

Effects of Forest Fire on Young-of-the-year Northern Pike, *Esox lucius*, in the Northwest Territories

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In 1998, a forest fire burned 58% of the forested shoreline surrounding Tibbitt Lake, Northwest Territories, including riparian vegetation used by Northern Pike (*Esox lucius*) as spawning habitat. This presented an opportunity to investigate the effects that habitat disturbance from a natural forest fire had on young-of-the-year (Y-O-Y) Northern Pike. Pike fry were collected from three burned and three unburned sites around Tibbitt Lake in 1999 (the first post-fire spawning season) and again in 2001. Differences in size and relative abundance were evaluated between sites. Y-O-Y Northern Pike were significantly larger at the unburned sites ($P < 0.01$) and the relative abundance of Y-O-Y Northern Pike increased significantly at burned sites ($\alpha = 0.1$; $P < 0.07$) following re-vegetation two years post fire. These differences may be due to fire-induced changes in physical habitat or food availability. Forest fires decrease the density of riparian vegetation, which likely provides better spawning and rearing habitat for Northern Pike in the long-term.

En 1998, un feu de forêt a brûlé 58% de la rive boisée entourant le lac Tibbitt, situé dans les Territoires du Nord-Ouest, y compris la végétation riveraine utilisé par le grand brochet (*Esox lucius*) comme habitat de fraie. Cet événement a présenté une occasion pour étudier les effets causés par un feu de forêt sur l'habitat de jeunes de l'année du grand brochet. Les jeunes brochets ont été recueillis sur trois sites brûlés et trois sites non brûlés autour du lac Tibbitt en 1999 (la première année de fraie après le feu de forêt) et à nouveau en 2001. La différence de grandeur et l'abondance relative des poissons ont été analysés entre les différents sites. Les jeunes grands brochets aux sites non-atteints par le feu étaient considérablement plus grands ($P < 0,01$) que ceux aux sites brûlés. Les sites brûlés, subissant une rapide revégétation dans les deux années après le feu, ont augmenté en abondance relative de jeunes grands brochets ($\alpha = 0,1$, $P < 0,07$). Ces différences peuvent être dues aux changements induits par le feu sur l'aspect physique de l'habitat ou sur la disponibilité de nourriture. Les incendies de forêt réduisent la densité de la végétation riveraine, qui fournit probablement de meilleure habitat de fraie et d'alevinage pour le grand brochet à long terme.

Key Words: Northern Pike, *Esox lucius*, Northwest Territories, spawning and rearing habitat, prey, forest fire, boreal forest, oligotrophic lake.

During the dry summer of 1998 (Water Survey of Canada 2004), lightning caused a forest fire north of Great Slave Lake, Northwest Territories, which lasted for three months and burned 160 382 hectares of taiga forest (Government of Northwest Territories – Environment and Natural Resources, unpublished data). It reached Tibbitt Lake in early August and burned 58% of the forested shoreline around the lake, comprised of riparian and littoral vegetation (Figure 1). The freshet for the Cameron River, just downstream of Tibbitt Lake, was one month earlier than average, with peak flows barely above the mean flows for the system. This was compounded by unusually low water during the summer months when the fire occurred (Environment Canada 2006). Due to low water at the time of the fire, areas of seasonally flooded riparian and nearshore littoral vegetation (emergent and submergent) were completely burned.

The fire burned large portions of the littoral and riparian vegetation surrounding Tibbitt Lake that would normally be used by Northern Pike (*Esox lucius*) as spawning and rearing habitat. The spring following the forest fire (1999) was the first spawning season where Northern Pike may have been affected by the fire.

The occurrence of the forest fires that reached Tibbitt Lake provided the opportunity to investigate the effects that habitat disturbance from a natural forest fire had on young-of-the-year (Y-O-Y) Northern Pike growth *in situ*. Y-O-Y Northern Pike exhibit very limited dispersal from their natal grounds (Inskip 1982; Cucherousset et al. 2009) and, as such, were potentially affected by habitat alterations caused by the fire. We present a case study investigating the differences in the size and relative abundance of Y-O-Y Northern Pike between burned and unburned habitats found within Tibbitt Lake following a natural forest fire. Unfortu-

