Major Fire Issues in the Euro-Alpine Region – the Austrian Alps

The extremely hot summer 2003 has demonstrated quite impressively that under suitable fire weather conditions it can burn in Austrian forests nearly everywhere, preferably in its mountainous regions (Fig.1). But forest burns have not played a major role in Austria so far. Most fires are less than one hectare in size; only very few reach ten or more hectares, the largest one during the last five years had 70 ha, more as an exception. But also 10 or 20 ha of a stand-replacing fire mean under our scattered and patchy ownership conditions often a disaster. Nevertheless are storm events, avalanches, bark beetle breakouts, and browsing and debarking damages by wild ruminants more important and a priority challenge for the forest protection efforts.

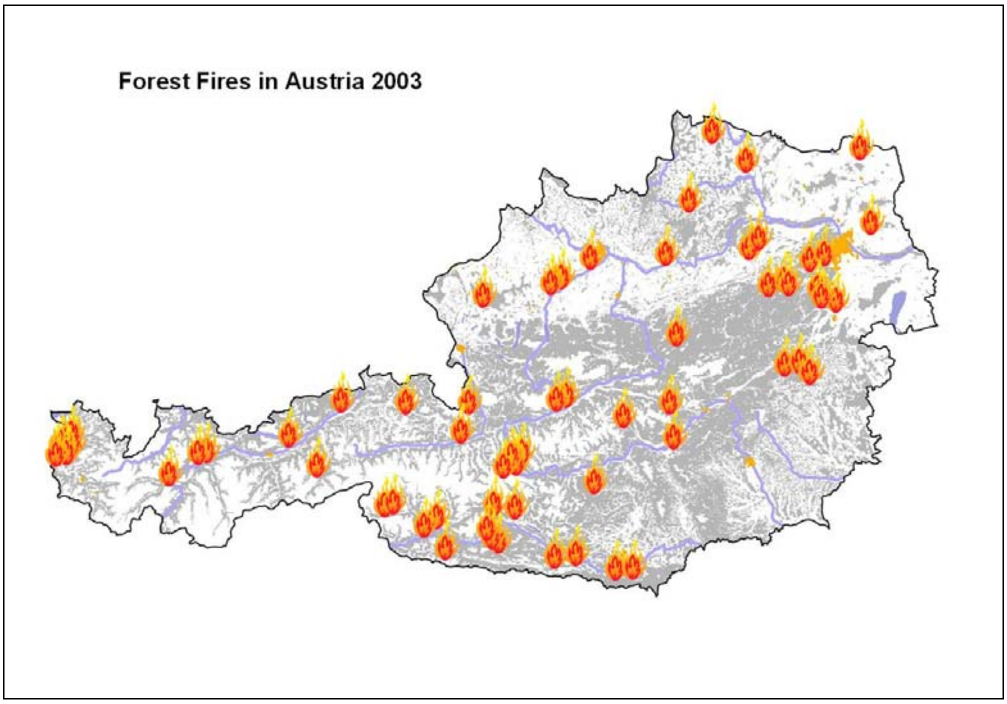

Figure 1. Distribution of forest fires in Austria in 2003. This a preliminary dataset, based on data in the News Archives of the Fire Fighter Associations initiated 2002-2003, but which was completed in later years yet: suited weather and fuel conditions allow forest fires nearly everywhere, but mostly in the Alps (with its higher coniferous forest amounts).

Our mountain forests do not fulfil the characteristics of fire ecosystems, and there are also no distinct fire regimes detectable. But it is hypothesized (Gossow et al. 2005, 2008) that the proposed increase of weather extremes in coming years and decades may increase the probability especially of mountain forest fires too (cf., for instance, Ahern et al. 2001; Goldammer 2001; Badeck et al. 2003; GLOCHAMORE 2007). Switzerland is aware of that already since the early 1990's (Conedera et al. 1996, 1997) when realizing an increase of forest fires especially in its southern region: therefore it became „more and more necessary to improve the forest fire management methods", with fire danger rating methods considered as „one of the most important elements of an effective fire management strategy". For the alpine region of Italy, „a fire danger rating implementation and calibration" project is running since a few years (Valese 2008). Discussions on a likely climate change increased the need to address climate dependencies of disturbance agents explicitly in decision support tools and models as well (Dale et al., 2000, Vacik and Lexer, 2007). Also Austria should definitely become more active in this respect in the very near future (Gossow et al. 2005, 2008).

