GUIDELINES FOR

WILDLIFE HABITAT MANAGEMENT

Department of Forests and Park Services
Ministry of Agriculture and Forests
Royal Government of Bhutan

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SECRETARY

ROYAL GOVERNMENT OF BHUTAN
Ministry of Agriculture & Forests
Tashichhodzong, Thimphu : Bhutan

FOREWORD

Under the benevolent leadership of our visionary monarchs, Bhutan has emerged into the 21st century as the champion of environmental conservation. Bhutan has over 71 percent of its geographic area under forest cover and more than 51 percent of country is under protected area system. With a record of more than 11000 species of wild flora and fauna, the country is truly a biodiversity treasure trove. Today, Bhutan is best known as one of the few carbon negative countries in the world.

However, the country's rich natural heritage is facing many threats from the changing landuse practices fueled by booming economic development and climate change. This is leading to loss, fragmentation and degradation of wildlife habitat which then manifests into other problems such as human wildlife conflict, loss of biodiversity and wildlife diseases. Therefore, protection, conservation and improvement of wildlife habitat is of paramount importance to prevent and resolve most of the issues being faced in nature conservation.

The Royal Government of Bhutan over the years have prioritized interventions for wildlife habitat management and has invested a huge amount of resources for conservation of wildlife and the natural habitats. Wildlife habitat management is identified as one of the indicators for agency key result areas in the 12th Five Year Plan of the Ministry and annually a substantial amount of fund is allocated to the Department of Forests and Park Services for management of wildlife habitats. Wildlife habitat management is also a key project activity under the Bhutan for Life program and other major conservation projects, so a standard guideline for habitat management intervention was felt necessary. I am glad that the department has realized this need and developed this guideline at a right time. I am optimistic that this document will guide the field implementers across the country to bring positive impacts on ground through wildlife habitat management interventions.

I would like to, therefore, express my appreciation to the Department of Forests and Park Services and all other stakeholders who have worked hard in formulating this guiding document. I would like to thank the Bhutan for Life Program, Royal Society for Protection of Nature and the Royal Government of Bhutan for the generous support to this important task.

Tashi Delek and Best Wishes!

Thinley Namgyel

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ACKNOWLEDGEMENT

The Department of Forests and Park Services recently started the implementation of wildlife habitat management interventions across the protected areas and forest divisions to improve and restore the degraded habitats and prevent habitat degradation, fragmentation and loss. Therefore, in order to have a need-based implementation of activities which are in line with accepted norms and standards, an urgent need for a guideline for implementation of wildlife habitat management activities has been felt. This wildlife habitat management guideline was developed to provide clear guidance to the field implementers who are responsible for carrying out habitat management interventions. The document includes concepts, processes, and techniques for wildlife managers and biologists on how to effectively manage and improve wildlife habitats.

This document is an outcome of the concerted efforts from different institutions and individuals, without whose support we would not have been able to publish this document. Therefore, I would like to extend my sincere appreciation to the Nature Conservation Division for coordinating this initiative and other offices under the Department for their contribution and support rendered in completing this important task. I also would like to extend my appreciation to all the individuals and institutions from outside of the Department such as National Biodiversity Centre and Royal Society for the Protection of Nature for their valuable contribution towards developing this document.

The guideline was developed with generous funding support from the Bhutan for Life program, Royal Society for Protection of Nature and Royal Government of Bhutan, therefore, I, on behalf of the Department also would like to thank all the donors for their kind support.

Thank you and best wishes!

Lobzang Dorji

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LIST OF ACRONYMS AND ABBREVIATIONS

BNC	Black-necked Crane
BTC	Bhutan Tiger Center
DoFPS	Department of Forests and Park Services
DFO	Divisional Forest Office
E.g.	Example
FPED	Forest Protection and Enforcement Division
FRMD	Forests Resources Management Division
HoD	Head of the Department
km	Kilometers
JDNP	Jigme Dorji National Park
JKSNR	Jigme Khesar Strict Nature Reserve
JSWNP	Jigme Singye Wangchuk National Park
masl	meters above sea level
m	meters
NBC	National Biodiversity Center
NCD	Nature Conservation Division
PNP	Phrumsengla National Park
PWS	Phibsoo Wildlife Sanctuary
RMNP	Royal Manas National Park
RSPN	Royal Society for Protection of Nature
SFED	Social Forestry and Extension Division
SWS	Sakteng Wildlife Sanctuary
UWICER	Ugyen Wangchuck Institute for Conservation and Environmental Research
WBH	White-bellied Heron
WCNP	Wangchuck Centennial National Park
WMD	Watershed Management Division

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CHAPTER I: INTRODUCTION

1.1. Wildlife Habitat

Wildlife habitat is an area with a combination of resources and environmental conditions that promotes occupancy by individuals of a given species or population and allows those individuals to survive and reproduce. The resources within a wildlife habitat are food, water, cover and space while the environmental conditions include temperature, precipitation, presence or absence of predators and competitors, etc. The wildlife habitats can be either primary or secondary (Lopez *et al.,* 2017). Primary habitat contains all the combined habitat components and environmental factors necessary to support a viable population of the species while in secondary habitats, organism spends part of its time but all life requirement may not be present (Harris, 1984).

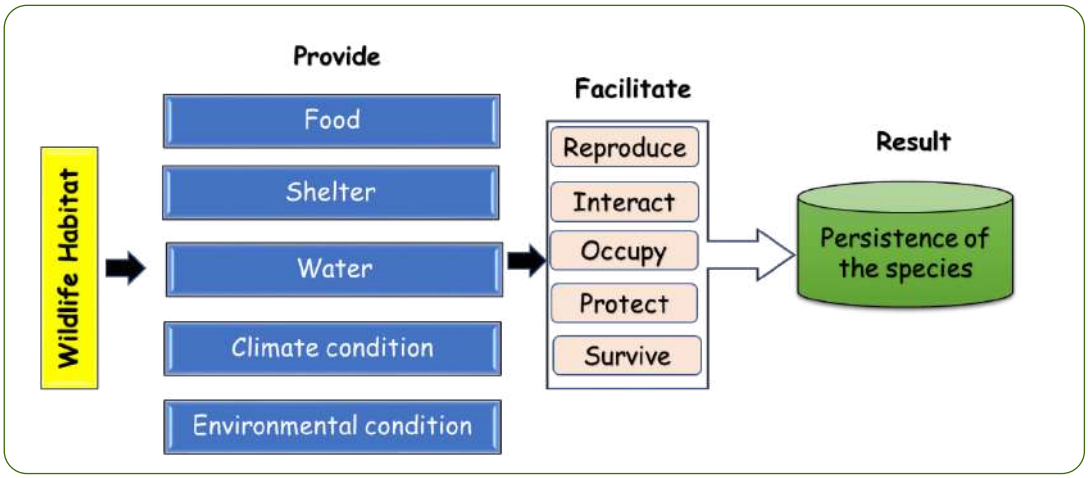


Figure 1.1. Schematic representation of wildlife habitat

Wildlife habitats can also be classified as macrohabitat and microhabitat based on the extent of an area. Macrohabitat refers to large spatial scale often at a landscape scale with large habitat features such as vegetation associations while microhabitat refers to smaller spatial scales, such as a specific valley, with finer-scaled habitat features, such as a tree within the valley.

Wildlife habitats can be categorized as critical habitats and unique habitats. Critical habitat is a specific area that contain the physical or biological features that are essential to the conservation of threatened species which may need special management or protection. The habitats of Pygmy hog *(Porcula salvania)* habitat in sub-tropical grasslands and habitats of *Paphiopedilum* species are examples of critical habitats. Unique habitat is an area which typically occur as patches of contrasting elements, each with its own sets of unique characteristics such as caves, snag trees and hot springs.

Figure 1.2. Wildlife habitat with a grassland transitioning into forest

1.2. Wildlife Habitat Management

Wildlife habitats undergo constant change across space and time due to the impacts from natural disturbances like fire, pest, disease, flood and extreme weather patterns resulting in ecological succession. Most of the species have evolved with natural disturbance regimes and are able to cope up with the changes over time. However, wildlife habitats are often impacted due to human induced disturbance regimes like land use changes, developmental activities, invasion by invasive and alien species and other anthropogenic influences which is exacerbated in the face of the changing climate. In this case, many of the wildlife species will not be able to respond and adapt to the impacts of the human induced disturbances.

Wildlife habitat management mainly involves influencing the successional stage and physical structure of vegetation to benefit particular species, or assemblages of species, considered to be of high conservation or other intrinsic value (Ausden, 2007). This is mainly to increase availability of food and cover for the wildlife. On the other hand, management interventions also manipulate the wildlife habitats for provisioning of water and minerals and removal of invasive species.

Some habitats require periodic natural disturbances to maintain their unique characteristics. Using the habitat management techniques, we can often mimic these natural disturbances in places where the disturbance has been eliminated or diminished. All species of wildlife require food, water, cover, and space for survival but the amount and type of each requirement differs amongst the species. Therefore, knowing the specific needs of each species, or group of species is very critical in wildlife habitat management to provide the correct habitat components through management interventions.

It is important to note that not all wildlife habitats require management interventions. Therefore, it is very essential to carefully assess and categorize portions and patches of habitat requiring management. The management techniques should be introduced only in those areas requiring management while other areas should be retained in its natural form. The management interventions may be targeted to provide or enhance one or more habitat components like food, water, cover and space. The purpose of habitat management is to improve the existing habitat to benefit wildlife and also maintain a productive and healthy ecosystem.

While habitat management is carried out to benefit one or more species, habitat management also needs to consider the wider environmental damage that management might cause, especially through increasing carbon emissions due to prescribed burning or vegetation removal.

Figure 1.3. Wildlife habitat with patches of fir and rhododendron forest in alpine meadows

1.3. Aims and objectives of the guideline

The main objective of this guideline is to provide concepts, processes, and techniques for wildlife managers and biologists on how to effectively manage and improve wildlife habitats in Bhutan.

At a broader scale, the document is developed with an intention to maintain and improve the wildlife habitats in Bhutan at an optimum level in the face of changing landuse practices and climate change for the persistence of wildlife in its natural habitat.

1.4. Scope and limitations

This guideline covers the processes for habitat management including habitat assessment and planning; and general techniques to be used for management of different wildlife habitats in Bhutan. In addition, techniques and processes for critical and unique habitats and few species specific requirements are also described. The extent of this document covers whole of Bhutan.

However, it does not address specific requirement of most of the species. The guideline further excludes the habitat management for exotic species and captive wildlife species. In addition, as the habitat management techniques are designed to be applicable for all the habitat types in Bhutan, it is desirable to accommodate site specific adaptations or adjustments.

1.5. Policy and regulatory guidance

The guidelines for wildlife habitat management draws the inspiration and guidance from the Constitution of Kingdom of Bhutan 2008, the National Forest Policy of Bhutan 2011 and the Forest and Nature Conservation Act 1995. The Forest and Nature Conservation Rules and Regulations 2017 mandates the requirement of technical guidelines for the implementation of wildlife habitat management activities.

In order to avoid contradictions and conflicts, the guideline should be interpreted and applied in conjunction with all other existing policies, legislations, regulations, codes, standards and other relevant guidelines such as but not limited to the following:

1. Biodiversity Act of Bhutan 2003
2. National Environment Protection Act 2007
3. Water Act of Bhutan 2011
4. Land Act of Bhutan 2007
5. Waste Prevention and Management Act of Bhutan 2009
6. Forest and Nature Conservation Code of Best Management Practices 2020
7. National Strategy for Plantation and Forest Nursery 2019
8. Norms and Standards for Nursery and Plantation 2020
9. Forestry Field Manual for Bhutan: Silviculture and Other Forestry Operations 2012

CHAPTER II: CLASSIFICATION OF WILDLIFE HABITAT IN BHUTAN

Located in the eastern Himalayas, Bhutan is at the junction of two major biogeographical realms; the Palearctic realms of the north and Indo-Malayan realms of the south. Terrestrial and aquatic are the two major biomes found in Bhutan. The wide range of habitats and the attitudinal variations creates a safe haven for rich biodiversity in the country. The diverse altitudinal and climatic condition ranges from sub-tropical (75 masl.) at the foothills of the southern belts to alpine (7500 masl.) in the north. Hence, the existence of three major ecological zones namely sub-tropical, temperate and alpine are indicative of diversity in climatic, biotic and edaphic factors. The plant community of a region is a function of time; however, altitude, latitude, slope, aspect, rainfall and humidity play vital role in the formation of plant communities and their composition (Kharkwal *et al.,* 2005).

