MOOSE HABITAT ASSESSMENT ON THE ALASKA PENINSULA:

Results to Date and a Proposal for Continued Study

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INTRODUCTION

During the past 30 years moose on the Alaska Peninsula have undergone first a rapid increase, then a sharp and sustained decline in numbers. Recent population data collected by the Alaska Department of Fish and Game (ADF&G) suggest the rate of decline has slowed, but consistently poor calf recruitment and an increasingly old female age structure are preventing population growth.

Field observations made during the mid to late 1970's indicated there had been a change in the relative abundance of browse species with preferred willows being replaced by species virtually unutilized by moose (Faro 1974). Later, in the course of a moose physiology study, Faro and Franzmann (1978) reported heavy browsing had occurred and many individual plants of preferred willows were decadent. At that time the decline was considered to be the result of poor reproductive success caused by past overuse of the range (Faro 1977). That conclusion was consistent with patterns found on the Kenai Peninsula and in interior Alaska where habitat related declines were characterized by poor reproductive success (Bailey 1978, Gasaway et. al 1977).

Prior to 1982 no quantitative data had been collected on moose habitat on the Alaska Peninsula. Therefore, in April of 1982 and May of 1983, ADF&G conducted winter range inventories near Pumice Creek and Painter Creek, respecitively. After evaluation of the 1982 results, different, more thorough methods were applied at Painter Creek in 1983. Sampling was conducted with the following primary objectives:

1. To document current species composition, availability and utilization of winter moose browse in selected areas of the Alaska Peninsula;
2. To establish permanent quadrats to assess trends in species composition, and browse production and utilization; and
3. To develop an estimate of carrying capacity on key moose winter ranges.

Secondary objectives included:

4. Assessing the nutritional quality of moose browse;

5. Identifying preferred browse species; and

6. Developing standardized methods of range inventory that are time efficient and sufficiently accurate to yield an estimate of the current year's browse utilization.

STUDY AREAS

Moose on the Alaska Peninsula primarily inhabit a band of shrub-tundra vegetative communities south from the Naknek River system to Mount Veniaminof along the west slope of the Aleutian Range. Because of varying vegetative composition, predator densities and hunting pressure moose densities are not constant within that range. Moose also occur at low densities south of Mt. Veniaminof and on the eastern slope of the Aleutian Mountains.

To adequately evaluate condition and trends in moose habitat, sample stands must be established in various vegetative types and in areas with different moose densities. The six study areas outlined below meet those requirements.

Because most of the moose range on the Alaska Peninsula is on National Park Service (NPS), or Fish and Wildlife Service, (USFWS) lands, the ADF&G encourages the NPS and the USFWS to assume the lead role in future cooperative habitat assessment programs.

Southern Katmai - Contact, Angle, and Takayoto Creeks converge to form the King Salmon River in the southwest corner of Katmai National Park. Moose presently winter at higher densities in that area than in other drainages on the Alaska Peninsula and are not hunted on their winter range. Creek bottoms and adjacent low hills support dense growths of willow and alder. Aircraft access during the spring is possible on gravel bars along Contact and Angle Creeks.

Featherly Creek. Featherly Creek is located on the southern shore of Becharof National Wildlife Refuge. Hunting pressure in the Featherly Creek drainage for moose is relatively light and moose densities are moderate.

Vegetative communities are dominated by willow/alder shrub lands interspersed with tundra. Bear densities during the summer months are high. Access to Featherly Creek is possible on large sand dunes near the mouth of the creek.

Painter Creek. Painter Creek flows north into the King Salmon River near the outlet of Mother Goose Lake and over most of its course lies within the Alaska Peninsula National Wildlife Refuge. Uplands in the drainage support willow/alder shrub communities on the steep slopes, dense stands of balsam poplar with a willow/*Viburnum* understory on the benchlands and balsam poplar/willow communities in the riparian zone. Moose and bear densities are relatively high in the Painter Creek drainage and hunting pressure for both species is high. A 4,000' graded runway 1 mile west of Painter Creek provides access.

Preliminary results of data collected near Painter Creek in May 1983 suggest moose densities are below carrying capacity, but many of the benchland and floodplain areas are dominated by low preference browse species.

