EIP-AGRI Focus Group
Forest Practices & Climate Change

MINIPAPER 3 – Prevention, Early Warning and Innovative Risk Management
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Authors

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1. INTRODUCTION

European forests are exposed to high risks resulting from climate change induced threats (changes in temperature and precipitation, changes in the probability of and vulnerability to pest occurrence, fires, storms and droughts).

In 2017 the raging forest fires in central Portugal have killed at least 72 people, in what the Prime Minister of Portugal called "the biggest tragedy" the country has experienced in years. Climate change projections suggest an increase in days conducive to extreme wildfire events by 20 to 50% in disasterprone landscapes, with sharper increases in the subtropical Southern Hemisphere and European Mediterranean Basin. A)

Beside the existential threats of forest fires in vulnerable areas the effect of climate change for forests have substantial economic, social and environmental impact. Natural disturbances caused by fire, storms, drought or insect infestation are integral parts of forest ecosystems, but intensified by climate change these disturbances represent considerable higher risks because they can destroy the valuable forest functions.

In general climate change may cause severe loss in the economic value of European forest land just because of productivity reductions**.** Little research has focused on the economic impact associated with forest fire and other climate change induced disturbances on natural ecosystems and the goods and services they provide. Although the prediction is difficult it is obvious that we have to expect huge negative economic impacts of the climate change induced disturbances on forestry in Europe.

Prevention, early warning and innovative risk management are needed to save lives and to reduce much higher economic costs for individuals and the society evolving from an inadequate dealing with the higher risk of severe disturbances.

In the last years several innovative methods and systems were implemented in European countries for forest protection. Although the forests in Europe are very heterogenous and differ in many ways forest managers can use a toolbox of adaptation measures[1)]. Beside adaptive silvicultural measures (see Minipaper 4 of this focus group) prevention, early warning and innovative risk management are an important part of adaption to climate change. These three adaption areas are needed to safeguard and increase the stability of forest stands.

The change of the climate conditions is demanding a change in forest protection and the development of an innovative risk management. Best practice examples can encourage decision makers in policy and forestry and practitioners to be open minded for new methods in this field. The aim of this paper is to rise the awareness of the importance of prevention and to show a few examples of the broad variety of new ideas and best practices highlighted in brief.

They show actions on very different levels used by individual forest owners (e.g. detecting dogs or drones) up to high tech developments like the integration of satellite imagery analysis or early warning systems for forest fires applicable on regional level by state authorities or forest research centers.

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2. EXAMPLES OF BEST PRACTICE

2.1 SYSTEMATIC PEST MONITORING TO PROTECT PINE STANDS IN POLAND AND GERMANY (BRANDENBURG AND SAXONY)

The systematic monitoring of the pine stands all over the territory is an official task of forest authorities in these states and is conducted independent of forest ownerships.
For the prognosis of pine tree pests, pheromone traps and sticky tree bands are used next to other methods. These include for example, systematic egg searches and a 'winter soil sampling'. A special advantage of this method is the assessment of the pests in numbers, vitality, reproductive potential and conclusions about the natural opponents. Further monitoring measures include moth flight and caterpillar census taking and also in the case of catastrophes, larvae assessment and excrement calculation[2]).


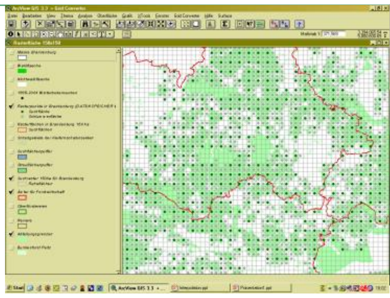


Fig. 1 winter soil sampling, fig. 2 systematic survey grid in pine stands; fig. 3 testing of vitality and reproductive potential of the samples in the laboratory of the forest research center in Eberswalde

2.2. DRONES

Over the past years, unmanned aerial vehicles (UAVs), commonly referred to as drones, have grown in popularity within forestry. Drones bridge the gap between field surveys on the ground and surveys carried out by helicopters or planes. UAVs are becoming more cost-effective and their performance is constantly improving.

