WATERFOWL RESPONSES TO SEASONALLY FLOODED FIELDS ON ALAKSEN NATIONAL WILDLIFE AREA, 1980-1991

John P. Hatfield
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TECHNICAL REPORT SERIES NO. 232

Pacific and Yukon Region 1995
Canadian Wildlife Service

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This series may be cited as: **Hatfield, John P. and G.E. John Smith. Waterfowl Responses to Seasonally Flooded Fields on Alaksen National Wildlife Area, 1980-1991 Technical Report Series No. 232. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.**

Printed on recycled paper

Issued under the Authority of the
Minister of Environment
Canadian Wildlife Service

Ministry of Supply and Services Canada 1988
Catalogue No. CW69-5/232E
ISBN 0-662-23504-5
ISSN 0831-6481

Copies may be obtained from:
Canadian Wildlife Service
Pacific Wildlife Research Centre
Pacific and Yukon Region
RR #1, 5421 Robertson Road
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ABSTRACT

Responses to two seasonally flooded fields on Alaksen National Wildlife Area by waterfowl from 1980 to 1991 are presented. Seven waterfowl species are the main beneficiaries of management operations: Mallard (*Anas platyrthyncos*), American Wigeon (*A. americana*), Northern Pintail (*A. acuta*), Green-winged Teal (*A. Creeca*), Gadwall (*A. Strepera*), Northern Shoveler (*A. clypeata*) and Canada Goose (*Branta canadensis*). Total duck-days increased significantly when fields were managed "flooded" as opposed to "dry". The net effect of flooding regimes on numbers of waterfowl present were studied for each field after adjusting for influences due to the month of the year, and the year itself. The significance of some management techniques are discussed.

RESUME

Ce rapport présente les réponses par la sauvagine à l'inondation saisonnière de 2 champs situés sur la Réserve de la Faune Alaksen entre 1980 et 1991. Les activités opérationelles ont surtout bénéficié à sept espèces de sauvagine. Ces espèces sont le Canard malard (*Anas platyrthyncos*), le Canard siffleur d'Amérique (*A. americana*), le Canard pilet (*A. acuta*), la Sarcelle à ailes vertes (*A. Creeca*), le Canard chipeau (*A. Strepera*), le Canard souchet (*A. clypeata*) et la Bernache du Canada (*Branta canadensis*). Le nombre total de canard-jours a augmenté de façon significative lorsque les champs furent inondés, par rapport à lorsque les champs furent secs. Le rapport présente également l'effet net des régimes d'inondation sur le nombre de sauvagine dans chaque champ, ajustés pour tenir compte de l'effet saisonnier (mois) et de variations annuelles. L'importance de certaines techniques d'aménagement est discutée.

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Acknowledgements

Our thanks to Pamela Whitehead for compiling the data and the drafting; and to Susan Garnham and Shelagh Bucknell for wordprocessing.

WATERFOWL RESPONSES TO SEASONALLY FLOODED FIELDS

ON ALAKSEN NATIONAL WILDLIFE AREA, 1980-1991

I. INTRODUCTION

A. Background

In 1984 the Canadian Wildlife Service (CWS) and Ducks Unlimited (DU) developed a coordinated management plan to flood Fields 8 and 9 on the Alaksen National Wildlife Area on a seasonal basis (Fig. 1). The plan called for intensive management consisting of partial cultivation, partial seeding and water manipulation. These management prescriptions took place from June 1985 to April 1991 (see Table 1 for schedule). This report describes the response of waterfowl in terms of use of those fields, in relation to flooding. Previous reports have indicated how important standing water is for field feeding waterfowl from October to March (Hatfield 1987 and 1991).

B. Structure of Fields 8 and 9

Field 8, eight hectares (20 acres) in size, is relatively flat, except for a low area in the southwest corner comprising approximately one-quarter of the field. The low point of this field is 0.43 meters (1.4 ft.) Geodetic Survey Canada (GSC), while the high point is 0.91m (3 ft.) GSC, giving a drop of 48cm (1.6 ft.) (Fig. 2). It is possible to completely cover this field with water from high tides. It is completely surrounded by trees, except for a small opening in the southwest corner. Canada Geese (*Branta canadensis*) like to roost and graze on a levee along the southeastern side, which was built in 1984 to enable the flooding of this and the adjacent field (Hatfield 1991 and Fig. 2).

The main structure controlling the flooding and drainage of Fields 8 and 9 is located approximately 152 meters (500 ft.) east from the northeast corner of Field 8. A stop-log structure built into the culvert leading into field 8 enables the manipulation of water levels either for this field alone or for both fields.

Field 9, ten hectares (25 acres) in size, slopes gradually from a low of 0.52m (1.7 ft.) GSC at the south end to a high of 1.19m (3.9 ft.) GSC at the north end, for an elevation difference of 0.67m (2.2 ft.) (Fig. 2). There are four small islands of spoil dirt exposed above the highest tide level. This field is completely surrounded by dykes and is open except for a few scattered conifers along the western, or foreshore side and two rows of conifers along the entire eastern side.

Both fields are flooded with high tides and drained on low tides. No water pumps are used. The highest water level that can be achieved with high tides is approximately 1.16m (3.80 ft.) GSC, in December.

C. Vegetation

"Habitat quality and vegetation diversity determine the number of wildlife species that can occupy an area" (Frederickson and Taylor, 1982).

Field 8 has been managed more intensively than Field 9 (Table 1). As a result the vegetation on the two fields differs. On Field 8, Smartweed (*Polygonum* spp.) is the most dominant plant, up to 100% on some parts of the field, and well established over the rest. White Clover (*Trifolim revens*), Bentgrass (*Agrostis alba*) and Water Foxtail (*Alopecurus geneculatus*) also occur commonly (see Appendix for a complete list of plants in Field 8). The topography of this field determines the vegetation. The low area described above remains wet throughout the year, while the high dryer areas have an entirely different vegetative composition. In 1989, barley was seeded and left standing. It grew to only about 20 cm (8 in.) due to the relatively low Ph conditions. In the years 1984 to 1988 and 1990 this field was disced, leaving a band of forage untouched along the northwest portion.

When the water level reaches 0.82-0.84m (2.70-2.75 ft.) GSC on the gauge, one-third is exposed land, while another one-third is emergent vegetation consisting of 5-10 cm (2-4 in.) of grasses and scattered plants of dock 61cm (24 in.) above the surface of the water. The exposed land and emergent vegetation provide loafing sites for waterfowl. This factor alone plays a significant role in attracting waterfowl to a flooded field. The rest of this field is under 'open' water, with no emergent vegetation and a water depth to approximately 36cm (14 in.).

In contrast, Field 9 has been partly disced (Table 1). It has more ditches, both man-made and natural, than Field 8. Ditches vary from 1.5-9m (5-30 ft.) across, thus providing a variety of habitats which attract both dabbling and, to a lesser extent, diving ducks. The dominant vegetation consists of Reed Canary Grass (*Phalaris arundinancae*), Bentgrass (*Agrostis alba*) and Cattail (*Typha latifolia*), along with lesser amounts of Smartweed (*Polygonum* sp.), Juncus (*Juncus* sp.), Water Foxtail (*Alopecurus geniculatus*) and Purple Loosestrife (*Lythrum salicaria*) (see Appendix for a complete list of plants in Field 9). In an earlier study on this field no Purple Loosestrife was seen, whereas now it is becoming very prominent. This is happening to a lesser extent in Field 8 (Couture and Koza, 1980). The Reed Canary Grass grows in dense, scattered clumps over approximately three-quarters of this field, to a height of 160-180cm (64-70 in.). No crops have been seeded in Field 9.

When the water level reaches 0.82-0.84m (2.70-2.75 ft.) GSC on the gauge, this field is covered by water over approximately three-quarters of its land mass, with only the north quarter above water. Because the vegetation is dominated by the emergent plants, there are no large open water areas as there are in Field 8.

D. Objective

Our objective was to investigate possible relationships between the numbers of waterfowl and species on each of the two fields in relation to water levels. On each observation day, counts were made of each species in each of the two fields. The species that provided data sufficient for analysis were Canada Goose, Mallard (*Anas platyrhynchos*), American Wigeon (*A. americana*), Pintail (*A. acuta*), and Green-winged Teal (*A. crecca*). While we include Gadwall (*A. strepera*) and Northern Shoveler (*A. clypeata*) in the tables and figures, their numbers were too low to provide reliable conclusions from statistical analysis. We present those results for information only.

II METHODS

A. Water depth

Water depth readings were based on geodetic elevations. This information is included for any readers who may wish to design and construct their own flooded field project along the coasts of British Columbia and Washington State. We have converted the GSC readings to mean water depths including the high and low depths in the two fields. To determine water depth, a permanent depth gauge in each field was read. Since the fields were not level, each gauge reading corresponds to approximately a 13cm (5 in.) range of depths (Appendix 4).

B. Salinity

Salinity readings were conducted weekly on Fields 8 and 9 from February 1985 to January 1986, inclusive. The purposes of this was to determine what effect, if any, water from the Fraser River and foreshore may have on the vegetation on those fields.

Salinities were determined for each field, at specific locations (Fig. 2), using a S-C-T Meter (Yellow Springs Instrument Co.). Readings are in parts per thousand.

C. Bird responses to field flooding

The numbers of waterfowl on Fields 8 and 9 were systematically observed and recorded from fall to spring starting in September of 1980 and continuing through to April of 1991 (Table 2). Out of a total of ten years of water management, four years were dry, (1980 to 1984) and six years were flooded, (1985 to 1991). We counted waterfowl from a vehicle, on Mondays, Wednesdays and Fridays for approximately 30 minutes, between 10 A.M. and 12 noon, using both binoculars and a telescope with a 20x eyepiece. (Waterfowl are more tolerant of a vehicle than a person walking along the dykes).

