Discussion Paper

FOREST FIRE PREVENTION AND CONTROL IN BWINDI IMPENETRABLE NATIONAL PARK, SOUTH WEST UGANDA

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EXECUTIVE SUMMARY

1. Worldwide, extensive tracts of tropical rainforests are burnt during El Nino droughts. Severe droughts have occurred previously without causing such extensive fires. This extensive burning is a result of forests becoming more fire-prone after disturbance mainly by logging.

2. Available information from southeast Asia and the Amazon rainforest landscapes suggest that the combined effects of logging, drought and fire increase the rates of tree, sapling and seedling mortality, truncate secondary succession and accelerate the rate of invasion of grasses, woody creepers, shrubs and exotics in tropical rainforests. In most cases the species composition is permanently altered leaving the regrowth in a burnt forest depauperate in species diversity and in regeneration of upper canopy tree species. Three aspects of forest wild animals' ecology render them susceptible to the negative effects of fire. These include diet, territoriality, and shelter requirements.

3. Fire has been one of the main management challenges and is considered one of the major long-term threats to forest biodiversity in Bwindi Impenetrable National Park. Most fires spread to the park from the adjacent local community agricultural land. In light of human pressures resulting in forest fragmentation and potential climatic changes, the continued occurrence of fire in Bwindi is highly probable. This calls for an immediate fire control plan for the park.

4. Fire prevention and control is an integral part of protected area management. Fire control can be achieved by knowing the cause of fire and fire behaviour. Preventive measures are necessary to check on fire outbreaks and prepare to meet situations that may arise as and when a fire breaks out. Preventive measures include public education and good public relations, legislation, regulations for lighting fire in the park, firebreak establishment, provision and maintenance of appropriate equipment, training of park staff in fire suppression measures, fire season declaration, maintenance of forest trail system for quick movement of fire fighting team, allocation of sufficient

funds to fire fighting, and an alert fire fighting organisation. To suppress wildfires while still small, a fire detection system is recommended. Once fire has broken out, a fire-fighting plan depends on fire behaviour, fuel available, wind direction and velocity. After fire suppression, an evaluation of the fire fighting process and damage to the forest must be done to avoid further fire outbreaks by developing appropriate management responses through lessons learnt.

1 BACKGROUND

1.1 Introduction

Wildfires are rare in most undisturbed, tall, closed-canopy, tropical rainforests because a moist microclimate and high rainfall create nearly non-flammable conditions (Mueller-Dombois, 1981; Kauffman *et al.,* 1988; Uhl *et al.*, 1988; Uhl & Kauffman, 1990). However, tropical landscapes are currently being radically transformed as human activities create a mosaic of logged forests, cleared fields, and successional forests. These changes in land use suggest that we are entering an era in which fire is a dominant form of disturbance in rainforest regions (Uhl & Buschbacker, 1985; Uhl & Kauffman, 1990; Kauffman, 1991). For example, in 1982-1983 3.5 million ha of selectively logged dipterocarp forest burned in east Kalimantan, Indonesia (Malingreau *et al.,* 1985; Leighton and Wirawan, 1986), and much more in 1997 – 98 (Brown 1998) while 1 million ha was affected in the Borneo forest in Malaysia State of Sabah (Malingreau *et al.*, 1985; Woods, 1989). In Brazil alone, Setzer & Pereira (1987) reported that as many as 8 million ha of forest were burned in 1987.

Forest disturbance such as logging cause an increase in the amount of woody debris and fine fuels (e.g., vines and herbaceous growth) present at a site (Kauffman *et al.*, 1988; Uhl & Kauffman 1990) while concurrently inducing significant changes in the microclimate (e.g., decreased canopy cover, increased daily maximum temperatures, increased wind speeds, and increased vapour pressure deficits; Kauffman & Uhl 1990), such that fuel dry-down rates are accelerated and fire susceptibility is achieved in as little as five or six days of no rain (Uhl & Kauffman 1990; Holdsworth & Uhl 1997). These factors, when combined with frequent use of fire for clearing slash, weed control, and conversion of forest to pasture (Uhl & Buschbacker, 1985) lead to frequent fires in those areas where logging or disturbance has occurred. Fire susceptibility is also increased in undisturbed forests that have lost portions of their leaf canopies because of severe seasonal drought (Nepstad *et al.*, 1995).

Given the abundance and continuous distribution of fuels and the flammable nature of these fuels in tropical forests (Kauffman *et al.*, 1988) it is most probable that fuel moisture, rather than fuel biomass or chemistry, is the limiting factor preventing forest fires (Uhl *et al.*, 1988). Overall, the fire regime in rainforests is changing from one characterised by very infrequent and probably low intensity surface fires to one in which fires are relatively frequent and of potentially high severity (Uhl & Kauffman 1990). Yet our knowledge of fire ecology in rainforests is very meagre because few quantitative studies have been made. Little is known of the biomass or arrangement of fuel loads (all dead and downed woody debris and litter, or necromass) in the plant communities of the rainforest ecosystem. In addition, microclimate conditions that influence the dynamics associated with fuel moisture contents and hence combustion potential, need to be quantified. Moreover, little is known about potential tolerance of rainforest tree species to fire and effects on the attendant wildlife. Given these gaps in knowledge, it is important that the risk of fire outbreaks in tropical rainforests be minimised.