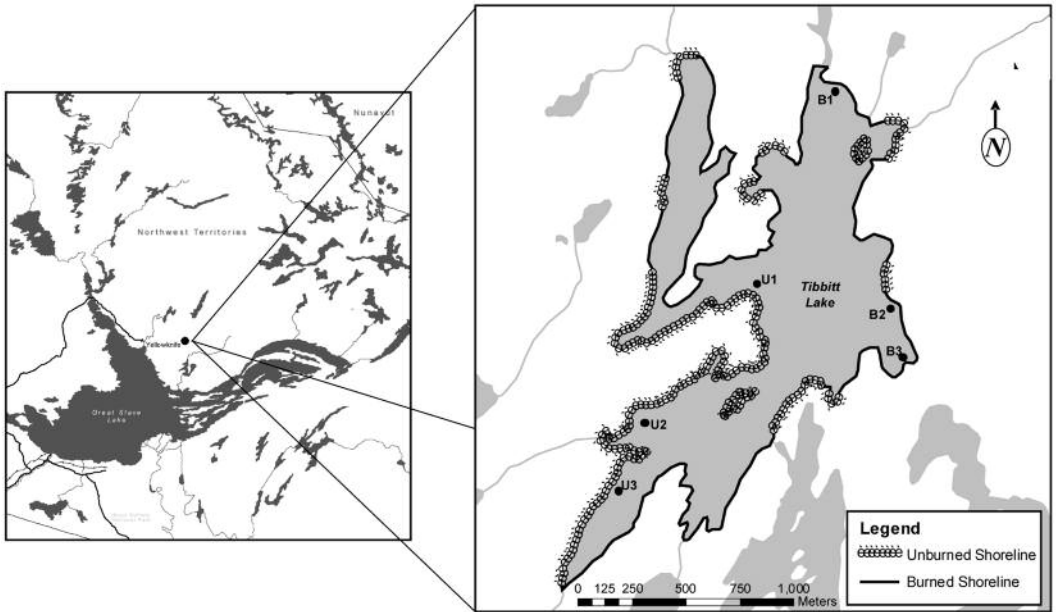


FIGURE 1. Location of Tibbitt Lake, Northwest Territories with the location of burned (B1, B2, B3) and unburned (U1, U2, U3) sampling sites illustrated in the inset.

nately, lakes in the study area are remote and poorly studied, and being a natural event, the fire could not be predicted. Therefore we did not have the virtue of valuable “before” impact data that might be available in more populated areas. As such, this study is opportunistic and observational in nature, using reestablished vegetation in burned sites eight years after the fire as a surrogate of what would be speculated as pre-burned conditions.

Research on the effects of forest fire on aquatic systems has been limited and largely focused on riverine systems (see Rask et al. 1998; Gresswell 1999). Recent literature on the effect of forest fires on lacustrine environments have focused on contaminants transfer (Allen et al. 2005; Garcia and Carignan 2005; Kelly et al. 2006) and fish-community interactions (St-Onge and Magnan 2000; Tonn et al. 2003; 2004). No specific information exists on the effects of forest fire on spawning and rearing Northern Pike, or their habitats in the Northwest Territories (NWT).

In lakes, Northern Pike spawn shortly after the ice has melted in shallow weedy bays and flooded terrestrial vegetation (Scott and Crossman 1973; Casselman and Lewis 1996; Richardson et al. 2001). Adult Northern Pike return to natal grounds in subsequent years to spawn (Frost and Kipling 1967; Raat 1988; Miller et al. 2001). Y-O-Y Northern Pike remain in the vegetative cover and shallow water of these spawning sites (Inskip 1982; Skov et al. 2002; Cucherousset et al. 2009). In a recent study by Cucherousset et al. (2009), it was found that Y-O-Y Northern Pike that had

a mean fork length of 51 mm (slightly larger than the mean length collected in this study) moved within an average radial distance of only 14.3 m, and tended to hold in localized habitat patches. As they grow, young Northern Pike gradually move to deeper water and new foraging areas (Franklin and Smith 1963; Inskip 1982; Bry 1996; Cucherousset et al. 2009).

Materials and Methods

Site Description

Located ~70 km east of Yellowknife, NWT, Tibbitt Lake (62°33'N, 113°21'W) is a 143.5 ha oligotrophic lake that connects to the Cameron River system, a 19 267 km² watershed that flows into Great Slave Lake (Figure 1). Northern Pike, Lake Whitefish (*Coregonus clupeaformis*), Longnose Sucker (*Catostomus catostomus*), White Sucker (*C. commersoni*) and Spottail Shiner (*Notropis hudsonius*) have been documented in Tibbitt Lake (Falk 1979). Sampling by the authors also revealed the presence of Burbot (*Lota lota*) and Lake Chub (*Couesius plumbeus*).