D. Statistical Analysis

We used a three-way analysis of variance (ANOVA) to study the effect of water depth on the numbers of waterfowl. Because the numbers vary greatly from one month to the next, and from one year to the next, we allowed month and year to be the other two factors in the ANOVA to enable adjustment for these factors when ascertaining the effect of water depth. Although a number of interactions among the three factors were significant, to simplify the presentation, we included the interactions with the error term. The analysis was done using the statistical package SAS/PC 6.03 for DOS.

Since the waterfowl counts were not normal and were skewed to the right, a logarithmic transformation was used to reduce the skewness and increase the homogeneity of the variance. Even so, due to the large number of zero counts, the transformed data were still not normal. However, we proceeded with a standard analysis of variance, realizing that the significance levels for the tests would be only approximate.

III RESULTS

A. Water depth

As mentioned previously, fields are flooded on tides of .15 m (+0.50 ft.) GSC or higher. The length of time flooding varied from day to day, since on some days tides are higher, and remain high longer, than on others. Heavy precipitation also helps to flood the fields. Another factor that affects the longevity of water on these fields during a dry period, is the amount of evapotranspiration. Research conducted at the University of British Columbia indicates that the approximate evapotranspiration rate for this area is 71cm (28 in.) annually.

Generally, the largest number of waterfowl occurred on both flooded fields during high tides, especially when the water touched the outer dykes along the foreshore. When that happens there are only a few small exposed land areas on the foreshore west of Field 9. During gusty wind conditions there are usually more ducks on the sheltered Field 9 than the exposed Field 8. When the winds are calm or light, the ducks are scattered over both fields (Hatfield, field notes).

As the fields freeze over, the ducks move out to the foreshore. During some winters, these fields may be frozen continuously for three to four weeks, while in others freezing occurs for two or more separate but shorter periods. However, when the ice leaves, large numbers of ducks move back. Should there be any open areas of water during freezing weather, a few ducks remain.

When Fields 8 and 9 changed from an upland field habitat to a seasonally flooded field habitat, the numbers of waterfowl using these fields increased dramatically (Table 2). The most common species using the flooded fields were Mallard, American Wigeon, and Northern Pintail. Green-winged Teal, Gadwall, and Northern Shoveler were also present but in smaller numbers. Canada Geese were occasional visitors to both fields while Lesser Snow Geese (*Chen caerulescens*) did not respond to the flooded field treatment.

B. Salinity

Field 8 had an average salinity of at 5.0 p.p.t. while Field 9 had an average of 3.6 p.p.t. (Table 3). The salinities in Field 8 ranged from about 10 p.p.t.in January and February to about 0.5 in June and July. Field 9 exhibited similar fluctuations, but the range was smaller (1.8 p.p.t.to 7.8 p.p.t.) with the minimum occurring earlier in the winter (December and January).

C. Bird responses to field flooding

(i) Canada Geese

Although small in number, Canada Geese showed a definite preference for Field 8. They generally started to graze on both fields before flooding started and continued to graze following flooding. Water depth did not significantly affect their numbers (Figs. 3 and 4).

The only major field treatment was the seeding of Field 8 to barley in 1989. Canada Geese responded to this treatment with a slight increase in goose days in the early fall of 1989 (Hatfield, field notes). A possible factor related to the increase of Canada Geese on both fields during the years 1986 and 1987 was the large numbers of Snow Geese on the other fields of Alaksen (Hatfield 1991). Field 9 was ploughed and disced in 1984, 1985 and 1987, thus benefiting Canada Geese by eliminating *Juncus* spp. and Reed Canary Grass, and encouraging Bent Grasses for easier grazing. This practice also cut down the high cover, from which Canada Geese shy away. As no discing was done from 1988 to 1990 inclusive, the Juncus and Reed Canary Grass grew back in dense scattered clumps over Field 9, resulting in a decline of Canada Goose numbers.

October had the largest numbers of grazing Canada Geese, especially in Field 8. Their numbers decline over the winter months and then increase again in February and March as they establish their nesting territories. They prefer Field 9 for nesting due to the number of small islands that remain while it is flooded (Hatfield, field notes).

(ii) **Mallards**

Mallards showed a distinct preference for Field 9 (Table 2, and Figs. 3 to 9). Mallard numbers peaked when water was 0.19 m (0.63 ft.) deep on Field 8, while on Field 9 their highest numbers occurred when water was over 0.38 m (1.25 ft.) deep. On Field 8 Mallards were generally seen loafing on exposed land or swimming and feeding in or near emergent vegetation when field water depth ranged from 5-10cms (2-4 in.).

Due to relatively small changes in elevation on Field 9, Mallards responded sooner to a rise in water depth, and their numbers remained relatively high even as the water levels rose. When the water level rises, more of the field's surface becomes covered with water from 5-15cm (2-6 in.) in depth (Fig. 3 and 4). Because of the relatively flat topography, mallard were seen throughout the field along with the reed canary grass and cattails providing the necessary cover.

On a yearly basis it is difficult to determine if field treatments played a role in the changing Mallard numbers. A possible factor that may have affected the numbers of Mallards from year to year on Fields 8 and 9 is the availability of food on the other fields of Alaksen (Hatfield 1987 and 1991, Figs. 8 and 9).

October shows a surge of Mallards on both fields, November and December show a decline. In January there is a substantial increase, but their numbers drop considerably following the closure of the hunting season at the end of the month. This same pattern is evident on the other fields of Alaksen (Hatfield 1991, Table 2 and Figs. 6 and 7).

(iii) **Wigeon**

Wigeon show a marked preference for Field 8. The largest numbers occurred when water was between 11cm and 19cm deep (4.3 in. to 7.5 in.). On Field 9, their numbers increased steadily as the water level rose. They are generally seen on the northern half of this field when most of it is covered with water. This is where most of the bentgrass is located. On Field 8 the majority of Wigeon are found over the same general area as Mallards. However, many can be seen tipping in the 'open' water, where the water depth ranges from 15-25cm (6-10 in.). Wigeon were not observed on Field 9 before flooding started in 1985 (Hatfield 1991, Table 2).

The amount of grazing and standing water available on other fields of Alaksen and elsewhere probably influenced the changes in numbers of wigeon observed on Field 8 and 9 on an annual basis. Wigeon numbers varied in earlier years on Alaksen as well (Hatfield 1991). Wigeon are the only dabblers seen grazing on the levee bordering the southeastern side of Field 8.

The highest numbers of wigeon occur in October for Field 8, where grazing is available on forages compared to the high Reed Canary Grass on Field 9. The largest numbers on Field 9 occur in January. This is likely due to the flooding along with available grazing and the fact that the hunting season is still open. Like the Mallards, Wigeon numbers drop considerably in February following the closure of the hunting season (Hatfield 1991, Figs. 6 and 7).

(iv) **Pintails**

Pintails show a marked preference for Field 8. They are definitely influenced by water depths, similarly to Mallards and Wigeon in both fields. While loafing on Field 8 Pintails can be seen on the same areas as Mallards and Wigeon. While feeding, however, they prefer deeper water than Mallards, ranging from 15-25cm (6-10 in.). On Field 9, they are usually scattered. These activities were observed at a depth of about 19 cm. (7.5 in.) when the largest numbers of Pintails occurred.

In 1989, barley was seeded in Field 8, contributing to the large numbers of Pintails, and a low number in Field 9. Otherwise, their numbers were relatively stable in both fields from 1985 to 1988.

The initial surge of Pintails, similar to Mallards and Wigeon for October on both fields, is probably due to migrants passing through. Again, the larger numbers of Pintails in January for both fields, are the returning migrants while the hunting season is still on. They remain in Field 8 during February due to the flooded field. However, they definitely disperse in March (Hatfield 1991, Figs. 6 and 7). Pintails were not observed on either field before flooding started in 1985 (Hatfield 1991).

(v) **Gadwall**

Even though their numbers were lower than the other dabblers, Gadwall still show similar responses to water depths for both fields. They show equal preference for both fields. Except for their unexplained higher numbers on both fields during 1986, their numbers were relatively stable for the other four years. Gadwall even show a small surge in October along with another increase in numbers for January and February, similar to the other dabblers. Their loafing and feeding pattern is very similar to Mallards (Figs. 3 to 9).

(vi) **Green-winged Teal**

Green-winged Teal show a preference for Field 8 (Figs. 3 and 4, 6 to 9). They loaf on exposed land or among emergent vegetation where the water depth is 1-3cm (.4-1.2 in.). They generally feed within the emergent vegetation located in water of 3-15cm (1.2-6 in.). Sometimes a few can be seen in open water 'tipping' while feeding. This occurs at a gauge reading of 0.84m (2.75 ft.) GSC. On Alaksen (inside the dykes), Green-winged Teal were only observed in or near standing water or flooded fields.

(vii) **Shovelers**

Consistently low numbers of Shovelers are present on Alaksen over the winter months. Shovelers were only observed in similar habitat as Green-winged Teal. Their numbers were not high enough for us to determine whether they had a preference for Field 8 or 9 (Figs. 3 and 4, 6 to 9).

(viii) **Other dabblers and geese**

Cinnamon Teal (*Anas cyanoptera*) and Blue-winged Teal (*A. discors*) had left for their southern wintering areas by the time our survey counts began in early September. In 1990 and 1991 we continued to count waterfowl in Fields 8 and 9 to early May. Both fields were still flooded in early May in both years by which time no standing water remained on other fields. These two Teal species return to Fields 8 and 9 about mid-April. Their habitat requirements appear to be very similar to those of Green-winged Teal. One to four Eurasian Wigeon (*Anas penelope*) were usually seen along with approximately 100 American Wigeon especially during the later years.