This paper is in response to a request by Bwindi Impenetrable National Park management to the Institute of Tropical Forest Conservation – Ecological Monitoring Programme to propose measures that can reduce on forest fires outbreaks in the park based on information gathered after the 1999 survey of burned areas. This document is meant to generate discussion, as such the control and preventive measures contained therein are not cut-and-dried.

1.2 Ecological Effects of Fire on Rainforest Ecosystems

Uhl (1998) observes that it has taken almost 30 years to fully appreciate the significance of fire in tropical rainforest ecosystems. First came the realization that fire has been part of the disturbance history of many tropical forests (Sanford *et al.*, 1985). Few data from charcoal studies in lowland tropical rainforests imply a fire rotation of hundreds or thousands of years (Saldarriage & West 1986). Next came the observation that these forests can actually burn. It only takes a strong El Nino event or a bit of open canopy, such as that caused by light logging, to tip the balance from a fire-resistant to a fire-ready forest

(Woods, 1989; Kinnaird & O'Brian, 1998). Now we are faced with the most surprising revelation of all: forest fires create positive feedback in future fire susceptibility, fuel loading, and fire intensity (Cochrane *et al*., 1999). Indeed, fire adds a whole dimension to tropical disturbance ecology. No other form of disturbance is known to have this self-reinforcing character with the potential to occur on such grand scale.

Much research needs to be done to fully characterize the ecological impacts of fire. It is likely that the extensive fires in the rainforests have already eliminated thousands of species particularly ground-dwelling organisms with limited ranges. Even for those that survive, these grand fires might be among the largest biological selection events in modern history. The greatest loss of biodiversity most likely comes from burning of parks and protected areas that were set aside because of their conservation value.

1.2.1 Effects on Vegetation

Studies from south east Asia rainforest landscapes (Woods, 1989; Kinnaird & O'Brian, 1998) and the Amazon (Uhl & Buschbacker, 1985; Uhl & Kauffman, 1990; Holdsworth & Uhl, 1997; Cochrane & Schulze 1999) show that wildfires destroy the litter layer, damage seedlings and saplings, mid-canopy and canopy trees. Fire kills the trees outright or injures them by exposing the cambium layer.

Destruction of the seedling-sapling layer adversely affects regeneration and increases the likelihood of invasion by exotic plants. Loss of canopy and mid-canopy trees exposes the lower strata to light and heat, contributing to post-fire mortality of seedlings and saplings. Fast growing grasses like *Imperata cylindrica*, and shrubs like the exotic *Lantana camara* invade areas previously carpeted with seedlings and sapling. Vines, creepers, grasses and shrubs overwhelm new seedlings and saplings in the burned area.

Young secondary growth forests, which tend to be open and support heavy vine loads are prone to extensive fire damage as the vines are much more flammable, allowing

fires to move into the crowns, resulting in the death of most trees. Bark thickness is another indicator of fire susceptibility. Most tropical forest trees are characterised by thin bark and therefore are highly susceptible to damage by fire (Uhl & Kauffman, 1990). Because bark thickness is diameter- dependent, it explains why smaller trees experience greater mortality from fires (Holdsworth & Uhl, 1997).

Though forest fires might be occasional, they can leave their mark on the forest for a long time (100+ years). Weedy vines and grasses, some of which are quite flammable even when green, quickly colonise twice-burned forests (Cochrane & Schultze 1998). Whitmore (1990) notes that where such catastrophes have occurred, trees have been observed to have kinks that are believed to be a result of regeneration through a dense tangle of climbers. Even if the forest fires are somehow controlled, the future structure and composition of a burnt forest will be dramatically changed with many mature forest tree species extirpated (Uhl & Buschbacker, 1985; Woods, 1989; Cochrane & Schulze, 1999)

Several adverse effects of fires can lead to the long-term decline of the rainforest system processes. Loss of leaf litter and standing forest biomass disrupts the forest's decomposition and nutrient cycling system. Increased tree mortality after drought and fire leads to a reduction in primary production through leaf loss and reduced photosynthesis. After a fire, there is a temporary reduction in secondary production and organic turnover through decomposition processes. Nutrient cycling is adversely affected by the loss of nutrients in smoke and windblown ash. Loss of the litter layer reduces the retention of nutrients by organic matter and increases losses due to surface runoff and leaching. Changes in soil pH reduce the rate of nitrogen fixation. These negative effects may result in long-term declines in soil fertility and structure and may hamper forest regeneration. There is evidence that areas of forest subject to a short fire-return time decline in biodiversity as fewer and fewer species are able to re-colonise and recruit in burned areas that have lost most nutrient- and moisture conserving capacity.