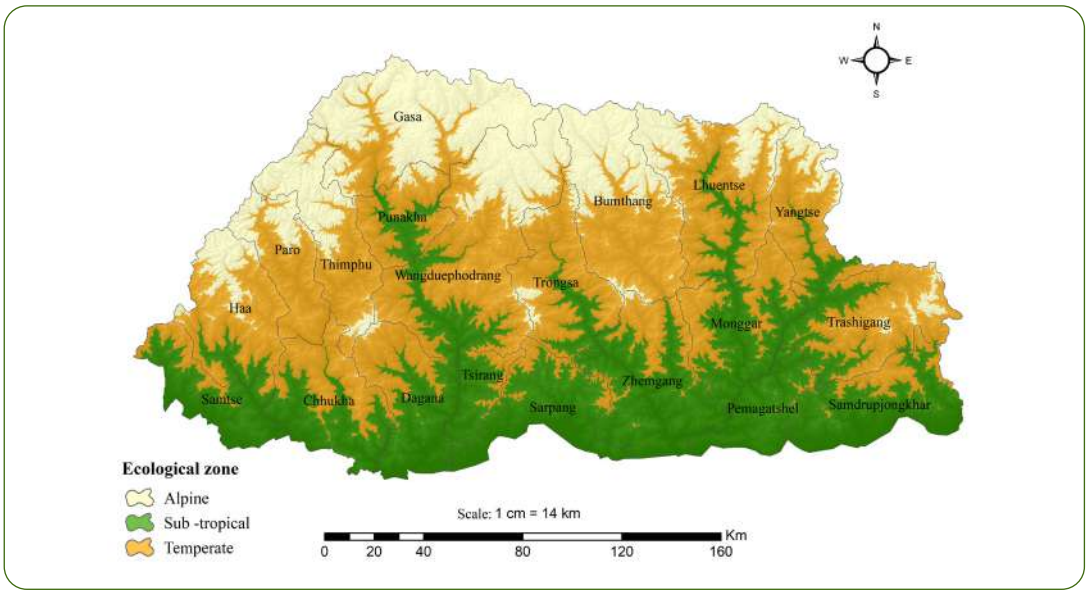


Figure 2.1. Map showing major ecological zones in Bhutan

For the purpose of managing wildlife habitats in Bhutan, there is no standard habitat class developed so far. Based on the existing literature reviews, many authors have classified according to their needs and objectives. Some of the examples are: 11 types of vegetation zones for Bhutan (Grierson & Long 1983), six vegetation zones (Ohsawa, 1987), seven habitat types (Rawat & Wangchuk, 2000), 14 ecosystem types (Sherub, 2004), 13 land use classes (FRMD, 2017), and three eco-floristic zones with different vegetation types (NBSAP, 2014).

In order to manage the wildlife habitats in Bhutan, three broad ecological zones and 15 habitat classes were classified based on elevation and land cover types using Digital Elevation Model (DEM) and Land Use and Land Cover map of Bhutan.

Table 1. Classification of wildlife habitats in Bhutan

Ecological zones	Main habitat classes and dominant flora (plants)	Key fauna species
Alpine Zone (> 4000 masl)	**Alpine and Sub–alpine:** It is dominated by Rhododendrons scrubs, Junipers and medicinal plants and herbs species such as A*conitum spp., Gentiana spp., Nardostachys spp., Delphiniu spp., Rhodiola spp., Meconopsis spp., Ophiocordyceps sinensis, Neopicrorhiza spp., Fritillaria spp., Onosma spp.,* etc.	Snow leopard, Blue sheep, Musk deer, Himalayan marmot, Tibetan wolf, Red fox, Bhutan takin, Raven, Himalayan monal, Blood pheasant, Tibetan snow cock, etc.
Temperate Zone (2000 – 4000 masl)	**Fir Forest:** 3000–4000 masl. It consists either of largely pure stands of *Abies densa* or mixed with other species such as *Juniperus* spp. and *Larix griffithiana.*	Tiger, Red panda, Clouded leopard, Golden cat, Goral, Serow, Himalayan black bear, Common leopard, Wild dog, Yellow-throated marten, Musk deer, Golden langur, Pheasants, Tragopan, Patridge, Wards trogon etc.
	Mixed Conifer Forest: 2500-3500 masl. It includes mixed stands of *Picea spinulosa, Tsuga dumosa, Juniperus, Abies densa, Larix griffithiana, Taxus baccata.* Some broadleaf species are also common particularly *Quercus semecarpifolia, Q.griffithii, Rhododendron spp., Acer spp., Betula spp, Cypripedium* spp.	
	Blue Pine Forest: 1500-3200 masl. It consists of pure or dominant stands of Bluepine *Pinus wallichiana*. It is sometimes mixed with *Q.semecarpifolia, Populus rotundifolia* and *Rhododendron* spp., Matsutake mushroom.	
	Cool Broadleaved Forest: 2000- 2900 masl. Found on moist exposed slopes. It consists of Oak-Laural forest in which both deciduous and evergreen tree species like *Quercus* spp., *Castanopsis tribuloides, Persea* spp., *Exbucklandia* spp., *Lithocarpus pachyphyllus.,* etc. are abundant together with dense shrubs, climbers, and epiphytes. *Dendrobium* spp, *Cymbidium* spp., *Bulbophyllum* spp., *Calanthe* spp., etc.	
	Warm Broadleaved Forest: 1000-2300 masl. It occurs at lower altitudes with high rainfall. It contains mixture of evergreen and deciduous broadleaved species of Thea-Laural forest comprising of *Schima wallichii, Castanopsis hystrix., Engelhardia spicata., Macaranga* spp., This habitat also harbors rich diversity of epiphytic orchids like *Pholidota* spp., *Gastrochilus* spp., etc.	

Sub-Tropical Zone (75 - 2000 masl)	**Chirpine Forest:** 700-2000 masl. This is a low altitude xerophytic forest occurring in dry river valleys of Bhutan. Understory vegetation comprise of *Cycas pectinate, Rhus paniculata, Phoenix loureiri, Mallotus philippensis, Chromolaena odoratum, Ageratina adenophora,* etc.	Water buffalo, Golden langur, Sambar deer, Tiger, Golden cat, Clouded leopard, Capped langur, Guar, Reptiles Hornbills, Peacock, Jungle fowl, Cattle egret,
	Sub-Tropical Forest: 75 - 1200 masl. Broadly classified as semi-evergreen but varies from almost totally deciduous on exposed dry slopes to almost evergreen in the moist valleys. Forest is multi-storied with high species diversity. Floristic composition consists of tropical genera like *Shorea robusta, Terminalia* spp., *Tetrameles nudiflora, Phoebe* spp., *Bombax ceiba, Daubanga grandiflora, Sterculia villosa* and *Acacia* spp., *Castanopsis indica, Dillenia indica, Ficus* spp., *Paphiopedilum farrianum, Spathoglottis jetsunae, Gmelina arborea* spp., *Albezia* spp.,	
Habitats that can occur in any of the ecological zones		
Habitat types	**Definition and characteristics**	**Key flora and fauna species**
Meadow	Meadows include any areas dominated by grasses of low height or any herbaceous plant without or with few scattered trees or shrubs on it. It occurs at all elevations, but is relatively more common at higher elevations. Indigenous grazing rights and practice of transhumance is common. Occurrence of high-altitude medicinal herbs is one of the distinct features of such habitats.	Sambar deer, Barking deer, Blue sheep, Takin, Himalayan Marmot, *Agrostis* spp., *Arundinella* spp, *Carex* spp., *Danthonia cumminsii, Pennisetum* spp., *Poa* spp., *Festuca* spp., *Digitalis* spp., *Gentiana* spp., *Nardostachys* spp., *Delphinium* spp., *Ophiocordyceps sinensis, Neopicrorhiza* spp., *Bhutanthera himalayana,* etc.
Grassland	Grassland includes any areas dominated by tall grasses or any herbaceous plant without or with few scattered trees or shrubs on it. It occurs at all elevations, but is relatively more common at lower elevations. They are considered as one of the most threatened habitats due to agricultural expansion, livestock overgrazing, uncontrolled fires, fodder and thatch collection.	Pygmy hog, Hispid hare, Tiger, Elephant, Buffalo, Guar, Sambar, Chital, barking deer, and Reptiles *Saccarum* spp, *Imperata* spp, *Cymbopogon* spp, *Neyraundia* spp
Wetland	Wetland mean areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, including snow and glacier. Wetland provides food, shelter, and water for birds and mammals. It is further divided into six categories as mention below. River: It refers the area of perennial flow of water and the river beds. It also includes artificially constructed reservoirs (Dam) along the course of perennial rivers. In Bhutan there are five major river basins (Amo Chhu, Wang Chhu, Punatsang Chhu, Manas, and Nyera Ama Chhu) and two minor basins (Jomo Chhu and Aye Chhu).	Golden Masheers, White-bellied Heron, Pallas's fish eagle, Great cormorant, Rudy shelduck, Bar-headed goose, Crested Kingfisher, Ottor

Wetland	Lake: It refers the area of perennial and natural water surrounded by land. It includes both natural and man-made. It functions as an important habitat for terrestrial and aquatic species, particularly during migration of birds.	Rudy Shelduck, Common Teal, Goosander, Common merganser, Amphibians, *Myriophyllum* spp., *Brasenia schreberi,* Macro invertebrates
	Pond: It refers the area filled with water surrounded by land, either natural or artificial that is relatively smaller than a lake. It serves as an important habitat for aquatic invertebrates, wetland plant, amphibians, wallowing species and water birds.	Pond heron, Black crake Amphibians, all faunal species that depends on water hole.
	Stream: It refers to the perennial and seasonal tributaries of river which are smaller than river.	Macro invertebrates, Amphibians, Crustaceans, *Nasturtium officinale*
	Marshy areas: Area that are either permanently or semi permanently waterlogged throughout and some part of the years dominated with sedges, reeds, grasses, other herbaceous plants.	*Rhododendron thomsonii, Acorus calamus, Cyprus* spp., *Juncus* spp., Black-necked Crane, Amphibians, Takin
	Riparian areas: It is the interface between land and a river or a lake, or a stream.	*Populus ciliata, Salix* spp., *Equisetum* spp., Kingfisher, Heron, Common sand piper, Otter
Agriculture Land	Arable land which is under permanent crops or fallow.	Ludlow's Bhutan Glory, Black-necked Crane, Peacock, Porcupine, Wild pig, Barking deer, Sambar, Rodents, House crow, Sparrow, *Macaca* spp. Edge dwelling species
Settlement Fringes	Areas surrounding or transition zone between the human settlements and forested areas.	
Rocky outcrops	Refers to natural cliffs, rocky and scree areas	Snow Leopard, Blue sheep, *Meconopsis bhutanica, Fritillaria* spp, *Rheum nobile, Gentiana urnula,* Goral, Takin, Serow,
Unique habitats		
Habitat types	**Characteristics and their importance**	
Cave	It is a natural or artificial chamber in the side of the cliff or hill, or one that is under the ground. It functions as the important habitat or roosting place for troglo-fauna species like bats, bear, swiftlets etc.	
Hot spring (Tshachu) and Menchu	Springs produced by the emergence of geothermally heated ground water that rises from the earth crust and rich in mineral contents. Mineral requirement of the Takin is supplemented from such areas.	

CHAPTER III: WILDLIFE HABITAT ASSESSMENT

3.1. Habitat Assessment

Wildlife habitat assessment is the evaluation of the relative habitat conditions both in quality and extent available to a focal group of wildlife. It also considers the present and past use of habitat, and assessments of impacts upon habitat where appropriate. This assessment is made based on the assumption that wildlife species is controlled by its habitat and the resources available in it (e.g. food, water, cover, and space). Thus, habitat conditions with respect to these resources are often used as a surrogate to make inferences about the presence, abundance, fitness, or productivity of wildlife populations, species, or communities.

Habitat requirements are different for different species and such requirements are often complex, involving hierarchical relationships. This makes habitat assessments a complex process in itself. This is especially relevant to the top carnivores such as tiger and snow leopard. For instance, a tiger might require a good cover and space considering its territorial nature requiring a larger home range, but the extent of its home range is determined by the availability of its primary prey species such as ungulates. For an ungulate population to thrive in the given habitat, basic habitat conditions will consist of good fodder species, adequate mineral licks and waterholes, with adequate cover and space to secure itself from predators. Therefore, for the conservation of threatened top carnivores such as tigers, its habitat assessment will involve the assessment of habitat requirement of ungulates.

An important aspect of habitat quality is the contribution of the habitat to the reproductive fitness of the population, and hence its ability to persist through time. However, the presence and abundance of species may not always reflect the quality of habitat. For instance, the prevalence of wild pig near the human settlement does not indicate the availability of quality habitat in such areas. In birds, territoriality may limit the number of breeding individuals that can occur in a particular forest stand.

Conducting the assessment is purely based on wildlife assessment in the given habitat, which can include the determination of the presence/absence of wildlife in the given habitat condition. Such assessment of wildlife can be done during the biodiversity survey and periodic monitoring of wildlife. In doing such wildlife assessment, it is very important that habitat attributes are also assessed. Major habitat attributes include the availability of palatable food resources, mineral licks, waterholes, presence of adequate cover for shelter and nesting, adequate space for flight and fight. Such assessment is useful as: 1) a screening tool to identify habitat stressors and; 2) a method for learning about the ecosystems and its functions.