Lesser Snow Geese have been seen on Field 8 on only a few occasions when there is grazing available. They have never visited Field 9. They are not influenced by flooded fields, however they will remain on a field all day where grazing is available, provided there is standing water as a source of drinking water (Hatfield 1991). Similarly to Canada Geese small numbers of White-fronted Geese (*Anser albifrons*) occasionally visit Fields 8 and 9 when grazing is available.

(ix) **Divers**

Although management practices for Fields 8 and 9 are designed for dabbling ducks, it has affected the use of those fields by divers. Prior to flooding, small numbers of Bufflehead (*Bucephala albeola*) and Canvasback (*Aythya valisineria*) were observed in the large sloughs of Field 9. Bufflehead were occasionally seen in the sloughs of Field 8 as well. The sloughs in Field 9 are approximately 60cm (24 in.) deep, while in Field 8 they are approximately 30cm (12 in.) deep, before flooding. The sloughs in both fields have very soft bottoms which help to create ideal habitat for aquatic invertebrates.

Following the implementation of controlled flooding, divers not only have increased in numbers, but they have become more consistent winter visitors on both fields. Up to 25 Bufflehead have appeared from late October to late April. They are also seen feeding in the deeper portion of Field 8 where the water depth is approximately 36cm (14 in.) Up to 12 Canvasbacks on the sloughs of both fields have also become consistent winter visitors.

American Coots (*Fulica americana*) have been present during the winter months, in the sloughs of the two fields, both before and after flooding. Up to 100 occur during October, then fall to about 10 for the remaining winter months on both fields.

Other divers: Lesser Scaup (*Aythya affinis*) , Ruddy Ducks (*Oxyura jamaicensis*) , Common Goldeneye (*Bucephala clangula*) and Hooded Merganser (*Lophodytes cucullatus*)) can be observed sporadically over the winter months on the sloughs of both fields. Increased depth and increased surface area of open water appear to be significant factors in attracting divers to a flooded habitat.

(x) **Shorebirds**

Migrating shorebirds are generally observed in September and early May on Field 8, with a few Greater Yellowlegs (*Tringa melanoleuca*) and Killdeer (*Charadrius vociferus*) on Field 9. These, along with large numbers of Dunlin (*Calidris alpina*), Long-billed Dowitchers (*Limnodromus scoopaceus*) and Western Sandpipers (*Calidris mauri*), have been observed when there is just standing water in the lower portion of Field 8.

One or two Great Blue Herons (*Ardea herodias*) are commonly seen throughout the winter. During the flooding process, herons will follow the rising water line to feed on escaping Voles (*Microtus townsendii*).

IV DISCUSSION

Water plays a significant role in the daily behaviour patterns of dabbling ducks. This has been illustrated from this study and past studies on Alaksen NWA (Hatfield, 1991). Using the natural topography and native vegetation of Fields 8 and 9 we have, through flooding, increased their use by ducks (duck-days), considerably, and also increased the number of species.

No cost accounting was done to compare row crops and pastures with these fields. Over a period of time, the flooded fields appear to be considerably cheaper to operate on a duck-day basis. The initial costs of installing culverts, flap gates and stop-log structures, can be averaged out over time as there is very little maintenance cost involved in operating a flooded field. There is no cost related to farming (e.g. planting row crops, fertilizing, etc.) and flooding is done using tides - no water pumps are necessary.

Emergent vegetation along with water depths are the two dominant factors that determine the use of a flooded area by dabblers. On Field 8, the majority of dabblers were seen either among or close to emergent vegetation. As the water depth increased, covering the vegetation, the total number of dabblers decreased and those remaining concentrated in what emergent vegetation was left. When the water depth reached approximately 30 cm (12 in.) or higher in the open areas of this field, Bufflehead moved into the field.

In Field 9 where the vegetation was considerably higher and where Reed Canary Grass and Bulrushes dominated, a deeper water depth was tolerated by dabblers. Mallards prefer the higher and denser emergent vegetation of Field 9 over the shorter and lighter emergent vegetation of Field 8. There is also the possibility that Mallards prefer the seeds from the Reed Canary Grass over what was available in Field 8 (Appendices 1 and 2). The opposite is generally true for Wigeon, Pintails and Green-wing Teal. There was always emergent vegetation in Field 9, even at the highest water depth, 0.60m (2 ft.). When the highest tides covered the majority of vegetation along the foreshore, dabblers moved onto Field 8 and 9 in large numbers, or moved into any remaining emergent vegetation or onto "islands" along the foreshore.

Dabblers were frequently seen loafing among the emergent vegetation, especially in the shallower portions and on any "islands" in both fields. These islands, created from spoil dug from the ditches, provide ideal loafing sites for dabblers.

Green-winged, Blue-winged and Cinnamon Teal, when present on Alaksen, are only seen on or near standing water and flooded fields. Eurasian Wigeon have been observed more frequently in habitat similar to that of Teal.

V CONCLUSION

We found that the regulation of water depth greatly enhanced the use of Fields 8 and 9 by dabblers. Approximately 19 times the use is made of these fields by dabbling ducks as there was before the water management regime was implemented (Table 2). There was also an increase in use by diving ducks, and the number of waterfowl species increased.

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Table 1. Field Management in Fields 8 and 9 by year (Six years flooded).

	1985	1986	1987	1988	1989	1990
Field 8	Disced and winter flooding	Disced and winter flooding	Disced and winter flooding	Disced and winter flooding	Disced and seeded to barley and winter flooding	Disced and winter flooding
Field 9	Disced and winter flooding	No cultivating, winter flooding	Disced and winter flooding	No cultivating, winter flooding	No cultivating, winter flooding	No cultivating, winter flooding

Table 2. Fall and winter use by dabbling ducks of Fields 8 and 9, on the Alaksen National Wildlife Area, during the period 1980-85 when the fields were not flooded, and during the period 1985-91, when the fields were flooded.

	Number of bird-days (in thousands)				Number of bird-days (in thousands)			
	1980-81 through 1984-85				1985-86 through 1990-91			
Species	Field No.8	Field No.9	Total	Average/ month	Field No.8	Field No.9	Total	Average/ month
Mallard	4.2	0.3	4.6	0.18	98.8	149.5	248.3	6.71
Wigeon	2.8	0	2.8	0.07	164.4	56.8	221.2	5.98
Pintail	0	0	0	0.0	69.7	14.3	84.1	2.27
Unident. dabblers	14.5	1.5	16.0	0.40	26.7	24.4	51.2	1.38
Totals	21.5	1.8	23.3	0.60	64.8	245.1	604.8	16.35

Table 3. Salinity Readings (p.p.t.) on fields 8 and 9.

DATE	MEAN[1]	STD. DEV.	N
FIELD 8	5.002 p.p.t.	4.831	47
Feb 85	9.275	3.500	4
Mar 85	7.600	2.467	4
Apr 85	3.050	1.850	4
May 85	1.075	0.629	4
Jun 85	0.525	0.330	4
Jul 85	0.633	0.462	3
Aug 85	1.200	0.935	4
Sep 85	2.425	0.380	4
Oct 85	2.975	1.072	4
Nov 85	5.967	3.523	3
Dec 85	12.220	4.963	5
Jan 86	10.425	5.171	4
FIELD 9	3.594	2.088	47
Feb 85	3.000	0.779	4
Mar 85	3.400	0.295	4
Apr 85	3.925	0.506	4
May 85	3.225	0.125	4
Jun 85	3.125	0.395	4
Jul 85	2.900	0.100	3
Aug 85	1.750	0.100	4
Sep 85	2.000	0.183	4
Oct 85	2.075	0.263	4
Nov 85	2.833	1.301	3
Dec 85	6.100	2.315	5
Jan 86	7.800	3.171	4

[1] Mean is based on three to five readings per month done at intervals of approximatley one week.

TABLE 4 Summary of results (P-values) for analyses of variance to determine the effect of water depth, month and year on numbers of waterfowl present.