1.2.2 Effects on Fauna

Because most animal species can move away from burning areas, fire over small areas is rarely considered harmful (Singer *et al.*, 1989). Mobility however is no guarantee that the animals escaped the fire. Three aspects of species' ecologies determine their susceptibility to the negative effects of fire. These include diet, territoriality, and shelter requirements.

Loss of fruit trees reduces food availability to a large number of omnivorous mammalian species, such as primates, rodents, civets, and ungulates. Reduction of densities of rodents for example can adversely affect food supplies for small carnivores such as civets. Loss of the leaf litter means the loss of its associated arthropod community, reducing food availability for omnivores and carnivores.

The destruction of dead logs on the ground and standing dead trees will likely affect the large community of cavity dwellers and ground skulkers. Birds like hornbills require tree cavities for nesting. Bats, rodents and civets all use tree cavities for shelter. Many lizards and snakes use the shelter of dead branches and logs on the forest floor to escape predators. Squirrels, rodents, civets and small cats also use logs on the forest floor as shelter and, in some cases, as foraging substrates. The loss of dead logs and trees therefore represents a significant change in the suitability of the forest for wildlife.

Ability to escape direct mortality from fire by moving is only a temporary respite for territorial species. If they cannot find a new space to settle, they eventually die. Displaced territorial species lose all the benefits associated with familiarity with a home range (escape routes, food sources, shelter). As they attempt to develop new territories, there may be extensive local disruption of the social system as territories are re-aligned to accommodate the influx of new animals.

It is difficult to predict the long-term effects of fires on forests. As the burnt area is re-colonised by herbaceous plants and fast growing pioneer trees, the habitat should improve for many ungulates, including the large mammals

like elephants. Browsing activity, however, may further retard forest recovery. Arboreal frugivores are likely to remain rare until canopy structure recovers and the density of fruit-bearing trees increases in the burnt area. The most threatening effect is the increased risk of future fires as trees continue to die and fall and as softwood pioneer trees become dominant.

1.3 Forest Fires in Bwindi Impenetrable National Park

Fire has been one of the main management challenges and is considered one of the major long-term threats to forest biodiversity in Bwindi Impenetrable National Park (Uganda National Parks, 1995). Although the park is usually too moist to burn, considerable areas burn during exceptionally dry years such as 1960/61 (Leggat & Osmaston, 1961), 1960s and 70s (Lind & Morrison 1974), 1984 (Butynski, 1984), 1992 (Otim, 1994) 1999 (Babaasa *et al.*, 1999) and 2000 (Kasangaki *et al.* 2000). The charcoal record in the late Pleistocene – Holocene sediments of Mubwindi Swamp (Marchant *et al.*, 1997) suggest that Bwindi Forest may have burned in the distant past. According to the Uganda Wildlife Statute (1996), it is illegal to burn vegetation in the Park. Nonetheless, most if not all, fires in Bwindi are man-made. Poachers, arsonists, honey gatherers, harvesters and trespassers may set such fires. Most fires spread to the park after they have gone out of control when local farmers start preparing land for cultivation (Babaasa *et al.*, 1999). There is no record of lightning induced fires because thunderstorms in the tropics are generally associated with rain which reduces the incidence of lightning fires.

Available information indicates that many sites are becoming increasingly more susceptible to fire in Bwindi. For example, while Otim (1994) reported 16 fire sites in 1992, Babaasa *et al.* (1999) observed 37 burnt areas in 1999 while Kasangaki *et al.* (2000) documents seven fire sites. This difference could partly be attributed to a much severe dry spell in 1999 than in 1992 (Bitariho *et al.,* 2000) and the significantly high number of “rainy days” in 2000 compared to 1999 (Kasangaki *et al.* 2000).

During both 1992 and 1999 long dry periods, there were a comparatively high number of fires in the “North Sector” of

Bwindi than in the rest of the Park. This is not only attributed to the poorly maintained park boundary (Babaasa *et al.*, 1999) but also to land-use practices that encourage the burning of land before cultivation. If such land management practices are not changed, recurrent forest fires will occur. As already noted the resultant fire regime, once established, will quickly and severely damage large areas of the forest which will be highly susceptible to colonisation by non-forest plants, and may eventually resemble scrub or savanna. This is already evident in large areas of the "North Sector" of Bwindi being predominated by bracken fern, the exotic *Lantana camara* and grasses such as *Setaria*, *Panicum* and *Hyparrhenia* with virtually no overstorey. Also, numerous gaps on the ridge slopes of Bwindi have been attributed to dry season fires (Lind & Morrison 1974). These gaps show no or little sign of tree regeneration (Babaasa *et al.* in prep.). The impact of fire differs from other natural or man-made gap forming processes in that most pre-existing seedlings and saplings are killed by fire (Woods, 1989). Although these fire-induced changes will take several years to occur, they are likely to be irreversible under current climatic conditions (Mueller-Dombois, 1981).

