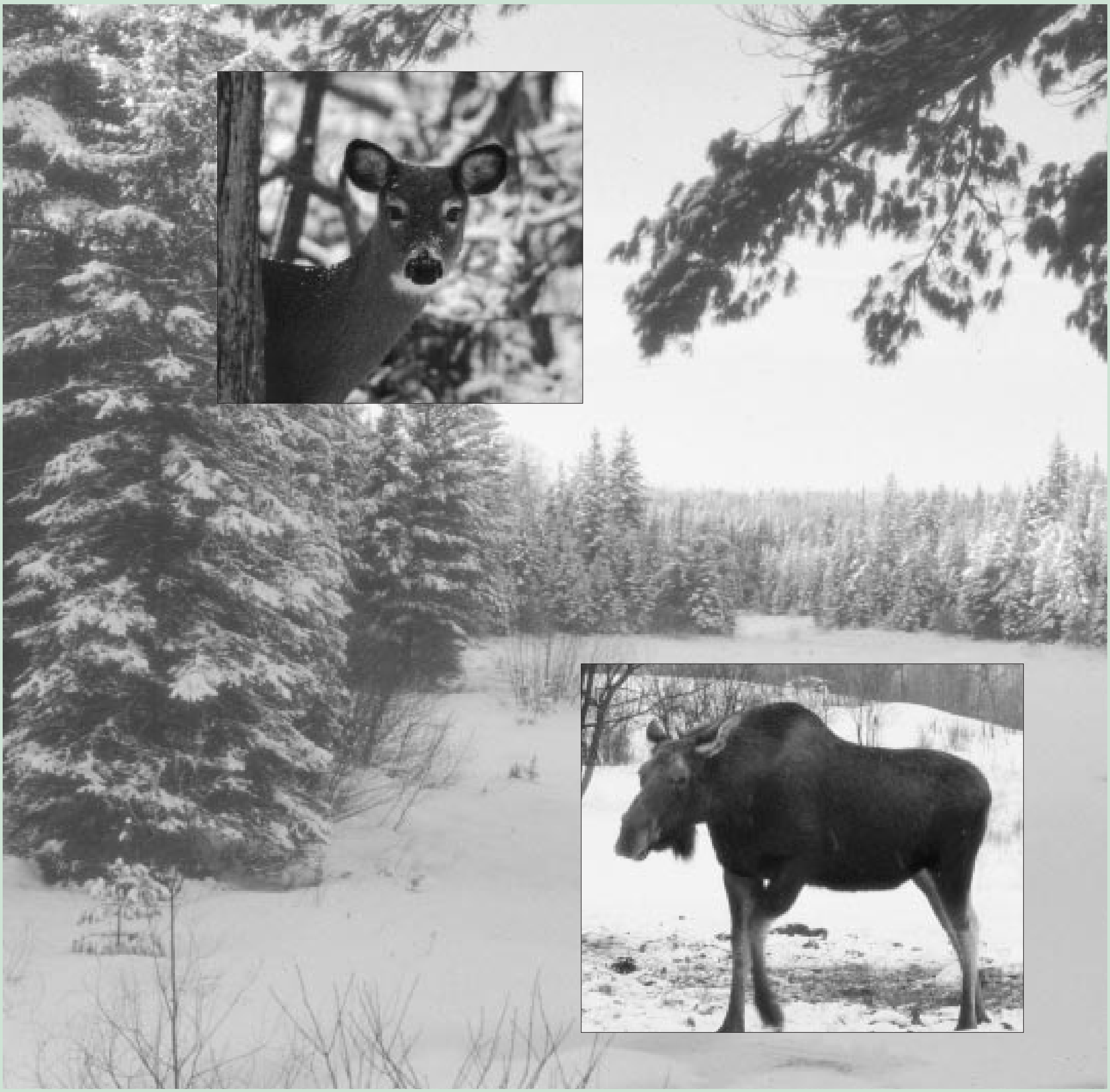
Ontario

Ministry of Natural Resources

The Snow Network for Ontario Wildlife

The Why, When, What, and How of Winter Severity Assessment in Ontario



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Part I

Operations Plan for the Provincial Snow Network

Abstract

A snow network has been operating in Ontario since 1952, providing information about provincial winter severity. Efforts have been made to ensure adequate provincial representation (mainly by research staff), but the operation of individual courses has depended largely on the perceived values to local staff, and funding.

Although the Snow Network for Ontario Wildlife (SNOW) was designed primarily for use in deer management, the data generated can be used by wildlife managers to monitor the effects of winter conditions on many wildlife species. It will help the Ontario Ministry of Natural Resources (OMNR) meet the requirements of the Terms and Conditions of the Timber EA by helping to understand population trends of indicator forest species. The information aids in management decisions regarding game harvest limits and regulations, and reintroduction programs for such economically important species as deer, moose, wild turkey and elk. The financial investment and income generated by hunting deer, moose and other game can be protected by effective population management which includes SNOW data.

SNOW has recently been automated through the province-wide OMNR computer network and the SNOW data management program, allowing access to historical data and providing greater uniformity in measurements.

In recent years, lack of funding and manpower has led to a deterioration of the network, and district decisions to close many snow courses. Immediate needs to create and maintain a standard provincial network include travel or contract funds for measurements at distant courses and funds to replace or repair course equipment.

The purpose of this plan is to design a minimum network of snow courses which will avoid redundancy and adequately cover the variation of winter severity across the province, providing information to wildlife and fire and flood managers, biologists, and the general public. With suitable funding in place and adherence to guidelines for SNOW winter severity measurement, the OMNR can provide effective and efficient monitoring of winter conditions across Ontario.

Introduction

In 1952, a network of snow courses was set up throughout Ontario to measure winter climatic conditions. Since then, the number, location, and sophistication of these courses has changed, but the network has continued to provide valuable data on snow and winter conditions. In 1996, there were about fifty snow courses operating across Ontario. Each district maintains the records of its snow courses and contributes copies to a central archive. This archive has yielded a large, valuable database which can be accessed through the OMNR computer network.

