Technical Note

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NOVA SCOTIA
Environment and Labour
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Protected Areas Branch

Preliminary Assessment of the Ecological Impacts of the Wallace Lake Fire on Tobeatic Wilderness Area

Summary

In May 2003 a human-caused wildfire burned almost 600 ha of Tobeatic Wilderness Area. The greatest ecological impact is at the landscape scale, where the fire has reduced the total area of the landscapes two largest forest patches, thus diminishing forest interior habitats. The fire also decreased connectivity and increased fragmentation of large contiguous forest patches in an already highly fragmented landscape. Local-level impacts are greatest in the high intensity burn areas. High-intensity areas and some moderately burned areas have greatly altered the maturity class structure and species composition of the forest. Local-level ecological processes and biodiversity are also affected by the fire.

Introduction

Tobeatic Wilderness Area (TWA) was designated under the Wilderness Areas Protection Act in 1998. The establishment of the Wilderness Area was the result of an extensive systems planning process that began in the late 1980s. TWA was selected for protection because of the numerous attributes it brings to a system of protected areas in Nova Scotia. A high diversity of ecosystems is protected in TWA, which contains portions of six of the provinces Natural Landscapes. As the largest protected area in the Maritimes, and because of its relative inaccessibility, TWA ensures that a wide variety of habitats remain undisturbed, and that ecological processes function with minimal anthropogenic interference. Its spatial location on the height of land is important in protecting a vast array of headwaters, ensuring that aquatic ecosystem integrity remains high. TWA provides habitats for an array of rare, unique and special wildlife species including moose, pine marten, northen goshawk, southern flying squirrel and coastal plain flora. TWA also contains a number of old growth forests and sites of ecological significance, including Sporting Lake Nature Reserve.

Between 19 and 25 May 2003 a human caused fire burned nearly 600 ha of TWA. The fire started near Lake Wallace and is known as the Wallace Lake Fire.

Fire has the potential to alter principal ecological processes such as succession, nutrient and water cycling, and to drastically change the vegetational composition of the landscape, thus affecting biodiversity. The purpose of the following report is to provide a preliminary assessment of potential ecological impacts of the Wallace Lake Fire on the Tobeatic Wilderness Area and surrounding landscape.

Natural Environment of the Burn Area

The Wallace Lake Fire occurred within the Roseway River Glacial Plain Natural Landscape. The Roseway River Glacial Plain covers about 218,000 ha in southwest Nova Scotia. It is characterized by Acadian coniferous and non forested ecosystems on a variety of glacial deposits. The landscape has low relief and drainage is parallel, with several large south-flowing rivers and many lakes.

The Wallace Lake Fire occurred in a northeastern finger of the Landscape. Here bedrock consists of slate and schist of the Halifax formation; greywacke, slate and schist of the Goldenville formation; as well as a smaller area of granitic rock intrusion. Surficial geology consists mainly of stony till with organic deposits and occasional drumlins. Soils are podsolic and range in textures from silt loam to coarse sandy loam (Mailman 1975). In the well-drained areas soils tend to be deeper with some cementing in the B horizon in local pockets. Moderately to imperfectly drained soils are shallower with mottling in the upper and lower B horizons with cementing being common in the lower B and C horizons (Mailman 1975).

The Wallace Lake Fire area is in the Western Nova Scotia climatic region, which has high rainfall (1400 to 1500 mm average annual precipitation) and warm temperatures (average temperature for July is 18^0C and for January is 5^0C).

Ecosystem types within the burn area include imperfectly drained coniferous forest hummocks, well drained mixed forest drumlins, shrub and treed bogs, and shrub and treed fens. Typically, poor to imperfectly drained coniferous forest hummocks are dominated by a thick cover of black spruce with some balsam fir, red maple and larch (Figure 1). In hollows, a humid microclimate produces diverse and well developed bryophyte and lichen flora. The ground in moister areas can be dominated by a thick *Sphagnum* carpet with Schreber's and stair-step moss in less moist areas. Within the Wallace Lake Burn, the hummocks have better drainage and often are dominated by white pine with spruce and some times red oak and shade-intolerant hardwoods. Many of the stands of white pine are tall with large-diameter trees and well developed crowns. These stands have been undisturbed for many years and show many of the characteristics of older forests. Seven white pine stands within the burn area have been identified in the Protected Areas Branch Significant Old or Unique Forest database. A drumlin and other types of glacial deposits in the area of the burn also contain white pine as well as some hardwood and spruce. Soils on the drumlin

