Wildland Fire and Fuel Modelling in the Swiss National Park

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INTRODUCTION & GOALS

Switzerland does not count as a wildland fire hotspot area. Nevertheless, every year approximately 90 forest fires occur in Southern and Eastern Switzerland, namely in the cantons of Valais, Ticino and Grisons. Changing land and forest use practices have altered vegetation growth patterns. Due to declining management measures, fuels are building up in remote mountainous forested areas. This process is very visible in the forests of the Swiss National Park (SNP), where Swiss Federal law protects all natural processes occurring within the borders of the SNP ever since it was founded in 1914. Natural wildland fires are counted among them and should not be extinct. In the IUCN category 1 national park strict nature conservation represents the primary goal. Except for the maintenance of the national road network no management and mitigation measures are allowed unless the park is put at risk in its very existence (Allgöwer *et al.* 2005).

At present all fires in the SNP are extinct. Due to Swiss Federal Legislation concerning the SNP (Nationalparkgesetz 1980), the SNP is confronted with the question whether fires should be extinct or not. Almost 100 years of strict nature protection have triggered fuels to build up to the point where natural fire cycles could come into play again. Paleobotanical studies also show that there has been a natural fire regime in the Ofenpass area during the Holocene. Fire cycles seemed to last approximately 250 years and where closely linked to the still dominant tree species of the area, the Mountain Pine *Pinus mugo* ssp. *uncinata* (Stähli *et al.* 2006). Pine species are known for their fire prone characteristics. Many of them are well adapted to fire, e.g. by serotinous cones that only open when exposed to fire. Their high content of etheric oils also render them highly flammable.

In order to properly decide where and why fires can be left to themselves and where, how and when fires need be extinct a so called fire management plan (FMP) is needed. The presented ongoing study is concerned with the fuel model part of the FMP for the Swiss National Park and is based on high resolution aerial photographs of the year 2000 (HABITALP data set) covering the whole SNP and its surrounding areas. Based on formerly developed fuel model values, the goal of the presented MSc thesis is to create (analogue and digital) maps of fire intensity and fire spread for the SNP on which decisions like suppression vs. non suppression can be made.

MATERIAL & METHODS

Study area

The SNP is situated in the Southeast of Switzerland in the middle of the Engadine Valley, Canton of Grisons, Switzerland. Rugged topography, Dolomite limestone and little precipitation (900 mm per year) create harsh environmental conditions. Forests cover one third of the Swiss National Park (Allgöwer *et al.* 2005). It covers an area of approximately 170 km^2 (see also Fig. 1).

Fire Management Plan (FMP)

A fire management plan contains all the fire relevant data of an area of interest and foresees all the necessary measures to be undertaken in the context of fire. It requires to be customized to the goals of the institution it is defined for. The principals have been developed in the 70ies and are still valid. Simard (1976) defines the FMP as *"the application of management, physical and ecological principles to the management of the wild fire process so as to render the impact of wildland fire on the natural resource base, the ecosystem and the environment consistent with the goals of the managing organisation. Wildland fire management includes the traditional fire control related activities (suppression, detection, etc.) as well as broader relationships between fire and wildland management, such as prescribed fire and fuel management".* Chandler *et al.* (1983) propose an extended list of thematic and spatial data of which fire occurrence, fire history, fuel inventories, topography, water catchments, and weather and climate as well as human infrastructure facilities and resources dedicated to fire management are the most important ones.

Fire history

Of the mentioned data fire occurrence and fire regimes have been investigated in former studies, reaching as far back as the Holocene (Stähli *et al.* 2006), touching the recent fire history of the past centuries with dendrochronolgical methods (Bur 2007) and finishing with a spatio-temporal analysis of today's fire situation (Langhart *et al.* 1998).

Fuel data acquisition and introduction to fire modelling for decision making

Specific SNP fuel models were established in former investigations (Allgöwer *et al.* 1998) and introduced to GIS-based fire propagation modeling (Schöning 1996/2000, Bachmann *et al.* 1997), together with a high resolution remote sensing campaign in 2002, which was based on LIDAR (Morsdorf *et al.* 2004) and Imaging Spectroscopy (Koetz *et al.* 2004.) So far six fuel models exist for Switzerland, three of them are customized to the coniferous mountain forests of the SNP area.

