AQUATIC FORAGE RATINGS ACCORDING TO WETLAND TYPE: MODIFICATIONS FOR THE LAKE SUPERIOR MOOSE HSI

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ABSTRACT: Because aquatic macrophytes are recognized as a critical forage for moose in parts of North America, habitat evaluation for moose in these regions requires estimates of the availability of aquatic resources. The habitat suitability index (HSI) model for moose of the Lake Superior region includes wetlands as a primary variable because they produce aquatic macrophytes. In northeastern Minnesota, representative samples of 10 wetland types were measured for areal cover and species composition of macrophytes, while biotic and physical variables that may serve to predict macrophyte presence were also recorded. Abundance of macrophytes favored by moose varied among wetland types, with slow streams and beaver ponds having higher levels than lakes and fast streams. We tested whether standard color or black-and-white aerial photos (1:15,840) would reveal extent of submerged and floating aquatics, based on known, measured sites, and found the photos unreliable. We conclude that specifications in the Lake Superior moose HSI for measuring aquatic resources can be significantly improved by including a classification of wetlands that relates more closely to the limnological conditions that favor macrophytes.

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Evaluating the effects of landscape alteration resulting from forest management practices on habitat quality has been a major issue in moose management. In 1987, moose experts from around the Lake Superior region contributed to the development of a habitat suitability index (HSI) model that a) synthesized existing habitat information and b) provided a semi-quantitative framework to facilitate integration of moose habitat needs with other resource activities (Allen *et al.* 1987, 1988). A key component of that model is the availability of aquatic forage for moose in summer.

Studies of moose-habitat relationships have indicated that moose seek aquatic macrophytes as their primary source of the essential mineral, sodium, which, in the Lake Superior region, is available at insufficient levels in terrestrial forage but is highly concentrated in aquatic vegetation (Botkin *et al.* 1973, Jordan *et al.* 1973, Peek *et al.* 1976, Brusnyk and Gilbert 1983, Fraser *et al.* 1984, Jordan 1987). The consistent use of aquatic plants in early and mid-summer by moose, particularly lactating cows, also indicates the importance of habitats that provide such forage (Belovsky and Jordan 1981).

The Lake Superior moose HSI lists riverine, lacustrine, or nonacidic palustrine wetlands (as defined by Cowardin *et al.* 1979) not dominated by woody vegetation as sources of aquatic forage. The contribution of the aquatic forage resource to overall habitat suitability is determined by the proportion of an evaluation unit comprised of such wetlands. The model assumes that the three wetland types are equally productive and that 10% of these wetlands support suitable, dense stands of accessible aquatic macrophytes. Species composition among macrophytes was judged to be of little importance to forage quality, given the relatively non-selective feeding reported by Aho (1978), Aho and Jordan (1979), and Fraser *et al.* (1984). These assumptions were necessary to create the link between the item operating on habitat suitability, aquatic forage, and the wetland inventory information available to land managers.

According to the HSI, "ideal" or optimum summer habitat should have the potential to support 2 moose/km^2. Given that the HSI format produces at best inexact point estimates, the wetland component of this optimum setting should comprise at least of 2.2% of the evaluation unit.

However, studies on Isle Royale (Jordan *et al.* 1973, Aho and Jordan 1979, Belovsky and Jordan 1981) have shown that super-optimal (as defined by the HSI) moose densities (3-4/km^2) may be obtained when actual sites producing aquatic macrophytes comprised far less than 1% of the land area. In addition, the capability of wetlands as producers of aquatic macrophytes has been shown to vary with physical features such as substrate, pH, temperatures, and flow rates (Aho 1978, Fraser *et al.* 1984). While measuring macrophyte density for each wetland is impractical on a landscape level, a classification scheme based on such characteristics might provide a more reliable link between aquatic forage production and wetland inventory, eliminate critical assumptions, and therefore result in a more refined model.

Our study goal was to determine whether better correlates of macrophyte productivity than the broad wetland types specified in the HSI could be found in northeastern Minnesota, and if so, recommend revisions to the model.

