Green Book Two

Towards a Common Approach:
Fire Prediction Systems in the Baltic Sea Region

Editors' Letter

This Notebook is one of nine in the Fourteen Point Three Notebooks collection brought together by the European Union Strategy for the Baltic Sea Region flagship project 14.3 (read: fourteen point three).

Eight Notebooks will present you with findings from our project's four different working groups (named Task Groups C, D, E and F), and one Notebook will introduce a general overview of the whole project.

We hope that the collection as a whole will give you a sense of the unfolding diversity and complexity of the project, whilst retaining homogeneity as a single vision and ideal.

The singular Notebooks present concrete results (studies, workshop reports, developed methodologies and scenarios). The structure of the entire collection intends to act as a mirror for the project as a whole, and to reflect on the process as much as the output. Each of the books can be read singularly as a study presenting concrete findings from working groups, at the same time they can be read as a collection. Manifested together we view this as the symbolic added value brought to the macro-regional conversation by the project 14.3.

These values could be: the network, the will for cooperation in general terms, the challenges in finding a uniform language among different civil protection cultures and traditions, and the motivation to find commonality amongst the different departure points.

Green Book One and Two bring you the body of the Task E work. Task E was one of the three, as we call them, "thematic tasks" of the project 14.3. This means that the Task E working group focused on one thematic-hazard, namely Forest Fire.
A precisely focused aim was determined by the group of six Baltic Sea region countries that participated in the Task. These experts set out the aim from the very beginning of the process: to find out whether a macro-region in which every country uses a different forest fire rating and prediction system, would benefit by adopting a single system, and if so what would be needed to develop such a system.

The 18 project months were too short to draw definitive conclusions regarding such a demanding and complex matter. However, it was enough time for this one group of experts to discover that a common macro-regional approach may not necessarily mean the adoption and use of one management and prevention system only. It may also mean a common attitude towards the value of shared experiences between the countries in the region. This understanding could only be borne by the actual practice of this getting-to-know one another and gathering. In order to arrive at such an understanding, a routine practice of sharing needs to be established. Task E of the project 14.3 took the first step towards this needed routine exchange in a macro-regional context.

It is our pleasure and honour to be sharing with you this vision of cooperation through our Green Books in particular, and the Fourteen Point Three Notebooks in general.

Editors of Fourteen Point Three Notebooks
Egle Obcarskaite – Anthony Jay Olsson

Summary of the Project

14.3 was a project implemented under the EU Strategy for the Baltic Sea Region (EUSBSR), Priority Area Secure (Priority Area 14 in the 2009 version of the EUSBSR Action Plan). The whole priority area calls for an insurance that contributions in the field of civil protection encompass the overall Strategy objectives (save the sea, connect the region, increase prosperity). The project 14.3 responds specifically to the objectives through addressing the necessities of bringing together and coordinating civil protection stakeholders and bolstering the capacity of individual countries, in order to ensure our region's uniform resilience to macro-regional risks.

14.3 was developed from a belief that considering the nature of the world that we live in today, only by ensuring a proper level of resilience on a macro-regional level can we ensure a higher level of resilience and preparedness on the national level as well.

Project 14.3 was a pioneering effort. →

Not only for addressing the topic of macro-regional risk in the Baltic Sea region (before this project there wasn't even a common concept discussed among the countries in the region), or for bringing up a complex all-hazards approach, but also for bringing together a partnership consisting of all countries in the region, to not only discuss and share but develop together a strategic approach to civil protection. As such, it thus constitutes a shift in the whole paradigm of the way civil protection may be conceived on a macro-regional level.

Why it is only now that 14.3 could have happened? →

Some say because there was previously never this level of openness in sharing information on civil protection tools and methods among different countries in the region; this could not have been imagined twenty or even five years ago. Others say it was because countries in our region finally openly recognized their individual vulnerability, as well as the fact that there may be situations to which even the most resourced country would face the need to ask for assistance from a neighbour. 14.3 partners came together admitting it straight: it is not enough to ask – you have to be ready to receive assistance.

Pioneering efforts also meant that 14.3 was a daring effort. →

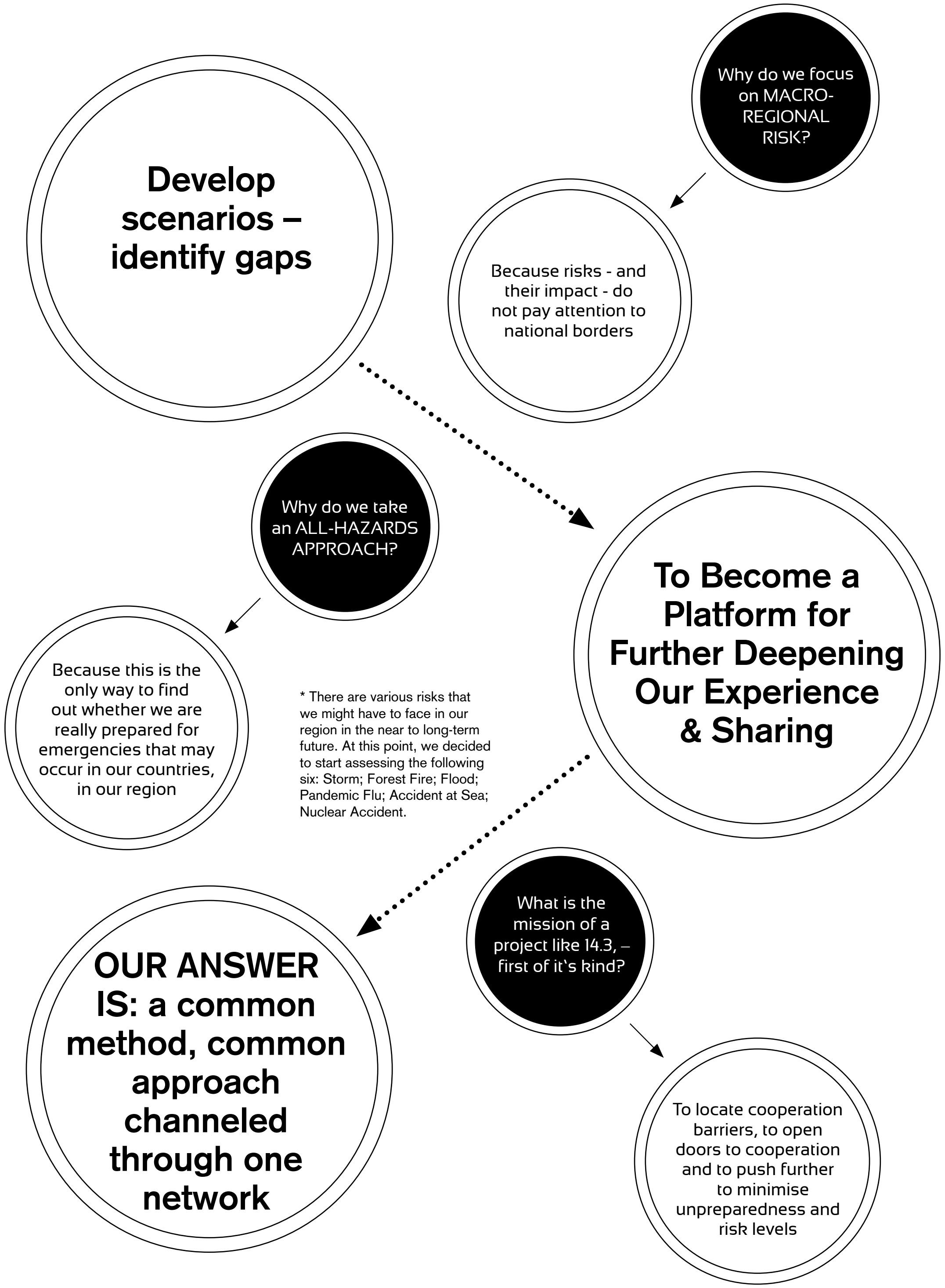
This was especially visible in how the all-hazards approach had to be adopted for the project. All-hazards approach is a challenging claim even on national level, as it requires crossing administrative and institutional boundaries. Which is the best way to achieve this? The answer is yet to be formulated.