3.2. Habitat Assessment Process

Assessment of wildlife habitat for management should be determined by identifying underlying environmental and social problems related to wildlife. Management of natural

wildlife habitat may not be necessary in an ideal natural environment. However, when changes are observed in the wildlife population or their ecology and behaviour, it becomes necessary for the wildlife managers to assess the habitat conditions.

The preliminary assessment process should encompass the review of available information for the habitat of concern and should also consider the experiences and expertise of the officials working for the given area.The process for undertaking wildlife habitat assessment is as per the schematic diagram below:

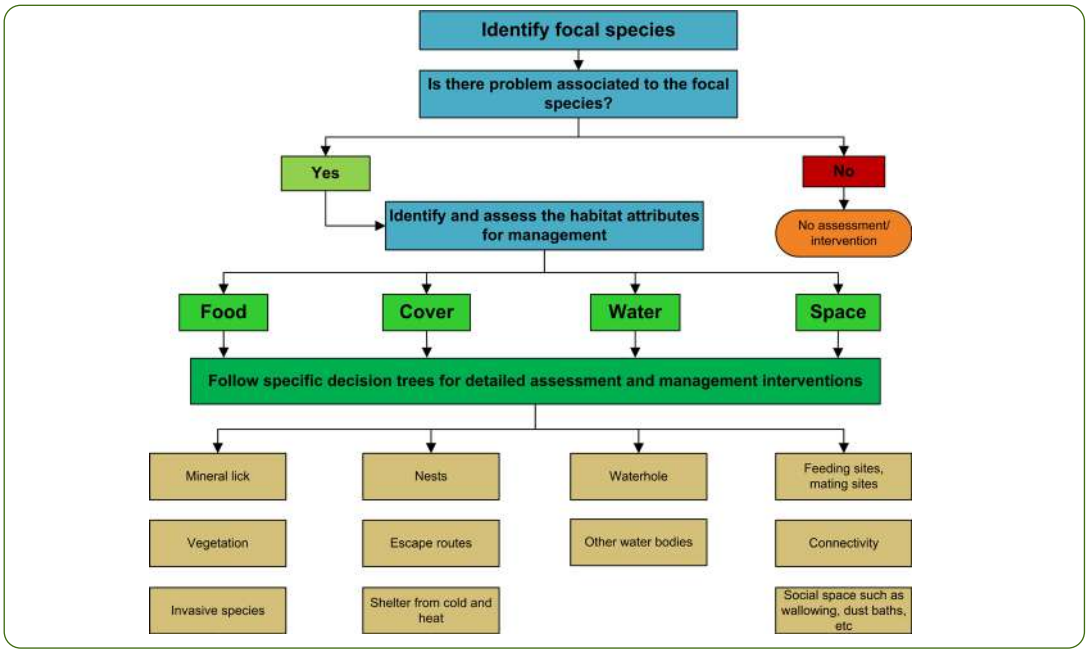


Figure 3.1. Schematic diagram showing steps for wildlife habitat assessment

3.2.1. Identify Focal Species

To ease the process of habitat assessment, focal species in a particular habitat are identified and the conditions and quality of the habitat are assessed in relation to that species. Species in focus can be of the following types:

1. Threatened species

The threatened species in this context will include both locally and globally threatened species. The globally threatened species which are listed under threatened categories of the IUCN Red List of threatened species and the endemic species. Threatened categories include the Vulnerable, Endangered, and Critically Endangered species. Locally threatened species are those species in Bhutan with restricted range or the population of which is very small or experiencing tremendous threats of extinction due to human induced threats even though they are not threatened globally. Endemic species on the other hand are species that are found only in Bhutan.

2. Species of ecological importance

An ecologically important species performs an important function in an ecosystem. The role of such species is critical that other species may not be able to take over. Identifying species of ecological importance whose functions cannot be for the holistic conservation of the ecosystem. Such species can be classified into the following groups;

a) Keystone species

Keystone species are species that play a large or critical role in supporting the integrity of its ecological community. The loss of a keystone species from an ecosystem would cause a greater than average change in other species populations or ecosystems functions, processes and integrity. They have a disproportionately large effect on other species in a community (IUFRO, 2005). Example: large carnivores, sambar deer *(Cervus unicolor),* fig tree (*Ficus spp.*), etc.

b) Flagship species

Flagship species are popular charismatic species that serve as symbols or act as an ambassador for a defined habitat to stimulate conservation awareness and action locally, nationally, regionally or globally (UNEP, 1992). Example: tiger (*Panthera tigris*), snow leopard (*Panthera uncia*), elephant (*Elephas maximus*), red panda (*Ailurus fulgens*), blue poppy (*Meconopsis gakyidiana*), etc.

c) Umbrella species

Umbrella species are species whose conservation confers protection to a large number of naturally co-occurring species (Roberge & Angelstam, 2004). They have the name "umbrella" because protecting these species indirectly protects the many other species that make up the ecological community of their habitat. These species generally need large territories for their populations to be viable. They tend to live for many years and be an important addition to their natural habitat. Example: elephant, tiger, snow leopard, etc.

d) Indicator species

Indicator species are species whose status provides information on the overall condition of the ecosystem and of other species in that ecosystem. They reflect the quality and changes in environmental conditions as well as aspects of community composition. (Heywood & Watson, 1995). Example: lichens, butterflies, mayflies, stoneflies, frogs, otters, etc.

e) Habitat specialists

Habitat specialists are those species adapted to specific habitats, or dependent on specific resources, or other specific environmental conditions. They are associated with a relatively narrow range of environmental conditions. Therefore, habitat specialists are more susceptible to change in habitat quality and extent; and other natural or anthropogenic disturbances. Examples of habitat specialist include pygmy hog, red panda, black-necked Crane, lady slipper orchid, etc.

3.2.2. Identifying Problems and Indicators

Once the focal species are identified, the problems facing the species population should be assessed and the underlying causes and threats needs to be identified. Wildlife habitat quality and extent are two significant parameters that determine in upholding the population, species, and community. Incessant use of natural resources by humans poses a certain magnitude of competition with wild animals over a limited resource. Therefore, resource depletion and habitat degradation are widely anticipated as one of the causes of human-wildlife conflicts. Sharing of natural resources between human and wildlife in the existing context of conservation practice warrants wildlife habitat management interventions. Some of the major indicators of habitat change are as follows;

a) Species population status (number and distribution)

Wildlife species numbers are very vast and it is very difficult to ascertain the population estimate of all the wildlife species in the habitat. However, for many focal species, wildlife managers can estimate the abundance of species or their probable occupancy in the habitat. Changes in this species population happen mainly due to change in the habitat or other environmental conditions.

b) Crop depredation by herbivores

Increased incidence of crop depredation by herbivores is an indication that there is change in behaviour or population of herbivores. Such changes may be induced by change in the habitat that the herbivores are living in. So, crop depredation by herbivores is an indicator of change in habitat quality or extent.

c) Livestock predation by carnivores

Livestock depredation by carnivores can happen in forest habitats or at the village periphery. Predation happening inside the forest habitat may be due to free ranging of livestock in the wildlife habitat. However, if predations happen in the settlement periphery, it may be due to increase in predator population or change in the habitat conditions.

d) Pest and diseases

The emergence of pests and disease in the wildlife and its habitats will have an adverse impact on the entire ecosystem. For instance, the prevalence of pests and disease in grasslands or tree species can adversely affect the ecology of wild animals like ungulates or birds in that grassland ecosystem. Pest and diseases can occur in both wild animals and its biotic habitat components. The emergence of pests and diseases in the wildlife can be due to change in the biotic components and environmental conditions induced either naturally or by humans.

e) Habitat connectivity

For many large mammals and migratory birds, large scale habitat connectivity is very vital to ensure population linkage and viable growth. Small scale connectivity is important for many smaller wildlife such as herpetofauna. Any disruption in their habitat contiguity will have an adverse effect on the wildlife ecology and behaviour.

3.3. Decision tree for assessment and management interventions

Once the focal species and the problems and indicators are identified, the next step is to assess each habitat component. For the assessment of specific components of habitat and decide which habitat management techniques to be applied, the following decision trees should be used.

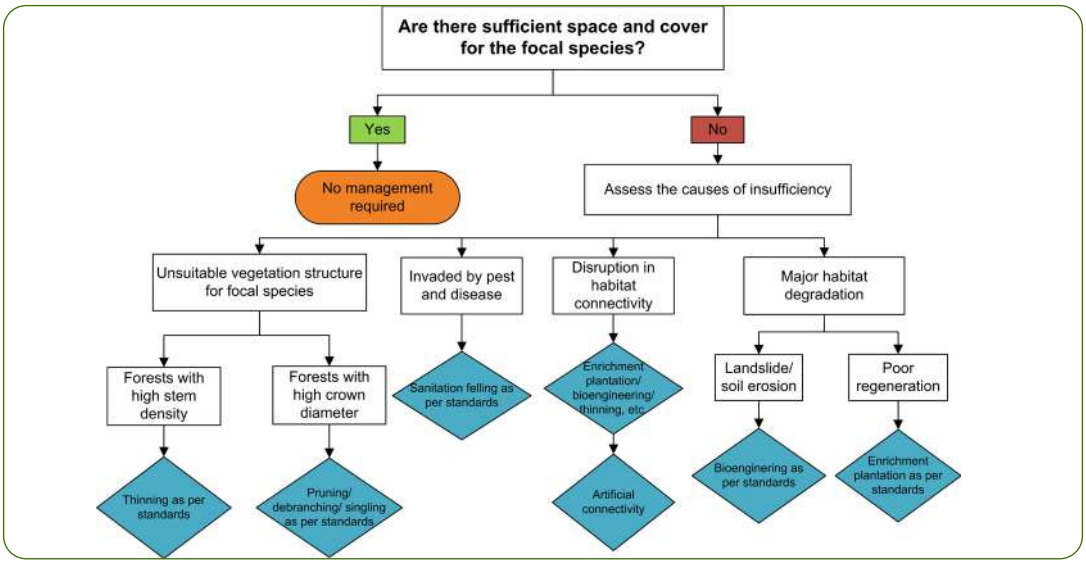


Figure 3.2. Decision tree for assessment of space and cover and management through mechanical treatments

