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Development of Dual Nutrient Diagnosis Ratios for Basswood, American Beech, and White Ash.

H. Jalilvand[1]

ABSTRACT

Foliar analysis of natural deciduous tree species of basswood (*Tilia americana* L.) (BA), American beech (*Acer grandifolia* Enrh) (BE), and white ash (*Fraxinus americana* L.) (WA) was carried out in 1994 in southern Quebec. The Diagnosis and Recommendation Integrated System (DRIS) was developed from the traditional method to find the preliminary norm and indices of N, P, K, Ca, and Mg for the above species. The growth decade 1983-1994 in a high yielding sub-population was used to develop DRIS norms for the identification of DRIS functions and indices in relatively depleted levels of those elements in the declined growth of three species. Foliar nutrient deficiencies were found with K (-3.72) and N (-2.96) for basswood, Ca (-10.43) and Mg (-4.93) for beech, and N (-6.16), Ca (-2.56) and K (-2.05) for white ash. The DRIS analysis indicated that basswood and white ash were relatively depleted of K and N, while beech had a deficiency of Ca and Mg, and white ash had a limitation of N. These results suggest the usefulness of DRIS for foliar tissue analysis as an indicator of nutritional status and elemental stresses in natural forests. The DRIS indices were also discussed from the traditional approach.

Keywords: DRIS, Forest tree nutrition: Ash, Basswood, Beech, Leaf analysis.

NTRODUCTION

There are several methods for assessing the nutrient status of trees growing in a particular environment (Zoettl and Huettl, 1986). A common and the simplest method is to find a standard for each element independently. One of the methods, which was used many years ago, was the critical level or univariate approach. Critical leaf nutrient concentrations are usually defined as the foliar nutrient concentrations at which a tree can achieve 90% of its maximum growth. The critical value approach (CVA) was affected to a large extent by nutrient interaction and plant age (Bates, 1971), and it is unable to rank the order in which nutrients are becoming limited when more than one nutrient is limited (Lozano and Huynh, 1989).

Beaufils (1957) found that the ratio between certain pairs of elements was closely related to the dynamic nature of foliar composition. He applied this technique known as "physiological diagnostic" in foliar nutrient and soil analyses to find the limitation on nutrient factors. After Beaufils, many papers have been published on the Diagnosis and Recommendation Integrated System (DRIS) for crop plants. This system reduced the effects of age and the interaction between nutrient elements (Sumner and Beaufils, 1975; Sumner, 1977) and generally shows greater diagnosis efficiency than CVA (Walworth and Somner, 1989).

The DRIS or bivariate system has received little attention in forestry, although its potential use with radiata pine (*Pinus radiata*) (Truman and Lambert, 1980), hybrid poplar (*Populus deltoides*) (Leech and Kim, 1981), eucalyptus (*Eucalyptus saligna*) (Ward *et al.* 1985), fraser fir (*Abies fraserie*) (Hockman *et al.* 1989), loblolly pine (*Pinus taeda*)

[1] Department of Forestry, Faculty of Natural Resources, University of Mazandaran, P.O. Box: 737, Sari, Islamic Republic of Iran.

(Hockman and Allen, 1989), walnut trees (*Juglans regia*, cvs. 'Hartley' and 'serr') (Klein *et al.* 1991), and sugar maple (*Acer saccharum* Marsh) (Lozano and Huynh, 1989; Paré *et al.* 1993) has been documented. However, all of these studies employed the DRIS approach on a preliminary or investigative basis only. All reports show that DRIS applications were successful with results indicating that the system was quite sensitive in detecting nutrient imbalances. Most plant analysis for diagnostic purposes in forest stands has been conducted on coniferous species, although much of the earlier work dealt with deciduous tree species (Hockman and Allen, 1989; Rathfon and Burger, 1991, Paré *et al*. 1993; Klein *et al*. 1991).