Project 14.3 proposed to take one step at a time and responded to the all-hazards challenge through structuring the project in four thematic tasks. There were three tasks dealing with the following hazards: floods, forest fire and nuclear accident. Whereas one task – Task C – engaged in an overall strategic discussion on how can risk be assessed and analysed on a macro-regional level, and how a common risk-discourse can decrease societal vulnerability of each singular country in the Baltic Sea region, as well as that of the macro-region as a whole.

Working Together on Macro-Regional Risk.

Project 14.3

Was the First Time that the Countries Around the Baltic Sea Worked Together on Macro-Regional Risk*



* There are various risks that we might have to face in our region in the near to long-term future. At this point, we decided to start assessing the following six: Storm; Forest Fire; Flood; Pandemic Flu; Accident at Sea; Nuclear Accident.

Here are the types of questions we asked ourselves in workshops and expert groupings

Fourteen Point Three Notebooks

Collection of Fourteen Point Three Notebooks is Set to Launch a CIRCULAR LOOP in which ONE PART Manifests The Whole and THE WHOLE Manifests One Part ⟶

Task C

Macro-Regional Risk

What will it take for us to have a common approach to risk and a common method to assess it? Do we need it? Why?

RED BOOK ONE / TWO

... Red Books represent the contribution

from our Task C experts whose main concern centred on beginning a discussion on the risk-assessment challenges in the Baltic Sea Region; a discussion that, for the first time, would include all countries from the area. In their two Notebooks they bring to us an insight on how our countries meet the challenge of assessing overall risk. They also question and explain what methodology can be used together, and they bring us their first attempt to develop a common language by drawing six different risk scenarios.

Task D

Floods

How can we best share our experience in coping with floods? Could this help us to reduce the national costs associated with flood prevention, preparedness and response?

BLUE BOOK ONE / TWO

... Blue Books represent the outcome

from the Task D Grouping who have discussed flood prevention practice in the Baltic Sea region. Floods are an annual occurrence for most of the countries in our region, and each one of them has developed a strong national know-how of coping with this type of emergency. However, the discussions focused on how can we increase the effectiveness of our actions in dealing with this emergency by sharing experiences of individual singular-country specific cases? The Blue Books give us a picture of various flood prevention experiences in the Baltic Sea region, as well as their conclusions and recommendations for further know-how sharing.

Task E

Forest Fire

What fire risk models are used already in the Baltic Sea region? How can these be bolstered? What kind of common system would we need and why?

GREEN BOOK ONE / TWO

... The Green Books focus on our regions foliage,

vegetation and forest cover and what happens when fire occurs. As our Task E experts discovered, all countries that participated in the work of Task E have their own national fire risk systems. These systems are both, similar and different at the same time. The question asked of experts was whether the region needs to have one fire risk system for the whole region? What would that system entail and how would that system borrow elements from other systems already developed elsewhere? This is to be decided in the future. For now, we have made a first step in this process providing you with an overview of existing fire risk systems in the Baltic Sea region.

Task F

Nuclear Accident

Would we be able to cope with a nuclear emergency which would impact several countries in the region? How can we create a common response and alertness mechanism?

ORANGE BOOK ONE / TWO

... Our Orange books investigate nuclear accidents

The nuclear question is probably one of those regional questions which we cannot afford to overlook in a macro-regional context judging by its potential impact. To show you why this is so, Task F experts developed a scenario for an hypothetical accident in Finland that may have severe consequences on other countries in the region. The second part of their task work was to assess this developed scenario and provide recommendations for further activities that would increase our preparedness towards accidents of this complex kind. The scenario and workshop report are both delivered to you in our Orange Books completing the circle.

The EUSBSR flagship project 14.3 was a novelty on various levels

Two of the most important 'firsts'

...partnership of diverse civil protection actors from every country of the Baltic Sea region was built

...the focus of the project was concentrated on an all-hazards approach through a macro-regional lens

The questions we asked ourselves were

How can we acknowledge and communicate the project's complexity, and capture it without reducing or subordinating it at the same time?

How can we talk about the methods and the substance of inquiry at once, whilst keeping both on an equal footing?

Green Book Two will highlight one of the first steps in the process of evaluating whether there is a necessity for the Baltic Sea region to use a common integrated forest fire behaviour monitoring and rating system, an inquiry articulated through demonstrating and comparing two different systems that are currently used in the region. It will also explore which features a common system would benefit by inclusion. Additionally it tracks the current state of play in tandem with Green Book One and other developments regionally in this field. →

Task E Fact Sheet

18 Months of...

MEETING →

Stockholm → Tallinn → Stockholm

The Task was led from Karlstad, Sweden

WORKING together →

Swedish Civil Contingencies Agency (MSB) – Frederikssund-Halsnæs Fire & Rescue Service (Denmark) – Estonian Rescue Board – Main School for Fire and Rescue Service in Warsaw (Poland) – State Fire and Rescue Service of the Republic of Latvia – Norwegian Directorate for Civil Protection (DSB)

SHARING experiences →

Leif Sandahl, Ulrika Postgård (SE) – Kim Lintrup (DK) – Katri Rüütel, Sven Jablonski, Teet Koitjärv (EE) – Agris Šūmanis (LV) – Heidi Vassbotn Løfqvist, Hans Kristian Madsen (NO) – Anna Szajewska (PL) (Consultant: Annie Johansson (SE))

LEIF SANDAHL Task E Leader:

"When it comes to forest fire prevention, each country in the Baltic Sea region has its own way of managing it. They have thus far chosen their own system of how to monitor, predict and rate fire behaviour. We don't know yet whether it would be better for the region to have one common system. It is however very useful to have an established practice of sharing experiences from countries within the Baltic Sea region. Task E made a major step in bringing forward the idea of establishing such practice"

TASK E Gave Us

→ A tailor made questionnaire on nationally used forest fire rating systems.
→ An overview of forest fire rating systems in six Baltic Sea region countries.
→ An understanding of the current gaps in the system – such as the lack of regional mapping of fuel grades and forest coverage.
→ A comparative demonstration of two forest fire behaviour analysis models currently used in the Baltic Sea region, including suggestions on their potential to become a basis for a common macro-regional model.
→ A first step in debating the need and demand for one common forest fire rating system in the Baltic Sea region.

The demonstrations of two fire spread models BEHAVE and *Prometheus*[1]

1 These demonstrations were prepared as a part of the Task E – Forest Fire – activities within the framework of implementation of EUSBSR flagship project 14.3

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Introduction

An integral part of the initial EUSBSR flagship project 14.3 Task E plan consisted of surveying the participating countries[2] with a questionnaire focusing on the wildfire risk systems and forecast systems that are currently in use in the region. Questions also focused, among other issues, on available information regarding forest types and grades of vegetation.