In 2004, Gossow initiated a first forest fire workshop in Austria, which was organised by Hans Zöcher of and at the Forest-Technological Training Center in Ossiach, Carynthia, together with forest fire and forest protection experts from Italy and Slovenia: they came from the neighbouring forest district administrations in Veneto (Emilio Gottardo) and Ljubljana (Jost Jaksa), respectively. Involved in this workshop were also fire fighter brigade and army representatives engaged in the fire fighting efforts in Carynthia as well as police, mountain rescue, and red cross units: they altogether demonstrated during the second day in a 'playback' operation of the "*Erzberg* Burn" suppression (spring 2003) their interactive fire fighting efforts just one year ago. But it took still some time more to initiate also a more engaged forest fire research project at BOKU university – which was started now in May 2008 (with support of the National Science Foundation FWF). In the time before, only some recordings of wildland fire events – by year, season, and locality – were published and commented in professional journal articles to make stakeholders and decision makers in the forest sector more sensitive about this possibility as a realistic danger (Gossow & Frank 2003; Gossow et al. 2005, 2008).

Nevertheless, for our forest protection experts, the storm events – especially those of the last winters like "Kyrill" & Co –, bark beetle outbreaks, and the still lasting ungulate game damages (cf. also Kräuchi et al. 2000) have priority – as being much more 'sustainable' and wide-spread and impacting much more forested land than our mostly small and less disastrous forest fires so far. Is this forest fire issue therefore only a fancy of a few interested people in Austria?, one may ask (cf. Gossow et al. 2005). At least the voluntary fire fighter brigades have realised the challenges of forest fires in steep terrain of mostly remote areas, and they have adapted to it also technically and operationally. And we want to make also our foresters more aware and better prepared and more supportive for the fire fighters, in infrastructural respect, within their forests – and likewise also in prophylactic forest protection respect.

There exists already a forest fire danger rating system by the Central Weather Service (ZAMG) in Vienna – based respectively on indices using mean temperature and precipitation data of the previous two weeks – which offers daily fire weather maps (five danger classes) for Austria. As no fuel classification and more forest fire related drought indices are used in this fire danger rating , there is some potential to improve the approach (cf. Valese et al. 2008**).** Also lightning strikes are recorded, mapped, and tabulated very well by ALDIS. The wildland fire events are recorded only, more or less precisely and completely, in the NewsArchives of the Wax or FireWorld Service for and by the fire brigades (but only since 2002/2003). The respective data collection by the ministery's forest section was reduced in its contents unfortunately after the year 1991, offering more detailed information only about the years and decades before (1958-91): They concerned only those fire events which were documented in connection with compensation payment applications. But at least, a more general trend is detectable as a decrease in the number of annual burns, and correspondingly in the burned area, but the burned area per burn remained comparatively stable (Tab. 1). Meanwhile, also BFW (the Federal Forest Research Institution) is collecting forest fire data. The data published in EFFIS so far appear doubtful (much too many fires!): perhaps, instead of single fire events the numbers of actively involved fire brigades (or something else) are summed up. To make use of MODIS data, the vast majority of Austrian forest fires is much too small (cf. Tab. 1) to be identified by the MODIS Rapid Response System, based on daily satellite images of the Earth's landmasses in near real time (around only 10% of the wildland fires for 2007, not only forest fires).

Table 1. Austrian Forest Fire Statistics, as edited by the Forestry Sector Section in the Federal Ministry. Source: Forstliche Jahrbücher 1958-2007.

