Factors Influencing the Abundance of Berry Plants for Black Bears, *Ursus americanus*, in Quebec

RÉMI HÉBERT[1], CLAUDE SAMSON[2], and JEAN HUOT[3]

[1]Département de biologie, pavillon Alexandre-Vachon, Université Laval, Québec, Québec G1K 7P4 Canada; e-mail: remi_hebert@hotmail.com; corresponding author

[2]Parks Canada, 3, passage du Chien-d'Or, C.P. 6060 Haute-Ville, Québec, Québec G1R 4V7 Canada; e-mail: claude.samson@pc.gc.ca

[3]Département de biologie, pavillon Alexandre-Vachon, Université Laval, Québec, Québec G1K 7P4 Canada

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Berries generally represent the primary food source used by Black Bears (*Ursus americanus*) during summer and sometimes fall. Our study attempted to identify factors influencing the abundance of these critical resources for Black Bears in Quebec. We used data from the ecological inventories of the Ministère de l'Environnement du Québec. Three different study areas were selected, including the Papineau-Labelle Wildlife Reserve (326 sample plots; 24 species), the Laurentides Wildlife Reserve (679 sample plots; 16 species) and the Côte-Nord administrative region (1944 sample plots; 30 species). Each site represented a different bioclimatic domain. Characteristics of the dominant vegetation (density and height), soil texture, and drainage classes (vertical or oblique) were used as analysis factors. In general, height and density of the dominant vegetation had a significant effect on the abundance of berry plants. Berry plants were more abundant in plots where dominant vegetation height and density were low. Soil texture had little effect on the abundance of berry plants, and the influence of drainage varied depending on the region. This study allowed us to determine the optimal sites of berry resources for Black Bears.

Key Words: Black Bear, *Ursus americanus*, berries, oblique drainage, seepage, soil texture, vegetation density, vegetation height, vertical drainage, wildlife reserve, Quebec.

Berries generally represent the major food source for Black Bears (*Ursus americanus*) during summer (Jonkel and Cowan 1971; Hatler 1972; Lindzey and Meslow 1977; Landers et al. 1979; Young and Ruff 1982; Maehr and Brady 1984; Irwin and Hammond 1985; Rogers 1987; Unsworth et al. 1989; Holcroft and Herrero 1991; Schwartz and Franzmann 1991; Kasbohm et al. 1995; Rudis and Tansey 1995; Noyce and Garshelis 1997; Welch et al. 1997). In fall, when hard masts are unavailable, Black Bears will also continue to eat berries (Young and Ruff 1982; Holcroft and Herrero 1991; Schwartz and Franzmann 1991; Boileau et al. 1994; Kasbohm et al. 1995).

In Quebec, the Black Bear's diet has been described in three main studies (Boileau et al. 1994; Samson 1995; Leblanc 2000). Similar to findings in studies across the rest of their range, Black Bears have a tendency to eat berries according to availability. The dominant berry species found in diets often vary according to geographic location. Boileau et al. (1994) found that in the Gaspésie Park, the berry species most consumed by Black Bears were serviceberries (*Amelanchier* spp.), Wild Sarsaparilla (*Aralia nudicaulis*), Red-osier Dogwood (*Cornus stolonifera*), American Strawberry (*Fragaria americana*), currants (*Ribes* spp.), raspberries (*Rubus* spp.), Pink Streptopus (*Streptopus roseus*), blueberries (*Vaccinium* spp.) and Lowbush Cranberries (*Viburnum edule*). In another study, conducted in La Mauricie National Park, Samson (1995) found Black Bears sought mainly Raspberries (*Rubus idaeus*), blueberries, cherries (*Prunus* spp.) and Bristly Sarsaparilla (*Aralia hispida*). To a lesser extent, Black Bears in this region consumed fruits from Beaked Hazelnut (*Corylus cornuta*), hawthorn (*Crataegus* sp.) and viburnums (*Viburnum* spp.). Fruits of Fetid Currant (*Ribes glandulosum*), Red-berried Elder (*Sambucus pubens*) and Mountain Ash (*Sorbus americana*) were infrequently observed in scats (fecal droppings) (Samson 1995). In a third study, in Forillon National Park, Red-osier Dogwood, Mountain Ash, Wild Sarsaparilla, viburnums, cherries, serviceberries and Beaked Hazelnut were the main species consumed (Leblanc 2000). To a limited extent, strawberries (*Fragaria* spp.), raspberries, roses (*Rosa* spp.), Bunchberry (*Cornus canadensis*) and currants were also consumed (Leblanc 2000).

