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## **Experimental Application of Prescribed Fire for the Management of *Calluna vulgaris* Heathlands on Abandoned Military Terrain in Poland**

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### **Abstract**

In the history of land-use in Eurasia, fire has been an important element in forestry, agriculture and pastoralism. The use of fire has contributed to shape landscape patterns of high ecological and cultural diversity, e.g. heathlands, open grasslands, meadows, and swidden (shifting) agriculture sites. In Central and Eastern Europe, including Poland, dry heathlands, dominated by *Calluna vulgaris*, have been shaped by site conditions, climate, intensive land use and fire. On former military terrain, especially on training and shooting ranges, the impact of mechanical disturbances, explosions and fire, have additionally contributed to shape structure- and biodiversity-rich ecosystems that are now protected under national legislation, registered under the Natura 2000 Network as Sites of Community Importance (SCI) under the Habitats Directive (92/43/EEC) or as Special Protection Areas (SPA) under the Birds Directive (2009/147/EC). The abandonment of military training activities and a general lack of substitutional maintenance measures have resulted in progressive succession on many conservation sites, associated with loss of open space habitats and progression towards a more species-poor forest cover. In 2015, the first prescribed fire demonstration and experiment in Poland was conducted in the landscape park Przemków. It revealed the feasibility of using fire as a conservation tool of dry *Calluna vulgaris* heath, involving burning techniques that are based on the state-of-the art science, safety considerations and institutional cooperation. The experiment was conducted in a cooperative effort with the Germany-based Global Fire Monitoring Center (GFMC) and the German Federal Forest Service Office Lausitz, Brandenburg State, Germany. The demonstration burn and the follow-up research revealed the utility, effectiveness and efficiency of using prescribed fire for the maintenance and regeneration of *Calluna vulgaris* heath on former military training areas in Poland. In conclusion, it is recommended to further explore the practicability of the use of prescribed burning in Poland and to continue and foster cooperative transboundary programmes between specialists and the forest services and conservation authorities of Poland and Germany.

**Keywords:** *Calluna vulgaris*, prescribed burning, military training areas, Natura 2000 Network, Special Protection Areas (SPA), Sites of Community Importance (SCI), Poland, Germany.

## 1 Introduction

In large parts of temperate-boreal Eurasia the use of fire, including historic swidden (shifting) agriculture, and other disturbances by land cultivation have contributed to shape landscape patterns of high ecological and cultural diversity and value, e.g. heathlands, open grasslands and meadows. In the Nordic countries, historic natural fires caused by lightning and burning practises have also significantly influenced the composition and structure of forest ecosystems.

Rapid socio-economic changes in the past four decades led to a change of land-use systems and landscape patterns, resulting in elimination of traditional burning practises. New air quality standards, and the generally prevailing opinion by the government administrations that fire would damage ecosystem stability and biodiversity, led to imposing of fire bans in most European countries.

It is now becoming evident that the abandonment of traditional land-use methods has resulted in the elimination of disturbances, which have characteristically shaped many valuable landscape types and ecosystems (REICHHOLF 2001, JENTSCH 2004, GOLDAMMER 2013). This also refers to those high-conservation value sites that have been created by military activities, notably on former training and shooting ranges. Mechanical disturbances by military tanks and tracked vehicles, the physical impacts of explosions and subsequent fires have had caused recurrent disturbances that created small- and large-scale open sites, which provide habitat requirement for species which would not occur in advanced successional stages governed by brush and tree cover.

After the end of the Cold War, many military ranges were abandoned. At the same time these regularly disturbed ecosystems were classified as high-conservation value areas and protected under national legislation or registered under the Natura 2000 Network as Sites of Community Importance (SCI) under the Habitats Directive (92/43/EEC) or as Special Protection Areas (SPA) under the Birds Directive (2009/147/EC). However, similar to other abandoned land-use practices the exodus of the military also resulted in the reduction of disturbances and thus in a rapid onset of successional development which led to the overgrowth of habitats that had been generated by the disturbances.

