Howth Peninsula Fire Management Strategy

Steve Gibson, Marc Castellou and Mary Tubridy

Mary Tubridy and Associates
Clontarf, Dublin 3
mtubridyassociates@gmail.com **February 2021**

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SUMMARY

The wildfire environment found on the Howth Peninsula can support large scale, high intensity fires. It poses a significant risk to the well-being of firefighters, and a potential risk to the local community and visitors to the area. It has the potential to have a significant impact on the Landscape, Recreation and Biodiversity values of the SAAO area and the Howth Head Special Area of Conservation.

Local weather conditions and the local topography on Howth can be highly supportive to wildfire. The vegetation mainly consists of fuel types that can be dried quickly during relatively short periods of supportive weather creating high fuel loads and high and extremely dangerous burning conditions across much of the landscape, particularly on East Mountain. The high quantity of vegetation/fuel arranged across the landscape is the primary cause of extreme fire behaviour, but this is also the one factor within the wildfire environment that can be managed. Although fire behaviour and the risk posed may vary within the heathland, the assessment determined that the risk of wildfire is high or unacceptable in most areas.

The Fire Management Strategy is proposing to manage the vegetation at critical points, creating a more fire resilient landscape and thus reducing the risk to the nearby community and properties. Although wildfire cannot be eliminated from the landscape and there is still a significant risk of serious fire, implementation of the plan will ensure that future fire events can potentially be limited in scale and impact.

It is also proposed that a Howth Wildfire Group be established to facilitate a collaborative and partnership response to wildfires on Howth. Furthermore, it is proposed that additional training and equipment be provided to the Dublin Fire Brigade to improve their wildfire fighting response where deemed necessary.

1 Introduction

1.1 The Howth Peninsula

Howth Peninsula is a rocky exposed headland situated on the northern side of Dublin Bay. While most of the peninsula has been developed for expensive housing there are substantial areas of semi-natural vegetation along its steep sides and rocky summit.

Fig.1 Heathland on the Howth Peninsula

A vocal local lobby has ensured that these areas are no longer available to developers and the undeveloped areas have been designated (with the co-operation of Fingal County Council) as a Special Amenity Area under the Planning Acts. A Management Plan has been prepared for this area, and a locally based multi stakeholder group the SAAO Management Committee has been set up to implement the Management Plan. This group includes representatives of interest groups, residents associations, their local representatives and officials from the Local Authority and national government. The vegetation includes 150ha of dry heathland present in a mosaic with acid grassland on the slopes above the sea cliffs and on and around the upper central headland summits. As s result of the presence of this type of vegetation much of the undeveloped parts of Howth is also an

SAC protected under the EU Habitats Directive (See Fig .1). As farming has effectively ceased on the peninsula and in the absence of grazing semi-natural vegetation dominated by Bracken and Common gorse has spread extensively in abandoned fields etc.

Fig. 2 Vegetation in an abandoned field

The main land uses within the undeveloped areas are recreation and horse grazing. The peninsula is popular with large numbers of visitors and tourists who want to enjoy the atmosphere of a coastal fishing village and also roam across the undeveloped lands which though privately owned are almost all traditionally open to walkers. Counters on the popular coastal cliff path surrounding the peninsula suggest that yearly visitor numbers have reached c.1 million.

As the vegetation has been left unmanaged in many places it is unbroken across wide expanses of the landscape. The resulting high levels of biomass have supported fires of extreme intensity that have resulted in large-scale fire events. The area has seen significant housing development and some properties have been built within or along the fringes of wild vegetation.

1.2 Fire history in Howth

Past fire scars can be easily found along the slopes above the cliffs, and within vegetation on the upper parts of the peninsula.
Tables 1 and 2 shows the seasonal pattern and nature of different types of wildfires attended by the Fire Brigade on the Howth Peninsula over the last ten years X month (Table 1) and X year (Table 2).

Table 1 Fire incidents attended in Howth X month between 2009 and 2019 (information from records compiled by Fire Brigade)

INCIDENTS BY MONTH AND TYPE							
MONTH/TYPE	FIRE/FIRE	FIRE/FOREST	FIRE/GORSE	FIRE/GRASS	FIRE/SMALL	FIRE/SMOKE	Total
JANUARY	1		1		3		5
FEBRUARY					4		4
MARCH	2		8	1	4		15
APRIL			7	2	15		24
MAY	3	3	42	4	17		69
JUNE	3		43	1	15		62
JULY	3		28	6	15	2	54
AUGUST	1		2	1	8	1	13
SEPTEMBER	1	1	4		15		21
OCTOBER	5		14	1	23		43
NOVEMBER	1		3		11	1	16
DECEMBER	1				4	1	6
Total	21	4	152	16	134	5	332

Table 2 Fire type X year between 2009 and 2019

INCIDENTS BY TYPE AND YEAR												
TYPE/YEAR	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
FIRE/FIRE	3	2	2	3	3	1	2	2	1	2		21
FIRE/FOREST				1	1	1	1					4
FIRE/GORSE	5	7	25	4	30	4	24	8	27	16	2	152
FIRE/GRASS		1	2	1	8	2			1	1		16
FIRE/SMALL	7	8	19	11	10	6	8	14	27	18	6	134
FIRE/SMOKE				1	1	1	1			1		5
TOTAL	15	18	48	21	53	15	36	24	56	38	8	332

The above information shows that 332 fire events occurred on the Howth Peninsula in the last ten years. While principally occurring between May and July they are also likely to occur at all other months. Peak incidents occur during the periods of peak visitor numbers.

1.3 Worldwide trends in climate affecting fire regimes

Within Ireland and internationally wildfires are now considered a serious threat. Whenever weather conditions are supportive, vegetation fires can occur and they cause significant damage to the landscapes, biodiversity and communities. As a result wildfire management has been receiving increased attention from researchers, policy makers and managers. See the glossary in Appendix 1 for an explanation of the technical terms used to describe wildfire.

The analysis of weather trends suggests that in north Atlantic countries there has been an increase in both maximum temperature and the amount of precipitation. These changes support vegetation growth resulting in an increase in biomass, and consequently, fuel loading. With milder winters, warm wet summers, high fuel loads and windows of hot supportive fire weather, the wildfire risk is growing.

Evidence suggests that countries such as the UK, Ireland and Norway are moving towards a fire regime that may become comparable to a wet fire season in Portugal. This comparison is important and realistic as although Portugal is in Southern Europe, like Ireland it falls within the influence of the Atlantic, and is the wettest Southern European country. As a result high fuel loads cause huge wildfires. Portugal has by far the most significant wildfire problem in Europe. It is now widely accepted that the threats posed by wildfire are likely to grow and evidence suggests that changes to weather conditions in the future will result in an increase in the frequency of wildfire events, more extreme fire behaviour and increased propagation.

1.4 The brief

As the Heathland Management Plan prepared for the Howth SAAO committee and Fingal County Council (Tubridy 2015) recommended improved management of wildfire Fingal County Council sought consultants in 2019 to carry out a study to provide information and advice on the following issues:

Identify and map access points & access routes or Fire Brigade services
Identify and map water supply points and access.
Identify and map high-risk areas where fire can have a significant impact on properties or infrastructure or nature conservation.
Map utility infrastructure (mainly overhead electricity lines) across heathland sites
To identify and map the locations of firebreaks and specify the management requirements for the firebreaks.
Identify and clearly map areas where communication equipment is known not to work (FCC and Dublin Fire Brigade to assist with this assessment)
Identify and map key vantage points for the fire officer controlling the fire fighting activities.
Identify any other measures required to manage wildfires on Howth, particularly in the context of vegetation management.
Identify the equipment and materials required to fight fire on Howth and compare this with the equipment and materials currently available to Dublin Fire Brigade and local community.
Identify the training requirements and training exercises for Dublin Fire Brigade
To outline how to develop a community fire watch service, outline the training requirements for people that wish to sign up for this and recommend a management and communication structure required to make this work efficiently.
Identify the review procedures and review period of the fire management plan
Develop a list of all recommended actions in an Appendix to the report with estimated costs

1.5 Approach

Mary Tubridy and Associates were appointed to carry out this project in 2019. The project was led by Steve Gibson from the UK, a specialist in wildfire operations who was assisted by Marc Castellnou, wildfire expert. Steve has extensive international experience in Africa, Europe (including the Mourne Mts, Northern Ireland) and the US with fire services and forest and land agencies. Marc Castellnou is a forest ecologist from University of Lleida (Spain, 1997) as well as a fire officer since 1999 in the Catalan Fire and Rescue Service. He serves the Catalan Fire Service as a Strategic Wildfire Analyst and Incident Commander as well as being Chief of the GRAF (Specialist Wildfire Unit Catalonian FRS) type one crews. He is also a Wildfire Expert for the European Civil Protection and Humanitarian Aid Operations (DG ECHO). Dr Mary Tubridy is an ecologist (author of the Heathland Management Plan) who has been involved in field-based studies in Howth since 2000.

The consultants interpreted the requirements of Fingal County Council as an Action Research project. Action research identifies problems or weaknesses and helps individuals or organisations to address them effectively, efficiently and collaboratively. Action research implies intensive consultations with all interest groups, the organization of actions which increase their awareness and the production of a report which provides background to issues and thus the rationale for management actions Therefore the project was broken down into a two-phase study. The first phase of research involved an analysis of the wildfire regime in Howth and its current means of control. The second phase involved the elaboration of actions to minimize fire risk and improve methods of control. Both phases required awareness of the nature of the vegetation subject to wildfire on Howth, the environmental conditions which affect fire behavior, consultations with the Local Authority and Fire Brigade all informed by consultants experience of best practice in wildfire management. It was accepted that while the topography of Howth is a constant and weather conditions are beyond control the threat posed by the third and possibly the most important factor, fuel, is manageable, a task which was highlighted in the brief *"Identify any other measures required to manage wildfires on Howth, particularly in the context of vegetation management"*. Phase two of the research focused on actions required to improve the management of the fire regime. As the Fire Brigade is the principal authority responsible for managing fires considerable efforts were made to investigate their capacity for wildfire management. As it is unlikely that the threat posed by wildfire can be eradicated the consultants took the approach that the future management of wildfire on Howth should be the responsibility of a partnership comprising the community, landowners and authorities.

Consultations at an early stage clarified that the "authorities" would include the local authority and Dublin Fire Brigade.

Following further consultations with Fingal County Council it was agreed that the output for this study would focus on:

How to improve the fire resilience of the landscape
Reducing the potential size, scale and impact of future wildfire events
Improving local understanding of the wildfire risk
Providing advice identifying any improvements that can be made to the extinction capacity of fire fighters
Developing an integrated and collaborative fire management response

2 Methodology

2.1 Introduction

The project involved desk research, fieldwork, the collection of information to inform 1) a preliminary assessment of fire risk and 2) a fire modelling exercise, consultations and information exchange with agencies and the community including the organization of a training exercise for the Fire Brigade.

2.2 Desk research

Desk research was carried out on:
The nature and location of the fuel loads throughout the Peninsula (using unpublished reports and information from Fingal County Council).
The prevailing weather conditions and the shape of the topography based on meteorological records and aerial photography.
An examination of recent literature on the management of fuel loads.

2.3 Fieldwork

Fieldwork enabled the team obtain a preliminary understanding of the past, current and importantly potential future impact of wildfire on the peninsula, provide a preliminary assessment of the likely fire behaviour within the fuel arranged across the landscape and any evidence of the impact of climate change within the fire environment/regime. The visits also provided the team members with an opportunity to meet with the primary stakeholders and seek their views regarding the values present on the various sites and obtain a full understanding of what they considered important to protect, including the interests of the project sponsors.

Therefore during several site visits, in 2019, the team familiarised themselves with the following:

The type of vegetation, its arrangement, continuity and its condition across the Howth Peninsula.

The topographic shape of the landscape and its likely impact on fire behaviour and spread.

Information on historic fire events

The economic, infrastructure, environmental and social values associated with the Howth Peninsula.

Potential urban interface and the risk to private property posed by wildfire.

The current actions taken on the ground to reduce the wildfire risk.

The weather conditions during which fires are likely to occur and the impact of these conditions

2.4 Consultations

Extensive consultations with Dublin Fire Brigade focused on the following:

DFB current wildfire training programme

Fire fighting tactics

Wildfire specific equipment

All fire brigades have constraints that may limit their response capability when dealing with wildfire incidents. Establishing an understanding of DFB's fire fighting capacity was considered when formulating the Fire Management Strategy. A request was also made to DFB for any historic records they held regarding wildfire events they had attended on the Howth Peninsula.