Information on winter severity is used by managers and biologists making wildlife management decisions, for fire and flood forecasting, for research, and for informing the general public of winter conditions affecting flooding and roof snow loads. Managers of deer populations use the information generated by the Snow Network for Ontario Wildlife (SNOW) for harvest decisions, implementation of emergency feeding, and in the Ontario Deer Model (ODM) used to plan optimal population levels (OMNR 1990). Managers of moose and other wildlife populations could use SNOW data to help adjust annual harvest limits and regulations, and for selecting suitable sites and population sizes for reintroductions of such species as wild turkey and elk.

Under the Terms and Conditions of the Timber Environmental Assessment (EA) the OMNR is required to monitor provincial population trends for representative forest vertebrates over time. Information generated by SNOW may be used to help calibrate the natural population tendencies associated with varying winter conditions.

SNOW has been recently linked through the OMNR computer network using the computerized SNOW data management program. Managers can send data directly to the central archive in digital form and can access the historical database to aid in wildlife management decisions.

Ontario has had a total of 191 snow courses in operation since the inception of this program in 1952. As redundancies have been identified and needs have dictated, courses have been discontinued or added in the last 45 years. In 1989, 100 snow courses remained in operation, and by 1994, only 68 courses were still open. Unfortunately, financial constraints have become a concern, and courses have been closed due to lack of manpower and funding, rather than lack of need. At the beginning of the 1996-1997 season, 55 courses were in operation, but 6 of these were in jeopardy of being abandoned. Although there are other sources of winter environmental conditions, none effectively measure the biological impact of winter severity on wildlife.

The purpose of this plan is to design a minimum network of snow courses which will avoid redundancy and adequately cover the variation of winter severity across the province. With suitable funding in place and adherence to guidelines for SNOW winter severity measurement, the OMNR can provide effective and efficient monitoring of winter conditions across Ontario.

Risk Assessment

In Ontario, winter environmental conditions have a significant influence on the survival and reproductive success of many wildlife species. Deer are particularly susceptible to winter severity because of their yarding behaviour. A severe winter can result in increased mortality due to starvation, especially of yearlings. The poor physical condition of pregnant females caused by a harsh winter may also result in increased abortion and post natal fawn mortality (OMNR 1997a). Emergency feeding can counteract these effects, and winter severity information is used extensively to determine when implementation of feeding should commence.

Severe winter conditions can have similar effects on moose. Although the results of a harsh winter may not be as extreme, the biological impacts may be equivalent because moose exist at lower densities and have a lower reproductive rate than deer do.

Managers of deer, moose and other wildlife populations can use SNOW information to adjust population trends for the effects of winter severity, and make decisions accordingly. For example, a severe winter may require a decrease in harvest limits for at least two years to avoid over exploitation of the harvest of game species and a further deterioration of the base population.

The OMNR must monitor the provincial population trends of representative forest species to ensure that timber management practices do not have adverse effects on the health of ecosystems. Precise estimates are necessary to detect potential declines in the population level of indicator species which may be indicators of deteriorating habitat. However, a change may be due to the effects of factors associated with winter severity. Accurate winter severity information might be used to explain at least part of population fluctuations and thereby calibrate and more accurately assess ecosystem health risks.

Economic Impacts

Hunters spend hundreds of millions of dollars each year on recreational hunting in Ontario (Legg 1995). $325.2 million was spent by resident hunters alone in 1991 (Legg 1995). A portion of these expenditures come from actively managed populations of such species as deer, moose and wild turkey. SNOW supplies information that can be vital to correct management decisions for these species, which, in turn, will ensure sustained population levels and revenue from hunting.

In 1993, deer hunting contributed $89.7 million to the Gross Provincial Income (GPI) in terms of value added (Legg 1995). This revenue generated 1670 person-years of employment, $61.1 million in labour income, and $32.6 million in tax revenues. This income should be protected by effective management of the deer population in Ontario. Winter severity data supplied by SNOW is used extensively in deer management. SNOW data plays a crucial role in determining when it is suitable to implement emergency feeding plans for yarding deer herds. Using the Snow Network information, managers can estimate and predict current and near-future impacts of weather conditions on adult and fawn mortality and decide when it becomes necessary to restrict harvests. Moose populations in Ontario also require effective management. Although winter severity information is used less, it should still play a role in moose management. In 1993, moose hunting contributed $89.9 million to the GPI in terms of value added, generating 1690 person-years of employment, $60.7 million in labour income and $32 million in tax revenues. The hunting of other game species in Ontario also contributes to the GPI, and SNOW provides data for management decisions for these populations as well. The data is currently used to analyze site suitability and winter carrying capacity for reintroductions of species such as wild turkey and elk.

The two major costs associated with SNOW are transportation to and from the snow courses, and the cost of labour required to take measurements. These costs may be reduced by contracting the measurements at remote courses. Using an estimate of 40 cents per kilometre and the distance to each course (Table 1), the total transportation cost per winter is $22, 368. This amount is based on an average winter length of 24 weeks and could vary depending on the duration of the winter and the subsequent number of weekly measurements taken.

The average time needed to drive to a course and take measurements is two hours per course per week. Most courses are measured by OMNR staff, but in some cases, contracts are given to private citizens if this is more cost effective. Current contracts appear to be more supplemented volunteer arrangements than business enterprises.

The seven courses currently utilizing contracts average $280 per year with a total yearly cost of $2,100.

Contract costs would be expected to be higher if they were based on fair market labour values. At a conservative $10 per hour, the 9 current volunteers would be paid about $480 per year for a total yearly cost of $4,320 per year.

Other costs involve equipment and are minimal, amounting to less than $50 per course per five year period, assuming all equipment needs to be replaced once every five years. The cost of SNOW information is exceedingly small (three tenths of one percent of deer licence revenues alone) compared to the financial benefits gained through effective wildlife management aided by winter severity data.

Principles

A large volume of data pertaining to provincial winter conditions is currently gathered by other meteorological stations. However, these weather stations do not gather the type of data needed by wildlife biologists.