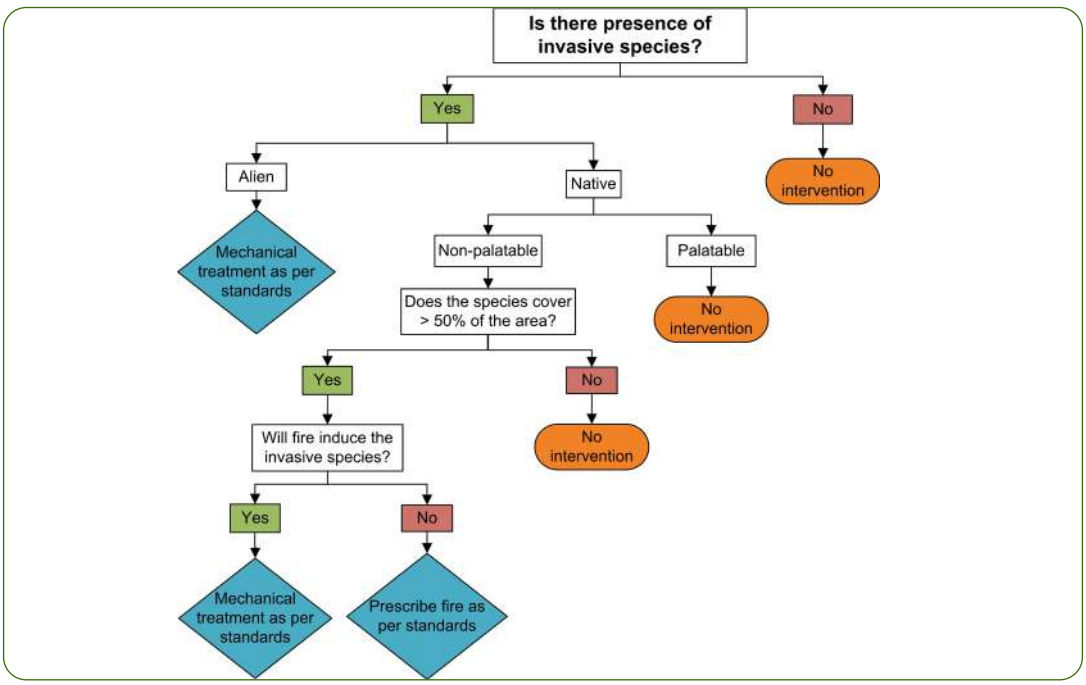


Figure 3.3. Decision tree for assessment and management of invasive species

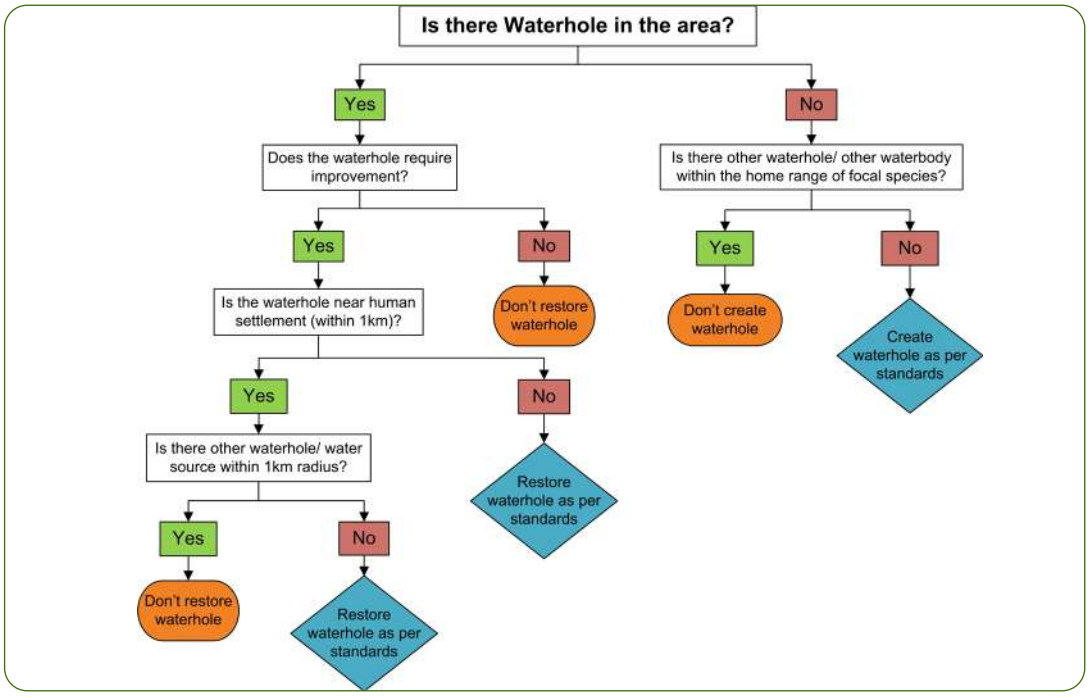


Figure 3.4. Decision tree for assessment and management of waterholes

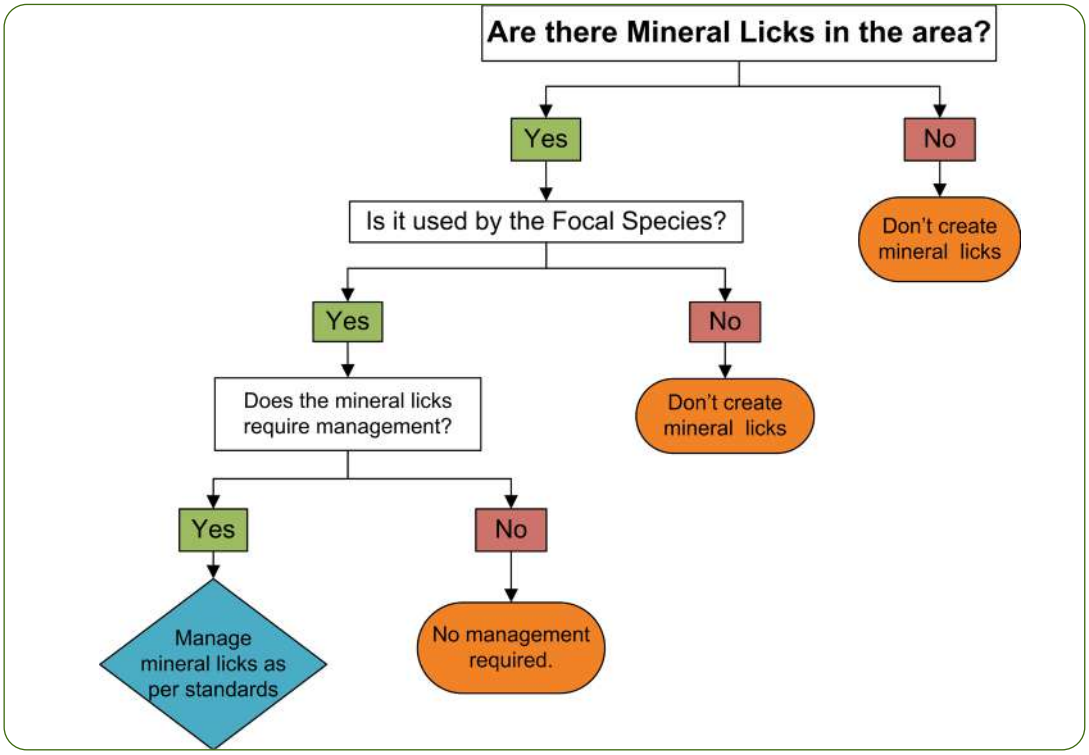


Figure 3.5. Decision tree for assessment and management of mineral licks

3.4. Wildlife Habitat Assessment Report and Implementation Plan

Once the habitat assessment is completed, the respective office should come up with wildlife habitat assessment report. The report should clearly spell out the rationale behind the assessment and the process followed during the assessment. As such, the report should clearly state the problems associated with the focal species and conditions of the habitat components assessed. Based on the assessment of the habitat components, as set of habitat management interventions should be proposed. The assessment report should be concise and may follow the following template:

1. Rationale:

This should focus on perceived threats and issues to the wildlife and habitat. The focal species identified for the given habitat should be described along with the problems being faced. For example, high depredation of livestock by tiger, perceived decline in population and health.

2. Assessment process:

This section should outline how the assessment was conducted describing the focal species, problems and indicators and use of decision tree.

3. Findings from the assessment:

Describe the condition of the habitat components based on the assessment.

4. Proposed management interventions:

Describe the habitat management techniques to be used, the location of each prescription to be conducted, and the implementation target (area, number) for each habitat management action.

5. Technical estimates (costing):

Include costing for implementation of each action along with cost breakdown.

6. Schedule of implementation:

Include annual implementation plan for each activity. Also specify seasonal requirement for implementation of an action.

7. Monitoring and evaluation:

This section should mention what will be measured and how often to measure to determine implementation plan was implemented as planned and if the actions were effective.

CHAPTER IV: WILDLIFE HABITAT MANAGEMENT (TECHNIQUES & APPLICATIONS)

4.1. General considerations

I. Administrative, financial and technical approval

Before implementation of any activity for wildlife habitat management, administrative, financial and technical approvals must be sought from the Head of Department (HoD) and relevant functional divisions.

1. Administrative and financial approval must be sought from the HoD
2. Technical approval should be sought from relevant functional divisions under the Department of Forests and Park Services. The proposal for technical approval must include proposed activity and location, time of implementation (season) and cost estimates.

While implementing any wildlife habitat management activities, the following safeguard measures should be taken into consideration wherever relevant and necessary. This is to minimize and mitigate any possible negative impacts on environment and social wellbeing in and around the area of implementation.

II. Environmental safeguards

1. Proper management of solid or liquid waste during the implementation of the work.
2. Minimize pollution of air, water and land.
3. Minimize disturbance to wildlife or community.
4. Prevent negative impact to any native, endemic, rare or threatened species.

III. Social safeguards

1. Avoid community restriction to access natural resources for their livelihood.
2. Avoid community restriction to religious and cultural sites.
3. Ensure occupational health and safety of the workers.
4. Ensure quality living of the workers including gender equality/equity.
5. Conduct community consultation prior to activity implementation wherever the communities will be impacted.

4.2. Prescribed fire

Prescribed fires, also known as prescribed burning or controlled burning is an application of planned or controlled fire under specified weather conditions to maintain or restore health of habitat or ecosystems that depend on the fires. Prescribed fires are not always beneficial. When conditions are wrong, prescribed fire can severely damage the very resource it was intended to benefit. Prescribed fire is a complex management tool, and should be used only with care under controlled conditions.

Figure 4.1. Prescribed fire used for management of sub-tropical grasslands in Royal Manas National Park

4.2.1. Technical considerations

While planning for prescribed burning, the following conditions need to be taken into consideration:

i. Fuel load

As fire frequency increases fuel load decreases. The largest fuel load available for burning will be on the first fire and lesser for second fire. If high fire intensity is needed to meet your objectives, the first fire is your best chance for success. If a low intensity fire is needed, be especially careful on the first burn and use firing techniques or weather conditions that will result in a low intensity or a cooler fire, even with a high fuel load.

ii. Weather

Prescribed fire programs are predominately weather dependent and its conditions just prior to and during a prescribed fire have a tremendous impact on fire behavior. Low surface fuel moistures (drought, low humidity) and burning before an approaching cold front (erratic winds, low humidity) are the most common causes of major problems on the fire line.

iii. Slope and aspect

When burning a landscape sized area, realize that fire behavior will vary greatly as the fire burns over different aspects. South and west slopes are drier and more susceptible to ignition and rapid buildups in intensity. Fire on any aspect, will build in intensity and speed as it goes up the slope.

iv. Time of year (season) and the day

There is value in burning at different times of the year. Two years of residual material is needed to carry a fire. Speedy burning happens in dry season when there is less surface moisture along with associated risks of wildfire. In a wooded site that has an erosion

potential, consider burning just before or during leaf drop. The residual leaves will provide some erosion control over winter until the herbaceous layer can respond to cover the ground.

v. Habitat type

When planning for application of prescribed fire, one must consider the habitat type. The implementation method may vary with target areas. The site specific implementation plan is required as the landscape and vegetation along with other associated site parameters may differs among different sites.

vi. Degree of fire

Finding the right balance of fire has long played a vital role in the management of the vegetation for the fulfillment of different objectives and goals. Too much fire can cause to alter the structure and composition of natural ecosystem while too little can predispose the natural ecosystem to larger and more severe wildfires.

vii. Wildlife safety

Prescribed burning can have detrimental impact on other biodiversity such as small mammals, herpetofauna and invertebrates. Therefore, prescribed fire must be applied by dividing target habitat into sub-compartment bound by fire lines. The different compartment or blocks should be burned in different time which allows wildlife to shift from one block to another.

viii. Preventive planning

The mitigation measures should be in place during the application of prescribed fire to avoid causing wildfire.

ix. Safety measures

The safety of people involved in conducting a burn should be the top most priority. Refuge area should be identified as a safe place. Adequate personal protective gear/equipment like helmet, leather gloves, goggle and respiratory mask; and first aid kit are required. The people involved should wear safety clothing and avoid flammable cloths.

4.2.2. Functions and benefits

1. Maintain vegetation structure and composition for maintaining healthy and vigorous habitats.
2. Control invasive, pests and diseases.
3. Increase biodiversity with improvement in habitat quality.
4. Induce seed germination.
5. Creates different stages of palatable young grass shoots.
6. Reduce hazardous fuel and reduce risk of extreme wild fires.
7. Reduce fire induced mortality to the arthropods and small mammals.
8. Recycles nutrients back to the soil.

4.2.3. Risks and Limitations

Risks

1. Accidental widespread of fire beyond target area and cause unintentional damage to wildlife as well as human life and property.
2. Inappropriate time-scales burning would lead to reduction of flora and faunal diversity.
3. Induce weed invasion along fire breaks or spread of soil-borne disease.
4. Source of fine particulate matter which impacts air quality.
5. Losing of undocumented threatened species.
6. Increase risk of soil erosion.
7. Operational health and safety of the workers.

Limitations

1. It is being strongly perceived as a threat.
2. Implementation is constrained by inadequate funding.
3. It is weather and fuel dependent and requires suitable weather for burning, and favorable landscape in terms of topography and vegetation continuity.
4. Environmental and ecosystem services implications limits prescribed burning.

4.2.4. Implementation

The implementation of the prescribed burning in different habitat types should be centred on action plan. The operation of the prescribed fire shall include the followings:

1. Demarcating the area.
2. Establishing firebreaks.
3. Inform the relevant agencies.

Methodology

a) Grassland

Site preparation: The area for burning with prescribed fire should be divided into small blocks to minimize the risk and for ease to manage the fire.

Fire line: Fire line should be constructed around blocks identified for burning. The width of the fire line shall depend on the amount of fuel load and type of vegetation present. As a rule of thumb, the fire line width should be at least three times the height of adjacent vegetation.

Burning technique: Mosaic burning technique should be followed where some blocks having higher native species should be left unburned. In addition, nesting sites, alternative food sources, and refuge cover for wildlife should also be retained.

Frequency: Burning every 2–3 years is recommended in tall grass while in case of invasive species, high frequency burning in several consecutive years is required.

Season: The early burning season (Nov-Dec) is more beneficial in terms of production.

b) Meadow

Site preparation: The area for burning with prescribed fire should be divided into small blocks to minimize the risk and for ease to manage the fire.

Fire line: Fire line should be constructed around blocks identified for burning. The width of the fire line shall depend on the amount of fuel load and type of vegetation present. As a rule of thumb, the fire line width should be at least three times the height of adjacent vegetation.

Burning technique: Mosaic burning technique should be followed where some blocks having higher native species should be left unburned. In addition, nesting sites, alternative food sources, and refuge cover for wildlife should also be retained.

Frequency: The burning interval of six years between burning is recommended.