Noyce and Coy (1990) reported that the abundance and productivity of berry plants as a food source for Black Bears diminished with increasing canopy density. Noyce and Coy (1990) also reported that berry plants were more abundant on well-drained soils with a sandy and loamy texture. In this study, we attempt to verify whether the abundance of berry plants, in different regions of Quebec, is influenced by the same factors as reported by Noyce and Coy (1990) in Minnesota. Thus, we hypothesize that, independent of the ecological region, berry plants should be more abundant in open forests and on well-drained soils. Although

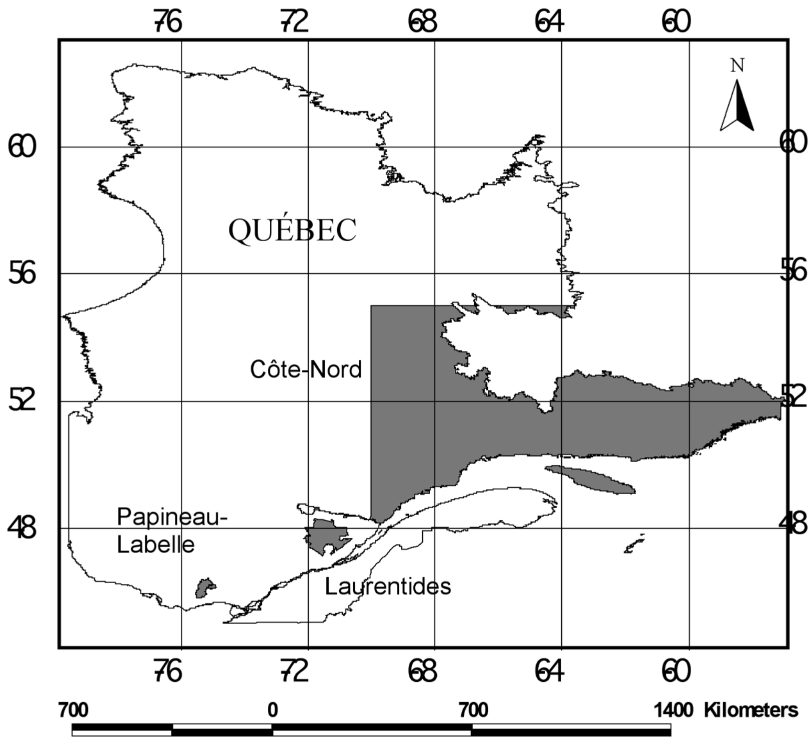

FIGURE 1. Location of the three study areas in Québec: the Papineau-Labelle Wildlife Reserve, the Laurentides Wildlife Reserve, and the Côte-Nord region.

many species of mammals and birds consume berries, we focused on berries as a resource for Black Bears.

Study Areas

We chose three different study areas located within Quebec (Figure 1), each representing a different bioclimatic domain. Our first study area was the Papineau-Labelle Wildlife Reserve, located about 80 km northeast of Hull. It was created in 1971 and has a total area of 1628 km^2 (Société des établissements de plein air du Québec 2000a). The Papineau-Labelle Wildlife Reserve represents the Sugar Maple (*Acer saccharum*) –Yellow Birch (*Betula alleghaniensis*) domain (Bérard and Côté 1996). The reserve receives 158 days of precipitation annually, falling as 819 mm of rain and 241 cm of snow (Chénéville station) (Environnement Canada 1993). Mean annual temperature is 3.8°C, with a mean temperature of -12.9°C in January and 18.3°C in July (Environnement Canada 1993).

Our second study area was the Laurentides Wildlife Reserve, located between Chicoutimi and Québec City. The Laurentides Wildlife Reserve was created in 1895 and has a surface area of 7961 km^2 (Société des établissements de plein air du Québec 2000b). It represents the Balsam Fir (*Abies balsamea*)–Paper Birch (*Betula papyrifera*) domain (Bérard and Côté 1996). The study area has 215 days a year with measurable precipitation, receiving 948 mm of rain and 593 cm of snow (Forêt Montmorency station) (Environnement Canada 1993). Mean annual temperature is 0.3°C, with a mean temperature of -15.3°C in January and 14.8°C in July (Environnement Canada 1993).