Pumice Creek. Pumice Creek flows north from the foothills of the Aleutian range through extensive flat shrublands that contain high densities of wintering moose. Much of the moose habitat along Pumice Creek is on State land. Hunting pressure in the area is relatively high, and aircraft access is possible on large cinder patches along the creek.

Results of vegetation sampling in the Pumice Creek area in 1982 indicated utilization of browse is light on the upland sites and moderate in the riparian zone. Past use was obviously greater than current use.

Cinder River. Much of the moose habitat in the Cinder River area lies within the Aniakchak National Park Preserve. An active guiding operation in the area places relatively high hunting pressure on a moderate density of moose. Moose habitat is characterized by willow/alder shrub stands on the steep slopes, and willow flats in the upper drainage. Access is possible by aircraft on large cinder patches and gravel bars along the River.

Black Lake. Black Lake is located in a broad valley on the west slope of the Aleutian Range, within the Alaska Peninsula National Wildlife Refuge. Moose habitat consists of scattered willow patches west of the lake and on the slopes north and south of the lake. It marks the southern most extent of significant moose numbers within the Refuge and hunting pressure is moderate. Aircraft access is possible on cinder patches north of the lake.

METHODS

Near Pumice Creek in 1982 percent cover and frequency of shrub species were determined from line-intercept readings. Twenty-five 10m transects were placed in an upland site and 5 in the riparian zone. At the beginning and end point of each transect browsing intensity (percent of current annual growth twigs that had been browsed) was determined on 2 plants, the nearest on the left and the nearest on the right.

Twigs were clipped from approximately 20 plants of each of 3 willow species (diamondleaf, feltleaf, and grayleaf) and alder (Alnus sp.) for nutritional analysis. Current growth twigs from willow clippings were seperated into old growth plant samples, and young plant samples for each species. The dried leaves were stripped from the old growth twigs and analyzed seperately. All clippings were air dried for at least 7 days before being sent to the Palmer Plant and Soil Analysis Laboratory, Palmer, Alaska for analysis. Each sample was analyzed by the Van Soest technique and each was also analyzed for the following elements: %N, %P, %K, %Ca, %Mg, %Na, ppmCu, ppmZn, ppmMn, and ppmFe.

To increase time efficiency, a less percise assessment of current and past use was made at 103 randomly selected points. At each point the current and past use of the nearest plant was subjectively classified into 4 use categories:

1. <10%
2. 10-50%
3. 51-90%
4. >90%

Although methods used at Pumice Creek are adequate for periodic habitat inventories, permanent transects or plots are needed for accurate trend assessment. In addition, most researchers from other areas of Alaska used stem density as a measure of relative abundance rather than percent crown cover. Therefore, to facilitate trend assessment and to provide data directly comparable with data collected in other areas, a different study design was used in the Painter Creek drainage in May 1983.

Two stands were delineated based on their vegetative homogeneity and their representation of the most abundant vegetative type, a 2ha stand on an upland site and a 1.5ha stand on the Painter Creek floodplain. Permenently staked 2 x 5m quadrats were randomly located within each stand, 20 in the upland stand, 15 in the lowland stand. The number of shrub and sapling stems, stem height and the number of browsed and unbrowsed twigs were recorded in each quadrat. In the upland stand tree densities we determined at one corner point of each quadrat using the point-centered quarter method (Mueller-Dombois and Ellenberg 1974).

One hundred twigs of each willow species were clipped at mean browsing diameter, air dried and weighed. One hundred current annual growth twigs for each willow species were similarly prepared and weighed.

RESULTS AND DISCUSSION OF WORK TO DATE

Pumice Creek

Shrub cover on the upland site was dominated by diamondleaf willow (*Salix pulchra*), the riparian site by feltleaf willow (*Salix alaxensis*) (Tables 1 and 2). Total shrub cover was 43% and 66% on the upland and riparian sites, respectively. On the upland site 7% of the shrub cover consisted of decadent willow, in the riparian area 15% of the shrub cover was decadent willow. Results of random point sampling indicated that past use was greater than current use. (Tables 3 and 4). Greatest use has and continues to occur in their riparian areas. Littletree Willow

Table 1. Percent cover, and browsing intensity determined from line transects on upland sites near Pumice Creek.