Average no. of	**1958-59**	**- 69**	**- 79**	**- 89**	**- 99**	**- 07**
burns/ year	332	276	248	171	101	56
hectares/ year	284	278	209	115	52	75
ha/ burn	0.86	1.01	0.84	0.67	0.51	1.34

A preliminary evaluation of the fire brigade reports – our main actual data source – showed seasonal as well as regional concentrations of forest fire events. As mentioned already, the distribution of forest fires in 2003 (Fig.1) concerned all parts of Austria, and this was similar in 2007, most of them in the mountainous region of the alpine main ridge. In 2006, most fires happened in Tyrol and Carinthia. Taking these three years together, the alpine fires make up nearly forty percent, and those in the South as well as in the N/NE both around thirty. It is interesting how much the burns decreased since the middle of the 20th century (Tab. 1), and likewise the burned forest acreage – differing a bit from other countries with often an increase in burn numbers, but a decrease of burned area.

Concerning their seasonality, the forest fires are happening now preferably in spring (40 %) and in summer months (45 %), whereas in former decades (1960's – 1970's) the fires concentrated in the spring months (March, April; cf. Tab. 2). In those last three years with a 'fire season', the forest fire peaks differed remarkably. In 2003 (Fig. 2) there was – besides two quite typical peaks of fire events in spring (second half of March) and in summer (August) – a third one detectable in the second half of June: it coincided with the period of midsummer fires and subsequent ritual fires with regard to Catholic feast-days. These fires are usually ignited high up in the mountains – where also most fires in this period were registered. The following two years were only poor in forest fires. But in 2006, after a winter season with heavy snow and rainfall, a few extremely hot weeks supported the outbreak of some 20 forest burns within a very short fire weather window in the second half of July, most of them in Carinthia and Tyrol, but distinctly concentrated in Southern Carinthia: this region appears to be(come) something like a wildland fire 'hot spot'. Another potential hot spot may be the utmost Eastern Limestone Alps with low annual precipitation and high black pine (*Pinus nigra austriaca)* amounts in the forests. In 2007, we had the most registered fires during the last years, half of them in April: again a spring peak. And in 2008, a year again with only few forest fires, but most of them in February, marked again a winter 'peak'. It has still to be analysed how well the forest fire danger mapping of ZAMG has corresponded with the really happened forest fires.

For 40% of the reported forest fires (from 2002 to 2008) no concrete causality is mentioned or known, another 40% are reported as of anthropogenic origin, and the remaining 20% were qualified as "natural fires", ignited predominantly by lightning strikes, very few apparently also by self-ignition. Austria as a predominantly alpine country is rich in thunderstorms with locally very high densities of lightning strikes; those ignited nearly half of the Carinthian forest fires in 2003, more than twice as much as the Austrian average that year (for similar experiences cf. Conedera et al. [2005] about lightning-caused forest burns in Switzerland). And similarly in 2006 – with a maximum of lightning strikes during the last 15 years (ALDIS) – , each third forest burn in Austria was lightning-released, but again nearly each second one in Carinthia and 40% in Tyrol. One may question, if this high amount of lightning-ignited forest burns is realistic, and not only an easy guilt-addressing to nature. But an ad hoc-study was able to confirm a high majority of the respective records as correct (Müller, in prep.).

Table 2. Changes in the seasonal distribution of forest fires in Austria in several periods during the last half century (in %). Winter = XII – II, Spring = III – V, Summer = VI – VIII, Autumn = IX – XI. Data sources as in Table 1.

