Chapter

Prescribed Burning to Restore Eastern White Pine Forests of La Mauricie National Park of Canada

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Abstract

Eastern white pine forests of La Mauricie National Park of Canada have been severely affected by logging and forest fire suppression since the 1850s, and by the exotic white pine blister rust since the beginning of the twentieth century. These alterations have changed the ecological trajectory of eastern white pine ecosystems, which now appear hardly sustainable. Eastern white pine saplings are nearly absent, and balsam fir saplings are strong competitors for space and light. Since 1991, Parks Canada uses prescribed burning for restoring eastern white pine ecosystems. We studied seven pine stands in which prescribed burning was applied and compared them with nine unburned stands. Over 63% of balsam fir saplings were killed by prescribed burning, thus eliminating a significant part of the competition to eastern white pine seedlings. These were four times more abundant in burned than in unburned sites (21,333 vs. 5178 seedlings/ha). In the short term, the eastern white pine regeneration objectives established by Parks Canada have been achieved. Pine seedlings growth is slow, and they should be monitored regularly to ensure long-term success of this restoration programme. If necessary, it might be helpful to increase light penetration by girdling mature balsam firs or spruces.

Keywords: *Pinus strobus*, eastern white pine, prescribed burning, ecosystem restoration, protected area, regeneration, competition, *Abies balsamea*, balsam fir

1. Introduction

Over the last decades, changes in forest composition from primeval stages and the rarefaction of certain tree species have raised several concerns for biodiversity conservation [1, 2]. For example, the widespread mortality of ash trees caused by the alien invasive Emerald ash borer (*Agrilus planipennis* Fairmaire), recently introduced in North America, could threaten 43 native arthropod species feeding or breeding only in ash trees [3]. Indeed, exotic insect pests and pathogens may lead to tree species shifts and be a driving force behind important changes in ecosystem processes [4]. This already occurred in western North America where the exotic white pine blister rust, *Cronartium ribicola* J.C. Fisch., introduced at the beginning of the twentieth century, affects seven of the eight white pines (subgenus *Strobus*) [5]. For instance, the whitebark pine (*Pinus albicaulis* Engelmann) has been extirpated locally because of the combined actions of the white pine blister rust, an indigenous insect, and fire suppression policies [6]. These authors consider the whitebark pine as a foundation species because it provides locally stable conditions needed by several co-occurring species. Its loss thus alters several ecosystem processes such as forest productivity and hydrology [6]. According to Tomback and Achuff [5], without active management, many pine-associated communities may disappear and their loss would result in severe impacts to biodiversity and other ecosystem services. They recommend using timely proactive restoration programmes to avoid or at least mitigate losses in pine ecosystems.

In eastern North America, the eastern white pine (*Pinus strobus* L.) was also much more prevalent in pre-settlement forests than it is today [7–9]. Eastern white pine is the tallest tree in eastern North America and ecologically typifies the northern forests of eastern United States [10]. This noble tree species has been important for economic, social, and cultural reasons [11]. As western white pines, it has been also severely impacted by the exotic white pine blister rust, *Cronartium ribicola* J.C. Fisch [12]. Moreover, fire suppression policies have altered the natural dynamics of eastern white pine stands by allowing shade-tolerant species, such as balsam fir (*Abies balsamea* L.), to outcompete pine seedlings [8, 10, 13–15]. Finally, selective logging of mature eastern white pines during the eighteenth and nineteenth centuries has reduced seed tree density and, thus, its regeneration potential [16, 17].

Historically, eastern white pine regeneration was favoured by surface fires, which improve seedbed quality, increase light availability, and reduce competition from saplings of other shade-tolerant tree species [7, 14, 18]. Mature eastern white pines survive most surface fires due to their thick bark [19], branch-free lower trunks, and deep roots [20]. Their needles have a low content of resin and thus are not highly flammable [21]. Eastern white pine reaches the northern limit of its range in the southern part of eastern Canada, where most ignitions are rapidly suppressed for safety reasons. Other than fire, the natural regeneration dynamics of eastern white pine in old stands is still poorly understood, mainly at the northern limit of its range [11]. Recent studies have recognized the importance of gap dynamics, which is closely related to understory light for seedlings [22, 23]. Uprety et al. [11] concluded that management strategies should be different near the northern range limits because site conditions and disturbances have different effects than in the centre of a species' range. Regenerating eastern white pine thus remains an important challenge and researchers still test methods to reduce the effect of competing vegetation [24]. However, this mainly involves using herbicides [24] or thinning [25], approaches not compatible with the mandate of national parks.