Field 8

SPECIES\FACTOR	WATER DEPTH	YEAR	MONTH
Canada Goose	0.8111	0.0157^2	0.0001^4
Mallard	0.0038^3	0.3898	0.0071^3
American Widgeon	0.0001^4	0.0001^4	0.0605^1
Pintail	0.0001^4	0.0001^4	0.0001^4
Green-winged Teal	0.0102^2	0.00199^3	0.0001^4
Gadwall	0.5143	0.0001^4	0.0809^1
Shoveler	0.1171	0.0045^3	0.0131^2

Field 9

SPECIES\FACTOR	WATER DEPTH	YEAR	MONTH
Canada Goose	0.1065	0.2041	0.0001^4
Mallard	0.0001^4	0.1407	0.0001^4
American Widgeon	0.0001^4	0.0688^1	0.0001^4
Pintail	0.0001^4	0.0165^2	0.0001^4
Green-winged Teal	0.0001^4	0.0001^4	0.0001^4
Gadwall	0.0004^4	0.2408	0.0001^4
Shoveler	0.0316^2	0.0001^4	0.0005^4

^{1} indicates $0.05 \leq p < 0.10$
^{2} indicates $0.01 \leq p < 0.05$
^{3} indicates $0.001 \leq p < 0.01$
^{4} indicates $p < 0.001$

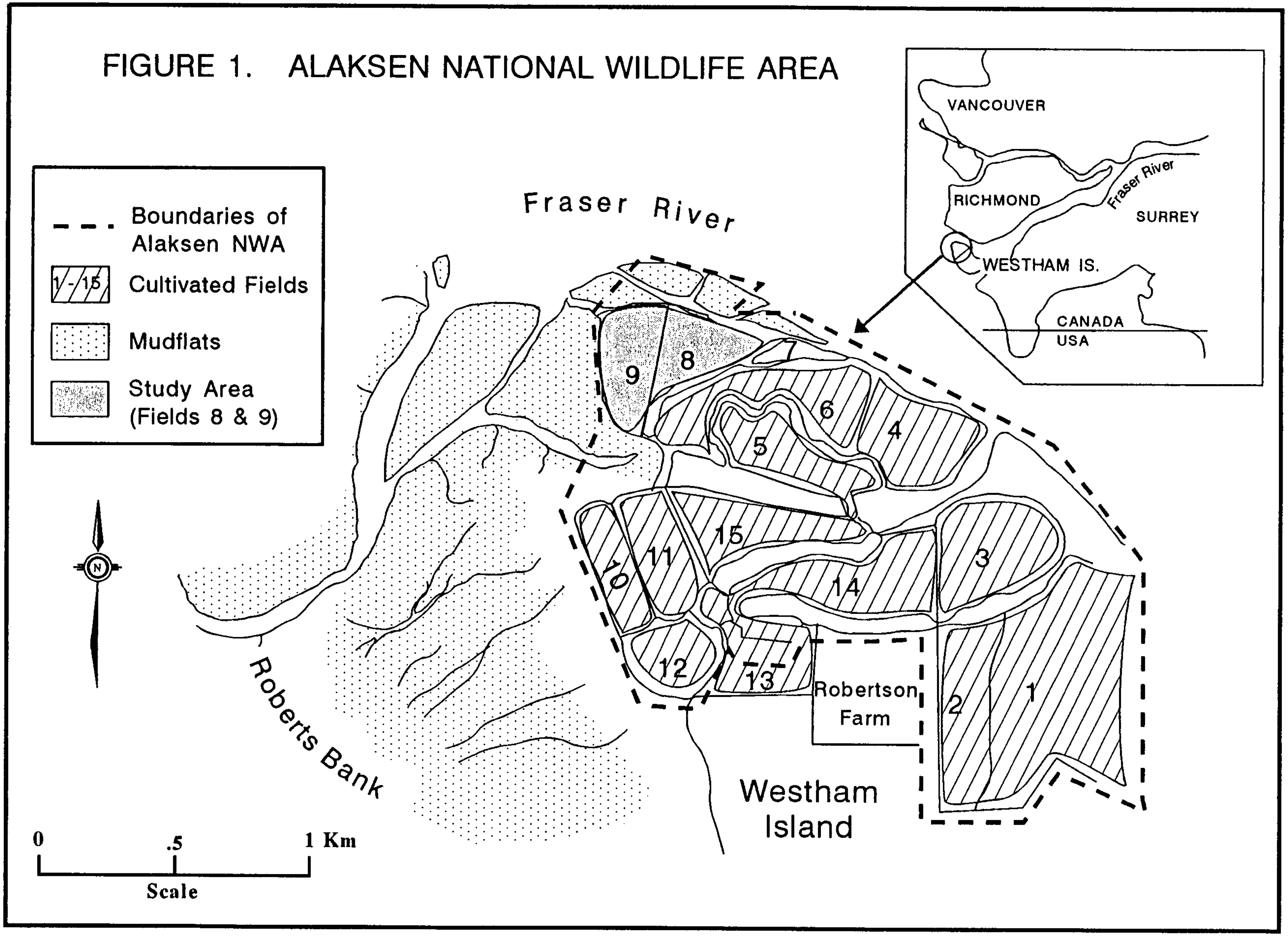


FIGURE 1. ALAKSEN NATIONAL WILDLIFE AREA

FIGURE 2. DEPTH CONTOUR AND SALINITY READING ON FIELDS 8 AND 9.

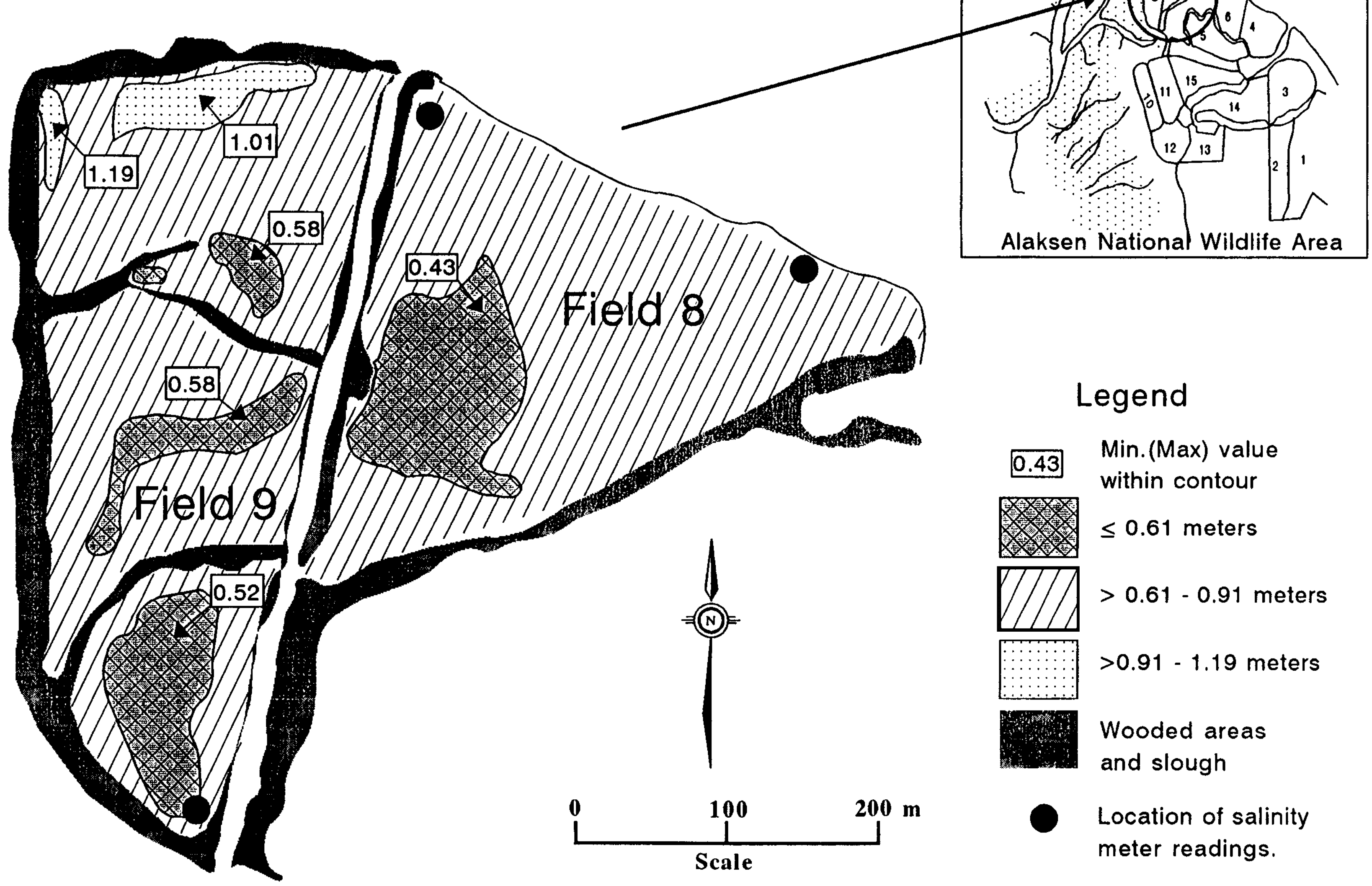


Figure 3. Field 8 - use by Waterfowl in relation to water depth.