Season	**1958-69**	**1980-91**	**2003-07**
spring	71,1	50,9	39,2
summer	11,9	37,1	45,4
autumn	9,2	6,9	10,8
winter	7,8	5,1	4,6

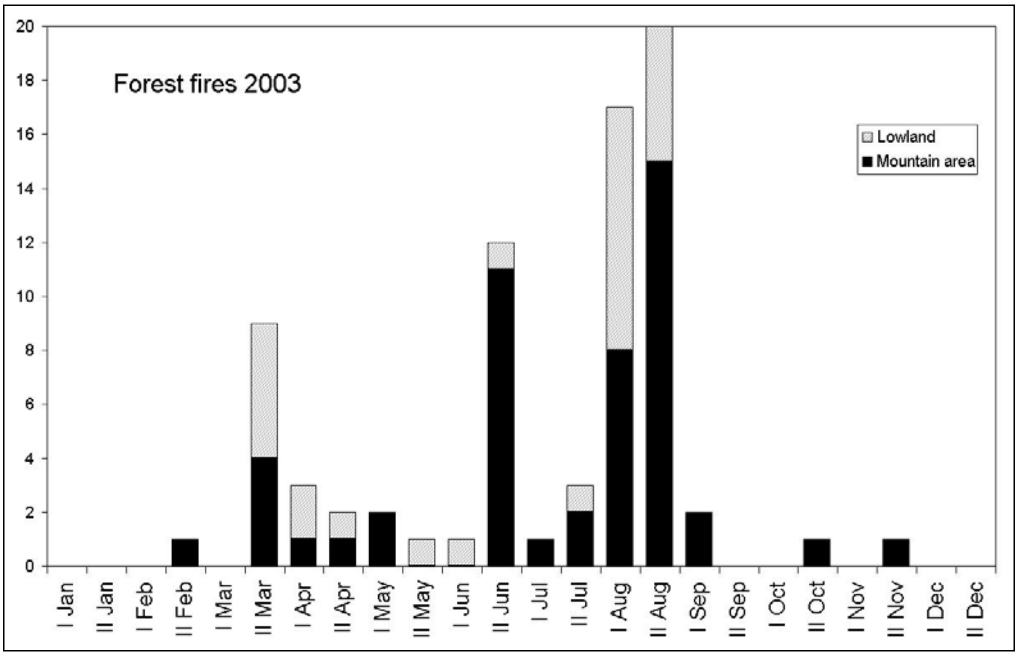

Figure 2. Monthly distribution of forest fires in 2003 (same sample as for fig.1) as summarized for 1st (I) and 2nd (II) half of each fire season month and for lowland and mountain areas, respectively.

2007 had the highest number of forest fires, but was very poor in lightning-caused ones (less than 10%). Most of our forest fires are surface burns and very small in size, but they may last comparatively long unsuppressed because of longer-glowing ground fires. Concerning the second half of the last century, the amount of lightning-ignited forest fires increased distinctly in (or since) the 1980s (cf. Tab. 3), whereas arson fires had something like a peak in the early 1970's.

Table 3. Causation trends of forest fires in Austria (as documented by the Austrian Forestry Sector Section in the Federal Ministry (Forstl. Jahrb. 1958-1991), for selected pentade samples especially for forest fires ignited by lightning and by railway embankment burns, respectively. Data are for Austria (AT) in total, and for the most concerned provinces Lower Austria (LAT), Tyrol (TYR) and Carinthia (CAR).

Pentade	**1963-67**	**1973-77**	**1983-87**
Lightning			
AT	4,1	3,0	26,5
LAT	3,0	0,4	8,1
TYR	8,0	11,6	52,5
CAR	2,2	4,8	23,8
Railway			
AT	35,5	12,2	5,6
LAT	47,3	22,4	4,0
TYR	5,3	5,8	3,1
CAR	17,6	2,5	5,7