The forest surrounding Tibbitt Lake is boreal. It is composed mainly of Black Spruce (*Picea mariana*), Jack Pine (*Pinus banksiana*), and White Birch (*Betula papyrifera*), with River Alder (*Alnus rugosa*) and willow (*Salix* spp.) dominating the 15.2 km shoreline. The landscape is undulating Precambrian bedrock, with a 4-9% slope, and well-drained mineral soils in the area have a 20-75 cm rooting depth.

Flooded riparian vegetation in unburned sites included willow, Bearberry (*Arctostaphylos uva-ursi*),

TABLE 1. Habitat characteristics at unburned and burned sites, Tibbitt Lake, Northwest Territories. Each site is bound by a transition to deeper water ('trans. deep'), from the wetted shoreline. The water depth at riparian/aquatic vegetation interface is 'trans. shallow'. Data represent re-vegetated condition (2006: 8 years after the fire), as a surrogate to the % cover of vegetation that existed prior to the fire.

Site	Site characteristics				Vegetation		Substrate							
	Area (m ²)	Slope	Depth deep (m)	Depth shallow (m)	% Cover deep	% Cover shallow	bedrock %	boulder %	rubble %	cobble %	gravel %	sand %	silt/clay %	detritus %
U1	1656	0.07	1.2	0.2	15	70	0	10	0	20	0	5	40	25
U2	2520	0.04	1.3	0.3	25	80	20	10	0	0	0	0	30	30
U3	1880	0.06	1.1	0.2	25	60	20	10	0	10	0	0	30	30
B1	3458	0.03	1.2	0.25	15	90	0	2.5	0	2.5	0	30	25	40
B2	1066	0.07	0.9	0.2	5	90	0	5	0	15	0	5	50	20
B3	1539	0.05	1.4	0.2	10	90	0	5	0	5	0	0	55	20

Dwarf Bilberry (*Vaccinium caespitosum*), Labrador Tea (*Ledum groenlandicum*), Water Birch (*Betula occidentalis*), Green Tongue Liverwort (*Marchantia polymorpha*), Wild Mint (*Mentha arvensis*), Bicknell's Geranium (*Geranium bicknellii*), Pink Corydalis (*Corydalis sempervirens*), Submerged Common Scouring-rush (*Equisetum hyemale*), Common Horsetail (*Equisetum arvense*), and sedges (*Carex* spp).

In lakes with unburned catchments, Northern Pike select spawning and rearing sites that are shallow, with soft bottom. The areas they select also have connectivity to deeper water, lack considerable water current and protection from prevailing winds, and possess a mix of seasonally flooded riparian and littoral vegetation (Bry 1996; Casselman and Lewis 1996; Richardson et al. 2001).

Field Sampling

We selected our sampling sites in both burned and unburned areas of the lake (Table 1). Burned sites were selected using the same criteria as unburned sites; however, burned sites were completely devoid of all riparian and littoral vegetation (Table 1). As a surrogate representation of the amount of vegetation cover that existed prior to the fire, a vegetation survey was conducted in mid-August 2006 at the sample sites once littoral and riparian vegetation had re-established in the burned shoreline areas (Table 1). This confirmed predictions that the burned sites selected likely represented good spawning and nursery habitat preceding the fire. Sites were located >200 m apart, separated by unsuitable habitat of exposed bedrock shoreline, which would make mixing of Y-O-Y Northern Pike between sites at time of sampling unlikely (Figure 1). A summary of habitat characteristics at the sample sites is given in Table 1. For a summary of the known habitat requirements for Northern Pike spawning and Y-O-Y rearing in the NWT see Richardson et al. (2001).

Sampling for Y-O-Y Northern Pike was conducted at the six sites in the last week of June 1999 and again the first week of July 2001, using kick nets at three sites in each of the burned and unburned areas. The nets were 650 mm by 1400 mm (64 µm mesh), with two pole handles, a floating top line, and a weighted ballast line.

Sampling was conducted by drawing an open net through the water with the ballast line at the substrate surface for 1 or 2 m and then drawing the net to the surface while folding, trapping the contents inside. Each net could sample a swath of habitat 1 m wide. Each site was sampled continuously for 50 minutes, with an average efficiency (including sorting) of 6.25 m²·min⁻¹. The contents of the net were sorted and all Y-O-Y Northern Pike collected. Northern Pike < 85 mm in total length were considered Y-O-Y (Scott and Crossman 1973). Y-O-Y Northern Pike were counted, weighed (to the nearest 0.001 g wet weight) and total length measured to the nearest 0.5 mm.