Most fire modelling applications are based on a semi-empirical model which was developed by Richard Rothermel in 1972 for the US Forest Service (Rothermel 1972). FARSITE, the most famous and robust implementation of the Rothermel equations, was developed by Mark Finney and Rob Seli from the Missoula Fire Sciences Laboratory at Missoula, Montana, USA. In the present study FARSITE is used for computing fire growth and fire behaviour. FARSITE requires input variables, coming from a GIS system. Topography (slope and aspect), wind and fuel data are the minimal requirements. FARSITE works in a deterministic way and thus allows relating results directly to the various input variables. To create a series of possible fire occurrence and propagation scenarios wind and weather scenarios are derived from nearby weather stations as well as lightning occurrence maps, provided by the Swiss Meteorological Service (Meteoswiss).

Transforming HABITALP data into fuel type maps for decision making

The present study concentrates on how to produce large scale fuel maps for the whole of the SNP and how these data perform in fire propagation modelling. The HABITALP data set is based on high resolution CIR (color infrared) aerial photographs of the year 2000 in the scale of 1:10'000. Orthophoto pixels represent a ground resolution of 20 cm. The HABITALP classification key contains a total of 8 main and 140 subclasses that differentiate the main classes. Forests types and stands are characterized by species, species mix, age classes and fractional cover (Haller *et al.*, in print). These data are reclassified into fuel types and combined with the existing fuel model data of the SNP. Within FARSITE different fire behavior scenarios are calculated in order to create maps of various fire intensity and fire spread. These maps are again input for the decision making process.

RESULTS

Results of the still ongoing MSc project are a number of different wildland fire occurrence and propagation scenarios, based on typical weather and wind scenarios the different forest type classes of the HABITALP data that have been turned into fuel maps and. The scenarios consider both, natural and human induced fire situations for the overall fire risk analysis. Based thereupon priority areas for fire suppression and fire allowance are distinguished. Of particular interest are areas with high density, especially within the fuel models for Mountain pines (*Pinus mugo* ssp. *uncinata*). In parallel, this MSc thesis also provides insights into complex data handling questions and online mapping services.

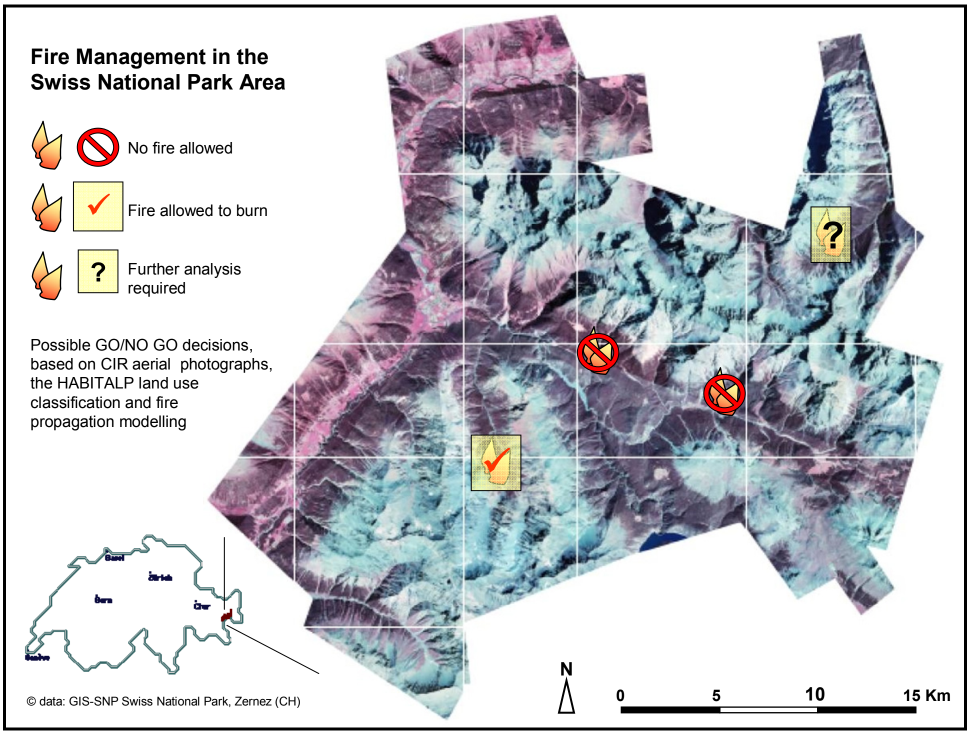

Fig. 1: Fire management scenarios in the Swiss National Park – GO / NO GO decisions, shown on the CIR aerial orthophoto mosaic covering the SNP area and its surroundings. (© all data: GIS Swiss National Park, Zernez, Switzerland)

CONCLUSIONS & OUTLOOK

The outputs of this master thesis can be used in several ways for the benefit of national park managers, fire fighting services and other relevant administrations (i.e., forest services of the surrounding communities). First of all the results can be used to establish fire risk classification schemes for the SNP during weather critical periods. Secondly, they can serve as a basis for taking decisions, where, why, when and how fire should be suppressed or left burning. Together with all the previously obtained results (i.e., for long-term fire history and fuel properties) a detailed Fire Management Plan (FMP) for the Swiss National Park can be elaborated. Since this FMP needs to consider both, nature conservation goals and societal requirements alike, it may serve as a model FMP for other forested nature conservation areas in the Alpine Arc.