Season: Early spring (Feb-March) and late autumn (Oct- Nov).

Figure 4.2. Grassland management in Royal Manas National Park

4.2.5. Cost Estimates

Prescribed fire is an economical and cost-effective habitat management technique. The cost per acre will vary based on the size and location of the target area. Some common costs to consider are as follows:

1. Labour costs (for site preparation, fire line preparation and burning).
2. Materials (fuel for drip torches, water, etc.).
3. Fire fighting equipment (protective gear, flapper, fire rakes, fire pump, water bag).
4. Staff cost for monitoring.

4.3. Mechanical treatments

For wildlife habitat management, mechanical treatment includes uprooting and removal (invasive alien species), harvesting management through silviculture operations (improvement and sanitation felling) and bioengineering works.

4.3.1. Uprooting and removal

Uprooting and removal intervention will be prescribed for management of invasive alien plant species. Invasive alien species (IAS) are non-native species which have been introduced intentionally or accidentally to a new habitat. Major invasive plant species identified (NBC, 2018) in Bhutan are:

Table 2: List of major invasive plant species in Bhutan

Sl. No.	Species	Ecological zone
1.	*Chromolaena odorata*	Sub-tropical
2.	*Mikania micantha*	Sub-tropical
3.	*Ageratina adenophora*	Sub-tropical and temperate
4.	*Lantana camara*	Sub-tropical
5.	*Parthenium hysterophorus*	Sub-tropical and temperate
6.	*Leucaena leucocephala*	Sub-tropical
7.	*Robinia pseudoacacia*	Sub-tropical and temperate
8.	*Tithonia diversifolia*	Sub-tropical
9.	*Opuntia vulgaris*	Sub-tropical
10.	*Trifolium repens*	Sub-tropical, temperate and alpine
11.	*Sida acuta*	Sub-tropical
12.	*Eichhornia crassipes*	Sub-tropical
13.	*Hyptis suaveolens*	Sub-tropical
14.	*Mimosa pudica*	Sub-tropical
15.	*Pennisetum clandestinum*	Sub-tropical, temperate and alpine
16.	*Ipomoea hederifolia*	Sub-tropical

4.3.1.1. Technical considerations

1. Control measures are required to be carried out before the flowering season specific to each species to prevent formation of seeds and its dispersal.
2. Use environment friendly mechanical equipment.
3. Assess the site for presence of native threatened species.
4. Consider those invasive plant species on which native threatened species are dependent for food and shelter.
5. Proper disposal of invasive species at identified sites.
6. The removed plant materials may be used as raw materials for further processing into useful products.

4.3.1.2. Functions and benefits

1. Maintain the integrity of natural habitats.
2. Prevent economic loss and health hazards.
3. Prevent extinction of native species.
4. Can be used in environmentally sensitive areas.

4.3.1.3. Risks and limitations

1. Land degradation (erosion, landslides).
2. Accidental spread of invasive species to new location.
3. Surprise effect: sometimes invasive species removal could result into unexpected proliferation of another species.
4. Low level of awareness.
5. Incur huge cost for management.

4.3.1.4. Implementation

Identification of the habitat for intervention based on the report of habitat assessment.

Equipment assessment

1. Manual – knives, spade, hand clipper and lopper, crowbar, pick-axe, axe, safety gears, hedge cutter etc.
2. Mechanical - Chain saw, mowers, grass cutter, excavator, power tiller, pick-up trucks.

Methodologies

Manual control: Manual removal/uprooting is referred to pulling or digging to remove the invasive and unpalatable plants. It works well for dealing with single plants or small patch of infestation that can be eradicated with small amount of labour. It is most effective if the invasive plants are shallow rooted and the soil is loose or moist. While using the manual control, minimizing soil disturbance and replacing soil to disturbed areas is very important. The advantages of manual include small ecological impact, minimal damage to neighboring plants, and low (or no) cost for equipment or supplies. Manual method, however, is extremely

labour intensive and effective only for relatively small areas, even when abundant volunteer labour is available.

Mechanical control: Mechanical control is eradication of unwanted plants from the habitat with use of equipment and machines. The method is labour intensive. However, it is the most recommended method in Bhutan due to lack of adequate research and knowledge on chemical and biological control measures.

Mechanical control ranges from the use of chain and brush saws, to mowers, bulldozers, and specialized logging equipment to remove woody plants. However, cutting woody and herbaceous plants by chain saw, brush saw, or mowers remove only aboveground plant parts without killing the roots. Mechanical removal with larger equipment may not be appropriate in natural areas because of disturbance to soils and non-target vegetation.

Disposal of debris

Both manual and mechanical methods will result in production of debris of uprooted parts of the unwanted plants, which if not disposed properly, would invade the same or nearby sites. Disposal of the debris should be in the same vicinity to avoid further spread of the species during transportation. Therefore, proper disposal should be carried out as follows

1. Collect the debris into heaps/piles (while removal/uprooting) at designated dumping site before flowering season.
2. Dry out the vegetative parts of the debris in the sun.
3. Burn the dried debris.
4. Bury in pit for species which is difficult to burn.

Preventive measures

1. Thoroughly clean and inspect all equipment and clothing used during removal/ uprooting of the unwanted plants to prevent spread of the species in the vicinity.
2. Early detection and identification of new species/population of unwanted plants at a given site.
3. Rapid response for eradication or containment before the species spreads.
4. Outreach and education on impacts of invasive species.

4.3.1.5. Cost Estimates

The cost of uprooting and removal under mechanical treatments will vary based on the area, terrain and accessibility. The cost for following activities and items should be considered while carrying out uprooting and removal for habitat management:

1. Field survey and consultation with stakeholders
2. Labour charges (for removal, uprooting and dumping of unwanted vegetation)
3. Machine charges (for cutting, uprooting and removal)
4. Transportation charges

4.3.2. Improvement and sanitation operation

Improvement includes operations such as thinning, singling, pruning and climber cutting for the purpose of improving wildlife habitats. Sanitation felling is defined as the removal of trees to improve stand health by stopping or reducing the actual anticipated spread of pests and diseases.

Figure 4.3. A mixed conifer forest stand in western Bhutan

4.3.2.1. Technical considerations

1. Retain threatened plant species.
2. Retain den and snag trees in broadleaved forest.
3. In conifer forest, it is advisable to remove dead and dying trees as these can attract pest and diseases.
4. Minimize environmental damage such as trampling of regeneration and under growth, exposure of top soil, blockage of streams, etc.
5. Manage the wastes from lops, tops and barks.
6. Dispose infected woody materials properly.

4.3.2.2. Functions and benefits

1. Ensures optimal use of forest resources (timber, poles, fire wood).
2. Enhance regeneration.
3. Control spread of unwanted plant species.
4. Create more space for wildlife by reducing canopy density and shading.
5. Improve quality and growth of remaining natural vegetation.

4.3.2.3. Risks and Limitations

1. Retain threatened plant species.
2. Change in natural forest dynamics.
3. Spread of pest and diseases.
4. Limited accessibility due to challenging topography.
5. Financial limitations.
6. Inadequate knowledge and skills on forest dynamics.

4.3.2.4. Implementation

I. Thinning

1. Carry out thinning depending on the silvicultural characteristic of particular stand.
2. The gap between two thinning cycles should not be more than 10 years.
3. Follow the appropriate thinning techniques and remove up to 25% of volume/stem in a single thinning.
4. Thinning should be done based on ecology of targeted wildlife species (avoid during breeding, mating, migration season, etc.)
5. All trees affected by parasitic plants (e.g. mistletoe in blue pine) should be harvested and disposed properly.

Figure 4.4. Pruning and debranching of juniper trees in Jigme Singye Wangchuk National Park

II. Singling

1. Carry out singling by selecting the strongest and/or straightest stem.
2. In case of coppice regrowth (e.g. broadleaved trees), select 1 or 2 of multiple new shoots and remove the others.
3. In the forked stem, select the best stem and remove the other.

III. Pruning/ debranching

1. Do not prune branches to more than 50% of the total tree height or do not remove more than half the crown of mature trees.
2. Pruning can be done for trees measuring more than 10 cm dbh or when it attains the pole size.
3. Prune live branches during the winter whereas dead branches can be removed at any time.
4. Use sharp tools to avoid breaking branches and damaging tree stems.

IV. Climber cutting

1. Avoid cutting climbers that serves as food for wildlife.
2. While cutting climbers, avoid damage to the tree stem.
3. As far as possible uproot or cut the climbers at the initial stage of its growth.
4. Cut the climber at the base/ground level.
5. Climber cutting may be started during the autumn to avoid its regrowth and repeat as and when necessary.

V. Sanitation feeling

Sanitation felling is conducted to prevent and control pests and diseases that will adversely affect the wildlife habitat. Common pest and disease threatening the forests in Bhutan are eastern Himalayan spruce bark beetle (*Ips schmutzenhoferi*) and Mistletoes (*Arceuthobium minutissimum* & *Taxillus kaempferi*) and root collar weevil (*Hylobitelus chenkupdorjii*).

Eastern Himalayan spruce bark beetle is a serious pest in conifer forests. It attacks mainly living trees or infests freshly felled logs of spruce and blue pine and occasionally larch. Mistletoe is a parasitic plant that affects mainly blue pine forest and mixed conifer forest types particularly in drier forests of western Bhutan. Hemlock and spruce trees are also occasionally infected. Root collar weevil affects the young blue pine trees by girdling the tree. The procedures for sanitation operation area as mentioned below:

1. Remove infected woody material from the sites as completely as possible and debark the stumps and branches up to 10 cm diameter immediately after felling.
2. If it is not possible to remove logs, debark them in the forest and burn the bark (with the beetles).
3. In case bark beetles are found under the barks, carefully debark logs placed on a tarpaulin sheet to prevent beetles from escaping.
4. In case bark beetle larvae are found under the barks, expose them to sunlight so as to kill them too.
5. Remove all affected trees with growing mistletoe during thinning operations and burn heavily affected trees and branches.

6. After felling, monitor the stand regularly to ensure whether the pathogen has been effectively controlled or eradicated.
7. Combine appropriate measures to ensure successful regeneration of the felled areas.

4.3.2.5. Cost Estimates

In case of improvement and sanitation operation, the costs should be considered for thinning, weeding and cleaning and sanitation operations. The main cost will be incurred for the following:

1. Field survey
2. Labour charges (for felling, site clearing, transportation)
3. Hiring of machines (for felling, transportation)

4.3.3. Bioengineering works

Bioengineering works are carried out to protect forest land from landslides and erosion. Bioengineering techniques include use of live vegetation either alone or in conjunction with civil engineering structures. It is carried out to reduce velocity of water flow, control soil erosion and enhance siltation of soil on slopes and to improve the forest's ability to protect watersheds and water resources. This technique is used as a protective measure to stabilize the eroded areas and gullies by constructing check dams and planting of grasses, shrubs and trees (SFED, 2020).

A careful assessment is required to determine whether this intervention will bring any tangible impact and is cost effective in wildlife habitat management.

4.3.3.1. Technical considerations

1. Bioengineering works is recommended for highly degraded or eroded sites that need to be urgently tackled.
2. Use local material and live vegetation in conjunction with civil engineering structures.
3. Minimize soil disturbance.
4. Avoid diversion of water course.
5. Geological characteristics of the site need to be taken into consideration.

4.3.3.2. Functions and benefits

1. Stabilizes the degraded land/habitat
2. Prevents landslide and erosion
3. It is eco-friendly
4. Use of live vegetation for bioengineering is cost effective
5. Improves water quality and ground water recharge

4.3.3.3. Risks and limitations

1. Using live vegetation is restricted to specific season
2. Availability of the local material/locally adapted plants may be limited
3. Lack of skilled and experienced labour in the locality for carrying out bioengineering works
4. It is labour intensive for civil engineering structures
5. It is less preferred due to availability of other concrete structures
6. Inadequate knowledge on bioengineering works
7. Low survival rate of cuttings

4.3.3.4. Implementation

Implementation works will be focused on mitigating two prominent habitat degradation factors such as formation of gullies and landslides which require bioengineering works. Some of the measures are:

- Use of live/vegetative cuttings - Vegetative cuttings are used in landslide areas to stabilize the soil, reduce erosion, runoff and soil loss. Cuttings, bamboo rhizomes, grass slip and wildlings are used as live or vegetative cuttings.
- Gully plugs – It is used in existing or developing erosion gullies. It is used to increase water infiltration and slow down water flow to trap soil and silt. It is applicable for small gullies.
- Check-dams- Check dams are used to reduce the velocity of run off and reduce the intensity of erosion. The maximum gully width that log check dam can tackle is 3 m and for stone check dam it is 5m. For gully width more than 5 m, gabion structure and other civil engineering structures are recommended. There are some important factors that need to be taken into consideration while constructing the check dams as follows:
    1. The no. of check dams will depend on the gradient and length of the gully bed.
    2. The space between two check dams need to consider the topography of the land and accordingly be spaced to reduce the speed of the flow in the gully.
    3. The spacing between two check dams in an ideal situation should be such that the crest of the downstream dam is at the elevation of the toe of the upstream dam.

