the areas of interest. For this, it was defined to start in 2015 (when this satellite was launched) up to 2020 in yearly time steps. To cover the whole areas of interest, at maximum 6 scenes are required for Germany, 7 scenes for Russia and 5 scenes for Ukraine for just one time period. Because we decided to use these images every year, there were downloaded 106 scenes in total. These images are in better condition compared to the Landsat images (especially first generations).

Images, both from Landsat and Sentinel-2 were downloaded, unzipped and stacked to receive multispectral images for all areas of interest. From the different channels, NDVI (Normalized Difference Vegetation Index) were calculated already for Landsat images. Next, NDVI will be calculated also for the Sentinel-2 image stacks.

WP 4: GIS data base (WP leader: SFTU)

Given the wide variety of GIS software that can be used for project purposes and the need for free exchange of information between partners, we decided to use the open access GIS software QGIS (https://www.qgis.org/en/site/). Similarly, for the purposes of the project, it is advisable to use data from open sources. Vector and raster data on forests in the territories of selected regions, road network, hydrological network, relief, climate and settlements are supposed to be used as the main GIS layers. A set of vector layers from web-site High Conservation Value Forest of Russia (https://hcvf.ru/en) was taken to characterize the forests of Leningrad, Novgorod and Pskov regions with respect to classes of forest vegetation cover, forest cover area gains and losses. Additional data of interest on road network, settlements, lakes, swamps, rivers and relief is possible to obtain from open geodata-sites as well as maps from websites (e.g., Bing, Google and Yandex).

It is planned to use also remote sensing data from open sources which offer additional options for image comparisons and analysis: Google Timelaps (assessment of the disturbance and dynamics of forest cover over the past decades), Landsat Explorer (assessment of vegetation indices and changes in vegetation cover), making renderings (combinations) of spectral bands on base of Landsat images archive, Sentinel Hub EO Browser (assessment of vegetation indices and changes in vegetation cover on base of the set of remote and GIS data like Landsat, Sentinel, DEM, results of automatic classifications etc.), for example, land cover classification map according to UN-FAO Land Cover Classification System.

Another valuable GIS layer is based on information about terrestrial sample plots established on study areas of all three countries with plots coordinates, tree stands characteristics as well as retrospective growth data on Norway spruce estimated by the measurement and analysis of increment cores.

Climate data, first of all air temperature and precipitation for vegetation season are important for modeling Norway spruce growth in spatial and temporal aspects. North-south temperature-precipitation gradient in Northwest Russia in comparison with elevation temperature-precipitation gradient in Western Ukraine and Southwest Germany offer a possibility to estimate the influence of possible climate changes on Norway spruce growth. The proper meteorological data from open sources will be important layer in the GIS project. As a suitable data source for time series of climate data the Climate Explorer has been identified (https://climexp.knmi.nl/start.cgi).

As a result, multilayer project GIS filled with a variety of information will offer a possibility for advanced combined cross-sectional and time series statistical analysis aimed at revealing the growth responses of Norway spruce trees/stands to environmental factors, first of all possible climate change.

WP 5: Growth simulation (WP leader: FVA)

This working package aims at modelling forest growth by use of the EFISCEN forest growth simulator. With EFISCEN, it is possible to stratify the data according to *region*, *owner*, *site class* and *species*. During project meetings, it was agreed to split site class, expressed as mean annual volume increment at reference stand age of 100 years into factor levels of width three (i.e., site class 5 refers to 4-6 m^3/ha/a). Region, owner and species (Norway spruce) is fixed by definition.

The requirements of the model were assessed and summarised. Data templates for data request were developed. Inventory data for Baden-Württemberg was analysed and prepared to be used in EFISCEN. Data from Russia was provided, for Ukraine the provision of data is expected soon.

As EFISCEN is based on many files and all parameters are distributed over these files, a R-package was developed to reproducibly run EFISCEN. So far, the package is able to prepare inventory data, estimate parameters of the EFISCEN-growth functions, supply required files and run EFISCEN directly from within R (https://www.r-project.org/). Functions exists to supply parameters for basic simulations. Functions to run different scenarios still need to be developed. To analyse the EFISCEN-output several functions exist to load and plot the generated files.

The analyses of the Baden-Württemberg data have started, particularly estimation of the growth function parameters.

WP 6 and WP 7: not yet started.