Our third study area was the Côte-Nord region. With an area of 328 693 km^2, it is the second largest administrative region in Quebec (Cartier 1990). The territory includes Anticosti Island and stretches for 1300 km along the coast between Tadoussac and Blanc-Sablon (Cartier 1990). The Côte-Nord region represents the Black Spruce (*Picea mariana*)-lichen domain (Bérard and Côté 1996). The study area has 179 days a year with measurable precipitation, receiving 782 mm of rain and 333 cm of snow (Natashquan A station) (Environnement Canada 1993). Mean annual temperature is 1.1°C, with a mean temperature of -12.9°C in January and 14.2°C in July (Environnement Canada 1993).

Methods

We used vegetation data collected by the Ministère de l'Environnement du Québec, from the ecological inventories program. Methodology is described by the

TABLE 1. List of berry species considered for Black Bears in our three study areas. The *n* indicates the total number of plots. For each species, the frequency (number of plots) and the corresponding proportion of plots (%) containing the species are shown.

Species	Papineau-Labelle Wildlife Reserve $n = 326$	Laurentides Wildlife Reserve $n = 679$	Côte-Nord region $n = 1944$
Amelanchier bartramiana	–	–	136 (7.0%)
Amelanchier sp.	4 (1.2%)	–	–
Aralia nudicaulis	89 (27.3%)	7 (1.0%)	45 (2.3%)
Aralia racemosa	4 (1.2%)	–	–
Arctostaphylos alpina	–	–	43 (2.2%)
Arctostaphylos uva-ursi	–	–	8 (0.4%)
Cornus alternifolia	6 (1.8%)	–	–
Cornus canadensis	14 (4.3%)	272 (40.1%)	773 (39.8%)
Cornus stolonifera	6 (1.8%)	–	25 (1.3%)
Cornus suecica	–	–	1 (0.1%)
Corylus cornuta	91 (27.9%)	–	–
Crataegus sp.	1 (0.3%)	–	–
Empetrum atropurpureum	–	–	2 (0.1%)
Empetrum eamesii	–	–	3 (0.2%)
Empetrum nigrum	–	–	356 (18.3%)
Fragaria virginiana	–	–	2 (0.1%)
Prunus pensylvanica	21 (6.4%)	1 (0.1%)	6 (0.3%)
Prunus serotina	49 (15.0%)	–	–
Prunus virginiana	9 (2.8%)	–	–
Ribes americanum	1 (0.3%)	1 (0.1%)	–
Ribes glandulosum	1 (0.3%)	83 (12.2%)	57 (2.9%)
Ribes lacustre	–	3 (0.4%)	22 (1.1%)
Ribes triste	–	5 (0.7%)	1 (0.1%)
Ribes sp.	2 (0.6%)	–	–
Rubus acaulis	–	–	4 (0.2%)
Rubus allegheniensis	3 (0.9%)	–	–
Rubus chamaemorus	–	102 (15.0%)	252 (13.0%)
Rubus idaeus	27 (8.3%)	73 (10.8%)	20 (1.0%)
Rubus odoratus	4 (1.2%)	–	–
Rubus pubescens	34 (10.4%)	5 (0.7%)	36 (1.9%)
Sambucus pubens	23 (7.1%)	37 (5.4%)	5 (0.3%)
Sorbus americana	–	7 (1.0%)	–
Sorbus decora	–	5 (0.7%)	73 (3.8%)
Vaccinium angustifolium	1 (0.3%)	60 (8.8%)	894 (46.0%)
Vaccinium cespitosum	–	–	283 (14.6%)
Vaccinium myrtilloides	3 (0.9%)	1 (0.1%)	19 (1.0%)
Vaccinium ovalifolium	–	–	32 (1.6%)
Vaccinium oxycoccos	–	–	27 (1.4%)
Vaccinium uliginosum	–	–	290 (14.9%)
Vaccinium vitis-idaea	–	–	288 (14.8%)
Viburnum cassinoides	8 (2.5%)	–	10 (0.5%)
Viburnum edule	–	5 (0.7%)	78 (4.0%)
Viburnum lentago	1 (0.3%)	–	–
Viburnum rafinesquianum	1 (0.3%)	–	–