The largest area affected by wildfires is still small, being only 0.8% of the park in 1999 (Babaasa *et al.*, 1999). However, these fires should not be taken lightly given that most of Bwindi has fuel loads and a microclimate perturbed by human activities especially the intense logging of the past. With small climatic changes, fire occurrence could be greatly increased throughout Bwindi. In light of human pressures resulting in forest insularity and potential climatic changes, the continued occurrence of fire in Bwindi is highly probable. It is against this background that a fire control plan is being developed for Bwindi to reduce on fire outbreaks.

2 FOREST FIRE CONTROL PLAN

2.1 General Information

2.1.1 Basis of the Plan

The proposed fire control and prevention measures are derived from Brown and Davis (1973), Uganda Forestry Department Working Plans and Departmental Standing Orders. The main objectives of this proposed fire control plan are to: -

(i) prevent as many fires as possible occurring in the park;

(ii) extinguish fires that start while they are still small; and

(iii) minimise the size and destructiveness of the fires that become big in spite of the control measures in place.

2.1.2 Area

This proposed plan applies to Bwindi Impenetrable National Park, which covers 331km^2. It lies in southwestern Uganda (0°53′ to 1°8′ south; 29°35′ to 29°50′ east).

2.1.3 Vegetation and Terrain

The Park is in a highly dynamic and disturbed state, partly because of a comparatively high proportion of treefalls on the steep slopes as well as extensive logging of the past. Overall, about 10% of the park remains intact, 61% has been heavily exploited by pitsawyers and 29% has been 'creamed' of its best timber trees by selective pitsawing activity (Howard 1991). In many cases pitsawing activity has opened gaps that are too large for tree regeneration to take place and are 'frozen' in a bracken fern, *Mimulopsis* or *Sericostachys* secondary state (Babaasa *et al*. in prep.). This fuel buildup predisposes the forest to fires, in addition to appropriate weather conditions and an ignition source.

The topography of the park consists of narrow, very steep sided valleys that run in all directions and are bounded by hillcrests lying between 1400m in the 'North Sector' and 2600m in the 'South Sector.' Because fires move more rapidly up-hill, where the headfire's flame is close to the forest floor and preheats the fuel, fires in Bwindi will spread with alarming rapidity because of the steep-sided hills. It is impossible for vehicles and very difficult for fire-fighting personnel to move on the slopes. Winds moving over hills and into valleys first cool and release moisture as they rise and then warm and absorb moisture as they descend. Such less humid winds moving upslope cause rapid spread of fires in a rugged terrain like that of Bwindi.

2.1.4 Climate

The dry periods are December to January and June to August, the latter being more severe and longer (Butynski 1984; Bitariho *et al*., 2000). The prevailing winds over the park especially during the dry seasons are from the southeast (Leggat & Osmaston, 1961). Fires spread at different rates and in different directions depending on time of day, direction of wind, weather and landscape. Fires are generally most intense during the day when humidity is low, winds are high, and temperatures are warm.

2.1.5 Causes of Fire

Previous fires recorded in Bwindi (Butynski, 1984; Otim, 1994; Babaasa *et al.*, 1999; Kasangaki et al., 2000) have been caused by: -

(i) Incendiary or arson - these are malicious fires caused by those who resent the management objectives due to poor public relations.

(ii) Land clearing for cultivation - fires started in the community land may spread over into the park.

(iii) Poachers for wild game and honey hunters.

(iv) Accidental fires started by beekeepers in multiple-use zones, miners and pit sawyers.

(v) Herdsmen who lit fire with the intention of maintaining the grasslands and improve pasture for livestock.

Potential sources of fire within the park can be: -

(i) Fires left burning by park staff, researchers or tourists camping in the forest.

(ii) Lightning – this is more likely at the beginning of the rainy season.

(iii) Smokers – throwing away burning matches and cigarette butts.

(iv) Quartzite rocks - after hitting each other may cause fire by igniting the vegetation.

2.1.6 Fire Behaviour

Knowledge of fire behaviour enables the person in charge of fire operation to properly allocate personnel and equipment and other accessory facilities.

A useful and long accepted classification of fire is based on the degree to which fuels from mineral soil up-wards to the treetops are involved in combustion (Brown & Davis, 1973). This, in effect classifies fire behaviour into:

(i) Surface fires

These fires burn the surface litter, debris on the forest floor and small vegetation. It sweeps all the fuels on forest floor like herbs, shrubs and debris. It may be a low energy fire where there is litter and sparse ground vegetation or a hot and fast moving fire where slash, inflammable under-storey, shrubs or other abundant fuel prevails. Surface fires may and often do burn into taller vegetation and tree crowns as it progresses. This is called “crowning-out.” However, as long as it is sporadic in nature, the fire remains in the category of a surface fire. Surface fire is

the least hot forest fire, has a visible flame of heights less than 1 meter, moves and consumes available surface materials according to the prevailing wind velocity and direction. Surface fire is the least damaging (char the outsides of trees but the principal species are not damaged). It passes gradually with moderate smoke and may be described as a “cool fire.” Most fires in Bwindi start as surface fires.