Consultations took place during specific meetings and also during a three-day wildfire training course organized by the consultants for Dublin Fire Brigade which was attended by representative from Fingal County Council and community.

Consultations with the community took place at several regular meetings of the Howth SAAO Committee and at an evening public meeting organized by Fingal Co Co to present preliminary results from the study and discuss some of its recommendations.

2.5 Preliminary assessment of wildfire risk

The assessment process used was the England's Uplands Management Groups Wildfire Risk Assessment Process (https://fd126f62-29b2-4499-84fa-0c0e1b7f92ac.filesusr.com/ugd/fdc287_561c28bb747f4b63a1f6a4b62656a55c.pdf). This has been specifically developed for the use by land managers who wish to assess the wildfire risk on their own land.

It is based on a field inspection of the peninsula to provide an expert assessment of the wildfire environment. Understanding of this evaluation and information in the remainder of the report would be assisted by familiarity with the terminology in Appendix 1 which contains a glossary of the terms used to describe wildfires and their suppression.

Consideration was given to the following factors within the Wildfire Risk Assessment:

The identification of hazards, both direct and indirect.

The identification of assets vulnerable to wildfire, including environment, people and property.

An evaluation of the risk, including likelihood of fire occurring and severity of incidents.

An analysis of the risk to agree appropriate actions

Factors that influence the risk of a fire starting are:

People (visitor use and numbers).

Access points (public rights of way, car parks, and open access land.

Presence of 'honeypot' areas (e.g. picnic sites, campsites).

Land management/land use type.

Adjacent land management/land use.

History of wildfires in the area (including identification of fire scars).

Factors influencing fire behavior include:

Vegetation type (susceptibility to drought and fire).

Vegetation growth (biomass/fuel loading).

Extent of habitat features / presence of natural firebreaks (continuity of fuel).
Distribution of habitats (continuity and arrangement of fuels).
Topography.
Soil type / soil moisture content.
Presence of ground fuels (peat soils).
Climate.
Fire fighting limitations are:
Wildfire training.
Availability of specific firefighting equipment.
The difficulty in access and egress onto the landscape.
Expected fire behavior.
Extent of mitigation (fire breaks, fuel treatment etc.).
Presence of buildings and other property
Speed of attack.
Assets/values at risk are:
People
Infrastructure
Property
Tourism
Public access
Highways
Cultural heritage
Priority habitats
Priority species
Historical features
Recreational assets
Air quality

2.6 Wildfire modelling

A number of global fire monitoring systems, satellite, and remote ground information systems and historic data bases were employed to analyse historic fire events that have occurred on the Howth Peninsula and to provide an indication of future wildfire events.

A study was made using the Global Forecasting System, to identify weather trends suggesting future fire behaviour likely to occur on the east coast of Ireland. Climate data was acquired from Terra Climate (Abatzoglou et al. 2018). The maximum monthly temperature, minimum monthly temperature, total annual precipitation, and mean annual deficit were derived from this dataset at a ~4-km (1/24th degree) spatial resolution for a time period of 1958-2017. Mean annual deficit is defined as the difference between PET and AET and is a measure of drought stress on plants. A study was also made of a number of sources providing information on weather trends.
Fire simulation was used to determine likely fire spread and intensity. The purpose of simulation is to establish an understanding of how the fuel, topography and supportive weather conditions on the Howth Peninsula interact, influencing fire behaviour and its spread across the landscape. Information on fuel load was obtained from Fingal County Council. This was customised by the team and converted into a usable format to inform a modeling exercise.

NEXUS and FLAMMAP models were used to perform the first simulations. NEXUS which is a simulation tool based on the Rothermel (1972) fire model which uses energy balance equations to predict the rate of spread. NEXUS (Scott, 1999) has been widely used as a simulation tool (e.g. Fule et al., 2002; Scott, 2006). It is based on the same basic principles as FLAMMAP, and adapts its graphical interface to perform simultaneous simulation of fire scenarios. Input data in NEXUS interprets fuel structure and weather conditions. Fuel structure can be defined in NEXUS either by pre-defined fuel models (Scott & Burgan 2005) or via the direct entry of stand descriptors. These fuel models gather numerical information about fuel load, fuel size, moisture content or heat of combustion.

The acquired understanding allowed the team to identify a number of areas on the landscape that provide significant support to fire development, in particular its intensity and spread amongst the fuels. These locations are termed to be Strategic Management Areas (SMA's). The reduction of biomass at the identified SMA's can have a significantly limiting effect on fire behaviour reducing potential scale and intensity.

2.7 Report preparation

The report was compiled by the team through an iterative process which involved discussion of drafts with the SAAO Management Committee and Fingal County Council. Consultations with the Fire Brigade clarified that they would produce the Wildfire Operational Management Plan. This document suitably titled the Fire Management Strategy will provide the rationale for all the works which needs to be done….what, why, where and by whom.

The Operational Plan being prepared by the Fire Brigade will guide their management of wildfire in Howth. The OP will follow the format used by the Fire Brigade and will be a much shorter document. It will probably include some of the mapping in this report, particularly that showing likely fire spread and intensities, the identification of windows of opportunity such as fire breaks or SMA's, safe access and egress routes for vehicles and for personnel on foot, passing points for vehicles, suitable marshaling areas and rendezvous points and areas of high risk to properties and infrastructure. Identification of fire quadrants and the locations where fuel reduction methods have been applied will probably be shown and regularly updated.

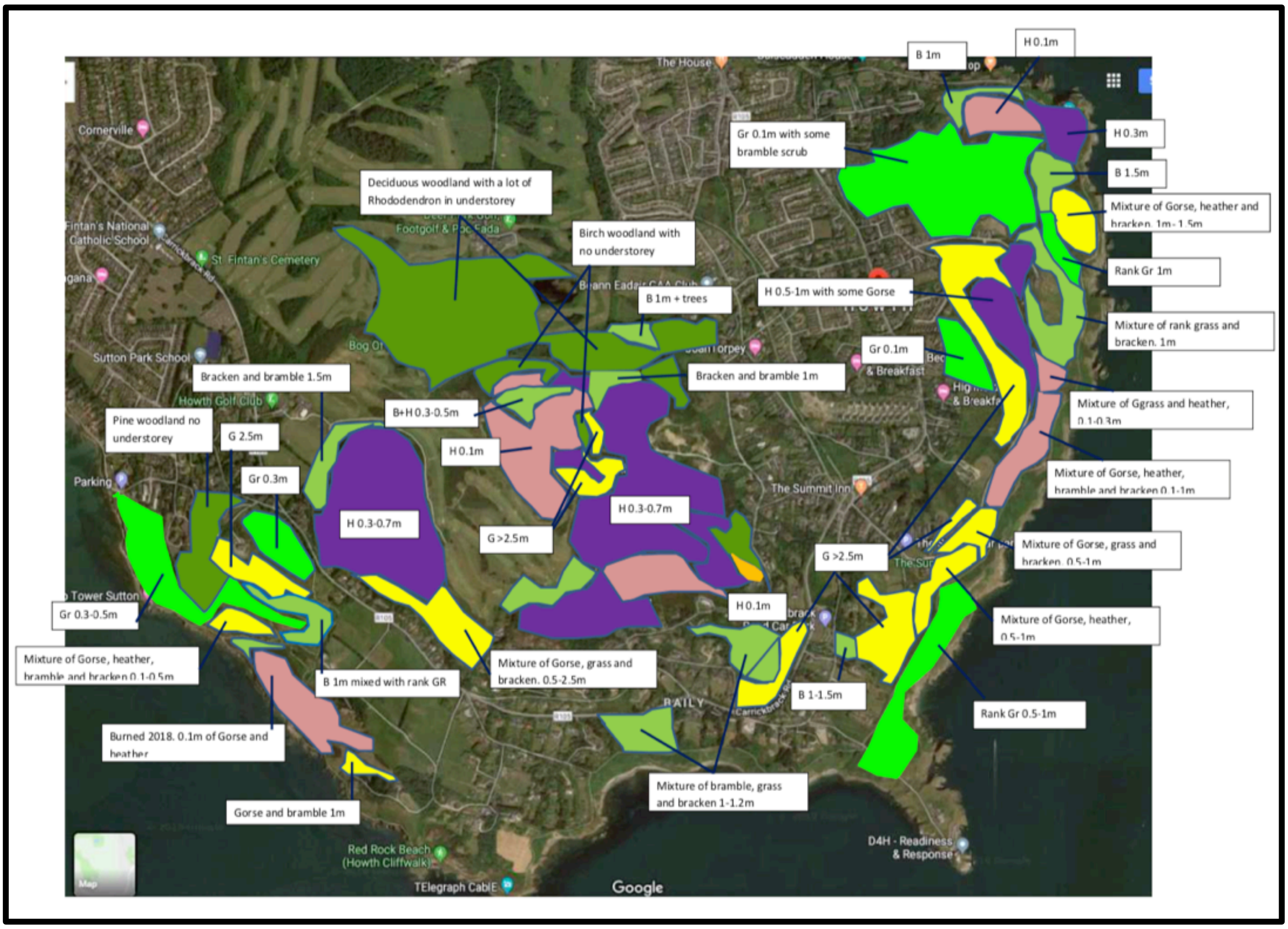
References at the end of the report relate to documents consulted for this study as well as general literature on wildfire management.

3 Results

3.1 Fuel load and fire behavior

Within the wildfire environment in Howth the main source of fuel is the vegetation arranged on the landscape. Fig. 3 shows the arrangement of fuels in relation to wildfire risk.

Fig. 3 Fuel loads on the Howth Peninsula



The type of fuel, its size and the way the vegetation is arranged across Howth affects the way it burns. Understanding how vegetation interacts with fire is important; such knowledge can be used, not only to understand present fire behaviour, but also to predict what it is likely to be in the future. This understanding is not limited to fire intensities but can also provide an accurate evaluation of future rate of spread and forecast the expected flame length, which is important with regards to fire fighting.

The behaviour of a wildfire in a given fuel source on Howth is dependent upon these characteristics of the fuels:
Size and Shape
Quantity
Arrangement
Moisture content
The size and shape of the available fuel is important particularly in regard to their ease of ignition. ***Smaller fuels, referred to as 'fine fuels', are more receptive to fire, while larger or more coarse fuel types generally rely on their interaction with fires in finer fuels before they will ignite***. ***Much of the heathland and grassland of the Howth Peninsula contains high quantities of fine fuels, which can burn readily and with high intensity***.
The relationship between any given fuel's surface area and its volume, and the fuel's size and shape, strongly influences the ease of ignition. The surface area of finer fuels, such as grass or heather, is much greater than the equivalent volume of coarser fuels such as branches and logs. Fuels with a higher surface area to volume dry quickly and require less exposure to heat for them to be raised to their ignition point.
Fine fuels are considered to be those with a diameter of up to 6mm, and include grass, small stems and the leaves of low-lying shrubs such as heather. Fine fuels can be found in huge quantities in larger plants, i.e. needles on Gorse, which is common on the Howth Peninsula.
The way in which fuel is arranged plays an important part in the way fire develops. The principal factors to consider are the continuity of vegetation across the landscape and how the vertical and horizontal fuel arrangement is able to interact. ***Across many parts of the Howth Peninsula the arrangement***

of the fuel is continuous, this can potentially allow a fire to spread over large areas of the landscape and may result in large scale and intense wildfires.

Fuel moisture content has a substantial effect on fire behaviour altering rate of spread, intensity and the likelihood of extreme fire behaviour. Both dead and living fuels contain moisture, which affects the way they will react during a wildfire. ***Much of the vegetation on the Howth Peninsula will dry quickly during short periods of wildfire supportive weather.***

Weather is a key wildfire factor and has a significant impact on the fuel complex and the broader wildfire environment. Weather influences fire intensities, rates of spread and levels of risk and it is vital that there is an understanding how the prevailing weather conditions can change wildfire behaviour.

It is a misconception to believe that wildfire is reliant on extreme weather conditions, that the threat of wildfire is limited to the summer months, or indeed that it requires a prolonged period of dry weather to create suitable conditions for wildfires to occur. ***A relatively short period of supportive weather can increase the risk of wildfire significantly and vegetation fires can occur at any time of the year***. Not only does the weather have an effect on the combustibility of fuel, it also has an influence on the combustion process itself.

Weather influences fire behaviour by:

Raising and lowering the temperature of fuels and the air.

Increasing and decreasing the moisture content of the air.

Changing the moisture content of fuels, particularly dead ones.

Supporting or limiting the development of strong convection plumes.