In 1999, water quality data were collected at each site using a Hydrolab Surveyor 3® multi-parameter meter. Measured parameters included dissolved oxygen, pH, conductivity, turbidity, alkalinity and total dissolved solids, suspended solids and water temperatures. Water samples were also collected from the littoral zone of each site and analyzed for selected trace elements and nutrients (Taiga Laboratory, Yellowknife, NWT). A one-way ANOVA ($\alpha=0.1$) was used to determine if selected chemical parameters were significantly different between burned and unburned sites and compared to the Canadian Environmental Quality Guidelines (commonly referred to as CCME Guidelines) for the protection of freshwater or aquatic life (Canadian Council of Ministers of the Environment 1999).

Statistical Analysis

Fish wet weights, lengths, and catch per unit effort (CPUE) were modelled as potential functions of two factors burn status and year, and a year/burn status interaction. Since the effect of burn is nested within site, a random effect was used to describe the among-site variability, and burn and year were treated as fixed effects. Since CPUE was measured on a site basis, the CPUE and site effects are completely confounded which could confuse interpretation. However, this problem was ultimately resolved since the random effect term proved unnecessary.

Mixed effects models were built following the principle of parsimony, with significance levels for term

TABLE 2. Summary of fixed effects for assessment of burn status on Y-O-Y Northern Pike weight and length.

	Source	Numerator df	Denominator df	F-Statistic	P-value
weight	intercept	1	196	30.25820	<.0001
	burn status	1	4	5.96309	0.0711
	year	1	196	61.86041	<.0001
length	intercept	1	196	549.1257	<.0001
	burn status	1	4	4.3525	0.1053
	year	1	196	30.0064	<.0001

deletion ≈ 0.05 . Likelihood ratio tests were used for random effects and marginal F-tests for fixed effects. Akaike's Information Criterion (AIC) adjusts the likelihood by penalizing the inclusion of parameters, because the addition of even non-informative parameters will improve model fit, as measured by the likelihood. Therefore the AIC was chosen between closely contending models.

Residual diagnostics included within-term residual plots to assess homogeneity, observed versus predicted plots to assess adequacy of fit and absence of residual structure, and Shapiro-Wilk tests to assess the normality assumptions of all models. Mixed effects model parameters were estimated using restricted maximum likelihood and parameters of general linear models were estimated using maximum likelihood.

The final mixed-effects models described fish wet weights or total lengths include terms for burn status, year and a random effect for site. The year/burn interaction term did not describe a significant proportion of variability in fish weight or total length and therefore was not retained in either model. The total length model uses a square root transformation on length to reduce kurtosis. The CPUE model is a simple general linear model rather than a mixed effects model.

This study was conducted as per the Freshwater Institute Animal Care Committee Protocol and scientific collection licenses (S. 52 of the Fisheries Act) SLE-99/00-215, SLE-00/01-229, and SLE-03/04-277 that were obtained for this project.

Results

Fixed effects model results for weight are presented in Table 2. The model shows that the wet weight of fish collected from unburned areas significantly increased at the 10% level of significance relative to fish collected from burned areas. The fish lengths were modeled as a function of burn status and year and a year/burn status interaction as described above. Fixed effects results for length are presented in Table 2.

The length of fish collected from burned areas significantly decreased in both years at roughly the 10% level of significance relative to fish collected from unburned areas. Both models also showed that there was a significant general increase in Y-O-Y Northern Pike size (weight and length) from 1999 to 2001. The mean total length of Y-O-Y Northern Pike captured in 1999 at the unburned sites was 35.2 mm (21.5-60.0 mm,

TABLE 3. ANOVA table for Y-O-Y Northern Pike catch-per-unit-effort model.