According to the questionnaire responses received from all six participating countries, they all have some sort of system for nationwide fire forecasts but there is no system in place which is comparable across the countries.

One of the purposes of and opportunities given by the project was to use the different models available showing forest fire spread as tools for macro-regional risk management. To this end some model demonstrations and subsequent comparisons of different spreading models were carried out. One of the opportunities to arrange such a demonstration to the project group was the workshop in Tallinn (15-16 January 2013).

Green Book Two provides the reader with the paper that describes how these demonstrations were conducted for a fire that occurred in northern Sweden in 2006, the so-called **Bodträskfors fire**. The document describes how input data is handled in the two different spreading softwares, namely BEHAVE and *Prometheus*. Besides the said fire spread model demonstrations, this paper consists of a brief description of the fire itself, as well as simulation results, a brief discussion and overall conclusions are also presented in this paper.

2 Denmark, Estonia, Latvia, Norway, Poland and Sweden

The fire in Boden (Bodträskfors fire), Sweden, 2006

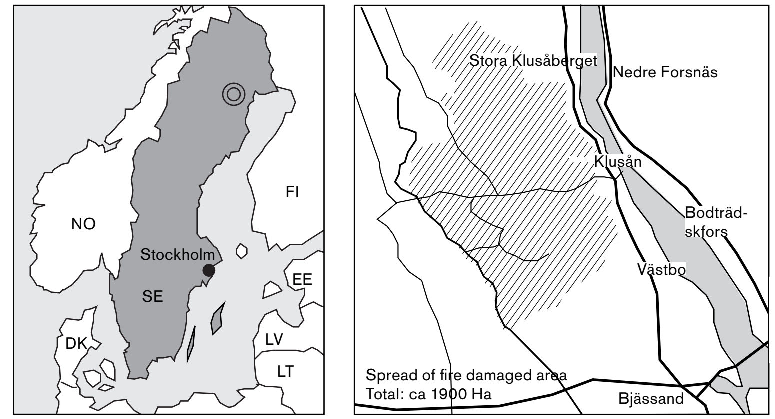


Figure 1 Map showing where the fire was localized and area affected by the fire

The fire occurred outside of the Northern Swedish town of Boden in Norbotten County on 11 August to 10 September 2006 (in the boreal forest region, latitude 65°, just below the Arctic Circle). It occurred after a long period of time with no precipitation, high Forest Fire Weather Indexes (FWI) and shifting winds.

Crews from many parts of northern Sweden were involved in the incident. People had to be evacuated from their homes. Fires of this size (app. 1900 ha) are very rare in Sweden. The fire was extinguished after almost **18 000 hours**.

This number is an estimate of uninterrupted labour to put out the fire, during the course of almost four weeks.

Based on the fire report, created by Boden Fire Department, two fire runs were used as “observed fire behaviour”. It must be noted that the fire report was not documented with the purpose of documenting the fire behaviour. Instead, the report focuses on documenting suppression actions, logistics and personnel. The information below focuses on Day 1 and Day 3, since data from these two days was used in the simulation.

Fuel Type in Bodträskfors

The area is dominated by standing pine forest, with small areas of clear cuts.

The pine stand is described as follows

Stand structure and composition: The stand is dominated by Scots Pine (Pinus sylvestris), (0-18 m in height, crown base height 50 % of tree height) and sparse undergrowth of Norwegian spruce (Picea Abies), (0-18 m height, with their crown extended to or near the ground) working as a ladder fuel.

Forest floor: The understory flora consisted of Bilberry (Vaccinium myrtillus), lingonberry (Vaccinium vitis-idaea), and a continuous mixture of feather mosses, (dominated by Hylocomium splendens and Pleurozium schreberi).

Organic layer: Compact and moderately deep to deep (10-20 cm).

Surface fuels: Moderate shrub cover, sparse understory conifer and no dead and down fuels.

Small parts of the fire area were clear-cuts from pine stands. These areas are covered by continuous feather moss, discontinuous needle litter and a moderately deep organic layer. The clear-cuts are also covered with a light load of slash from logging mature Scots Pine. This fuel type is comparable with FBP fuel type S1, with light fuel load. In the simulations the FBP fuel type S1 is used.

Topography

In the northern part of the area, the smaller mountain Klusåberget rises 273 m above sea level. The southern part of the fire area is assessed as flat about 80-100 m above the sea level.

The fire was spread over the southern part of the area the first three days.

Weather

Weather data from The Swedish Meteorological and Hydrological Institute (SMHI) is used. FWI values used in the simulations come from the Swedish vegetation fire risk system ("Brandrisk skog och mark"), produced by SMHI. The fire occurred after 10 days (based on SMHIs data system MESAN[3]) with no precipitation. The used FWI values in BEHAVE are recalculated, since the original values included rain on Day 2, which was not observed at the fire area.

No weather readings were done on site.

3 Mesan - an Operational Mesoscale Analysis System
SMHI has access to many different types of observations such as manual observations (called synop or metar), automatic station data, satellite and radar imagery. The best estimate of a meteorological parameter is given by combining all available observations of that variable in an analysis. The analysis is made on a grid where every value represents the mean for a grid square. In that process the quality and the representativety of each observation is taken into account. That means that an observation at a large distance from the square will have less influence on the value than an observation close to it. This is what is done in Mesan for different parameters such as: • 2-meter temperature, • relative humidity at 2 meters, • precipitation (rain and fresh snow cover), • visibility, • wind at 10 meters (mean and gusts), • clouds (total, low clouds, base, top, and significant clouds)

Diagram 1 **Weather data from SMHI Mesan shows the period before the fire had little precipitation**

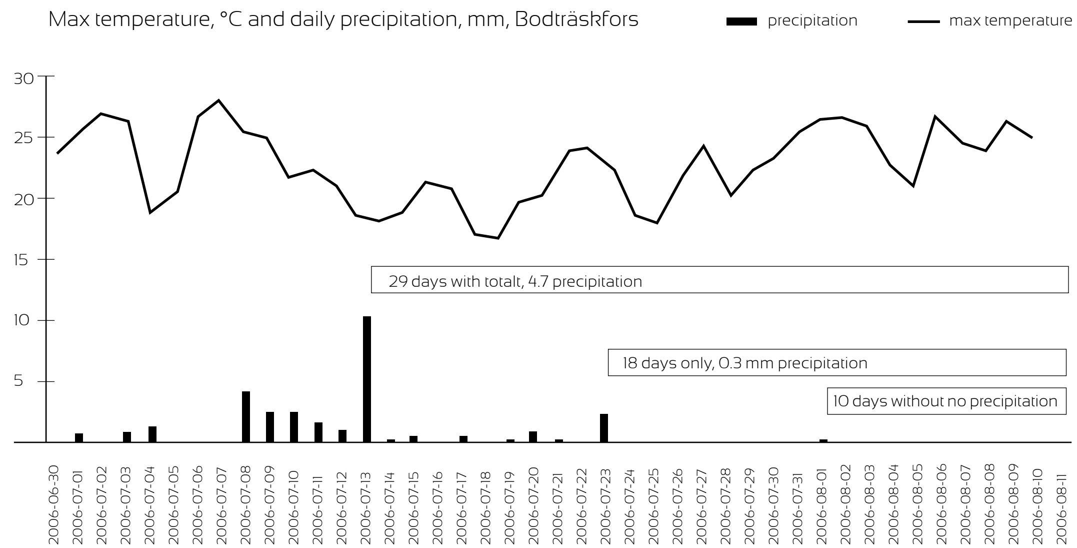


Table 1 **Recalculated FWI values used in BEHAVE (data from"Brandrisk skog och mark" 14.00 local time)**