There is no DRIS norm or standard of nutrient pattern for most of deciduous species in southern Quebec, although a preliminary DRIS standard for each macro-element has been created for basswood (BA), American beech (BE), and white ash (WA) in southern Quebec. This study was based on the chemical analysis of mature leaves on high and low productive sites. The objectives of this study were: 1) to establish a set of foliar DRIS norms for N, P, K, Ca, and Mg based on high productivity stands of BA, BE, and WA; 2) to formulate the appropriate set of DRIS index equations; and 3) to validate the indices.

MATERIAL AND METHODS

The study site was located in the Morgan Arboretum on the West Island of Montreal in Southern Quebec (45^o $25^'$ N, 73^o $57^'$ W; 15.2 m above sea level). Sampling for this study was carried out in both low and high growing sectors. The nearest weather station is Saint-Anne-de-Bellevue (No. 7026839, latitude 45^o $26^'$, longitude 73^o $56^'$, altitude 39 m. The mean annual temperature was 6.2^o C with a mean minimum temperature of 4.9^o C and a mean maximum temperature of 7.5^o C. The average of the last ten years total precipitation was 942.4 mm.

According to Lozano and Huynh (1989), leaves and increment cores were taken in a total of 60 individual dominant-codominant basswood (20), beech (22), and white ash (18) in four sectors. Those sectors were selected using a map from highly productive and less productive stands. Sampling was carried out in the middle of August since foliar tissues have a highly dynamic nutritions and the variation in leaf mineral nutrients was very low at that period. From each tree, one core was taken at DBH level using a Pressler increment borer to measure the tree-ring width over the last decade. Tree height was measured using a Haga instrument.

Leaves were dried at 65^o C for 48 hours in an oven until constant weight was reached. The samples were ground in a Cyclotic mill in order to pass through a 40-mesh screen. Leaf tissue was digested according to the procedure set out in Thomas *et al*. (1967). Automated colorimetric methods were applied for N and P analyses and cation (K, Ca, and Mg) determinations were made through atomic absorption spectrophotometry (Hockman and Allen, 1989). The cores were air dried and smoothed by sand-paper. Tree-ring increments were measured using a modified microscope.

Growth was determined by calculating the mean annual increment based on basal area growth over the last 10 years. The annual basal area growth calculated from the average of those years was selected as the best estimate of current stand yield, because it was highly correlated in terms of diameter, height, and volume growth ($r = 0.85, 0.79, 0.90$, at $P < 0.0001$, respectively). A range of growth variables were studied by Kopp and Burger (1990) and Hockman *et al.* (1990). They found that diameter measured at the groundline was the variable that correlated most closely with tree nutrition in the Fraser fir Christmas tree. In both studies a single location and individual trees or group of trees were used.

DRIS norms were calculated according to traditional DRIS methodology (Beaufils, 1973; Lozano and Huynh, 1989; Hockman

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and Allen, 1989). DRIS norms are defined as the average value of foliar nutrient pair ratios for high yielding sectors. To develop these norms, the data set was separated into two classes according to Lozano and Huynh (1989). Based on annual basal area growth, a selected performance was measured at 3.75, 2.21, and 2.80 m^2 ha^{-1} yr^{-1} for BA, BE, and WA, respectively. Sixteen circle plots (an area of 1000 m^2 each) were assigned to the high (8) and low (8) productivity class sites in order to select two or three individual trees for measuring the growth characteristics and for foliar tissue sampling. In each productivity site, descriptive statistics were computed for foliar nutrient (N, P, K, Ca, and Mg) concentrations and for any dual ratio for each productivity group. A completely randomized design was used to find differences between univariate and pair ratios of foliar nutrient concentrations in high and low productivity sites for each nutrient separately by species. Mean differences between low and high productivity foliar nutrient concentrations and pair ratios or inverse ratios were calculated using the T-test ($p < 0.10$ or < 0.20) to prepare the data set for formulating DRIS function and indices. Correlation technique was used to find the functional relationship between tree growth characteristics (basal area, diameter, height, and volume). All statistical analyses were carried out by Lotus (1992) and SAS (SAS Institute 1990) computer softwares. From the ten nutrient ratios for each species, seven, eight and eight pair ratios were significant for BA, BE, and WA respectively. Based on the ten nutrient ratio norms of five elements in the high growth classes, a set of five DRIS nutrient-index equations for three species were developed for a full set of index functions with four functions in each index. The graphical method developed by Hockman and Allen (1989) was used to validate DRIS norms.