Curing (drying of) fuel.

Changing the direction, strength and type of prevailing and local winds.

Changing the level of stability in the atmosphere.

Periods of dry supportive weather conditions have an obvious impact on the wildfire environment drying fuel and increasing the amounts of vegetation available to burn. This impacts on the severity of a fire and the likelihood of it spreading over larger areas of the landscape. Drought can be particularly damaging to areas within the Howth heathland within its shallow soil and its predominant fuel types, such as heather, which can be stressed or even killed by prolonged dry conditions. The Howth Peninsula is one of the driest places in Ireland as measured by estimates of potential evaporation and excess evaporation during summer months. (Jeffrey, 1989)

Fig. 4 Heather affected by drought

Topography can be described as the configuration of the Earth's surface, including its relief and position of natural and man-made features, arranged across the landscape. In the wildfire environment topography plays an integral part in determining how a fire will develop and spread across a landscape. These influences will have a direct and indirect impact on fire behaviour, and if the topographical influences are understood, this knowledge can be used to determine the likely fire severity at different points across the landscape.

Topography should be considered to be a fixed or known factor that will influence variables such as fuel types, fuel quantities, relative humidity, wind speed and direction and the potential size and shape of the fire footprint. In addition, topography plays an important part in fire intensity, direction and rate of travel.

The shape of the landscape will influence wildfire behaviour in a number of important ways and consideration should be given to the following:

Orientation and angle of slope in relation to the position of the sun

Steepness of slopes

Shape of the topographical features

The effect of topography on the types and amounts of vegetation

Water drainage features
The effect of topography on wind direction and its strength
Barriers to fire travel such as tracks, roads, streams, rivers, wetlands and other fire obstacles

As the topography of Howth is complex, the fuels arranged on the slopes and atop of the coastal cliffs, as well as on the upper heathland areas, are subjected to winds that are strongly influenced by the physical shape of the peninsula. This will result in a complex pattern of fire spread that may burn large areas of the landscape and create challenges for fire fighters and other responders.

3.2 Background to wildfire development

A fire burning in uniform fuels will normally start at a single point of ignition and the resulting flames firstly consume the surrounding fine fuels. As the fire develops, convection currents draw the flames towards the centre and away from the surrounding fuel. Fire development at this stage is mainly caused by flame contact with any unburnt fine fuels.

In the absence of any alignment with wind or slope the convection plume will continue to dominate early fire development, the fire will burn more or less equally in all directions and most of the heat will be drawn into the convection plume and lost to the atmosphere. This situation will continue until there is a variation in the fuel or its combustibility, or where the fire finds alignment with wind or slope.

When the outer edge of a fire is supported by wind or slope and the strength of this alignment is stronger than the convection force created by the fire, equilibrium is lost. The part of the fire that finds most alignment with wind or slope will overcome the influence of the plume, and the flames at this part of the fire will angle towards the fuel, at the same time the flames at the rear part of the fire are bent away from the fuel. As a result the fuels at the front of the fire are subjected to more preheating and the fire is able to penetrate these with more ease, increasing fire intensity and rate of spread. The fire at the rear has less interaction with the fuel and activity is reduced. The shape of the fire footprints are likely to change and depending on the strength of alignment may become elongated as the front part of the fire develops what is termed to be a head.

The head of the fire has the most sustained alignment and as a result is the fastest moving and most intense part of the fire. Depending on the fuel and its arrangement, the head fire is the part of the fire that has the greatest flame length, flame depth and rate of spread. It is essential to understand that fire intensity can change around the fire perimeter, and any part of a fire that aligns with wind or slope can potentially develop head fire behaviour.

The sides of the fire are termed to be the flanks and these burn outwards into the unburnt vegetation. This results in the flanks having less alignment than the head, normally reducing their intensity and rate of spread. Flank fire intensity nearest the head is normally more intense, particularly where the flanks meet the head which is known as the 'shoulder'. The flanks of a fire can make up most of the fire perimeter, and therefore there may be variations in fire activity due to changes in fuels or topography along its length. This can lead to a different fire behaviour being demonstrated by each flank and one becoming more dominant than the other. This can be explained by the fact that usually one side of the fire will have better alignment or be burning in more supportive fuel types.

The wildfire environment is one that is subject to almost constant change and although some of these variations will be subtle, others will result in a dramatic and rapid change to fire intensity and rate of spread. To ensure that firefighters remain safe and effective it is imperative that they and their managers have an understanding of the circumstances that will bring about these changes. The appreciation of when, and where, fire behaviour is likely to alter will assist firefighters to apply suppression tactics safely and at times and at locations where they are most likely to succeed in bringing the fire under their control. Changes will result in a fire becoming more or less responsive to its environment and increasing or decreasing levels of risk. If managers have an understanding of when and where these changes are likely to occur, they can apply this knowledge to the decision making process and adopt appropriate control measures within a suppression plan.

Understanding the changes in fire behaviour at a wildfire will also assist fire commanders to take the correct tactical decisions. Timing is crucial and taking full advantage of windows of opportunity where the fire is within the threshold of control of available resources is hugely important. The application of appropriate tactics and successful fire management techniques will ensure that changes are controlled within the governance of an effective incident command system and safety regime. ***The actions outlined within the Howth Management Strategy are intended to lower fire intensity at key locations across the landscape sites to more manageable levels, creating potential opportunities for control measures by responders.***

Fig. 5 Burnt area colonized by bracken

3.3 Preliminary assessment of the wildfire regime

The concept of a fire regime provides an integrated way of classifying the impacts of these diverse spatial and temporal patterns of fire and impacts of fire at an ecosystem or landscape level (Hardy et al. 1998; Morgan et al. 2001; McKenzie, Miller, and Falk 2011). Understanding the historic and potential fire regimes and the factors that can alter these fire regimes is important for understanding and predicting potential interactions between fire and climate. Not only does climate (as reflected in dominant weather patterns) directly affect the frequency, size and severity of fires, it also affects fire regimes through its influence on vegetation vigour, structure, and composition.

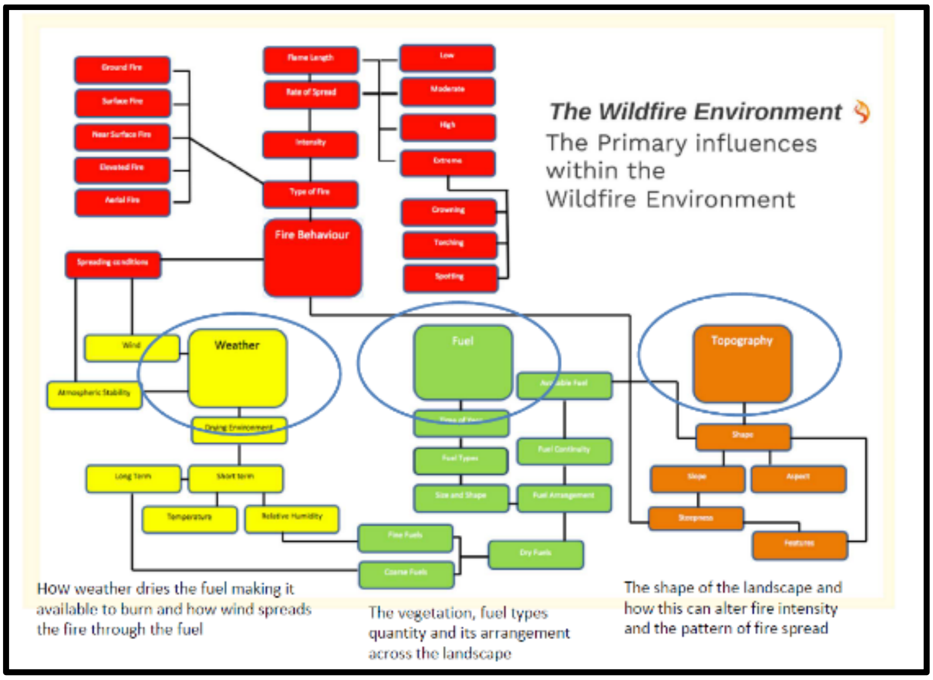


Fig. 6 Factors affecting the wildfire regime on Howth

The graphic above summarises the principal factors affecting the fire regime in Howth.

The table below provides an expert assessment of the relative severity of the wildfire risk having regard for how weather, topography and wildfire fuels interact and influence fire behaviour.

Table 3 Wildfire Assessment Risk Howth

Wildfire Risk Assessment Matrix

Severity	Likelihood 1	2	3	4	5	Category	Score	Risk Rating
1	1	2	3	4	5	1	1 - 5	Low
2	2	4	6	8	10	2	6 - 10	Moderate
3	3	6	9	12	15	3	12 - 16	High
4	4	8	12	16	20	4	20 - 25	Unacceptable
5	5	10	15	20	25			

Fig 7 Wildfire assessment in Howth (based on Forestry Commissions Best Practice Guide Building Wildfire Resilience (2014).

This expert assessment considers that there is a high and unacceptable risk of wildfire on Howth.

Where the risk assessment exceeds the threshold of acceptability, mitigation measures should be built into a Wildfire Management Plan (Forestry Commission 2014). The following section provides a detailed analysis of the wildfire regime in order to inform such mitigation measures.

3.4 Fire modelling

The following maps produced by the modeling exercise illustrate the important characteristics of Howth wildfire.

Fig. 8 shows fire polygons defined on the basis of fuel type. ? Check map

Fig. 8 Fire polygons based on vegetation coverage

The above mapping indicates the connectivity between the fuels arranged across the Howth Peninsula, the red perimeter indicates all fuels that are potentially available to a fire outside the urban areas, the yellow perimeter encloses the areas of high fuel loading.

Fig. 9 Potential fire runs

Fig. 9 indicates the most significant fire runs identified during the simulations, these show the possible fire runs across each of the sites, they are not intended to show the potential connectivity between the various sites.

Fire intensity is illustrated by Figs. 10 and 11.