Species	% cover	% browsing intensity	Sample size
S. pulchra	25.9	3.6	3,298
S. glauca	13.6	3.7	1,119
Decadent willow (all spp.)	3.2	--	--
Nonbrowse spp.	58.1	--	--

Table 2. Percent cover and browsing intensity determined from line transects on riparian sites near Pumice Creek.

Species	% cover	% browsing intensity	Sample size
S. pulchra	14.3	38.2	228
S. glauca	14.9	20.4	98
S. alaxensis	23.3	32.1	243
Alnus sp.	3.1	59.5[a]	42
Decadent willow (all spp.)	10.0	--	--
Decadent alder	0.3	--	--
Nonbrowse spp.	41.3	--	--

[a] Note small sample size.

Table 3. Percent of plants classified into each of 4 use categories at randomly selected points in an upland area near Pumice Creek.

	Current use category[a]				Past use category[a]			
Species	1	2	3	4	1	2	3	4
S. glauca (N = 24)	83	17	--	--	66	12	21	--
S. pulchra (N = 24)	76	9	15	--	55	18	24	3

[a] Use categories: 1 = 10%; 2 = 10-50%; 3 = 51-90%; 4 = 90%

Table 4. Percent of plants classified into each of 4 use categories at randomly selected points in a riparian area near Pumice Creek.

	Current use category[a]				Past use category[a]			
Species	1	2	3	4	1	2	3	4
S. glauca (N = 12)	67	33	--	--	25	67	--	8
S. pulchra (N = 11)	64	18	--	18	36	55	9	--
S. alaxensis (N = 23)	48	26	22	4	17	44	26	13

[a] Use categories: 1 = 10%; 2 = 10-50%; 3 = 51-90%; 4 = 90%

(Salix arbusculoides) occurred at low densities, was heavily browsed by moose, but was not encountered in the line transects or at the random points.

Crude protein content showed little variation between age classes or species, averaging 9.1% among the 7 twig samples (Table 5). In vitro dry matter disappearance values (IVDMD) showed a considerable difference in digestibility of old and young growth feltleaf willow, the younger plants producing more digestible forage. However, there was virtually no difference between the old and young growth grayleaf willow. IVDMD values for diamondleaf willow were higher in the old growth sample, but the residual leaves of diamond-leaf and feltleaf willow proved to be virtually indigestible; IVDMD values were 17.1% and 5.7% respectively. Surprisingly, the lowest lignin and non-detergent fiber (NDF) values were in the alder sample; however, digestibility as determined by IVDMD was not as proportionately high.

Mean nutritional values from willow twig samples collected at Pumice Creek are compared in Table 6 with values from other studies in Alaska. The values given for the Moose Research Center (MRC) special diet are considered optimal.

On the Alaska Peninsula during their investigation of moose physiology and productivity Faro and Franzmann (1978) analyzed blood samples that indicated a degree of nutritional stress, including: low protein intake, low fatty acid intake, and moderately low condition indices. However, based on the nutritional composition of browse samples analyzed from the Pumice Creek area, at least an average level of protein and digestibility are presently available to moose. Gasaway and Coady (1974) reported a mean winter browse

Table 5. Results of Crude protein and Van Soest analyses of samples collected near Pumice Cr., early April 1982.

Sample*	Crude Protein[a] %	% NDF	% ADF	% Lignin	% Cellulose	% Ash	% IVDMD
S. alaxensis							
old growth	9.4	50.5	36.1	14.4	20.1	1.5	27.2
young growth	8.4	50.8	34.9	11.6	21.7	1.6	47.5
leaves	7.5	62.2	47.3	23.0	21.7	2.5	17.1
S. pulchra							
old growth	9.4	49.5	33.2	13.4	19.1	0.6	41.3
young growth	8.4	56.4	39.1	13.3	24.7	1.1	36.7
leaves	8.4	65.1	50.5	24.6	23.5	2.3	5.7
S. glauca							
old growth	8.3	50.1	36.5	10.7	24.4	1.4	40.5
young growth	9.0	53.9	37.8	12.3	24.2	1.2	39.7
Alnus sp.	10.8	38.4	24.1	7.4	15.6	1.1	35.0

* All twig samples current annual growth; leaf samples, overwinter dried leaves

a %N x 6.25

Table 6. Pumice Creek nutritional values with those reported from other areas and in different seasons.