(ii) Ground fires

When the forest floor contains a lot of dry, woody material, compact humus layer, then the fire will penetrate the humus layer underground. In very deep organic material under drought conditions, the fire may penetrate several centimeters below the surface and travel entirely underground. A ground fire often follows a surface fire depending on the moisture content of the organic layer. A true ground fire spreads within rather than on top of the organic mantle. Ground fires are often hard to detect and are the least visible and slowest moving. Ground fires burn very slowly with no flame due to limited oxygen supply. The amount of heat produced and destruction caused are intense. Much of the damp humus is carbonized and consumed during the fire. Ground fires are very hot and independent of wind velocity and direction. All organisms and materials under the humus layer are destroyed, superficial root system killed and tender bark trees damaged. Ground fires produce thick, black and white smoke and changes the physical conditions of the soil like colour and texture. These fires are common in Bwindi in areas with accumulated dead plant material.

(iii) Crown fires

A crown fire may be defined as a fire that advances from top to top of trees or shrubs more or less independent of surface fire. Lichens, climbers and lianas contain a lot of inflammable aromatic materials as such a surface fire can be easily conveyed up to the tree crowns. To distinguish the degree of independence from surface fires, crown fires are often classified as “running” – having climbed up the crowns, it does not depend on surface fire or “dependent” – still having to be fed by surface fire. Crown fires

generally start as surface fires. If a surface fire gains in intensity, it creates its own advective weather column, sucking wind toward it and upward. The fire preheats the overstorey canopy causing it to burn rapidly as a crown fire – either as a passive crown fire if it occurs behind the surface fire front, or an active crown fire if it advances without the surface fire's preheating the crown.

Crown fires are the most damaging. They consume all or most of the trees. They have a big flame and a lot of smoke. They are easily influenced by changes in the atmospheric conditions like wind, temperature and oxygen supply. Crown fires are the least common of the forest fires in Bwindi.

(iv) Fire combinations

In actual fire situations, these three kinds of fire may occur simultaneously and in all kinds of combinations. Surface fires are by far the most common and nearly all fires start as such. A surface fire may spread into the crowns and develop into a sweeping crown fire. A crown fire may drop to the ground and become a surface fire. Similarly a surface fire may develop into a ground fire. On hot, dry and windy days, a ground fire may be fanned into a surface or crown fire. Such fire combinations are the most prevalent in Bwindi.

2.2 Fire Protection Measures

2.2.1 Education and Public Relations

Protection of forests against fires, more often than not, is a community job and cannot be handled by the field staff and employees of the park alone. Friendly relations should be established with the communities adjacent to the park. Personal contacts with occupiers of land adjacent to Bwindi should be made as an endeavour to obtain mutual cooperation.

Education as a means of fire prevention is a vital tool and it should involve all age groups living around the protected area. For the case of Bwindi, this can be achieved through

public rallies or lectures, film shows and radio programs. The school children should also be targeted, as they will be the adults of tomorrow. Adult groups should be regarded as the primary target, conscious of the fact that they are the ones who in every sense of forest fire prevention and control, ought to be participatory.

Protected area managers should make good use of other people such as politicians, educators, local councils, and religious leaders as they are always in contact with the communities. In all communications, emphasis should be on the values of protected areas, such as employment opportunities, revenue to government, environment and protective aspects.

There is need to work with farmers abutting the park boundary to use fire more appropriately and effectively to clear fallow lands, control pests and weeds and, provide nutrients. Fires have been used by generations to clear fallow lands, clear pests and weeds, and provide soil nutrients (through the production of ash). Recent experience, however, suggests that pest and weed control and soil productivity can be improved without use of fire.

There is need for Park to liase with the Department of Agriculture in the sub-counties adjacent the park to work with farmers to demonstrate the use of other techniques that do not require the use of fire but increase soil fertility and protect crops against pests.

The underlying assumption is that farmers will not use fires as much once they see the benefits of using other techniques. Farmers will be more cautious in their use of fire once they understand how best to control it. They will also be less likely to let fires get out of control once they realise how it can have negative effects on the park.

2.2.2 Legislation (The Uganda Wildlife Statute No. 14, 1996)

The law protecting conservation areas under Uganda Wildlife Authority from fire is covered under Section 22 sub-section 1(f) of the Uganda Wildlife Statute of 1996 under the general offenses in wildlife conservation areas.

The Statute provides penalties for the offence of causing unauthorised fire in a protected area under general penalty Section 75 sub-section (a) and (b).

Under Section 27 sub-section 2(c), the Uganda Wildlife Statute provides for making regulations including the use of fire or general prohibition on the use of fire within a conservation area.

People using the park or adjacent the park should be made aware of these legal provisions (Appendix 1). It is, however, better to convince people of the values of forests and thus win their cooperation instead of threatening them with penalties for infringements of the Statute.

2.2.3 Lighting of Fires

It is forbidden to light fires within the park. Exceptions are made for those carrying out work that requires fire lighting. In this case, after the work, the fire must be fully extinguished with water, until there is no dry ash or coal remaining. Failure to do so will result in the levying of penalties specified in the Uganda Wildlife Statute or confiscation of park-use rights that should have been accepted in lieu of forest fire protection. Memoranda of Understanding (MoU) between the park and community governing the bee-keeping zones, problem animal control and harvesting of resource plants should include responsibilities for fire prevention and fire fighting. This should be emphasised since wildfires cause damage to the resources they harvest from the park.