RESULTS AND DISCUSSION

The means and coefficients of variations (CV) of individual nutrient concentrations and their ratios are shown in Table 1 for BA, BE, and WA for the high and low productivity groups. A total of 30 ratios was developed and used in the calculation of the DRIS norms, of which ratios of three, two, and two for BA, BE, and WA were not significant (Table 1). A somewhat greater than usual alpha level of 0.10 was included to test the significant differences between the rich and poor subpopulations. Significantly larger mean nutrient concentrations of N and K (BA), Ca and Mg (BE), and N (WA) were found for the high growth groups. In contrast, the nutrient concentrations of Ca (BA), P and K (BE), and P (WA) were significantly lower in the higher productivity class and those of P and Mg (WA), N (BE), and K, Ca, and Mg (WA) did not differ between high and low productivity sites. Low Ca and high N and K (BA) levels from the highly productivity class could be due to poorly drained sites. High Ca and Mg (BE) in the low class could be the result of a well-drained system.

Some of the original pair ratios (e.g. N/P and N/Mg) were significant, but others were not since the inverse significant ratios (e.g. P/N and Mg/N) were used. All significant and insignificant ratios or those significant at low probability (in total, seven from 30) were used to provide DRIS function and DRIS index equations for more balanced diagnoses. In this case, all mean values for the nutrient ratios did differ between the high and low productivity classes, except for those ratios including: N/P, P/Mg, and Mg/Ca (BA); P/K and Ca/Mg (BE); and N/Ca and Ca/Mg (WA) (Table 1).

The relatively uniform variability of the Mg ratios with Ca (BA, BE, and WA) and P (BA); with K (BE); and Ca with N (BE), regardless of productivity classes, suggested that these ratios were lesser importance as DRIS discriminators. The atypically low Ca (BA), P (BE, WA), and K (BE) in the high class and the high N (BA, WA), K (BA), and Ca and Mg (BE) in the low productivity class, as noted for the mean nutrient concentrations (Table 1), had a major influence

Table 1. Nutrient concentration and dual ratio means, standard deviations (SD), and coefficient of variations (CV) for the high and low performance[a] growth of basswood, beech, and white ash.