Term	df	Mean Square	F-Statistic	P-Value
Year	1	274.62	4.2303	0.06675
Residuals	10	64.92		

± 1.2 [SE], $n=69$) and at the burned sites was 22.4 mm (9.5-37.0 mm, ± 1.5 [SE], $n=22$) (Figure 2a). In 2001, the mean total length of Y-O-Y Northern Pike captured at the unburned sites was greater than those caught in the burned sites, at 43.4 mm (22.0-73.0 mm, ± 1.8 [SE], $n=49$) and 30.6 mm (14.0-47.0 mm, ± 1.8 [SE], $n=63$), respectively (Figure 2a). In both years, the mean wet weights of Y-O-Y Northern Pike captured at the unburned sites were heavier than those captured at burned sites, with 0.40 g (0.07-1.68 g, ± 0.04 [SE], $n=69$) and 0.11 g (0.07-0.43 g, ± 0.03 [SE], $n=22$) at the unburned and burned sites in 1999, and 0.92 g (0.10-3.19 g, ± 0.10 [SE], $n=49$) and 0.28 g (0.02-0.88 g, ± 0.02 [SE], $n=63$) at the burned sites and unburned sites in 2001 (Figure 2b). Regardless of site, all Y-O-Y Northern Pike sampled in 2001 were proportionately larger (approximately 30%) than those sampled in 1999; likely because sampling was conducted later in the 2001 growing season (Figure 2a, 2b).

CPUE is significantly affected by year (P -value = 0.0668; Table 3). The mean CPUE of Y-O-Y Northern Pike caught in 1999 at the unburned sites was greater, at 13.8 fish \times h $^{-1}$ (± 7.3) than the CPUE of pike caught at the burned sites at 4.4 fish \times h $^{-1}$ (± 2.9) for Y-O-Y Northern. This was not the case in 2001, with 16.3 fish \times h $^{-1}$ (± 3.2) collected in the unburned sites and 21.0 fish \times h $^{-1}$ (± 3.1) in the burned sites (Figure 2c).

Most parameters of water chemistry vary between burned and unburned lakes, (Carignan et al. 2000). None of the water quality parameters sampled in 1999 were found to be significantly different between unburned and burned areas, and therefore, these parameters were not sampled in 2001. However, the similarities in water quality parameters measured would not be unexpected in a lake the size of Tibbitt Lake, and was likely due to effective mixing by lake circulation driven by wind mixing (Fee et al., 1996; Wetzel, 2001) and river flow through the lake (Wetzel 2001). No water chemistry parameters sampled in 1999 exceed-