Service des inventaires écologiques (1981). In each sample plot, vegetation was identified to species (Table 1). Only berry species sought by Bears were selected. Each species was quantified with a Braun-Blanquet (1932) abundance-dominance index (1 = <5% (median = 2.5%); 2 = 5-25% (median = 15%); 3 = 26-50% (median = 38%); 4 = 51-75% (median = 63%); 5 = ≥76% (median = 88%)). In order to determine the abundance of food for Black Bears in each sample plot, we totaled the median value of all species potentially part of the Black Bear's diet. To keep the same number of classes the initial data had, we converted the total percentage cover of berry plants to an abundance index with equal classes (1 = 1-20%; 2 = 21-40%; 3 = 41-60%; 4 = 61-80%; 5 = 81-100%).

The environment of each sample plot was described using the following variables: density and height of the dominant vegetation, soil texture, vertical drainage and oblique drainage (seepage). To determine the relationship between these environmental variables and the total abundance of berry plants, we first used a model averaging approach, based on Akaike's Information Criterion (AIC). The lowest delta AIC value indicates the best model (Burnham and Anderson 2002; Maze-

TABLE 2. Results of the model selection analysis to determine which environmental variables explain best the total abundance of berry plants in three regions of Québec. The lowest delta AIC value indicates the best model.

Models	Papineau-Labelle Wildlife Reserve		Laurentides Wildlife Reserve		Côte-Nord region	
	Rank	Delta AIC	Rank	Delta AIC	Rank	Delta AIC
Density	6	13.0	8	42.6	3	127.1
Height	3	6.8	2	4.6	6	183.5
Density and height	2	5.8	3	5.1	2	10.8
Soil texture	7	14.3	6	41.8	8	235.1
Vertical drainage	8	14.5	4	33.6	7	205.9
Oblique drainage	4	8.2	7	41.9	5	167.3
All drainage	5	10.9	5	35.3	4	156.3
All variables	1	0.0	1	0.0	1	0.0

rolle 2006). We then compared the influence of each variable using *t* tests for simple comparisons or Bonferroni *t* tests for multiple comparisons. We considered results of statistical tests to be significant at $P < 0.05$.

A total of 326 plots were sampled in the Papineau-Labelle Wildlife Reserve, containing a total of 24 berry species potentially important for Black Bears. In the Laurentides Wildlife Reserve, there were 679 plots containing a total of 16 berry species. Finally, a total of 1944 plots were sampled in the Côte-Nord region, containing a total of 30 berry species of interest to Black Bears. No sample plots were located on Anticosti Island.

Results

Forty-four species of berry plants sought by Black Bears were found in the regions under study (Table 1). We examined the influence of the selected environmental variables on the total abundance of these berry plants in each study area. The model selection analysis indicated that the general model that included all the variables is the best model that explains the total abundance of berry plants for Black Bears (Table 2). However, density and height of the dominant vegetation were the most important variables in the models. The effect of density was significant only in the Côte-Nord region, but the tendencies in all study areas indicated that berry plants were mostly found in stands were the density of the dominant vegetation was low (Figure 2). The results were clearer with the height of the dominant vegetation, where berry plants were significantly more abundant in open stands (height of the dominant vegetation <3 m) in all three study areas (Figure 3).

Soil texture and drainage (vertical and oblique) always ranked among the weakest variables. Berry plants had a tendency to be more abundant in sand-loam soils, but there was a greater variability in silt-clay soils (Figure 4). Influence of vertical and oblique drainage varied depending on the region. In the Laurentides Wildlife Reserve, berry plants were more abundant in plots with humid vertical drainage (Figure 5). In the Papineau-Labelle Wildlife Reserve and in the Côte-Nord region, berry plants were more abundant in plots with dry vertical drainage (Figure 5). Oblique drainage had a significant influence only in the Côte-Nord region (Figure 6).