During the last two decades, changing paradigms in ecology and nature conservation led to the reconsideration of fire-exclusion policies in certain sectors of nature conservation, forestry and landscape management. It was recognized that the composition and extent of Atlantic and dry heathlands (mainly dominated by *Calluna vulgaris*) has been shaped by grazing, cutting of heath, sod and turf layers and by burning throughout centuries. The use of prescribed fire for mimicking the traditional use or accidental occurrence (e.g. by the military) of fire is now practiced in many parts of Europe, e.g. in Germany (GOLDAMMER et al. 2009, 2012, 2016, MAUSE 2008, BRUNN 2009a, 2009b), United Kingdom (DAVIES et al. 2008, SCOTLAND GOVERNMENT 2008), Denmark (JENSEN 2004), the Netherlands (VOGELS 2008, BOBBINK et al. 2009), Norway (KVAMME & KALAND 2008) and to a lesser extent in Southern European countries such as Portugal and Italy (ASCOLI et al. 2009). Endangered target species for habitat conservation burning include e.g. the Black Grouse (*Tetrao tetrix*) or game species such as Red Grouse (*Lagopus scoticus*).

## **2 Status of *Calluna vulgaris* heathlands in Poland: The example of the Przemkowskie Heath**

### **2.1 General history**

*Calluna vulgaris* heath is considered as a precious plant formation, which was generated and survived mainly due to military activities in the country. It is of interests not only to botanists, ecologists and biologists but also to geographers, landscape planners and historians. However, today heath areas in Poland are still not yet distinguished on the topographical maps as a separate category of the land cover. From a historical point of view, heath is classified as a poor pasture land. According to the heath inventory of the Pomerania region, heath is nowadays endangered in Poland (KUNZ & NIENARTOWICZ 2011). Road construction, industrialization and housing are among the major causes of decrease of heath cover in Poland. Until recently heath has been considered as wastelands and there is a general public acceptance for its transformation into areas for urban and industrial development. In addition, heath is endangered by forest succession. The changes in the spatial extent of the heath during the last hundred years distinctly point out that military activities, associated with fire, remove forest succession and thus are a factor conducive for maintaining this plant formation by removing forest succession and maintaining the open sandy habitats (KUNZ et al. 2011).

The degeneration of *Calluna vulgaris* heath begins at the age of 20 to 30 years. The cessation of activities on the military areas and accumulation of the dead biomass is leading to succession by highly competitive grasses, shrubs and trees, and causes the changes of the heath structure and its degradation. Since the heath is a critical habitat for the very rare black grouse (*Tetrao tetrix*), which requires open spaces adjacent to the forest boundary, the containment of the secondary succession is one of the methods to protect and restore black grouse populations. At the same time heath is the source of precious heather honey. Therefore the heath of the Lower Silesia Coniferous Forest is registered as “Protected Geographical Indication” (PGI).

### **2.2 Use of fire and the law**

The “Act on Forests” of 28 September 1991 is a basic, normative act regulating the use of fire in the forests of Poland (ANONYMOUS 1991). The “Forest Fire Protection Manual” is the second basic act for the internal use within the State Forests National Forest Holding only (ANONYMOUS 2015a). Both regulations strictly forbid the use of open fire within the forest area and within the distance up to 100 m from the forest edge during non-forest management activities.

According to the Forest Fire Protection Manual, the use of the fire in the frame of forest management activities requires:

- Agreement by the Forest District Chief for the application of fire;
- Notification of the Command Post for Forest and Fire Service Alarm;
- A fire must not be kindled within the distance shorter than 6 m from standing trees and the flame height must not exceed 2 m;
- Appropriate supervision must be provided while using open fire in the forest;

- It is forbidden to use open fire on peat land, young stands and when the canopy level is lower than 10 m above the ground as well as on areas with reed grass, high grass and heather.