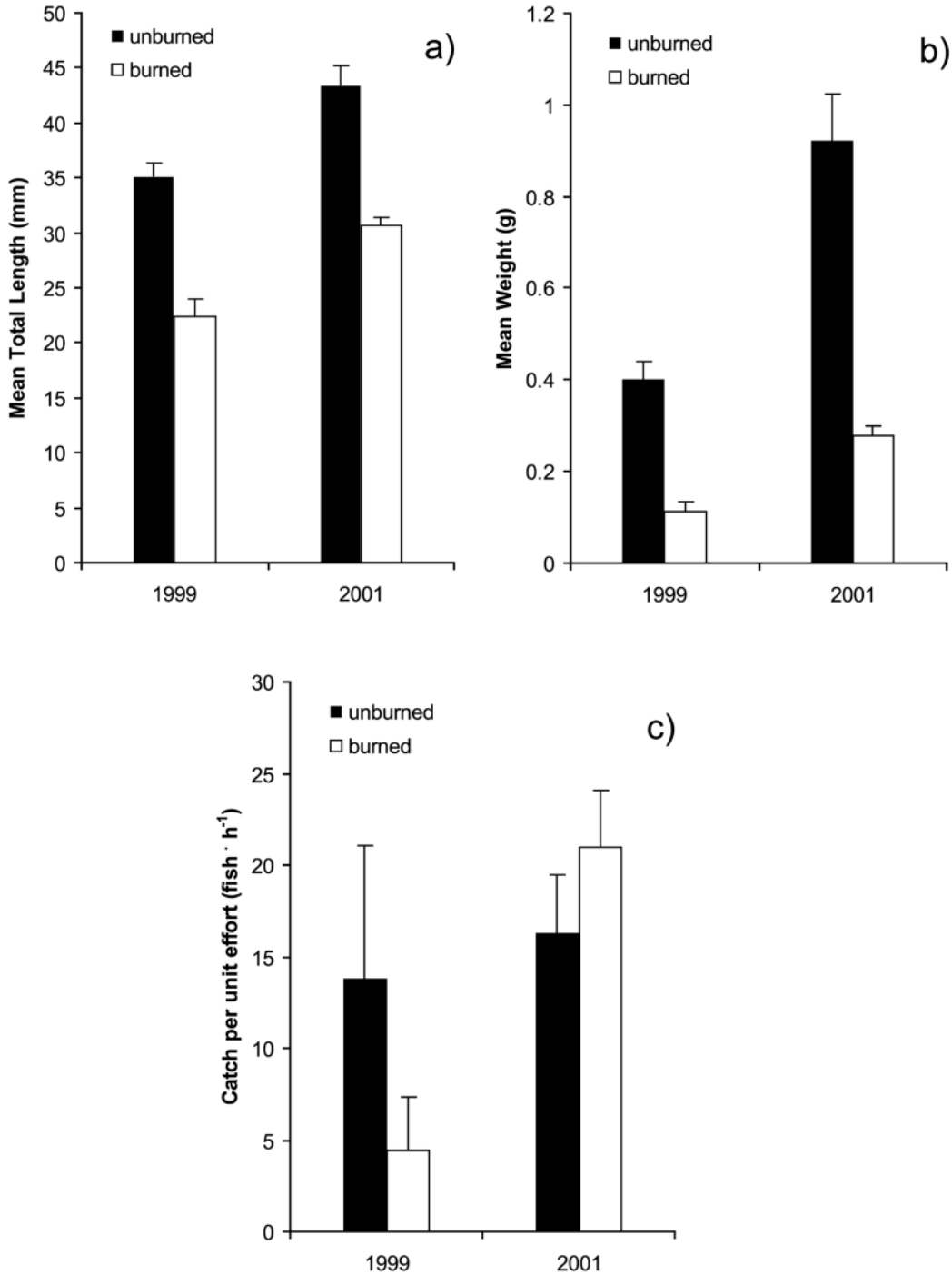


FIGURE 2. A comparison of a) mean total length (mm) \pm [SE]; b) mean weight (g) \pm [SE]; and c) abundance (catch per unit effort) \pm [SE], for young-of-the-year Northern Pike sampled at burned and unburned sites in 1999 and 2001, Tibbitt Lake, Northwest Territories.

ed the CCME Guidelines for the protection of freshwater or aquatic life, and are not presented herein.

Unburned habitat remained similar between the years 1999, 2001 and 2006 as would be expected. Burned sites were void of riparian and emergent vegetation in 1999. Some macrophytes were present, but sparse and in deeper water. In 2001, the burned sites were between 40–60% re-vegetated. By 2006, unburned and burned sites were similar in terms of vegetation type and coverage (Table 1).

Discussion

Both of the variables considered (i.e., year and burn status) were associated with changes in Y-O-Y Northern Pike growth. After accounting for year effects, burn status caused reductions in growth through changes to spawning and rearing habitat. This was influenced by the complete removal of seasonally flooded riparian and littoral vegetation due to the fire. Growth increased with the variable year, possibly owing to the slightly later sampling period in 2001 compared to 1999.

Northern Pike growth can be influenced by food quantity and quality, temperature, length of growing season or a combination thereof (Franklin and Smith 1963; Frost and Kipling 1967; Scott and Crossman 1973; Craig and Babaluk 1989; Casselman 1996; Venturelli and Tonn 2006). It is plausible that the consistently smaller size of pike fry in burned areas compared to unburned areas in the years studied may be associated with changes in physical habitat and poorer food resources. Growth rates of Y-O-Y pike can be highly variable and dependent on habitat (Casselman 1996; Skov and Koed 2004), and can be rapid, with lengths of up to 43 mm possible in their first month (Scott and Crossman 1973).

Northern Pike fry eat invertebrates such as insect larvae and large zooplankton that is primarily found in shallow vegetated areas (Scott and Crossman 1973; Bry 1996; Beaudoin et al. 1999). These same types of vegetated areas existed where fire affected Tibbitt Lake. Where invertebrates are limited in terms of abundance or due to interspecific competition, cannibalism may increase (Beaudoin et al. 1999). It is possible that the quality and quantity of invertebrates were greater in undisturbed habitat at the unburned sites, and offered better feeding opportunities to Y-O-Y Northern Pike compared to those from the burned sites. Minshall (2003) suggests that changes to macro-invertebrates in streams following a burn are generally minor and difficult to discern. However, a reduction in macro-invertebrate density and diversity in association with forest disturbances was noted by Rinne (1996). In lakes, burns have been shown to increase productivity due to nutrient enrichment (Garcia and Carignan 2005). Increases in productivity have led to changes in growth rates of macro-invertebrates, and in turn shifted diet preferences of fishes (Kelly et al. 2006; Allen et al. 2005). Dietary alterations can lead to enhanced growth