The *Canada National Parks Act* requires maintaining or restoring the ecological integrity of the parks through the protection of natural resources and ecological processes. Ecological integrity is defined as 'a condition that is determined to be characteristic of its natural region and likely to persist, including abiotic components and the composition and abundance of native species and biological communities, rates of change and supporting processes' [26]. Because several parks have been established in areas previously disturbed by logging, Parks Canada often needs to develop management approaches to restore these ecosystems to make them sustainable for future. The objective of restoring the ecological integrity of eastern white pine forest ecosystems to pre-settlement conditions, or at least within their historic range of variability [27, 28], might be achieved by using prescribed burning as a management approach [29, 30]. In the context of a national park, prescribed burning represents a tool for reintroducing a natural ecological process. Prescribed burning has been shown to promote regeneration of several fire-favoured pine species, such as *P. ponderosa*, *P. pungens*, and *P. rigida* [31–34], but its efficacy remains to be demonstrated in eastern white pine forests.

In La Mauricie National Park of Canada, eastern white pine proportion was estimated at 5–12% in pre-settlement forests but now represents only 0.5% of the current forest composition. Meanwhile, balsam fir has increased from 13.1 to 31.8% [35–37].

Between 1991 and 2005, a total of 10 Eastern white pine stands have been treated with prescribed burning in La Mauricie National Park of Canada. The objectives of prescribed burning are to generate ecological conditions for increasing eastern white pine seedling density (short-term objective) to bring saplings density up to 100/ha (mid-term objective) in order to increase the cover of eastern white pine-dominated stands to 3–4% (long-term objective) in the future forested area of the park [15]. As the number of published studies addressing the ecological effectiveness of management practices in protected areas is limited [38], this restoration programme represents a unique opportunity to evaluate the effects of prescribed burning, as a sustainable management practice for a national park. The objective of this study was to determine if prescribed burning reduces competition and favours eastern white pine regeneration. We hypothesized that prescribed burning would kill most balsam fir competing saplings, thus reducing competition for light and promoting eastern white pine regeneration.

2. Materials and methods

2.1 Study area, stand selection, and burn treatment

The study was carried out in La Mauricie National Park of Canada (**Figure 1**), which is located in Quebec, Canada. The park was established in 1977 and covers 536 km^2. It belongs to the sugar maple-yellow birch bioclimatic domain and is a typical Laurentian Mountains landscape moulded with hills and lakes. Annual precipitations vary between 900 and 1400 mm and annual mean temperatures vary between 2.5 and 5.0°C [39]. Seven stands treated with prescribed burning between 1995 and 2005, and nine unburned stands, were selected over an area of 40 km^2. The altitude of the 16 selected stands ranged between 217 and 341 m and their slope varied between 1 and 47% (**Table 1**).

Prescribed burning was used in stands where eastern white pine density was >15 trees/ha, the slope <50%, and balsam fir saplings dominated the understory. In these sites, eastern white pine seedling and sapling densities were considered too

Figure 1.
Old white pine stand along the Wapizagonke lake in La Mauricie National Park of Canada.

Site	Fire intensity	Humus (cm)	Altitude (m)	Slope (%)
Burn 2005	3	2.7	242	4
Burn 2004	3	4.3	245	2
Burn 2003	3	3.7	341	41
Burn 2001	3	5.3	286	26
Burn 1999	4	6.7	217	5
Burn 1997	2	7.3	250	4
Burn 1995	2	6.7	262	1
Control 1	-	6.0	259	5
Control 2	-	9.0	314	38
Control 3	-	9.3	303	47
Control 4	-	6.7	220	1
Control 5	-	6.7	277	46
Control 6	-	5.3	249	9
Control 7	-	4.3	264	16
Control 8	-	5.7	259	18
Control 9	-	9.3	239	9

Table 1.
Description of the 16 sites studied at La Mauricie National Park of Canada.