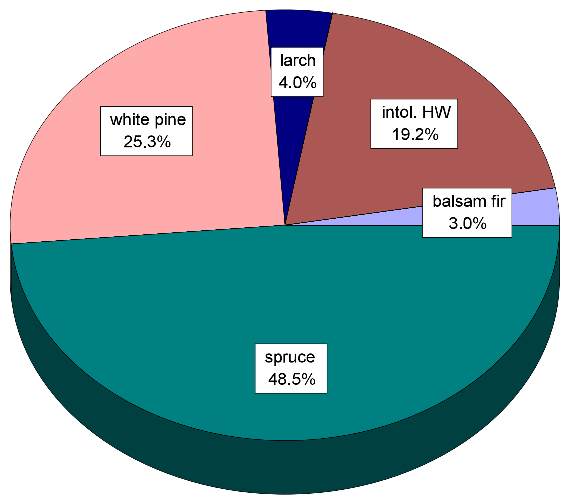

Figure 1 Tree species within the Wallace Lake Fire area pre-fire condition. Data from NSDNR Forest Inventory (2002)

are well drained and much richer than much of the surrounding landscape. Drumlins typically produce a rich diversity of flora because of these soil conditions.

Approximately 24% of the area burned was wetland, consisting mostly of shrub, treed and open bogs and fens, and small areas of red maple swale. About 75% of the burned area was forest. A small portion of the burn (<1%) was shrub and lichen barren.

The largest portion (51%) of the burned forest was considered to be in the stem exclusion development stage (Figure 2). Thirty-nine percent of the burn affected forest was classified as being in the understory initiation stage. Understory initiation stands were largely spruce and/or white pine dominated and had the greatest potential to develop old growth characteristics soonest. About 10% of the burned forest was edaphic climax having moist to saturated organic soils.

The development stage distribution reflects the history of the area. Heavy logging occurred in the area 50 to 60 years ago (Mailman 1975). There has been little human disturbance since then and forests were beginning to develop climax conditions for the Natural Landscape.

Large forest patches with interior forest habitat are important landscape features. The burn occurred on part of a large expanse of contiguous forest. The large patches are ecologically significant because little interior forest occurs in this highly fragmented landscape. There are large open barrens to the west and recent logging north, east and south of this portion of TWA, making the forest within the burn area regionally significant for a variety of species. Wildlife species that may depend on this type of continuous forest are generally rare. Species which have been associated with large continuous forest in Nova Scotia are varied and include moose,