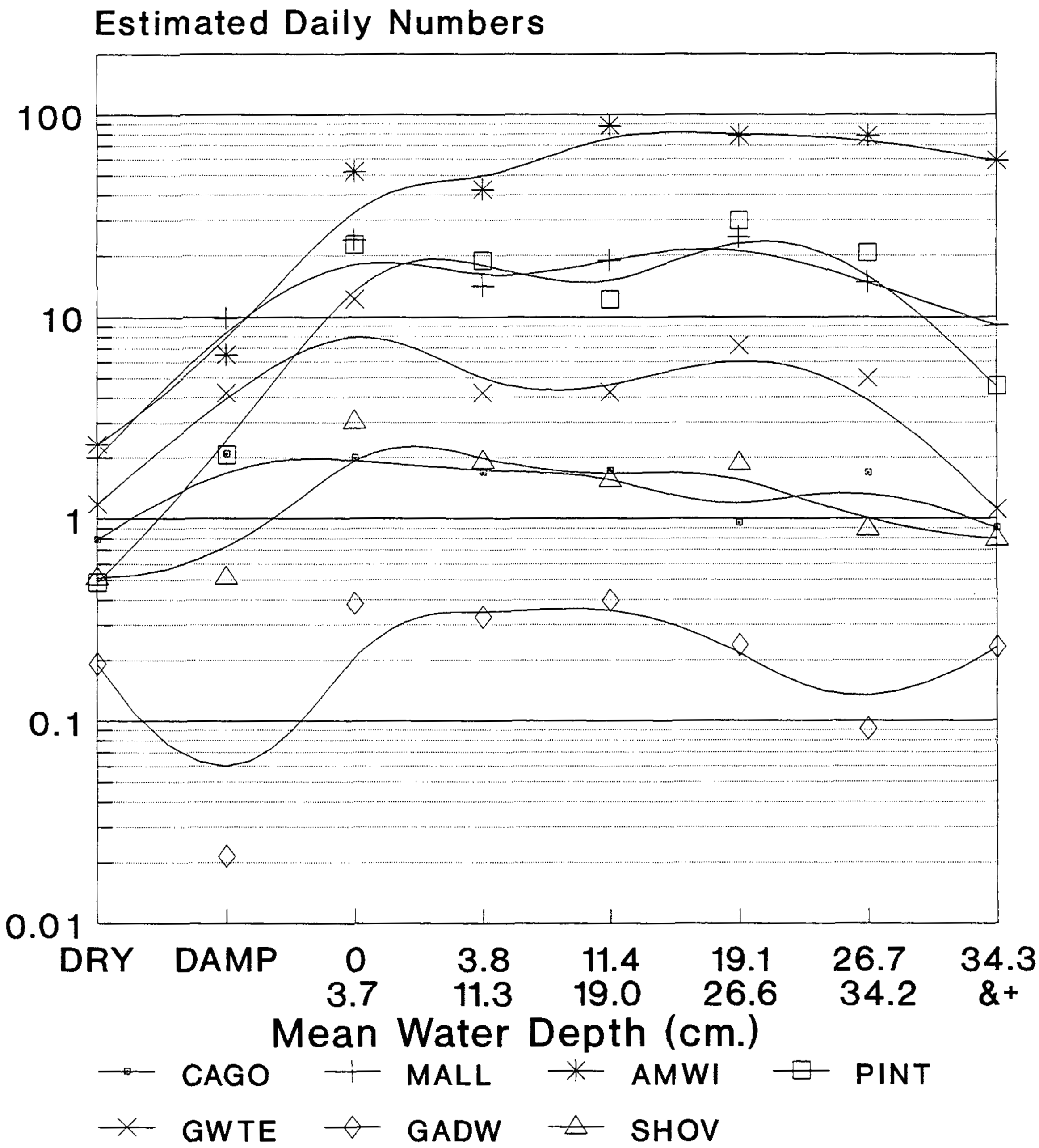


Figure 4. Field 9 - Use by Waterfowl in relation to water depth.

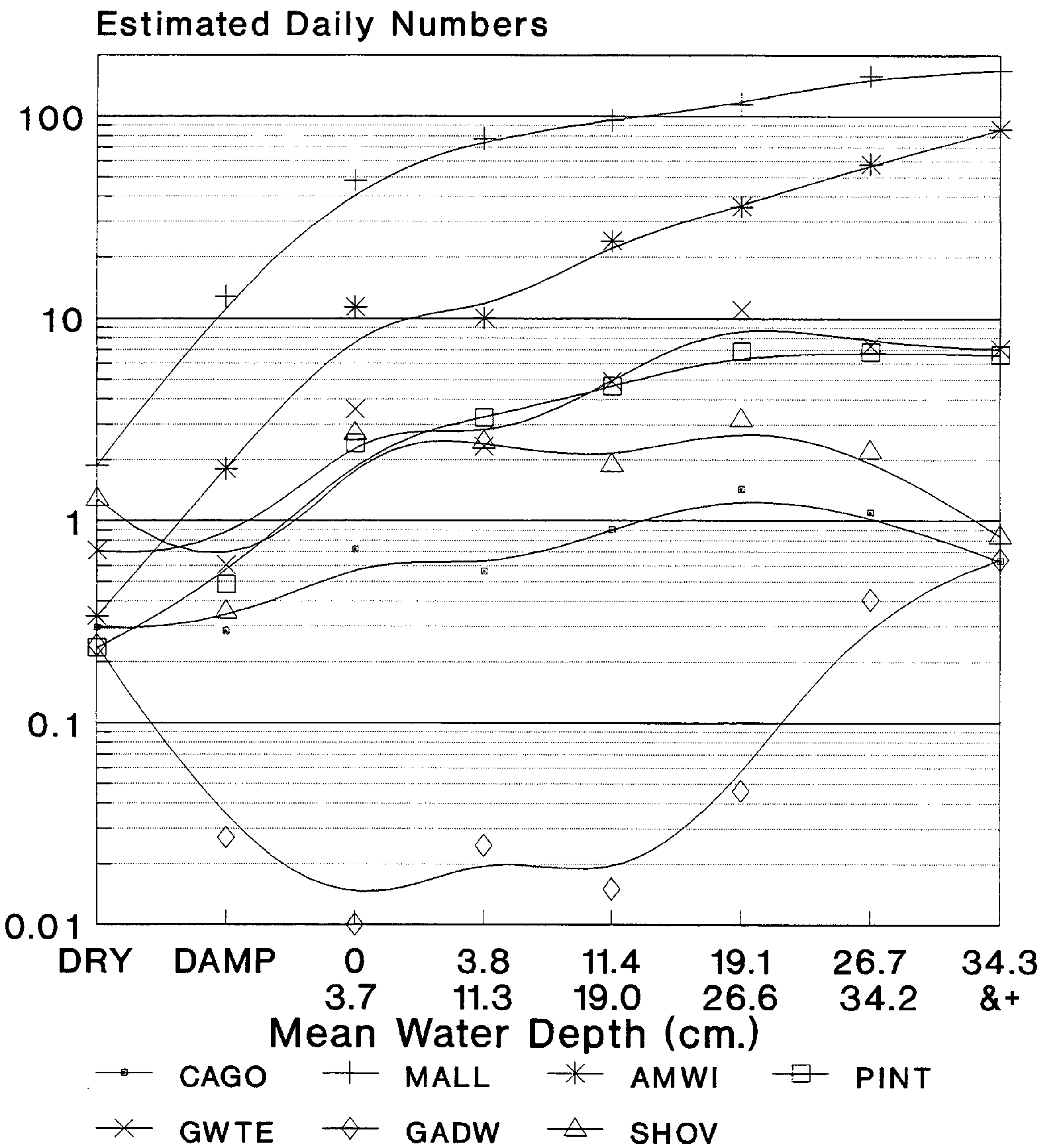


Figure 5. Use by Mallard, Pintail and Wigeon in relation to water depth.

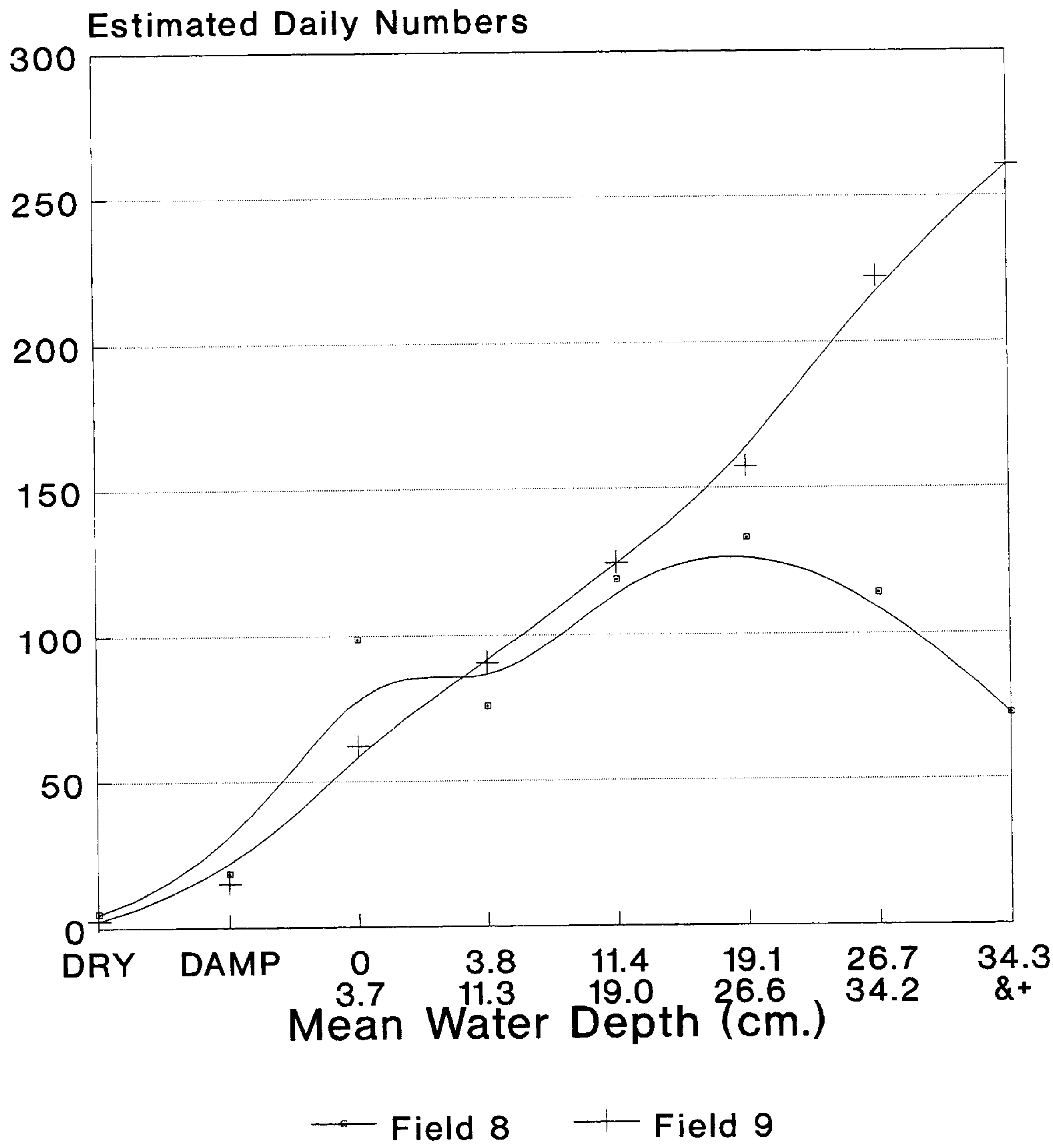


Figure 6. Field 8: Monthly use by Waterfowl, 1985 - 1991.