STUDY AREA

A survey of wetlands was conducted in northeastern Minnesota during July-August 1990. Sampling sites were distributed over some 2500 km^2 within the Tofte and Gunflint Ranger Districts of the Superior National Forest, and lay from 1.5 km to 35 km inland of Lake Superior. Local climate, topography, and vegetation, particularly as they affect habitat for moose, are detailed by Peek *et al.* (1976). Forests are primarily boreal, with common upland species being paper birch (*Betula papyrifera*), quaking aspen (*Populus tremuloides*), white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), and jack pine (*Pinus banksiana*), with lowland forests of black spruce (*Picea mariana*), northern white cedar (*Thuja occidentalis*) and larch (*Larix laricina*). Non-forested wetlands occur widely throughout the region and have been described in general by Eggers and Reed (1987). Ecology and dynamics of moose in this region were described by Peek *et al.* (1976). Estimates for average moose density in the study area are about 0.4/km^2 (Minn DNR 1990), although densities may vary locally.

METHODS

Our wetland classification system was based on two related criteria: a) physiographic differences among types were sufficiently distinct to affect macrophyte production, and b) these differences were detectable using maps showing wetland morphology or aerial photos. The resulting types chosen for macrophyte analysis were:

a) large lakes, > 5 ha (LL)
b) small lakes, 1-5 ha (SL)
c) ponds formed in natural depressions, < 1 ha (P)
d) ponds created and maintained by beavers (BP)
e) slow streams and rivers (SSR)
g) fast streams and rivers (FSR)

Lake size was included because wind-caused wave action in larger lakes may affect distribution of aquatic macrophytes. In addition, a large portion of these lakes may be too deep (> 2m) for moose. For this reason only those portions of larger water bodies available to moose, i.e. shallow shoreline zones, were considered in coverage estimates. Lakes were also subdivided according to bottom type: a) rocky, dominated by exposed boulders (R); b) mucky, dominated by soft silty or organic sediments (M); and c) sandy, dominated by sand or fine gravel (S). Slow streams were defined by a meandering form and flows weak enough to facilitate sediment accumulation; while fast streams were typically swept clean of fine sediments and had a rocky substrate. Uniform segments of a stream or river were sampled separately, so a given stream might have been divided into fast and slow sections, and only unshaded portions of a stream or river were sampled.

A rough, stratified, weighted design was developed to efficiently allocate limited time for sampling. First, preliminary estimates of relative macrophyte productivity among the 10 wetland types were derived from the literature (Aho and Jordan 1978) and from an earlier survey by our group (Dorweiler and Quincer 1987, unpubl. data). This led to more intensive sampling of large and small lakes with mucky bottoms, ponds in natural depressions, ponds created by beaver activity, and slow streams. Sedge meadows were not sampled as these are not generally used by moose (Peek *et al.* 1976).

Areal coverage of macrophytes was esimated visually and coupled with species identifications from collected samples. Generally, a single observer surveyed from a canoe, or from shorelines where canoeing was difficult. Each site was traversed so as to see all major patches of macrophytes. Areal extent of macrophytes, which generally occur in dense patches, was classified as none or trace, <1/3, 1/3-2/3, or >2/3 of the surface area of the wetland. Coverage estimates did not include scattered individual plants, not only to simplify the survey, but also because moose probably do not forage for such scattered individuals. All encountered species (following Moyle and Hotchkiss 1968) were tentatively identified, and their rank order of abundance was estimated. Identification was limited to species which covered >5% of the wetland surface. The extent and composition of emergent vegetation was also recorded for possible correlation with macrophytes abundance.

Aerial photographs used by the Forest Service for standard inventory- black-and-white 1982, 1:15840; and color 1988, 1:15840- were examined under a 10-X magnifying stereoscope to determine whether macrophyte patches that we found in the field could be identified. The photos had been taken in mid- to late summer and we assumed that most patches found in our 1990 survey would have been present earlier, at least in 1988.

