Use of prescribed burn in high-altitude rangeland areas

Standard Operating Procedure

Forest Resources Planning and Management Division
Department of Forests and Park Services
Ministry of Energy and Natural Resources
Royal Government of Bhutan

March 2025

Department of Forests and Park Services
Ministry of Energy and Natural Resources
Royal Government of Bhutan

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Contents

Preface

High-altitude rangelands contribute significantly to Bhutan's economy, food and water security, nutrition and health, biodiversity conservation, and several other spheres. Like in many countries in the Hindu Kush Himalaya (HKH) region, rangelands in Bhutan are integral components of protected areas, biological corridors, and state and community forests. These areas not only serve as grazing resources for pastoralism but also represent crucial habitats for wild ungulates that are a vital prey base for globally significant species such as the snow leopard and tiger. Additionally, well-maintained rangelands act as carbon sinks.

However, the sustainability of mountain pastoralism depends on the availability of high-quality fodder from seasonal pastures at different elevations. Over the past three to four decades, policies restricting traditional pasture management practices, along with demographic changes in the mountain regions, have led to the gradual recolonisation of alpine or subalpine pastures by shrubs, thereby significantly reducing forage quality and availability in the summer pastures. Transitional pastures and winter grazing areas are either overused and highly eroded or dominated by invasive or unpalatable plants that produce minimal fodder. Shrub invasion and land erosion further diminish the growth and availability of highly valued medicinal plants and herbs. In some instances, pastures are fully overrun by pioneer woody species, while critical water sources for wildlife, livestock, and herders are drying up. These trends have led to adverse effects on rangelands, making mountain pastoralism economically unfeasible.

Among traditional practices, burning to improve fodder productivity has been an age-old practice among pastoral communities in Bhutan. If used wisely, fire can be an important ecosystem management tool. It is based on this recognition that the revised Forest and Nature Conservation Act of Bhutan (2023) acknowledges fire as a strategic tool for managing deteriorated ecosystems. This legislation, by permitting prescribed burning in State Reserved Forest Land, addresses the necessity of minimising the risk of forest fires, while also enhancing the management of wildlife habitats and improving grazing areas.

It is with great pleasure that I introduce this new standard operating procedure (SOP) for prescribed burning which was endorsed by the Technical Advisory Committee (TAC) of the Department of Forests and Park Services (DoFPS) during the 65th meeting of the TAC. This SOP was carefully developed through field exercises and extensive consultations with multiple stakeholders. This endeavour represents a broader vision aimed at utilising fire as a strategic tool for managing forest pastures to benefit both wildlife habitats and domestic livestock grazing. Notably, this SOP has undergone proper field testing and refinement in order to ensure their practical applicability and efficacy.

In fact, I am extremely happy to learn that this document emerges as a timely and indispensable resource, particularly as the National Land Commission Secretariat undertakes the mission of redistribution and leasing of national “tsamdros” (grazing lands) among herders whereby pasture management plans are a mandatory prerequisite for lease acceptance by the pastoral households. By addressing the multiple challenges and opportunities inherent in forest pasture management, I am optimistic that this new SOP can unlock the underlying potential of rangelands and foster resilience and sustainability across our landscapes.

This SOP is a formal document to support the Forest and Conservation Act of Bhutan (2023) and the governmental initiative towards tsamdro redistribution. As we move ahead with this collective endeavour, I extend my heartfelt appreciation to the DoFPS and all the stakeholders who have contributed to the development of this SOP. In particular, I wish to extend our gratitude to the International Centre for Integrated Mountain Development (ICIMOD) for technical support, and the Himalayan Resilience Enabling Action Programme (HI-REAP) funded by the United Kingdom International Development through its Foreign Commonwealth and Development Office (FCDO). Together, let us accelerate our efforts with the confidence that our concerted actions will pave the way for a brighter, more resilient future for Bhutan and its rangeland resources.

Karma Tenzin
Director
Department of Forests and Park Services
Ministry of Energy and Natural Resources

Abbreviations and acronyms

AFAC	Australasian Fire and Emergency Service Authorities Council
CFO	Chief Forestry Officer
CID	Citizen Identity Card
DoFPS	Department of Forests and Park Services
DoL	Department of Livestock
FNCA	Forest and Nature Conservation Act of Bhutan
FNCRR	Forest and Nature Conservation Rules and Regulations of Bhutan
HI-REAP	Himalayan Resilience Enabling Action Programme
ICIMOD	International Centre for Integrated Mountain Development
MoENR	Ministry of Energy and Natural Resources
PAs	Protected Areas
RBP	Royal Bhutan Police
SRFL	State Reserved Forest Land
TAC	Technical Advisory Committee
URC	User Right Certificate
UWIFoRT	Ugyen Wangchuck Institute for Forestry Research and Training

Chapter 1: Introduction

1. Introduction

1.1 Why is this SOP needed?

This SOP has been developed to standardise the technical and operational procedure of using prescribed burns for rangeland management in Bhutan. More specifically, they have been designed to achieve the following purposes:

1) **Safety assurance**: To ensure that the burns are carried out safely, following safety measures, thereby reducing the risk of harm to individuals and property.

2) **Environmental protection**: To help minimise the adverse effects on the environment during prescribed burns; and to preserve ecosystems and maintain biodiversity.

3) **Effective goal attainment**: To ensure that the prescribed burns achieve their intended objectives, such as reducing fuel loads to prevent forest fires, promoting ecosystem health, increasing fodder quality and productivity, and rehabilitating natural habitats.

4) **Regulatory compliance**: By adhering to this SOP, prescribed burns align with legal and regulatory requirements, thereby ensuring that all such practices follow established laws and standards.

5) **Community considerations**: To make sure that prescribed burns are conducted thoughtfully and responsibly, considering community concerns such as smoke, air quality, and fire-spread risks.

6) **Building institutional capability**: To strengthen the institutional capacity of DoFPS, the Department of Livestock (DoL), and communities concerning the use of prescribed burns to achieve productive ecosystem management goals.

1.2 What is inside this SOP?

This SOP comprises five chapters. The first chapter serves as an introduction, describing the background, purpose, and the intended readers of the SOP. In the second chapter, readers get to know about the definition of “prescribed burn”, its applications in ecosystem management, its relevance in Bhutan, and the legal framework surrounding its use. The third chapter consists of the modality for authority, implementation, and approval process for the prescribed burn. The fourth chapter constitutes the core of the SOP, outlining six key steps for conducting a prescribed burn: 1) review of regulations; 2) site evaluation; 3) burn plan development; 4) pre-burn preparations; 5) execution of prescribed burn; and 6) post-burn evaluation and reporting. Chapter 5 addresses specific issues that require careful consideration by managers. Additionally, there are annexures which include a burn plan template, a field reporting form, and a logistical preparation checklist.

1.3 For whom is this SOP designed?

This SOP is designed for individuals and organisations involved in planning, approving, implementing, and monitoring prescribed burns on rangelands to support wildlife habitats and domestic livestock grazing. The primary users include managers and policymakers from forestry, agriculture, and livestock sectors, as well as local government authorities. Additionally, schools and fire agencies can utilise this SOP as teaching material. A simplified version can also be used for training and awareness building of local communities.