Variable	High growth			Low growth			
	Mean	SD	CV	Mean	SD	CV	T-tes
				Basswood			
N(mg/g)	26.90	4.07	15.12	22.99	1.77	7.71	2.79***[b]
P(mg/g)	3.30	1.29	39.11	2.86	0.57	19.85	0.99[ns]
K(mg/g)	24.46	8.28	33.84	15.32	3.47	22.61	3.22***
Ca (mg/g)	16.36	5.68	34.47	20.45	2.98	14.54	2.02*
Mg (mg/g	2.98	1.18	39.43	3.43	0.72	20.85	1.04[ns]
N/P	8.96	2.47	27.52	8.36	1.89	22.57	0.61 [ns]
K/N	0.91	0.29	31.37	0.67	0.18	24.41	2.37*
N/Ca	1.09	0.87	45.56	1.14	0.15	13.29	2.73***
Mg/N	0.10	0.05	43.17	0.15	0.03	22.35	2.13*
K/P	8.40	3.94	46.52	5.53	*0.15*	28.69	2.13*
P/Ca	0.16	0.16	66.28	0.14	0.03	24.09	1.96[a]
Ca/K	0.79	0.50	63.40	1.43	0.56	39.23	2.71***
K/Mg	9.60	4.67	48.65	4.51	0.77	17.18	3.40***
P/Mg	1.44	1.25	86.78	0.87	0.31	35.90	1.40[ns]
Mg/Ca	0.18	0.06	33.91	0.17	0.05	30.84	0.62[ns]
				American beech			
N (mg/g)	19.78	5.06	25.60	20.01	1.86	9.27	0.14[ns]
P(mg/g)	1.25	0.14	11.55	1.74	0.29	16.73	5.06***
K(mg/g)	6.45	1.40	21.64	9.03	1.11	12.26	4.80***
Ca(mg/g)	6.65	0.74	11.12	5.49	0.83	15.17	3.46***
Mg(mg/g)	1.83	0.44	24.18	1.41	0.16	21.28	2.92***
N/P	15.82	3.94	24.89	11.80	2.51	21.28	2.85***
N/K	3.19	1.04	32.62	2.23	0.28	12.37	2.94***
N/Ca	2.97	0.75	25.31	3.70	0.60	16.25	2.52**
N/Mg	10.99	3.16	28.72	14.32	2.54	17.71	2.73***
P/K	0.19	0.04	18.37	0.19	0.03	17.14	0.25[ns]
Ca/P	5.37	0.61	11.44	3.24	0.78	23.97	7.12***
P/Mg	0.71	0.15	21.77	1.25	0.28	23.00	5.62***
K/Ca	0.97	0.23	23.25	1.67	0.29	17.47	6.23***
K/Mg	3.72	1.16	31.23	6.46	1.04	16.08	5.83***
Ca/Mg	3.77	0.76	20.03	3.89	0.45	11.46	0.43[ns]
				White ash			
N(mg/g)	20.82	2.20	10.58	17.51	2.88	16.47	2.88***
P (mg/g)	1.84	0.50	26.93	3.39	0.68	20.15	5.81***
K(mg/g)	11.03	4.14	37.55	13.12	3.20	24.38	1.26[ns]
Ca(mg/g)	17.44	3.86	22.10	17.41	5.76	33.06	0.02[ns]
Mg (mg/g)	2.67	0.39	14.54	2.68	0.93	34.61	0.01[ns]
P/N	0.09	0.03	38.12	0.20	0.06	28.93	5.35***
K/N	0.54	0.23	43.58	0.78	0.27	34.51	2.13*
N/Ca	1.23	0.27	22.00	1.06	0.23	21.75	1.58[ns]
Mg/N	0.12	0.02	14.87	0.15	0.04	24.17	1.76[a]
P/K	0.18	0.05	30.37	0.26	0.06	23.92	3.29***
Ca/P	10.12	3.15	31.14	5.40	2.47	45.80	3.73***
Mg/P	1.57	0.55	34.94	0.84	0.43	51.24	3.30***
K/Ca	0.65	0.27	41.64	0.83	0.38	45.90	1.26[ns]
K/Mg	4.24	1.83	43.09	5.35	2.43	43.97	1.34[ns]
Ca/Mg	6.55	1.24	18.97	6.65	1.29	19.40	0.17[ns]

[a] High and low growth sub groups represent stands with annual basal area growth equal to or higher than 3.75, 2.21, and 2.28 $m^2ha^{-1}yr^{-1}$ for basswood, beech, and white ash, respectively. [b]ns, a,*, **, and *** indicate not significant (ns) and statistically significant between high and low grow at the 10, 5, 2, and 1% levels, respectively.

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on the nutrient ratios. However, their variability in the high group showed greater CVs. These variations could be inflated in all of the ratios, and therefore they might have reduced the sensitivity of all the nutrient index equations. Ratios with high CVs received little attention in the index equations. For example, in the basswood nutrient DRIS indices, from among fifteen functions of dual ratios, one function of N (N/P) in the N and P indices and two functions of Mg (P/Mg and Mg/Ca) in the P, Ca, and Mg indices were not significant. The addition and subtraction components of each dual function were included in an index when at least two of the four ratios were significant or higher in the high subpopulation. The functions of the P index for basswood, and of Ca and Mg for three species were less sensitive to assess in the relative balance optimal equations than the other functions because of low and/or nonsignificant ratios and a larger simple amount of nutrition on the low subpopulation group (Table 1 and 2).