2.2.4 Establishment of Fire Breaks/Fire Lines

These are open belts to prevent fire from crossing such barriers or belts. They may be natural such as rivers or artificial such as roads. It is not feasible to construct fire lines inside Bwindi, as it is not possible to predict where the fire is likely to break. Also fire lines require being wide and extensive so may adversely affect the ecology of the forest ecosystem. It is therefore recommended that external fire lines (boundary lines) be regularly maintained to prevent fires from the community fields from crossing over into the park. This is due to the fact that park

management has no control over the surrounding areas and the factors that induce the fires. Fire lines should be as clean as possible clear of any fuel. Width of fire lines depends on height of the surrounding vegetation. The higher the vegetation, the stronger the wind velocity, the wider the fire line and vice-versa. With higher vegetation, surface fire may easily change into crown fire. External fire lines can be 5 – 6 meter wide. Since fire is only a threat to the park during the dry season, fire-breaks must be free of any plant material and other fuel load by the end of the rainy season to be effective during the dry season. The process of boundary opening around fire-prone areas in Section 1.3 should be ensured every dry season.

Evergreen trees can be planted as fire lines as they are not easily burnt because they contain a lot of moisture.

2.2.5 Provision and Maintenance of Equipment

Given the limited resources available to park management and the extremely rugged topography of Bwindi, hand tools are the only ones that can be used in preparation against and for suppression of fires. This equipment for convenience can be grouped under:

(i) Those for construction and maintenance of firebreaks – rakes, spades/shovels, machetes, slashers and hoes.

(ii) For communication and transportation – hand-held radios, vehicles, sirens, whistles and hooters.

(iii) For fire suppression – pack pumps, beaters, saws, brooms, safety wear.

(iv) For fire detection – binoculars.

Note that most of the equipment used in the pre-suppression efforts is also used in the fire fighting itself. When the types of equipment have been selected every effort should be made to have them available in sufficient quantity. They should be stored at every ranger outpost during the dry seasons and at park headquarters during the wet periods.

2.2.6 Training

Park staff should be specially trained in fire suppression methods. Those trained will form a fire-fighting crew. A lot of time and effort can be wasted when untrained or inexperienced crew is deployed to combat a fire. Training in simple techniques like determining fire behaviour, filling and refilling pack pumps and water containers from any water sources, use of beaters, backfiring systems, signals, how to operate walkie-talkies should be given to every person at the fire front and those directing the operations. Organisation can only be effective, if and when each crewmember is fully aware of what is required of him / her when opportunity dawns. A training course in fire control is recommended for the fire fighting crew of Bwindi. Nyabyeya Forestry College, Masindi is an ideal place in Uganda to do the training as they have experienced personnel and equipment for training purposes.

2.2.7 Fire Season Declaration

A fire hazard season is declared basing on past experience in when the fires are likely to erupt. Climatic data can assist in determining the fire season and reference should be made to the data that is being collected by the Institute of Tropical Forest Conservation – Ecological Monitoring Programme. The following are the recommended steps to be taken by the protected area manager: -

(i) Fix the fire season based on experience to indicate months when the probability of big fires is high.

(ii) During this season declare an emergency. Fire protection should take priority over other activities. Fire fighting crew should be on alert on a 24-hour basis. All other staff should be alert as much as possible.

(iii) Do a lot of publicity. Before the main fire season, community conservation wardens and/or rangers should give talks at convenient centres, including schools, to people around the park to make them conscious of their responsibility towards forest fire protection.

(iv) Propaganda posters and notices ("Prevent Forest Fire") shall be displayed along all roads and paths entering the park and in accessible areas along the park boundary before the main fire season. However, the posters must be taken down at the end of the dry season or else the message will be disregarded the following year because of over-familiarity.

2.2.8 Forest Trail System

The present forest trail system in Bwindi should be maintained as to enable the fire fighting crew to move quickly from one part of the park to another, which may be burning. This is important, as most parts of Bwindi are inaccessible by roads.

2.2.9 Fire Fighting Organisation

During times of extreme fire danger, the fire fighting crew shall be constantly on full alert. There shall be a warden or ranger in charge of them – herein referred to as the Fire-in-Charge – with provision made for a substitute if he/she is away.

The fire fighting crew should practice fire fighting before the onset of the long dry season. Local people should rarely be called for fire fighting practices, as they may then tend to ignore the call for fighting real fire.

One vehicle with adequate fuel and in good working condition stationed at park headquarters and fire fighting equipment in every ranger outpost will be on permanent fire standby duty during fire hazard periods. Regular checks (once in a fortnight) should be undertaken by the Fire-in-Charge on all equipment to be used during the fire season.

Adequate funds shall be estimated for the efficient protection of the park. Annual budgets shall include a provision for fire fighting which will be prioritised in the allocation of funds.