Chapter 2: Prescribed burns for ecosystem management

2. Prescribed burns for ecosystem management

2.1 What is a prescribed burn?

Prescribed burns, also referred to as prescribed burning, planned burning, controlled burning, prescription fire, planned fire, or prescription burning, are intentional fires that are deliberately set under controlled conditions for specific purposes. The definition of prescribed burn varies. In this SOP, we adopt the one from the Australasian Fire and Emergency Service Authorities Council (AFAC): "The controlled application of fire under specified environmental conditions to a predetermined area and at the time, intensity, and rate of spread required to attain planned resource management objectives" (AFAC's Forest Fire Glossary, 2012).

Prescribed burns are a valuable tool in maintaining ecosystems, reducing wildfire risks, and promoting overall landscape health, and are widely used in many countries such as China, the United States of America, Australia, and Canada to achieve a wide range of forest or rangeland management goals. They are typically carried out by trained professionals. The physical operating environment and the context in which prescribed burn is applied are important as a range of key factors significantly affect how prescribed burns can be planned and implemented.

2.2 What can prescribed burns achieve in rangeland management?

Prescribed burn stands as a secure, efficient, and economical method for enriching native rangelands. With a historical track record spanning thousands of years, prescribed burn benefits both humanity and the environment in numerous ways:

Sustains open grasslands and fosters healthier native plant communities by:

- Fostering robust plant growth and vitality
- Augmenting seed production and viability
- Promoting the development of plant bud banks
- Bolstering grass density
- Enhancing plant diversity, particularly when coupled with grazing
- Amplifying the nutrients available for plant growth

Manages the proliferation of undesirable and invasive species in grasslands by:

- Limiting the expansion of unwanted woody plants on grasslands
- Exercising control over certain noxious weeds
- Potentially reducing the necessity for widespread chemical applications, which may inadvertently harm native flora and fauna

Enhances soil health by:

- Mitigating soil erosion through the stimulation of healthier grass growth
- Facilitating the growth of beneficial soil microbes
- Improving ecosystem nutrient cycling

Improves wildlife habitat by:

- Augmenting the variety and abundance of the wildflowers (forbs) preferred by wildlife
- Increasing pollen and nectar sources for the pollinators
- Promoting the resprouting of nutritious browse for wildlife grazing
- Establishing snags utilised by wildlife for nesting
- Reducing wildlife parasites such as ticks
- Cultivating superior grassland wildlife habitat
- Supplying forage that has higher nutritional value
- Potentially increasing wildlife carrying capacity through the removal of undesirable plants
- Increasing forage production

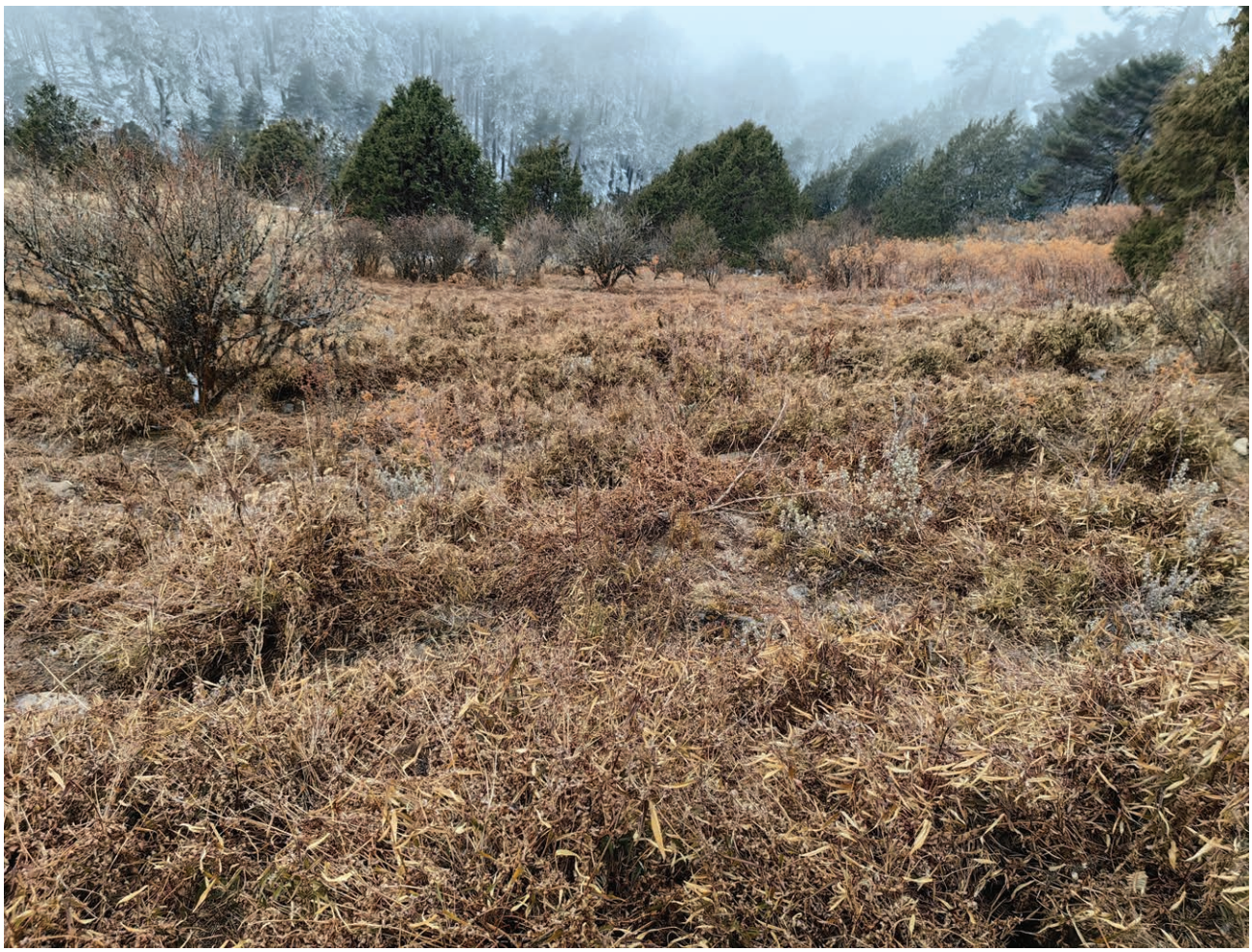
Benefits livestock development and pastoralism by:

- Enhancing forage quantity, quality, height, and density
- Improving the nutritional value and consumption of rangeland plants
- Enhancing animal performance, including stocker cattle weight gains and cow body condition scores
- Increasing calf-weaning weights
- Reducing tick and horn fly infestations
- Providing additional grazing distribution and season-of-use options for managers
- Altering the physical properties of plants, such as thorns, that deter grazing
- Potentially increasing stocking rates through the removal of undesirable plants and increasing forage production

2.3 Relevance of prescribed burn in Bhutan

Bhutanese tradition incorporates the use of fires for productive purposes, with herders employing periodic burning tactics to enhance fodder quality and quantity while preventing shrub encroachment into the rangelands. Anthropogenic factors, particularly grazing and associated management practices, have significantly influenced the biodiversity, ecosystems, and landscape of Bhutan, similar to the broader Himalayan region. However, due to a lack of active pasture management in recent decades, many traditional grazing areas are now overgrown with young trees, shrubs, or weeds, thereby drastically reducing available rangeland and fodder for pastoral production. This encroachment has also reduced habitat quality and forage supply for herbivorous wildlife like blue sheep.