Physical characteristics of the wetlands were measured to test for correlations with macrophyte density and composition:

a) bottom type
  i) muck dominated by organic matter as visually identified
  ii) fine-grain, non-organic
  iii) gravel
  iv) boulders
b) slope of the shoreline
  i) steep- roughly > 45°
  ii) moderate- between 30° and 45°
  iii) shallow- roughly < 30°
c) average depth based on 5-10 mid-wetland points
d) current velocity
  i) fast- roughly 10 km/h
  ii) moderate- perceptible but without visible eddies
  iii) slow- barely to not perceptible
e) temperature, and pH- using a pHep meter at the center of the wetland at 0.5m depth

Signs of moose- trails, underwater tracks, and uprooted vegetation attributed to their foraging were recorded, as were dams, lodges, and other signs of beaver activity. Moose and beaver sign information obtained in 1987 by Dorweiler and Quincer (unpubl. data) was also included in the analysis. The visibility of moose travelways may be a function of bottom type, however, with tracks least visible in rocky clean substrates. Durability of tracks may also vary with current. Moose use may also be a function of local densities and the surrounding upland vegetation.

RESULTS

The density and composition of aquatic macrophytes varied among the wetland types examined (Friedman's test, T = 23.328, p< 0.01). Low macrophyte cover (0 to 1/3) was most common in larger and deeper lakes with rocky bottoms (Fig. 1). Higher abundance (> 2/3 coverage) was consistently found in slow streams, small lakes with mucky bottoms, and beaver ponds. Fast streams were insufficiently sampled for stating comparisons with other types; however, limited observations suggest that fast streams are consistently low in macrophytes.

Signs of beaver activity, moose travelways, and disturbed vegetation did not differ significantly among wetland types. Beaver activity was observed at most sites (Fig. 2). Uprooted aquatic macrophytes, assumed to be a sign of moose activity, were most common in large lakes with rocky bottoms, slow streams, and beaver ponds. However, on larger lakes occurrence of floating plant parts could result from wind and wave action rather than feeding activity. Beaver activity appears to correlate well with coverage of aquatic macrophytes. Moose travelways were not common and did not seem associated with any particular type.

Little relationship appeared to exist between macrophyte abundance and any of the hydrologic measures. No significant differences in mean temperature among wetland types were found. The pH readings varied little among wetland types, and all were slightly basic. Wetlands that were surrounded by bog-type ericaceous plants might be assumed acidic, but their centers tended to be neutral. We did not take pH in the edge zone of the wetlands, where acidic leachates may affect pH. The validity of comparisons among wetlands may be questionable. Temperature and pH were taken from mid-June through late August, and some wetlands, such as shallow ponds, may be more subject to temperature or pH changes during this period than relatively stable wetlands such as fast streams and deep lakes.

Aquatic vegetation was positively associated with soft organic or silty bottoms. Rocky bottoms, especially in lakes subject to wave action, frequently were devoid of vegetation. The depth of most wetlands surveyed was well within the range reported by Aho and Jordan (1979) as useful to moose and suitable for aquatic vegetation.

There were clear differences in macrophyte species abundance among the different wetland types (Table 1). Larger lakes, small lakes, and slow streams provide the greatest species richness, and beaver ponds