REFERENCES

Allgöwer, B., Stähli, M., Bur, M., Kötz, B., Morsdorf, F., Finsinger., W., and Tinner., W. (2005). Long-term Fire History and Remote Sensing Based Fuel Assessment: Key Elements for Landscape Management in the Swiss National Park, *In: Kaserer S, Bauch, K. Hohe Tauern National Park, ALPARC*, editor; 2005 September 15-17, 2005; Kaprun, Austria. Network of Alpine Protected Areas & Hohe Tauern National Park Council, 11-14

Allgöwer, B., Harvey, S., and Rüegsegger, M. (1998) Fuel Models for Switzerland: Description, Spatial Pattern, Index for Crowning and Torching. In: *Proceedings of the 3rd International Conference on Forest Fire Research / 14th Conference on Fire and Forest Meteorology,* D.X. Viegas (ed.), Luso, Portugal, November, 16 – 20, 2: 2605-2620

Bachmann A., Schöning R., and Allgöwer B. (1997) Feuermanagement mit Geographischen Informationssystemen. *Geographica Helvetica* 52 (1): 27 – 34

Bur, Michael (2006). Verbrannt oder geschlagen? *Eine Untersuchungsmethode zur Rekonstruktion der rezenten Feuer- und Holzschlaggeschichte der Wälder des Schweizerischen Nationalparks*, Diplomarbeit Geographisches Institut, Universität Zürich, pp. 239

Chandler, C., Cheney, P., Thomas, P., Trabaud, L. und Williams, D. (1983). *Fire in forestry*, John Wiley & Sons, New York.

Haller, H., Schwabe, B., Allgöwer, B., Hauenstein, P., (2008, in print) Eine Flächendeckende Landschaftsinventur als Basis für die Beschreibung der Wald Entwicklung im Schweizerischen Nationalpark, *Bündner Wald* (in print)

Kötz, B., Schaepman, M., Morsdorf, F., Bowyer, P., Itten, K, and Allgöwer, B. (2004) Radiative Transfer Modeling Within a Heterogeneous Canopy for Estimation of Forest Fire Fuel Properties. *Remote Sensing of Environment*, 92 (3): 332 – 344

Langhart, R., Bachmann, A., and Allgöwer, B. (1998) Spatial and Temporal Patterns of Fire Occurrence (Canton of Grison, Switzerland). In: *Proceedings of the 3rd International Conference on Forest Fire Research / 14th Conference on Fire and Forest Meteorology,* D.X. Viegas (ed.), Luso, Portugal, November, 16 – 20, 2279-2292

Lotz, A. (Ed.), 2006, Alpine Habitat Diversity – HABITALP – Project 2002 – 2006. EU Community Initativ INTERREG IIIB. Apine Space Programme. Nationalpark Berchtesgaden, pp. 196

Morsdorf, F.; Meier, E., Kötz, B., Nüesch, D., Itten, K., Dobbertin, M., and Allgöwer, B. (2004) LIDAR Based Geometric Reconstruction of Boreal Type Forest Stands at Single Tree Level for Forest and Wildland Fire Management, *Remote Sensing of Environment*, 92 (3): 353 – 362

Nationalparkgesetz 1980. Bundesgesetz über den Schweizerischen Nationalpark im Kanton Graubünden vom 19. Dezember 1980 (Nationalparkgesetz)

Schöning, R. (1996/2000) *Modellierung des potentiellen Waldbrandverhaltens mit einem Geographischen Informationssystem,* Diplomarbeit, Geographisches Institut Universität Zürich, Abt. Geographische Informationsverarbeitung/Kartographie, Zürich, in Geoprocessing Series Vol. 29 (2000), pp. 140

Simard, A. J. (1976). "Wildland fire management: the economics of policy alternatives." *Forestry Technical Report 15,* Department of Fisheries and Environment, Canadian Forestry Service.

Stähli, M., Finsinger, W., Tinner, W. and Allgöwer, B. (2006). Wildfire history and fire ecology of the Swiss National Park (Central Alps): New evidence from charcoal, pollen and plant macrofossils. The Holocene: 16 (6): 805 – 17