Prescribed burn is an economical and effective method to control shrub encroachment, thus enhancing both wildlife habitats and domestic grazing areas. Additionally, prescribed burn promotes the natural regeneration of native plants and contributes to the maintenance of healthy ecosystems and the rehabilitation of wildlife habitats. It also supports traditional land management practices.



Integrating prescribed burns into a comprehensive land stewardship strategy will enable Bhutan to achieve ecological, social, and economic sustainability goals. Specifically, prescribed burn in Bhutan serves various rangeland management objectives, including:

- Improving fodder quality and quantity and the available grazing area for domestic animals
- Preventing woody vegetation encroachment, maintaining open spaces, and promoting desirable grass species growth
- Creating and sustaining diverse habitats to support a wide array of plant and animal species
- Enhancing carbon sequestration by promoting plant diversity and averting catastrophic forest fires that emit substantial carbon dioxide
- Minimising forest fire risk by strategically reducing fuel loads in vulnerable areas, especially in dry winter months

2.4 Policy and legislative context for using prescribed burn in Bhutan

The following regulations and policies allow for the controlled use of prescribed fires for ecosystem management in Bhutan:

1) Forest and Nature Conservation Act of Bhutan (1995)

This legislation empowers the nodal ministry to establish rules regarding the use of fire in Government Reserved Forests. These rules may include the requirement of permits for all fires (excluding controlled campfires) within Government Reserved Forests, as well as mandates for obtaining permits for setting fires near these forests to avert significant fire-related risks.

2) National Forest Policy of Bhutan (2011)

This policy advocates for the utilisation of prescribed fires as a management tool to prevent and manage forest fires in fire-sensitive ecosystems so as to enhance ecosystem health.

3) Forest Fire Management Strategy for Bhutan (2013)

This strategy promotes the judicious use of fire as a tool to manage land activities under the supervision of forest officials and with the requisite permits.

4) Forest and Nature Conservation Rules and Regulations of Bhutan (FNCRR, 2017/2023), Chapter XI

This chapter specifies that the DoFPS shall develop guidelines for forest fire management activities as and when necessary. Additionally, prescribed burning in State Reserved Forest Land for purposes such as research, forest fire management, and fire hazard reduction is permitted based on approved technical prescriptions from the department.

5) Forest and Nature Conservation Act of Bhutan (FNCA, 2023)

This Act outlines a holistic approach to conservation efforts and allows prescribed burning for habitat management and prevention of forest fires.

6) Forest and Nature Conservation Code of Best Management Practices of Bhutan (2020)

This plan highlights the significance of forest management for the well-being of biodiversity and the environment.

7) Guidelines for Wildlife Habitat Management (2021)

This document includes a dedicated chapter on the use of prescribed fires in wildlife habitat management and provides specific guidance for implementation.

8) National Environment Protection Act (2007)

This Act promotes environment-friendly technologies and provides financial incentives for environment protection and compliance with environmental regulations.

9) Biodiversity Act of Bhutan (2003)

This Act supports practices promoting biodiversity conservation and utilisation.

10) The Land Act of Bhutan (2007)

This Act supports management activities for improving the productivity of tsamdros.

Chapter 3: Authorities, implementation, and approval of prescribed burning

3.1 Management authorities

Section 78 of FNCA 2023 permits controlled or prescribed burning for habitat management and forest fire prevention. The DoFPS is the sole authority to grant official approval to carry out prescribed burning in Bhutan.

3.2 Implementation agencies

3.2.1 Habitat management

The agencies authorised to conduct prescribed burns for habitat management are the DoFPS, educational institutions, and other relevant bodies.

3.2.2 Pasture improvement

The personnel authorised to conduct prescribed burns for pasture improvement are livestock herders (who are heads of household with registered "thram"/User Right Certificate – URC) under the supervision of trained officials from the DoFPS, the DoL, and the dzongkhag administration.

3.2.3 Research purposes

The agencies wishing to conduct prescribed burns for research purposes should acquire formal approval from the Ugyen Wangchuck Institute for Forestry Research and Training (UWIFoRT), which is under the DoFPS.

3.3 Approval procedure

3.3.1 For pasture management

Annual area limit:

- An applicant may propose a maximum of five hectares for burning annually, within the limits of their total allotted tsamdro (as per the URC).

Application and approval procedure:

- Applicants must visit the nearest forest office and submit the following documents:
  - Copy of Citizen Identity Card (CID)
  - URC
  - Application specifying the location of the pastureland and the tentative area that is to be burned

- The Range Officer shall conduct a joint inspection along with livestock and gewog officials.
- There will be an evaluation as to whether the proposed site requires burning and a check will be conducted for encroachment by unpalatable woody shrubs, weeds, or invasive species.
- The area to be burned will be finalised based on the field verification.

Approval based on area:

- Area: 1–2 hectares: To be approved by the Range Officer.
- Area: 3–5 hectares: To be approved by the Chief Forestry Officer (CFO).

Arrangements:

- The applicant must have all the necessary equipment and manpower required for the burning operation.
- Technical support will be provided by officials from the forest and livestock offices.

3.3.2 For habitat management

Approval process:

- The Range Officer/Implementing Officer shall forward the application and the burn plan to the CFO of the divisional forest offices/protected areas (PAs).
- The CFO will review the application and then either approve or reject it.

Approval based on area:

- State Reserved Forest Land (SRFL) of < 5 hectares: To be approved by the Range Officer
- SRFL of 5 to 10 hectares: To be approved by the CFO concerned
- SRFL of > 10 hectares: To be approved by the Director of the DoFPS

3.4 Who should prepare the prescribed burn plan?

Habitat management: A forest official shall prepare the prescribed burn plan in consultation with the gewog administration.

Pasture improvement: Herders, assisted by livestock and forest officials, shall prepare the prescribed burn plan in consultation with the gewog administration.

3.5 Restricted areas for prescribed burning

- Sacred and cultural sites or within their vicinity (within 500 m)
- Core zones of PAs; but prescribed burning can take place in such areas if the head of the DoFPS grants special approval
- Settlements or within their vicinity (within 500 m)
- Areas having the presence of Schedule I wildlife species and endemic plant species

3.6 Liabilities and penalties

Forest fire outbreaks from a prescribed burning area with or without approval from the DoFPS shall be dealt with as per Section 339 of the FNCRR, 2023.

Chapter 4: Six steps for planning and implementing prescribed burns

The following six steps describe how a prescribed burn has to be planned and implemented:

Step 1: Reviewing related policies and regulations, and obtaining formal approval

Before initiating prescribed burning, a thorough review of relevant policies and regulations and acquisition of formal approval by the related department are paramount to ensure legal adherence, safety, environmental preservation, community involvement, and operational efficacy. It is crucial to assess the applicability and specifications of state, district, and local rules and regulations governing prescribed burning in your area. The approval process must be followed as per section 3.3.

Step 2: Evaluating the target area for the prescribed burn

After the regulation review, the second step is to evaluate the site planned for the prescribed burn. The purpose of the evaluation is to determine:

1) What is the intended objective of the burn (e.g. reducing shrub coverage or enhancing grass growth by a certain percentage)?
2) What type of fire "prescription" (e.g. fire behaviours[1]) is needed?
3) What conditions (e.g. weather, fuel moisture, firebreaks, etc.) are needed to meet the objective of the burn?
4) What is the time frame within which the burn should be conducted?
5) What type of firing method or methods should be used?