Figure 2.
Parks Canada crew using a driptorch to run a prescribed burning experiment in a white pine stand at La Mauricie National Park of Canada.

low to ensure eastern white pine renewal, thus preventing the park from reaching its objective of maintaining or restoring ecological integrity [40]. Burning prescriptions were defined using the Canadian Forest Fire Danger Rating System [41] and the software FBP97 for forecasting fire behaviour [42]. Prescribed burnings were carried out during spring because burning conditions are more suitable before bud flushing of broadleaved trees and shrubs [43]. When conditions were appropriate, fire was ignited using burners (driptorch; **Figure 2**) or a helicopter equipped with a Premo MK3 aerial ignition device. Low-intensity surface fires were isolated and controlled with natural and artificial firebreaks. Flame height and length were recorded during each prescribed burning event by the park's staff and were used to estimate fire intensity based on the Canadian forest fire behaviour prediction system [41] (**Table 1**). For low-intensity surface fires, these classes range from 1 (frontal fire intensity < 10 kW/m; flame length < 0.2 m; flame height < 0.1 m) to 5 (frontal fire intensity > 4000 kW/m; flame length >3.5 m; flame height >2.5 m). In our study, fire intensity in burned sites mostly belongs to class

3 (frontal fire intensity: 500–2000 kW/m; flame length: 1.4–2.6 m; flame height: 1.0–1.9 m). However, fire intensity reached class 4 in the stand burned in 1999 (frontal fire intensity: 2000–4000 kW/m; flame length: 2.6–3.5 m; flame height: 1.9–2.5 m) and killed many mature trees including some eastern white pines.

2.2 Forest inventory

Three 400-m^2 circular plots located 50 m apart along a transect and at a minimum distance of 50 m from stand or treatment edges were set up in each stand to describe the forest environment. In each plot, we recorded the slope (%), altitude (m), surface deposit, drainage, and thickness of the soil organic layer (litter and humus) (**Table 1**).

Species, diameter at breast height (hereafter DBH), and decay class of each standing tree or snag ≥9.1 cm at DBH were recorded. Decay classes were determined according to Hunter classification [44], which recognizes nine classes for trees (1: alive and 2: declining) and snags (3: dead tree with bark intact up to 9: stump). Because most pines were large and tall, their density was rather low and, to get more accurate estimates of their basal area, we enlarged the sampled plots up to 1200 m^2 (radius = 19.55 m). In each 400-m^2 plot, four smaller plots of 25 m^2 (radius = 2.82 m) and four micro plots of 4 m^2 (radius = 1.13 m) were established at 8.46 m from the plot centre, in each cardinal direction. Saplings and seedlings were recorded in the 25 and 4-m^2 plots, respectively. Saplings were defined as young trees in which DBH ranged between 1 and 9 cm, whereas seedlings were very young trees with DBH smaller than 1 cm [45]. Sapling DBH was measured and seedling height was recorded into 5-cm classes. Eastern white pine relative dominance was estimated on the basis of its relative basal area (hereafter BA, in m^2/ha) in 1200-m^2 plots, in relation to BA of other tree species estimated in the 400-m^2 plots.

2.3 Statistical analysis

As stands had not been sampled before treatment, the short-term effects of prescribed burning were assessed using the percentage of recent tree or sapling mortality in 1- to 7-year-old burns (older burns could not represent short-term effects of prescribed burning) and compared to unburned stands. Tree BA and sapling density (stems/ha) were calculated for eastern white pine, balsam fir, spruces, and broadleaved species. Then, the percentages of recent mortality (Hunter classes 3 and 4) were calculated for both burned and unburned stands. Student's t-tests were used to compare recent mortality of trees and saplings in both stand types. We also used Student's t-tests to compare seedling density in burned and unburned stands. Sites burned in 2004 and 2005 were excluded from the seedling analysis because no seed crop had occurred after the treatment, thus precluding the establishment of regeneration in these stands. Logarithmic transformations (log x + 1) were used to normalize the distributions and stabilize variances when necessary. When transformations did not achieve equality of variances, we used results obtained with Satterthwaite's approximate t-test, a method that belongs to the Behrens-Welch family [46]. Analyses were performed using SAS software v. 9.1. [47].