Day	Temp (deg C)	RH (%)	Wind (km/h)	Rain (mm)	FFMC	DMC	DC	ISI	BUI	FWI
1	24	44	6,2	0	91	94	490	6,7	126	26,5
2	24,3	36	7,6	0	91	96	497	7,3	130	28
3	25,2	28	12,6	0	92,2	100	505	11,1	134	38
4	25,5	30	9,4	0	92,2	104	513	9,4	138	34
5	20	46	11,9	0,2	90,2	106	519	8	141	31
6	20,7	58	8,3	0	88,2	108	526	5	143	23
7	17,1	73	7,2	0,1	85,3	109	532	3,2	144	16
8	17,3	76	7,6	3,1	61,9	79	528	0,7	115	4

The fire starts on **11 August** in a newly logged area

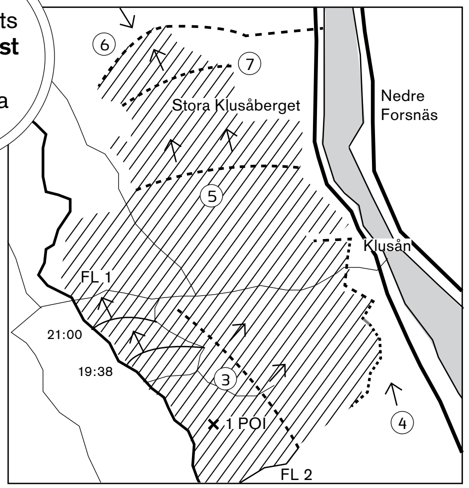


Figure 2

A map with estimated fire chronology and development

03:00 → SOS gets an alarm; smoke has been seen in the area around Västbo. The fire department is already out in that area putting out a smaller wildfire and makes the conclusion that the reported smoke is from that fire.

06:11 → A new alarm reaches the fire department in Boden. Two fire fighters from the closest fire department in Harads are sent out.

08:00 → They find a fire about 300 m x 50 m (Figure 2: Point 1, POI). The wind is pushing the fire across the road to the north.

12:00 → The estimated time when the fire crossed the road is 12:00.

Day 1 → A helicopter pilot notices the distance from the front and the northern fire line (FL 1), to approx 400 m at 21:00. Based on these observations, the ROS (rate of spread) was app 4 m/min between 12:00 and 21:00, which is used as reference and observed fire behaviour for Day 1.

Day 3 at 11:35 → A strong wind shift is logged and the whole east side (approx 2,8 km) is now the new front (picture 2: line 3). The situation is now more serious when the fire spreads in the direction towards the village of Västbo, along the Luleå River. The police are sent out to warn and evacuate the people living there. Some crew members are evacuated from the fire by helicopter. The front stops close to the village at 17:45 (Figure 2, line 4). This afternoon the head fire moved approx 2800 m in 6 hours and 10 minutes which is a ROS of 7 m/min. These values are used as reference and observed fire behaviour for Day 3.

In the morning of Day 3 as the temperature is rising, relative humidity (RH) goes down and the wind speed increases, the FWI rapidly increases. The FWI almost triples during three hours, which results in a higher ROS and higher intensity (See Table 2 below). In the afternoon some of the personnel has to be evacuated, since they are now in front of the new head fire. The standard daily Fine Fuel Moisture Code (FFMC) (the index value at 1600 hours) from Day 3 is 92,2. Spot fires are indicative of the FFMC of 92.

Day 4 → The wind is again from the south. The fire spreads northwards towards Stora Klusåberget (Figure 2: line 5). The fire is running with high ROS (rate of spread) up to the top of Klusåberget. There are no documented positions from the head fire from this or any of the following days that are used in this simulation.

Day 5 → The fire is moving north and is 400 m from the new fire line at 04:45 in the morning (Picture 9: line 7). The fire is still growing on Day 6, mostly towards the north.

On the northern side of Klusåberget the fuel type changes. In the new fuel type the continuity on the ground fuel is broken and the open soil considerably slows down the fire. This together with a calm wind and higher relative humidity stops the fire close to the newly built road.

The following 3 weeks → The following three weeks consist of a heavy workload while the necessary clear-up takes place. The fire had a heavy impact on the organic layer, which results in both trees and power lines continuously falling down. Because of the high risk of falling trees nobody is allowed go more than 50 m inside the perimeter. The landowner starts the patrol work, when the fire department end their operation on Day 29.

Table 2

Diurnal FWI values for diurnal FWI from 10:00 to 13:00 on Day 3

Local time	FWI
10	12.6
11	17.6
12	27.0
13	34.9

Use of Fire
Growth Simulation
Programs in Task E

One of the objectives of the project 14.3 within its Task E was to test and evaluate two different fire growth simulation programs using data from fires that had already occurred in any of the participant countries. The two simulation models used are BEHAVE by Remsoft 5.0 and *Prometheus*. The fire chosen as the example to pick data sets from for the simulation was the Bodträskfors fire outside of Boden in Sweden that occurred in 2006 (11-29 August 2006) which was described above.

Demonstration of BEHAVE by Remsoft, 5.0

The fire modelling system BEHAVE is based on the Fire Behaviour Prediction System[3]. BEHAVE is a Fire Behaviour Prediction and Fuel Modelling System that gathers available fire models into a system that is driven by direct user input. BEHAVE is run by user-supplied input. The programme can be used for a large amount of fire management applications, including predicting wildfire fire behaviour, prescribed burning and fuel hazard assessments.

An overview of the programme, required input information, output data and possibilities of the programme was presented at EUSBSR flagship project 14.3 Task E Workshop 2. Information from the Bodträskfors fire was used in the simulations. After the presentation of the programme, participants discussed advantages and disadvantages of this fire behaviour prediction programme as well as the demonstration itself.

3 A detailed description of FBP and CFFDRS is provided in Green Book One of Fourteen Point Three Notebooks.

Input Data

The following information is needed as input data:

- Projection date
- Yesterday's Fine Fuel Moisture Code (FFMC)
- Duff Moisture Code (DMC) and Drought Code (DC)
- Noon air temperature (°C)
- Noon relative humidity (RH%)
- Noon 10 meter wind speed (km/h)
- Time of projection
- 24 hour precipitation
- Fire Behaviour Prediction (FBP) fuel type
- 10 meter wind speed (km/h)
- Cardinal wind direction (°)
- Percent slope (%)
- Aspect of slope (°).

The user can choose Metric or English units.