Besides establishing the burn objective, pre-burn site assessment should gather information on the following aspects which are critical for developing a comprehensive burn plan:

- **Amount and type of fuels to be burned**: This includes dead vegetation, leaf litter, and other organic materials. Understanding fuel loads helps in predicting fire behaviour and intensity.
- **The topography of the site, including slope, aspect, and elevation**: Steep slopes may influence fire behaviours, and understanding the terrain features helps in planning firebreaks and controlling the direction of the fire.
- **The type and structure of vegetation in the target area**: Different ecosystems may have varying responses to fire, therefore, understanding the composition of plant species is crucial for planning a successful burn.
- **The soil characteristics, including texture, moisture content, and organic matter**: Soil conditions influence fire spread and intensity. Moist soils may reduce the likelihood of fire spreading underground.
- **The presence of wildlife habitats in the area**: In terms of ecological conservation, timing the prescribed burn is crucial to minimise impacts on nesting birds, hibernating animals, or other sensitive species.
- **The cultural and historical significance of the site**: Some areas may have archaeological or cultural importance, and these considerations should be integrated into the planning process.
- **Adjacent land utilisation to prevent unintentional spread of fire to unintended areas:** This is essential to protect neighbouring properties, infrastructure, and other sensitive areas.

[1] Fire behaviour refers to how a fire behaves, such as its intensity, rate of spread, flame height, and smoke diffusion. Different fire behaviours result in different burning effects. Unpredictable or uncontrollable fire behaviours can lead to catastrophic consequences. Fire behaviour is determined by weather, air humidity, fuel properties, soil moisture, and topography. Besides, ignition techniques can have significant influence on fire behaviour. "Prescribed burn" tries to "manage" fire behaviour to achieve management purposes by "choosing" the right range of factors (e.g. fuel moisture, wind speed, direction of burning) influencing fire behaviours. The process of "choosing the right range of factors influencing fire behaviours" is akin to a medical doctor "prescribing" treatment for a patient.

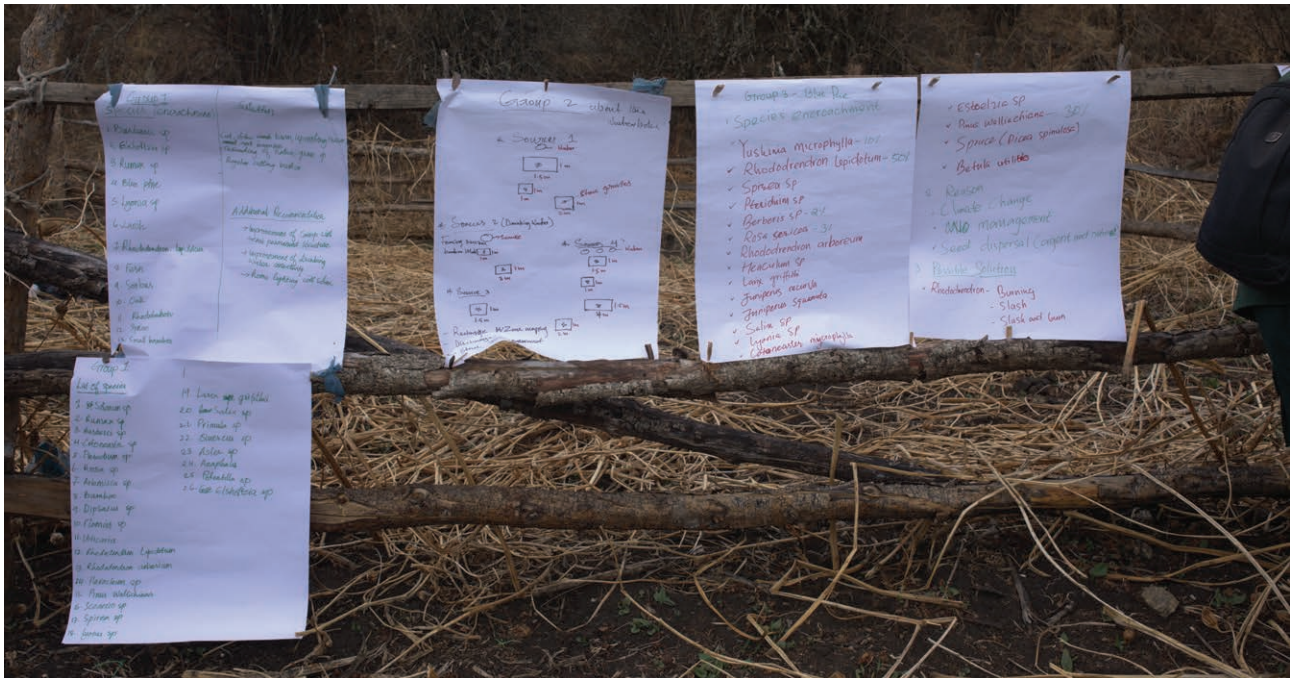
- **Access to firefighting personnel and equipment**: Safety considerations, including escape routes and emergency response plans, should be well defined. Take with you an aerial photo or map and walk through the entire site. Mark the location of roads, trails, water bodies, natural firebreaks, smoke-sensitive areas, utility lines, utility poles, fences, buildings, homes, fuel tanks, trash piles, poison ivy patches, and other important features. Preferably, this should be done 6–12 days before the intended burning period. This will provide ample time to address any problem areas; it will also help in installing the needed firebreaks, making contact with neighbours, and planning for equipment needs.

Step 3: Preparing a burn plan

The third step is to prepare a burn plan. A burn plan must be developed for every proposed prescribed burn. The plan concerns the operational strategy and outlines the activities to be carried out on a specified burning day.

A burn plan should include the following information:

- **Map**: Detailed maps delineating the burn boundaries, neighbouring landowners, topographical features, and existing and planned control lines.
- **Burn objective**: Clearly define the specific goals of the burn, such as reducing shrub coverage or enhancing grass growth by a certain percentage. These objectives serve as the foundation for establishing the parameters (fire prescription) governing the burn operation.
- **Burn unit description**: Provide an overview of the fuel types present in the burn area and the terrain characteristics. Highlight any variations in vegetation density or moisture levels within the area, as these factors significantly influence fire behaviour and planning.
- **Adjacent land description**: Assess the fuel types and terrain features adjoining the burn unit, particularly areas susceptible to fire from wind-blown sparks arising from the burn.
- **Areas of concern**: Identify and elaborate on potential safety, health, or smoke-related hazards both within and outside the burn area. Outline mitigation measures to address these concerns, thereby facilitating awareness among the stakeholders.
- **Pre-burn site preparation**: Provide details about the necessary site preparations preceding the burn, including the construction of control lines or firebreaks if required. Specify the methodology for constructing these lines.
- **Equipment requirements**: Enumerate all the equipment essential for the burn operation, encompassing communication devices, water storage and spraying apparatus, vehicles, as well as tools such as leaf rakes, flappers, and ignition equipment.