3. Results

Forest composition of unburned stands was dominated by conifers, with slightly more than 75% of the tree basal area belonging to eastern white pine and other conifers, mostly spruces (**Table 2**). Balsam fir represented less than 10% of tree basal area, and broadleaved trees slightly more than 15%. Prescribed burnings significantly

Stage	Species	Initial BA[1] or density[2] of live trees		% of recent mortality		df	t	p
		Burned	Unburned	Burned	Unburned			
Tree	*P. strobus*	13.7 ± 2.8	11.4 ± 2.0	1.4 ± 0.8	2.4 ± 1.5	14	0.52	0.611
	A. balsamea	3.1 ± 0.7	3.1 ± 1.1	38.2 ± 12.7	3.7 ± 2.1	14	3.20	**0.006**
	Other conifers	14.6 ± 2.7	18.1 ± 2.9	18.4 ± 6.8	10.7 ± 2.8	14	1.07	0.304
	Broadleaves	6.1 ± 1.3	5.8 ± 1.2	39.0 ± 8.8	14.3 ± 3.3	14	2.81	**0.014**
	Total	37.8 ± 3.4	38.1 ± 2.2	18.8 ± 4.5	11.3 ± 1.8	14	1.65	0.120
Saplings	*P.strobus*	9 ± 6	26 ± 11	0.0 ± 0.0	0.0 ± 0.0	-	-	-
	A.balsamea	2590 ± 372	2396 ± 427	67.4 ± 7.3	9.2 ± 2.6	14	4.28	**0.001**
	Otherconifers	214 ± 144	437 ± 132	43.4 ± 18.0	4.1 ± 2.0	14	1.37	0.192
	Broadleaves	238 ± 57	189 ± 44	37.0 ± 11.7	6.1 ± 3.2	14	2.42	**0.030**
	Total	3052 ± 333	3048 ± 391	63.6 ± 6.9	9.2 ± 2.3	14	4.46	**0.001**

[1] basal area for trees (Burned sites = 7 / Unburned sites = 9)
[2] density for saplings (Burned sites = 5 / Unburned sites = 9)

Table 2.
Comparison of average (± S.E.) initial tree basal area and sapling density (before burning) and of the % of recent mortality of different species in burned and unburned stands. Student t-tests were used to compare mortality averages between treatments (significant ones are in bold).

increased the mortality of balsam fir and broadleaved trees, with respectively 38.2 and 39.0% compared with 3.7 and 14.3% in unburned stands (**Table 2**). Mature eastern white pine trees and other conifers were not significantly affected by the burning treatment, except in the 1999 burn which was the most intense (**Table 1**). Eastern white pines were well distributed among DBH classes, with maximum densities recorded between 20 and 60 cm of DBH (**Figure 3A** and **B**). However, small balsam fir trees (≤20 cm) as well as saplings outnumbered eastern white pines (**Figure 3C** and **D**). Balsam fir saplings represented 80% of total sapling density while eastern white pine represented only 0.9% (**Table 2**).

Saplings of balsam fir and broadleaved species were significantly affected by the burning treatment (**Table 2**; **Figure 4**). Mortality averaged 67.4 and 37.0% respectively for balsam fir and broadleaved saplings in burned stands compared with 9.2 and 6.1% in unburned stands (**Table 2**). The most severely burned stand (1999) had killed 93% of the balsam firs, which was 25% higher than in any other burned stand. Overall, mortality of saplings was significantly higher in burned stands (63.6%) than in unburned ones (9.2%) (**Table 2**). However, after burning, the density of balsam fir saplings was still high, mostly because patches of the forest remained unburned in some stands (**Figure 3C**).

Eastern white pine seedling density was lower than for balsam fir in each height class observed in unburned stands (**Figure 3F**) and they represented only 26.7% of all seedlings (**Table 3**). Moreover, they never reached more than 75 cm in height (**Figure 3F**). Prescribed burnings increased the density of eastern white pine seedlings significantly when compared with unburned stands (**Table 3**), their proportion increasing from 26.7 to 83.7% of all seedlings in burned stands. By contrast, the proportion of balsam fir seedlings decreased from 39.6% in unburned stands to 20.6% in burned ones (**Table 3**). However, eastern white pine seedlings were largely dominant in the first five height classes (1–25 cm), but they rarely exceeded 50 cm. Balsam fir seedlings were more evenly distributed up to 130 cm and dominated eastern white pine seedlings in all height classes higher than 25 cm (**Figure 3E**).