There are several types of check-dams based on the materials used such as:

- Brush wood check-dams (dry branches and other materials)
- Log check-dams (logs)
- Stone check-dams (stones)
- Gabion structure (stone and wire structure)

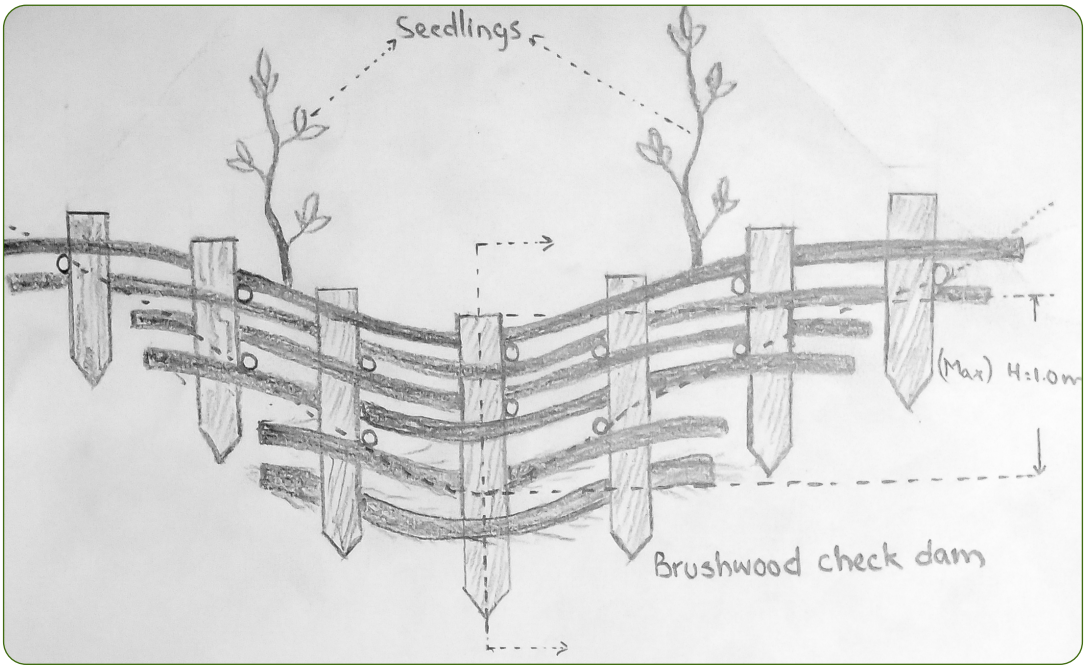


Figure 4.5. Brushwood check dam

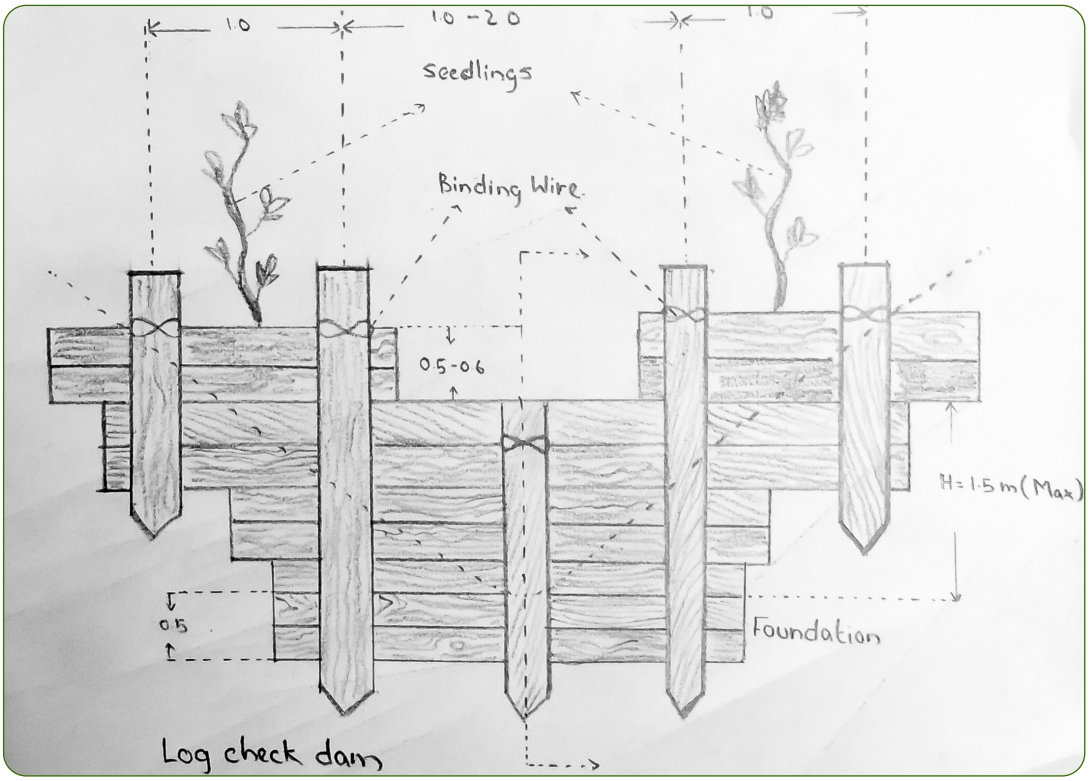


Figure 4.6. Log check dam

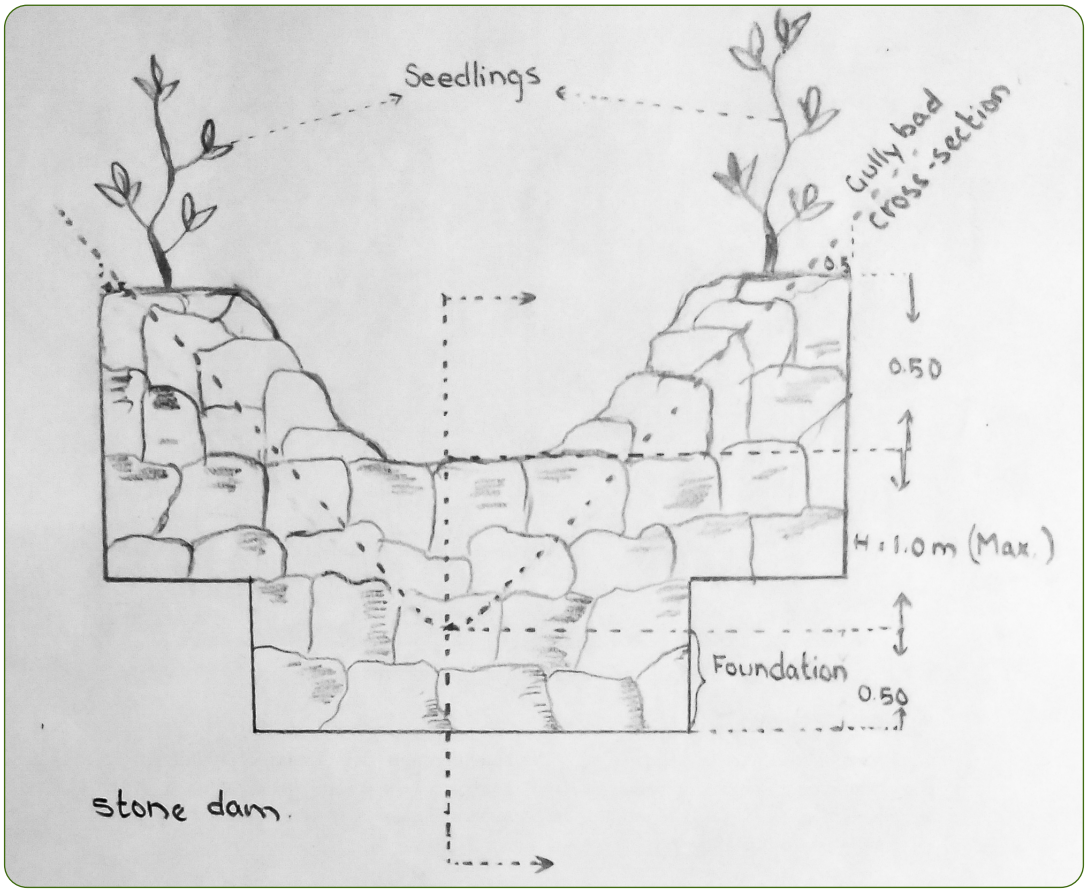


Figure 4.7. Stone check dam

Contour trenches – Trenches are long, narrow ditches dug into the ground to reduce runoff and soil losses in drier sites. It is usually combined with plantation and should be levelled along the contour.

Procedure for implementation of bioengineering works

1. Assessment of the degraded site for bioengineering interventions
2. Consultation with relevant stakeholders (wherever necessary)
3. Identify the appropriate bioengineering technique for the site.
4. Measurement of gully dimensions
5. Preparation of the cost estimate for the bioengineering work
6. Collection of the materials including labors
7. Implementation of work

4.3.3.5. Cost Estimates

The costs for bioengineering works will depend mainly on the type of bioengineering work to be carried out. In addition, cost will vary based on the extent of area, location and accessibility. The costs should be calculated based on the need for following sub-activities and or items:

1. Labour charges
2. Hiring of machines
3. Procurement or collection of seedlings/ cuttings/ rhizome
4. Materials (stones/ logs/ mud)
5. Transportation charges

4.4. Habitat enrichment plantations

Habitat enrichment plantation refers to planting of desired plant species within the wildlife habitat that does not meet the minimum ecological functions (and may pose threat to the survival of the species in that area) without elimination of the already existing species by improving the degraded habitats. Degraded or under-stocked areas with the following conditions should be considered for enrichment plantation:

a) Areas with less than 40% crown cover.

b) Areas with unpalatable monoculture species.

c) Areas with poor regeneration.

Habitat enrichment planting generally consists of transplanting nursery grown seedlings or wildlings into the natural openings in forest, felling gaps or lines opened specifically for this purpose.

4.4.1. Technical considerations

The following considerations should be taken into account:

1. Sites selected for undertaking habitat enrichment should not restrict community rights (traditional grazing and leaf litter collection).
2. Fulfil site specific objectives (e.g. the objective of plantation in degraded water catchment areas is to rehabilitate or conserve catchment areas rather than timber needs of the community).
3. Preference should be given for plantation of native and endemic species over exotic species
4. Maintain species diversity in the area.
5. The species planted serve the purpose (food, cover, shelter, soil stabilization, etc.) of the targeted habitats.
6. Source seedlings from the nearest nursery or through wildling.
7. Follow appropriate season for plantation.
8. Follow approved plantation norms and standards for cost estimation

4.4.2. Functions and benefits

1. Maintain ecosystem balance through improved water retention capacity, soil land protection and enhanced species and ecological diversity.
2. Improve the quality and stocking of the forests to make it economically and ecologically viable.
3. Provide cover to wildlife as an important component of the wildlife habitat.
4. Contribute towards mitigating human-wildlife conflict.

4.4.3. Risks and limitations

Various risks are associated while implementing the activity.

1. Uncertainty of survival (climatic factors, browsing and trampling).
2. Non availability of preferred seedling in nearby nurseries or wildlings.
3. Introduction of pest and diseases and invasive species.

4.4.4. Implementation

Enrichment plantation in the forested areas: Gap planting

Gap planting is replanting and tending gaps within the identified habitats areas having poor regeneration. Under this method, the first step is to identify and segregate large and small gaps. Areas with openings more than 600 m^2 are considered as large gaps and less than those as small gaps. Light demander species are recommended for planting in large gaps while shade bearer species in smaller gaps. The specification for carrying out the plantation should be followed based on the approved Norms and Standards for Nursery and Plantation.

The following are the techniques for undertaking gap planting in the forested areas;

1. Seedling/ wildling plantation

Seedling and wildling plantations are the most common form of plantation practiced. Seedling plantations are carried out by using seedling raised in the nursery while the wildling plantations are done by collecting the seedlings from the naturally regenerated areas in the wild.

2. Stem cutting plantation

Some species with strong woody stems can be propagated by taking cuttings from the stems. Each cutting should have at least three nodes; one near the top, one at the bottom and one in the middle. The cuttings can be planted straight into the ground or after rooting at the onset of the growing season based on species. The cuttings should be set into beds with one node above the ground, and the beds should be shaded or mulched with biodegradable materials and watered to ensure survival.

3. Rhizome and tuber plantation

Rhizomes and tubers are stems that grow underground which can be used for propagation. Rhizomes and tubers can be propagated by splitting it into sections with bud scars. These can be planted out directly into the ground if they are dug up at the beginning of the growing

season of respective species or into nursery beds during the dry season as long as they are kept watered.

