STUDY ON USER REQUIREMENTS FOR REMOTE SENSING APPLICATIONS IN FORESTRY

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ABSTRACT:

State forest administrations in Central Europe have to adapt to future climatic and socioeconomic conditions. This results in new demands for actual and precise forest information - especially in regard to increasing forest damages by natural hazards. Therefore the data requirements of professional foresters were investigated to derive development goals for remote sensing applications in forestry. A questionnaire was sent to 655 professionals in Southern Germany and answered by 347 of them. Two third describe deficiencies in their forest information and 90 % of them expect improvements by the application of remote sensing techniques. The majority of the professionals want to be supported by a forest information system integrating existing data bases and remote sensing derived information. More than 200 examples were defined for the potential use of remote sensing applications. The majority of the examples are related to the management of natural hazards and the consulting of private land owners. Improvements of the present situation are expected especially by annual updates of the forest data bases at stand level resolution.

1. INTRODUCTION

Remote sensing is expected to become more important for sustainable forestry in Central Europe. The main reasons are a growing number of geospatial applications, the reorganisation of the forestry sector, and the need to improve forest management especially in regard to forest damages caused by increasing natural hazard frequencies. The study therefore arises from the expected problems of information availability for sustainable forest management and addresses the information needs of forest professionals for remotely sensed forest information in Bavaria/Southern Germany.

2. INFORMATION NEEDS

An inventory of existing literature detected several user need assessments in forest remote sensing from regional to global scales (International Institute for Aerospace Survey and Earth Sciences, 1999; Beule et al., 2004; Institute of Digital Image Processing, Graz et al., 2000; Schneider et al., 1998; Blaschke, 2002). In a globally comprehensive study the user requirements for remote sensing based spatial information in sustainable management of forests were collected from all countries (International Institute for Aerospace Survey and Earth Sciences, 1998) and can be used as a reference:

- The most spatial information is needed in regard to planning/implementation, monitoring/assessment, area demarcation/mapping and policy development/advising.
- The highest demand for remote sensing data exist in the fields of determination of forest area and its change, thematic mapping including past decades, monitoring of species and biodiversity, land use and forest land classification, forest production, and site classification.
- New remote sensing data should be distributed annually or at least every 5 years.

2.1 Demand on regional level

In a workshop user requirements for remote sensing applications were collected from 21 experts of the Bavarian State Forest Administration using business process analysis techniques (Rosenkranz, 2006). As a result the following regional processes and demands for remote sensing were documented:

2.1.1 Surveillance of sustainable forest management: The national forest inventory is not sufficient for the purpose of the state forest administration. Therefore a method is required to conduct a low cost regional forest inventory to quantify the forest area, forest age classes, tree species composition, vertical and horizontal diversity, forest stand height and density, growing stock and increment, and areas of damaged forest. The data are required on forest stand level and should be collected at least every 5 years. The regional inventory would improve the surveillance of a sustainable forest management of all forest owners - especially in regard to the detection of cleared areas and losses of growing stock. It could be used by further processes described below.

2.1.2 Forest protection: The terrestrial detection of insect pests is time consuming and therefore always fragmentary. Hence remote sensing technologies are needed to improve the early localisation of the origin of pests, the prognosis of the propagation, and the development of treatment plans. The information is needed every week during the critical development phases of insects and has to focus on the detection of single tree species, dead wood, and defoliation on stand level. In the case of large scale abiotic and biotic calamities ad hoc data of damaged areas, damage intensities, affected tree species, volumes of damaged timber and reforestation areas are needed on stand level.
Large-scale monitoring of the forest condition is presently based on the annual terrestrial surveys. In order to reduce monitoring costs remote sensing can be used to determine tree species, tree age, defoliation, discolouration and other visible

damages on tree level at the inventory points. The new procedure must coincide with the monitoring standards of the last years to continue the present time series.

2.1.3 Nature conservation: The management of nature conservation areas (e.g. Natura 2000) should be supported by remote sensing. Besides the information of a new regional forest inventory, specific parameters have to be collected in the protected areas e.g. dead wood volumes on stand level, single biotope trees and specific topographical/hydrological features. The linkage of protection areas to biotope networks needs remote sensed data of linear biotope structures in open areas (i.e. hedges) and of the fragmentation effects by infrastructure.