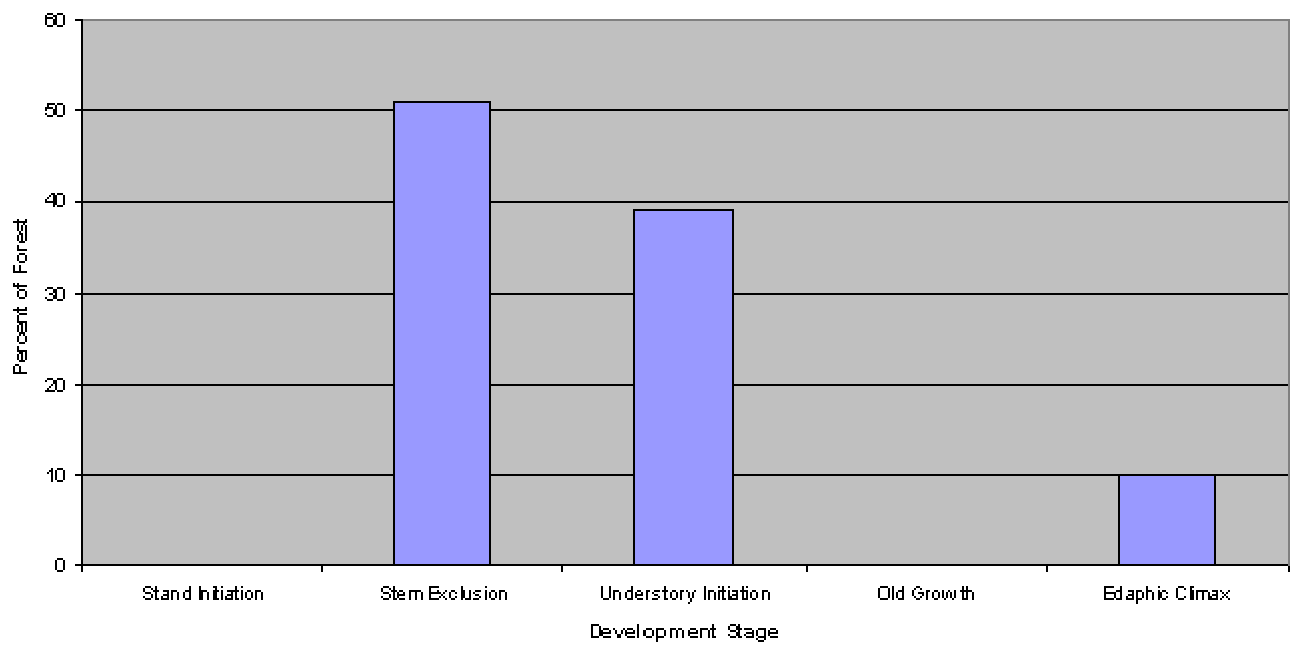

Figure 2 Forest Development Stages of the pre-fire forest of the Wallace Lake Fire.

pine marten and northern goshawk as well as certain lichens, bryophytes and beetles.

Fens and bogs have relatively low productivity and diversity of biota but contain a unique assemblage of species and provide hydrologic storage and maintenance of water quality.

Natural disturbances in the Roseway Glacial Plain include large-patch, small-patch and gap disturbance types. Typically, these natural disturbances are created by fungi, insects, wind and fire. High humidity, high precipitation and warm summer temperatures provide ideal conditions for fungal disease. Normally, fungi will attack single trees creating small gaps in the forest as trees die. There are few natural cyclic or irruptive insects in the Roseway Glacial Plain. Commonly, insects in the area kill individual trees or small groups creating gaps or small patches. Occasional large outbreaks of insects, like hemlock looper, may create larger patches. Nova Scotia is at the convergence of three storm tracks, resulting in frequent high winds and occasional hurricanes (Davis and Brown 1998). Thus, wind can occasionally create large patches of blown down trees. Generally, however, wind blows down individual trees and small groups.

The role of natural fire in The Roseway Glacial Plain is small. The Roseway Glacial Plain contains part of the Shelburne Barrens and because barrens have been frequently burned by human-caused fires in the last several centuries, some speculate that the area is naturally a fire disturbance driven system. There is little doubt that fire has probably occurred naturally in the Roseway Glacial Plain. However, the importance of fire as a natural disturbance in this landscape is overstated.

Most evidence suggests that fire is only one of several natural disturbances in the area and may not be the most important natural disturbance for this landscape. The frequency and size of lightning caused fires in Nova Scotia (and southwestern NS) is significantly less than human caused fires (Wein and Moore 1979). Wein and Moore (1979) attribute the smaller size of lightning caused fires to the effect of accompanying thundershowers which may control the wildfires. Lightning caused fires account for only 1% of the total number of wildfire occurrences in Nova Scotia (Wein and Moore 1979). Further, much of the Roseway Glacial Plain is within a band of some of the highest annual precipitation in the province and has been classified as a "rain forest" by some ecologists (Holien and Tonsberg 1996, Alaback 1991, Whittaker 1975).

Assessment Methods

The fire began near North Mountain Bald Brook, Shelburne County. The fire was human caused, starting from a campfire on 19 or 20 May. On Tuesday, 20 May the fire was first detected and action taken by the NS Department of Natural Resources to control it. By Wednesday 21 May, the fire was intense enough and large enough that water bombers from Newfoundland were despatched. By 22 May, after burning nearly 600 ha, the fire was under control. Mop-up operations continued until 25 May.