The Aviation, Flood and Fire Management Branch of the OMNR take readings of snow depth and density, but measure bi-weekly rather than weekly, and take only one reading, rather than an average of ten readings. The measurement sites are located in open areas such as fields or airports which may exhibit winter severity conditions very unlike those found in deer yards or other wooded habitat.

Ontario Hydro also conducts snow surveys, recording depth and water content of snow, as well as percent of normal water content. Again, the measurement sites are often located close to roads and along riverbeds, resulting in values different from those found in deer yards or other wooded habitat.

Environment Canada atmospheric stations record snow depths and maximum and minimum temperatures at stations across the province daily, but do not record crust conditions. Unfortunately, the measuring stations are located in open areas which exhibit winter conditions quite different from those found in deer yards, and the geographic distribution of these stations does not account for some of the important variation in winter conditions found in Ontario's primary deer range.

The following principles are important for an effective and efficient winter severity monitoring plan to provide information for wildlife management:

1) A basic snow course includes only snow depth and crust measurements. Chillometer and Snow Penetration Gauge data may be collected to enhance local interpretation of winter severity.

2) Winter severity measurements must be taken consistently according to the standards and guidelines outlined in "The Snow Network For Ontario Wildlife: The Why, When, What, and How of Winter Severity Assessment in Ontario" (OMNR 1997b).

3) Most wildlife data are gathered on a Wildlife Management Unit (WMU) basis. The province must maintain a SNOW network which will provide a reliable estimate of winter severity for each WMU.

4) Districts will be expected to operate their share of the network. The number of snow courses will depend on the variation and severity of snow conditions across the province. Districts may run additional courses at their expense. Data collection will be managed by district and area offices.

5) In the event that a snow course location is destroyed or must be discontinued, a new course in the same vicinity will replace it. For data continuity and collection purposes this new course will be considered the same as the old.

6) SNOW data should be recorded using the SNOW data management software. Snow data should be automatically included in those programs where it is required (i.e. WMU reports). This will guarantee

uniform measurements, make historical and current winter severity data analysis possible, and make the transfer of data to the central archive much easier (OMNR 1995). It will also simplify the work for SNOW users and help maintain an interest in accurate data.

7) SNOW data should be archived or sent to the central archive as quickly as possible to protect data and ensure its maximum use for all purposes.

8) Central funding should be available to ensure that the network is maintained. Because the system is based on the minimum number of courses, loss of any part of the system will result in unacceptable gaps in information.

Data Requirements and Perceived Needs

The snow network must provide snow depth, crust, and winter duration as minimum requirements for effective wildlife management decisions:

1. **Snow depth:** Staff take ten snow depths to provide average weekly readings. The cumulative total of weekly values provides a winter severity index called the Snow Depth Index (SDI).

2. **Crust type:** Staff uses one of three values to indicate crust strength each week.

3. **Winter duration:** Weekly reports, beginning when the first snow occurs and ending when no snow remains, automatically indicate the onset of winter and duration of winter conditions.

In the past, many districts have measured winter severity using the Passmore Snow Severity Index (PSSI) or the Ontario Winter Severity Index (OWSI). Both Snow Penetration Gauges (SPG's) and chillometers are necessary to calculate these indices. SDI requires only snow depth data. Recently, strong correlations between SDI and OWSI and PSSI have been demonstrated. For this reason, and because of the difficulty in maintaining chillometers, replacement and repair of SPG's and chillometers will not be funded. Districts may, at their own expense, collect snow penetration and winter chill data if they feel it helps local interpretation of winter severity.

A survey of all of the individuals responsible for each snow course was performed in October 1996 and March 1997 to assess the current needs of snow courses and wildlife managers in terms of funding for travel and measuring contracts. Table 1 represents the minimum number of courses required to provide adequate provincial winter severity information, and related costs for 1997.

Priority Setting

Because the system of snow courses evolved without a holistic overview, questions were raised about the potential for duplication of information. Reviews were conducted provincially in 1982, and for the central region again in 1988. Many courses were closed, some were moved and the resulting network was thought to be representative of the province's winter conditions, without unnecessary repetition. Since that time, however, there have been further reductions in the number of courses due to insufficient man-power and/or funding.

Some districts and areas with unique environmental conditions have been left without representative snow courses. There should be enough courses to accurately assess the winter severity of each WMU. In some districts this will mean one or two courses, but more will be required in districts where there is great annual or geographic variation in winter conditions. If districts run additional courses, data from these courses will be included in the provincial archive and SNOW data management program.

Courses which have failing or missing equipment should be upgraded to allow for uniform and accurate measurements. Metre sticks and snow stakes can be purchased and replaced. Snow Penetration Gauges and chillometers will not be replaced, and their use is considered optional.

Courses within the core deer range (ie, south-central Ontario) should be given the highest priority. Courses outside of the deer range, which do not supply data critical to wildlife management programs should be given the lowest priority. Should funding be reduced, it is recommended that the value of courses outside of the deer range be critically tested for usefulness and that these be considered for closure before others.

Logistic Considerations

Some courses require extremely long round trips in order to take measurements. Several courses in the northern districts require round trips of over 200km with the Armstrong course in Thunder Bay district having the longest round trip of 600km. It may not be cost-effective to have OMNR staff visit these stations and the safety of winter highways may affect weekly visits. Measurements are not difficult and do not require special training to perform. It may be more reasonable to contract reliable people living near snow courses to take measurements.

The value of SNOW information for other wildlife seems intuitive, but this has not yet been fully demonstrated and applied to operational programs.

As stated earlier there are several other sources of winter severity data. Current opinion suggests that these sources do not provide adequate information to assess the impact of winter severity on wildlife . With the proper distribution of snow courses, standard collection procedures, and new statistical approaches such as digital elevation modeling (McKenney, pers.com.), it might be possible to convert other sources into useful winter severity information. Research would be needed to make correlations between AES data (such as snow depth) and SNOW data and models such as ODM would have to be modified. The cost of acquiring provincial AES data would be approximately $450 dollars per year.

Proposed Courses

Table 1 presents a proposed system of 56 courses which will meet the following requirements:

1) The network provides a sufficient number of courses to obtain reliable information for sound management decisions in each WMU, recognizing the variability in winter conditions found across the province. Table 2 provides a representative course or combination of courses for each WMU.