No distinctive pattern in eastern white pine seedling growth was obvious along the burning chronosequence. Stands burned in 2004 and 2005 only harboured 417 seedlings of eastern white pine per hectare because these sites (1–2 years after burning) had not yet benefited from a good seed production year [48, 49].

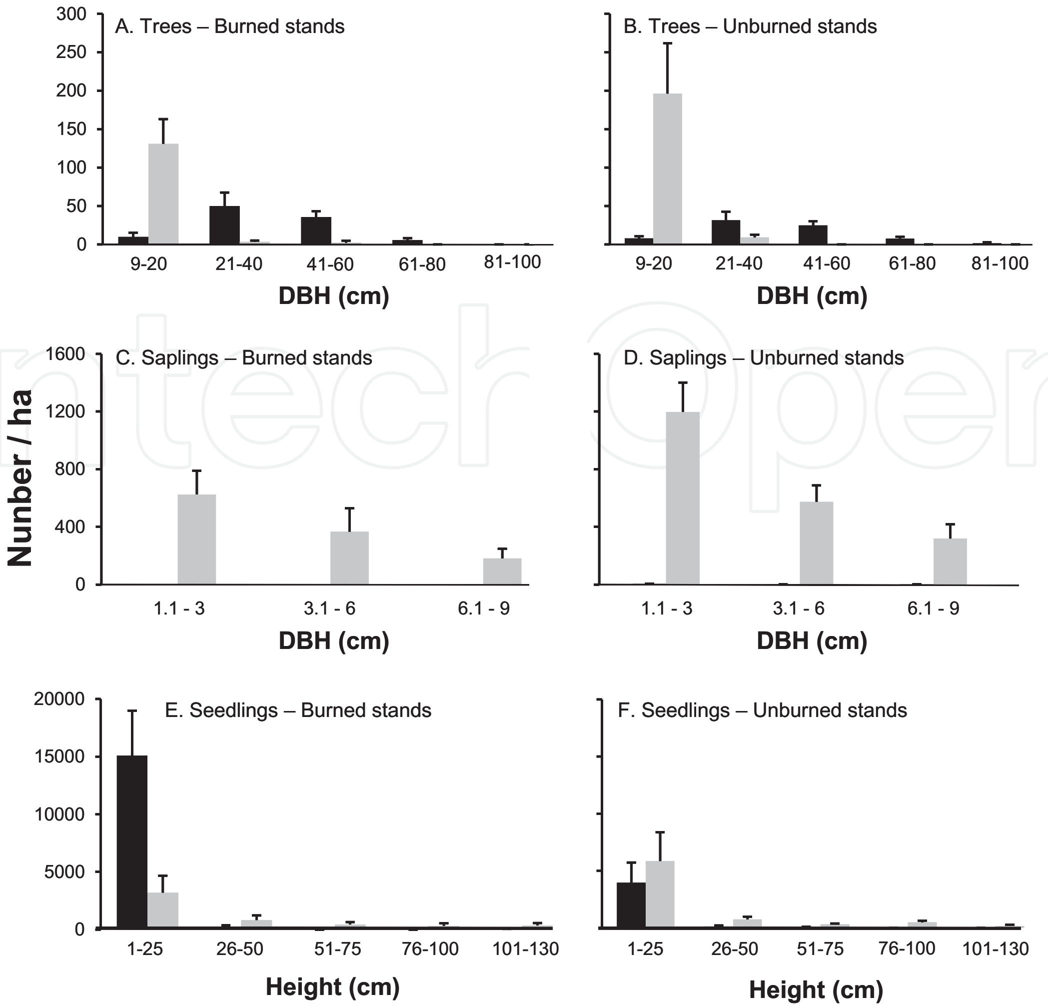

Figure 3.
Comparisons of eastern white pine (black bars) and balsam fir (grey bars) tree (A and B), sapling (C and D), and seedling (E and F) densities (mean ± S.E.) between burned (n = 7) and unburned white pine stands (n = 9) of La Mauricie National Park of Canada.