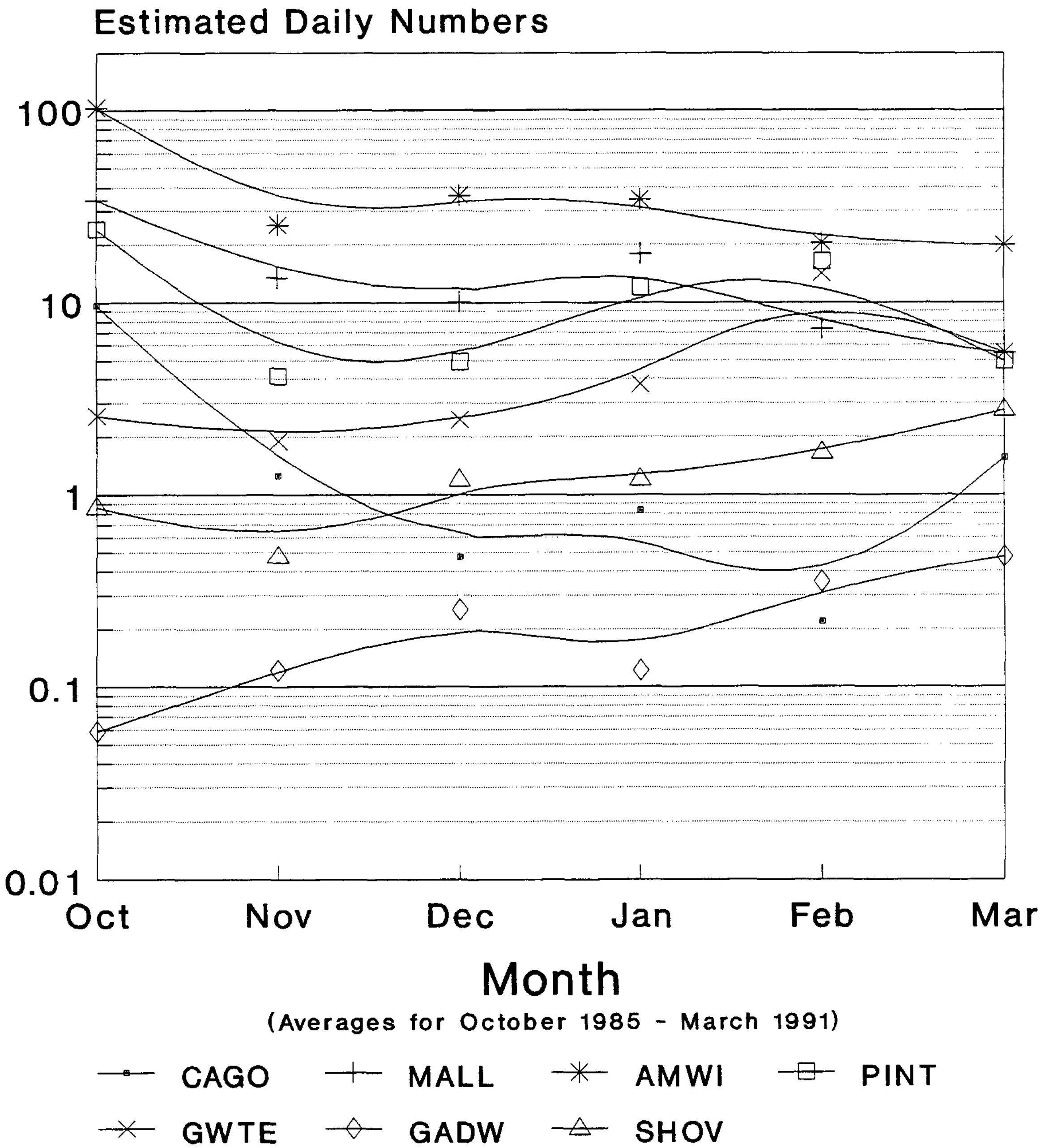


Figure 7. Field 9: monthly use by Waterfowl, 1985 - 1991.

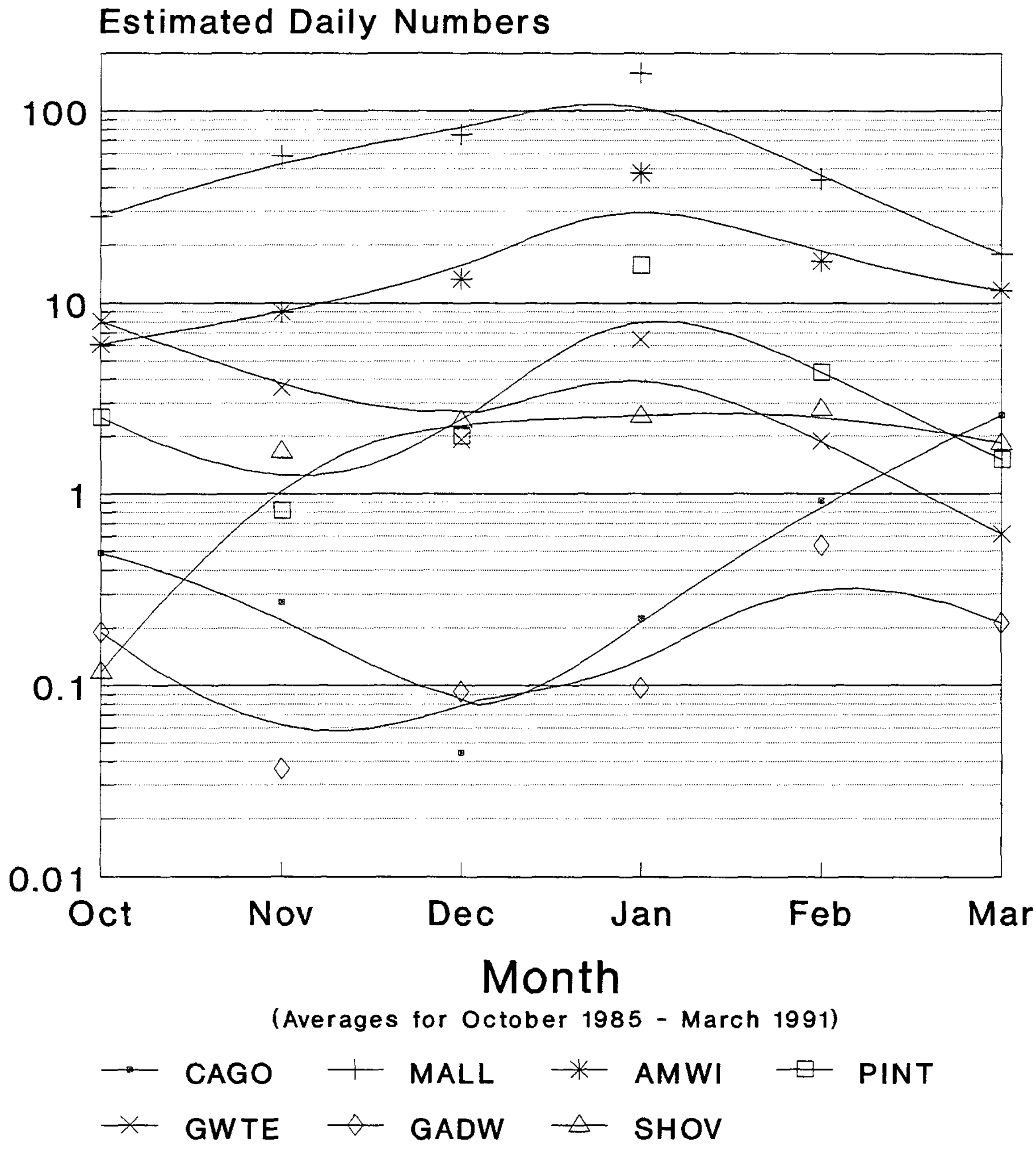


Figure 8. Field 8: Yearly use by Waterfowl, 1985 - 1991.