2) Each course will generate information that is needed and used for wildlife or habitat management, fire and flood analysis, or public information.

3) Each course will provide unique data which is not duplicated by nearby courses.

4) The network will provide information for the entire province south of latitude 51°15′.

5) Courses are selected for a relatively even geographic distribution.

6) There are a greater number of courses in areas with a greater variation in winter conditions (coincidentally, this is also the heart of deer range).

7) Courses which appear redundant or unused are recommended for closure.

This network of courses was selected primarily for its ability to adequately represent the climatic variation in each of Ontario's WMU's. To do this, course and WMU locations were plotted against several provincial maps of snow depth variation (Mackey et.al. 1996, McKenney pers.com.).

This network is cost efficient, streamlines data collection, avoids redundancy, and supplies all of the data needed for management decisions across the province which require knowledge of winter severity. These are the courses which will be supported by central funding. Data collected from additional courses run by the districts will still be included, archived, and analyzed using the SNOW data management program for the convenience of district staff and other potential values it may hold.

Funding

Travel costs and staff time are the largest expenditure associated with SNOW. Of the 55 courses currently running, 35 have requested funding for travel or contract expenses. Measurements are taken once a week for an average of 24 weeks and a maximum of 32 weeks. Round-trip distances for the proposed network of 56 courses range from 0 to 600km. Courses which have round-trips longer than 100km will only be funded for a maximum of 100km and are encouraged to contract personnel who live near the courses to take measurements as this is much more cost-efficient and reduces safety hazzards associated with winter driving. Table one summarizes the costs associated with each course. The total estimated costs for each course are calculated as follows:

Total = (round trip distance x $0.40) x 24 weeks + contract amount

Driving, contract, and upkeep costs total about $17,000 per year, and measurements require approximately 2352 hrs of labour per year. SNOW is a low-cost item with the potential for a very great return on investment when SNOW data contributes to effective wildlife management.

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TABLE 1

SNOW STATION COSTS: Proposed snow courses network with an estimate of annual operating costs for 1998 based on either mileage or contract.

Region	District	Course	Course Code	Round Trip (km)	Contract Costs ($)	Estimated Cost (24 wk)
NORTHWEST	Red Lake	Red Lake	RL	0		10
	Sioux Lookout	Pickle Lake	PK	0		10
	Kenora	Kenora	KR	10		106
		Minaki	MK	60	600	610
		Sioux Narrows	SN	0	600	610
	Dryden	Ignace	IG	20		202
		Dryden	DY	41		404
	Fort Frances	Arbour Vitae	AV	160	425	435
		Rice Bay	RB	30		298
		Atikokan	AT	0		10
	Nipigon	Geraldton	GR	50		490
	Thunder Bay	Upsala	UP	200	1000	1010
		Whitefish	WF	150	1000	1010
		Thunder Bay	TB	50		490
		Armstrong	AM	600	1000	1010
NORTHEAST	Wawa	Red Rock (Wawa)	RW	0		10
		Manitouwadge	MA	0		10
	Hearst	Kapuskasing	KP	17		173
	Moosonee	Moosonee	MO	0		10
	Cochrane	Cochrane	CO	30		298
	Timmins	Timmins	TI	0		10
		Gogama	GO	0		10
	Chapleau	Chapleau	CH	40		394
CENTRAL	Sault Ste. Marie	Poplar Dale	PD	0		10
		Batchawana Bay	BT	5		58
		St. Joseph's Island	SJ	0	450	460
		Red Rock (Gladstone)	GS	0	450	460
		Kirkwood	KW	0	450	460
	Sudbury	Sandfield	SA	0	250	260
		Killarney	KY	200	300	310
		Walkhouse	WK	0	250	260
	Temagami	Temagami	TM	0		10
		Haileybury	HB	0		10
	North Bay	Loring	LO	220	300	310
		Mattawa	MT	0	600	610
		Balsam Creek	BC	40	600	610
	Parry Sound	Parry Sound	PS	0		10
		Grundy Park	GP	150	1000	10
		Oranmore	OM	80		778
		Bracebridge	BB	0		10
	Algonquin Park	Finlayson	FI	0		10
		Sproule	SP	0		10
	Pembroke	Fraser	FR	80		778
	Bancroft	Bancroft	BA	20		202
		Apsley	AY	80		778
		Bon Echo	BE	200	300	310
		Minden2	HI	50		490
Southern	Kemptville	Charleston Lake	CK	0	250	260
		Mississippi	MP	30	250	260
		LaRose	LR	0		10
	Tweed	Sandbanks	SX	0		10
		Tweed	TW	0		10
	Maple	Nonquon	NQ	0		10
	Midhurst	Copeland	CP	0		10
		Cyprus Lake	CY	0		10
		Grey County	GC	50		490
		Beausoleil Island	BO	0		10
						16914

TABLE 2

Representative course or formula for accurate winter severity information for each Wildlife Management Unit (WMU) in Ontario.

WMU	Representative Course or Formula
1	MO
2	(2RL+AM)/3
3	(AM+RL)/2
4	(2AM+RL)/3
5	(3SL+DY)/4
6	(MK+DY)/2
7A	SN
7B	KR
8	DY
9A	(DY+RB)/2
9B	RB
10	AV
11A	AT
11B	AT
12A	(IG+UP)/2
12B	UP
13	(WF+TB)/2
14	UP
15A	IG
15B	(IG+AM+UP)/3
16A	PK
16B	(2AM+PK)/3
16C	(2PK+AM)/3
17	MO
18A	PK
18B	(MO+PK)/2
19	(2PK+AM)/3
20	(IG+AM)/2
21A	(2MA+GR)/3
21B	(2GR+MA)/3
22	(GR+KP)/2
23	(GR+KP)/2
24	(KP+MO)/2
25	MO
26	MO
27	(2CO+MO)/3
28	(2GO+HB)/3
29	(GO+TI)/2
30	(TI+CO)/2
31	(GO+CH)/2
32	CH
33	(CH+RW)/2
34	RW
35	(CH+BT)/2
36	(SJ+KW)/2
37	(2GS+SJ)/3
38	(TM+GO)/2
39	(KY+GO)/2
40	(TM+GO)/2
41	(3BC+TM)/4
42	KY
43A	WK
43B	SA
44	WK