Output Information

Some of the outputs that can be calculated by using BEHAVE are:

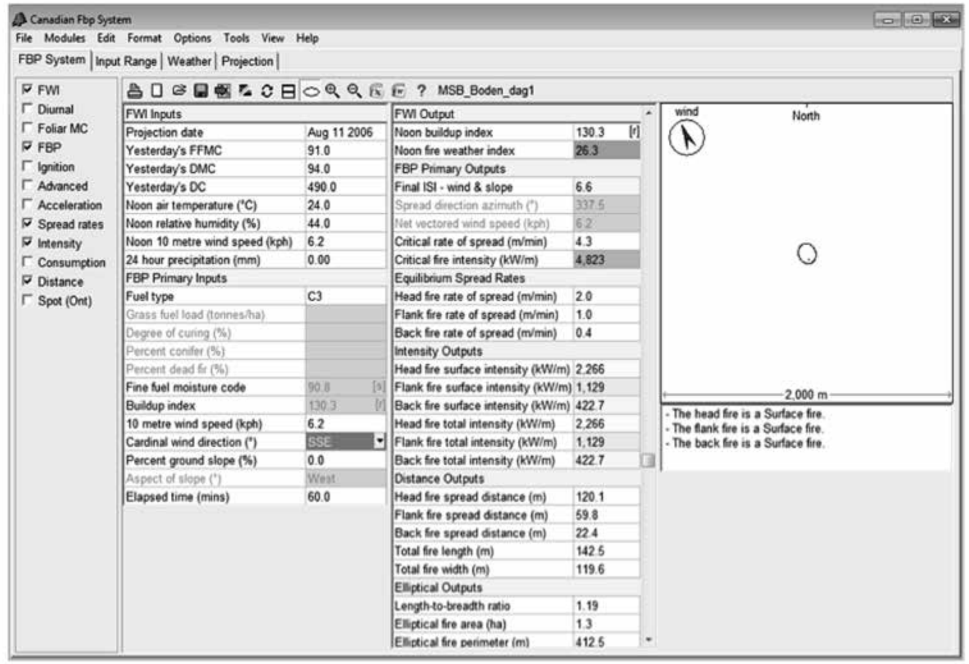
- Rate of spread (head, flanks, back fire)
- Intensity and type of fire
- Spread distances
- Perimeter growth
- Fuel consumption
- Probability of ignition
- Crown fraction burned
- Length-to-breadth ratio.

Time since ignition will allow calculation of an estimated fire size.

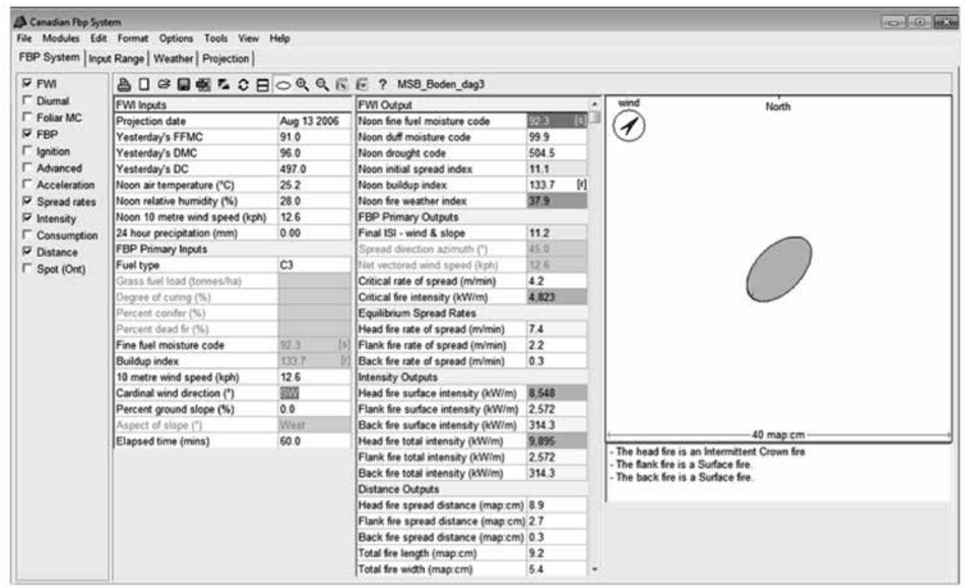
Demonstration of BEHAVE

For the purposes of the simulation carried out during the project 14.3 Task E workshop, the fire that occurred in Boden was used to demonstrate the programme BEHAVE. In Picture 1 the values from the Swedish fire risk system, Brandriskprognoser (Fire Risk Prognosis), is used. The used FWI values in BEHAVE are recalculated, since the original values included rain on Day 2, which was not observed at the fire area. BEHAVE gives a ROS of 2 m/min indicating that it was a surface fire.

On Day 3 a wind shift is noted in the logbook at about 11:35. After that the east flank, about 3 km, became the new head fire. Over the next few hours the temperature rose, RH went down and the wind speed increased, resulting in higher ROS and higher intensity (See Figure 3 for estimated fire area the first three days).



Picture 1 Screenshot from BEHAVE using input values from Day 1



Picture 2 Screenshot from BEHAVE using input values from Day 3.
The result is a ROS of 7.4 m/min and an intermittent crown fire.

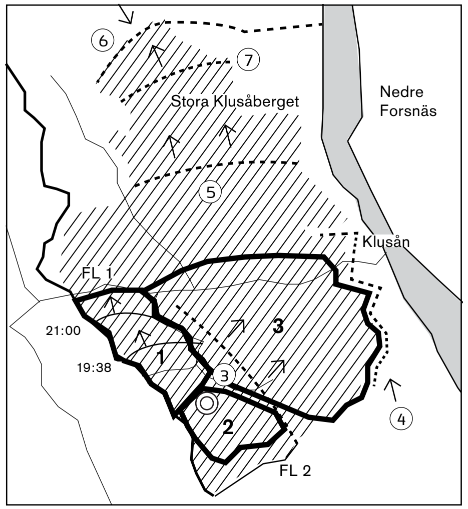


Figure 3

Estimated fire area from the first three days of the fire. Day 1 and 3 are used in the simulations.

Demonstration of BEHAVE →

That afternoon some of the personnel had to be evacuated, since they were now in front of the new head fire. With this background some tests were made, by using BEHAVE and trying out different wind speeds to see the results in ROS and type of fire. This was made to show some of the possibilities of using this kind of programme.

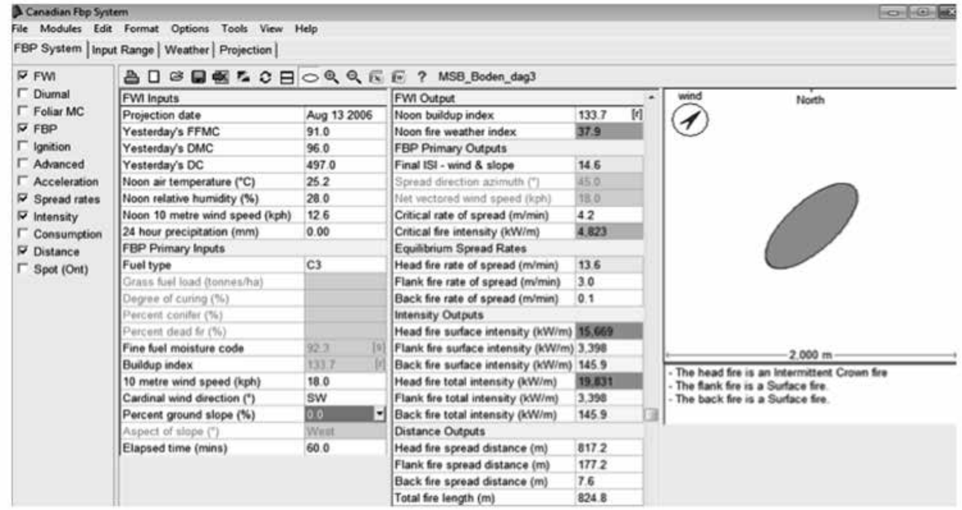
The screenshots from BEHAVE below (Picture 3 and 4) show two fire behaviour predictions, using FWI indexes from Day 3. In the first case the wind speed is 18.0 kph (5 m/s) which would be an intermittent crown fire. In the next case the wind speed has been changed to 19.8 kph (5,5 m/s) which results in a continuous crown fire. By trying two different wind speeds BEHAVE gives an indication of the threshold value for the wind speed, to be a significant change in fire behaviour.