Data Source & Season	Protein	% NDF	ADF	Lignin	Cellulose	Digestibility in vivo[a] invitro[b]
Kenai[1] July	6.9	44.9	40.6	18.2	--	42.6[b]
Kenai[2] April	7.5	--	--	--	--	39[a]
Interior[3] June	12.0	51.7	40.2	11.7	28.5	--
Interior[3] October	6.0	68.9	58.9	18.5	40.4	
MRC Special	11.75	47.2	26.5	--	--	64.3[a]
Pumice Cr.	8.8	51.9	36.3	12.6	22.4	38.8[b]

1. Franzmann and Schwartz, 1982
2. Schwartz et. al. 1981
3. Gasaway and Coady, 1974 (rumen samples)

protein content of 8% on the Kenai Peninsula and listed the minimum required protein content for ruminants as 7%. However, protein content of current growth twigs varies seasonally. In arctic tundra and riparian areas, translocation of nitrogen from below ground stems and the root system occurred throughout the summer (Chapin, et al. 1980). Whether the 9.1% mean crude protein value found in the Pumice Creek twig sample reflects a value higher than the mid-winter mean is not known, but that seems unlikely considering the late spring greenup that occurred on the Alaska Peninsula in 1982. The first leaves did not appear on willow shrubs until mid to late May, at least 30 days after the samples were taken.

The results of macro and micro nutrient analysis are presented in Table 7. The literature lacks information on the specific needs of moose for most of these nutrients, but some attention has been given to the seasonal variation in dietary sodium and copper levels. On Isle Royale terrestial vegetation containing 3-28 ppm sodium was thought to provide only 7-14% of the sodium requirement for adequate reproduction and maintenance in moose (Botkin et al. 1973; cited by Belovsky and Jordan 1981). Aquatic vegetation was high in sodium however, and in that study was heavily utilized by moose. Based on their figures, sodium concentrations of 200-400 ppm would satisfy the sodium requirement. Sodium concentrations in twigs collected near Pumice Creek ranged from 200-1000 ppm. Assuming even higher concentrations in aquatic vegetation, the probability is small that sodium is limiting to moose in the Pumice Creek area.

Table 7. Results of macro and micro nutrient analysis from Pumice Creek browse samples, early April 1982.

Sample	% P	% K	% Ca	% Mg	% Na	ppm Cu	ppm Zn	pmm Mn	ppm Fe
S. alaxensis									
old growth	0.18	0.44	0.69	0.13	0.02	4	150.0	47.5	107
young growth	0.15	0.39	0.56	0.10	0.10	4	119.8	30.0	71
leaves	0.12	0.16	1.18	0.23	0.12	6	100.2	101.0	244
S. pulchra									
old growth	0.17	0.39	0.41	0.14	0.10	5	214.5	252.4	57
young growth	0.15	0.36	0.40	0.13	0.10	6	180.8	185.0	43
leaves	0.09	0.11	0.49	0.17	0.06	3	160.8	452.1	86
S. glauca									
old growth	0.14	0.44	0.40	0.16	0.03	9	152.7	131.5	64
young growth	0.15	0.38	0.33	0.12	0.10	7	176.3	79.4	56
Alnus sp.	0.15	0.31	0.41	0.09	0.10	4	32.0	94.3	51

Copper deficiencies have also been associated with reduced reproductive potential in moose. On the Kenai Peninsula a mean of 5.72 ppm copper in browse plants was considered marginally sufficient and was linked to faulty hoof keratinization and decreased reproductive rates (Flynn et al. 1977).

Results of the Pumice Creek sampling indicated the potential for a copper deficiency in Alaska Peninsula moose. Mean copper levels were 5.6ppm in the twigs of all browse species combined. Mean levels in diamondleaf and feltleaf twig samples were 4 ppm and 5.5 ppm, respectively.

Painter Creek

Much of the upland area in the Painter Creek drainage is covered by dense stands of balsam poplar (Populus balsamifera). Understory species include high bush cranberry (Viburnum edule), grayleaf willow, Barclay willow (Salix barclayi), and diamondleaf willow. Grayleaf and Barclay willow were the most common and were the only two willow species encountered in the upland sample quadrats.