Figure 4.
Photo showing abundant competing balsam fir seedlings and their reduction 1 year after a prescribed burning in an eastern white pine stand at Lac Guilinette of La Mauricie National Park of Canada.

Stage	Species	Density / ha (mean ± SE) Burned	Density / ha (mean ± SE) Unburned	p	Proportion (%) Burned	Proportion (%) Unburned
Seedlings	*A. balsamea*	5250.0 ± 1869.7	7592.9 ± 2451.8	0.543	20.6	39.6
	P. strobus	21333.0 ± 1368.7	5135.8 ± 1716.6	<0.0001	83.7	26.7
Saplings	*A. balsamea*	746.4 ± 250.6	2017.2 ± 296.1	0.016	52.0	80.1
	P. strobus	6.6 ± 6.6	24.2 ± 9.7	0.255	0.3	0.9

Table 3.
Comparison of living sapling and seedling densities (after burning) of Eastern white pine and balsam fir in burned (n = 5; 2004–2005 excluded) and unburned sites (n = 9).

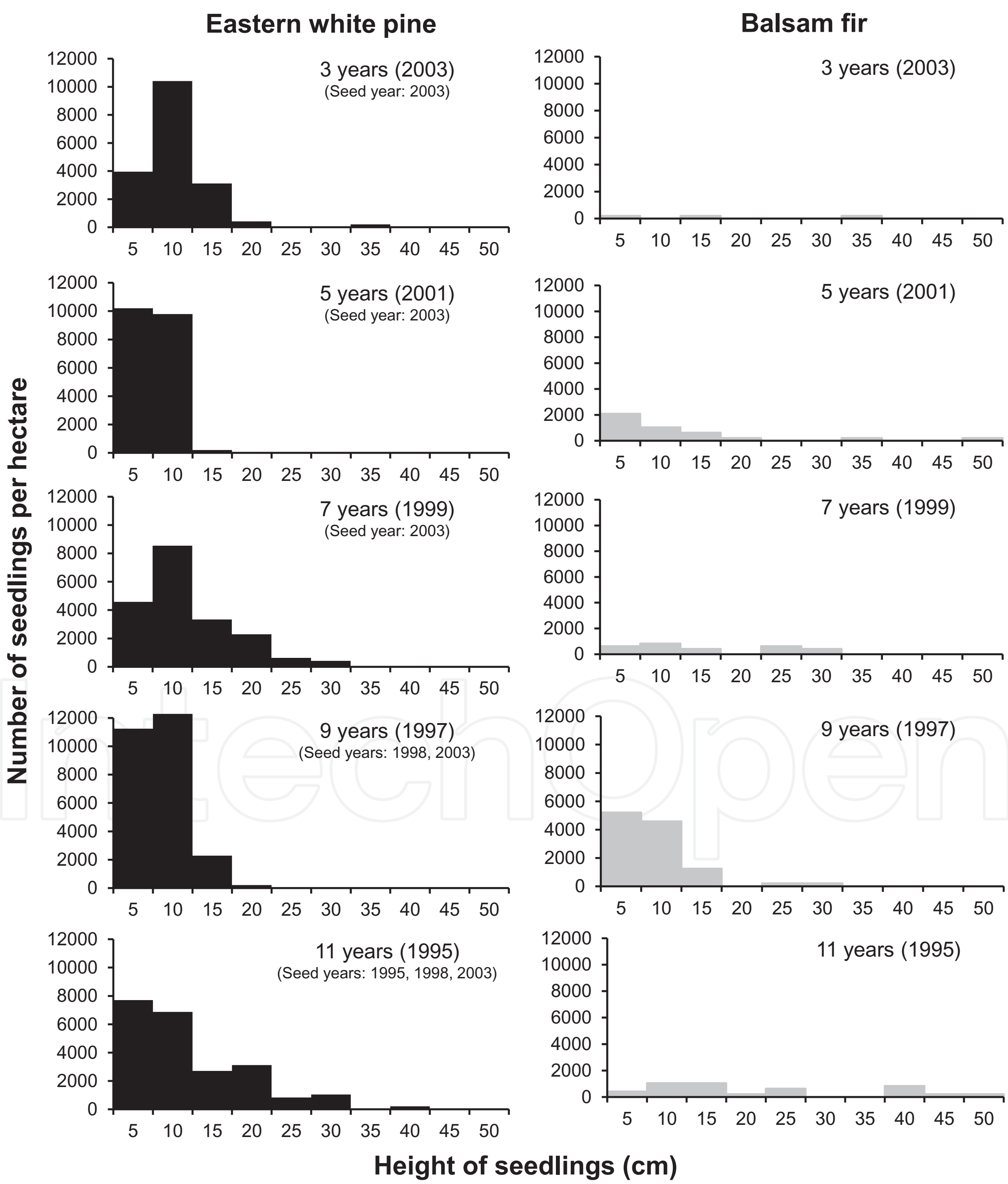

Figure 5.
Distribution of eastern white pine and balsam fir seedlings among 5-cm height classes in burned stands of various ages in La Mauricie National Park of Canada. No eastern white pine seedling exceeded 45 cm of height.

The stand burned in 2003 (3 years) was exposed to a good seed crop the summer after the treatment and regeneration was the most plentiful in the 5- to 10-cm height class. The stand burned in 2001 (5 years) was exposed to a good seed crop 2 years after the treatment and seedlings were slightly more abundant than in the stand burned in 2003, with almost all seedlings being found in the 5- to 10-cm height class (**Figure 5**). In the stand burned in 1999 (7 years), eastern white pine seedlings were asymmetrically distributed to the right of the 5- to 10-cm height class, with seedlings reaching 25–30 cm (**Figure 5**). However, the stand burned in 1997 (9 years), which benefited from two good seed crops (1998, 2003), did not harbour more eastern white pine seedlings than the other stands, with its seedlings being mainly found in the first two height classes (1–5 cm and 5–10 cm) (**Figure 5**). In the oldest burned stand (1995; 11 years) that benefited from three good seed crops, seedlings were mainly found in the first two height classes. However, eastern white pine seedlings reached their maximum height (40–45 cm) in this stand. Balsam fir seedlings <50 cm high were not abundant in any of these five burned stands compared with eastern white pine seedlings, the only one showing more than 10,000 balsam fir seedlings/ha being the one that burned in 1997 (**Figure 5**).

4. Discussion