WMU	Representative Course or Formula
45	(SJ+PD)/2
46	(PS+GP)/2
47	LO
48	(MT+FR)/2
49	(PS+OM)/2
50	(3OM+FI)/4
51	(2FI+FR)/3
53	BB
54	(3FI+BB)/4
55A	(SP+3FR)/4
55B	FR
56	(3HI+BA)/4
57	(BA+SP)/2
58	(FR+BA)/2
59	(FR+BE)/2
60	AY
61	AY
62	(2TW+BE)/3
63	(3BE+LR)/4
64	(3MP+LR)/4
65	(2MP+BA)/3
66	TW
67	(2TW+CK)/3
68	(2CK+TW)/3
69A	SX
69B	CK
70	SX
71	(SX+TW)/2
72A	TW
72B	TW
73	(NQ+TW)/2
74	(NQ+TW)/2
75	AY
76	BO
77	(2CP+BO)/3
78	CP
79	CP
80	GC
81	GC
82	(2GC+BB)/3
83	CY
84	CP
85	CP
86	(GC+CP)/2
87	(GC+CP)/2
88	CP
89	(CP+SX)/2
90	(CP+SX)/2
91	CP
92	SX
93	SX
94	SX
95	SX

PART II

Guideline for Operating Courses in the Provincial Snow Network

Abstract

A network of snow courses has been providing provincial winter severity data since 1952. The Snow Network for Ontario Wildlife (SNOW) is linked province-wide through computer networking and the information it generates is accessible to managers and biologists making wildlife management decisions.

Up to three types of measurements are taken at each snow course. 1) Winter chill is measured with a chillometer and assesses the effects of wind and temperature in terms of metabolic costs. 2) Snow penetration gauges are used to measure sinking depth or the depth to which deer will sink in accumulated snow. 3) Snow depth and crust conditions are recorded at all stations.

The Passmore Snow Severity Index (PSSI) and Ontario Winter Severity Index (OWSI) have been used to assess winter severity. However, because of a strong correlation between these indices, and the simplicity of SDI (both in data requirements and calculation) the OMNR now uses SDI as the standard winter severity index.

Winter severity can affect deer and other wildlife populations in several ways. Deep snow and severe crust conditions may restrict animal movement and forage availability , resulting in a reduced carrying capacity of deer yards and increased winter mortality due to starvation. Severe conditions may also result in increased fawn mortality in the spring.

Winter conditions may necessitate emergency feeding of managed deer populations as well as influence optimal population levels and harvesting rates. Wildlife mangers must take these effects into account when making management decisions.

Snow courses are set up according to a set of standard guidelines, and collected data is managed, archived, and accessed for analysis using the SNOW software and the OMNR computer network.

In this document, most of the information will be related to deer. However, some of the theories, indices, data, and methods can be related to other wildlife species. The Snow Network For Ontario Wildlife has been applied primarily in deer management, but in areas where moose are the primary ungulates, it is also useful. Data from the Snow Network has been used for other purposes, such as selecting suitable areas for reintroductions of elk and wild turkey. Therefore, while the term "deer" is most often used in this document, it can often be interchanged with or other wildlife species.

Introduction

In 1952, a network of snow courses was set up throughout Ontario to measure winter climatic conditions. Since then, the number, location, and sophistication of these courses has changed, but the network has continued to provide valuable data on snow and winter conditions. There are more than fifty snow courses currently operating across Ontario. Each district maintains the records of its snow courses and contributes copies to a central archive. This archive has yielded a tremendous database which can now be accessed through computer networking.

The Snow Network for Ontario Wildlife (SNOW) has been recently linked across the province using the computerized SNOW data management program and the OMNR computer network. Managers can now send data directly to the central archive in digital form and can access the historical database to aid in wildlife management decisions.

Today, the SNOW is used by managers and biologists making wildlife management decisions, fire and flood managers to anticipate severe winter conditions, and to inform the general public of snow and winter conditions. Managers of deer populations use the data generated by the SNOW for decisions on harvest restrictions, implementation of emergency feeding, and in the Ontario Deer Model (ODM).

SNOW information can be applicable to the management of deer, moose, and other game species, such as wild turkey.

In addition to its applications in deer management, for which it was primarily designed, SNOW has great potential to be used for many other wildlife species. Moose and elk can be affected by severe snow conditions, the absence of snow may have a negative impact on small mammal surveys, and snow crust conditions may affect the movements and foraging of grouse and wild turkey.

Measurements

Each district maintains one or more snow courses depending on the variation of winter conditions across the district. Each of these courses consists of one or both of the following:

1) 10 stations where snow depth and sinking depth are measured.
2) A chillometer site where temperature and wind effects are measured.

Up to seven types of measurements and observations can be recorded at each course:

1) Snow Crust (given a code of A, B, or C)
2) Snow depth reading (cm)
3) Snow compaction, or Snow Penetration Gauge (SPG) reading (cm)
4) Chillometer reading (kwh)
5) Observations of deer mobility
6) Observations of deer mortality
7) Comments on weather events and conditions

■ Winter Chill

Temperature and wind combine to produce atmospheric chill, and during the winter this chill can increase the number of calories needed by deer to maintain a constant internal body temperature. The greater the chill factor, the faster a deer loses heat and the more calories it requires to stay warm. To measure this effect on deer, Louis Verme developed a catatherm, or chillometer, in Michigan in 1968, and although its original design has been modified, the principle remains the same. The chillometers used bythe OMNR are modified pressure cookers containing distilled water which is kept at a constant temperature of 4°C using an electrical element. The weekly amount of electricity used by the element is recorded by a hydro meter. The chillometer simulates a deer maintaining a constant body temperature, and the amount of electricity used represents the energy required to do so. This measurement can give managers and biologists an idea of the relative metabolic energy costs of deer during severe winter conditions. An increase in this cost can, in turn, be translated into an increased demand on available food resources in the winter yard.