Preferred browse species such as feltleaf willow, littletree willow and diamondleaf willow were observed in the riparian zone, but of those only diamondleaf willow occurred in the lowland sample stand. Most of the shrublands on the floodplain appeared to be dominated by Barclay willow. Machida (1979) reported Barclay willow was the least preferred willow of moose in his Kenai Peninsula study area, and Milke (1969) gave both grayleaf and Barclay willow low preference ratings in his interior Alaska study.

Estimated percent dry weight utilization by moose of willow at Painter Creek was 9.8% and 0% in lowland and upland stands, respectively. Some browsing had occurred in the upland stand, however browsing intensities were very low and none of the sample quadrats were browsed. Results of quadrat sampling are summarized in Tables 8 and 9.

Willow production and utilization values indicate moose numbers in the Painter Creek drainage are below the carrying capacity of the range. However, additional sampling is needed in other shrub communities within the drainage that may contain a greater proportion of preferred browse species.

REVIEW OF PROPOSED METHODS FOR FUTURE SAMPLING

Telfer (1974) described the major problems inherent in sampling designs such as that used at Pumice Creek in 1982. He noted, "Periodic inventories are subject to an error factor that varies with the size of the sample and the survey design in relation to the variability of the vegetation. The errors range from 5 to 25 percent or more." Small random samples taken from the same stand in two consecutive years would probably result in different estimates of stem density and species composition; and it would be impossible to differentiate between real changes and apparent changes caused by random variation. However, definite, consistent trends in estimates over a period of several years could probably be attributed to actual changes in range condition.

Permanent marked plots, points, stems, or line transects allow remeasurement of the same individual plants and therefore produce a real indication of trend. To produce unbiased estimates, the permanently marked sample units should initially, be chosen randomly. However, because of a tendency

Table 8. Stem density, browse production, and browse utilization estimates from 2 x 5 quadrats on an upland site near Painter Creek (N=20).

Species	Stem density Stems/ha (SE)	Browse Production Kg/ha	Browse Utilization Kg/ha
S. barclayi	2,050(1104)	12.7	0
S. glauca	2,150(805)	11.3	0
V. edule	19,650(3369)	-	-
P. balsamifera (saplings)	8,600(939)	-	-
P. balsamifera (trees)	2,014(172)	-	-

Table 9. Stem density, browse production, and browse utilization estimates from 2 x 5 m quadrats on a lowland site near Painter Creek (N=15).

Species	Stem density stems/ha (SE)	Browse Production Kg/ha	Browse Utilization Kg/ha	% Twigs Browsed (SE)	% Stems Browsed (SE)
S. barclay	35,500(6820)	203.5	18.2	2.9(0.9)	16.7(4.5)
S. pulchra	4,400(2270)	9.6	2.7	1.1(0.9)	7.4(7.0)

for clumped distributions within vegetative communities, purely random selection may not give a representative estimate at practical sample sizes.

As a compromise a randomized block design was used in the Painter Creek sampling. Each stand was divided into a number of systematically delineated, equal sized blocks. Then, a sample quadrat was randomly located within each block.

Rectangular quadrats were chosen as sample units at Painter Creek, but, plotless sample units are also applicable to estimates of stem density, browsing intensity, productivity and utilization. Oldemeyer and Regelin (1980) compared 9 methods of stem density estimation on the Kenai Peninsula. Those included 6 plotless methods and 3 different sized quadrats (1x1m, 1x5m, and 2x5m). After evaluating the methods in stands with known stem densities they recommended the 1x5m rectangular quadrats because of time efficiency at acceptable units of accurancy. In addition quadrat sampling allows all shrub species in the stand to be sampled simultaneously.

The accuracy of shrub density estimates has also been considered by Lyon (1968). He applied 19 variations of quadrat and plotless sampling techniques. He concluded that only square and rectangular quadrats, and the wandering quarter method produced acceptably accurate density estimates, but the sample sizes required to produce that accuracy were impractical. According to Lyon a search of 0.4ha was required to produce a 95% conficence interval precise to within $\pm$ 10% of the mean. However, such precision is not often achieved in vegetative sampling, and Oldemeyer and Regelin (1980) apparently considered a 95% confidence interval precise to within $\pm$ 28% of the mean to be acceptable when recommending the 1x5m quadrat.