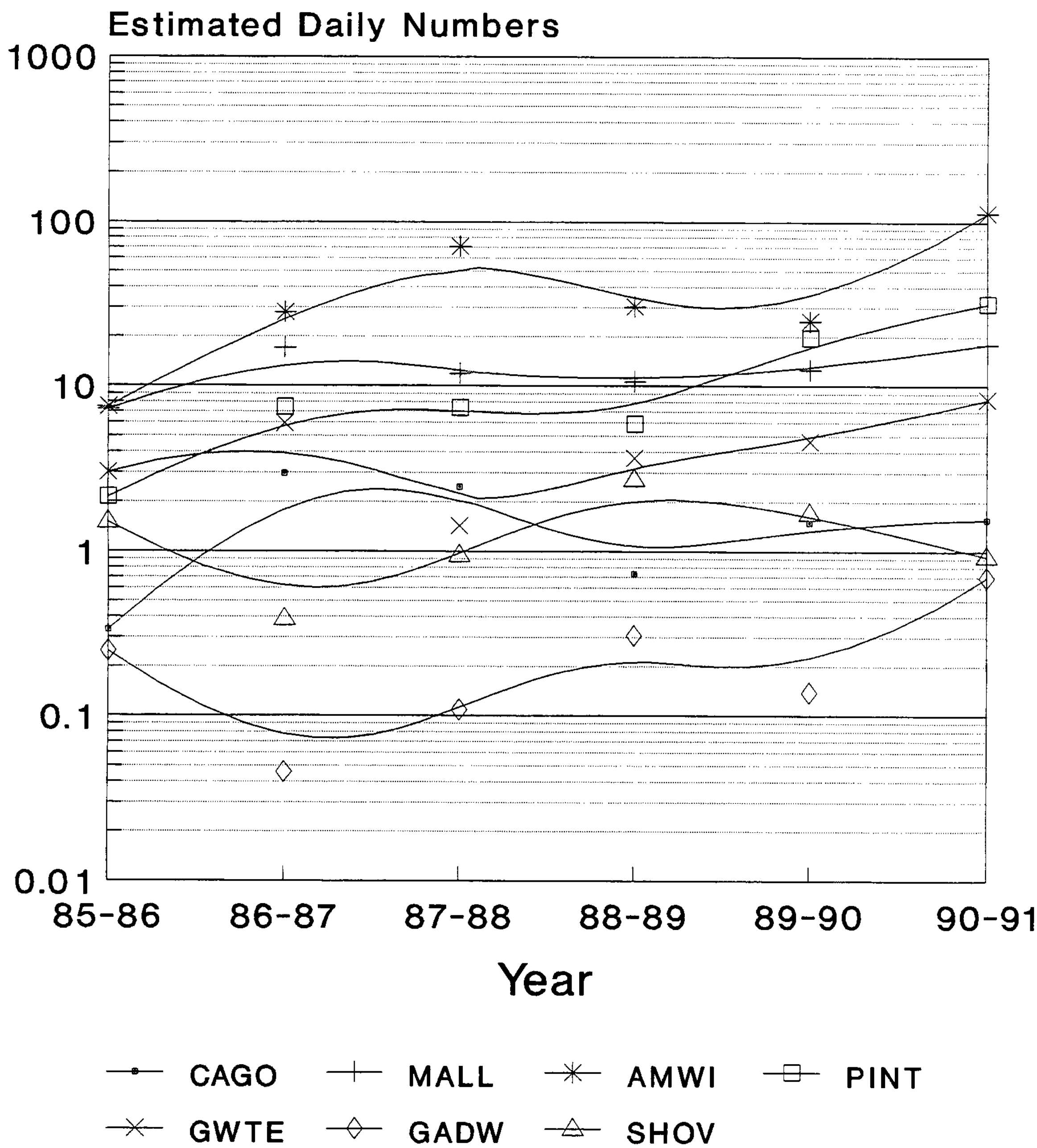
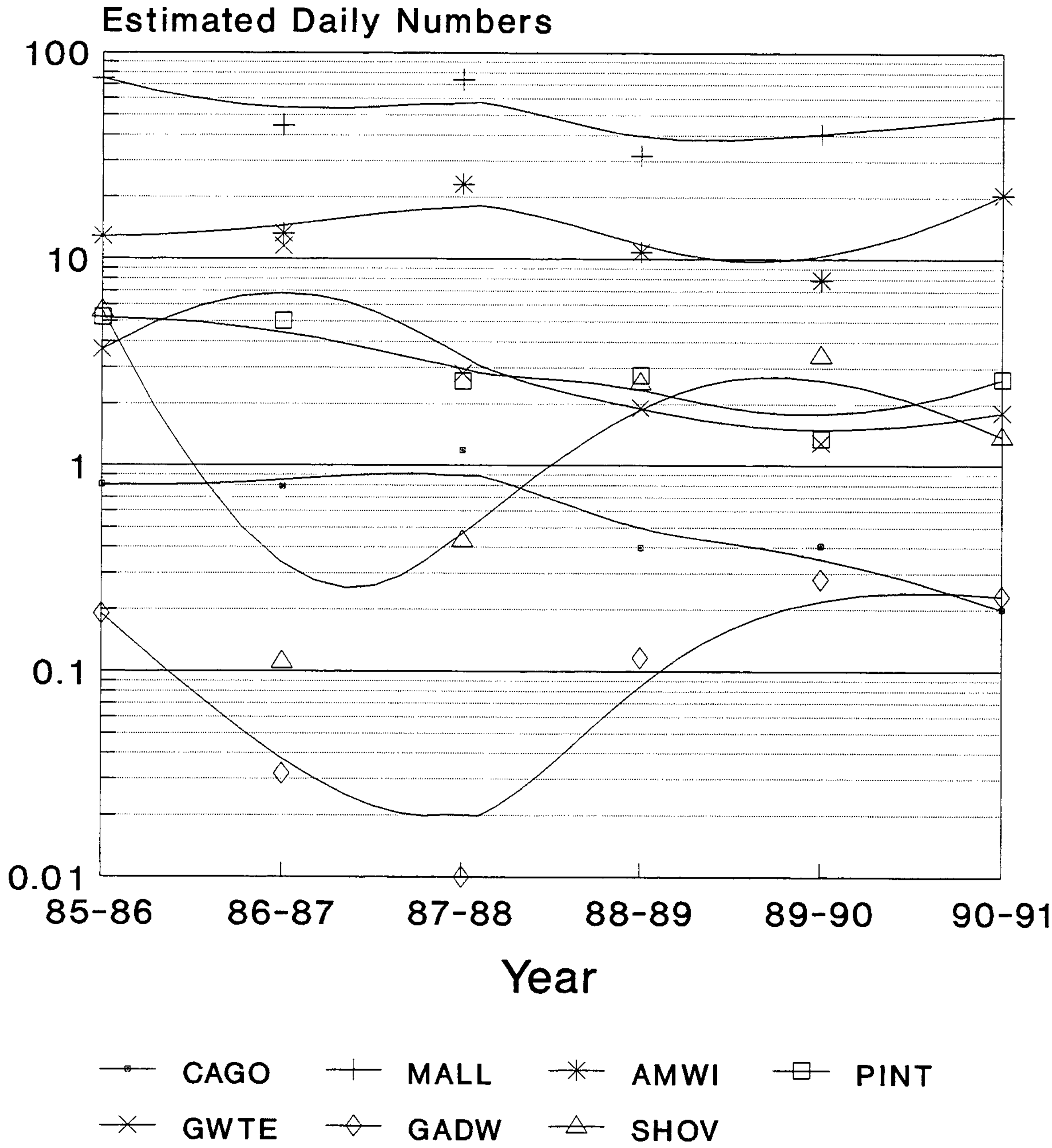


Figure 9. Field 9: Yearly use by Waterfowl, 1985 - 1991.



Appendix 1. List of vascular plants in Field 8, 1991

Agrostis alba - Bent Grass

Alopecurus geniculatus - Water Foxtail

Brassica campestris - Yellow Mustard

Chenopodium album - Lamb's Quarters

Cirsium arvense - Canada Thistle

Cotula coronopifolia - Brass Buttons

Echinochloa crusgalli - Wild Millet

Elymus spp. - Ryegrasses

Equisetum arvense - Common Horsetail

Gnaphalium uliginosum - Cudweed

Holcus lanatus - Velvet Grass

Iris pseudacorus - Yellow Iris

Juncus spp. - Juncus

Lythrum salicaria - Purple Loosestrife

Phalaris arundinacea - Reed Canarygrass

Phleum pratense - Timothy

Plantago spp. - Plantain

Polygonum spp. - Smartweed

Rumex spp. -Dock

Scirpus spp. - Bulrush

Trifolium revens - White Clover

Typha latifolia - Common Cattail

Appendix 2. List of vascular plants in Field 9, 1991.

Agrostis alba - Bent Grass

Alopecurus geniculatus - Water Foxtail

Cirsium arvense - Canada Thistle

Gnaphalium uliginosum - Cudweed

Holcus lanatus - Velvet Grass

Iris pseudacorus - Yellow Iris

Juncus spp. - Juncus

Lythrum salicaria - Purple Loosestrife

Phalaris arundinacae - Reed Canarygrass

Plantago spp. - Plantain

Polygonum spp. - Smartweed

Rumex spp. - Dock

Scirpus spp. - Bulrush

Trifolium revens - White Clover

Typha latifolia - Common Cattail

Appendix 3. List of vascular plants in Field 9 in 1980.

Agropyron repens - Quack Grass

Agrostis alba - Redtop

Agrostis palustris - Creeping Bentgrass

Agrostis stolonifera -

Alopecurus geniculatus - Water Foxtail

Cirsium arvense - Canada Thistle

Epilobium adenocaulon - Willow-weed

Equisetum arvense - Common Horsetail

Galium trifidum - small Bedstraw

Holcus lanatus - Velvet Grass

Juncus effusus - Common Rush

Juncus filiformis - Thread Rush

Phalaris arundinacea - Reed Canarygrass

Plantagod spp. - Plaintain

Potentilla pacifica - Pacific Silverweed

Ranunculus spp. - Buttercup

Rumux salicifolius - Willow Dock

Trifolium hybridum - Alsike Clover

Trifolium repens - White Clover

Typha latifolia - Common Cattail

APPENDIX 4 Relationship between gauge reading and depth of water.