Details of contingency plans to be adopted during a major fire outbreak e.g., provision of food, water, first aid to

staff and labour engaged in a protracted fire fighting operation should be made by the Fire-in-Charge.

2.3 Fire Detection/Watch System

One of the objectives of a fire control organisation is to prevent as many fires as possible and to suppress any which starts, when still small. This is only possible through prompt detection of the fires. Fires should be precisely located and a warning and full information passed on to the nearest ranger outpost and to the Fire-in-Charge fast enough. If detection is inefficient, fires that start are likely to grow out of all proportions before the suppression force arrives. Under such conditions even a well-organized and equipped group may prove incapable of handling the situation. To be effective, detection must be planned, making use of all possible means such as:

2.3.1 Fire Watch Towers/Points

These are observation posts for watching fire around the forest for example, a man standing on a hilltop, treetop or properly built structures with appropriate climbing systems. It is therefore suggested that watchtowers be constructed in fire-prone areas such as Rushaaga in the “South Sector” and Kanungu area in the “North Sector.” These should be near ranger outposts in those areas for ease of manning. A number of fire watchtowers are vital to cross check the fire spot and locating the fire source as a pre-requisite to subsequent suppression operations. A person in the watchtower should be equipped with a pair of binoculars and a hand radio to communicate with the Fire-in-Charge. Where the elevation is good enough to see a big part of the forest, there is no need of a fire tower. A simple shelter can be built.

2.3.2 Fire Watch Patrols

Park Rangers should walk around the park and should be equipped with simple fire fighting tools such as hoes, pangas, beaters, whistle or hooter and hand held radios to fight small fires and call for help. Patrols should be intensified during the fire season especially along the

boundaries to ensure that fire does not enter the park from adjacent land.

2.3.3 Vulnerable Site Monitoring

Sites that are known to burn almost during the driest years and seasons need to be monitored closely. If the sites are near the villages, it makes sense for park management to recruit some community volunteer monitors who are responsible for contacting the park headquarters or nearest ranger post as soon as they see signs of fire.

2.4 Suppression of Fires

In case of fire the following actions should be taken: -

(i) Anyone seeing fire in or threatening the park will raise an alarm by whistling or shouting.

(ii) A fire tower lookout hearing a whistle or shout or seeing smoke in or near the park will radio to the Fire-in-Charge and the nearest ranger outpost.

(iii) On receiving a radio call or hearing whistles or shouting the Fire-in-Charge or rangers in the outpost will:

- Sound the siren.
- Send out a vehicle with fire fighting crew to the ridge above the fire.
- Go out on foot with all the men who answer the siren to the fire itself, with the equipment and tools available.

(iv) The Fire-in-Charge or an experienced ranger will control and direct the fire fighting team.

Fire in the forest has a given behaviour depending on fuel available, wind direction and velocity. The fire boss must study the behaviour of the fire in respect to the above essential factors. The total burnt area on the surface of a forest is called a fire burn. A fire burn takes up different shapes depending on the fire behaviour. Behaviour of fire is different on each of the sides of the fire burn –

maximum damage at the front, moderate damage on the flanks and minimum damage at the rear. The Fire-in-Charge should deploy maximum equipment and manpower at the front since it is where there is maximum damage.

2.4.1 Suppression of Surface Fires

(i) Raking – make a fire line by quickly removing fuel – grass, leaves and other materials using a rake to expose mineral soil that is fuel free.

(ii) Use of shovels, green brooms or beaters to beat the fire aimed at excluding oxygen supply to the flame. Beaters should be used with a horizontal sweeping motion towards the fire, and not vertically, as this tends to spread sparks.

(iii) Use water for beating the fire. Water chokes the fire by excluding the oxygen. This method is called fire sprinkling. Back-pack pump operators should get as close to the fire as possible and direct a spray (not a jet) at the base of the fire, not at the flames or smoke.

(iv) Mopping up operation to remove dry pieces of wood or other fuels. The purpose is to extinguish all remaining sources of fire. The burnt site should be watched very carefully for 24 hours to ensure fire does not break out again. This should be done under the detailed supervision of the fire boss.

2.4.2 Suppression of Ground Fires

(i) Trenching – a trench is dug since the fire is travelling underground. The purpose of the trench is to break fire continuity. This method is for small fires.

2.4.3 Suppression of Crown Fires

(i) The fire boss should direct staff to clear a belt of forest all around the fire using saws and other equipment that can do it quickly. The emergency line created should be hoed. The purpose is to localize

the fire within an area by creating open space or firebreak. This is possible when the wind is not so strong to cause crown-to-crown fire transfer.

(ii) Backfire or counter fire. This is done in case the above firebreak fails and fire is so fierce - like a very large area burning at once, winds blowing very strongly and other environment factors influencing the fire like pressure difference (depression). Back burning to it can increase the effectiveness of the firebreak when wind conditions are suitable. A backfire is set to clear the fuel ahead of an abnormal fire. A backfire can easily be controlled unlike the abnormal fire. This method should only be used as a last resort and with greatest caution and after consideration by the Fire-in-Charge of the sacrifice involved since it involves surrendering part of the forest. All men should be withdrawn from the fire itself to the other side of the backfiring line before starting the second fire. Special caution should be made to avoid blocking of wildlife fleeing from the fire.