These are the main reasons why fire as a tool in the forest has not been widely spread in Poland. More often burning of the forest residues after clear cut or thinning is practiced in the winter. Recently, the amended “Environment Protection Act”, which entered into force several months after the below-described experiment on 28 August 2015, allows the use of fire in the forest in justified cases, for example to protect endangered species like heather (ANONYMOUS 2015b).

### **2.3 The Przemkowskie Heath: An example of an endangered conservation site**

The first experimental demonstration of prescribed burning for the conservation of *Calluna vulgaris* heath was conducted in conjunction with the first national conference “Fire in Forest Management and Nature Conservation”, which was held in Łagów on 17 March 2015. This conference was jointly organized by the Directorate General of the State Forests National Forest Holding and the national headquarters of the State Fire Service. The main aim of the event was to provide substantial knowledge about the techniques, rules and benefits of the controlled use of fire. The lectures of invited foreign speakers revealed the progress of the science and application of prescribed fire as a tool for nature conservation and as a method to be applied during wildfire suppression.

The second day of the conference was devoted to the demonstration of practical application of prescribed burning on *Calluna* heath. It took place in the landscape park Przemków, which was established in 1997 and has a size of 22,340 hectares (ha). The largest portion of the park is the former military training range of the Soviet Army, which was the largest Soviet training range (12,000 ha) and was actively used until 1992. In the center of the training range, it included an exercise air field (2000 ha) as a training site for aerial operations. The whole former training range has a high conservation value.

Currently, the landscape park includes four nature conservation areas:

- Przemków Pond (Lake) District (1046 ha)
- Przemków Floodplain Forest (140 ha)
- Piotrowicka Beech Forest (171 ha)
- Borówki Moorland (37 ha)

Furthermore, two areas are classified as Special Protection Areas (SPA) under the EU Birds Directive:

- Przemków Pond (Lake) District [Code: PLB020003] (4605 ha)
- Lower Silesia Forests [Code: PLB020005] (172,093 ha)

Three Sites of Community Importance (SCI) under the Habitats Directive were established:

- Przemków Wildlife Reserve [Code: PLH020097] (63 ha)
- Szprotawsko-Piotrowicka Beech Forests [Code: PLH080007] (171 ha)
- Przemków Heath [Code: PLH020015] (6664 ha)

The SCI „Przemków Heath“, which hosts the *Pohlio-Callunetum* dry heath in the North and Northwest of Poland (KUJAWA-PAWLACZYK 2004), is characterized by the following habitat types (HT) listed in Annex I of the Habitats Directive:

- **HT 2330:** Inland dunes with open *Corynephorus* and *Agrostis* grasslands (30.5 ha – equivalent to 0.46% of the protected area)
- **HT 4030:** European dry heath (1999 ha – equivalent to 30% of the protected area)
- **HT 91T0:** Central European lichen pine forests (6.5 ha – equivalent to 0.1% of the protected area)

With the size of the habitat types the SCI “Przemków Heath” is one of the largest *Calluna* complexes of Poland. It needs to be mentioned that the Conservation Status of Habitat Type 4030 is ranked excellent (A), i.e. the highest rating. The species occurring in the open and semi-open habitats listed in Annex I of the Birds Directive include the European nightjar (*Caprimulgus europaeus* A224), wood lark (*Lullula arborea* A246), tawny pipit (*Anthus campestris* A255), red-backed shrike (*Lanius collurio* A338) and also black grouse (*Lyrurus tetrix* A409).

The Forest protection plan for the Przemków Heath Natura 2000 site assumes necessity of an active protection to be implemented on the habitat type 4030. Protection must include removal of conifers and deciduous trees, especially pine and birch. Mowing is the most common method for the removal of unwanted vegetation. However, according to some specialist it might increase grass expansion. At the same time, it is a costly method requiring regular repetition.