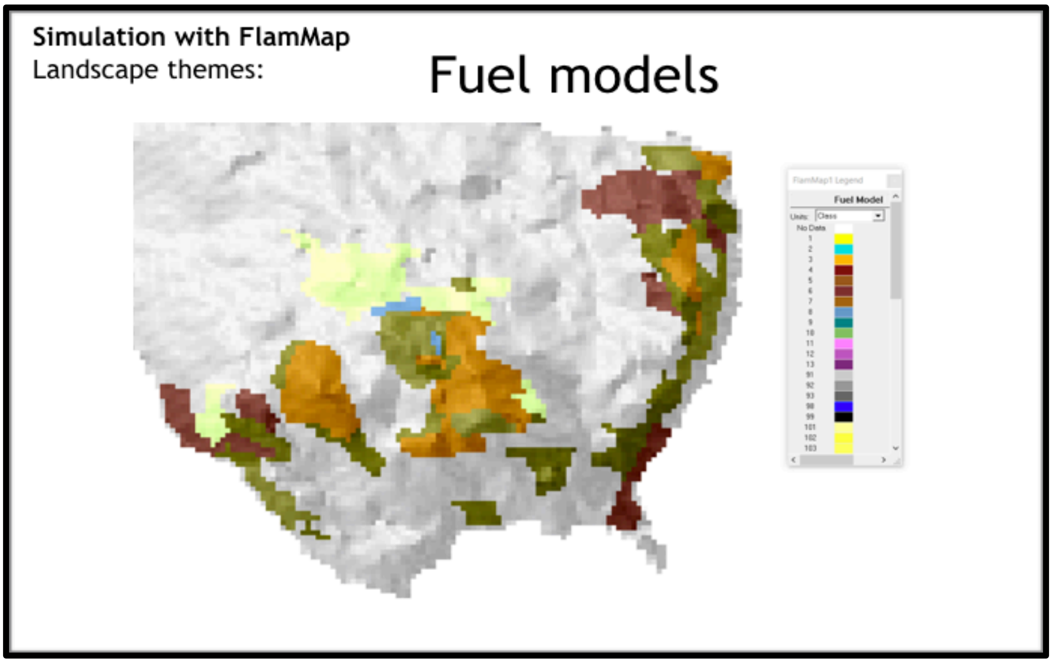


Fig. 10 The fuel model used in the simulations

Fig. 11 Potential fire intensities within the fuels（FLAMMAP）

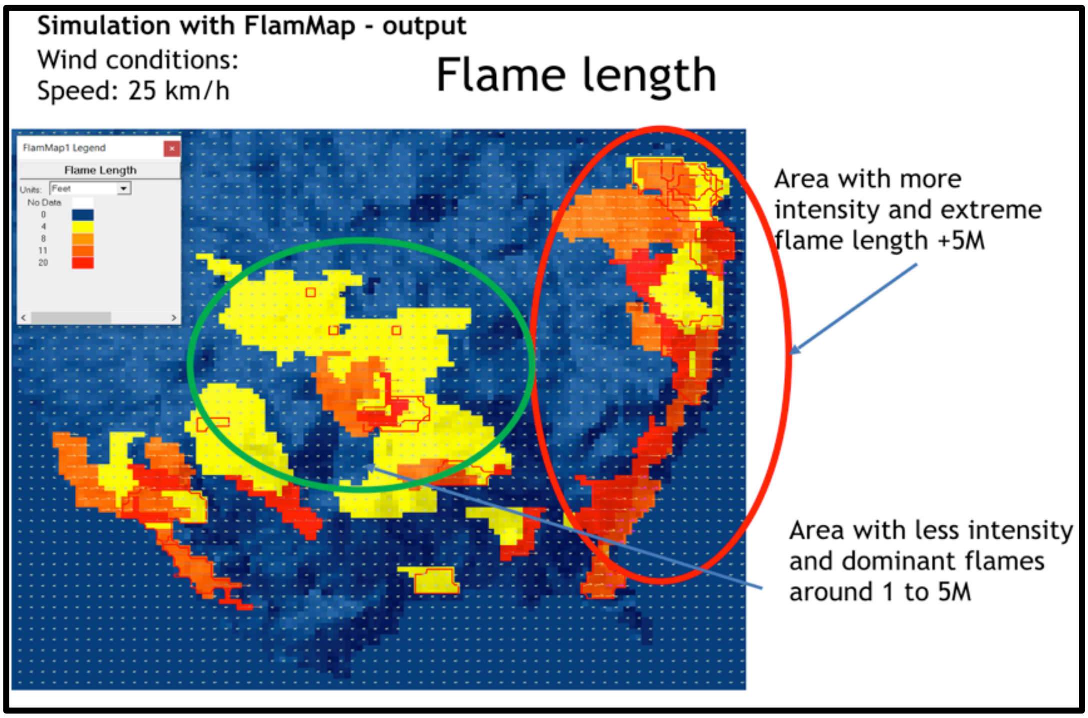


Fig. 12 Fire scenario modeling

Fig. 12 shows the result of fire scenario modeling. It shows a fire ignition occurring within the area marked in white and spreading over the landscape over a time period of approximately five hours. Every coloured line represents the distance the fire spread over one hour. The above mapping also shows the potential risk to urban areas and the high risk to property. This scenario should be considered to be an extreme example and one that although possible, is unlikely to occur.

The diagram above presents the worse case fire scenario. It shows how the present connectivity between the different parts of the landscape may allow the fire to spread across much of the Howth landscape. The continuous coloured lines indicate where the fire can spread further, broken lines indicate where within the simulations, the fire stopped due to a lack of available fuel. As this was simulated fire behaviour further fuel reduction measures may have to be taken.

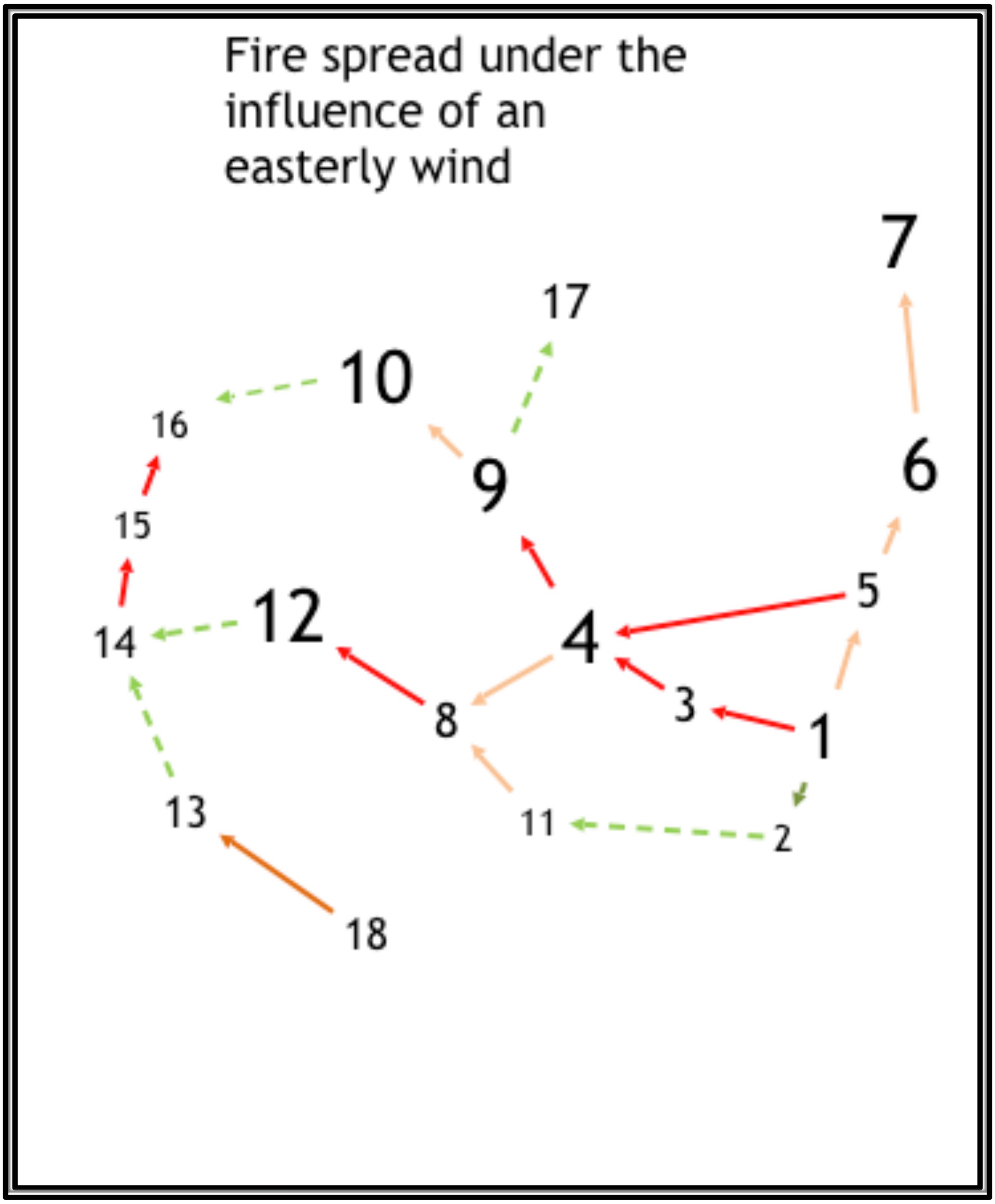


Fig. 13 Shows the sequence of potential fire spread across the landscape under the influence of an easterly wind. The size of the numbers indicates the size of the polygon.

Red Arrow - Fire spread through head fire behaviour

Brown Arrow- Fire spread through flank fire behaviour
Green Arrow - Fire spread through spotting fire behaviour

Fig. 14 shows the sequence of potential fire spread across the landscape under the influence of a westerly wind. The size of the numbers indicates the size of the polygon.

Red Arrow - Fire spread through head fire behaviour
Brown Arrow - Fire spread through flank fire behaviour
Green Arrow- Fire spread through spotting fire behaviour

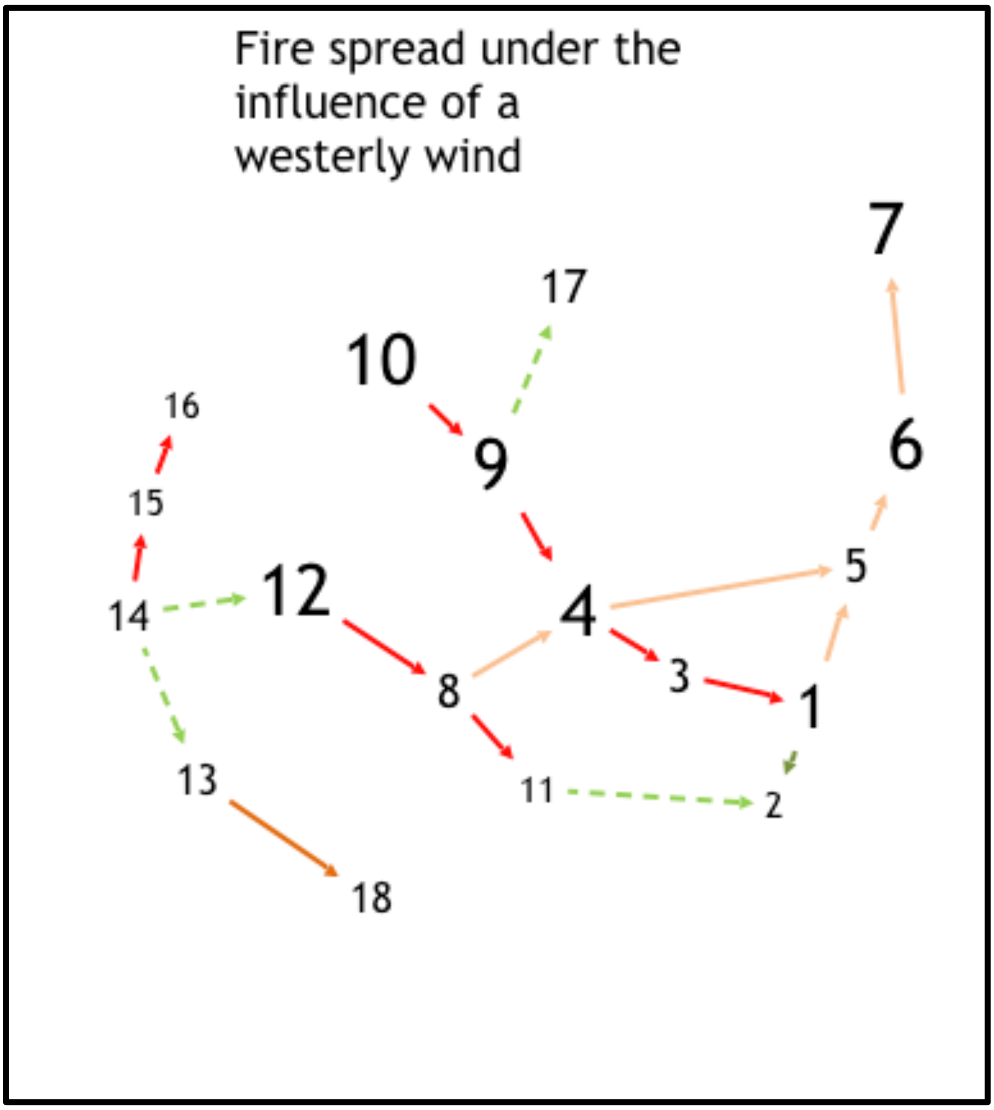


Fig. 15 summarises the relative fire intensities among polygons and sub polygons based on the output from the model.