Storm blow-downs in Austria – the last major events in 1990, 1999, 2002, 2007 and two more early in 2008 (from *Wiebke* to *Kyrill, Paula* and *Emma)* – have created much uprooting in older spruce and pine stands. These events – like the often subsequent bark beetle-outbreaks – contribute also to the fire susceptibility, especially at steeper slopes with southern aspect: In these areas, salvage logging is very often only very selective and correspondingly incomplete because of the bad accessibility and the lower timber quality, resulting in a lot of coarse woody debris and logs but also in more grassy and brushy vegetation, and therefore offering extremely good fuel and fire spread conditions (Gossow and Frank 2003). Slash-burning and similar activities get also often out of control and can ignite adjacent forest stands (as a major amount of all fires from anthropogenic origin in 2002 – 2008). Roots of remaining uprooted stocks may burn down and loose their connection to their soil-rockbeds. The concerned rootstocks then often roll and jump downhill while burning and thus transferring fire also to lower elevations. This, for instance, became a major problem during the “*Stagor*-Burn“ (2002) on a previous storm blown-down slope. But even glowing pine cones may act with similar effects when rolling down on steep terrain, after the surface vegetation has been burned down: as, for instance, in the “*Potokkessel* Burn“ (Frank 1988, pers. comm.).

Figure 3. Fire fighting demo during a first International Forest Fire Workshop in Ossiach (Carinthia/Austria) in May 2004. The site is nearby Erzberg / Bad Bleiberg, where a large fire occurred in March 2003 on a storm-thrown area because of negligent salvage logging operations.

The meteorologists (for instance at ZAMG) are not convinced that the more recent increase in storm events is a real climate change effect: According to Austrian and Czech weather data (wind speed measurements) over the last 200 years, the 19th century was more stormy than nowadays (ZAMG 2008). But the practised forestry during the last two centuries had produced forest stand types (by tree species and structure) more susceptible to storms as well as to bark beetles, deer browse and bark stripping, and also to fire. The storms nowadays are able to provoke more acute damages.

Besides storm blow-downs, also snow breakages may add to the fuel loads, especially within the “wet snow zone“, where early and heavy wet snowfalls produce a lot of broken canopy biomass falling to the ground. What appears important is an assessment and classification scheme of our various fuel types and loads and of their inflammability under which fire weather conditions.

The in former times comparatively “clean“ forestry was fairly fire-proof. With the socio-economic changes after WW II and especially in the expanding EU, or also in the more SE countries of Europe since the *Fall of the Iron Curtain*, more extensive land use practices became and become obvious (e.g. Goldammer 2002). This includes also deficiencies in forest thinning and tending efforts – like very pronouncedly in Austrian forests (with high and increasing overstocking reserves according to the last forest inventory 2002) –, and is increasing consequently the amount of wildland fuel loads further and quite generally. That demands again a more conscious and targeted fuel management: in advance at least in fire-prone areas, as a prophylactic effort, but also as post-suppression measures – see the “Fire Paradox“. Perhaps, the recent bio-energy interests and forest-biomass burning may return this trend again (cf. WWF 2006).

Figure 4. Mobile communication center (in a Volkswagen bus) for catastrophic forest fires, during which besides the fire fighting squads also red cross, mountain rescue, police, and army units are involved (the latter especially with aerial attacks).

Figure 5. Forest fire box for the use at higher elevations with bad access or too long-lasting driving distances - to be transported with helicopter support.

Another source of forest ignition can be burning railway embankments with adjacent forest stands or connective slopes with grassy and shrubby vegetation as fire spread corridors. Sparks from braking trains caused embankment and subsequently forest fires remarkably often in the early1960's in more than a third of the noted cases (according to older forest fire statistics of the ministry; Tab. 3). This is especially critical in hilly and mountainous areas where curves and downward direction of railway tracks necessitate frequent braking. These track sections should become part of a fire danger rating procedure for prophylactic and post-burn measures (Arndt 2007): especially, adequate fuel reduction, control of fuel loads, and more fire-resistant vegetation types may be suited options.

During the last few years, these railway embankment burns could again – after a continuous decrease already in former decades (Tab. 3) – be drastically reduced, due at least partly to new brake-technical improvements. However, train braking (especially of not yet so well-adapted freight trains) may become again more relevant as an ignition source, if and where embankment upkeep to reduce fuel amounts and fire proneness becomes too negligent (Arndt 2007). Our alpine railway routes are quite avalanche- and rockfall-proof through protective forest stands above them. Stand-replacing forest fires in these areas could mean an increased avalanche and rockfall danger.