- **Personnel requirements**: Outline the personnel necessary to execute the burn safely and efficiently. Typically, three to four personnel per control line is advisable, with designated roles in fire laying, line control, and general assistance.
- **Persons to be contacted**: List the names and telephone numbers of neighbours and local authorities. Each of these entities should be contacted as part of the burn plan preparation phase. It is important to contact the local authorities and fire personnel during the planning stage in order to ensure that the burn complies with local laws.
- **Acceptable burning parameters**: This part is the key for "fire prescription". You should list the range of conditions that must be met at the time the prescribed burn is to take place. The following parameters should be included:
  - *Time of the year*: Time of the year when weather conditions and moisture content of the fuel are most conducive for conducting prescribed burns. This always depends on the burn objective.
  - *Time of the day*: The best time of the day to conduct the burning operation. Remember that in Bhutan, most of the sites are mountainous and microclimate varies from place to place. Usually, gust winds start around 10:00 am and burning becomes risky thereafter.
  - *Relative humidity range*: As much as possible, implement prescribed burning when the relative humidity is between 40 and 55 per cent when the fire behaves relatively mildly. When the relative humidity drops below 30 per cent, burning can become dangerous.
  - *Wind speed range*: Greater wind speed helps the smoke to disperse. However, in a mountain context, it also increases the risks of fire escaping as it has a great impact on the flame height and the rate of fire spread. Generally, wind speed between 1 and 3 mph is preferable.
  - *Temperature range*: Under most prescribed burning objectives, the air temperature for late winter to early spring burn should range from 20 to 60 Fahrenheit.
  - *Soil moisture*: Soil temperature has a great influence on fire behaviours and the impact of burning on plants and soil organisms. Damp soil protects the root zone of grasses, forbs, and trees from being killed during a fire. It also protects soil microorganisms. Under most prescribed burning objectives, the soil should be damp to moderately wet.
  - *Allowable wind directions*: Wind directions usually depend on the location of smoke-sensitive areas, control lines, and structures, as well as the type of fuels inside and outside the burn area, and topography.
- **Firing methods/firing/ignition techniques**: List the firing methods that can safely achieve the burn objective. Please see Annexe 1 for Firing Techniques.
- **Fire escape contingency plan:** Prepare a step-by-step contingency plan in case the fire were to escape from the burn site. All crew members should review this section of the plan before the prescribed burn is initiated.

A burn plan not only helps us prepare for a prescribed burn carefully and thoughtfully, but also provides detailed information to others who might be involved in implementing the burn or affected by the implementation of the burn, such as members of your fire crew, the local authorities, and neighbours. In addition, there are usually only a few days during most burning seasons when weather conditions meet burn prescription parameters. By developing a burn plan and addressing site and equipment needs before the burning season, we can quickly take advantage of burning opportunities when they arise.

Rule of thumb in Bhutan's context: The optimal time of the year to conduct prescribed burning is from the second week of March until the first week of May. The optimal time of day is from 6:00 am to 9:00 am and 5:30 pm to 7:00 pm. However, before initiating an evening burning operation, it is imperative to evaluate all relevant environmental parameters and weather conditions. The operation should only commence if these factors are deemed appropriate.

Please see Annexe 2 for the template of the burn plan.

Step 4: Pre-burn preparation

Once the burn plan has been developed, the subsequent steps will be to finalise all the necessary preparations to ensure that the burn is conducted legally, safely, and efficiently. This entails:

1) Reviewing and approving the burn plan, and fulfilling any additional obligations mandated by laws or regulations

2) Compiling a comprehensive checklist of the equipment and resources required for the burning operation. Prescribed burns demand a diverse array of equipment and resources to ensure safety, efficiency, effective communication, and successful execution. Annexe 2 outlines the common and vital items needed for prescribed burning operations. Ensure that all the listed equipment is properly prepared and operational. Please refer to Annexe 3 for the template for equipment and resources preparation checklist.

3) Notifying the public about the impending burn. This notification should be issued ahead of the prescribed burn and should contain details such as the specific burning time, location, scope, precautions, etc.

4) Establishing control lines[2] by physically clearing vegetation using hand tools, chainsaws, or other handheld equipment. The width of the firebreak is determined by factors such as vegetation type, fire behaviour, and the desired control level. In dense vegetation, wider firebreaks are typically necessary to ensure effective containment. A broader firebreak creates a larger buffer zone, thereby reducing the risk of embers crossing and igniting vegetation on the other side. While widths may vary, they commonly range from a few metres to tens of metres.

5) Deploying trained staff. In prescribed burning operations, supervision by trained staff is crucial for ensuring the safe and effective execution of the burn. Trained personnel play a vital role in implementing the burn plan, managing fire behaviour, and in mitigating potential risks. Backed by such expertise, prescribed burning operations can be conducted with professionalism, precision, and safety.

6) Assessing water availability near the burn sites. This is a critical aspect of pre-burn preparation for prescribed burning operations. This assessment involves evaluating the proximity and accessibility of water sources that can be utilised for firefighting and burn management purposes.

Step 5: Conducting the burning operation

1) Determine the burning date by assessing weather conditions and availability of human resources and fuel availability.

   **It is very important that the "burning date" be decided by the prescribed conditions (e.g. weather), and not by the availability of staff, as weather conditions, such as air temperature, humidity, and wind, are the major parameters of fire prescriptions.*

2) Verify that all the requirements for the burning operations are fulfilled by referring to Annexe 1 for acceptable parameters and Annexe 4 for a pre-burn checklist.

3) Provide comprehensive briefings to all the field crew regarding their responsibilities during the burning operations.

4) Conduct a trial burn in a small area. Performing a trial burn is crucial for evaluating fire behaviour under specific conditions on the

[2] Control lines, frequently called fire lines or firebreaks, are features of the landscape used to stop, slow, or control the spread of a prescribed fire. To be effective, firebreaks should be at least 15 to 20 feet wide and border the entire burn area. Mostly, four types of firebreaks are used. Natural firebreaks are existing physical features that inherently do not contain combustible fuels, such as rivers, streams, lakes, ponds, and roads. However, caution should be exercised when using certain wetlands as control lines. Constructed firebreaks are areas where the vegetation has either been completely removed by tillage practices, sprayed with water or a fire retardant, or frequently mown to remove any build-up of fine dead fuels within the control line from previous growing seasons and, thereby, consisting only of standing "green" vegetation. Green-crop firebreaks are control lines that utilise a fire-resistant crop, such as winter wheat, barley, annual ryegrass, or clovers that are typically "green" during the burning period. As the term implies, green-crop firebreaks consist of actively growing "green" crops. Firebreaks may also be created by establishing black lines. Black lines are typically created by setting fire to the leeward portion of a fuel bed, and then allowing the fire to slowly advance in a controlled fashion against the wind. Once the fuel has been burned off to a specified width, the fire is extinguished.

scheduled burning day. Through careful execution of a trial burn, the field crew can acquire valuable insights and confidence to ensure the safe execution of the main prescribed burn.

5) Initiate the burning operation from designated points on the site and proceed accordingly. Given the rugged terrain typical of Bhutan, a backing fire technique is always preferable for burning vegetation on the slopes[3].

6) Implement mop-up operations (extinguishing burned areas). Mop-up operations are indispensable for safely concluding the prescribed burning activities, mitigating environmental impacts, reducing the threat of wildfires, and ensuring public safety. Although it may take several hours to extinguish fire embers, the mop-up operations are effective.

In case of an emergency or if the fire spreads beyond the planned area:

- Report to the related authorities.
- Move all persons to safety zones[4], such as man-made firebreaks, paved, gravel, or dirt roads, permanent bodies of water, or to areas already blackened by the fire.
- Contact all neighbours who may be potentially affected.

Rule of thumb for pilot burnings:

The most effective firing technique observed in areas with a slope gradient of over 35 per cent is the implementation of an improvised method that consists of strip-heading fire and backing fire (downslope ignition). In this combined method, the Ignition Officer will ensure that all the fuel present in the first 7–10 metres of width is burned by executing the backing fire from upslope, resulting in a line of blackened strip. This ensures and reduces the risk of fire escaping in the event of an abrupt change in wind direction, as well as provides an additional line of defence in the event of an uncontrolled fire.