Discussion

Influence of dominant vegetation height and density on the abundance of berry plants

Observed tendencies concerning the effect of dominant vegetation height and density on the abundance of berry plants agree with the existing literature. Noyce and Coy (1990) reached the same conclusion as our study, finding berry plants to be more abundant in open areas. Noyce and Coy (1990) also reported that berry productivity was the highest in open areas, so it might also be the case in our study. Hellgren et al. (1991) found that clearcuts and burned sites are good producers of berries. Boileau et al. (1994) affirmed that clearcuts had more berry plants in the Gaspésie Park. In another study, Irwin and Hammond (1985) noted that clearcuts, located in high altitude in Wyoming, contained several berry species consumed by Black Bears. Selective cuts, where the canopy is partially removed, also provide a good variety of berries for Black Bears due to the reduction in canopy density (Young and Beecham 1986; Unsworth et al. 1989). However, berries are generally less abundant in selective and partial cuts than in clearcuts (Costello and Sage 1994). Rudis and Tansey (1995) confirmed that Black Bears were using berry species typically found in clearcuts and other disturbed areas during summer months. Finally, in Quebec's mixed forest, Hébert (2000) found that there were significantly more berry plants for Black Bears in small gaps (< 200 m^2) than under the adjacent forest cover.

Furthermore, studies have found that as open areas closed, their capacity to maintain berry plants diminished. On Long Island, Washington, Lindzey et al. (1986) reported that Black Bear numbers diminished as the vegetation in clearcuts gradually regenerated itself. However, in recently disturbed areas, berries often become abundant only after a few years, which could eventually put more variability in the relation between

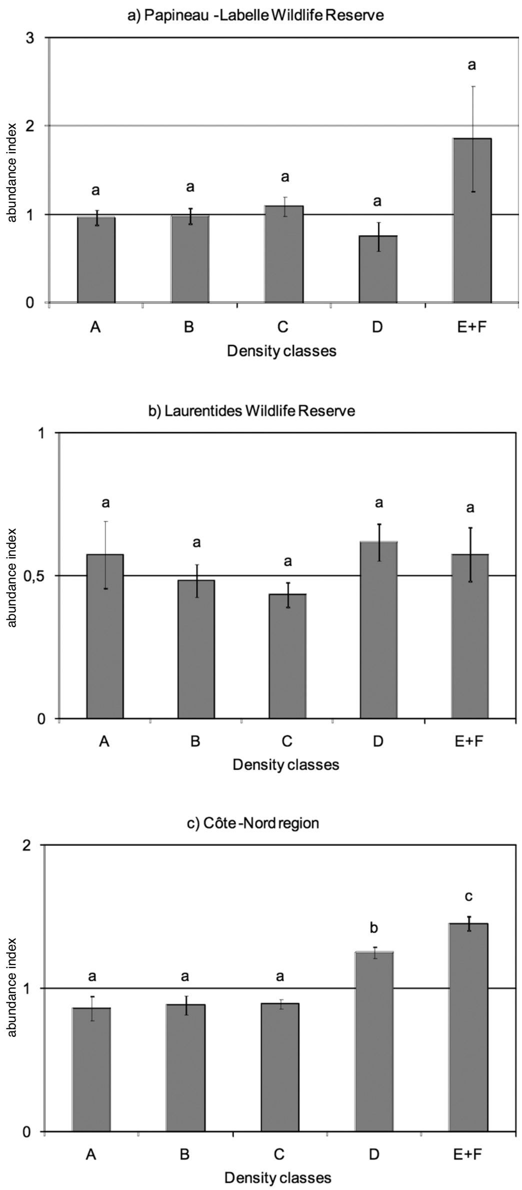

FIGURE 2. Influence of dominant vegetation density on the abundance (mean ± standard error) of berry plants for Black Bears in three regions of Québec. Class A represents the highest density whereas class E+F represents the lowest density. Means with the same letter were not significantly different.