Figure 6. Heli-supported fire suppression during the Stagor mountain fire (on a former stand-replacing storm event near Steinfeld, February 2002). The photograph shows water filling operation at the Weissensee in Southern Carinthia. Access to water was possible only after part of the thick ice layer was sawn and the many resulting ice blocs put on the lake ice (in the foreground).

The use of controlled biomass burning has been a prototypical tool for the preparation and multi-use of rural and forested lands in Europe (e.g. Goldammer at al. 1997, 2004), and so also in Austria. An agro-forestry use of fire is documented locally, like in Upper Styria, till the 1960's (Schneiter 1970). Since a few years, fire is used again as a management tool on several Carinthian alpine pasture grounds, in order to control the overabundant growth of heather (*Calluna*) and other dwarf brushes – as a measure to improve the grazing quality for domestic livestock (Kerschbaumer 2007; Huber et al, in print). Controlled burning may get out of control – also in such experimental burns and may enter adjacent forests too. Additionally, this burning includes also certain wildlife habitat and biodiversity changes. These experimental burning areas – at present only with exception permits – serve insofar for testing and improving burning techniques and combining it with a biodiversity monitoring and other investigations (Kerschbaumer and Huber 2002; Huber et al., in print).

But now also a first „Austrian Forest Fire Research Initiative" (AFFRI/FWF-TRP L539-N14) was started at BOKU university (May 2008). Its study design encompasses two major objectives: (i) to identify forest fire "hot spots" in Austria in relation to vegetation, climate, and site conditions, and (ii) to develop a fire-vegetation model for Austrian conditions, improving also the recent fire danger rating procedures of ZAMG. This includes – for both objectives – the consideration of fire weather options and topoclimatological aspects as well as the classification of fuel situations for both the more fire-sensitive forest types, and for more fire-endangered railway sections, especially in the Alps and its foothills. Based on comparable international approaches a forest fire hazard model will combine a socio-economic risk model (SERM; Arndt et al., in print), appropriate drought indices, and a fuel classification approach to estimate the expected probability of forest fires. The forest fire hazard model will describe the relationship between socio-economic factors (e.g. distance to infrastructures, housing density, day of the week, season, tourism activities), fire weather options, topoclimatological aspects as well as different forest types and forest fire behaviour options.

In order to describe and model forest fire behaviour, we will do a comparative assessment of two contrasting modelling approaches. The hybrid 3D-patch model PICUS v1.41, which has been particularly developed for Austrian mountain forest conditions (e.g. Lexer and Hönninger 2001, Seidl et al. 2007) will be extended by a fire risk and fire spread module and compared with Fire-BGC, a model successfully tested for North-American and partly also for Austrian conditions (cf. Hasenauer et al. 2005; Pietsch and Hasenauer 2006). We aim at capturing the driving factors for fire behaviour in mountain forests in order to evaluate the fire-vegetation simulator with selected fire cases. In that context a scenario analysis will be done to explore the interaction of management, suppression impacts, and a changing climate according to (i) the effects of different management regimes on fire behaviour, and (ii) the effects of climate change scenarios on fire behaviour.

The reconstruction of some of the major forest burns of the last years (partly in cooperation with GFMC) shall take into account also the respectively involved fire fighter teams and how their operations influenced fire behaviour and spread. Also their more specific preparedness, communication and cooperation experiences – especially under the more difficult mountainous conditions – shall be considered and evaluated (as far as accepted). With regard to our optional Carinthian forest fire “hot spot“, a cooperation of AFFRI with neighbouring colleagues in Slovenia and in Italy makes sense, for instance with the Veneto fire danger rating initiative (cf. Valese 2008 and this IFFN Special): In the Western Alps, winter and spring fires appear (still) more dominating (e.g. Conedera et al. 1996, Valese et al. in prep. and in this issue of IFFN), but with a trend towards also more summer fires; in the Austrian Alps summer fires seem to become more important besides the spring fires which dominated in former decades. These differences as well as differences in forestry and land use practice have to be considered adequately and monitored more precisely in the next future.