The Ignition Officer can subsequently progressively descend the slope, burning the remaining fuels in a strip fashion within a width of 4–5 metres until one-third of the total area has been burned. The officer can then burn the remaining area from the base of the slope and conclude the burning operation after all of these steps have been completed.

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[3] If the trial burn has been executed satisfactorily, begin the prescribed burn by starting a **backing fire along the most downwind (leeward) portion of the field, according to the burn plan**. Allow the backing fire to burn inward from the control line to a distance of at least 20 feet, making sure the downwind edge of the control line has been secured, and the fire has not crept across the firebreak. As the backing fire continues to burn against the wind, lengthen the peripheral edges of the backing fire by igniting short segments of the flanking control lines. Allow the flanking fires to burn inward and away from the flanking control lines. Never set fire to more areas along the flanking control lines than what the fire crew can control. At least one crew member should routinely check back along the burned control lines to make sure that the fire has not escaped across the lines. At this point, the ignition of additional lines of fire varies according to what type of firing technique is specified in the burn plan. If the backing fire is being used only to burn the entire unit, continue setting fire at short distances along the flanking control lines to keep ahead of the advancing backing fire. When flanking fires have been set to the most windward (upwind) section of the field and the flanking control lines are secure, lay fire along the windward control line to complete the prescribed burn. If the strip-heading technique is going to be employed, stop and reassess current conditions. If it is still appropriate and safe to perform a strip-heading fire, move upwind approximately 20 feet from the advancing backing fire and begin laying a strip of fire in a line parallel to the backing fire and perpendicular to the wind direction. Before laying each successive strip of fire across the field, check to see if wind speed, wind direction, and the rate of spread at which the backing fire is advancing are such that the strip-heading technique is still appropriate and safe to employ. If the ring fire technique is prescribed, stop and reassess the current conditions. If it is still appropriate and safe to perform a ring fire, continue laying fire along the flanking control lines and allow the fire to burn inward and away from the flanking control lines to a width equal to at least twice the height of the flames or 20 feet, whichever is greater. Once these conditions have been attained, lay fire to the most windward control line to complete the prescribed burn. Ring fires can be very hot and can create strong convection columns and wind speeds, which can carry hot sparks across control lines and into neighbouring fields.

Crew members should be constantly on the lookout for spot fires that might erupt in nearby fields or breach control lines. Once the prescribed burn has been completed, the crew members need to ensure that the fire is completely out. Smouldering embers can quickly reignite or be blown into neighbouring areas and start wildfires. Check all the fields adjacent to the burn area at least twice to ensure that the fire has not escaped. Drench all smouldering debris and hot embers with water. Check the area again that night and the next day, especially if conditions have turned windy and dry.

[4] Safety zones are vital areas within or near a prescribed burn site, offering refuge in case of unexpected fire behaviour or emergencies. Crucial for overall safety, they are strategically designated and communicated in the burn plan, considering factors like terrain and wind. These zones must be spacious, with minimal flammable vegetation, and marked clearly before the burn starts. Communication protocols ensure that all team members are informed of safety zone locations via radio or cell phone. Accessible routes lead to safety zones, with primary and secondary retreat paths pre-established and adaptable based on real-time conditions. Regular training and drills prepare personnel for emergencies, with a clear system for emergency communication in place.

Step 6: Post-burn evaluation, monitoring, and reporting

Post-burn activities, including evaluation, reporting, and monitoring, are crucial components of prescribed burning and are designed to evaluate the effectiveness of the burn, monitor ecological responses, and ensure that the desired objectives have been met. Post-burn activities are essential for learning from each prescribed burn, refining management strategies, and ensuring that the ecological benefits are maximised while minimising potential risks. Regular monitoring and evaluation contribute to the overall success and sustainability of prescribed burning programmes.

The post-burn activities should include all or some of the following, depending on the specific situation:

1) Evaluate if the fire was contained within the designated zones.
2) Check the effectiveness of firebreaks in preventing fire spread beyond the designated area.
3) Assess the extent to which the targeted vegetation and fuels have been consumed, considering the overall fuel reduction objectives.
4) Monitor the recovery and regrowth of vegetation in the burned area.
5) Observe and document changes in wildlife habitat and behaviour following the prescribed burn.
6) Compare the results of the prescribed burn with the initial objectives outlined in the burn plan. Assess whether the burn achieved its intended goals for fuel reduction, habitat improvement, or ecosystem restoration.
7) Evaluate changes in soil composition, nutrient levels, and organic matter content.
8) Examine water run-off from the burned area to assess potential impacts on water quality.
9) Document all post-burn observations, including ecological changes, wildlife sightings, and any unexpected outcomes.
10) Compile a comprehensive report summarising the burn process, outcomes, and any lessons learnt. Such a report will be valuable for future planning and regulatory compliance.
11) Based on the post-burn assessment, adjust future prescribed burn plans as required. Adaptive management allows for continuous improvement in achieving management objectives.
12) Share information about the prescribed burn, its outcomes, and the ecological benefits with the public and other stakeholders. This helps build understanding and support for the prescribed burning programmes.
13) Continue monitoring the burned area over an extended period to track long-term ecological changes and to ensure the ecosystem's resilience.

Chapter 5: Special considerations

5.1 Smoke management

Smoke management should be considered at all the steps of planning and implementing the prescribed burning process in order to minimise the impact on air quality and public health. This is achieved through careful consideration of weather conditions, including wind patterns. The following aspects should be considered to reduce the detrimental effects of smoke:

1) When preparing for a prescribed burn, assess the potential impacts both on-site and off-site that could be influenced by smoke.
2) Schedule the prescribed burns for days when atmospheric conditions are favourable, especially in the early morning hours when smoke can rise and dissipate quickly.
3) Refrain from burning when wind patterns might carry smoke over roadways, airports, residential areas, or public spaces.
4) Before the burn, conduct a small-scale test fire with the intended fuels to evaluate smoke behaviour.
5) Whenever feasible, utilise backing fires as they consume dead fuels more effectively and generate less smoke.
6) Notify nearby stakeholders well in advance of the burn and provide additional reminders on the day of the operation.

5.2 Waste management

Waste management in prescribed burning involves handling and disposing of the waste generated during the burning process in an environmentally responsible manner. The following aspects should be considered in managing waste in prescribed burning:

1) Before conducting a prescribed burn, assess the area to be burned and identify potential waste materials that need to be managed. This may include fallen branches, dead vegetation, and other debris.
2) Burn materials efficiently to ensure complete combustion, and reduce the amount of unburned residue.
3) After the burn, monitor to assess the site for any remaining unburned materials. Any remaining waste has to be collected and disposed of appropriately.
4) It is essential to properly document waste management activities, including the disposal of residues, for regulatory compliance and accountability. This includes keeping records of the amount and type of waste generated and how it was managed.