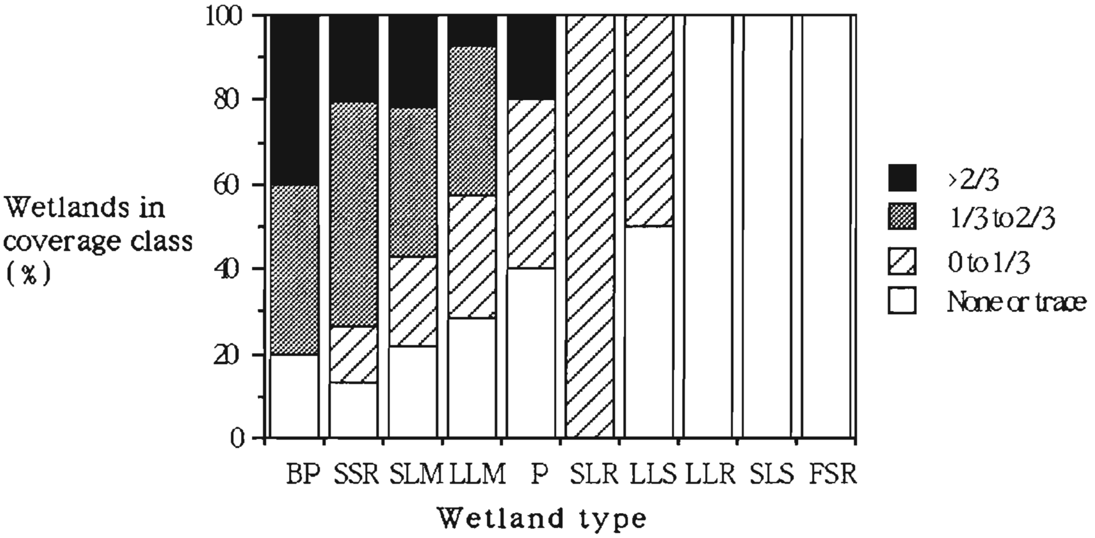

Fig. 1. Distribution of the extent of macrophyte coverage according to wetland type. The number of wetlands sampled for each type is given by n2 in Fig. 2.

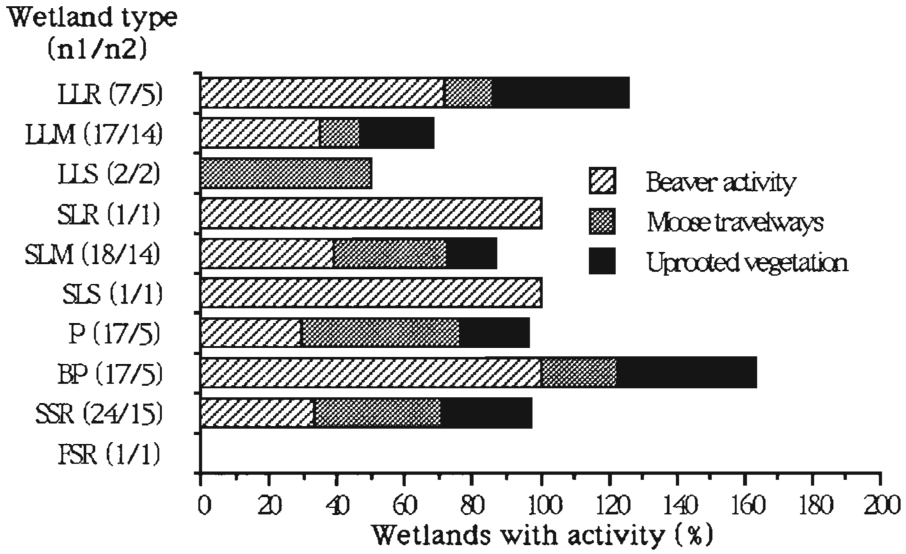

Fig. 2. Frequency of activity sign according to wetlands type. Beaver activity and moose travelways incorporate data from 1987 (Dorweiler and Quincer, unpubl.) and 1990 (n1), while uprooted vegetation was observed only in 1990 (n2).

were most abundant in those species shown by others (Fraser *et al.* 1984) to be most commonly consumed by moose.

Wetlands with abundant emergent vegetation often contained abundant and easily visible macrophytes, but the usefulness of this association for predicting abundance of the latter (as from an aerial photo) appears doubtful. The presence and extent of emergent vegetation seems related mainly to the extent of the littoral zone; however, a number of sites with steep banks and little emergent shoreline vegetation did have abundant submerged and floating macrophytes.

Utility of aerial photos for identifying even the most dense stands of aquatic macrophytes was not consistent for any of the wetland types. Only 59% of the black-and-white and 41% of the color photographs (among all sites) provided images useful for identifying the presence and extent of macrophyte patches. Surface glare precluded estimation of macrophyte coverage in many of the photos. On the other hand, areal coverage estimates made from photographs without glare frequently corroborated our ground estimates. However, detection of submerged macrophytes, which may provide a significant portion of the forage resource, was virtually impossible.