of Northern Pike and other fishes, and longer food chains can occur in post-fire lakes as a result of increased productivity restructuring food webs and enhancing the trophic position of piscivores (Kelly et al. 2006). If productivity increased, poor spawning and rearing success at the burned sites may have been compensated for by increased success at the unburned sites. Alternatively, stunting of Northern Pike growth rates can occur if diet is poor (Venturelli and Tonn 2006). If the fire negatively impacted the quality and quantity of food sources in the burned sites, this could account for the proportionately smaller pike fry at these sites compared to the unburned sites. Growth rates can be compromised in one year or less following environmental disturbances where prey quality and quantity are affected (Venturelli and Tonn 2006). We do not have general pre-fire data or data specific to invertebrate populations. Whether the fire altered prey items in Tibbitt Lake, and subsequently affected pike fry, is speculation.

All of the components of suitable Northern Pike spawning habitat (Bry 1996; Casselman and Lewis 1996; Richardson et al. 2001) were found at the sample sites (Table 1). However, one notable exception of the burned sites is that seasonally flooded riparian vegetation and littoral vegetation was absent the year following the fire. Northern Pike spawn after ice out, which, in a lake the size of Tibbitt Lake (143.5 ha) would have occurred at the same time for all six sites sampled. However, it is possible that Northern Pike preferentially selected the undisturbed habitat of the unburned areas as spawning sites. The lack of cover, and possibly prey, would amount to more energy expenditure and less energy uptake in the burned sites compared to the unburned sites, and could influence growth of Y-O-Y Northern Pike. Skov and Koed (2004) found that pike fry within more complex habitats (as opposed to open water) were faster growing.

No difference in CPUE of Y-O-Y Northern Pike was found at unburned sites between years. This was expected since the unburned habitat was not altered during that time. However, there were more Y-O-Y Northern Pike sampled at the burned sites during 2001 than in 1999. It is possible that Northern Pike fry experienced greater survival during 2001 in the burned areas because vegetation grew back. Skov and Berg (1999) attributed the preference of Y-O-Y Northern Pike for complex habitats to a decrease in predation. The vegetation re-growth would have improved physical habitat quality, increased cover thereby reducing predation, and presumably increased the quality and quantity of prey items. As with average weight, any increase in the relative abundance of fish is indicative of a response to reduced stress or a positive change in living conditions (Regier and Loftus 1972).

Mortality of Northern Pike eggs and young can be as high as 99% in stressed environments (Scott and Crossman 1973). In Tibbitt Lake, an increase in egg

and fry mortality may have contributed to low catches associated with burned sites during 1999 relative to 2001. Lower pike fry abundance is likely a result of a lack of flooded riparian and littoral vegetation (as a result of the fire) used for spawning substrate and cover, and possibly due to a combination of increased cannibalism, reduced quality and quantity of food supply (Figure 2c). Research conducted in the upper Mississippi River, USA, found that catches of Y-O-Y Northern Pike were 10 times greater in vegetated areas compared to non-vegetated areas (Holland and Huston 1984). Dense flooded terrestrial vegetation provides cover and ambush opportunities for Northern Pike fry and keeps them spatially separated from each other, while preventing access by larger Northern Pike that may feed on them (Inskip 1982; Raat 1988). In the absence of suitable cover, young Northern Pike are known to exhibit increased cannibalism (Bryan 1967; Inskip 1982; Raat 1988). Cannibalism also may increase as a result of reduced invertebrate abundance associated with less vegetated habitats (Franklin and Smith 1963). St-Onge and Magnan (2000) reported reduced catches of young Yellow Perch (*Perca flavescens*) and White Sucker in Shield lakes affected by logging and fire, and suspected that the resultant lower food quality had a negative effect on the survival of young fish. Kelly et al. (2006) reported that fishes that were previously benthivores became piscivores when availability of fish-based food sources improved, increasing their trophic position.

Northern Pike in Tibbitt Lake selected both unburned and burned sites to spawn (as evident by pike fry captured at all six sites), despite the latter being very poor quality habitat the year following the fire. Frost and Bryan (1967); Kipling (1967); and Cott (2004) reported that Northern Pike spawn over a variety of habitat types if ideal spawning habitat is not available. Also, Frost and Kipling (1967); Raat (1988); and Miller et al. (2001) reported spawning and natal site fidelity by Northern Pike. The occurrence of Northern Pike fry in the vegetation-deficient burned areas supported these findings. With the ability of a single Northern Pike able to produce >500 000 eggs (Scott and Crossman 1973), it is reasonable to assume that some eggs released at the burned sites would have hatched despite the habitat limitations.