Aerial images are very common in forestry for several decades for forest inventories or mapping damages. The use of UAVs to capture image data can be planned flexible and image products are quickly available. Drones are used to gain an overview of larger areas. They can fly even under heavy clouds using various types of high-resolution camera and sensors. The results can be used in a wide variety of analyses and applications (e.g. analyse water, snow, hail, storm and fire damage, monitor insect outbreaks, determine extent of dead wood, optimize skid trails in mountainous areas, count game, measure forest sites and trees, create 3D surface models).

Multicopters have a lot of advantages. They take off and land vertically. Controlled by a laptop, with live images of the flight they maintain their position and altitude by GPS based flight control even in bad weather conditions and can fly autonomously up to one hour. The level of image stability improved very much. With georeferenced digital images the location of objects can be precisely determined.

Using drones enables inventories and surveys of forests with a high degree of accuracy. Infrared images and NDVI (normalized difference vegetation index) photos enable to measure plant growth, the extent of vegetation and the production of biomass.
Because cameras and sensors can be tilted 360° in contrast to planes the recording even of slopes is very precise.

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Fig. 2 Multicopter detecting barkbeatle infestation in Thuringia, Germany. Photo: © *Carmen Rudolph*

2.3 DETECTING DOGS (AUSTRIA, GERMANY, SWISS, SWEDEN)

In several European countries, like Austria, Swiss, Sweden and Germany, dogs are trained to detect *Anoplophora glabripennis* and *Anoplophora chinensis* (ALB and CLB) and barkbeetles.

Anoplophora detection dogs have been trained at the Federal Forest Research Center (BFW) in Vienna, Austria, since 2009. They are able to differentiate the scent of all developmental stages of A. glabripennis and A. chinensis in different host species. Additionally, the dogs can not only detect empty galleries and exit holes, but also overgrown oviposition sites A new study, published in the EPPO Bulletin, proves that in outdoor tests indicating real life settings (wind, temperature, noises) 75 to 88 percent of the samples were correctly identified. Under abstract standardized conditions the percentage of correctly indicated samples was even higher, 85 to 93 percent. [3)].

Fig.3 dog detecting ALB (Foto: BFW/Katrin Grollnigg)

Fig. 4 Detecting bark beetles (Foto:T Kolbabová)

Field trials made by SnifferDogs Sweden, in collaboration with the Swedish University of Agricultural Sciences (SLU) and the Swedish Forest Agency, shows that detection dogs trained to detect and locate trees infested by bark beetles is an efficient tool to rapidly find trees recently attacked by bark beetles.[4)]

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2.4 PEST MONITORING BY SATELLITE WITH RAPIDEYE (BRANDENBURG, GERMANY) [5) 6)]

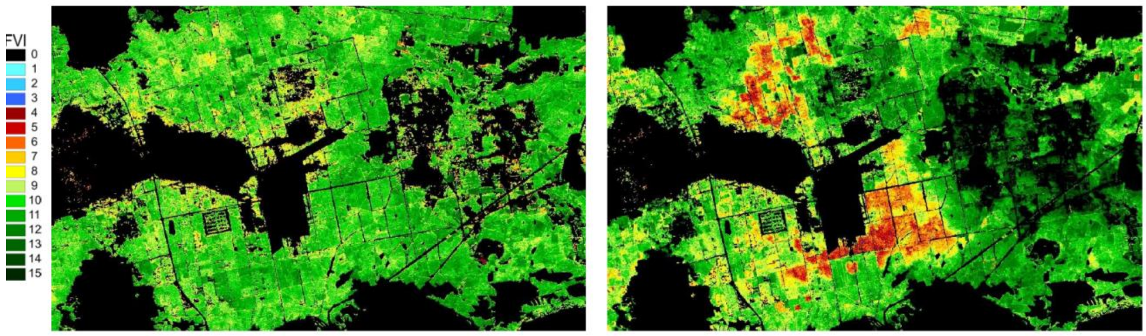
Changes due to forest health issues is a fact of nature in the forest area. For example, outbreaks of defoliating insects affect pine forests in the region each year. The locations of defoliator infestation must be detected and pinpointed to plan and execute suitable measures.