3. Contribution towards the funding initiative's specific goals

[In this program, the Foundation wants to strengthen cross-border cooperation between scholars, scientists, and academic institutions from the countries [involved in this conflict]. Thereby, it intends to contribute to building rapprochement, confidence, and understanding in the region and to maintain a dialogue with colleagues in Germany, too.]

The partnership between Albert-Ludwigs-University Freiburg, Ukrainian National Forest University and St. Petersburg State Forest Technical University persists since many years with frequent exchange between students and researchers. This tradition is enforced and sustained by the SURGE-Pro project. During the last year, monthly virtual meetings were held to keep track of the work program. Since beginning, all project members work jointly and well towards the common goal of providing insight to the development of the important tree species Norway spruce. Besides quite different ecological and administrative conditions, all involved researcher aim at advantageous compromises towards the project's goals. So far, the circumstances of the global Covid-19 pandemic and current political tension between Russia and Ukraine did not harm the collaboration and willingness between all partners. Unfortunately, planned meetings in Russia and Ukraine have not been possible due to the Covid-19 pandemic. This is a pity especially from cultural and personal perspective but also for understanding and knowledge of the partners, their institutes and ecosystems they work on.

Nevertheless, several research stays at University of Freiburg, Germany, of Russian and Ukrainian researchers is planned for 2022 and 2023. A joint project meeting in Freiburg, Germany, is scheduled for May 2022.

4. Comparison with original goals and planned objectives

[unexpected findings, other intrinsic/methodological divergence]

Besides the postponed project meeting in St. Petersburg (originally scheduled for 11th to 17th of October 2021), the original goals and planned objectives are still valid. The project milestones have been achieved and the project is on schedule. The "St. Petersburg meeting" is now planned to be held in Freiburg (16th to 20th of May 2022).

5. Gain in knowledge

[as result of interdisciplinary and international cooperation]

With the working package 1 almost ending, we gained overview on the development of Norway spruce during the last 30 to 40 years in the three partner regions (see section 1). The other working packages are quite involved in field works and preparatory works. New gains in knowledge are expected for the next year of the project.

6. Inclusion of junior researchers

SPSFTU: Two students prepare their final thesis of the bachelor's degree in forestry using the collected increment cores of the project. The students learn to measure annual tree-ring width using the station LINTAB 6, obtained during the implementation of a previous project funded by Volkswagen Stiftung (SURGE: Strengthening the Adaptive Potential of the Forests of Western Ukraine, Northwest Russia and Southwest Germany to Changing Environmental Conditions and Societal Needs – Strategies and Measures for Increasing and Sustaining the Provision of Forest Ecosystem Goods and Services).

UNFU: A master student (Ivanna Pron) worked for 5 months for the project. She assisted in sample core acquisition (preparation of paper tubes for transporting cores), data collection and field data digitization. She also prepared and defended on 20. December 2021 her master's thesis on the topic 'Peculiarities of natural regeneration of tree species in spruce forests of Holovetske forest district of the Slavske State Forestry Enterprise" (supervisor – Prof. Dr. habil. Vasyl Lavnyy).

ALU: Since September 2021 a junior researcher, Philipp Eisnecker, is employed to assist in preparatory and methodological work, in writing code for automated EFISCEN analysis as well as literature study.

7. Further perspectives and sustainable effect of the project

During a difficult situation with respect to political and sanitary issues, the project offers continued partnership and collaboration between all three member institutions of the project. Besides, new contacts between members of the different institutes could be established.

The two LINTAB 6 stations for the measurement and analysis of increment cores, acquired for SPSFTU and UNFU during the previous project SURGE, are used for increment core analysis.

8. Other aspects

[e.g. any particular advantageous or constraining circumstances, appraisal of cooperation, integration in the scientific or institutional environment]

The planned project meeting in St. Petersburg (originally scheduled for 11th to 17th of October 2021) could not be held due to the Corona-pandemic. The meeting was postponed to 16th to 20th of May 2022. Additional constraining circumstances arose due travel restrictions to Germany (vaccination with EMA certified vaccines required) and due to the political tension between Russia and Ukraine. Travel between both countries are strongly restricted and only possible by state authority permission. Hence, we plan to hold the next meeting in Freiburg/Germany.

In consequence, the planned participation at the meeting in St. Petersburg of the ERASMUS coordinator at University of Freiburg (Ms. Felicitas Höfflin-Trefzer) to deepen the partnership with St. Petersburg State Forest Technical University could not take place.