DISCUSSION

The Habitat Suitability Index model for moose of the Lake Superior region (Allen *et al.* 1987) represents a synthesis of understanding of the habitat requirements of moose in northeastern Minnesota. The HSI variable for aquatic habitats calls for a measure of the extent of riverine, lacustrine, or palustrine wetlands not dominated by woody vegetation. The sub-model for growing season (i.e. summer) habitat designates that if an adequate area of these wetlands exists within the unit being evaluated, then aquatic forage requirements will be met. The model also infers that the composition of wetland types within the evaluation unit is irrelevant provided they meet the model criteria. Our work suggests that the types of wetlands included within the model's broader categories are very important. Clearly beaver ponds, slow streams, and small lakes with mucky bottoms were more

Table 1. Frequency of occurrence of submerged and floating macrophyte species according to wetland type, given as percent of sites in which the species was recorded.

	Large Lakes			Small Lakes					Slow	Fast	
Species	rocky (LLR)	mucky (LLM)	sandy (LLS)	rocky (SLR)	mucky (SLM)	sandy (SLS)	Pond (P)	Beaver pond (BP)	streams & rivers (SSR)	streams & rivers (FSR)	All types
Brasenia schreberi	-	7	-	-	7	-	-	20	-	-	5
Callatriche palustris	-	-	50	100	7	-	-	-	23	100	11
Ceratophyllum demersum	20	57	100	100	36	100	20	40	31	100	43
Eriocaluon septangulare	-	7	-	-	7	100	40	20	23	-	16
Hippurus vulgaris	-	7	-	-	7	100	40	20	23	-	16
Lemna minor	-	-	-	-	7	-	-	20	15	-	6
Myriophyllum verticulatum	20	36	-	-	14	100	20	-	-	-	16
Nitella flexis	40	7	100	100	14	-	40	-	7	-	18
Nuphar variegata	100	71	50	100	71	100	100	60	69	-	79
Nymphaea odorata	20	36	-	-	43	100	-	-	30	-	30
Polygonum amphibium	-	14	-	100	-	-	-	40	15	-	11
All *Potamogeton* including spp.	100	79	100	100	79	100	100	100	100	100	95
Potamogeton amplifolius	80	50	50	-	36	100	-	20	15	-	33
Potamogeton epihydrus	80	79	-	100	64	100	100	60	46	100	70
Potamogeton filiformis	20	43	-	-	50	100	40	20	61	100	46
Potamogeton gramineus	-	21	50	-	7	-	20	60	54	100	27
Potamogeton natans	-	35	-	100	7	-	60	-	-	-	16
Potamogeton richardsonii	40	35	50	-	21	-	-	-	15	-	21
Potamogeton robinsii	20	-	-	-	-	-	-	-	8	-	3
Potamogeton strictifolius	-	-	-	-	-	-	20	-	-	-	2
Potamogeton zosteriformis	-	-	-	-	7	-	-	-	-	-	2
Sparganium chlorocarpum	20	-	-	-	7	-	-	20	15	-	8
Sparganium fluctans	100	71	100	100	64	100	100	80	100	100	80
Utricularia spp.	60	50	-	100	64	-	100	40	62	-	60
Vallisneria americana	-	14	50	-	7	-	-	-	8	-	8
Unknown	-	-	-	-	-	-	-	20	-	-	2
Percent of all submerged and floating macrophye species encountered in wetland type	52	76	40	44	88	40	52	60	32	76	

productive in macrophytes than fast streams and large lakes with rocky bottoms. Yet all of these fall within a single type according to the model.

The authors of the HSI also did not consider how to incorporate larger (eg. > 5 ha) lakes in the evaluation of aquatic habitats. Our work suggests that only the littoral zone (depth < 3 m) of large water bodies provides an aquatic macrophyte resource, and therefore only this area should be included in the HSI wetland habitat area calculations.

Beaver ponds may vary in productivity with age. Beaver ponds take time to develop the characteristics which favor macrophyte production, and very old ponds may break down with a resultant loss in productivity. For this reason beaver ponds may have a greater variance than more stable systems such as streams and small lakes.

While our data are derived from one sector of northeastern Minnesota, they follow several reports from Isle Royale (Aho and Jordan 1979) and Ontario (Fraser *et al.* 1984). It is suggested that adding modifications to the model would strengthen its aquatic resource function (Table 2).