On 12 June the Wallace Lake Fire was flown over with a helicopter. Digital video photography was taken of the entire burn area. Staff conducted on-the-ground examinations of the burn in two locations. The locations were selected to provide access to the greatest diversity of soil, topography and burn intensity. Detailed notes of observations were made. Four soil pits were dug to determine depth of burn and soil conditions.

For the purpose of mapping, burned areas were classified according to level of burn intensity (low, moderate, high). A high-intensity burn resulted in trees being completely burned with no leaves or fine branches remaining. Shrubs and existing ground flora were completely burned. Ground litter was also completely burned in the high-intensity area as well as duff in some areas. High intensity areas compose about 200 ha or 38% of the burn area. Areas of moderate burn intensity consist of trees with blackened trunks and browned or burned leaves. Scattered trees have green foliage. Most shrubs, herbs and ground litter were burned. Approximately 216 ha or 41% of the area experienced a moderate burn. Areas of low burn intensity resulted from ground fire. Here, herbs, moss and some shrubs were burned. The fire was patchy in this area and left unburned areas. In these areas the tree canopy remains green. About 111 ha, or 21% of the area had a low-intensity burn.

Wetlands received the greatest intensity of disturbance, with 78% of the area of burned wetlands being in the high-intensity fire class. Only about 25% of the area of burned forest was in the high-intensity class.

Digital video photography was used to map burn areas according to intensity onto 1:10,000 aerial photography. Aerial photographs were then digitized for analysis using GIS.

Forest development stages were interpreted from NSDNR Forest Inventory. One hundred percent of high intensity burn areas and fifty percent of moderately burned areas are forecasted to return to the stand initiation development stage.

For patch analysis, areas of contiguous forest were mapped. Contiguous forest was considered forest with tree heights greater than five meters, crown closure greater than 50% and spatially connected. Patches were considered unconnected if separated by a 1:10,000 double line river, unforested areas, forests with crown closure of less than 50% and/or tree heights less than 5m and roads clearly discernable on the 2001, 1:10,000 colour aerial photographs.

In order to assess the impact of the fire at a landscape level an area approximately 40,000 ha surrounding the Wallace Lake Fire was selected for analyses.

Ecological Impacts

Short-term Local Impacts

The impacts of the fire will vary with intensity of the burn. However, all burned areas received some degree of ground fire and therefore all areas will have some degree of ecological impact to soil and ground organisms and processes.

All burned areas will have nutrient loss and reduced water retention. The majority of ground contains a layer of burned leaf litter. Studies have shown a decrease in wettability of burned soil, particularly for species with high levels of organic acids such as the ericaceous shrubs found in the Wallace Lake Fire. Reduced wettability reduces the amount of rainwater reaching the soil. Water tends to run off the surface until a sufficient layer of organic debris has built up. Also, with fewer live plants in the burn, less rainwater is retained. As a result, short-term impacts include increased erosion and nutrient leaching. Nutrient leaching and runoff are exacerbated by the rapid nutrient release caused by burning. Normally, nutrients contained within the biomass of ecosystems are recycled slowly through the ecosystem. Fire results in a rapid release of nutrients, some of which become volatile and lost through wind dispersal. Other nutrients are lost from increased rainwater runoff. As much as 60% loss of an ecosystem's nitrogen has been reported for wildfires. Both newly invading plants and plants that survived the fire may be able to take advantage of the nutrient flush, but this is a short-term benefit to the plants (Jeffrey 1987).

Increased erosion and associated ecological impacts will likely occur. Burned areas will exhibit decreased slope stability and a tendency for hastened particulate removal as a result of lost vegetation and increased soil exposure. Increased runoff from fires has been shown to have negative impacts to fish, aquatic invertebrates and amphibians (Gresswell and Bury 2003). Some of these impacts may be experienced in the Wallace Lake Fire because of its adjacency to the Jordan River and Stoney Brook.