RESULTS of the Simulations for BEHAVE →

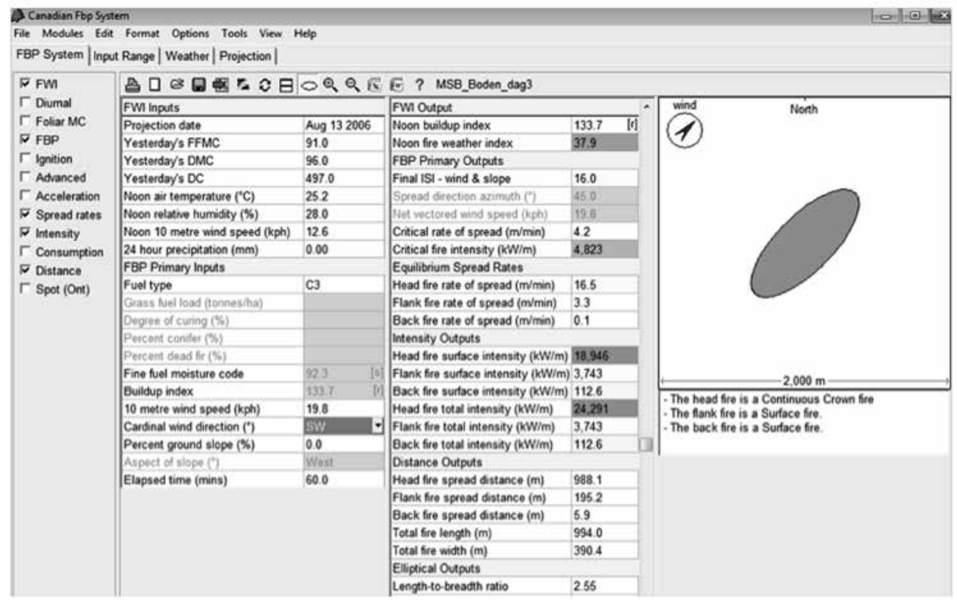
Using the data from Day 1 the outputs from BEHAVE are ROS 2 m/min and each, head-, flank- and back fire are surface fires. According to the observed fire behaviour, using the fire report, the ROS was 4 m/min and the head fire is an intermittent crown fire, flank and back fire are surface fires.

On Day 3 the outputs from BEHAVE are: ROS 7 m/min and an intermittent crown fire, that can be compared with the observed fire behaviour that were ROS 7 m/min and an intermittent crown fire.

The wind speed by Day 3 was recorded as 3.5 m/s. When using the wind speed 5 m/s, BEHAVE is giving the ROS of 13 – 14 m/min and an intermittent crown fire. If the wind speed 5.5 m/s are used the ROS is 16 – 17 m/min and the fire is a continuous crown fire.



Picture 3 A screenshot from BEHAVE shows a fire behaviour prediction, using FWI indexes from Day 3. A wind speed of 18.0 kph (5 m/s) results in an intermittent crown fire.



Picture 4 A screenshot from BEHAVE shows a fire behaviour prediction, using FWI indexes from Day 3. A wind speed of 19.8 kph (5.5 m/s) changes the fire from an intermittent crown fire to a continuous crown fire.

ADVANTAGES with Using BEHAVE

A fire modelling programme like BEHAVE can be used for various purposes. BEHAVE can for example be used to:

- support tactical decisions
- predict worst case scenarios
- provide training in fire behaviour
- analyses of occurred fire behaviour
- investigation
- research
- documentation
- prescribed burning

The experience of using BEHAVE in the project 14.3 showed that the programme is not complicated to use. The results are easily visible since the programme gives a good overview. BEHAVE provides the user with an opportunity to choose the level of input data from the standard window or a more advanced level of input, such as crown fuel load, foliar moisture content and acceleration model which gives more detailed output information. All prediction can be saved, and also exported to excel files. Weather data files can be imported into the programme. A mobile application version of the programme is under development.

In this project threshold values were calculated for what wind speed that was needed to change the type of fire from an intermittent crown fire and continuous crown fire. This is one example that shows how the user can change the input values and see varied output results.

DISADVANTAGES with BEHAVE

Some properties of the programme were noted as disadvantages. The output is an ellipse, based on calculations made from point A to point B or during a set time, and this ellipse is not connected to a map or geo-referenced. The user has to “translate” the results to the landscape and level of topography. The model is based on the FBP System, and that includes all the assumptions for that system. The user has also to be aware of the fact that the system was prepared to *assist* field staff and is intended to supplement the experience and judgment of fire managers.

It is important to note that the programme was developed in Canada and is used for Canadian conditions. Therefore, according to the 14.3 project participants, input data like FWI values in high resolution or FBP fuel types are not available for their request.

Demonstration of *Prometheus*

Prometheus is a shareware software that can be downloaded from http://firegrowthmodel.ca

The model is a deterministic wildland fire growth simulation model based on the Fire Weather Index (FWI) and Fire Behaviour Prediction (FBP) sub-systems of the Canadian Forest Fire Danger Rating System (CFFDRS).

Model Installation

The model is easy to install, the webpage includes well documented information on all steps that are required. As for all installations you need to have an administration license on your computer. The model can be installed on several operating systems.

Model Setup

Projection

To simulate a fire you need to define which projection you will use.

The projection is defined in a projection file, ESRI’s[4] projection file formats are standard format used. The model supports several different projections.

For the simulation of the fire in Bodträskfors the projection Universal Transverse Mercator[5] has been used. The projection Universal Transverse Mercator has defined the globe in zones; therefore also the zone needs to be specified in the projection file. Universal Transverse Mercator zone 32-34 covers Sweden and Bodträskfors is in zone 34.

Input Data for the Fire Simulation

Some input data is required for the whole model domain and some only for a point. Some input data can also be polygons from a shape-file.

Input data for the whole model domain has to be in ASCII Grid format[6] (see next page), if more than one ASCII grid file is used as input they must cover exactly the same area and have the same grid resolution and the same projection as defined in the projection file.

4 International supplier of Geographic Information System (GIS)software and geodatabase management applications.
5 The Universal Transverse Mercator (UTM) geographic coordinate system uses a 2-dimensional Cartesian coordinate system to give locations on the surface of the Earth. It is a horizontal position representation, i.e. it is used to identify locations on the Earth independently of vertical position, but differs from the traditional method of latitude and longitude in several respects. The UTM system is not a single map projection. The system instead divides the Earth into sixty zones, each a six-degree band of longitude, and uses a secant transverse Mercator projection in each zone.
6 ASCII Grid format is a good means of distributing raster image data files: it is an ASCII format so it is both humanly readable and hardware independent; it is widely supported and easy to import and export from most GIS software, easy to convert with a small script if necessary, and stores data in a reasonably compact raster format when compressed.