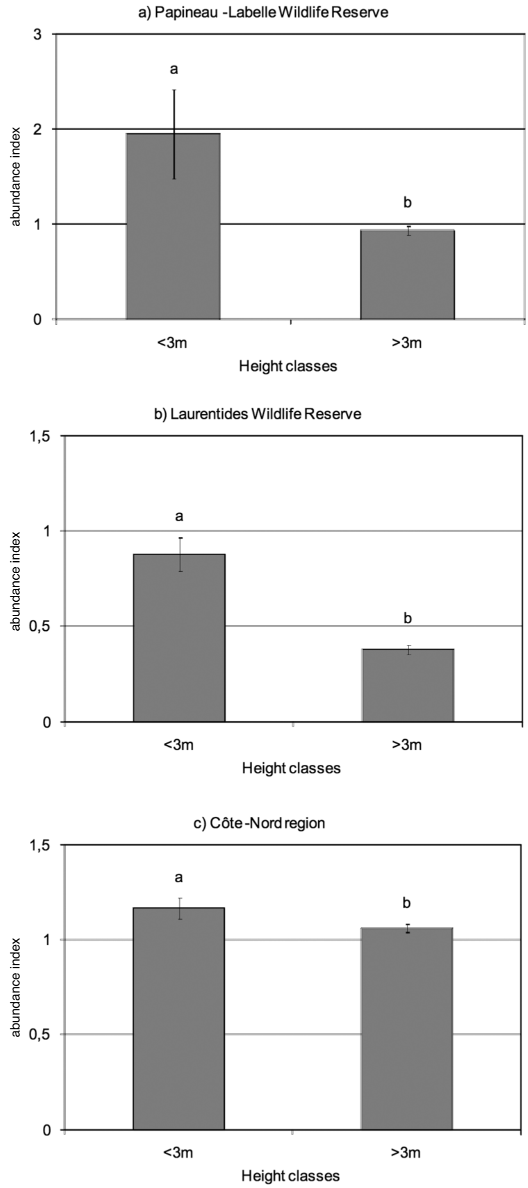

FIGURE 3. Influence of dominant vegetation height on the abundance (mean ± standard error) of berry plants for Black Bears in three regions of Québec. Means with the same letter were not significantly different.

density and height of the dominant vegetation and the abundance of berry plants. In the State of New York, the abundance of berries peaked in 9 to 24 year-old clearcuts (Costello and Sage 1994). In Minnesota, berries were most abundant between 5 and 8 years following disturbance, but became gradually less abundant after 16 years (Noyce and Coy 1990). In the Gaspésie, clearcuts younger than 15 years old had more berries than older cuts (Boileau et al. 1994).

Finally, Mabry et al. (2000), after a classification of vegetation by morphological traits, affirmed that having berries is a feature associated with high site exposure, or solar radiation potential. Thus, plants with this morphological trait are mostly found in open areas.

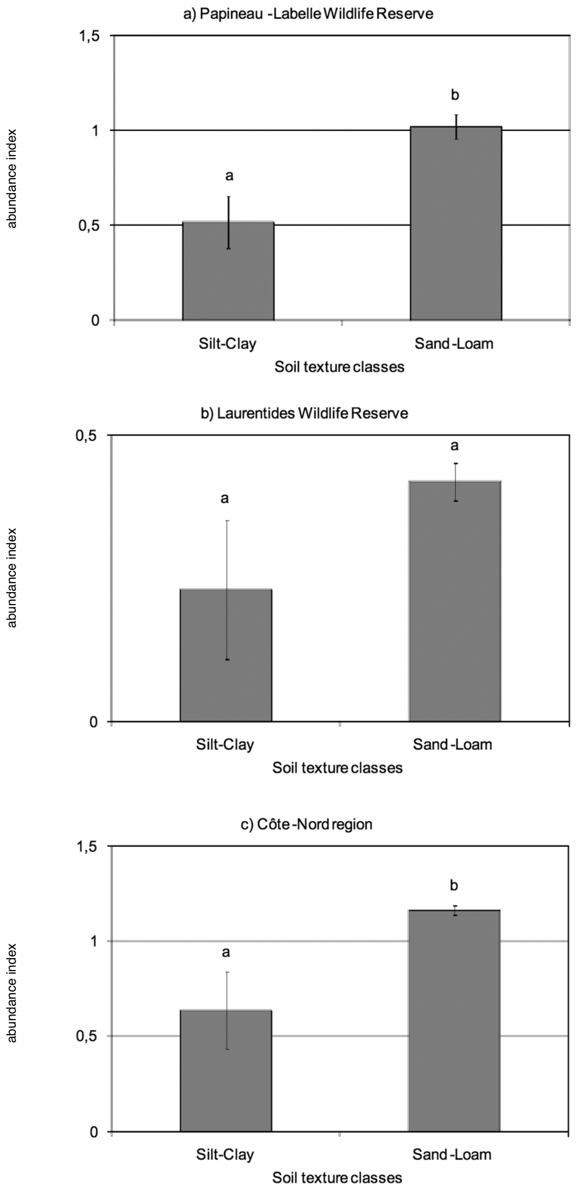

FIGURE 4. Influence of soil texture on the abundance (mean ± standard error) of berry plants for Black Bears in three regions of Québec. Means with the same letter were not significantly different.