Increased soil temperatures will have varying effects. Higher soil temperatures will occur as a result of changes in reflectivity, decreases in insulation and reduction of evaporative loss. For low and moderate burn intensities, higher soil temperature may increase soil microbial activity, at least initially, as more nutrients are available. High-intensity burn areas will see higher soil temperatures than moderate and low-intensity burn areas. This could result in a decrease in soil microbial activity due to high temperatures and low available moisture (Marshall 1992). Low microbial activity, high temperatures and low moisture create ideal conditions for establishment of stress tolerant early successional species and make it more difficult for stress intolerant forest-inhabiting species to survive or re-invade.

Soil processes will be most severely affected in high-intensity burn areas. Soil organisms are extremely important in ecosystem processes and may be affected by the ground fire. However, since the burn seemed to only penetrate a few centimeters into the duff, soil organisms will likely quickly recover in low and moderately burned areas. Soil processes may be affected by loss of mycorrhizae. Complete loss of mycorrhizal vascular symbionts results in complete loss of the mycorrihzal fungal symbiont. This may occur in high-intensity burned areas where complete burning of vegetation occurred. Re-colonization of these areas by fungal mycorrhizae requires dispersal from adjacent forest. Since most mycorrhizal fungi in this area are endomycorrhizal and therefore generally host specific, continued existence of populations requires presence of host species. Presence of host species is not assured in intensively burned areas as early successional species are more likely to establish. Reduced growth and survival of planted trees due to loss of endomycorrhizae has been shown to occur in clearcuts in western North America (Chanway 1992).

Short-term impacts of the fire to biodiversity are considerable. The types and numbers of organisms in the post-fire forest are greatly reduced from pre-fire conditions. High- and moderate-intensity fire areas provide ideal conditions for early successional annuals and biennial invasive species. As a result, the species composition within the current growing season may change dramatically.

Many invasive species in southwestern NS are exotics. Should exotic plant species become established, there may be long-term impacts and limited ability for some native species to reestablish. The likelihood of exotic species invasion is increased by the proximity of logging roads in adjacent lands, which tend to act as corridors for dispersal. In high and moderate intensity burn areas, some perennial plants that had not yet sprouted seem to be unaffected by the fire. Post fire sprouting was seen for painted trillium, bracken fern and pink lady's-slipper. Other perennials with well developed root systems are also likely to recover.

The change in plant species within moderate and high intensity burn areas also results in loss of certain habitat types. Older forest species will certainly be lost from the area for many decades. Half of the total forest is now in the stand initiation stage. More than 200 ha of the oldest forest (understory initiation and edaphic climax) has been set back to an earlier development stage (Figure 3).

Sprouting of burned hardwoods and establishment of early successional species in moderate and high intensity burn areas will likely increase winter browse for moose, deer and hare and increase summer forage for deer and hare.

Low-intensity burn areas will see fewer impacts to biodiversity and habitat except with regard to coarse woody debris. There will be an increased amount of coarse