Model Setup

Required input data are a Fire Behaviour Prediction (FBP) fuel type grid and corresponding FBP fuel type grid, weather data and fire ignition. Example on additional optional input data are:

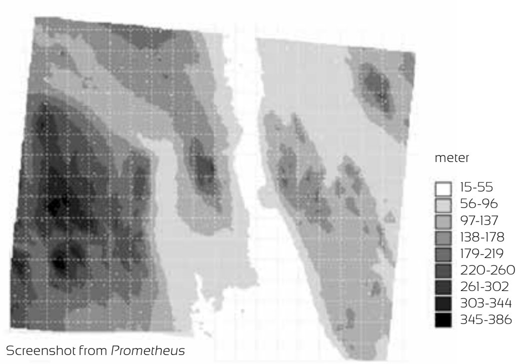
- elevation grid
- green-up grid
- slope grid
- aspect grid
- wind speed grid
- wind direction grid
- fuel breaks.

Elevation grid

An elevation grid is not required as input data for a fire simulation but the fire in Bodträskfors moved over a hill, therefore an elevation grid has been used in this fire simulation.

In Sweden, a national elevation model has the grid size 50 m and decided in this case the grid size. The elevation data was transformed to Universal Transverse Mercator zone 34 and to an ASCII Grid file. The initial lines in the ASCII Grid file contain information about the numbers of grid points in south-north direction and in east-west direction, the grid size and the coordinates for the southwest corner of the model domain in Universal Transverse Mercator zone 34. Also missing values need to be defined in the initial lines. After the initial lines a matrix with numbers of rows that are the same as the numbers of grid points in south-north direction and numbers of columns that are the same as the numbers of grid points in west-east direction.

The new Swedish national elevation laser scanned data with a spatial resultion of 2 x 2 m and better accurancy was not used because there is no matching detailed fuel type information.



Screenshot from *Prometheus*

Picture 5 The elevation grid used in Bodträskfors (from the old Swedish digital elevation model with a spatial resolution of 50 m.

Fire Behaviour Prediction (FBP) Fuel Type

Specific fuel types and classes for the forests in Sweden is not available, instead we have used the FBP fuel types identified in Canada that is the default FBP fuel type in the model. The most dominant forest in Bodträskfors is mostly like C3 Mature Jack or Lodgepole Pine. A homogenous grid, with C3, for the same area and grid size as for the elevation grid, was made for the FBP fuel type grid. Afterwards areas with other FBP fuel types were manually inserted into to the model from an aerial photo, for example, S1 Jack or Lodgepole. Areas with divergent FBP fuel types can also be inserted from shape-files. This is a flexible and useful way of inserting FBP fuel types. If no high resolution FBP fuel mapping is available you make a homogeneous grid with the dominated forest and then add interactively or from shape-files the divergent FBP fuel types. Rivers and lakes can also be inserted interactively into the model or imported from shape-files. In the model setup for Bodträskfors, rivers have been imported as shape-files (Lantmäteriets Översiktskartan (Land Survey Overview Map) http://www.lantmateriet.se/Kartor-och-geografisk-information/Kartor/Oversiktskartan/)

Examples of further data that can be used or changed in the model:

- Burn period
- Degree of Curing
- Green-up
- Percent Conifer
- Dead Fir
- Crown Base Height
- Tree height and fuel amount.

Weather Data

Weather data, both daily and hourly, for a point can be inserted directly to the model or imported from a text file. Weather grids can also be used for wind directions and wind speed.

Hourly and daily weather data for a point can be imported as comma, space, tab or semi-colon delimited file.

For hourly weather data the parameters: date, hour, temperature, relative humidity, precipitation, wind direction and wind speed are needed, independent if they are directly inserted to the model or from a file.

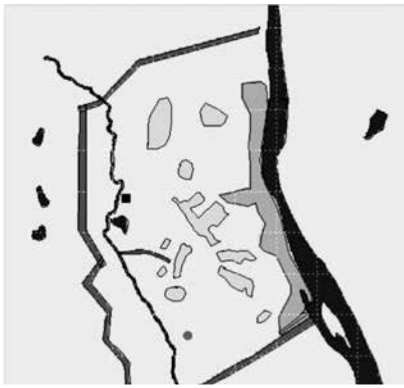
For daily weather data the parameters: date, minimum and maximum temperature, the minimum relative humidity, precipitation, the minimum and maximum wind speed and wind direction. If FFMC, DMC and DC are known the weather data only need to cover the fire periods that are simulated, alternative weather data can be used from the beginning of the fire season (from the snow melt).

For the Bodträskfors fire hourly weather data for the whole fire season has been used. The data has been ordered from the Swedish Meteorological and Hydrological Institution (SMHI). The data represents a grid point value from a mesoscale analysis system (MESAN[7]) developed at SMHI.

7 Häggmark, L., Ivarsson, K-I., Gollvik, S. and Olofsson, P-O. (2000). MESAN, an operational mesoscale analysis system. Tellus Series A No 1, 2-20.

Fire simulation

The model domain and setup in *Prometheus* is shown in Picture 6.



Screenshot from *Prometheus*

Picture 6 The model domain with the dominant FBP fuel type C3 - Mature Jack or Lodgepole Pine (background) imported from a Grid ASCII file.
Cut forest, manually painted with FBP fuel type S1-Jack or Lodgepole.
Fields, also manually painted, with FBP fuel type set to O-1b-standing grass,
Fire lines manually painted, the fuel type is here set to blank for fuel.
Lakes and rivers imported from a shape-file.
The black square is the position for the gridpoint where weather data are collected from and the red circle is the fire ignition point.

RESULTS
in the Simulations
for *Prometheus*
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Bodträskfors

The fire simulation in *Promethus* was stopped for the times were manually observed fire extent were available, see Figure 4.

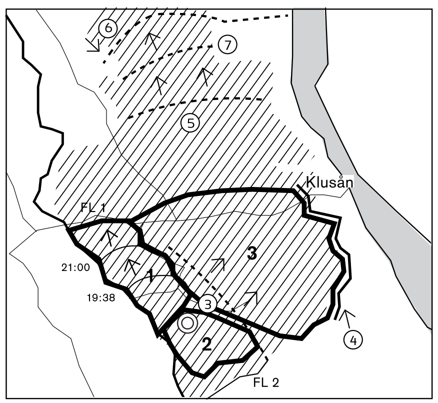

Figure 4 Observed fire extent at 21:00 local time 11 August (Day 1), night between 12 and 13 August, 12:00 local time 13 August (Day 3, line to the left) and 18:00 local time 13 August (Day 3, line to the right)

RESULTS
in the Simulations
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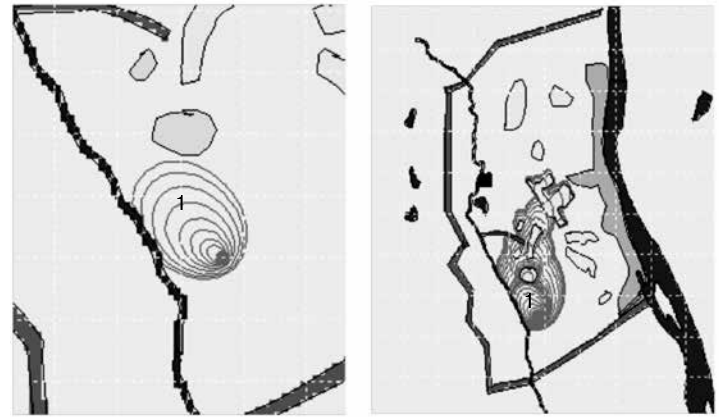
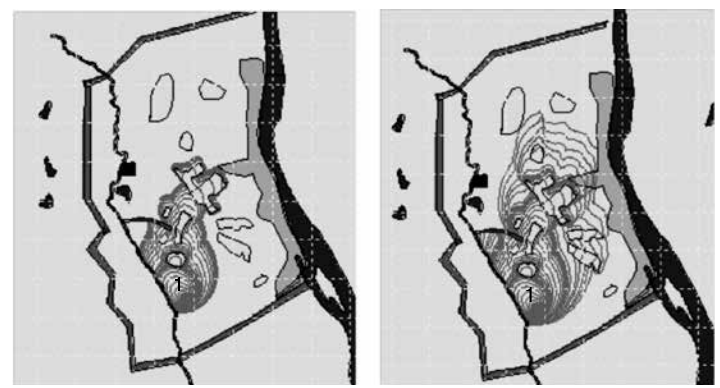