### 3 First experimental and demonstration of prescribed burning in Poland

The demonstration burn took place in the SCI „Przemków Heath“ on 19 March 2015 and covered an area of 5.5 ha. The proper phyto-sociological taxonomic classification of the Przemkowskie Heath is *Pohlio-Callunetum molinietosum*. Beside the typical cover with heath shrubs (density of around 100%) mosaic cover of species characteristic for the *Spergulo-Corynephoretum* association were present. Before burning the whole area was covered by ageing heath, 40-60 cm of height, and all of the accessible niches for this species were already occupied. The occurrence of lichens and the expansion of mosses (mainly two species: *Dicranum polysetum* and *Pleurozium schreberi*) was observed on the typical lobes with high density of heath shrubs. Mosses created a dense layer, a significant obstacle for the reproduction of lichens.



Fig. 1-2: Pre-fire ground views of over-aging *Calluna vulgaris* stands in Przemkowskie Heath, which are subjected to invasion and overgrowth by Scots pine (*Pinus sylvestris*) and birch (*Betula pendula*). Photos: Forest Research Institute, Sękocin Stary, Poland.



Fig. 3-4: Aerial photograph of the pre-burn area (left) shows the Przemkowskie Heath embedded in the surrounding pine (*Pinus sylvestris*) forests. The right photo was taken by a drone directly before the experiment after surrounding the area with a ploughed fire-break. Drone photo: Courtesy The National Centre for Coordination of Rescue Operations and Civil Protection, The National Headquarters of the State Fire Service, Warsaw, Poland.

The main aim of the experiment was to demonstrate the application of prescribed burning as a method for active nature conservation. In addition, the experience in the utilisation of prescribed fire would provide knowledge of the rules and techniques to be applied when using fire as a backfire (counter fire or suppression firing) during wildfire suppression.

The following parameters were recorded before or during the experimental burn:

- **Fuel load** (amount of biomass per area unit, e.g. per square meter or per ha) was measured two days before burning. The mean fuel load amounted to 1.6 kg / m<sup>2</sup>.
- **Moisture content** of the fuels was measured on the due day, 30 minutes before the start of the fire and amounted for heath 38%, grass 10% and duff 45%.
- **Meteorological data** were collected at the State Forests meteorological measuring point, located 10 km from the experimental site. The mean daily air temperature amounted to 5°C and relative humidity ranged between 50% (at noon) and up to 100% in the evening. There was no rainfall recorded during the last three days before the burning.

A fire safety plan was elaborated by the group of specialists, appointed by the Lower Silesia Commander of the Provincial Headquarters of State Fire Service, together with State Forests and Forest Research Institute employees. The terrain was actively secured by the subdivision of fire fighters with fire engines located around the burning area. The area designated for burning was surrounded by the ploughed strip of land, 4-5m wide, for passive protection of the adjacent forest (Fig. 5). The methodology and initiation of the prescribed burn was conducted by the personnel of the Global Fire Monitoring Center (GFMC) / Fire Ecology Research Group and the German Federal Forest Service District Lausitz, Brandenburg, who handed over the application of the prescribed fire to the staff of the Forest Research Institute and State Forests during the demonstration and exercise.

The prescribed fire was set at an “anchor point” at the downwind (lee) side of the experimental plot, which was secured by a ploughed strip (Fig. 5 and 6).





Fig. 5-6: Ploughed fire break used for securing the start of the fire at the anchor point and the follow-up ignitions at the perimeter of the demonstration area. Photos: Courtesy Directorate General of the State Forests National Forest Holding, Warsaw, and Forest Research Institute, Sękocin Stary, Poland.



Fig. 7-8: Continuation of setting the fire along the area perimeters. After securing the perimeters, head fires (fires burning with the wind) were set. Photos: Forest Research Institute, Sękocin Stary, Poland.



Fig. 9-10: Various burning techniques resulting in different fire intensities and severities allowed the demonstration of fire effects on the shrub layer and the invading trees. Photos: Forest Research Institute, Sękocin Stary, Poland.