The weekly chillometer value (kilowatt hours used for the week) is combined with snow depth and snow compaction measurements to calculate an Ontario Winter Severity Index (OWSI) value.

■ Snow Penetration

One of the strategies used by deer to conserve energy during the winter is the use of established trails to move around during periods of deep snow. A deer struggling through deep snow uses much more energy than when walking uninhibited. For this reason, deer are reluctant to

A chillometer meaures the combined effect of temperature and wind stray from established trails, especially when they sink more than 50 cm in the deep surrounding snow. Unfortunately, once restricted to trails, their food supply becomes limited to those trees and plants accessible from the trails. This can drastically reduce the carrying capacity of a deer yard and result in malnutrition or mortality.

Because snow depth does not always equal sinking depth due to varying snow density and crust, a device, the Snow Penetration Gauge (SPG), was developed to measure sinking depths. The SPG consists of an aluminum plunger supported by a coiled spring mounted inside a copper tube. When placed on the snow surface, the plunger and spring simulate the pressure that an average deer hoof exerts (28 pounds per square inch), and the distance the plunger sinks into the snow is the sinking depth for an average deer. The restrictions on deer movement and foraging capabilities can be estimated and predicted using this measurement. It is also combined with chillometer and snow depth readings to produce an OWSI value.

A Snow Penetration Gauge measures sinking depth

Snow Depth and Crust

Snow depth and crust conditions have a great influence on the availability of food resources for deer. Deep snow and moderate crusts can restrict deer movement to over-browsed areas, and reduce the effectiveness of ground foraging by covering food. Conversely, a lack of snow, or strong crusts which can support deer, can increase the availability of food resources by allowing deer to ground forage, move about freely, or even stand on top of the snow to reach previously unattainable browse. These measurements can be combined to produce a Passmore Snow Severity Index (PSSI) value. Snow depth is also combined with chillometer and SPG readings to produce an OWSI value. Each week, the snow depth measurement is added to a cumulative total to produce an alternative severity index called the Snow Depth Index (SDI).

Winter Severity Indices

Passmore Snow Severity Index (PSSI)

The Passmore Snow Severity Index (PSSI) assigns a weekly rating from the following chart based on that week's snow and crust conditions.

	Snow Depth (cm)				
Crust Type	<38.1	38.1 - 50.7	50.8 - 63.4	63.5 - 76.1	>76.1
A	0	0	1	2	3
B or C	0	1	2	3	3

The cumulative total of these weekly ratings gives an indication of the severity of the winter to date, with the following classifications of winter severity for PSSI values at the end of winter:

<10	mild
10-19	moderate
20-29	severe
>29	extreme

Although simple and easy to calculate, this index does not always give a true indication of the effect that winter conditions are having on deer. PSSI not only gives the same value to many different snow conditions, but also assumes that all crusts are a detriment to foraging deer. However, a strong crust can support deer, and increase the availability of food by allowing them to reach previously unattainable browse.

Ontario Winter Severity Index (OWSI)

A weekly OWSI value incorporates three of the measurements taken on Ontario snow courses, and is calculated as follows:

$$OWSI = \frac{A}{30} + \frac{B}{30} + C$$

where A = average SPG reading (cm)
B = average snow depth reading (cm)
C = chillometer reading (kwh)

A cumulative total of these values gives an indication of the severity of the total winter (based on an average winter yarding session of 16-20 weeks). Cumulative OWSI value can be interpreted as follows at the end of the winter:

<100	mild
101-125	moderate
>125	severe

This index was developed for conditions in Michigan and Minnesota, but is used extensively throughout Ontario. Unfortunately, although it is an accurate indicator of winter severity, it requires that all three types of measurements be taken at a snow course. In many cases this is not possible, due to lack or failure of equipment.

■ Snow Depth Index (SDI)

The SDI value for a snow course is the cumulative total of the weekly average snow depth readings. This simple measurement gives a basic indication of the ability of deer to obtain food resources. Winter-end values can be interpreted as follows:

<590	mild
591-760	moderate
>760	severe

Present winter and historical SDI patterns can be used to assess current winter severity and predict severe conditions for the end of the winter.

Using the following type of graph, wildlife managers can determine where current conditions stand in relation to a worst and best historical winter, and a calculated average winter. A similar graph has been prepared for each snow course and is available for use through the SNOW data management program.

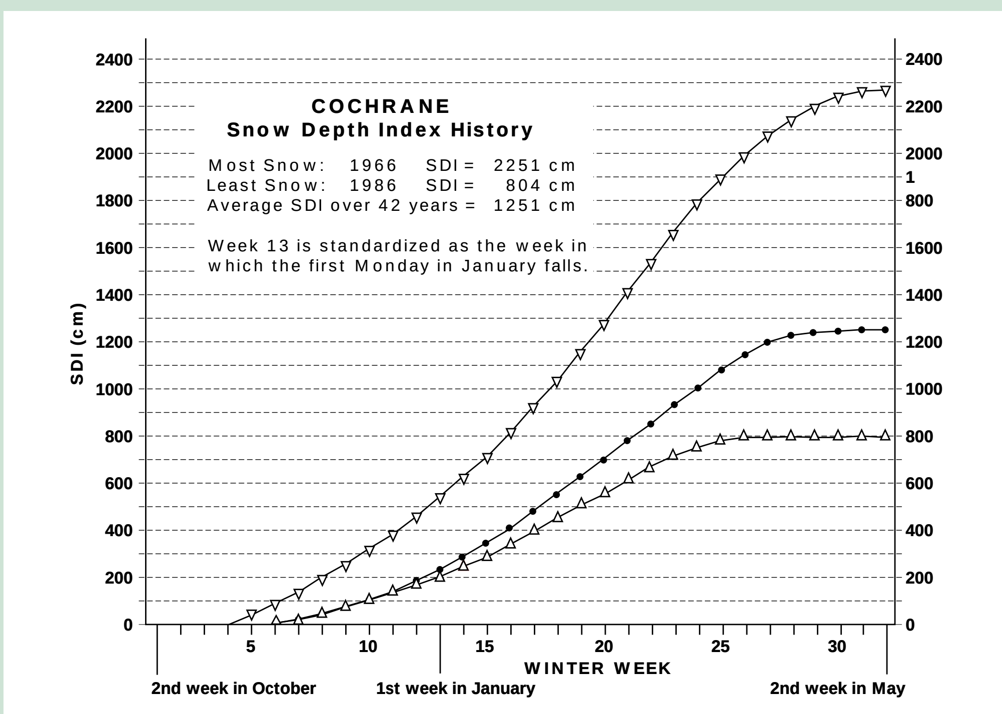
In addition, using the predictive model, managers can anticipate late winter conditions based on conditions earlier in the same winter.