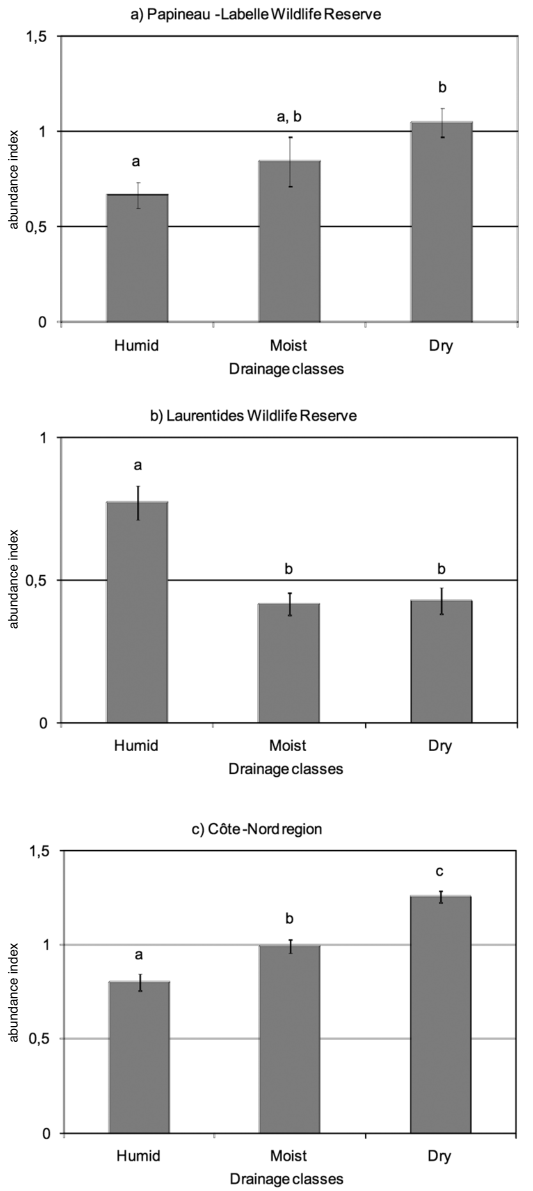

FIGURE 5. Influence of vertical drainage on the abundance (mean ± standard error) of berry plants for Black Bears in three regions of Québec. Means with the same letter were not significantly different.

Influence of soil texture on the abundance of berry plants

According to our results, the influence of soil texture is weak on the abundance of berry plants for Black Bears. According to the results of Whitney (1991), the association of berry plants with soil texture (sand and gravel) was variable depending on the species. In another study done by Noyce and Coy (1990), preference of soil texture was also variable among species.

The general influence of soil texture on plant vegetation is not always obvious. In Missouri, Lyon and Sagers (1998) found that soil texture only poorly explains variation in the vegetation of riparian forests. In the Haut-Saint-Laurent, in Quebec, Meilleur et al. (1992) observed no effect of soil texture on vegetation. In a steppe in the USA, more shrub species were found