DRIS indices for leaf nutrients can range from positive to negative, but they always sum to zero. A positive or negative index indicates an excess or deficiency of a particular nutrient relative to other nutrients. The more positive or negative index values show a greater excess (luxury consumption) or a greater limitation of that particular nutrition. Thereby, one of two intermediate functions of a nutrient dual ratio was standardized depending on whether the selected ratio was greater or lesser than the norm. Using traditional methods (Beaufiles, 1973), indices are also weighted with the inverse of the CVs norm and the variability of norms on high growth of individual trees which are included in the intermediate function. An average estimate of the overall balance of nutrient relative to each other was provided by index equations (Table 2).

The large variation in the high growth group could be due to the leaf sampling from the crown position compared with the foliar sampling conducted in the low growth

Table 2. DRIS indices equations for assessing the relative N, P, K, Ca, and Mg status in basswood (A), Beech (B), and white ash (C) native deciduous tree species in southern Quebec.

(A). Basswood:	N_{Index} = [f (N/P) + f (K/N)] - [f (Mg/N) + f (N/Ca)]
	P_{Index} = [f (P/Ca)] - [f (P/Mg) + f (K/P) + f (N/P)]
	K_{Index} = [f (K/P) + f (K/Mg)] - [f (Ca/K) + f (K/N)]
	Ca_{Index} = [f (Ca/K) + f (N/Ca) + f (Mg/Ca)] - [f (P/Ca)]
	Mg_{Index} [f (P/Mg) + f (Mg/N)] - [f (Mg/Ca) + f (K/Mg)]
(B).Beech:	N_{Index} = [f (N/P) + f (N/Ca)] - [f (N/Mg) + f (N/K)]
	P_{Index} = - [f (N/P) + f (Ca/P) + f (P/K)] + [f (P/Mg)]
	K_{Index} = [f (P/K) + f (K/Mg) + f (K/Ca) + f (N/K)]
	Ca_{Index} = [f (Ca/Mg) + f (Ca/P)] – [f (K/Ca)] + [f (N/Ca)]
	Mg_{Index} = [f (N//Mg)] - [f (K/Mg) + f (P/Mg) + f (Ca/Mg)]
(C). White ash:	N_{Index} = [f (N/Ca)] - [f (K/N) + f (Mg/N) + f (P/N)]
	P_{Index} = [f (P/K) + f (Mg/P) + f (P/N)] - [f (Ca/P)]
	K_{Index} = [f (K/N) + f (K/Mg)] – [f (P/K) + f (K/Ca)]
	Ca_{Index} = [f (Ca/P) + f (K/Ca)] - [f (N/Ca)] + f (Ca/Mg)]
	Mg_{Index} = [f (Mg/N) + f (Ca/Mg)] – [f (Mg/P)+ f (k/Mg)]
Example:	
If n/p > 8.96	f(N/P) = [((n/p) / 8.96) - 1] x (100/27.52)
or	
If n/p < 8.96	f(N/P) = [1-(8.96 I (n/p)] x (100/27.52)

where n/p is the foliar N/P ratio in a tree species (basswood) under investigation. 8.96 is the reference N/P ratio (DRIS norm) in the high growth classes (Table 1). 27.52 is the coefficient of variation for this norm.

class (Leaf, 1973). However, it has been reported that the DRIS norms were not affected by position of sugar maple leaf sampling (Lozano and Huynh, 1989). The sensitivity of nutrient ratios should be improved if the number of tissue sampling is increased in both productivity classes. Also, sampling from the selection of high and low productivity sites in the other stands would be important for identifying better DRIS norms. Early results suggested that the optimum nutritional balance for three species may vary depending on soil drainage, soil nutrient availability, and soil homogeneity.

Table 3 shows the function ratios that were used to calculate DRIS indices. These data were computed using DRIS functions as set out in Table 2. The indices showed the order of nutrient limitations for three species. The nutrient limitations are shown for: K (-3.72) and N (-2.96) for BA; Ca (-10.43), Mg (-4.93), and N (-0.72) for BE; and N (-6.16), Ca (-2.56), and K (-2.05) for WA. The lowest indices were K for BA, Ca and Mg for BE, and N for WA. The best overall nutrient balance index (B_I) was achieved for BA (13.35), BE (32.15), and WA (2.69).