Gauge Reading	Minimum Depth cm (ft & in)	Mean Depth cm (ft & in)	Maximum Depth cm (ft & in)
0.0 - 1.9	0 (0' 0")	0 (0' 0")	0 (0' 0")
2.0	0 (0' 0")	0 (0' 0")	3 (0' 1")
2.1	0 (0' 0")	0 (0' 0")	6 (0' 2")
2.2	0 (0' 0")	2 (0' 1")	9 (0' 3")
2.3	0 (0' 0")	5 (0' 2")	12 (0' 5")
2.4	2 (0' 1")	8 (0' 3")	15 (0' 6")
2.5	5 (0' 2")	11 (0' 4")	18 (0' 7")
2.6	8 (0' 3")	14 (0' 6")	21 (0' 8")
2.7	11 (0' 4")	18 (0' 7")	24 (0' 9")
2.8	14 (0' 6")	21 (0' 8")	27 (0'11")
2.9	17 (0' 7")	24 (0' 9")	30 (1' 0")
3.0	20 (0' 8")	27 (0'10")	33 (1' 1")
3.1	23 (0' 9")	30 (1' 0")	36 (1' 2")
3.2	26 (0'10")	33 (1' 1")	39 (1' 3")
3.3	29 (1' 0")	36 (1" 2")	42 (1' 5")
3.4	33 (1' 1")	39 (1' 3")	45 (1' 6")
3.5	36 (1' 2")	42 (1' 4")	48 (1' 7")
3.6	39 (1" 3")	45 (1' 6")	51 (1' 8")
3.7	42 (1' 4")	48 (1' 7")	54 (1' 9")
3.8	45 (1' 6")	51 (1' 8")	57 (1'11")
3.9	48 (1' 7")	54 (1' 9")	60 (2' 0")
4.0	51 (1' 8")	57 (1'10")	64 (2' 1")

Explanation of table

Gauge readings are measured in feet from markings on the gauge pole. At a gauge reading of g_0 = ***2.5'***, the water depth ranges from 2" to 7" or an average of h_0 = ***4.5"*** (4.5x2.54 = 11.43 cm.). Every unit change in the gauge reading is 12" or 30.48 cm. Hence, the relationship between ***h***(water depth in cm.) and ***g***(gauge reading) is

$$\frac{h-h_0}{g-g_0}=30.48 \quad or \quad \frac{h-11.43}{g-2.5}=30.48$$

Solving for ***h***, we obtain

$$h=11.43+30.48\times(g-2.5)$$

The minimum depth is obtained by subtracting 2.5" or 6.35 cm. from the mean, and the maximum by adding this amount.

APPENDIX 5 Detailed analysis of variance tables by field and species

******** F I E L D 8 ********

Class Level Information

Class	Levels	Values
GCAT	8	0 1 200 225 250 275 300 325
YEAR	6	85 86 87 88 89 90
MONTH	6	10 11 12 13 14 15

Number of observations in data set = 249

Dependent Variable: CAGO

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	22.24095819	1.30829166	3.62	0.0001
GCAT	7	1.33987462	0.19141066	0.53	0.8111
YEAR	5	5.16889703	1.03377941	2.86	0.0157
MONTH	5	9.59367195	1.91873439	5.32	0.0001
Error	231	83.37544454	0.36093266		
Corrected Total	248	105.61640273			

R-Square	C.V.	Root MSE	CAGO Mean
0.210582	162.9931	0.600777	0.36859021

Dependent Variable: MALL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	21.41626185	1.25978011	2.25	0.0038
GCAT	7	10.71227138	1.53032448	2.74	0.0095
YEAR	5	2.92982669	0.58596534	1.05	0.3898
MONTH	5	9.14841317	1.82968263	3.27	0.0071
Error	231	129.07640712	0.55877233		
Corrected Total	248	150.49266896			

R-Square	C.V.	Root MSE	MALL Mean
0.142308	64.30318	0.747511	1.16247870

Dependent Variable: AMWI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	65.67892501	3.86346618	5.75	0.0001
GCAT	7	25.39862530	3.62837504	5.40	0.0001
YEAR	5	23.54664786	4.70932957	7.01	0.0001
MONTH	5	7.21880037	1.44376007	2.15	0.0605
Error	231	155.12310532	0.67152859		
Corrected Total	248	220.80203033			

R-Square	C.V.	Root MSE	AMWI Mean
0.297456	50.19176	0.819468	1.63267532

Dependent Variable: PINT

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	65.30526409	3.84148612	7.72	0.0001
GCAT	7	24.26388355	3.46626908	6.96	0.0001
YEAR	5	21.44589952	4.28917990	8.62	0.0001
MONTH	5	13.38791955	2.67758391	5.38	0.0001
Error	231	114.98682483	0.49777846		
Corrected Total	248	180.29208892			

R-Square	C.V.	Root MSE	PINT Mean
0.362219	64.60408	0.705534	1.09208918

Dependent Variable: GWTE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	37.41718212	2.20101071	4.50	0.0001
GCAT	7	9.28328346	1.32618335	2.71	0.0102
YEAR	5	6.70188206	1.34037641	2.74	0.0199
MONTH	5	12.85975221	2.57195044	5.26	0.0001
Error	231	112.99091023	0.48913814		
Corrected Total	248	150.40809235			

R-Square	C.V.	Root MSE	GWTE Mean
0.248771	96.07719	0.699384	0.72793977

Dependent Variable: GADW

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	2.42505553	0.14265033	2.93	0.0001
GCAT	7	0.30357970	0.04336853	0.89	0.5143
YEAR	5	1.37929168	0.27585834	5.67	0.0001
MONTH	5	0.48441444	0.09688289	1.99	0.0809
Error	231	11.24426087	0.04867645		
Corrected Total	248	13.66931639			

R-Square	C.V.	Root MSE	GADW Mean
0.177409	217.5442	0.220627	0.10141729

Dependent Variable: SHOV

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	10.68716630	0.62865684	2.78	0.0003
GCAT	7	2.64129038	0.37732720	1.67	0.1171
YEAR	5	3.95433501	0.79086700	3.50	0.0045
MONTH	5	3.33954355	0.66790871	2.96	0.0131
Error	231	52.17020470	0.22584504		
Corrected Total	248	62.85737101			

R-Square	C.V.	Root MSE	SHOV Mean
0.170022	127.1189	0.475232	0.37384800

******** F I E L D 9 ********

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GCAT	8	0 1 200 225 250 275 300 325
YEAR	6	85 86 87 88 89 90
MONTH	6	10 11 12 13 14 15

Number of observations in data set = 248

Dependent Variable: CAGO

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	12.16380979	0.71551822	4.71	0.0001
GCAT	7	1.82274850	0.26039264	1.71	0.1065
YEAR	5	1.10837994	0.22167599	1.46	0.2041
MONTH	5	5.76895430	1.15379086	7.60	0.0001
Error	230	34.93524025	0.15189235		
Corrected Total	247	47.09905004			

R-Square	C.V.	Root MSE	CAGO Mean
0.258260	180.4379	0.389734	0.21599324

Dependent Variable: MALL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	139.3920593	8.1995329	24.97	0.0001
GCAT	7	50.99132460	7.28447494	22.18	0.0001
YEAR	5	2.75503842	0.55100768	1.68	0.1407
MONTH	5	17.30861576	3.46172315	10.54	0.0001
Error	230	75.5232410	0.3283619		
Corrected Total	247	214.9153003			

R-Square	C.V.	Root MSE	MALL Mean
0.648591	34.87882	0.573029	1.64291325

Dependent Variable: AMWI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	132.9176117	7.8186830	21.21	0.0001
GCAT	7	43.65551233	6.23650176	16.92	0.0001
YEAR	5	3.83347786	0.76669557	2.08	0.0688
MONTH	5	12.75680717	2.55136143	6.92	0.0001
Error	230	84.7715602	0.3685720		
Corrected Total	247	217.6891719			

R-Square	C.V.	Root MSE	AMWI Mean
0.610584	53.55311	0.607101	1.13364351

Dependent Variable: PINT

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	61.81868114	3.63639301	13.21	0.0001
GCAT	7	11.21244597	1.60177800	5.82	0.0001
YEAR	5	3.90863542	0.78172708	2.84	0.0165
MONTH	5	22.08248203	4.41649641	16.05	0.0001
Error	230	63.29587661	0.27519946		
Corrected Total	247	125.11455775			

R-Square	C.V.	Root MSE	PINT Mean
0.494097	86.26147	0.524595	0.60814472

Dependent Variable: GWTE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	49.22548112	2.89561654	8.15	0.0001
GCAT	7	25.62195788	3.66027970	10.30	0.0001
YEAR	5	12.03276350	2.40655270	6.77	0.0001
MONTH	5	10.98661372	2.19732274	6.18	0.0001
Error	230	81.71845537	0.35529763		
Corrected Total	247	130.94393649			

R-Square	C.V.	Root MSE	GWTE Mean
0.375928	105.0982	0.596068	0.56715400

Dependent Variable: GADW

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	2.58336813	0.15196283	4.41	0.0001
GCAT	7	0.96507766	0.13786824	4.00	0.0004
YEAR	5	0.23391478	0.04678296	1.36	0.2408
MONTH	5	1.12885753	0.22577151	6.56	0.0001
Error	230	7.91845092	0.03442805		
Corrected Total	247	10.50181905			

R-Square	C.V.	Root MSE	GADW Mean
0.245992	320.9911	0.185548	0.05780470

Dependent Variable: SHOV

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	26.33057038	1.54885708	8.42	0.0001
GCAT	7	2.89042677	0.41291811	2.24	0.0316
YEAR	5	9.65266909	1.93053382	10.49	0.0001
MONTH	5	4.25108197	0.85021639	4.62	0.0005
Error	230	42.31424548	0.18397498		
Corrected Total	247	68.64481586			

R-Square	C.V.	Root MSE	SHOV Mean
0.383577	92.57884	0.428923	0.46330572