Frequent monitoring of forest health is critical to sustainably manage forest resources. Forest managers need to know the effected area, the extent and at which intensities pests, diseases, or other problems are changing the forest condition. Finding principal areas of infestation and accurately delineating damaged areas are difficult and labor-intensive activities for ground crews.

The proven statistical relationship between defoliation in pineforests infested by insects e.g. nun moths (*Lymantria monacha*) and the spectral bands of the satellite-based RapidEye sensor, including the derived normalized difference vegetation index (NDVI) and the normalized difference red-edge index (NDRE), enables a remote sensing system for forest protection.

The enterprise Planet Labs Inc. collects RapidEye-satellite imagery of the forest at high frequency within time windows specified by the Forestry Authority of Brandenburg/Germany. The results are damage and change maps derived from Planet data with adequate image analysis techniques that can be easily integrated in the existing Forest Geographical Information System (GIS) with digital forest base maps and a variety of other monitoring data such as egg counts, pupae counts, for moth count data from pheromone traps.[8)]

The analysis of the integrated data leads to a higher accuracy in delineating infestation risk areas for the next vegetation season. The damage maps are also directly used in the current season for reporting duties. Foresters use in their districts the maps to directly navigate to the infestation sites for verification. The time consuming visual assessment of defoliation intensities and in-field mapping of the spatial extent can be omitted.



L1a: FVI_2012-03-25 L1b: FVI_2013-08-06

Fig. 5 Mapping of the Forest Vitality Index (FTI) on base of an pre- and post satellite image of an pine-tree lappet moth outbreak in Brandenburg/Germany (pictures: Alexander Marx, Panet Labs Inc., berlin)

2.5 MONITORING THE STATUS OF EUROPE'S FORESTS BY SENTINEL-SATELLITES IN IRELAND

Copernicus, previously known as GMES (Global Monitoring for Environment and Security), is the European Programme for the establishment of a European capacity for Earth Observation. The Copernicus Land Monitoring Service can provide geographical information on forest extent, type, state and damage, thereby supporting rapid countermeasures and sustainable forest management.

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The sentinel-2 satellites within the Copernicus program (Sentinel 2 B was launched on 7 March 2017) provide high-resolution optical imagery allowing services for forestry.

The aim is to improve the satellite-based damage detection by developing an integrated, multisensory (e.g. Sentinel-1, -2 and -3) earth observation system for forest damage monitoring in forests, to enhance Earth observation based support for forest authorities and to install an integrated forest management systems using satellite and in situ data[8)]

The use of the satellite imagery enables a damage assessment at local and regional scales and a rapid mapping of windfall areas and to produce pre- and post-storm situation maps

Fig. 6 The map shows extensive damage (orange) of significant forest areas in several provinces of the Limerick County, Ireland. The damage was caused by a series of storm-force winds and heavy rainfall events occurring between 5 December 2013 and 12 February 2014.Source: GIO EMS Mapping; Based on: Pléiades [9)]

2.6 THE "FIREWATCH-SYSTEM– AN AUTOMATED EARLY DETECTION OF FOREST FIRES

The **FireWatch system** uses an Optical Sensor (OSS) developed by the German Aerospace Centre, originally made for a space mission. IQ Wireless Ltd brought it into production in collaboration with the forest public service of the German Federal State of Brandenburg.

Today,175 sytems are installed in Germany and 112 several other states in Europe (Lithuania 82 , Estonia 5, Cyprus 2, Spain 4, Portugal 1, Slovakia 18). 20 installations are outside the EU (Kazakhstan 9, Mexico 2, USA 6, Chile 3).

The sensors are mounted on towers, cell phone masts or high buildings. Each sensor turns on its axis once every 4 to 8 minutes (depending on the setting), analyzing up to 700 square kilometres (70,000 hectare). The cameras are able to distinguish barely detectable smoke clouds from the 16,000 greyscales in a radius of up to 15 km with a minimum size of 10m x 10m.