Validation of DRIS Norms

Figure 1 shows the plotting basal area increment against individual nutrient indices and the nutrient balance index for three species (basswood, A; beech, B; and white ash, C), to test the performance of DRIS by applying the equation indices to the data base. The scatter plots of basal area growth and DRIS indices were evident for delineating the limitation between the two productivity classes (using horizontal reference lines). Although the plots revealed a distinct boundary relation between growth and all nutrient indices for BA, BE, and WA, dotted lines were drawn to approximate the boundary condition.

The performance horizontal line was

Table 3. The function rationing and DRIS indices of declined growth in basswood (BA), beech (BE), and white ash (WA) foliar nutrient concentrations (N, P, K, Ca, and Mg).

	Basswood		Beech		White ash	
Nutrient	Mean	SE	Mean	SE	Mean	SE
			Functions[a]			
N/P	-0.44	0.34	-1.56	0.33	3.34	0.49
K/N	-1.40	0.36	-0.92	0.08	1.09	0.40
N/Ca	0.08	0.10	0.97	0.24	-0.80	0.40
Mg/N	1.04	0.24	1.06	0.24	0.93	0.65
P/K	-1.38	0.34	-0.12	0.36	1.58	0.41
Ca/P	-0.29	0.13	-6.51	1.10	-4.13	0.64
K/Ca	-0.21	0.10	3.09	0.39	0.79	0.49
K/Mg	1.28	0.35	2.36	0.27	0.77	0.49
P/Mg	-2.46	0.28	3.48	0.54	-4.00	0.85
Ca/Mg	-0.42	0.35	0.15	0.18	0.01	0.40
			Indices			
I_N	-2.96	0.29	-0.72	0.30	-6.16	1.24
I_P	1.73	0.61	11.66	1.62	5.04	0.74
I_K	-3.72	0.51	4.41	0.68	-2.05	0.46
I_{Ca}	1.23	0.31	-10.43	1.63	-2.56	0.77
I_{Mg}	3.71	0.38	-4.93	0.65	5.72	1.15
B_I	13.35	1.49	32.15	4.46	21.54	2.69
Status	K<N<Ca<P<Mg		Ca<Mg <N<K<P		N<Ca<K<P<Mg	

[a] Function ratios K/P, P/Ca, Ca/K and Mg/Ca for BA; N/K and N/Mg for BE; P/N and Mg/P for WA.