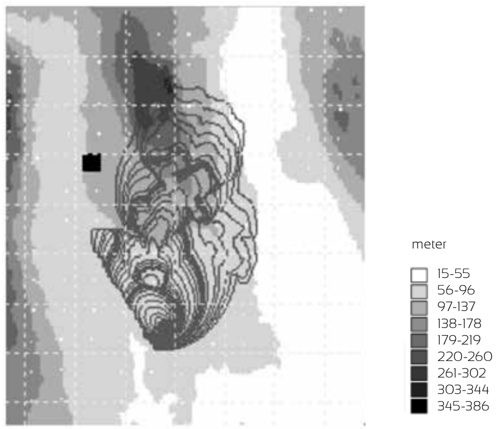
Screenshots from *Prometheus*

Picture 7 Fire spread calculated in *Prometheus*, lines 1 show the spread for each hour. To the left, fire extent at 21:00 local time 11 August. The mean rate of spread for the period 12:00 -21:00 local time 11 August was in *Prometheus* calculated to 1.6 m/min. To the right, fire extent at midnight between 11 and 12 August. The mean and maximum rate of spread was in *Prometheus* calculated to 2.5 and 11 m/min during 12 August.



Screenshots from *Prometheus*

Picture 8 Fire spread calculated in *Prometheus*, lines 1 show the spread for each hour. To the left, fire extent at 12:00 local time. To the right, fire extent at 18:00 local time 13 August. The mean and maximum rate of spread was in *Prometheus* calculated to 8.33 and 15.6 m/min during 12:00-18:00 local time 13 August. The hourly FWI at 10:00 to 13:00 local time 13 August increases from 12.6 to 34.9.



Picture 9 Fire extent with elevation as background

RESULTS
in the Simulations
for *Prometheus*
Used for the
Fire in Bodträskfors

It is also possible to simulate only a part of the fire spread. In the figure below a line is used as ignition instead and the fire start is set to 12:00 local time and stopped at 18:00 local time 13 August.

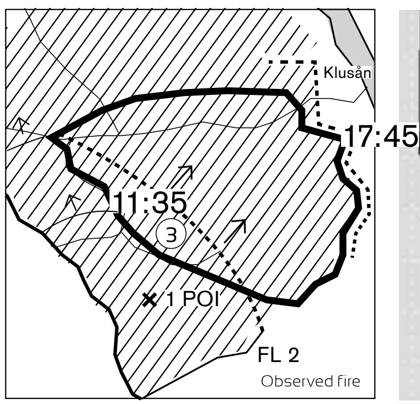


Figure 5 To the left the observed fire spread from 12:00 to 18:00 local time 13 August is illustrated. In the right Picture the same fire spread is calculated in *Prometheus* with the fire ignition as a line

Picture 10

Discussion

Within the context of the EUSBSR flagship project 14.3 Task E, only one country uses FWI in their fire risk system. Sweden has used FWI since 1999, which makes it possible to find FWI values for a fire that occurred 2006. All the six countries within the Task E can use FWI data from European Forest Fire Information System EFFIS, with the notice that these values resolution are wider. None of the participant countries are using FBP fuel types. In this simulation photos from the fire area where used to match the vegetation from the fire with a FBP fuel type. Notice that the FBP fuel types are not verified for Swedish conditions.

The results from the simulation compared to observed rate of spread and fire behaviour will not be further analysed. Instead, input data, possibilities and usability are in focus. In general it has been shown or demonstrated that the spread models result is at the same scale as the fire behaviour in the Forest Fire at Bodträskfors.

This demonstration shows the importance of collecting data and proper documentation of the fire behaviour on wildland fires.

If the countries in the Baltic Sea region will use this model standard, weather readings have to be used, FWI values have to be calculated and the vegetation has to be classified into verified fuel types. When this data is available, this model is one way to predict fire behaviour.

When BEHAVE is compared to a more advanced model like *Prometheus*, the simplicity of BEHAVE is expressed, by the participants, as one of the main advantages. The learning time is much shorter for BEHAVE which makes this programme well suited for usage by the operating staff.

Conclusions

In the process of collecting data to be used for simulation from previous wildland fires it has been shown that the documentation about fire behaviour today is incomplete.

↓

It is not possible to make fire behaviour case studies or correct fire behaviour analyses based on available documentation.

↓

In order to analyse future fire behaviour there is a need to develop methods, checklists etc. to collect the proper data during and after fires have occured.

If digital data is available the programme *Prometheus* could probably be used for national risk assessments but questions were raised if it can be used on a local level.

↓

The programme BEHAVE is much simpler to use. In order to use both models - education, training and planning is needed.

↓

One solution is to develop papers, guidelines or rules of thumb that can be used in the field during fires.

If the Baltic Sea region were to adopt and introduce an existing fire danger rating system and fire spread model programme - deeper evaluations of existing systems would be needed.

↓

EUSBSR flagship project 14.3 Task E working group, meanwhile, used one algorithm only for two software programmes (BEHAVE and *Prometheus*) which were chosen for simulations.

↓

It is preferable to learn from other countries experiences about the introduction phases in order to receive basic data for decisions.

Notes

Notes

This publication was conceived as part of the EU Strategy for the Baltic Sea Region EUSBSR Flagship Project 14.3 (January 2012 – June 2013); the project aimed to develop macro-regional risk scenarios and, based on their analysis, to identify capacity gaps in Baltic Sea region preparedness to cope with potential risks on macro-regional level.

The project was supported by the EU Civil Protection Financial Instrument. Project Lead partner and Coordinating Beneficiary – Council of the Baltic Sea States (CBSS) Secretariat

Project partners

Frederikssund-Halsnæs Fire & Rescue Service (Denmark)
Estonian Rescue Board
Finnish Radiation and Nuclear Safety Authority (STUK)
Hamburg Fire and Rescue Service (Germany)
State Fire and Rescue Service of Latvia
Fire and Rescue Department under the Ministry of the Interior of the Republic of Lithuania
Norwegian Directorate for Civil Protection and Emergency Planning (DSB)
The Main School for Fire Service in Warsaw (SGSP)
Swedish Civil Contingencies Agency (MSB)
Swedish Institute

St. Petersburg University of State Fire Service of EMERCOM of Russia (under external funding agreement secured by the Swedish Institute)

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EUSBSR Flagship Project 14.3 Visual Identity by Jacek Smolicki

Special thanks to Dr. Christer Pursiainen who is now with the EC Joint Research Centre, ERNCIP, Italy

Co-financed by the EU-Civil Protection Financial Instrument

ISBN 978-91-981257-3-3

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14.3 is a flagship project under EUSBSR Priority Area Secure www.bsr-secure.eu