Predicting Severe End to Winter

Percent chance of severe conditions by late March

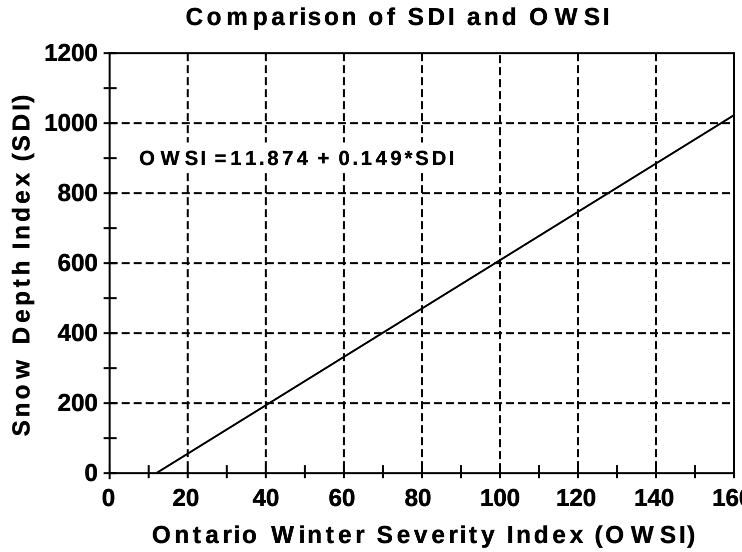
Early Winter Conditions		Period		
SDI	OWSI	Time 1	Time 2	Time 3
<300	<56	<30	<25	<10
301-350	57-64	<60	<50	<25
351-400	65-71	65	60	50
401-450	72-79	75	75	70
>450	>100	>80	>80	>80

Time 1 - last week of January
Time 2 - first week of February
Time 3 - second week of February



▪ Severity Index Correlations

Recent analysis of winter severity indices has shown a reliable correlation between SDI, OWSI, and PSSI. Because of this inter-relationship, SDI values, coupled with data on winter duration and pattern, provide a good basis for wildlife management decisions.



Deer Ecology and Winter Severity

In Ontario, winter environmental conditions have a significant influence on the survival of many wildlife species, including deer and moose. Temperature and wind chill affects an animal's ability to maintain a constant body temperature, while snow depth and crust conditions affect its mobility and ability to forage effectively. These elements, in concert with an early winter onset, or long duration, can deplete an animal's food supply and fat reserves, resulting in poor physical condition, starvation and offspring mortality. Managers of deer, moose and other wildlife populations must take the effects of winter conditions into account when making decisions about habitat management, reintroductions, and emergency feeding or trail-breaking plans, as well as harvest regulations.

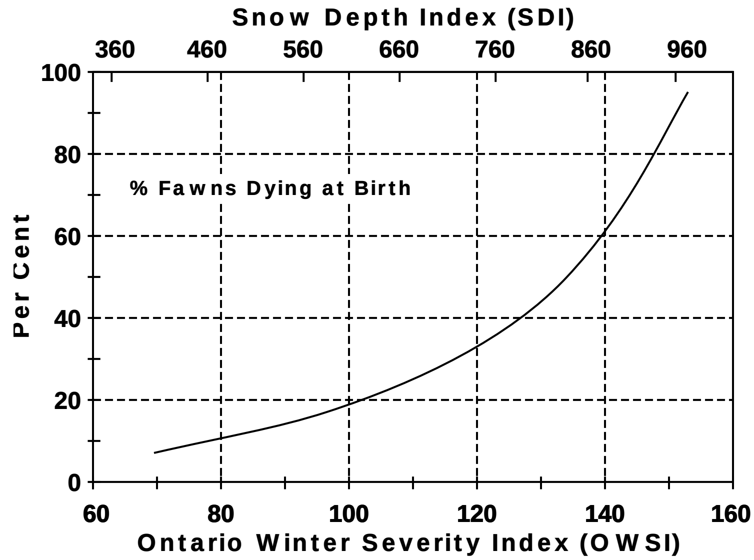
▪ Winter Mortality and Forage Availability

Winter mortality can be a very important component of managed wildlife populations as it is additive to hunting mortality rates. While moose may be negatively impacted by a harsh winter, deer can be even more susceptible to severe conditions because of their yarding behaviour. Confined to winter concentration areas or yards all winter, deer must depend on the food available within these areas. They are unable to move to new areas if the food resources dwindle.

Winter mortality rates are closely related to the physical condition of yarding deer, which in turn is related to the abundance of food or carrying capacity ("K") of the winter yard. Winter conditions can affect the carrying capacity of deer yards and the health and size of deer herds both functionally and absolutely. A severe winter can reduce population through direct adult mortality, fawn abortion, and post-natal fawn mortality. Conversely, a mild winter may result in a significant increase in population size through increased survivorship and recruitment. The carrying capacity can be drastically reduced in the event of severe winter conditions. Deep snow can cover ground and understory forage and restrict deer to trails, and cold temperatures and wind can increase energy (and therefore food) requirements to maintain body temperature. The amount of food available may be inadequate if there is an early start to winter and/or a late spring. If snow conditions force deer to spend an additional 30 days in the winter yard (yarding periods average 16 weeks, or 110 days) the carrying capacity of the yard can be reduced by 20%. An additional 50 days can result in a decrease in carrying capacity of 35%.