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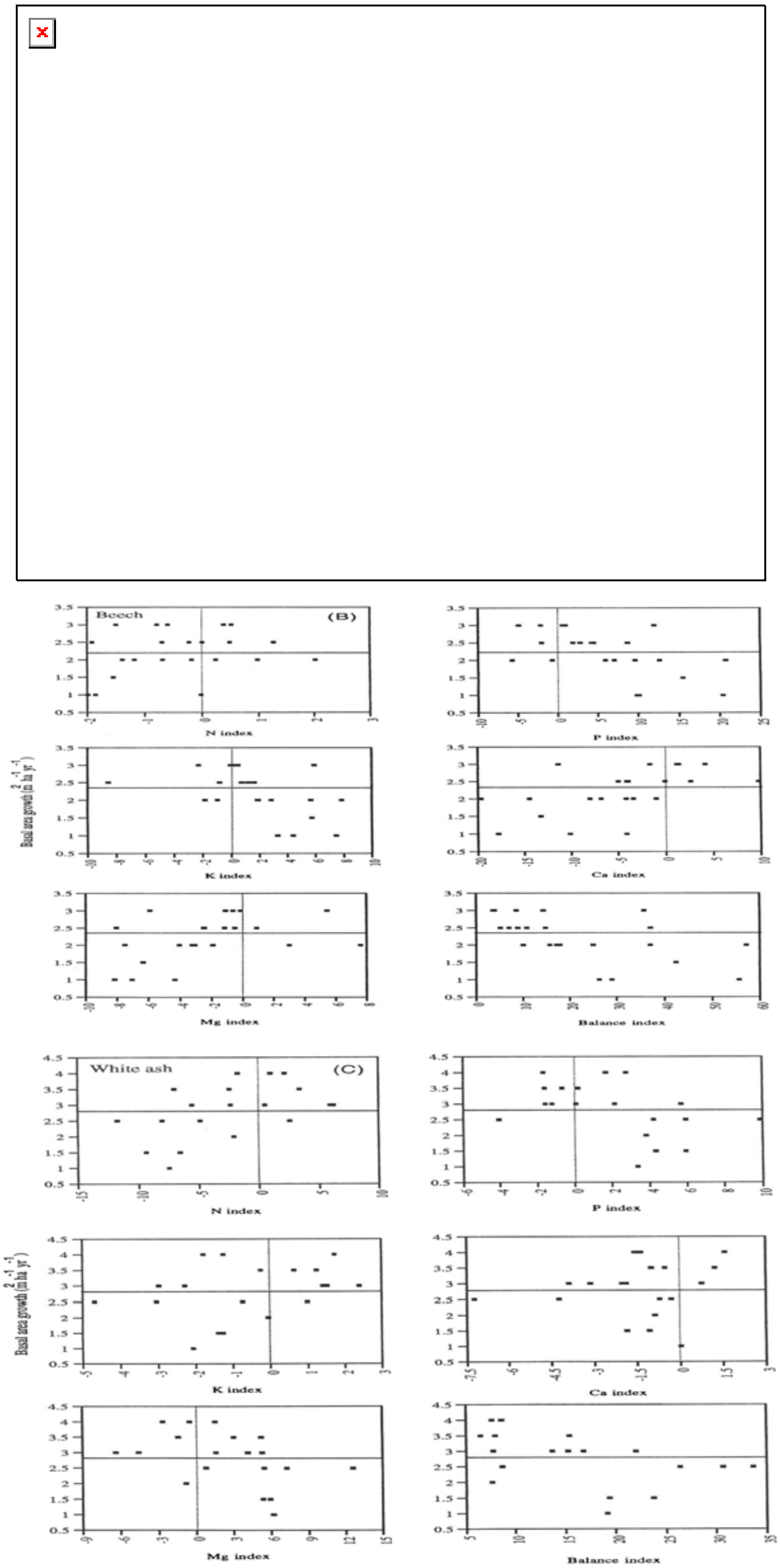

Figure 1. Relationship between basal area growth and DRIS N, P, K, Ca, Mg indices, and the nutrient balance index. Horizontal reference lines delineate limit between high and low growth classes. Vertical reference lines indicate the optimum balance of those elements for basswood (A), beech (B), and white ash (C).

clearly divided between low and high growth levels. The vertical, dotted balance index line (the zero line) shows the criterion for evaluation of nutrients by cross-section with the performance line. Nutrient deficiency for specific nutrition on declined growth is found when most of the scatter points on the lower part of horizontal line are the relatively to the lower left-hand side of the plots (at the bottom of the horizontal line and left of the vertical line). Nutrient sufficiency for specific nutrition is revealed when most data points accumulate on the bottom right- hand side of the plot from the base line. A larger distribution of points on the left-or right-hand sides of these areas shows a greater limitation or sufficiency of nutrition. For example, in Figure 1(A) for BA, most of the data points for the N and K indices in the lower part of the plots are accumulated on the left-hand side, but for P, Ca, and Mg, they accumulated heavily on the bottom right-hand side of the plots. Therefore, these plots show deficiency in N and K and a sufficiency of P, Ca, and Mg. For the most important test of the validity of DRIS norms it is necessary for the fertilizer applications recommended by the order limitation of DRIS indices to be completed.