Enrichment plantation in the grasslands

The grassland enrichment plantation includes plantation of grass seed, grass slip, rhizome and stem in the targeted grasslands for the purpose of habitat management. Trees may also be planted in the grassland apart from the grasses to provide cover and shelter based on the requirement of the target species. The following planting techniques can be used for grassland enrichment (Harrison, 1992):

i. Seed broadcasting
ii. Slip plantation
iii. Rhizome and tuber cutting plantation
iv. Stem cutting plantation
v. Seedling/ wildling plantation

Seed broadcasting

Broadcasting is method of scattering seeds by hand or mechanically over an area. Broadcasting is usually carried out at the beginning of the monsoon in flat or gentle slope areas where the chances of surface runoff are low. Most grasses can be propagated from seed. The seed should be collected before it falls from the inflorescence.

Slip plantation

Slip planting is plantation of large and mature clumps of grasses which are split into small portions with some roots and shoots in each piece. These smaller pieces are called slips and can be planted out. The leaves of the slips should be cut back to 10cm or less to stop them drying so quickly after they are planted out.

4.4.5. Cost Estimates

The preparation of cost estimation for any plantation programs shall be based on the Norms and Standards for Plantation and Nursery, wherein the following cost components may be considered:

a. Public consultation
b. Site preparation works

1. Detail surveying of the area preferably using GPS
2. Clearing of proposed site for management intervention (enrichment plantation) depending on the site-specific requirements
3. Aligning and stacking based on the design and technique of plantation to be adopted/applied
4. Soil preparation (digging of planting pits, tilling, terraces & thallies)

c. Procurement of seedling and fencing materials.
d. Transportation of materials (seedling & fencing materials).

e. Plantation works
f. Planting of seeds/seedlings (bare root, poly-pot, ball of earth, stumps, rhizomes & wildings).
g. Protection measures (fencing or type of fencing to be decided on site-based needs including fire line construction).
h. Provision for water supplement facility (construction of tanks or reservoirs, water pipes).
i. Signage/sign board
j. Maintenance
k. Refilling of seedlings
l. Weeding and cleaning

4.5. Waterhole Management

Waterholes play a vital role in regulating animal distribution and behaviour and they influence the functioning of ecosystem. Waterholes are often sites of animal congregation which may lead to conflict between different species or within the same species and might also result into transmission of diseases. Therefore, balanced distribution of waterhole in a habitat is very important for the uniform distribution of wild animals in the habitat.

In Bhutan, with the development and increase in per capita requirement of water resources, most water resources are trapped from the source thus reducing access to the wild animal. Therefore, need for creation and improvement of waterholes are deemed necessary. The management of waterhole is required to ensure continued supply of water throughout the year in a habitat. In certain habitats where there is a scarcity and urgent need of waterholes, the creation of new waterhole is recommended.

Figure 4.8. A male sambar deer quenching the thirst from a waterhole in the habitat

4.5.1. Technical considerations

1. Minimize creation of new waterhole unless it is necessary.
2. Use natural raw materials as far as possible or use biodegradable materials.
3. While bringing water from the source to the waterhole, consider the topography of the land and the volume of water at source.
4. Maintain drainage for spillover.
5. Size of the waterhole will depend on target species, habitat type, soil type and geographical features.
6. If water is channeled from nearby stream or river, environmental flow in its existing course should be maintained.
7. For improvement and restoration there should not be drastic alteration to the natural state of the waterhole.

4.5.2. Functions and benefits

1. Enrich the habitat by providing as drinking source, mud wallow and breeding ground for wildlife.
2. Reduce Human Wildlife Conflict (e.g. Deter wildlife from visiting settlements during dry seasons)
3. Contribute towards increasing carrying capacity/genetic diversity of the area
4. Enhance wildlife corridors and gene flow.
5. Promote aquatic biodiversity.
6. Helps to recharge watershed area and soil moisture conservation.
7. Serve as tourism product (wildlife watching)
8. Help in studying animal behavior.

4.5.3. Risks and Limitations

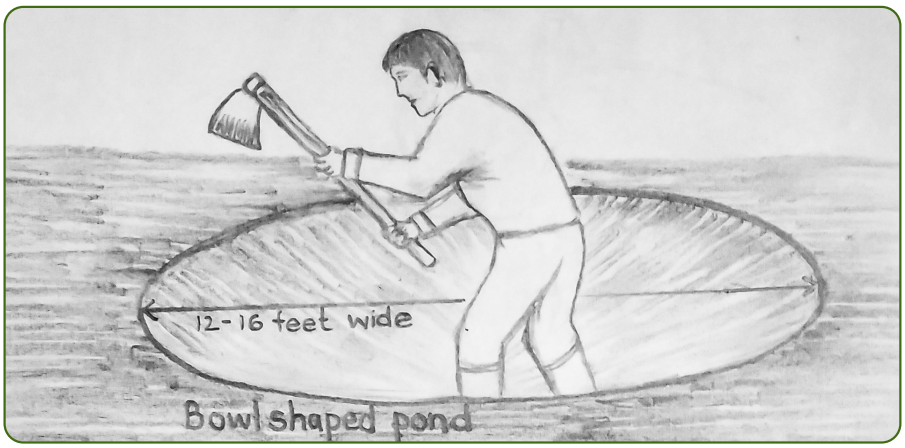
1. Increase risk of communicable diseases.
2. Increase the vulnerability of animals from poaching.
3. Creation of new waterhole may lead to environmental disturbance in the locality.
4. Creation of new waterholes may limit the movement of the animals thereby increases the chance of genetic depression.
5. Larger water holes may lead to erosion and flash flood especially during peak rainy season.

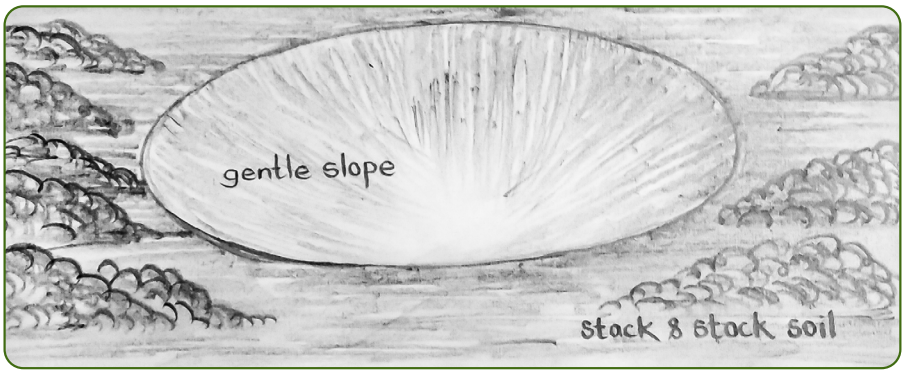
4.5.4. Implementation

New Creation

1. Dig and excavate earth to prepare bowl shaped pond.
2. If the waterhole is fed by seasonal rain, the size of the waterhole should be maximum of 16 feet wide and less than three feet depth.

3. If the water source is from perennial stream, size of the waterhole can be small.
4. If the dugout soil is clay, stack and stock for later use to smear the pond floor.
5. Prepare edge of the waterhole into gentle slope and shoreline into irregular shape.
6. Prepare smooth floor surface.
7. Layout waterproof canvas tarpaulin over the smooth floor surface.
8. Cover edge of the canvas tarpaulin with soil, stone and grass; to hold down and prevent tarpaulin from exposing the ground surface.
9. Place flat stones on top of the canvas tarpaulin and cover it with clay soil.
10. Establish quick cover grass within the disturbed periphery of the waterhole.
11. Source water from the identified water source into the waterhole.
12. If the area between the water source and the waterhole is located in the steep terrain, water need to be brought in high density polyethylene (HDPE) water pipes. Whereas if the water source in located in the gentle slope, water can be channeled through open cannels or drains.
13. In the areas where there is no water source available, harvesting the rain water and underground water for the waterholes may be explored.





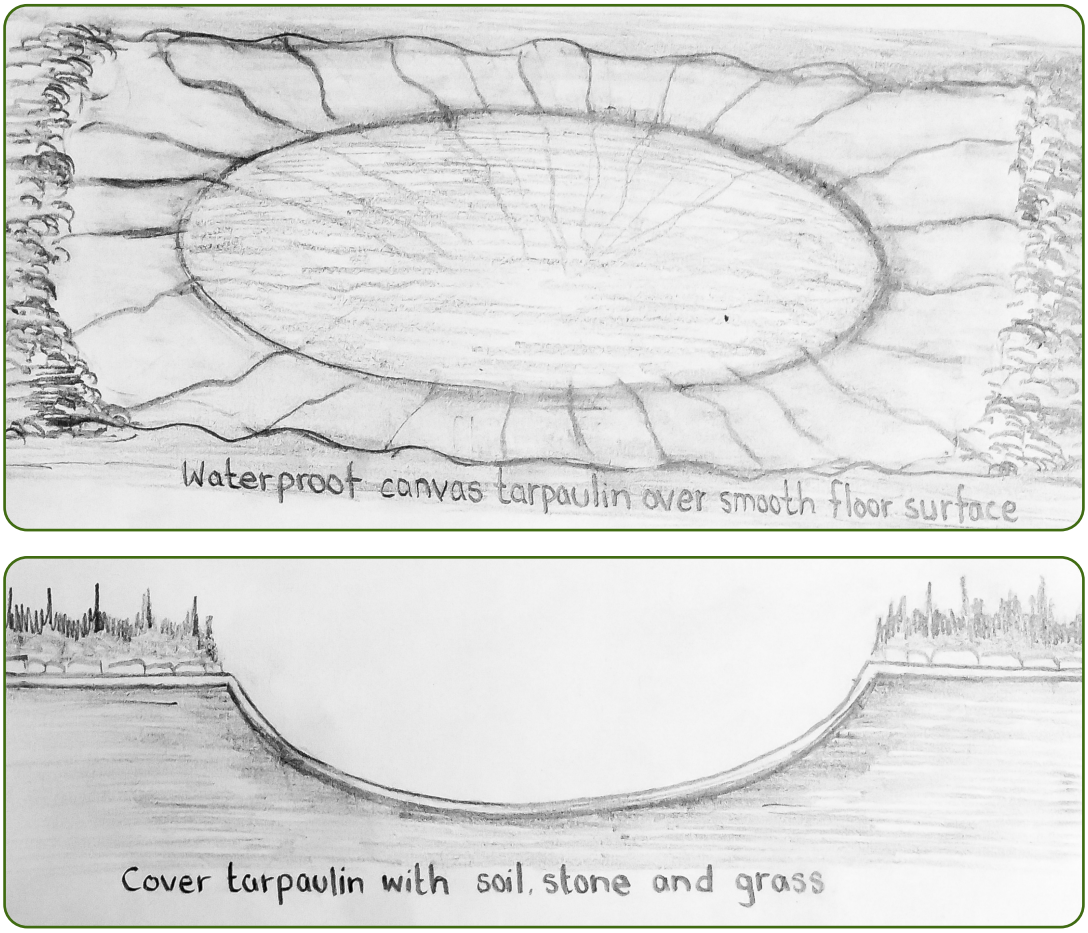


Figure 4.9. Design, shape and dimension of a waterhole

Figure 4.10. Waterhole improvement work in Royal Manas National Park

Improvement and restoration

1. Remove accumulated debris from the waterhole and dispose properly.
2. Leaf litter and accumulated sediment or mud should not be kept on the slope of inlet water flow.
3. In area where there is no adequate flow or no possibility to store water, consider fixing wooden tub.
4. The maximum length of wooden tub should be two meters.
5. Fix the tub at the side of the water course below ground level.
6. Channel only part of water into the tub and let the rest follow its original course.
7. In case of marshy areas or areas with noticeable underground water flow, create simple bowl shaped ponds for water collection.

4.5.5. Cost Estimates

The cost estimates for construction and maintenance of waterholes should be based on the following sub-activities and cost items:

1. Consultation with local communities (only if necessary).
2. Labour charges (for earth work, cleaning works, transportation of materials).
3. Hiring of machines (transportation of materials, earthwork).
4. Materials costs (canvas tarpaulin, stone, clay, sand, PPE gears, spade, crowbar, pick axe, knife, rope, shovel).

4.6. Mineral Licks Management

Mineral licks are deposits of mineral salts used by wild animals primarily by herbivores to get essential nutrients like calcium, magnesium, sodium and zinc to supplement their nutrition requirement. Some animals also use minerals to cleanse their internal system. In the context of Bhutan, mineral licks include naturally occurring mineral deposits on rock faces, black and brown soil, hot springs (*Tsha chhu*), mineral springs (*Maen chhu*), limestone caves and muddy areas.

Figure 4.11. A herd of elephant and gaur using the mineral lick area inside Royal Manas National Park

4.6.1. Technical considerations

1. No new creation of artificial salt or mineral licks shall be undertaken.
2. Spreading of any salt and mineral supplement to the existing natural mineral lick sites is not recommended.
3. If required, mineral supplement may be undertaken with special approval of the department.
4. Plantations should not be carried out in landslide areas used as mineral lick by wildlife.
5. Areas used as mineral licks by wildlife should be protected.

4.6.2. Functions and benefits

1. Supplements mineral requirements for wildlife.
2. Contribute towards increasing improving genetic diversity of the area.
3. Protects and prevent from possible diseases relating to nutritional deficiency.