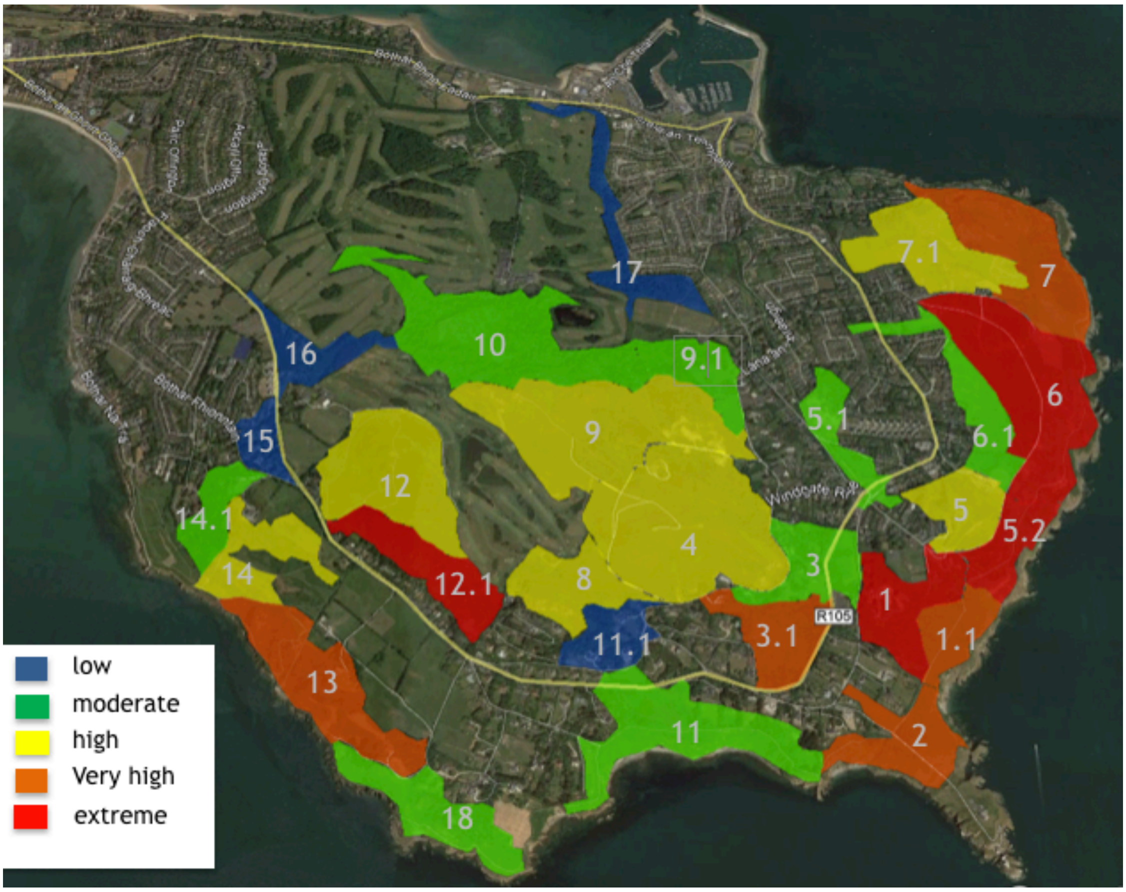


Fig. 15 Fire line intensities X polygons

Some polygons have been further broken down into sub polygons, this clearly indicates the potential changes to fire behaviour that may occur within the same polygon. The intensities shown within the polygons are those that are generally predominant but other pockets of different fire behaviour either of higher or lower fire-line intensities may occur within them.

The fire simulations combined with the wildfire knowledge and experience held within the team, allowed for an understanding of how fire is likely to behave across the Howth landscape. The topographic shape and fuel connectivity between different areas, create 'fire paths' that enable fire to spread from one part of the landscape to another.

Having an understanding of how fire can spread between the different polygons, makes it possible to identify the potential routes a fire will use to cross the area. The diagrams show not only the linkages between the quadrants, but also visually displays the strength of each linkage and potential strength of momentum it has as it moves from one polygon to another. This knowledge assists in developing an understanding of the critically important linkage between polygons and where these need to be weakened or broken. The following section describes actions required to minimize the fuel load to reduce the severity of fire events.

4 Management of fuel load

4.1 Vegetation management

The main vegetation types arranged across most of the undeveloped land consist of heathers, grasses and gorse, these provide substantial quantities of 'fine fuel` (fuels with a diameter of less than 6mm). The fuel is arranged with connectivity and continuity over the landscape, providing fires with the potential to spread across these flammable landscapes for considerable distances. The vegetation has been largely left unmanaged and as a result the fuel loading at some locations is extremely high. The stands of gorse for example will burn with extremely dangerous intensity. Although the valuable heathland on Howth covers a relatively small area of about 150ha, the potential for large and damaging fires within it, is high.

What remains of the healthy heathland on the Howth Peninsula shows signs of it being significantly impacted by fire. Future fires present a further threat to the appearance and the biodiversity of the landscape and may present a substantial risk to citizens who live nearby or who visit the area. At many locations within the heathland the vegetation will support surface fires of high or extreme intensities, these fires also have the potential to move within the fuels at an alarming rate of spread. The resulting fire behaviour will present a significant challenge to firefighters and may place them at significant risk of entrapment. Climate change will impact on the local wildfire environment, warmer wet conditions appear to be bringing seasonal change, lengthening the growing periods of vegetation which increases the amounts of biomass available to burn. In recent years there also appears to be substantially more periods of fire supportive weather, these normally consist of a short period of high temperatures that quickly dries out the fuel bed, or longer periods of hot weather leading to drought conditions, drying fuels and increasing the amounts of dead fuel within its arrangement. This further increases the vulnerability of available fuel within the fuel complex, increasing fire intensities and rate of spread.

Landscape fuel management can reduce wildfire potential, by reducing fuel availability at key areas in the landscape. Land managers have a number of options available to them and the chosen method will depend on the particular outcome required and resources available. Although the focus is on fuel load reduction, it is also important to look at fuel type and the ecological impact of the management processes used. For example burning will remove both dead and live fuels while cutting will remove live fuels but increase dead fuel availability. This is an important consideration as dead fuel is more vulnerable to fire during periods of fire supportive weather.

Management methods can include some or all of these options.

Mechanical treatments

Mechanical thinning has been applied to reduce *Calluna vulgaris* dominance following boreal forest ecosystem disturbance, such as fire and clear- cutting, that may convert forestland into heathland. Calluna is known to effectively exclude other vegetation and causes ``growth check'' or stagnation of conifer seedlings to result in poor tree regeneration. The aim of these mechanical treatments applied in heather is to increased establishment and growth of Scots pine seedlings. (Norberg et al. 2001). Mars (1984) found that mechanical treatments did not adversely affect the Calluna understory, and these treatments tended to increase the number of regenerating Calluna seedlings. Mechanical treatment can achieve similar results to those obtained through prescribed burning, in terms of reducing the potential of crown fire behaviour. A significant difference being the creation of substantial amounts of dead fuels. In a wildfire situation this can lead to a slow moving higher intensity surface fire which can damage the seed base contained in the soil. It

can also result in the fire penetrating into existing peat resulting in further damage and the increased likelihood of pollution caused by water run-off. Fuel reduction should not be viewed as a negative, it is an opportunity not only to reduce the threat posed by wildfire, but through careful planning it creates the possibility to improve the health and biodiversity of the vegetation and habitats found on the landscape. Through the application of well chosen fuel management treatments heathland can be restored to a more healthy state and at the same time become more fire resilient.
It should also be noted that any measures to reduce fuel load/manage vegetation will be subject to approval from the NPWS through the formal process required under the Habitats Directive.

Prescribed burning
This involves the use low-intensity fire under controlled conditions to reduce the amount of surface fuel.

The effect of burning on the communities of plants and animals is complex. In general terms, burning prevents or reverses succession processes that would eventually result in the conversion of heathland to woodland, but the specific outcome of a burning regime depends on many factors, notably the frequency and heat (intensity) of burning and the age of heather when it is burnt (Yallop et al. 2005). Heather passes through a series of growth phases over the course of forty years or so. Vegetative regeneration of heather following burning declines in the mature phase of its growth and is absent in the degenerative phase, when regeneration is solely from seed. If vegetative regeneration of heather is vigorous, then the heather will quickly come to dominate burnt areas, while if it is weak or absent, these areas may become dominated by moor grass *Molinia caerulea* or bracken *Pteridium aquilinum* (Stevenson et al., 1996). Too-frequent burning favours fire-resistant species like common gorse and bracken, and may in time result in the conversion of dwarf-shrub heath to acid grassland or monocultures of bracken. In contrast, too-infrequent burning can also lead to the loss of the dwarf-shrub community where over-mature or degenerate stands of heather are burnt and regeneration is by seed (Yallop et al. 2005).

While prescribed burning is an effective method in terms of time and costs it requires particular expertise. The fire period to burn during supportive weather conditions is also very short 1st September to 29th February.

Grazing - Uses herbivores to reduce the fuel load during a certain periods and can often be used to manage vegetation post burn.

Grazing (with goats) has been used with success in Howth heathland where it had a dramatic effect on tree cover and thus would prevent conversion of heathland to woodland (Tubridy 2015). Its medium to long term impacts depends on the initial vegetation composition, intensity of grazing, and the time of the year. In simulated grazing experiments light to medium grazing increased the number of shoot apices of heather, but heavy grazing eventually caused a decline in cover. Summer grazing may be more detrimental than winter grazing (Hester et al., 1991). Adamsom & Critchley (2007) give some guidelines for grazing as a management tool on heather.

The effects of burning could be linked with those of grazing (Miles, 1988). Burning promotes young growth for grazing. However excessive grazing can eliminate regeneration completely, leading to the loss of dwarf-shrub heath and the spread of grassland or bracken. This is because heather regrowth on newly opened habitat after a burn is preferentially chosen as food by grazing livestock. Heather that is re-growing from seed after over-mature stands have been burnt is unlikely to survive this selective grazing if the stocking density is too high (Yallop et al. 2005).

Herbicides – Normally used to remove specific fuel types such as bracken or gorse.

To achieve certain outcomes a number of different treatments could be applied at the same location. For example fire or mechanical cutting may be used to quickly remove vegetation and then the same area may be grazed to prevent regrowth.

Fuel reduction should be viewed as an opportunity not only to reduce the threat posed by wildfire, but through careful planning it creates the possibility to improve the health and biodiversity of the vegetation and habitats found on the landscape.

Through the application of well chosen fuel management treatments the habitats can be restored to a more healthy state and at the same time become more resilient and resistant to fire.

The best method depends on the region, the time of the year and the economic resources. It also depends on the vegetation and communities involved. A decision on the approach which is taken is likely to rely on scientific evidence, common sense and resources which are available. It also requires consent from NPWS as a consequence of the designation of much the undeveloped land in Howth is designated as an SAC.

4.2 Protecting the urban interface

As can be seen through mapping the urban area encroaches onto the very fringes of the heathland and in some cases is actually built within it. The close proximity of the housing to areas of vegetation is an obvious risk and one that should be addressed as a priority. Consideration could be given to creating a buffer zone between the housing and the heathland, which will lower the risk of urban involvement to acceptable levels. The creation of a buffer zone will also increase the fire resilience of the landscape as it will further reduce the connectivity of the fire polygons and fuel loading within them.
Therefore it is recommended that a plan to prevent fire spreading from polygons, 3, 3.1, 5, 6.1, 7.1 and 12.1 and into the urban fringes should be formulated.

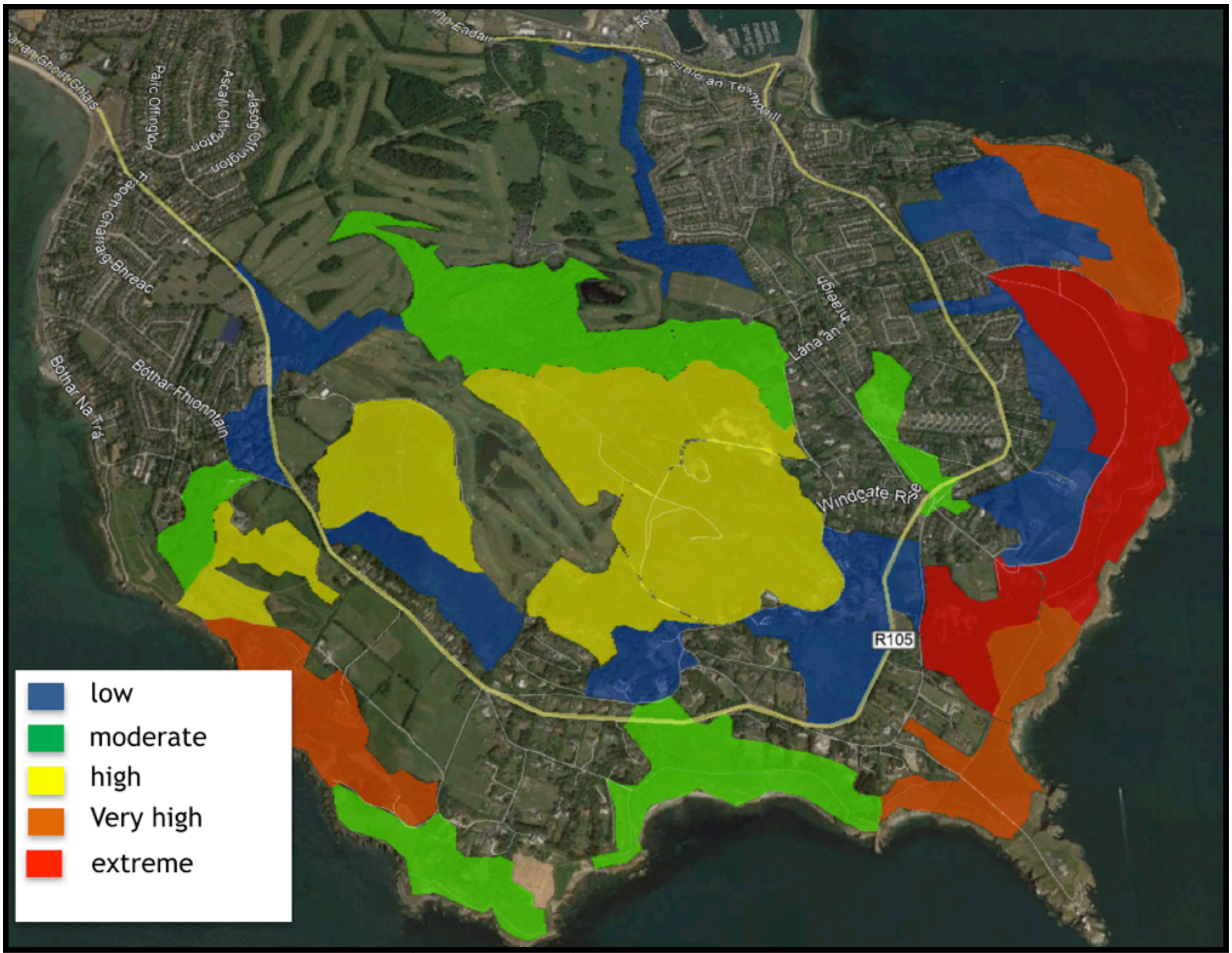


Fig.16 Suggested buffer zone (area in blue)

Fig.16 shows the location of a buffer zone coloured in blue which will serve to protect the urban areas surrounding the landscape sites

4.3 Breaking fuel connectivity

Fig. 17 Site of fire breaks

Fig. 17 indicates critical points (SMA's Strategic Management Areas) labeled as ABCD on the landscape where the connectivity and continuity of fuels should be managed. The SMA B is in Blue to highlight its importance.