Magnesium is known to be more soluble and thus more available for plant uptake at a lower pH (Tisdale *et al*. 1985). A high level of Mg in foliar tissue of basswood in the low groups would be due to more solubility of this element amongst the poor classes. This should affect the uptake of K and N in the low productivity group.

CONCLUSION

In this test, the DRIS bivariate approach allowed for the diagnosing of nutrients for three natural tree species. The functional ratios seemed to define the limitations of nutrients for three species well, even though high random effects have been shown in the dual ratio of mobile and immobile nutrient elements. The values for the indices derived from the performance criteria as defined for high productivity groups would depend on tree species, site characteristics, and the norms. The larger value of Ca or Mg could have an effect on the interaction between untrients and interpretation of the results. Furthermore, the test showed that interaction among nutrients could be a factor that must be considered in diagnosing the nutrient status of these species. A DRIS preliminary norm data set representing the site condition was developed in the Morgan Arboretum.

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توسعه روش دوگانه تشخیص و توصیه (DRIS) برای گونه‌های نمدار، راش و زبان گنجشک سفید

ح. جلیلوند

چکیده

آنالیزبرگ گونه‌های نمدار(.*Tilia americana* L)(BA)؛ راش آمریکایی(*Fagus grandifolia* Enrh)(BE)، و زبان گنجشک سفید (.*Fraxinus americana* L)(WA)، در ایستگاه تحقیقاتی جنگل‌های طبیعی، در جنوب جزیره مونترال (جنوب استان کبک، کانادا) صورت گرفت. از روش سنتی دریس (سیستم تشخیص کمبود عناصر غذایی و توصیه ایجاد تعادل تغذیه‌ای)، به منظور یافتن الگو و استاندارد اولیه شاخص‌های عناصر غذایی ازت، فسفر، پتاسیم ، کلسیم و منیزیوم ، برای گونه‌های بالا استفاده گردید.

میزان رشد بالا در ایستگاه‌های حاصلخیز به عنوان زیر جمعیت مورد بررسی در توده‌های جنگل طبیعی، جهت تعیین استانداردهای دریس (DRIS) ، شناسایی توابع آنها و شاخص‌های نسبت داده شده عناصر عمده غذایی، که در افت رشد سه گونه فوق دخالت داشتند، درنظر قرار داده شد. نتایج معلوم کرد که در تغذیه برگی، کمبود عناصر پتاسیم (۳/۷۲-) و ازت (۲/۹٦-) درگونه نمدار، عناصر کلسیم (۱۰/٤۳-) و منیزیوم (٤/۹۳-) در گونه راش آمریکایی و عناصر ازت (٦/۱٦-)، کلسیم (۲/٥٦-) و پتاسیم (۲/۰٥-) در زبان گنجشک سفید، نسبت به استاندارد وجوددارد. آنالیز دریس نشان داد که به طور نسبی کمبود عناصر پتاسیم و ازت در برگ گونه های زبان گنجشک سفید و نمدار دیده می شود، زیرا هر دو گونه در یک موقعیت مکانی مشترک قرار دارند. اگر چه ایجاد محدودیت در رشد گونه زبان گنجشک، توسط کمبود عنصر ازت در برگ، نسبت به پتاسیم و کلسیم بیشتر بود. کمبود عناصر کلسیم و منیزیوم که درگونه راش مشاهده شد، احتمالاً مربوط به پایین بودن اسیدیته خاک و خالص بودن توده راش می باشد. با توجه به مطابقتی که از طریق ترسیمی بین اندیکاتورهای حاصله با شاخص های دریس به عمل آمد، می توان به نتایج بدست آمده اطمینان داشت. نتایج مشخص کرد که روش آنالیزهای نسبی دوگانه در ترکیب دریس، به منظور تعیین میزان بالانس تغذیه عناصر در بافت برگ و موقعیت عناصر غذایی در جنگل‌های طبیعی، قابل استفاده می باشد. در این مقاله، چگونگی استفاده از روش‌های سنتی شاخص‌های دریس برای توسعه این روش در توده‌های طبیعی گونه‌های مذکور نیز مورد بحث قرار داده شده است.

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