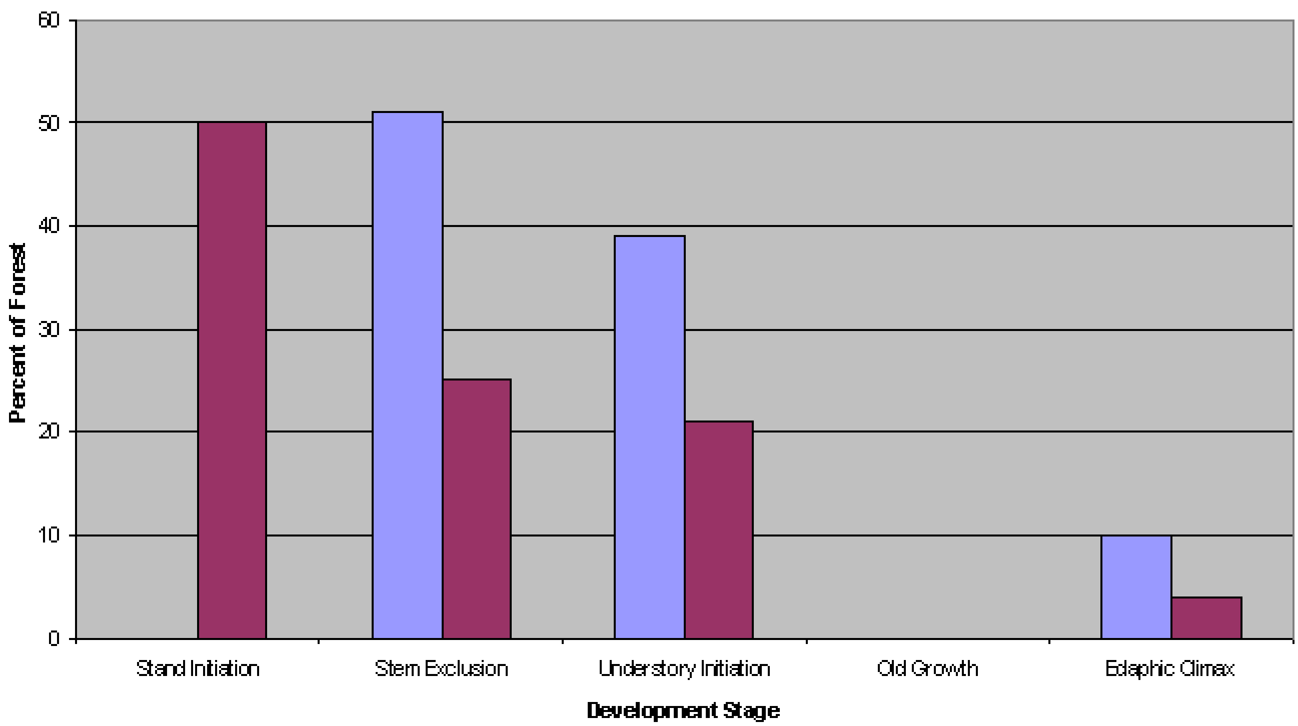

Figure 3 Change in forest development stage as a result of the Wallace Lake Fire. Light shading is the pre-fire and dark shading is the post-fire forest.

woody debris in low-intensity and some moderately-intensity burned areas. Injured trees will likely succumb to fungal and insect attack. Injured trees and trees killed by the fire will provide habitat for cavity nesters and coarse woody debris for many dependent species. High-intensity burn areas had a reduction in volume of pre-fire existing coarse woody debris. However, it is expected that this will be offset in the short-term by trees killed in the fire.

Trees injured in the fire may become epicenters for irruptions and dispersal of insect and fungi. Injured trees are more susceptible to attack by disease and insects (Schowalter 2000). The high number of injured trees from the fire may cause local increases in populations of these tree invaders. One result of the population increases may be a spread to adjacent mature forests and mortality of healthy trees.

Long-term Local Impacts

Most bogs and fens within the fire area were burned intensively. Little live above ground vegetation remains within these wetlands. Even *Sphagnum* species within the burn are burned or dead through heat or dessication.

However, it is expected the areas will return to pre-fire conditions relatively rapidly. Conditions that created the bog still exist and will favour re-establishment of bog species. High water table, acidic soil and a thick layer of organic material encourage species such as ericaceous shrubs, *Sphagnum* species and other bog inhabiting plants. Further, many of the roots of plants such as ericaceous shrubs likely survived the fire and will reprout. Seed banks within the lower unburned layers of organic material also have an opportunity to sprout.

Moderate- to high-intensity burned forest has seen considerable change in forest structure. This change will largely be in the form of a return to an early successional stage. For very high-intensity burn areas this may mean a return to a pioneer forest with early successional species. Typically in Nova Scotia, these species include aspen, white birch, cherries and red pine. Should this occur the area will take as much as 100 to 200 years to return to the former condition. Post fire condition of moderately-burned areas is more difficult to predict; however they are less likely to become entirely pioneer communities. There could well be a mix of pioneer species with climax species mixed in. This will not likely be an even mix; there will be pockets of pure climax species, of pure pioneer species and areas containing both. Successional patterns will be less well defined. In many cases pioneer species will quickly overtop later successional species. However because late successional species have some degree of shade tolerance, they may survive in the understory until the overstory begins to break up. Return to pre-fire conditions may take 60 to 100 years.