2.1.4 Forest Planning: Planning tasks generally can be improved by the results of a new remote sensed based regional forest inventory. Within the mapping of forest functions specific tasks are the distinction of forest and open areas and the classification of stand structures in regard to habitat, landscape and recreational functions. In the case of the management of mountain protection major inaccuracies can be eliminated by a detailed detection of open forest areas, bare land and avalanche zones. For the rehabilitation of mountain protection forests 5-year information on tree species composition, vitality, regeneration, ground vegetation, forest gaps, snow height and snow dynamics should be supplied on stand and tree level respectively.

2.1.5 Advice and financial support: The technical advice of forest owners shall be improved especially in regard to the expected climate change aspects. Therefore an integrated information system is requested, which combines the results of the regional forest inventory with data about forest owners as address, forest ownership and financial aids. For the control of granted subsidies very detailed information on project areas ($\pm 10 m^2$), species composition (±5%), individual trees (i.e. biotope trees) and unstocked areas ($\pm 10 m^2$) are needed.

2.1.6 Public awareness: Forest management relies on the support by the public. Forest development and human intervention must be understood by the people (e.g. the adaptation of the present forest to climate change conditions). Therefore the results of the remote sensing applications play an important role for the information of the public with quantitative data and visual media.

2.2 Demand on local level

A census of the forestry professional staff at the local forest offices in Bavaria was conducted to derive the information requirements on local level. The postal questionnaire (Atteslander et al., 2008) consists of three parts: (a) Questions on existing information gaps and presently applied remote sensing techniques (4 multiple choice questions and 1 open question). (b) Questions on potential fields of application for remote sensing and on requirements for the determination of forest parameters (12 multiple choice and 4 open questions). (c) Voluntary personal information to build up a user panel.
The questionnaire was distributed to 655 individuals anonymously. The evaluation of the questionnaire took place by classification procedures for open questions and descriptive statistics. 347 persons (52 %) responded to the questionnaire.
The results of the questionnaire were used to answer the following research questions:

2.2.1 Can any benefits be expected from remote sensing applications for forestry practice? Two-third of the respondents indicated, that they can not sufficiently fulfil all duties, because the required information is not available. 90% of them expect that the information gap can be closed by remote sensing.

2.2.2 Which remote sensing techniques are applied at present? One-half of the respondents interpret visually official aerial photos and satellite images from the internet. Frequently agricultural information systems, which contain remote sensing applications, are applied for forestry tasks.

2.2.3 What are the priorities for a better application of the present remote sensing techniques? Two-third of the respondents awaits a major improvement by more actual remote sensing products - especially aerial photographs. One half expects more information by a better quality of remote sensing data. One fifth of the respondents claimed a higher repetition frequency by high resolution remote sensing techniques.

2.2.4 What are the future potential fields of application for remote sensing in forestry? 217 potential applications for remote sensing were proposed. The main application fields are the management of forest damages caused by natural hazards and the consulting of private forest land owners.

2.2.5 Which forest parameters have to be addressed by remote sensing applications? Out of 63 forest parameters the determination of tree species composition, forest areas, forest boundaries and forest stand heights are the most relevant (Table 1). This information should be available on an annual base and at least updated every 5 years. In most cases there exist no constraints concerning the recording period during the year. The spatial resolution of the delivered information should be at least on forest stand level.

Parameter	Relative frequency
Tree species	12%
Area of forest, forest stands or damages	11%
Boundary of forest, stands or damages	9%
Stand height	9%
Growing stock	5%
Forest stand age	4%
Forest stand density	4%
Location of logging roads	4%
Broadleaved/conifer stands	3%
Succession type	3%
Vitality	2%
Insect pests	2%
Forest gaps	2%
Forest regeneration	2%
Tree species mixture	2%

Table 1 Ranking of the 15 mostly mentioned parameters to be collected by remote sensing

2.2.6 How should forest professionals be supplied with remote sensing products? Two-third of respondents prefers to work with standardized remote sensing products available through a spatial forest information system. One tenth of the staff would use remote sensing data directly or have a demand for case specific data analysis by experts.

3. CONCLUSIONS

The survey showed a high demand for additional forest information concerning most duties of a state forest administration. A comparison of user requirements with available remote sensing technology shows, that the most parameters can be determined by remote sensing methods (Falkowski et al., 2009) or in combination with existing geospatial forest information (Förster, 2008). Therefore it can be foreseen that the integral development of remote sensing based geospatial forest information systems may remove most of the existing information gaps.
The results of this study are generally in line with the findings of other studies from local to global level. Even though there exist differences in the spatial resolution and ecological conditions there appear to be strong similarities in the requirements profile for remote sensing applications in forestry and forest administrations. Therefore new remote sensing products for forestry can be developed according to the demands of the global market.

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