Most recently, we became – together with ZAMG – also partners of ALP-FFIRS (ALPine Forest FIre waRning System), an all-alpine INTERREG (EU)-research network which was initiated by Italian colleagues: its main target is ”to improve forest fire prevention in the Alpine Space with the creation of a shared warning system based on weather condition affecting fire potential”. Major target is the univocal Alpine Space Forest Fire Danger Scale definition and common danger level interpretation with resulting preparedness plans and operational procedures” (to be started in summer 2009).

IFFN contribution by

Hartmut Gossow
Universität für Bodenkultur (BOKU) Wien
Department of Integrative Biololgy, Wildlife Biology Institute
Gregor Mendel-Str.33
Vienna
Austria
e-mail: hartmut.gossow@boku.ac.at

Rudolf Hafellner
Univ. Bodenkultur (BOKU) Wien
Department of Integrative Biololgy, Wildlife Biology Institute
Vienna
Austria
e-mail: rudolf.hafellner@boku.ac.at

Harald Vacik
Univ. Bodenkultur (BOKU) Wien
Department Wald- u. Bodenwissenschaften, Institute for Silviculture
Vienna
Austria
e-mail: harald.vacik@boku.ac.at

Thomas Huber
Büro am Berg – Wildtierökologie & Landschaftsplanung
Tassach 13
Afritz
Austria
e-mail: thomas.huber@amberg.at

References

Ahern, F.J., J.G. Goldammer, C.O. Justice (eds.) 2001. Global and Regional Fire Monitoring from Space. SFB Acad. Publ., The Hague. 302 pp.

Arndt, N. 2007. Problems of Fires on Railway Embankments in Austria. MSc Thesis Univ. Bodenkultur (BOKU) Vienna. 142 pp.

Arndt, N., A. Arpaci, H. Gossow, P. Ruiz Rodrigo, H. Vacik (in print). A forest fire hazard based on the estimation of tourist hot spot activities in Austria. 7th Interntl. Workshop on Advances in RS and GIS Applications in Forest Fire Management, Matera (Italy), 2009.

Badeck,F-W., P. Lasch, Y. Hauf, J. Rock, J. Suckow, K. Thonicke 2003. Steigendes klimatisches Waldbrandrisiko. AFZ-Der Wald 58, 2 – 5.

Conedera, M., P. Marxer, C. Hofmann, W. Tinner, B. Amman. 1996. Fire ecology and history research in the southern part of Switzerland. IFFN No.15, 13 – 21.

Conedera, M., R. Bolognesi, D. Mandallaz, P. Ambrosetti 1997. Fire danger prediction in the southern part of Switzerland. IFFN No.16, 2 – 6.

Conedera, M., G. Cesti, A. Kaltenbrunner, B. Pezzatti, 2005. Die Blitzschlagbrände in den Alpen. Bündnerwald 58(6), 65-66.

Dale, V.H., Joyce, L.A., McNulty, S., Neilson, R.P., 2000. The interplay between climate change, forests, and disturbances. Sci. Total Environ. 262, 201-204.

GLOCHAMORE 2007. Global Change and Mountain Regions Research Strategy. ETH Zurich (ed., 2nd), 4 – 47.

Goldammer, J.G. 2001. Current state of synthesis initiatives in global vegetation firemonitoring. In: Ahern et al. (eds.), 71 – 103.

Goldammer, J.G. 2002. Towards international cooperation in managing forest fire disasters in the Mediterranean Region. IFFN No.27, 81 – 89.