The demonstration of different burning techniques followed the state of the art and the EuroFire Training Standards and Materials (GFMC 2015a):

- Backing fire (burning against the wind)
- Head fires (burning with the wind)
- Flanking fires (single- or multiple-line ignition into the wind)
- Grid ignition or spot fires as example of multiple ignitions

Figure 11 provides a scheme of ignition exercises in the first phase of the fire. More details can be seen in a video coverage by an unmanned aerial vehicle (drone) on a special GFMC website of the demonstration burn (GFMC 2015b).

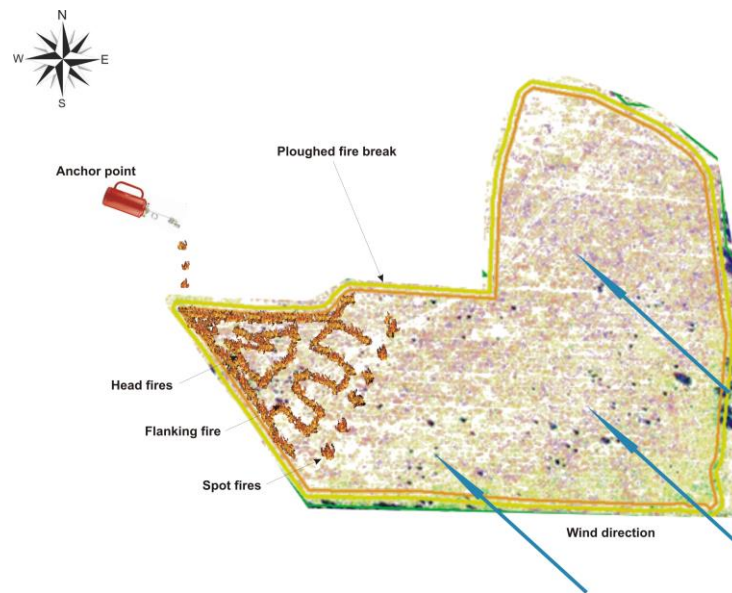


Fig. 11: Scheme of the start of the prescribed fire and demonstration of different burning techniques.

The prescribed fire demonstration was also used to create confidence and skills of fire teams to use hand tools, such as backpack pumps, for controlling low- to medium-intensity fires (Fig. 12).



Fig. 12: The fire experiment provided opportunity for exercising the use of hand tools for fire suppression. Photo: Forest Research Institute, Sękocin Stary, Poland.

On the day after the experiment (19 March 2015) at 09:50 UTC, the overpassing satellite Landsat ETM+ acquired the post-fire scene. Figure 13 illustrates the burn scar visible on the Landsat ETM+ image (band composite 5, 4, 3). Figure 14 shows the temperature distribution (in °C) in the area affected by fire and surroundings. The temperature was calculated based on the thermal band recorded by Landsat ETM+ on 19 March 2015.