Production estimates have been made by total clipping, or subjective estimation, but in Alaska browse production and utilization have most often been estimated using a modification of the Shaefer twig count method (Shaefer 1963, Machida 1979, Telfer 1974, Wolf and Cowling 1981, Wolff and Zasada 1979, Wolff 1978). Twig length/weight regressions or diameter/weight regressions have also been useful in determining availibility (Gysel and Lyon 1980), but extensive preliminary sampling is required to establish the necessary correlations. Browsing intensity, the percentage of twigs browsed, was used by Wolf and Cowling (1981) as an index to utilization and by Milke (1969) as an indication of browse preference. An even more easily applied index to utilization suggested by Regelin (pers.comm.) was percent stems browsed. However, at Painter Creek, the percentage of stems browsed consistently over estimated browsing intensity because many browsed stems had only a few twigs removed. Nevertheless, repeated sampling could establish a consistent relationship between percent twigs browsed and percent stems browsed.

A problem in all vegetative sampling is generating an estimate with a low variance at practical sample sizes. Although Machida (1979) achieved acceptable results with 20 quadrats in a 2ha stand in an interior Alaska study, that sampling intensity in our study at Painter Creek resulted in 95% confidence levels that varied from ± 38-107% of the mean. That high variability in the Painter Creek data could have resulted from inadequate sample sizes or from insufficient homogeneity in the sample stands. Because both stands were selected to take advantage of the greatest degree of homogeneity available, increased sample size would be the only practical means of reducing the variance.

At Painter Creek 2x5m quadrats were used, rather than the 1x5m quadrat suggested by Oldemeyer and Regelin (1980). I expected the larger quadrat would lump more vegetative subtypes within the quadrats thereby reducing variation between quadrats. However, because the 1x5m quadrat is more time efficient, future sampling should employ a larger number of 1x5m quadrats. Density/ area curves could be developed on experimental stands first, to determine adequate sample size for representative stands. Alternatively, an adequate sample size could be determined during the actual sampling by repeated calculation of stem density means and variances, as sample sizes are increased.

Appendix A outlines proposed methods for conducting moose habitat assessment on the Alaska Peninsula. I recommend sampling be conducted in early to mid April before bud development. One experimental sample stand should be established after leaf drop in the autumn in a representative area near King Salmon to develop and refine sampling techniques and "calibrate" observers.

Within each study area it may be desirable to establish more than one sample stand, dependent on the diversity of community types. Then, given a stable, low density moose population, each study area should be sampled every third year. A rotating sampling schedule in which two study areas are sampled each year would allow all six study areas to be sampled at 3 year intervals. If, however, moose densities increase, biennial or annual sampling should be used; the choice dependent on the observed rate of increase.

Aerial reconnaissance, ground reconnaissance, and use of detailed aerial photographs should, over several years, provide a map of the distribution and size of willow shrub communities. Estimates obtained from the sample stands could then be expanded to yield an overall inventory of moose habitat on the central Alaska Peninsula.

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APPENDIX A

METHODS OUTLINE

1. Locate and delineate homogeneous stand at least 2ha in size.
2. Quadrats will be placed by a randomized block design. Number of quadrates should be determined from stem density/area curves.
3. Establish a 1x5 meter quadrat at each random point. Stake and string at minimum browsing height (0.5m).
4. Within each quadrat:
   a. Count stems in each quadrat (a stem is any branch that joins with other branches or roots below the minimum browsing height and is above the minimum browsing height at the tip of its highest shoot). Record stems by species. If unidentifiable label as species A etc. and attach a plastic tag.
   b. Count number of browsed and unbrowsed twigs on each stem, record by species. A twig is considered to be greater than 1" in length and was produced during the previous growing season. On each stem check if browsed or unbrowsed.
   c. Record height of tallest part of each stem.
   d. Leave two diagonal corners staked (random point and diagonal) and move to next point.
5. Measure dpb on 100 twigs of each species. Clip 100 each species at dpb.
6. Measure dcag on 100 each species, clip at dcag on 100 each species. All clipping must be done outside quadrats but within 2ha stand.
7. Tree density will be measured by the point-centered quarter method. The point will be defined by the random point used to locate the quadrats, the quarters by the 2 sides of the quadrat originating at the random [illegible]. At each point record distance to nearest tree in each quarter, record species, dbh, approximate height, and if available to moose, as browsed or unbrowsed.