2.5 Post-suppression Measures

After fire suppression activities, there are a number of post-suppression measures to be undertaken. The purpose of post-suppression measures is to prevent another fire outbreak. It is also important if lessons learnt from fire destruction are to be taken seriously.

2.5.1 Mopping-up Operation

This is undertaken after a fire hazard to make the area as fire free as possible. Burning stumps and other fuels are extinguished. The exercise also includes digging trenches, use of water or beating burning pieces. This is an important exercise that should be supervised by an experienced staff.

2.5.2 Fire Reports

Two copies of a Fire Report Form (Appendix 2) should be completed and one copy forwarded as soon as possible to Warden-in-Charge at park headquarters while another is retained at the ranger outpost. Every attempt must be made to complete every heading on the form and if accurate information is not available even an estimate is very useful, so long as the fact that it is an estimate is noted.

- Date
- Location
- Time alarm sounded
- Time of arrival of various parties to the scene
- Time fire extinguished
- Labour and equipment employed
- Outside help given (list of names of villagers if possible)
- Details of action taken
- Cause of fire if known
- Damage done (including map of area damaged and destroyed)
- Cost of action (including rewards to villagers, if given)
- Criticism of working of Fire Control Plan

2.5.3 Remedial Measures

Park management should study the above reports and remedial measures to be instituted. Remedial measures may include:-

(i) Re-enforcement of already existing measures e.g. if equipment was not maintained properly either through carelessness, lack of understanding, lack of funds, poor maintenance of fire lines either through lack of knowledge on their importance, misuse of vehicles, irresponsibility and negligence of duty and any other valuable equipment.

(ii) Take new suitable steps where existing ones are not appropriate e.g. boundary clearance, fire watchtowers, need for certain types of equipment.

(iii) Review staff performance – their public relations, reputation, efficiency.

(iv) Make an assessment and review of the local community views and assistance.

2.5.4 Follow – up

The effects of fire disturbance on tropical rainforests are poorly known. Given the amount of previously burned forest already existing and that burned forest might become a larger element of the future landscape, the time has come to study this 'new' landscape element. Areas known to have been severely impacted by uncontrolled forest fires in recent years should be selected. An extensive sampling design to incorporate areas subjected to single and multiple fire events as well as different fire intensities. The objectives in this preliminary study should be to: -

(i) determine the effects of fire upon forest structure;

(ii) investigate changes in species composition caused by fire;

(iii) characterise the heterogeneous nature of repeatedly burned forest.

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4 APPENDICES

Appendix 1

The Uganda Wildlife Statute No. 14, 1996.

Statutes Supplement to the Uganda Gazette No. 32 Vol. LXXXIX.

22. (1) Unless provided for by this Statute any person, who in any wildlife conservation area unlawfully-

(f) starts or maintains a fire without lawful authority;

shall be guilty of an offence.

27. (1) Subject to section 7, the Minister may, on the advice of the board, make regulations regulating acts or omissions within a wildlife conservation area declared under section 18 of this Statute.

(2) The regulations under subsection (1) may include –

(c) regulations on the use of lighting picnic fires, lamps, fires or general prohibition on the use of fire in a wildlife conservation area;

75. Subject to the provisions of this Statute, a person convicted of an offence under this Statute for which no other penalty is provided shall –

(a) in the case of a first offence, be liable to a fine of not less than thirty thousand shillings but not exceeding three million shillings or to imprisonment for a term of not less than three months or to both such fine and imprisonment;

(b) in the case of a second or subsequent offence, to a fine of not less than three hundred thousand shillings but not exceeding six million shillings or to imprisonment for a

term of not less than six months, or to both such fine and imprisonment

Appendix 2

Fire Report

Date and time fire discovered

Alarm raised by

Fire origin *(inside/outside)*

Cause of fire

Location *(Name of site & GPS coordinates)*

Type of fire *(ground, surface, crown, ground/crown etc)*

Estimated area burned *[measure the length L (largest distance from the burnt edge to burnt edge) and width W (largest distance perpendicular to the length) then use the formula for an ellipse (most burnt areas are shaped at least roughly like an ellipse; $A=\pi LW/4$)]*

Date and time of arrival of various parties on the scene

Date and time fire extinguished

Direction of wind: blowing from

Strength of wind *(nil, light, medium, strong)*

Ground slope *(nil, gentle, moderate, steep)*

Fuel: type *(grass, leaves, branches etc)*

Quantity *(light, medium, heavy)*

No. of park staff fighting fire

No. of volunteers fighting fire and names

What suppression measures were taken *(how was the fire fought, kind and quantity of tools, direction of attack)*

How effective were the suppression measures

What post-suppression measures were taken

General account of the fire and comments *(improvement required in organisation, tools times, community response, money spent and on what, mistakes and successes)*