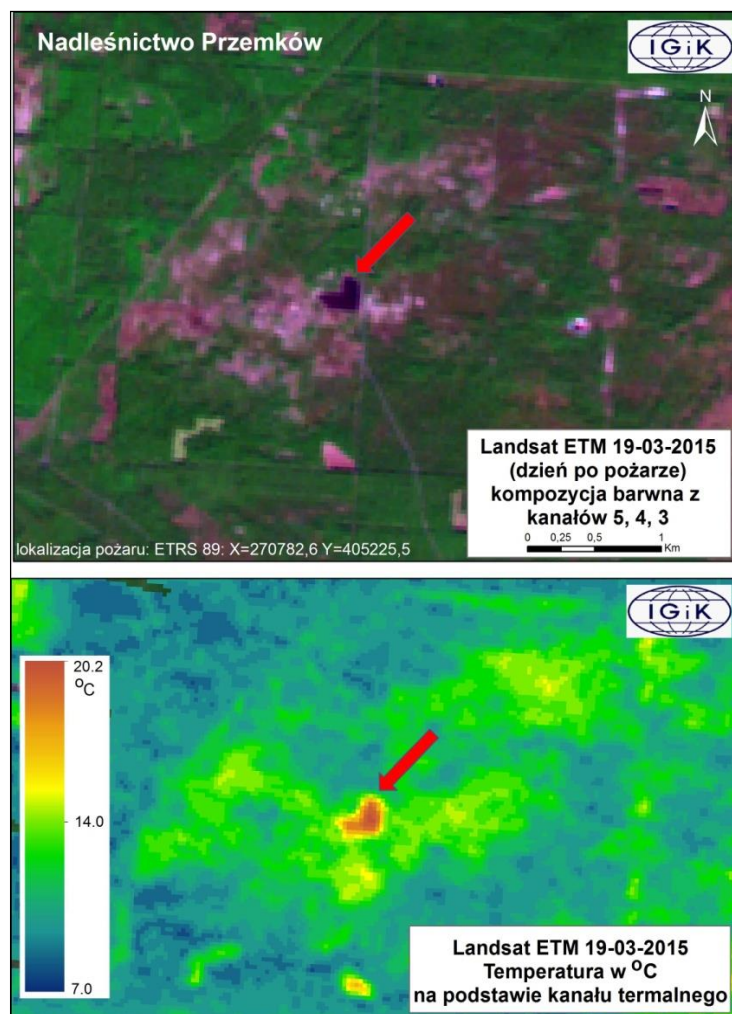


Fig. 13-14: Satellite imageries of the experimental area acquired on the day after the experiment (19 March 2015) at 09:50 UTC by Landsat ETM+. The top image illustrates the burn scar visible on the Landsat ETM+ image. The lower image shows the temperature distribution in the area affected by the fire and its surroundings. Source and credit: Agata Hościło, Remote Sensing Center, Institute of Geodesy and Cartography, Warsaw, Poland.

The burning was recorded by the State Fire Service – see monitoring videos by the State Fire Service drone (GFMC 2015b). The immediate effects of the prescribed burn on the area are followed since the day of burn (Fig. 15 and 16) and are subject of scientific analysis for the coming years. Wrocław University will lead the ecological part of the research. Changes in the fuel load will be monitored by Forest Fire Protection Laboratory of the Forest Research Institute.

Results of preliminary ecological research by Wrocław University are available and describe the situation of the first regeneration stages of the heath (SZCZĘŚNIAK et al. 2015). Reference areas were selected on the unburned part of the heath area. The research is focussing on the state of preservation and regeneration stage of the flora and fauna. The methodology of the research was based on one main West-East transect with the location of the plots depending on the object of research. The first results are very promising. During the first control, the burned area (on 8 May 2015) was almost completely devoid of any vegetation (Fig. 15), but slowly emerging young shoots of heather (*Calluna vulgaris*), red bilberry (*Vaccinium vitis-idaea*) and leaves of purple moor-grass (*Molinia*

*caerulea*) appeared several months later (Fig. 16). In general, the herbaceous layer covered only 10% of the ground, yet it was possible to observe areas without any vegetation at all. Diagnostic species of pioneer sand grasslands (*Corynephorus canescens*, *Spergula morisonii*, *Rumex acetosella*) were observed on some spots. During the next control visits, the mortality of pine trees, regeneration of heather and growth of *Molinia* were observed (Fig. 17 and 18). Browsing by ungulates such as red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) was another factor affecting the regeneration: 80%-100% of the *Corynephorus canescens*, *Agrostis vulgaris*, *Deschampsia flexuosa*, *Carex* cfr. *ericetorum* clusters, but only 20% of *Molinia caerulea*, were browsed. Young shoots of heather were also browsed to a smaller extent (30% of the clusters). The most drastic changes are now observed where the heather was very dense with a thick layer of mosses. Nowadays the ground is bare, with a very intensive colonization of lichens. The differences in colonization rate are mostly due to the different behaviour: Herbaceous plants mainly regenerate while mosses and lichens mainly settle on the exposed land. There was no fuel load inventory in the same year of burning (2015). This will be done in subsequent years.