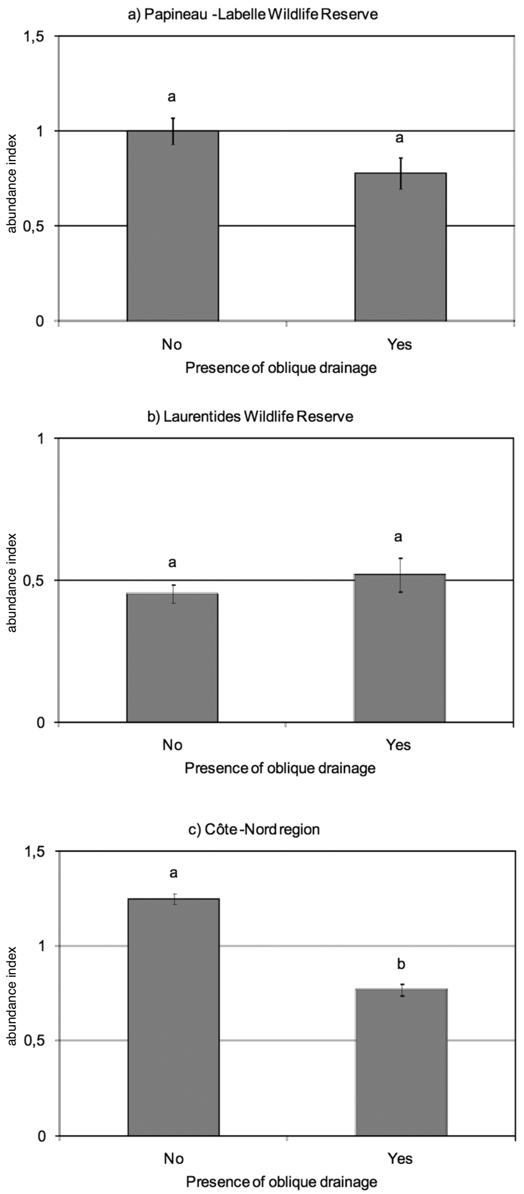

FIGURE 6. Influence of oblique drainage (seepage) on the abundance (mean ± standard error) of berry plants for Black Bears in three regions of Québec. Means with the same letter were not significantly different.

in intermediate soil textures, whereas more herbaceous species were encountered when soil texture was finer (Dodd and Lauenroth 1997; Lane et al. 1998). However, even in these studies, soil texture did not have a significant effect on the aboveground net primary production (Lane et al. 1998).

According to Meilleur et al. (1992), soil texture is less important than general drainage conditions. However, it is well known that soil texture can affect the water retention potential (Dodd and Lauenroth 1997; Lane et al. 1998; Singh et al. 1998).

Influence of vertical and oblique drainage on the abundance of berry plants

Contrary to existing literature, the results of our study show no clear tendency in the preferences of berry plants for specific drainage patterns. Other studies have found marked effects of drainage on general vegetation composition and abundance (Laine et al. 1995; Laiho 1996; Minkkinen et al. 1999). In Finland, several wetlands have been converted to dry areas for forestry. When the water level was permanently reduced, a secondary vegetal succession initiated itself, favoring a forest-type community (Laine et al. 1995; Laiho 1996; Minkkinen et al. 1999). Among the forest species that established themselves, Laine et al. (1995) noted the presence of *Vaccinium* spp. among others.

Several attempts involving ecological classification of vegetation have also been done (Whitney 1991; Carter et al. 1999; Motzkin et al. 1999; Mabry et al. 2000). In those classifications, drainage is sometimes used to characterize plant communities. However, when considering only the berry species used by Black Bears in those classifications, conclusions are equally variable as those in our study (Whitney 1991; Carter et al. 1999; Motzkin et al. 1999; Mabry et al. 2000). Mabry et al. (2000) even identified some morphological traits of berry species that are linked with a dry or humid drainage. The results of Motzkin et al. (1999) were quite variable, showing that the best predictor of the presence of some berry species is sometimes drainage, sometimes the kind of land use, sometimes the soil quality, or sometimes the presence of natural disturbances. Whitney (1991) also found that the association of berry plants with types of drainage varies from one species to another. However, Noyce and Coy (1990) reported that the abundance of berry plants for Black Bears was greatest on well-drained soils, moderate on poorly-drained mineral soils, and lowest on poorly-drained organic soils.

Conclusion

As underlined by Motzkin et al. (1999), a major goal of plant ecology is to determine the factors that control species distributions and community composition. For berry species, the most important variables appear to be height and density of the stands, which are related to the amount of light reaching the plants. Soil texture appears to have a weak influence on berry plants in Quebec. As for drainage, the variability of the effects from region to region could be explained by two main factors. First, many species examined may have a wide range of tolerance to variability in drainage. Therefore, some species could survive equally well in humid as in dry drainage. Secondly, we grouped all berry species together. Some berry species may be strongly associated with a certain drainage pattern while others do better under the opposite conditions. Hence, when grouped together, the drainage preferences mask each other and we observe no tendency. However, this study allowed us to determine the optimal sites of berry resources for Black Bears.

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