4.6.3. Risks and Limitations

1. Increase wildlife poaching.
2. Increase the transmission of communicable diseases

4.6.4. Implementation

1. Carry out clearing of animal trails leading to mineral licks blocked by logs, boulders, landslide or others.
2. Divert human trail/routes away from the mineral lick areas.
3. Create awareness for the mineral licks located along roads or major trails
4. Install speed breakers and signage where ever necessary.
5. Strengthen monitoring of the mineral lick areas (SMART patrolling, camera trapping).

4.6.5. Cost Estimates

The cost estimates for maintenance of mineral licks should be based on the following sub-activities and cost items:

1. Labour charges (clearing of trails, boulders, landslides).
2. Materials costs (signages, speed brakers).
3. Awareness costs.

4.7. Special habitat management

Special habitats in the context of this document refer to the habitats for which the management interventions were not mentioned in the earlier habitat management prescriptions. Some of the special habitats that requires management interventions are as follows:

1. Habitats for Black-necked Crane (BNC)
2. Habitats for White-bellied Heron
3. Wildlife migratory routes
4. Habitats with den and snag trees

Other special habitats such as caves, cliffs, hibernation sites, escape terrain for ungulates, habitat for *Paphiopedilum* sp., migratory route for Takin and snag trees should be identified and mapped for protection.

4.7.1. Black-necked Crane Habitat

Black-necked Cranes are winter visitors for Bhutan and they prefer special habitats in few areas such as Phobjikha, Khotokha, Bumthang and Bumdeling. Special attributes of their habitats are wetlands, dwarf bamboos and agricultural lands which the bird use for various purpose such as roosting, feeding and stop over during their migratory flight. Therefore, different management interventions are required for respective purposes.

I. Creation and protection of roosting areas

Technical considerations

1. Improve roosting areas if the roosting area in the crane habitat are degraded.
2. Create roosting areas if there are high predation incidences in the wetland.
3. Create and improve roosting areas at least 300 meters away from human settlement and 100 meters away from tree line.
4. The managed roosting sites should not be very far from the feeding sites.
5. Create/maintain roosting area one month prior to their arrival.
6. Ensure minimal disturbance to the habitat during the activity implementation.
7. The use of weedicides and insecticides in and around the roosting sites is not recommended.

Functions and benefits

1. Minimize predation of cranes by predators.
2. Roosting sites are also used by other water birds.
3. Help in watershed management.

Risks and limitations

The new roosting area may also be visited by other water birds and congregations increase the risk of spread of avian diseases.

Implementation

1. Removal of grasses and woody vegetation in the proposed roosting sites.
2. Build dykes for roosting in the wetland. The dykes should not be taller than 0.6m and the length will depend on the number of BNCs visiting the area. It is usually kept at 50m.
3. The dykes should be built from mud blocks.
4. Conservation of the surrounding watershed for wetland sustainability.
5. Adequate awareness to the surrounding communities for building stewardship for species conservation.

Cost estimation

1. Labour charges (removal of grasses, building of dykes).
2. Material costs.
3. Awareness costs (signages, meeting).

Figure 4.12. Black-necked Crane roosting site maintenance at Phobjikha

II. Management and maintenance of safe flight paths

Technical considerations

1. Discourage installation of overhead cables along the flight paths.
2. Marking of overhead cables with flight diverters.
3. Encourage installation of underground power cables.
4. Use recommended brands/shapes/reflectiveness.

Functions and benefits

1. Reduce bird mortality due to collision.
2. Improve the aesthetic beauty of the landscape.

Risks and limitations

1. Installation and maintenance of underground power cables is expensive.
2. Uncertainty on the effectiveness of flight diverters

Implementation

1. Install bird flight diverters with 2 m interval
2. Install diverters with alternating colours

Cost estimation

1. Labour charges (installation of flight diverters)
2. Material costs (procurement of flight diverters)

III. Management and protection of foraging grounds and roosting sites

Technical considerations

1. Paddy fields and farm fields known to have hosted BNCs are to be left fallow in the winter.
2. Incentivize the farmers to maintain farmlands beneficial to BNCs.
3. Encourage organic farming to minimize use of chemical fertilizers and weedicides.
4. Monitor grazing by livestock in natural foraging grounds.
5. Restore historical foraging grounds and stopovers including farmlands.

Functions and benefits

1. Creates suitable foraging grounds for the cranes.
2. Built stewardship for species conservation.
3. Provides adequate food for the cranes.
4. Enhance livelihood of the surrounding communities.
5. Benefit other lesser known species dependent on similar habitats.

Risks and limitations

1. Reluctancy by the surrounding communities to cooperate with the proposed interventions.
2. Change in the farming practice by land owners.

Implementation

1. Remove overgrown vegetation in the foraging grounds and add top soil for enrichment.
2. Removal of flood debris in the wetland.
3. Encourage farmers to grow high yield (high drop) wheat/paddy.
4. Revival of fallow lands identified as important foraging ground.

Cost estimation

1. Labour charges (removal of vegetation and debris)
2. Seeds and seedlings for farmers

4.7.2. Management and protection of White-bellied Heron habitats

The White-bellied Heron (WBH) is found in riverine ecosystems of the inner Himalayas and foothills up to 1800 masl. They occupy inland swamps, lakes, and rivers with sand or gravel bars, often within or adjacent to temperate and subtropical/tropical broadleaved forests. It is preferably piscivorous, and it is mostly found feeding along the shallow banks with medium to low riffle at 30–60 cm water depth. They require tall trees of over 15 meters for roosting and nesting which are usually located near the water bodies. White-bellied Herons are sensitive to disturbances, particularly human caused disturbances and require a minimum of 150-200 m of flush distance. Disturbances often result in heron shifting to new habitat or even abandoning the area for a prolonged period.

Technical considerations

1. Ensure that the habitats (feeding, roosting, nesting) are identified and protected.
2. Minimize disturbance to WBH feeding, roosting and nesting sites.
3. Proper planning for alignment of transmission lines and other infrastructure

Functions and benefits

1. Protection of last remaining WBH habitats/riverine habitats.
2. Increase population and secure gene pool of WBH
3. Reduce transmission line collusion and electrocution of WBH
4. Community participation and stewardship in conservation.

Risks and limitations

1. Restriction of resource use by local communities sharing habitat with WBH.
2. Require huge financial cost.

Implementation

1. Map all feeding, roosting and nesting sites.
2. Install flight diverters in existing transmission lines within 200m from priority habitats.
3. Delineate the regular feeding sites along the river as sites prohibited for fishing.
4. Reduce human disturbances by delineating no go areas.
5. Restrict resource extraction from the identified no go areas.
6. Install DOs & DON'Ts information boards and signages in strategic locations and educate relevant stakeholders.
7. Conduct inter-agency collaboration meeting to reduce impacts of infrastructure development in the WBH habitat.

Figure 4.13. White-bellied Heron

Cost estimation

1. Field survey costs (mapping of feeding, roosting and nesting sites).
2. Labour charges (installation of signages, flight diverters).
3. Material costs (flight diverters).
4. Awareness costs (signages, meeting).

4.7.3. Management of Wildlife Movement Corridors

Description

Wildlife movement corridors are linear features that facilitates the movement of wildlife between two significant habitats. Such linear features have important attributes such as availability of adequate food, water, shelter and cover. With the development of linear infrastructure such as roads and power transmission lines, the wildlife movement corridors are often fragmented. In order to prevent such fragmentations and ensure seamless movement of wildlife across the landscape, it is vital that the movement corridors are protected and managed.

Technical considerations

Ensure animal movement corridors are considered while issuing forestry clearance.

Functions and benefits

1. Reduce road kills and electrocution.
2. Facilitates easy crossing and safe movement thereby increasing gene flow.
3. Help reduce human wildlife conflict.

Risks and limitations

1. Increase the risks of poaching.
2. Incur additional costs.

Implementation

1. Install appropriate information signages at strategic wildlife crossings.
2. Construct animal passages (crossing paths/ underpasses) at important animal crossings sites along the roads.
3. Set up canopy bridge/ feeder ropes/ glider poles connecting canopies for arboreal species.
4. Clear blockages (e.g. fallen tree/ landslide) if any along the animal trails or movement routes.

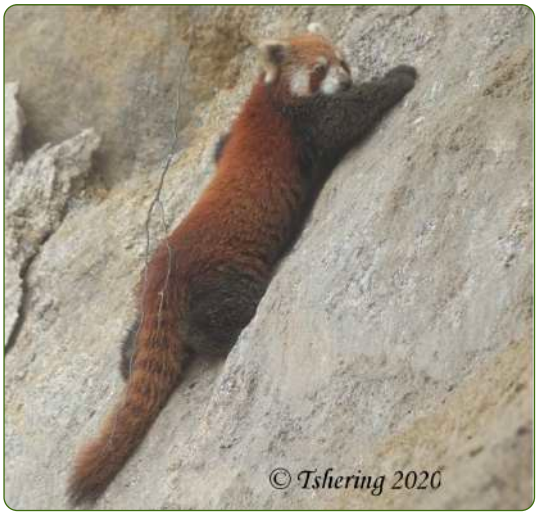


Figure 4.14. Red panda struggling to cross a steep road slope cutting

Cost estimation

1. Labour charges (removal of blockages, earthwork, masonry).
2. Hiring of machines (for creating crossing paths).
3. Material costs (feeder ropes, glider poles).
4. Signage costs.

Monitoring and evaluation

1. No. of road kills.
2. Usage of the wildlife crossing by migratory species.

4.7.4. Den trees and snags

Description

Den trees are living or dead upright trees and snags are dead upright trees with cavities or dead limbs that provide important habitat for a variety of birds, mammals and reptiles. The cavities are used for nesting, feeding, perching, escape cover and protection from the weather. Therefore, preserving and protecting the existing snag and den trees will protect the habitat for many species of birds, mammals and reptiles.

I. Retention or creation of den trees and snags

Technical considerations

1. Den and snag trees should be away from access roads and trails to reduce disturbance.
2. While selecting den or snag trees, look for broken-off tops and large branches, old scars, and existing cavities.
3. Trees with cavities closer to the top of the tree and with different diameters are ideal.
4. Live trees showing signs of reduced vigour, broken limbs, or scars may be good candidates for replacement of snags.

5. In the areas with outbreak of pests and diseases, snag trees should be removed.

Functions and benefits

Snags and den trees can provide feeding, nesting and roosting sites for a variety of wildlife.

Risks and limitation

1. The dead trees may invite pests and diseases.
2. Prone to accidents including forest fires

Implementation

1. Retain trees that have cavities of varying sizes and are located in the upper trunk of the tree.
2. Retain snag trees wherever required.
3. Repair den cavities based on the requirement of the species.
4. In case of den cavities on a clean bole, facilitate perching by fixing a piece of wood.

Figure 4.15. Great Hornbill

Cost estimation

1. Labour charges (repair of dens, fixing of perching stands)
2. Materials for perching stand (stand wood, nails, climbing gears)

CHAPTER V: MONITORING AND EVALUATION

While the habitat management interventions are implemented with a good intention to improve the wildlife habitat over time, there are every risk that the interventions can result into undesirable outcomes. Therefore, monitoring and evaluation is important to keep track of both positive and negative impacts of the management interventions through which timely interventions and rectification measures can be implemented. Regular monitoring of the activities should be planned and conducted by tying up with the existing monitoring mechanisms. However, in order to document and record status and trend of the outputs and outcomes, a separate monitoring of wildlife habitat management activities is recommended following the monitoring template below.

Table 3. Template for monitoring of wildlife habitat management activities

Activity	Unit	Baseline	Target	Location (Site name and GPS coordinates)	Observations	Recommendation

The monitoring activity should focus on the wildlife habitat management objectives as laid out in the management plan and measure outputs and outcomes from implementing the activities. The monitoring program should consist of the following two main components:

1. Determining whether the wildlife habitat management interventions are implemented correctly which is relatively straightforward.

2. Determining whether habitat management interventions had the desired physical and biological effects which is often much more complex, more difficult, and require longer term.

One important part of monitoring is assessing the habitat condition before and after the management interventions. An effective monitoring program will serve as the basis for making an objective evaluation and tracking courses of action and, when necessary, modifying the management plan.

The response of a target wildlife species to a habitat management intervention might entail many years of monitoring, given the lag time between the intervention, benefits of the intervention (e.g., food production), and the response of the wildlife species (e.g., density, productivity). Therefore, the duration of monitoring will depend on the nature of habitat management interventions and should be conducted accordingly. The findings from the monitoring of the activities should be incorporated into the management plan and necessary amendments should be made in the plan if the intended outputs and outcomes are not achieved.

Periodic evaluation of the wildlife habitat management interventions should be conducted both at central level and at respective field offices. The evaluation should be conducted based on the goals and objectives of the management plan while appropriate evaluation methods can be adopted. The evaluation process should consider the findings and inputs from the monitoring activities besides assessing the impacts of the habitat management interventions.

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