Forest fires can be detected at an early stage by day and night. As soon as the camera spots what may be smoke, it acquires images and sends them to the forest fire centres, where the coordinates of the fire are automatically determined and shown on a map.

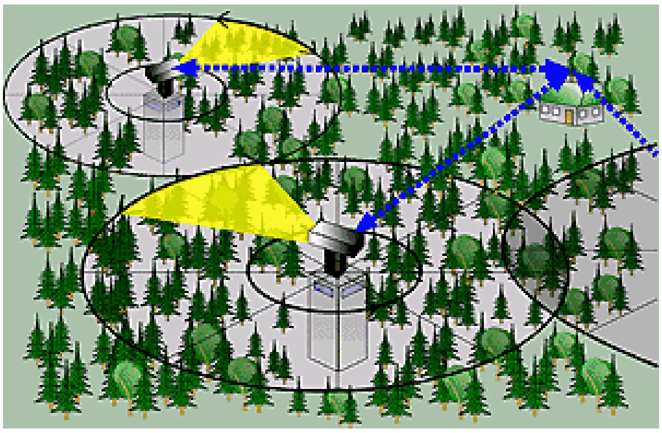

Fig. 7: Automated Forest Fire Monitoring System "Fire Watch". Sectors and images are shown on a monitor; the detected fire location is identified on a topographical map. (Source: IQ wireless Ltd)

As a result of the installation of firewatch the early detection and fast deployment of the fire service, the average forest area destroyed by fire is reduced. About 60 % of all forest fires in Brandenburg were discovered by the sensors. The system is being continually developed.

Fig. 8 Alert of the system "firewatch"

2.7 THE USE OF SENTINEL TREES

Sentinel plants can be an early warning method against alien species. In this method, trees are strategically distributed along areas where invasion risks are higher in order to quickly identify alien species invasions at the importation country, and define eradication or mitigation strategies. But sometimes the knowledge about these new species it's not enough to allow phytosanitary inspectors to act, because the symptoms are not recognizable in the autochthonous trees.

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Several projects in Europe are establishing sentinel nurseries or using foreign trees already existing in botanical gardens and arboretums, to study the effects (signs and symptoms) of the pests and diseases on those trees in order to provide the phytosanitary inspectors at the plant importing countries with the necessary identification tools (diagnostic support). [10), 11),12)]

2.8 RESEARCH PROJECTS

"WAHYKLAS" - FOREST HEALTH ADAPTATION STRATEGIES TO MITIGATE INCREASING HARMFUL EFFECTS OF PATHOGENIC ORGANISMS IN CLIMATE VULNERABLE REGIONS UNDER INCREASING RESTRICTIONS.

The joint project of several German forest research centers aims to develop sustainable healthy forest concepts for selected regions in Germany, which either currently or in the future are expected to be highly vulnerable to the effects of climate change, globalization, and agglomeration. The study area extends along a diagonal transect from southwest to northeast of Germany, connecting similar sensitive habitats with limited water availability and under increased heat conditions. Therefore, the expected results obtained in this case study can be transferable and used for predicting future conditions and mitigating adverse effects. The project focuses on adapted tree species (oaks and pines), which are characterized by a wide ecological amplitude and are very important for the future forestry. The investigations aim at promoting the natural resilience, adaptation and optimization of diagnostic, monitoring and prediction methods, as well as to future oriented forest protection with broad acceptance of the society. [13)]

„DSS-RISKMANN" - DECISION SUPPORT FOR THE ALLOCATION AND LIMITATION OF RISKS ARISING FROM CLIMATE CHANGE IN FORESTRY

In the face of climate change site conditions will change within a production period. Information commonly used in forest management planning needs to be supplemented by dynamic risk prognoses and adaptation strategies derived from models.

The aim of the project DSS-RiskMan is to develop an information and decision support system, accessible via the internet, for the estimation of risks and for the adaptation of forest management at the level of forest stands or site units.