Prescribed burnings carried out in La Mauricie National Park of Canada killed 38 and 67% of competing balsam trees and saplings respectively and increased eastern white pine seedling density up to an average of 21,133 seedlings/ha, compared with 5135 seedlings/ha in unburned stands. This is higher than the 12,000 seedlings/ha reported 5 years after small scale (0.2 ha) prescribed burning trial done in an eastern white pine stand at the Petawawa forest research station located in Ontario [41]. Stands burned in 2004 and 2005 had very low density of eastern white pine seedlings when compared with other burned stands because no seed crop occurred after the treatment was applied and the time of our study. However, in these stands, the bracken fern species (*P. aquilinum*) was abundant with an average cover of 26%. This fern is highly competitive in recolonizing burned stands when it is present prior to treatment. It is a fire-adapted species that possesses deep fire-resistant rhizomes [50]. Bracken ferns are strong competitors for light and their presence is known to increase the level of competition for the establishment of eastern white pine seedlings [13]. In the future, after a first good seed crop, it would be important to monitor and measure the regeneration of eastern white pine and the effect of the abundance of this fern on pine dynamics. The production of a good seed crop is important after fire or a burning treatment in order to establish strong pine regeneration. Moreover, the succession of various events may also be favourable to establish pine regeneration as described by Lynham and Curran [51]. They reported 50,000 red and white pine seedlings per hectare 5 years after a low-intensity natural fire followed by a good seed crop 2 years later and a blowdown 4 years after the fire. This generated optimal conditions for regenerating pines. Such condition may explain why one of our unburned stand, which was located on an island, had a high density of eastern white pine saplings (100/ha) even though its seedling density was rather low (625/ha). This stand had been disturbed by a small blowdown due to its location on an island. Gaps produced in the forest cover were large enough to favour the growth of eastern white pine seedlings up to the sapling stage. This is important for eastern white pine forest renewal as Stiell [52] demonstrated that pine's ability to compete is greatly improved when the sapling stage is reached. However, even if all the saplings recorded in our unburned stands would reach the canopy, their numbers would still remain below the density objective of 100/ha [40].