Goldammer, J.G., A. Held, D. Nagy 2004. Stand und Perspektiven der Anwendung von kontrolliertem Feuer in Naturschutz und Landschaftspflege in Deutschland. NNA-Berichte 17 (2), 13 – 17.

Gossow, H., G. Frank. 2003. Waldbrand auf Windwurf – eine unheilige Allianz? Österr. Forstz. 114 (9), 8 – 9.

Gossow, H., R. Hafellner, F. Kraxner, L. Ziehaus 2005. Waldbrand – Thema oder Tick? Österr. Forstz.116 (8), 14 – 15.

Gossow, H., R. Hafellner, N. Arndt. 2008. More forest fires in the Austrian Alps – a real coming danger? Proc. Conf. “Managing Alpine Future“, Innsbruck 2007.

Hasenauer, H., K. Merganicova, S.A. Pietsch 2005. Modelling biogeochemical cycles within old-growth forest ecosystems. Forest, Snow Landsc. Res. 79 (1/2), 81 – 90.

Huber, T., N. Kerschbaumer, S.Aigner, G. Bergthaler (in print). Kulturlandschaftsprojekt Kärnten – Fallbeispiel Alpine Brandwirtschaft. In: Kärntrner Naturschutznachrichten.

Kerschbaumer, N. 2007. Über alpine Brandwirtschaft in Kärnten. Festschriftbeitrag in “Bergwelt im Wandel”, 141 – 148. Klagenfurt, Kärntner Landesarchiv..

Kerschbaumer, N., T. Huber, 2002: Alpine Brandwirtschaft – Auswirkungen auf Vegetation und Fauna. Fallstudie im Auftrag der Kärntner Landesregierung.

Kräuch, N., P. Brang, W. Schönenberger, 2000. Forests of mountainous regions: gaps in knowledge and research needs. For. Ecol. Manage.132, 73 – 83.

Lexer, M.J., Hönninger, K. 2001. A modified 3D-patch model for spatially explicit simulation of vegetation composition in heterogeneous landscapes. For. Ecol. Manage. 144, 43-65.

Müller, M.M. (in prep). Analyse der durch Blitzschlag verursachten Waldbrände in Österreich. MSc Thesis, Univ. Bodenkultur Wien.

Pietsch, S.A., H. Hasenauer 2006. Evaluating the self-initialization procedure of large scale ecosystem models. Global Change Biol. 12, 1658 – 1669.

Schneiter, F. 1970: Agrargeschichte der Brandwirtschaft. Forschungen zur geschichtlichen Landeskunde der Steiermark XXV, 7 – 161.

Seidl, R., P. Baier, W. Rammer, A. Schopf, M.J. Lexer 2007. Simulating tree mortality from bark beetle infestations in Norway spruce forests. Ecol. Modell. 206, 383 – 399.

Vacik H., Lexer M.J. 2007. The role of Decision Support Systems regarding Knowledge Transfer. Forst und Holz, 62 (9), 28-33; ISSN 0932-9315.

Valese, E. (in prep). Wildland fires in the Alpine Region of Italy: what’s old, what’s new. What’s next?

Valese, E. (in prep). FDR implementation and calibration in the Alpine region of Italy.

Valese, E., T. Anfodillo, S. Rossi, V. Carraro, A. Deslauriers, M. Carrer, M. Monai, A. Lemessi, E. Ramon 2008: Implementation and spatialisation of the Canadian Fire Weather Index in the Veneto Region. Forest@, 2008, 5: 176 – 186.

Valese, E., G. Cesti, T. Anfodillo (in progress paper). Models to predict critical live fine fuels moisture content and potential eruptive fires in the Italian Alps (Aosta Valley).

WWF 2006. Potenziale der Biomassenutzung aus dem österreichischen Wald unter Berücksichtigung der Biodiversität (in Zusammenarbeit mit den ÖBF und als Auftrag durch diese). http://www.bundesforste at/fileadmin/template/Publikationen/Biomassestudie.pdf.