Were the recommended aquatic habitat functions included in the HSI, they would appear as follows (from Allen *et al.* 1987):

$$M3 = \frac{\sum_{n=1}^{10} SIVw_n * WAw_n}{1.1}$$

where $M3$ = potential number of moose that can be supported by aquatic forage

$SIVw_n$ = The wetland type suitability modifier from Table 2

WAw_n = The area encompassed by wetland type n in the evaluation area (ha)

1.1 = The density of highly productive wetland required to support 1 moose (ha/moose)

M3 is incorporated into the growing season portion of HSI model 1 as described in the HSI.

Most of these wetland categories may be readily translated into the classification system developed by Cowardin *et al.* (1979)(Table 2). Macrophyte abundance varies little in larger water bodies, therefore large lakes (> 5 ha) may be classified as lacustrine (> 8 ha). The aquatic bed and emergent wetland classes, incorporate assumptions about aquatic macrophyte presence, and therefore may not be appropriate for an analysis of macrophyte production capabilities based on wetland structure. Other classes which also incorporate assumptions about vegetation (eg. rock bottom) are based on wetland structure and therefore more compatible with the system proposed here. A modifier indicating beaver-created wetlands will be necessary when using the Cowardin system. If the HSI is applied to U.S. Forest Service lands, Land Use Class 265 (beaver pond) may provide a substitute.

The HSI does not include other possible sodium sources, such as mineral licks, that might substitute for aquatic macrophytes. Use of salt blocks to improve areas lacking sources of aquatic macrophytes is possible but not recommended (Faber *et al.* 1988). Furthermore, protecting and increasing wetlands favors many types of wildlife besides moose.

It would appear that standard, small scale photos taken without regard to water surface reflectance are unsuitable for consistent aquatic inventories. There is need to develop special techniques that might include polarizing filters or a specific photo angle related to the sun's angle, and a maximum allowable wind or cloud cover. Even then, some aquatic sites, such as submerged macrophytes in turbid

Table 2. Properties of the structural wetland classification system used in our analysis, including appropriate categories from the system developed by Cowardin *et al.* (1979). Mean coverage was derived by assigning none or trace = 0, 0 to 1/3 = 1, 1/3 to 2/3 = 2, and >2/3 = 3. Since mean coverage ranged from 0-2.0, modifiers for the HSI aquatic habitats function ($SIVw_n$) were determined by $SIVw_n$ = mean coverage/2.

	Cowardin *et al.* (1979)					
Structural Classification	System	Subsystem	Classes	Subclasses	Mean Coverage	$SIVw_n$
Large lakes with rocky bottoms (LLR)	Lacustrine	Littoral	Rock bottom	Bedrock Rubble	0.2 ± 0.4	0.1
			Unconsolidated bottom	Cobble-gravel		
Large lakes with mucky bottoms (SLM)	Lacustrine	Littoral	Unconsolidated bottom	Mud Organic	1.1 ± 1.0	0.6
Small lakes with sandy bottoms (SLS)	Palustrine		Unconsolidated bottom	Sand	0	0
Large lakes with sandy bottoms (LLS)	Lacustrine	Littoral	Unconsolidated bottom	Sand	0.5 ± 0.7	0.3
Small lakes with Rock bottom (SLM)	Palustrine		Rock bottom	Bedrock Rubble	1.0 ± 0.0	0.5
			Unconsolidated bottom	Cobble-gravel		
Small lakes with mucky bottoms (SLS)	Palustrine		Unconsolidated bottom	Mud	1.6 ± 1.1	0.8
Ponds (P)	Palustrine		Rock bottom	Bedrock Rubble	1.0 ± 1.2	0.5
			Unconsolidated bottom	Cobble-gravel		
			Unconsolidated bottom	Sand		
			Unconsolidated bottom	Mud Organic		
Beaver ponds (BP)	Palustrine		Unconsolidated bottom	Mud Organic	2.0 ± 1.2	1.0
Slow streams and rivers (SSR)	Riverine	Lower perennial	Unconsolidated bottom	Mud Organic	1.8 ± 0.9	0.9
			Unconsolidated bottom	Sand		
Fast streams (FSR)	Riverine	Upper perennial	Rock bottom	Bedrock Rubble	0	0
			Unconsolidated bottom	Cobble-gravel		

waters or at depths > 2 m, may be unpredictably less apparent.