These are priority areas for which fuel reduction plans should be developed. The objective of these plans should be aimed at reducing fuel continuity, changing fire behaviour and significantly reducing the connectivity between polygons.

The management of available fuels within these areas will have a significant impact on the scale and intensity of future wildfire events. Where fuel loads are already low within SMA's then the plan should be to ensure that this situation is maintained in the future.

Simulations carried out indicate that SMA's A and B and D are the most important to manage as they will significantly reduce the potential size of wildfires and limit the involvement of the urban interphase.

Breaking connectivity between polygons 3 and 4, and 5 and 4 is important, and areas 8 and 9 would also benefit from treatment. Breaking areas 4, 5, 6, 9, 8 and 12 into different vegetation mosaics, thus reducing fire intensities would create a much more fire resilient landscape. Efforts should be concentrated on bringing any potential fire behaviour, particularly within the SMA's to intensities that is within Dublin Fire Brigades fire fighting capacity of control. A secondary objective is to reduce fire intensities or prevent fire spreading into ecologically sensitive areas.

The creation of cleared areas could be considered as Fire breaks.
A Firebreak is an area on the landscape where there is a discontinuity in fuel, which will lower the likelihood of combustion or reduce fire intensity or rate of spread. Firebreaks may be naturally occurring or may be deliberately created as part of mitigation or prevention activities. They fall within two categories:

1. Those that will totally prevent surface and sub-surface fire spread.

This will require the fuel to be completely removed exposing the bare mineral earth, the width of these should be no less than 3 times the width of the flame length of any potential fire that may occur within the surrounding vegetation.

2 Those that are intended only to reduce surface fire intensities and rate of spread to a safe and manageable level, creating an opportunity for responders to prevent spread beyond these containment areas.

The area treated depends on the fire intensity responders are able to safely contain, fire intensities within these areas on the Howth landscape should where possible not exceed 0.5 meters.

It is recommended that action within these areas should be taken as soon as possible, particularly within the buffer zones around the urban areas. Short-term objectives should be to significantly reduce the fuel loading by removing the vegetation that will support high-intensity fires, particularly gorse. The longer-term objective should be the creation of areas of grassland that are continually grazed or otherwise managed. All material cut from these areas should be removed.

Fuel within the buffer zones surrounding the urban areas should not produce fire intensities above 0.5 meters (i.e. ideally grass or very low heather) and be wide enough to provide sufficient time for intervention by the Fire Brigade to take place. The width of these buffer zones should be decided following consultations with Dublin Fire Brigade. Consideration should be given to the surrounding types of vegetation, but as a general guide, the defensible space should be a minimum 35M wide and where the surrounding vegetation is gorse this should be made significantly wider. Further advice on increasing the resilience of the urban interface can be found within the UK's Firewise toolkit. (The application of the measures outlined within this toolkit by local residents should be encouraged)

Another mitigation process is termed to be *Fragmentation*, which is where large areas of continuous areas of fuels are broken into smaller discontinuous areas, this leads to a change to fire regimes through the alteration of fuel arrangement resulting in a reduction to fire intensity and rate of spread.

It is also recommended that safety zones are identified or if appropriate, additional safety zones i.e. areas which are at low risk of wildfire and provide sanctuary.

The final decision to be made on the exact size of the areas to be managed and the form of mitigation to be undertaken should be made through discussions between the local authority, the Fire Brigade and (ideally) a local fire group.

5 Wildfire response management

5.1 The role of Dublin Fire Brigade

Dublin Fire Brigade (DFB) is a professional fire service that is required to respond to many different emergency situations and incident types. Responsibility is focused on saving life and property and therefore its resources are concentrated in areas of higher risk, normally within more populated locations. The training and equipment provided to personnel is therefore more related to structural fire fighting or intervention at urban/transport rescue incidents.

Wildfire suppression tactics can include:

Direct Attack – where personnel and resources work at, or very close to the burning edge of the fire. Firefighting crews aggressively attack the fire either by applying water or extinguishing the fire using 'hand tools' and 'beaters'.
Indirect Attack – this method involves applying suppression tactics that take place away from the burning edge of the fire. Either by using control lines to contain fire spread or the proactive use of fire as a suppression tool.
Helicopters and fixed-wing aircraft - can also use direct and indirect attack methods. Water drops directly applied onto the fire, are an example of direct aerial attack; while drops made to strengthen or create fire breaks some distance away from the fire's edge are an indirect attack tactic.

At present Dublin Fire Brigades tactical fire fighting methodology is mainly limited to direct attack. Although an appropriate tactic, direct attack is a relatively ineffective and inefficient method when fighting high intensity or fast moving fires. Wildfire events, due to their potential complexity, scale and risk, can be managed more effectively if fire brigades have undertaken wildfire specific preparatory actions prior to an incident occurring.

Having robust and resilient preparedness arrangements including those made with other stakeholders will assist in ensuring that all potential issues have been considered in advance of an incident and effective control measures have been identified and implemented. Key to this proactive approach is the development of integrated planning and response arrangements with wildfire partner agencies and actors.

Due to the lack of fuel management and almost unbroken fuel continuity across much of the landscape on the Howth Peninsula, once a fire is out of control there are few existing opportunities for the fire brigade to safely contain fire spread, especially when their tactics are limited to using direct attack suppression methods. Consideration should be given to the fact that in certain areas of the heathland, unless the fuel loads are lowered, DFB, however well prepared will have few opportunities to safely contain fire spread.

Through appropriate training the service could be shown how to consider other tactical options that would allow it to take more effective action away from the fire edge (indirect attack) such as building control lines or the use of fire to carry out tactical suppression burns. The use of alternative 'indirect attack methods' can prove to be more effective than direct attack methods and can often be applied with a greater emphasis on personnel safety and by fewer resources.

Like all Fire Brigades, Dublin Fire Brigade has limitations that impact on their wildfire suppression capacity, the main restrictions being:
The effectiveness of the training provided
The tactical options available
Equipment provision and available resources
The fire behaviour likely to occur at fires
The fire behaviour at any wildfire is the result of a complex interaction between a number of environmental factors including, the type and

arrangement of the available fuel, the influence of the topography over which a fire will burn, and the impact of weather on the fire environment. These influences will alter throughout a fire and as a result fire behaviour remains in a state of constant flux. Therefore it is of great importance that fire behaviour is continually analysed to ensure that potential significant changes to fire behaviour are identified in advance.

All personnel operating at a wildfire incident should have a basic understanding of the fire environment and the likely fire behaviour it will support, enabling them to assess levels of risk within their operational situation. Officers in supervisory roles, or those that are responsible for command must have a level of knowledge that allows them to effectively analyse fire behaviour and predict when and where significant changes will occur, or in other words where and when the situation will get better or worse. This ensures the ongoing safety of all personnel and allows plans to be based on *'expected'* fire behaviour and not merely reacting to unexpected change. Fire Brigades should ensure that personnel operate within an effective safety system specific to the risks posed by wildfire, the LACES safety protocol is a recognised and effective protocol that has been developed to manage safety at all wildfire incidents. The Wildfire Prediction System (WPS) is a tool that helps identify likely fire behaviour, therefore it can be applied to provide risk critical information.

In order to improve capacity for Dublin Fire Brigade consideration should be given to improved training and the provision of appropriate equipment. Training should occur first in order to clarify the equipment required. Training could occur through the following exercises:

- Training of senior staff by GRAF group in Catalonia and the optional inclusion on this visit by members of the Local Authority and Howth Wildfire Group.
- Visit to Howth by a GRAF team to demonstrate the use of fire as a fuel management method.
- Training course by Northumberland Fire and Rescue Service to be delivered in Dublin.

Following appropriate training a review should be carried out of equipment needs. Effective operational response to wildfire depends on the provision of suitable and appropriate equipment, this can often be provided by partners or other stakeholders. For example, if there is a reliance on water as the primary method of fire fighting, consideration should be given as to whether there is the sufficient capacity to access, store and deliver appropriate quantities of water to where it is needed. This does not imply that the Fire Brigade should purchase additional equipment but that it makes arrangements to obtain the use of specific items of equipment or other resources when required. Equipment which could be of value to fire fighters could include:

- Back packs
- 25mm hose
- Branch pipes
- Dividers
- General tools
- Goggles
- Wildland fire fighting suits
- Portable dams and
- Wildland fire fighting respiratory protection

This project has identified the critical parts of the landscape that need to be managed and provided an understanding of the way a fire is likely to move across the landscape. It is important that this information is utilised by the DFB and its partners during the planning and operational phases. Although this information provided may be useful it is only generic. DFB must train officers who have the capability to analyse actual fire behaviour and predict the expected behaviour that will occur within different environmental circumstances.

Weather conditions should be monitored and particular records should be gathered on the amount of precipitation, and the extent and severity of any drying period. This information should be made available to stakeholders and partners, it can be used to establish knowledge of the weather conditions that increase the risk of wildfire, when they occur and how severe they are under the influence of different climatic conditions. (This task could be shared with stakeholders and other actors).

This information could be used to trigger responses/actions to address increased levels of risk, this task could be one allocated to the Wildfire group. A raised level of awareness could trigger increased monitoring of the landscape, placement of information signage warning the public of the increased risk, etc.

Post incident information should be gathered and collated, this should include point of origin, size, fuel types involved, fire intensities, pre-incident weather condition, prevailing weather conditions, tactical methods used, learning points.

DFB could consider developing a number of wildfire hub stations within its operational area. Personnel on these stations could receive more advanced wildfire training and be appropriately equipped. They could provide a cohort of specifically trained and equipped personnel that could be deployed to all wildfire events. They could also assist in developing operational plans, take part in fuel reduction treatment programmes and other risk reduction measures. Training at these hubs should include instruction on the methods that can be used to construct control lines, these can be used to break fuel continuity and thereby contain fire spread. These wildfire hubs could be used to play a leading part in wildfire group activities, and take on relevant and necessary tasks within the group. This could include assisting in training personnel from the land/rural sector and in the development of effective and collaborative standard operating procedures.

5.2 The role of a local wildfire group

In order to address wildfire risk, it is imperative that a collaborative approach is taken involving residents, interest groups and authorities. The formation of local wildfire group provides the means to establish trust and bring benefit to all stakeholders; this concept of 'benefit to all` should be a fundamental principle guide to the activities of the group.

There are a number of partnerships that have been developed throughout the UK, that have brought wildfire actors, stakeholders and practitioners together to improve planning, prevention and response, and at the same time enhancing cross-sector liaison and facilitating the sharing of knowledge and best practice. These examples of good practice could be used locally, and where relevant copied. Groups normally consist of members drawn from a wide range of different sectors. Although the aims of the groups can be diverse, and each member may have specific reasons for joining, ***the key focus should be on issues surrounding wildfire preparedness, prevention and intervention***

Local wildfire groups are an invaluable point of contact, networking and capacity building. They are a particularly useful mechanism for the development of closer links between Fire Brigades and other partners that can include, with the agreement of the Fire Brigade, tactical and logistical operational assistance in the event of a wildfire incident. A wildfire group could seek to establish a framework that results in a collective response to wildfire emergencies. This support will maximise the effective and efficient use of resources, prevent duplication, and to some degree minimise and share cost.