Tonn et al. (2004) found fewer small Northern Pike in lakes subjected to forest fire in Northern Alberta compared to those that were not, suggesting possible population level impacts. If fire results in the loss of habitat, and in turn, reduced spawning success and the potential for increased cannibalism, this could reduce the abundance of the cohort spawned in years immediately following a forest fire. This impact would be exacerbated if the fire follows a low water period, as in the case of the Tibbitt Lake fire. Low water levels result in less flooding of riparian vegetation and therefore less spawning habitat. Also, lower water levels increase

the susceptibility of that habitat to being burned in the event of a forest fire, as was clearly the case at Tibbitt Lake. Reduction in suitable habitat has been demonstrated to increase aggression and competition among Y-O-Y Northern Pike in the nursery areas (Frost and Kipling 1967), factors that may lead to higher mortality and a weak year class (Scott and Crossman 1973).

New vegetation had begun to establish by the end of the summer in the year following the fire. Although it is well recognized that vegetation is an essential component of Northern Pike habitat that provides spawning, feeding, rearing and cover opportunities (Witcomb 1965; Scott and Crossman 1973; Benson 1980; Bry 1996; Casselman 1996; Grimm and Klinge 1996; Skov and Berg 1999; Skov et al. 2002; Skov and Koed 2004), vegetation that is extremely dense can be undesirable and can hinder the Northern Pikes' visual-based hunting tactics (Headrick and Carline 1993; Casselman and Lewis 1996). Further, Eklov (1997) found the size of Northern Pike is inversely related to vegetation density in oligotrophic lakes (i.e., pike fry occupy more densely vegetated areas than do adults). Northern Pike fry also require intermediate densities of vegetation for rearing habitat (Anderson 1993; Casselman and Lewis 1996). The fire may have had a positive effect for Northern Pike by burning dense vegetation, coarse woody debris and other detritus, allowing these sites to reestablish with new vegetation that is more accessible for spawning and provides better nursery habitat, relative to unburned areas.

Despite the opportunistic nature of this study, the results of this study, augmented by consideration of un-measurable confounding factors, suggest that forest fires which burn riparian and littoral vegetation can affect the size and abundance of Y-O-Y Northern Pike. The results show that Northern Pike fry at the unburned sites were significantly larger than those sampled at burned sites, both in the year following the fire and three years after the fire. As there were no differences in water chemistry between burned and unburned sites, the differences in Northern Pike growth between sites is likely due to changes in physical habitat. There was no significant difference in relative abundance (as measured by CPUE) of Y-O-Y Northern Pike between unburned and burned sites in a given year, but relative abundance increased in the burned sites as vegetation reestablished. In low water years, reduced flooding of back bays and other low-lying shorelines can make these habitats more susceptible to the effects of fire. Periodic burning of shoreline vegetation may be a beneficial effect of forest fires, by thinning out vegetation that is too dense to be useful for pike spawning. Fire suppression around shorelines may therefore have more detrimental effects on the long-term success of Northern Pike populations than if shorelines were left to burn naturally. This is consistent with the current NWT forest fire management practices where fire retardants are not applied on riparian areas (Lance

Schmidt – Environment and Natural Resources, Government of Northwest Territories, Yellowknife, NWT, personal communication 2004).

The boreal forests of the NWT have had a fire cycle of approximately 80 – 110 years. Such disturbances are integral in the functioning and ecology of boreal ecosystems (Kimmins 2004). Northern Pike have also been a part of this ecosystem since the departure of the last continental glaciers and have successfully survived in this fire disturbance regime. Forest fires that burn seasonally inundated riparian vegetation and littoral vegetation may have negative short-term effects on Northern Pike populations through disturbing spawning habitat. However, this type of burning may provide long-term benefits by allowing new vegetation to reestablish, providing better spawning and rearing habitat for Northern Pike.

This study provides insight into the effect forest fire has on Northern Pike, possibly through changes in their spawning and rearing habitat. The study would be strengthened if data on diet and invertebrate populations were collected, yet a similar opportunity would need to be presented in the future. These data, or if pre-fire data available, would greatly assist in determining the causality of changes in the size and relative abundance of pike fry by enabling an assessment of the quality and quantity of prey available (including rates of cannibalism) between burned and unburned areas.

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