According to the preliminary observations the prescribed fire did not influence the invertebrate populations. This is explained by the fact that the burnt area might be more accessible for many different species of spiders, ants and beetles.



Fig. 15-16: Immediate fire effects on the day after burning (20 March 2015) and heather regeneration at the end of the growing season (16 September 2015). Photos: Forest Research Institute, Sękocin Stary, Poland.



Fig. 17-18: Further regeneration of *Calluna vulgaris* heath and documentation of tree mortality (*Pinus sylvestris*) (left) and the recovery of the ploughed firebreaks (right) 14 months after the fire (24 May 2016). Photos: Jan Kaczmarowski, Directorate-General of the State Forests, Warszawa, Poland.

Ideally, the regeneration of the heath should enable the return of the species which had to leave it due to the degenerative stage of heather. Deer willingly visit the burned area

due to the fresh, easy accessible forage. Raptors and wolfs are frequent guests in this area as well. There was no fuel load control in the same year of burning.

In summary, the prescribed fire did not lead to a significant reduction of the number of plants and lichen species as well as invertebrate species after one growing season. Despite the severe drought during the vegetation season 2015, 85% of the heather clusters have regenerated (Fig. 16).

#### **4 Addressing common regional problems by cross-border cooperation**

The need and the obligation to preserve the *Calluna vulgaris* heathlands in Europe, particularly in Central Europe, are of transboundary nature. All countries and custodians of conservation areas and protected landscapes are facing the same challenges of maintaining the openness, specific structures and dynamics of these ecosystems. In some regions of Europe the legislative framework and limited experience in the application of prescribed fire in conservation are calling for the exchange of expertise and sharing of scientific-technical knowledge.

The ecological conditions, the history of genesis and the problems for the future of conservation of dry *Calluna* heathlands are very similar between Poland and the regions of Eastern Germany. Here, the application of prescribed burning in heat conservation started in 2001 in a collaborative effort of the Fire Ecology Research Group (which is merged with the Global Fire Monitoring Center) and the Federal Forest Service on former military terrain in Brandenburg State, Germany (BRUNN 2009a, b). Since then a number of joint projects and “routine burning” operations have been conducted by these partners in Brandenburg State and elsewhere in Germany (GOLDAMMER et al. 2009, 2012, 2016, SCHMID et al. 2013). Intensive theoretical and on-the job training of personnel responsible for the management of conservation areas on active and abandoned military terrain has been conducted by the Federal Forest Service and GFMC starting in 2014 (GFMC 2014).

The prescribed fire demonstration burn experiment of 2015 in the landscape park Przemków involved the technical and advisory services from these partners from Germany and led to the consolidation and intensification of Polish-German cooperation in conservation and forestry.

#### **5 Conclusions**

The prescribed fire demonstration burn and experiment of 2015 in the landscape park Przemków has revealed the feasibility of using fire as a conservation tool of dry *Calluna vulgaris* heath, involving burning techniques that are based on the state-of-the art science, safety considerations and institutional cooperation. The experiment will be followed-up by researchers from Wroclaw University and provide the data needed for conservation burning. This will be important for the future of these ecosystems, given the uncertainties of ecosystem response to climate change.

In conclusion, it is recommended to further explore the practicability of the use of prescribed burning in Poland and to continue and foster cooperative transboundary programmes between specialists, the forest services and conservation authorities of Poland and Germany. Legal provisions should provide the necessary regulatory framework, which on the one side would allow the use of prescribed fire on active and former military terrain as well as other habitats, and on the other side continue to exclude the misuse of fire.

The cooperation between the forest service, the fire service and the structures responsible for conservation in Poland would also provide opportunities for defining new ways and methods of joint management of forests and open land habitats for the benefit of forestry, conservation and biodiversity management.

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