The stands burned in 2001 and 2003 benefited from a good seed crop in 2003 and they had numerous seedlings, approximating 20,000 seedlings/ha. Most pine seedlings were grouped in the 5- to 10-cm height class and showed a normal growth rate for eastern white pine [13]. The stand burned in 1999 was submitted to the highest fire intensity and showed the highest recent mortality of trees, including some pines. It also produced taller eastern white pine seedlings than the site burned 2 years before. No competing vegetation reinvaded this stand and the good 2003 seed crop allowed regenerating eastern white pine, even if it occurred only 4 years after the treatment. Furthermore, the taller seedlings observed indicate better growth conditions in this stand. This could be linked not only with better soil conditions but also with a higher penetration of light due to higher tree and sapling mortality. Finally, the tallest eastern white pine seedlings were observed in the oldest burned site, but these only reached 50 cm of height, which shows a slow growth rate after 11 years [13].

5. Conclusions

Active management is an important approach for restoring the ecological integrity of ecosystems in Canadian national parks. The current policy states that when park ecosystems have been seriously altered by human activities and natural processes cannot achieve restoration objectives alone, intervention may be prescribed. In La Mauricie National Park of Canada, the ecological integrity of eastern white pine forest ecosystems has been altered by logging, fire suppression, and the introduction of the exotic white pine blister rust. On a short-time scale (10–15 years), the prescribed burning programme implemented in the park has been successful in increasing eastern white pine seedling density significantly. However, in the near future, it would be important to continue monitoring each burned stand to make sure that local environmental conditions remain favourable for the growth of eastern white pine seedlings. Initial growth of eastern white pine usually averages 10–15 cm after 5 years [13], which is slow compared with faster growing competitors such as firs and hardwoods. In order to evaluate the ecological integrity of a national park, Timko and Innes [53] recently recommended such monitoring for assisting managers in evaluating the effectiveness of their management actions.

According to Ontario Ministry of Natural Resources [54], eastern white pine seedlings that receive more than 45% of full light have a higher probability of reaching the sapling stage. Otherwise, seedlings will probably survive but might not be able to grow rapidly enough to outcompete firs and broadleaved species. Waldrop and Brose [31] have shown that low-intensity prescribed burnings in Ponderosa pine stands do not open sufficiently the overstory strata to ensure survival and fast growth of seedlings established after treatment. In such cases, it might be necessary to use further treatment to reach the objective of restoring pine forest ecosystems. It might be the case in burned stands of La Mauricie National Park of Canada as densities of eastern white pine seedlings are high, but their growth appears rather slow. Eastern white pine seedlings may benefit from opening the canopy to increase light penetration. In Ponderosa pine stands, it has been shown that thinning was more effective than burning to open the overstory and kill a higher proportion of mature trees [33, 34]. These authors concluded that the combination of thinning and burning was the most effective option for optimizing light penetration and ensuring good seedling growth. In eastern white pine stands of La Mauricie National Park of Canada, we may hypothesize that this objective could be achieved by girdling mature balsam fir or spruce trees or by increasing fire intensity in future prescribed burnings. Girdling appears as a better option than thinning for a national Park as it leaves large diameter snags on site which increases the treatment value with respect to the concept of ecological integrity. Prescribed burning effectiveness for killing mature trees can be enhanced by increasing fire intensity but, this also increases risks of escaping the fire, which represents a fragile equilibrium between the ecological value of the treatment and safety rules [34]. Nevertheless, continuous monitoring of seedling growth in burned stands would help managers to confirm that such management practices are useful in La Mauricie National Park of Canada to restore eastern white pine ecosystems. These evaluations would also promote adaptive management and ensure that decision-making is based on sound science [55].

Acknowledgements

We thank Yves Dubuc from Natural Resources Canada as well as the summer students Jennifer Naples, Félix-Antoine Boucher, Jonathan Boucher, Éloïse Laurier, and Vincent Mandon for their help with field work. We also acknowledge Victor Kafka, Raymond Quenneville, and Michel Thériault from Parks Canada for their logistical support.

Funding

Financial support to run this project was provided by Parks Canada and Natural Resources Canada.

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