The following are features of a successful Wildfire Group:

- The group should be a consortium made up of equal partners.
- A small steering group should manage the groups activities and act as a decision making body.
- Measures should be taken to ensure that all 'key` stakeholders join the group
- The secretariat of the group and all members of the steering group, should ideally have an understanding of wildfire.
- The group should have a clear mandate and terms of reference.

- There should be a willingness to work together for the benefit of the group.
- There should be effective methods of communication between members, meetings should be held when necessary but kept to a manageable number.
- The group could have a written constitution and terms of reference that should include: aim of the group should be the maintenance, development and promotion of the Howth Wildfire Strategy, preparing and responding to wildfires through joint working and training, raising awareness of wildfire issues and the protection of the local community, the natural environment and cultural heritage of the area.

6 Implementation of the Fire Management Strategy

6.1 Introduction

The production of the Fire Management Strategy has been a useful exercise. However unless turned into action it will be of little benefit to the community or environment. Actions need to be taken to establish a Howth Wildfire Group, build on good relations with the community and Fire Brigade, carry out vegetation clearance in pilot SMA's and initiate a training programme to improve the understanding of wildfire and its control among fire fighters and community. The final section of this report elaborates on actions which are required.

6.2 Howth Wildfire Group

A Howth Wildfire Group should be established to take ownership of recommendations made in this report under the umbrella of the Conservation and Recreation sub committee of the SAAO Management Committee. It already has representation from some of the necessary actors and stakeholders, other members such as from the local fire brigade could be added.

An inaugural meeting should be called by the SAAO Management Committee to decide and agree the aims and objectives, membership constitution and work plan of the group. Before the first meeting contact should be made with Rob Stacey, secretary of the Northumberland Fire Group. Contact details are: Tel: 01670 621167.
Email: robert.stacey@northumberland.gov.uk

Meeting schedule could include a meeting in February and one in October before and after the fire season. There are a number of dwellings/properties that may be at risk due to their positioning on the landscape and their proximity to vegetation that can support high intensity fires. Residents of these houses should be encouraged to join the Wildfire Group and to take action to lower the risk to these properties by instigating and supporting the fuel reduction program. Information available through the Fire Wise program may also prove to be useful. (http://www.firewise.org/)

At the first meeting agreement should be reached on the principal activities of the group guided by the principles laid out in Section 5.2 of this report.

Further discussion could cover the following:

- Policies and actions in connection with wildfire prevention, preparedness and response
- Engaging with stakeholders and potential stakeholders
- Arranging meetings
- Developing a joint training program between the Fire brigade and other stakeholders
- Providing agreed support activities to the Fire Brigade during incidents
- Gathering and sharing information and other resources
- Arranging an annual joint wildfire exercise

- Agreeing land management methods including managing strategic areas identified within the report
- Monitoring weather and collate its impact on fire events, their size and the resources required to bring them under control
- Gathering information with regards to risk
- Developing wildfire signage that can be used during high risk periods to raise awareness of the general public and the local community
- Implementing an educational programme for residents and the community
- Recording wildfire events i.e. date and location to inform an annual report to complement Fire Brigade records.

In the longer term and to reduce risk further, the Fire Group could develop fuel reduction plans and describe the types of mitigation action necessary for all vulnerable areas.

Some fires originate at fringe locations surrounding heathland. One of the primary tasks of the fire group should be to gain an understanding of 'at risk' locations and instigate a program of fuel reduction within these areas. This could be an advantage to the local community and reduce the risk to properties located in these areas.

If members were sufficiently interested the group could develop their own strategy, based on for example 1, 3, and 5-year plans. The 1 year plan should include taking critical actions/ steps that will significantly reduce risk to the landscape. Less urgent or less achievable objectives should be included in the longer-term plans.

Partnerships could be formed that will assist the Fire Brigade to monitor weather conditions effecting the Howth Peninsula and its effect on fire behaviour. Consideration should be given to the placement of a weather station(s) on the landscape to monitor weather and record the conditions during which wildfires occur. This will help identify periods of high risk and trigger appropriate responses/actions.

The Wildfire Group could provide, train and equip a rapid response fire fighting team to respond to wildfire events. The early deployment of a well-trained unit will significantly reduce the impact of many fire events. This is something that will have to be agreed by the Dublin Fire Brigade. This unit could train and exercise with Dublin Fire Brigade officers and local Dublin Fire Brigade station personnel.

Members of the Fire Group and other relevant actors and stakeholders could participate in training that provides appropriate information on wildfires and their control.

Dublin Fire Brigade should be encouraged to participate in a local wildfire group to support a collaborative approach to wildfire prevention, response and intervention. Due to the importance of early intervention the DFB could consider developing a co-response capability within the Howth Wildfire Group. Limitations could be set to restrict the involvement of non DFB personnel in fire fighting activities but consideration should be given to the value of such support particularly with regards to the containment of the fire at the initial stages of an incident prior to the arrival of the fire brigade.

Other local initiatives which have an indirect impact of wildfire management, could be promoted by the Wildfire Group. While there has been significant amount of housing development in recent years, little consideration appears to have been given to the threat of wildfire posed to some of the properties. Planners should be encouraged to include a wildfire risk assessment within their core planning strategy. The footpaths used on the mountains could be mapped and where appropriate strengthened so that they can be used as effective firebreaks or control lines (others could be created). The group should consider adopting a policy of encouraging the use of some footpaths rather than others, this could be achieved through the development of a visitor guide in which a map of preferred routes are provided.

6.3 Vegetation management

It is recommended that a programme be put in place immediately to manage vegetation at SMA's (Strategic Management Areas) to reduce the risk of wildfire. These operations should principally involve the cutting of common gorse *Ulex europaeus* and should only take place outside the bird-nesting season (1st September to 28th February). The width of area cleared should be determined by the expected flame length associated with burning of adjacent vegetation i.e. area with tall gorse requires a wider band of cleared vegetation, area with low gorse or bracken a narrower zone. The practical guideline is that cleared area is ten times height of vegetation. Vegetation should support fire intensities of less than 0.5M. When positioned on slopes fire breaks should be significantly wider.

If found no cutting should be carried out of autumn gorse and heathers (ling and bell heather) as these species are associated with the internationally important dry heathland habitat.

To reduce the risk of fire from their presence, all cuttings should immediately be removed off site.

In areas dominated by common gorse plants could be totally removed from the site. As revegetation will occur naturally in cleared areas this should be managed to limit the height of gorse regrowth through grazing or cutting.

6.4 Further research and networking

Connections could be made with research organisations interested in fire management. Researchers might be interested in monitoring the impacts of vegetation following clearance, perhaps experimenting with the impacts of different management treatments such as the presence/absence of grazing, While reseeding with locally collected grass seeds collected from plants growing in nearby acid grassland /dry heathland habitat could be considered this initiative would need Ministerial consent.

As there is considerable interest in wildfire management in Ireland but few examples of active wildfire management, Howth Management Committee and the Wildfire Group should communicate the results of this project to interested individuals and organisations in Ireland (north and south). Such networking could be facilitated by the Irish Uplands Forum and could involve contacts with agencies concerned with wildfire management or /and heathland ecology.

Appendix 2 contains an estimate of the costs of actions related to training and vegetation management.

7 Conclusions

This project has been complex and has brought a new and innovative approach to wildfire risk management; this has required a great deal of research into the causes of large-scale wildfires on the Howth Peninsula. A great deal of information was gathered and is now available for future use, this may provide solutions to issues that presently exist, or that may arise in the future.

The number, size and intensity of historical fires provided evidence that the current approach is failing and the local community and landscape remains under severe threat from landscape-sized incidents. To reduce risk it is essential that action is taken that limits any fires potential, and this can only be achieved by managing the fuel/vegetation that is available to burn. The actions outlined within this report will significantly reduce the risk of fire spreading over large areas, and from one part of the landscape to another. It also includes information on the advantages of setting up a Wildfire Group which amongst other things can take on the responsibility to establish a long term and sustainable fuel management plan.

While the report has suggested solutions to particular problems its principal purpose is to start a conversation among the community and statutory agencies on wildfire management. These conversations should improve understanding of wildfire and its environment within Dublin Fire Brigade, the local authority, other stakeholders and individual actors. Only then can partners work together effectively and make informed decisions.

There is a great deal of evidence to suggest that the threat posed by wildfire on the island of Ireland and Howth will increase in the future. By addressing the issues now, members of any Fire Group and the organisations that they represent can build up knowledge of the phenomena; this will permit an improved response in future years.

In particular the effects of weather on fire behaviour should be understood, and by monitoring the number, size and intensities of wildfires, a history of events can be built up. This analytical approach will provide an understanding of risk and help identify the actions that can be taken to reduce this in the future.

If a Wildfire Group is established, this will ensure a collaborative approach is adopted that can be used to share appropriate responsibility between members and will provide valuable support to the Dublin Fire Brigade.

The Fire Brigade will also benefit from the suggestion of adopting a risk-based approach and the development of better-trained fire teams at local fire stations. These could also be deployed to other areas in Ireland where the fire fighters may be less experienced and knowledgeable.

The adoption of the project proposals and recommendations, will provide managers with the means to move from crisis fire management, to a situation where the size and spread of fire, is controlled and managed by planned intervention bringing the current unacceptable levels of the wildfire risk to acceptable level.

Mary Tubridy and Associates, would be pleased to offer further advice and guidance regarding the treatment program outlined within the Fuel Treatment Plan, this could be in the form of further consultations, assistance with specific training requirements, site visits and active field support during management operations.

The primary objective of this programme is to reduce the threat posed by the phenomena known as wildfire. Nevertheless it is our advice that through the application of the correct methodology it is also an opportunity to improve the eco-systems, habitats and general health of the heathlands arranged across the Howth Peninsula, increasing its social and economic value. Mary Tubridy and Associates have the capacity to arrange specific wildfire training at both an introductory and/or advanced level. This can be delivered in Ireland by a UK provider, or on the continent, where we have an excellent arrangement with wildfire training providers in Spain who have trained hundreds of fire officers from across Europe in advanced fire fighting techniques. Information on this training can be provided to interested parties.

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Appendix 1 Glossary of useful wildfire terms

Aerial attack	A fire suppression operation involving the use of aircraft to release water or retardant on or near a wildfire.
Anabatic wind	Upslope winds. Anabatic winds occur when daytime solar radiation heats air at lower elevations causing it to flow upslope.

Anchor Point	A location on the landscape which is strong enough to act as barrier to fire spread. The commencement of suppression operations from an anchor point ensures that a wildfire cannot escape from an area of containment which could threaten the success of the operation and/or the safety of suppression personnel. It may be necessary for anchor points to be strengthened before use or even created by hand or machine. The creation of an anchor point is sometimes a key element included within the LACES safety protocol.
Area of origin	General geographical location within a fire scene where the point of ignition is believed to be located.
Aspect	The direction a slope faces in relation to the sun.[3] Aspect is a force of alignment.

Attack a Fire	A generic term for the various methods that can be used to suppress a fire or parts of a fire, including: Direct attack – An offensive fire suppression tactic which involves an attack being made at or near the fires edge. This technique normally relies on the use of hand tools and or water. **Indirect attack** – Any suppression methods implemented away from the fire edge. **Aerial attack** – Fire suppression operation involving the use of aircraft to drop water or retardant on or near a wildfire. **Flank attack** – Attacking the fire along the flank or both flanks simultaneously. **Parallel attack** – Method of fire suppression in which a control line is constructed approximately parallel to and some distance away from the fire edge.
Available Fuels	The proportion of the total fuel that would burn under specified burning and fuel conditions.

Back burn	An operational burn ignited along the inner edge of a control line to consume the fuel in the path of an advancing wildfire or to change the direction of force of the wildfire's convection column.
Backing Fire	A lower intensity fire or part of a fire which burns against the wind and/or down slope.
Black Area	An area of fuel that is black in appearance because some or all of the fuel has been burnt. A black area may support a second burn if some fuel remains and this could represent a safety risk to suppression personnel.
Burn plan	A pre-determined strategic scheme or programme of activities which is formulated in order to safely and effectively accomplish the objectives of a managed burn. A burn plan will outline the selection of tactics, selection of resources, resource assignments and how performance will be monitored during a managed burn. It should be noted that a burn plan may need to be dynamic to take into account any changes in conditions or circumstances.