5.3 Being culturally sensitive

Prescribed burns should be sensitive towards areas of cultural importance, and local communities should be consulted to honour their beliefs, traditions, and environmental concerns. Key considerations include:

1) Consult local communities and Indigenous groups at the outset of planning. Seek their insights, wisdom, and approval, while acknowledging their spiritual and cultural ties to the site.
2) Integrate traditional ecological knowledge into prescribed burn planning and execution.
3) Acknowledge and honour the spiritual and cultural significance of sacred groves. Familiarise yourself with the rituals, taboos, and customs associated with these sites.
4) Tailor the approach to each sacred grove by considering its unique cultural context. This might entail adjusting burn plans, timing, or methods to accommodate cultural rituals or beliefs.
5) Conduct education and awareness programmes about the ecological benefits of prescribed burning and how it can align with cultural values. This can help build trust and understanding among community members.

5.4 Documentation and archiving

Proper documentation provides valuable information for future planning, research, and evaluation. Documentation and reporting play a crucial role in ensuring accountability, knowledge

transfer, and continuous improvement within prescribed burning programmes. They also serve as a foundation for learning from past experiences and ensuring the ongoing effectiveness and safety of prescribed fire. The documentation and reporting process must include the following:

1) Detailed records of ignition procedures, including the type of ignition used, ignition patterns, and any deviations from the original plan
2) Records of weather conditions during the burn, including wind speed, direction, humidity, and temperature
3) Records of observations of fuel types, fuel moisture levels, and actual fire behaviour throughout the burn
4) Documentation of radio or communication exchanges between team members, including any decisions or changes made during the burn
5) If applicable, updates to maps indicating the progression of the burn and any unexpected developments
6) Assessment of the burn's success in meeting its objectives and contributing to ecosystem management goals
7) Monitoring and documenting the ecological response to the burn, including changes in vegetation and wildlife habitat
8) Documentation of any issues or needed maintenance identified during or after the burn
9) A comprehensive analysis of the burn, including lessons learnt, areas for improvement, and recommendations for future burns
10) Submission of the required reports to regulatory agencies, detailing adherence to permits and environmental regulations
11) If necessary, provide information to the public about the prescribed burn, its objectives, and safety measures
12) If the prescribed burn contributes to scientific research, share relevant data and findings with researchers and land management agencies
13) Maintaining a centralised repository for all documentation and records related to prescribed burns, thereby ensuring accessibility for future reference
14) Creating a historical record, including photos of prescribed burns conducted in the area, thereby aiding in long-term land management planning
15) Using the documentation and reporting process to inform future burn plans and amending strategies based on the outcomes and experiences of previous burns
16) Identifying areas for improvement in procedures, training, and equipment based on the documented experiences

Please see Annexe 5 for a template for field records of burning operations.

Annexes

Annexe 1: Common firing techniques used in prescribed burning

Many firing or igniting techniques can be used to influence fire behaviour and achieve objectives of safety and efficiency. Once the area to be burned is decided, at what time of the day or year the fire is set off and from which location the fire is ignited as well as how the wind blows at the time of burning will have a big impact on the behaviour of the fire – how intensely it will burn and how fast it will spread. Firing techniques allow the person conducting the fire to control the fire to some extent. The four firing techniques used most are: backing fire; strip-heading fire; flanking fire; and ring fire.

Backing fire: This firing technique is the easiest and safest method for completing a prescribed burn, provided wind speed and wind direction remain steady. The rate of spread is relatively slow compared to other firing techniques and can be more easily controlled. Backing fire should always be the first line of fire set in any prescribed burning sequence. A backing fire is always started along a firebreak or other barrier at the most leeward (downwind) edge of the burn area and is allowed to go against the wind. This method can be used successfully provided that the wind is consistently blowing in one direction, the relative humidity is low, and there is a continuous source of fine dead fuels throughout the area to carry the burn. Since a backing fire burns slowly against the wind, completing the prescribed burn using only a backing fire may take several hours. When used with other firing techniques, backing fire is set first and allowed to burn an area at least equal in width to the expected average flame length, before setting any other fires. This helps ensure that any fire moving in a windward direction because of additional fires ignited upwind will be contained within the blackened area created behind the backing fire.

Strip-heading fire: This technique employs the use of a backing fire, followed by a series of strip fires set in sequential order along lines upwind from the control line and perpendicular to the wind. The ignition timing and the distance between the firing lines are adjusted so that no strip of fire becomes too robust before it meets a downwind firebreak or another line of fire and dissipates. The distance between strip fires is used to control the average flame length, which is dependent on topography, wind speed, fuel height, and fuel load. When using this method, the first step is to set a backing fire along the downwind control line and allow it to burn a strip wide enough to control and contain any upwind strip fires. Strip-heading fires can be used to reduce the amount of time needed to perform a complete burn or to help carry fire through areas having low fuel loads or high relative humidity and high fuel moisture.

Flanking fire: The flanking fire technique employs the use of fire set in lines parallel (flanking) to the wind. Flanking fires are typically used along the flanking control lines (firebreaks) to burn vegetation within the burn area away from the control lines, like the results obtained by a backing fire. Flanking fires should not be ignited until a backing fire has burned and blackened a strip wide enough along the baseline to control and contain any upwind fire resulting from the ignition of flanking fires. Flanking fires are frequently used in between the ignition of strip-heading fires to reduce flame height along the flanking firebreaks. The use of flanking fires also reduces the amount of time necessary to complete a prescribed burn.

Ring fire: This firing technique creates the hottest fire and is best used when the burn objective is to control the invasion of woody stems. The ring fire technique is first initiated by using a backing fire to establish a wide, blackened control line at the downwind edge of the burn area. Once the baseline is secured with a wide, blackened area, the remainder of the perimeter is ignited, starting at each end of the backing fire and moving in the windward direction. As the perimeter fires merge, flame height and temperature become quite intense and can create a very strong convection column, capable of carrying the fire a considerable distance downwind. As a result, ring fires are more apt to start wildfires in neighbouring fields. The ring fire technique should only be used by experienced personnel or where the downwind landscape is composed primarily of bare mineral soils, such as ploughed crop fields. To properly employ the ring fire technique, at least two persons carrying their ignition source are needed to simultaneously set the fires around the perimeter.

Annexe 2: Template for a burn plan

1. Location

1.1 Name of the area:

1.2 Gewog:

1.3 Dzongkhag:

1.4 Area size (hectares/acres):

1.5 Location with geo-coordinates:

1.6 Land tenure:

2. Burn objective (tick the appropriate one)

2.1 Improvement of pasture for domestic animals

2.2 Wildlife habitat management

2.3 Insect and disease control

2.4 Species manipulation

2.5 Hazard reduction

2.6 Research purpose

2.7 Other

3. Burn unit description

3.1 Topography and terrain – slope, aspect, elevation:

3.2 Vegetation type and structure:

3.3 Major fuel types:

3.4 Soil conditions:

3.5 Current weather conditions – wind direction, wind speed, humidity, soil moisture, air temperature:

3.6 Wildlife habitat considerations:

3.7 Cultural and historical significance:

3.8 Regulatory compliance:

3.9 Community engagement:

3.10 Accessibility and safety:

3.11 Adjacent land description:

3.12 Time (years) since the last fire or prescribed burning:

4. Fuel load analysis

Fuel type Low (1%–30%)		**Fuel load (mt/ha)**			**Continuity**	
		Moderate (31%–60%)	**Heavy (61%–100%)**	**Depth (cm)**	**Vertical**	**Horizontal**
Fine fuel	Grasses (dead and live)					
	Leaf litter, needles					
	Small twigs					
Large fuel	Dead branches					
	Shrubs					
	Snags, logs, and trees					

5. Area of special concern

Briefly describe the important assets (heritage, private, or public properties) that are to be protected while conducting the burn.