Given the relatively permanent nature of aquatic habitats, including beaver ponds, an inventory of wetlands with an accompanying macrophyte rating ($SIVw_n$) may be easily developed for the region and incorporated into a GIS. Such an inventory might be derived from from existing systems of wetland classification, such as that currently employed by the U.S. Fish and Wildlife Service, and could be easily applied to forest maps. Aerial survey should still be useful if polarizing glasses or filters are employed. Modifications may be necessary as the nature of the wetlands change.

Aquatic habitats are an essential component of moose habitat in the Lake Superior region. Our work has demonstrated that the contribution of individual wetlands to moose habitat suitability is variable, and should be reflected in the HSI. Further efforts to clarify the significance of aquatic habitats should lead to more successful application of the model.

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REFERENCES

AHO, R.W. 1978. Ecological relationships of moose, aquatic plants, and sodium on Isle Royale National Park, Lake Superior. M.S. Thesis. Univ. of Minnesota. 71 p.

_______., and P.A. JORDAN. 1979. Production of aquatic macrophytes and its utilization by moose on Isle Royale National Park. pp. 341-348 *in* R.M. Linn, ed. Proc. First Conf. Sci. Res. in Natl. Parks. Natl. Park Serv. Trans. Proc. Ser. 5.

ALLEN, A.W., P.A. JORDAN, and J.W. TERRELL 1987. Habitat suitability index models, moose, Lake Superior region. U.S.F.W.S. Biol. Rep. 82(10.155) 47 pp.

_______., J.W. TERRELL, and P.A. JORDAN. 1988. An overview of a habitat suitability index model for moose: Lake Superior region. Alces 24: 118-126.

BELOVSKY, G.E., and P.A. JORDAN. 1981. Sodium dynamics and adaptations of a moose population. J. Mammal. 62(3): 613-621.

BOTKIN, D.B., P.A. JORDAN, A.S. DOMINSKI, H.S. LOWENDORF, and G.E. HUTCHINSON. 1973. Sodium dynamics in a northern ecosystem. Proc. Nat. Acad. Sci. 70(10): 2745-2748.

BRUSNYK, L.M., and F.F. GILBERT. 1983. Use of shoreline timber reserves by moose. J. Wildl. Mange. 47(3): 673-685.

COWARDIN, L.M., V. CARTER, F.C. GOLET, and E.T. LaROE. 1979. Classification of wetlands and deepwater habitats of the United States. U.S.F.W.S. FWS/OBS-79/31. 131 pp.

EGGERS, S.D., and D.M. REED. 1987. Wetland plants and plant communities of Minnesota and Wisconsin. U.S. Army Corps of Engineers, St. Paul, MN. 201pp.

FABER, W., A. PERSON, G. CEDERLUND, and P.A. JORDAN. 1988. Aquatic feeding by moose in Sweden- with implications concerning sodium. Alces 24: 126-132.

FRASER, D., E.R. CHAVEZ, and J.E. PALOHEIMO. 1984. Aquatic feeding by moose: selection of plant species and feeding areas in relation to plant chemical composition and characteristics of lakes. C. J. Zool. 62(1): 80-87.

JORDAN, P.A. 1987. Aquatic foraging and the sodium ecology of moose: a review. Swedish Wildl. Res. Suppl. 2: 119-137.

_______, D.B. BOTKIN, A.S. DOMINSKI, H.S. LOWENDORF, and G.E. BELOVSKY. 1973. Sodium as a critical nutrient for the moose of Isle Royale. Proc. N. Am. Moose Conf. Workshop 9: 13-42.

MINNESOTA DEPARTMENT OF NATURAL RESOURCES. 1990. Aerial moose survey results. unpubl., 6 pp.

MOYLE, J.B. and N. HOTCHKISS. 1968. Key to the common aquatic plants of Minnesota. MN Dept. of Conserv., Tech. Bull. 3.

PEEK, J.M., D.L. URICH, and R.J. MACKIE. 1976. Moose habitat selection and relationships to forest management in northeastern Minnesota. Wildl. Monogr. 48. 75pp.