Burning Conditions	The state of the combined components of the fire environment that influence fire behaviour within available fuels. Burning conditions are usually specified according to the factors of aspect, weather, slope/ topography, and fuel type and load.
Burning Out	The intentional burning of parcels of fuel to prevent fire spread. This is normally carried out to consume fuel between a control line and the fire edge.
Canopy	The upper layer of aerial fuels which will contain the crowns of the tallest vegetation present (living or dead).
Clean burn	A fire that consumes all vegetation and litter above the ground exposing the mineral soil.
Coarse fuels	Fuels that are more than 6mm in diameter. Due to their size and shape they burn more slowly and ignite less readily than finer fuels. Examples of coarse fuels include thick stems, logs, and branches. Coarse fuels can either be living or dead.
Condition of Vegetation	Stage of growth or degree of flammability of vegetation that forms part of a fuel complex. This will be dependent upon time of year, amount of curing and weather conditions.

Containment	An area of a fire where control has been established and no breakout is anticipated.
Controlled fire	A fire with a secure perimeter, where no breakouts are anticipated.
Control Line	An inclusive term for all constructed or natural barriers and treated fire edges used to control a fire.
Cooperating agency	Any organisation supplying resources to assist with the implementation of a fire suppression plan. A cooperating agency differs from a partner agency in the sense that it only comes to the assistance of a suppression agency when a wildfire occurs.
Counter burn	A planned operational burn which is ignited to burn into a wildfire and to take advantage of in-drafts towards the fire front.
Critical Point	This is a point in time or space when/where there will be a significant influence on fire spread, rate of spread and/or fire intensity.
Crown	The upper foliage of trees and shrubs, normally containing large amounts of fine fuels.
Crown fire/Crowning	When a fire burns freely in the upper foliage of trees and shrubs.

Curing	A process that leads to the reduction in moisture content of dead vegetation.[9] This usually causes the vegetation to turn brown in appearance.
Dead fuels	Fuels with no living tissue. The moisture content of dead fuels is mostly controlled by external weather conditions, for instance, relative humidity, precipitation, temperature, and solar radiation.
Direct Attack	An offensive fire suppression tactic which involves an attack being made at or near the fires edge. This technique normally relies on the use of hand tools and or water.
Drip Torch	A hand tool used to drop flaming fuel onto the ground to intentionally ignite a fire as part of an operational or prescribed burn.
Drought	A prolonged period of abnormally low precipitation within a particular geographical area.
Elevated fuels	Any fuel found at a height of 1.5-3.5 metres. The presence of elevated fuels will increase the risk of vertical fire spread into aerial fuels and the canopy.
Extreme fire behaviour	Fire behaviour that becomes erratic or difficult to predict due to its rate of spread and/or flame length. This type of fire behaviour often

	influences it environment.
Fine fuels	Fast-drying dead fuels which are less than 6mm in diameter. Fine fuels ignite readily and are rapidly consumed by fire when dry. Examples of fine fuels include: grass, leaves, ferns, mosses, pine needles and small twigs. When dried, fine fuels are referred to as flash fuels.
Fine fuel moisture	The moisture content of fast-drying fuels. Measurement of moisture content will indicate the relative ease of ignition and flammability of a fine fuel.
Fire behaviour	The reaction of a fire to the influences of fuel, weather, and topography.
Firebreak	An area on the landscape where there is a discontinuity in fuel which will reduce the likelihood of combustion or reduce the likely rate of fire spread.
Fire footprint	Outer shape of the fire perimeter at a given point in time.
Fire front	Any part of the fire perimeter that displays continuous flaming combustion.
Fire growth	The evolution of a fire from ignition to self-sustaining propagation and

	its movement through available fuels.
Fire intensity	The rate at which a fire releases energy in the form of heat at a given location and at a specific point in time, expressed as kilowatts per metre (kW/m) or kilojoules per meter per second (kJ)
Fire management Plan	A plan detailing predetermined fire suppression strategies and tactics to be implemented following the occurrence of a wildfire within a particular area.
Fire prediction system	A method or tool used to forecast future behaviour of a fire.
Fire regime	The pattern of fire occurrence, fire frequency, fire seasons, fire size, fire intensity, and fire type that is characteristic of a particular geographical area and/or vegetation type.
Fire risk	The calculation of the probability of a wildfire occurring and its potential impact on a particular location at a particular time. Wildfire risk is calculated using the following equation: Fire risk = probability of occurrence x potential impact.
Fire season	The period or periods within a year when wildfires are most likely to occur.

Fire spread	The movement of a fire through available fuels arranged across the landscape.
Fire suppression plan	A pre-determined scheme or programme of activities which is formulated in order to safely and effectively accomplish fire suppression objectives. A fire suppression plan will outline the selection of tactics, selection of resources, resource assignments and how performance and safety will be monitored and maintained at a particular incident. Fire suppression plans need to be dynamic to take into account any changes in conditions or circumstances.
Flanks	The parts of a fire's perimeter that are roughly parallel to the main direction of fire spread. The flanks usually have less fire intensity than the head fire because they have a weaker alignment with wind or slope.
Forces of Alignment	A collective term for the forces that have a significant impact on wildfire behaviour. These forces can support or hinder fire development and can be used to predict likely fire behaviour, including fire spread and fire intensity. Wind, slope and aspect are considered to be key forces of alignment.

Fuel	Any material that can support combustion within a wildfire environment. Fuel is usually measured in tonnes per hectare.
Fuel Arrangement	The horizontal and vertical distribution of all combustible materials within a particular fuel type.
Fuel Continuity	The extent to which fuel arrangement will support fire spread.
Fuel layers	The classification of fuels according to their height relative to the ground surface. There are five general fuel layers: **Aerial fuels** **Elevated fuels** **Near surface fuels** **Surface fuels** **Ground fuels**
Fuel Load	The amount of fuel present within a particular area. Fuel load is measured in weight per area measured (usually in kilograms per square metre). Fuel loading is expressed in relative terms as either "heavy fuel loading" or "light fuel loading".
Fuel management	The process of managing fuel or fuel arrangement. The aim of fuel management is usually to create a discontinuity in fuels to achieve

	fragmentation.
Fuel moisture content	Water content of a fuel expressed as a percentage of fuel weight when oven dried.
Head Fire	The leading part of an advancing wildfire at a particular point in time. The head fire will usually exhibit the highest level of fire activity of any part of the fire.
Horizontal Fuel Arrangement	A description of the distribution of fuels on the horizontal plane. The horizontal arrangement of fuels will influence the relative ease with which fire can spread horizontally across an area of land.
Ignition patterns	A generic term for the three key techniques for igniting a managed burn: Line ignition Points of fire Fingers of fire
Indirect attack	Any suppression methods implemented away from the fire edge.
Initial response	The first suppression resources mobilised to an incident following the detection of a wildfire. These resources will be available to participate in initial attack

	operations.
Katabatic Wind	Down slope winds. Katabatic winds occur when air at higher elevations is cooled (often at night) and is subsequently pulled down slope by the force of gravity.
LACES	An essential safety protocol which should be implemented at wildfire incidents to address risks and hazards. The correct implementation of LACES helps to ensure that suppression personnel are appropriately supervised, informed and warned of risks and potential hazards and that they are aware of how and where to escape should a high-risk situation occur.
Ladder fuel	Fuels that provide vertical continuity which allow fire to move through the vertical fuel arrangement.
Landscape	The physical appearance of the land comprising of the features of terrain, vegetation and the human impact caused by variations in land use.
Live fuels	Fuels with living tissue. The moisture content of live fuels is controlled largely by internal physiological mechanisms.

Managed burn	A planned and supervised burn carried out for the purpose of removing fuel either as part of a Fire Suppression. Plan (an operational burn) or a land management exercise (a prescribed burn).
Operational burn	A controlled supervised burn which is carried out by a burn team as part of a fire suppression plan. An operational burn can be classified as either offensive or defensive, depending upon its purpose: Offensive operational burn – ignited along a control line to burn into an advancing flame front. Defensive operational burn – ignited along a control line to strengthen/ expand the control line, but will be extinguished prior to the arrival of an advancing wildfire.
Parallel Attack	A method of fire suppression involving the construction of a control line approximately parallel to and some distance away from the fire edge. The intervening strip of unburned fuel may or may not be burned out as the control line proceeds. This decision will be influenced by an assessment of whether the unburned fuel is considered to pose a threat to the

	control line.
Partner agency	Any organisations that work together to prevent, investigate and/or suppress wildfires. Partner agencies will work together on preparedness activities and plans and are likely to have formulated pre-agreed partnership agreements.
Pinching	Attacking a fire by working along the flanks either simultaneously or successively from a less active or anchor point and endeavouring to connect the two lines at the head.
Preparedness plan	A pre-determined strategic scheme or programme of activities which is formulated in order to satisfactorily prepare an organisation or a geographic area to respond effectively to wildfire incidents.
Prescribed burn	A planned and supervised burn carried out under specified environmental conditions to remove fuel from a predetermined area of land and at the time, intensity and rate of spread required to meet land management objectives.

Rate of Spread	A measurement of the speed at which a fire moves across a landscape. Rate of spread is usually expressed in metres per hour.
Relative Humidity	The amount of water vapour present in the air expressed as a percentage of the amount of vapour needed for saturation to occur at the same temperature. Saturated air is referred to as 100% relative humidity.
Response	Response encompasses the actions taken to deal with the immediate effects of a wildfire emergency. In many scenarios it is likely to be relatively short and to last for a matter of hours or days – rapid implementation of arrangements for collaboration, co-ordination and communication are, therefore, vital. Response encompasses the effort to deal not only with the direct effects of the emergency itself but also the indirect effects.

Slope affect	Variations in fire behaviour induced by slope. Slope can both support and hinder fire spread and development and the angle of the slope will have an important influence on the degree of effect. Fires spreading upslope –The flames of a fire spreading upslope will be angled towards the unburned fuel above it which will pre-heat the fuel in front of the advancing fire. This pre-heating increases combustibility and rate of spread for fires travelling upslope. Fires spreading down slope – The flames of fires burning down slope will be angled away from the fuel and will, therefore, lead to less preheating of the fuel in front of the fire. Consequently, the effect of slope on a fire burning down slope is a reduction in combustibility and rate of spread.
Spot Fire	A fire outside the main fire perimeter which is caused by flying embers transported by the wind or convection column.
Standard Operating Procedures (SOPs)	SOPs are written instructions that detail the necessary steps that must be taken when completing a particular process or activity. The

	purpose of a SOP is to ensure that a particular process or activity is always carried out safely, effectively and in the same manner.
Swipe	Used to cut small shrubs such as heather down to ground level. Depending on local conditions the resulting break in the vegetation can either act as a barrier to fire spread, or reduce fire behaviour significantly.
Tail fire	The rear most part of a wildfire/forest fire, it is normally out of alignment with wind and slope, and consequently will usually demonstrate less fire activity than the head fire because it usually has less support from wind or slope. Sometimes referred to as the heel part of the fire.
Test burn	A small burn which is ignited to observe and evaluate fire behaviour prior to igniting a larger operational or managed burn.
Topography	The description and study of the shape and features of the land surface.
Uniform fuels	Identical or consistent fuels distributed continuously across an area or landscape. It is usually easier to predict fire behaviour for fires burning in uniform fuels than it is

	for fire in mixed vegetation types.
Vertical Fuel Arrangement	A description of the distribution of fuels on the vertical plane, from the ground up to the canopy levels of vegetation. The vertical arrangement of fuels will influence the relative ease with which fire can spread vertically through the fuel layers.
Weather Station	A collection of sensors and monitors which gathers, records and reports meteorological data. Weather stations may be permanent structures or hand-held/semi-portable/portable units.
Wildfire	Any uncontrolled vegetation fire which requires a decision or action regarding suppression. Wildfires are commonly classified according to size and/or impact upon suppression resources.
Window of opportunity	A period of time or location on the landscape when/where it will be particularly advantageous to adopt particular suppression tactics or actions.

Appendix 2 Estimated Costs to Implement the Fire Management Strategy

Costs of training include 4k for a Northumberland Training Course, expenses (air fares and subsistence) for GRAF course and ditto for Fire Brigade trip to participate in course in Spain.

Vegetation Management

Initial cost of gorse clearance with strimmers and chain saws (15k/acre), annual maintenance cost for fire breaks 25k).

Equipment

Initial equipment list included cost is 20,000 Euro.