6. Targets of the burn operation

List a few quantitative or qualitative indicators as targets to judge if the burning has achieved its objectives; for example, removing 50–60 per cent of the shrub cover or above-ground shrub biomass. These indicators must be related to the "burn objectives" of the plan.

7. Burn prescriptions or acceptable burn parameters

List what kind of fire behaviours you want and under what conditions you are going to implement prescribed burning so that you can have the desired fire behaviour to achieve the objectives and targets of the burn.

SN	Parameters	Prescriptions
1	Time of the year	
2	Time of the day	
3	Relative humidity range	
4	Wind speed range	
5	Temperature range	
6	Soil moisture	
7	Allowable wind direction	
8	Firing methods	

8. Preparation needed at the pre-burn site

Such as fire line construction, snags to be felled or protected, special features to be protected, and warning signs to be placed.

9. Required resources

Manpower (the number depending upon the size of the burn)

Tools/equipment (their number should be proposed depending on the site condition). Such tools and equipment are: fire rake, flapper, spade, drip torch, leaf blower, power chainsaw, grasscutter, anemometer, compass, Kestrel meter (to measure humidity, wind speed, temperature, etc.), PPE (helmet, goggles, gloves, P2 mask), two-way radio, and water tanker.

10. Community notification

This notice should be prepared by the local staff before conducting a burn in order to avert hazards; the notice should be distributed to adjacent landowners, relevant agencies, the local government, and the general public.

11. Fire escape contingency plan

A step-by-step contingency plan should be prepared in case the fire were to escape the burn site.

12. Organising the burn

An organisational chart should be made, with individuals assigned specific responsibilities.

13. Maps and photos

13.1 Fire control lines – labelled

13.2 Escape routes and safety zones

13.3 Values, assets, and infrastructure

13.4 Ignition point

13.5 Topography and property boundaries should be marked.

13.6 Location of roads, trails, water bodies, natural firebreaks, smoke-sensitive areas, utility lines, utility poles, fences, buildings, homes, fuel tanks, trash piles, and other important features should be noted.

Annexe 3: Template for equipment and resources preparation checklist

*This checklist is indicative and should be used according to the specific context. However, it is very important that the field operators have the minimum set of equipment and resources to guarantee safe execution of each prescribed burn.

Activity	**Items**
Manpower	Sufficient firefighters
Fire ignition	Drip torches, lighter or matchbox, petrol, diesel (the mixture of fuel is 70% diesel and 30% petrol)
Firebreak construction and suppression equipment	- Spade - Fire rake - Shovel - Patang (local machete) - Sickle - Flapper - Water backpack - Power chainsaw - Blower - Water pump engine with hosepipe - Grasscutter - Fire engine with water tanker (optional)
Personal protective equipment	- Helmet - Leather gloves - Goggles - Respiratory mask - Water bottle - Safety boots - Cotton clothes - Torch - Safety kits
Communication	- Handsets - Mobile phone
Weather equipment	- Kestrel/pocket psychrometer (to measure air humidity) - Weather meter (temperature, wind speed, humidity) - Anemometer (to measure wind speed)

Annexe 4: Checklists for conducting the prescribed burn

A. Implementation – burn day

i. Checklist to make sure every requirement has been met

Activity	Yes (✓)	No (×)	Remarks
Firelines have been cleared.			
Adequate equipment is available and ready.			
Notification has been circulated.			
Adequate crew members are available as required and they are in proper attire.			
The crew has been briefed and responsibilities assigned as per the burn organisational chart.			
Weather conditions are favourable.			

ii. Pre-burn briefing (for field commanders)

a. Explain the purpose and objectives of the burn to all personnel.

b. Explain the chain of command.

c. Make sure all burn personnel understand their assignments.

d. Explain the prescription parameters and expected fire behaviour.

e. Explain the type of ignition pattern and sequence being used and why.

f. Discuss the positions of the igniters with each other.

g. Explain mop-up and patrol assignments.

B. Implementation – post – burn

i. Check and mop up all fires and ensure that no live embers are left behind.

ii. Ensure that all the crew members and the public involved have been counted and are safe.

iii. Prepare inventories of the tools/equipment used for the burn.

C. Monitoring

In order to ensure the success of the burn, long-term monitoring is strongly recommended.

Pictures taken from permanent photo points and transects of the plots revisited in the years following a burn will be provided. Longer-term monitoring may be necessary to determine if the objective has been met.

D. Contingency plan

If fire spreads beyond the prescribed area, declare it as a “forest fire” and inform the CFO, the local government, the dzongkhag, the fire services of the Royal Bhutan Police (RBP), and other relevant stakeholders for extra help and support to suppress the fire. Also, ask for extra resources like manpower and tools/equipment.

E. Post-burn activities

After the burn and mop up, conduct constant monitoring of the burned area. An evaluation exercise should also be undertaken to determine if the burn objectives have been met or not.

Annexe 5: Template for field record and post-burn appraisal

*The purpose of this record is to collect information that can be used to analyse burning results, improve burning prescriptions, and generate empirical knowledge. This form must be diligently filled by the professional staff after each burn.

Categories	Parameters	Units/Figure/Information
Basic site information	Name of the burned site (district/gewog/chiwog/name of yak cooperative/name of tsamdro/name of owner)	
	Coordinates	1) Latitude..... 2) Longitude.....
	Elevation (m) of site for burning	
	Slope (%)	
	Aspect (i.e. E, W, N, S)	
	Total area to be burned	
	Date of the burning operation	
	Contact address & phone number of the person in charge	
	Access to water source	
	Forest cover nearby – if relevant; this is to know about the risk of forest fire	
	Fire history – how many years since the last burn?	
Fuel information	Vegetation type	
	Major species	
	Phenology of the major species	
	Average height (cm)	
	Cover (%)	
	Above-ground biomass (kg/sq. m)	
	Fuel load (kg/sq. m)	
	Moisture content of dry leaves and twigs (at the time of burning) (%)	
	Moisture content of stems at the time of burning (%)	
	Continuity of fuels (horizontal)	
	Continuity of fuels (vertical)	
	Soil moisture content at 10-cm depth	
Prescriptions (proposed conditions for the burn or acceptable parameters)	Time of the year	
	Time of the day	
	Relative humidity range	
	Wind speed range	
	Temperature range	
	Soil moisture (e.g. damp to moderately wet)	
	Allowable wind directions	
Actual weather and climatic conditions at the time of the burn	Burn start time	
	Hours since last rain	
	Weather at the time of the burn	
	Air moisture/humidity (%)	
	Air temperature (Celsius)	
	Wind speed (m/sec)	
	Wind direction	
	Burn end time	

Pre-burn preparations conducted		
Ignition techniques used (if feasible, attach maps or hand-drawn sketches)		
Fire behaviour information	Rate of spread (m/sec)	
	Average height (m)	
	Maximum height (m)	
	Smoke and direction	
	Flammability	
	Intensity/duration	
After-burn information	Total area covered by the burning operation (ha)	
	Shrub cover removal (%)	
	Grass removal (%)	
	Soil exposure (%)	
	Time taken for the mop-up operation	
	Death of wildlife, etc.	
Cost analysis	Number of people engaged in the mop-up operation	
	Total working days involved	
	Total amount of water used for the mop-up operation	
	Non-human cost	
Special observations if any		
Personnel	Field Commander	
	Fire crew	
	Reporter	

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