Risk management requires detailed knowledge of the different risks associated with each tree species, to obtain tree species-specific risk profiles. Complex interdependencies among environmental influences should therefore be determined by quantitatively modelling the vectors of the most important specific risks and then, with the aid of a survival model, combining the individual risks to obtain an overall risk by site and by stand. This information forms the core of the decision support model strived for, with which the expected risks for a given site can be assessed. This model would be effective both in the long-term planning process in the case of tree species selection as well as in medium-term planning of the direction of forest development, from stand establishment through to the harvest.

In forest management, actual decision support would be provided by digital risk maps and tree species suitability maps based on the risk profiles modelled.

In view of the existing database, the system is initially being developed for north Germany. However, the methods applied will enable a stepwise expansion to other regions in Germany.[14)]

„LIFE HEALTHY FOREST" - EARLY DETECTION AND ADVANCED MANAGEMENT SYSTEMS TO REDUCE FOREST DECLINE CAUSED BY INVASIVE AND PATHOGENIC AGENTS

The main objective of LIFE HEALTHY FOREST project is the design, application and monitoring of advanced methodologies to achieve a more sustainable forest management at EU level in the field of control and prevention of forest decline caused by invasive and pathogenic agents taking into account both their environmental and socio-economic impact. Two of the specific objectives of this project are directly related to

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early detection: 1) Implementation of the early detection system in large-scale demonstration plots, giving a comprehensive vision of the status of forest health, as knowledge base for the EU policy; 2) Development and implementation of a GIS infrastructure for the estimation of economic and environmental impact of forest decline, causal agents and the detailed proposal of forest management activities applicable in the EU, assessing a key set of protocols of early detection of decline at different levels.

3. CONCLUSIONS

The chosen examples show the wide range of possible technical methods useful to adapt to the challenges of climate change in forestry. Especially for forest protection new innovative high-tech solutions (satellite imagery analysis, automated early detection of forest fires, drones with specialized sensors) were developed in the last years and are ready to use by forest practitioners now.

But also less expensive and man-power based techniques like the example of the winter soil search in pine stands or the sniffer dogs for barkbeatles and quarantine pests are parts of the toolbox.

Only with the help of forest agencies, research centers and state authorities it is possible to get these tools in the European forests into practice. The majority of the forests is owned by private owners, often family enterprises. The forest owners structure requires state aid to implement adequate new tools.
It is a task of the European society, especially the member states of the EU, to safeguard the implementation of new prevention, early warning and risk management techniques.
Knowledge transfer of new techniques for adaption to climate change is crucial.

4. IDENTIFIED RESEARCH NEEDS

1. How to transfer best practice examples to other regions/states.
2. Define data for insurances for drought and pest damages.
3. Remote Sensing/Satellite imagery: How to provide access to analyzed data.

5. IDEAS FOR INNOVATIONS

Ideas for innovative projects/ solutions

1. The development of Innovative training seminars (smart tool kit) to the staff of Forest Authorities to use effectively satellite imageries and earth observation data to map dry soil conditions and drythermic types of vegetation, as forest fires often occur over these areas. These tools will support forest authorities to be able to make decisions to mitigate risk of fires.
2. The development of intelligent technologies (early warning, satellite imageries and maps etc.) to tackle and response to natural or man-induced forest disasters. These new, innovative technologies will make forests healthier and better able to withstand- and even take advantage of the effects of climate change.
3. Computer applications in sustainable forest management. The development an innovative digital forestry, as digital forestry is the science, technology and art of systematically acquiring, integrating, analyzing and applying digital information to support sustainable forests (Zhao et al. 2005).

6. POTENTIAL EIP operational groups

1. "Effects of climate smart silviculture on carbon stores and forest resilience in Europe"

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2. "Development of early warning system applied to forests (related pests, vitality loss) mainly based on remote sensing techniques"

Further research needs coming from practice, ideas for EIP AGRI operational groups and other proposals for innovation can be found at the final report of the focus group, available at the FG webpage **https://ec.europa.eu/eip/agriculture/en/content/focus-groups/new-forest-practices-and-tools-adaptation-and**

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