One of the larger concerns is that high-intensity burn areas will be invaded by ericaceous shrubs. Some species of erricacous shrubs are allelopathic (producing chemical substances which reduce establishment and/or survival of other species) and reduce ability of tree species to establish. This greatly slows the rate of succession. The pattern of ericacous species invasion and retardation of succession was seen in adjacent areas of the Shelburne Barrens. Should this occur within the Wallace Lake Fire area, return to pre-fire condition will likely take centuries.

Landscape Impacts

Patch Sizes

One of the most significant ecological impacts of the Wallace Lake Fire was the reduction in size of the largest contiguous forest patches in the landscape. Within the landscape in which the fire occurred, there are a large number of small contiguous forest patches, but few large patches (Figure 4). For example, there are only three patches of contiguous forest greater than 500 ha. The Wallace Lake Fire burned portions of the two largest patches in the landscape thus reducing the overall size of these large patches and the amount of available interior forest habitat. The two largest patches are the Dog Lake Patch which was 6790 ha and the Silver Lake Patch which was 1640 ha. Forest interior species are some of the most uncommon species in Nova Scotia because the rarity of large patches of contiguous forest.

Loss of Older Forest

Conversion of about 200 ha of older forest to an early development stage reduces the opportunity for maintaining biodiversity across the landscape. Older forests contain species not found in younger forests. Maintaining diversity within a forested landscape requires that a significant portion be maintained in old growth (Hunter1990). Less than 0.2% of the total area of Shelburne County contains Significant Old or Unique white pine forest (Protected Areas Branch SOUF). Several of these SOUF stands were burned in the fire and have been converted to an earlier development stage.

Connectivity

The Wallace Lake Fire increased the fragmentation of large forest patches and decreased the connectivity between the large patches. Fragmentation and decrease connectivity can have significant impacts on forest interior species.

Fragmentation and isolation of large contiguous forest patches has occurred as a result of the fire. The two large forest patches in which the fire occurred are part of a cluster of large patches in a fragmented landscape. West of the large patch cluster is a large, open, unforested barren. North, east and south of the large patch cluster there has been recent tree harvesting and construction of numerous roads. Tree harvesting and road construction have been increasing over time in these areas causing, increased fragmentation of the landscape. The burn occurred in the south-central portion of the large patch cluster, creating a large open area and thus fragmenting the large forest cluster.

Connectivity of the large patch cluster has also been compromised by the fire. The two largest forest patches, which were partially burned, are separated in the north of the study area by lakes and numerous roads. However, the West Branch Jordan River separates these two patches in the south and central portion by only 30 to 10 m, thus providing only a narrow separation between the two largest forest patches. In the burn area the separation has been increased to hundreds of meters.

The landscape level impacts of the Wallace Lake Fire will vary in duration between species. For example connectivity for some species may re-occur shortly after the burn is re-vegetated. For other species, connectivity may not be possible until the forest returns to pre-fire conditions in 100 to 200 years.

Different types of landscape-level impacts can compound one another, can be cumulative and can have long-lasting or permanent effects. For example, the landscape of the burn area has been highly fragmented by frequent tree harvesting and road construction in the last two decades. The shrinking of yet more interior forest as a result of the Wallace Lake Fire compounds this problem and at some point sensitive species will be lost, if they have not been lost already.

Conclusion

The greatest ecological impact is at the landscape scale, where the fire has reduced the total area of the landscapes two largest forest patches, thus diminishing forest interior habitats. The fire also decreased connectivity and increased fragmentation of large contiguous forest patches in an already highly fragmented landscape. Local-level impacts are greatest in the high intensity burn areas. High-intensity areas and some moderately burned areas have greatly altered the maturity class structure and species composition of the forest. Local-level ecological processes and biodiversity are also affected by the fire.

Follow Up Activities

This report is an initial evaluation of the Wallace Lake Fire impacts. It is the intention of Protected Areas Branch to collect additional information on plant species occurrence and abundance and ideally, soil organism species occurrences and abundances over time. Pre and post fire satellite imagery will be used to help define the extent and intensity of the burn. Scientific research through partnerships will be encouraged to help provide more in depth study.

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