Deer conserve energy by yarding in the winter

An early winter can also force deer to yard before they have reached optimal fat reserve levels, in which case they may exhaust energy supplies toward the end of winter at time when the yard's food resources are normally depleted. Indeed, mortality rate estimates based on weight losses show a rapid increase at the end of winter; even a small delay in spring can result in increased mortality due to malnutrition. Managers should closely monitor both herd size, and winter conditions, especially during the critical period just before spring, to anticipate winter mortality and fawn loss or initiate emergency procedures.



■ Fawn Mortality

Reproduction is an expensive energy cost in addition to everyday survival. Severe winter conditions can result in an energy deficiency during the crucial period just before spring when a pregnant female's energy demands are greatest. This deficit can cause deer to become stressed and malnourished, and females may occasionally abort unborn fawns. More frequently, the poor physical condition of females by spring may result in low fawn birth weights and a high rate of post-natal mortality. Even in an average winter, there is about a 20% fawn mortality rate. After severe winters, fawn mortality can rise to over 75%. Managers should consider that fawn crop loss can be an even greater effect of severe winter conditions than direct adult mortality due to malnutrition. Both SDI and OWSI can be used to predict post-natal fawn losses. The following graph and table provide predictions:

Prediction of Fawn Loss at Birth

Winter Category	Winter Severity		Fawn Loss at Birth
	SDI	**OWSI**	
Mild	<590	<100	0-20%
Moderate	591-760	101-125	20-40%
Severe	>760	>125	>40%

Management Decisions

■ Emergency Feeding

The winter diet of deer, consisting primarily of deciduous buds and twigs, arboreal lichen, and conifer needles, is far less nutritious and harder to digest than the summer diet. In fact, a winter diet does not contain enough protein and energy to prevent weight loss during the winter. Severe winter conditions can restrict access and increase the need for this already meager resource. By using the model, managers can predict severe conditions and plan the implementation of emergency procedures before the health of the herd becomes critical. Because deer are reluctant to use the energy needed to break new trails through deep snow, creating a network of trails is often enough to prevent malnutrition and starvation. Trails can be created with snowmobiles, bulldozers, or skidders to increase access to unused food sources. In some cases, winter conditions may cause the depletion of the yard's food resources to the point where emergency feeding is needed. Food may be brought to the yard, or unreachable browse may be cut down. Before deciding to feed deer, managers may want to consider other factors, such as when the deer started to yard, and the subsequent predicted duration of the yarding period.

Complete details on winter feeding of deer can be found in the OMNR fact sheet "Guidelines for Winter Feeding of Deer in Ontario".

■ Population and Harvest Management

Managers of deer herds may be presented with many issues or problems which require regulation of the deer population. Optimal harvesting rates vary from year to year and must be calculated from several factors including the impact of weather conditions. Effective management of deer populations involves an understanding and monitoring of reproductive and mortality rates, which can be greatly affected by winter severity. Severe winters can result in additive mortality. An increase in winter or fawn mortality due to severe conditions may require a reduction in the percentage of the herd that should be harvested the following fall, and perhaps for several years.

Emergency feeding can reduce winter mortality

Target populations for deer are calculated based on the quantity and quality of habitat in both the summer and winter ranges. It is important to consider that while the deer population may be at a low percentage of the carrying capacity of the summer range, it may reach or exceed the carrying capacity of the winter range. This percentage will further increase in the event of severe winter conditions which reduce the availability of food, and increased winter and fawn mortality may follow. Populations that are allowed to consistently exceed the carrying capacity of the winter yard may reduce the long-term forage production and habitat quality of the winter range, thereby reducing the number of deer it will support.

The Ontario Deer Model (ODM) is a tool used by deer managers to calculate recruitment potential, harvest and tag allocations, etc. by simulating the growth of deer populations. The model incorporates seasonal environmental changes and requires winter severity data to run a simulation. The network of snow courses should allow effective prediction of winter severity and provide reliable data for ODM simulations in all areas where deer management occurs.

Managers of other wildlife populations can also use the SNOW to evaluate reintroduction situations. Historical winter severity data can play a role in selecting suitable locations for reintroductions. SNOW data should also be considered when calculating the winter carrying capacity of the new location and the subsequent size of the relocated population.

Running a Snow Course

The following information is only a basic guide to setting up and running a snow course. For more detailed information on such topics as calibrating chillometers, equipment blueprints, etc., see the Standards and Guidelines for Measurement of Snow and Winter Severity in Ontario. Because of the good correlation between SDI and OWSI and the difficulty of maintaining a chillometer, the operation of SPG's and chillometers is considered optional. A standard snow course will record only snow depth and crust, but chillometers and SPG's may still be used to enhance local interpretation of winter conditions.

Course Setup and Maintenance

In order to maintain data uniformity, snow courses must be set up and maintained according to a standard layout. Snow conditions are strongly influenced by exposure to wind, slope and aspect of terrain, and the surrounding forest type. Therefore, all snow courses should meet the following conditions:

Forest Cover: Location should be in a pure hardwood stand, of moderate to full stocking, with an average tree height of 6m or more. In northern regions where pure hardwood stands do not exist, the location should be in a mixed stand with minimal conifer content.

Terrain: Ground should be as level as possible with little or no overall gradient. Minor topographical undulations are acceptable. Areas of abnormally deep snow accumulations such as alder or willow swales and waist-high conifer regeneration must be avoided.

A typical snow course

Stakes: Stakes are driven into the ground to anchor the metre stick rulers, or facers. Wooden stakes are inexpensive, but must be replaced every 2-3 years, while metal stakes can last indefinitely. Stakes should be numbered 1-10 and should extend at least 50cm above the attached metre stick in areas of high snow levels. Each stake should be driven into a level area free of obstacles that could influence snow accumulation. Stakes should be placed at least 2m away from rocks, logs, or depres-sions and 10m away from conifers which may trap falling snow.

A snow stake for measuring snow depth

Metre Sticks (facers): Plastic or aluminum metre sticks marked at at least 2cm intervals should be anchored to the snow stakes and used for measurements. Two metre sticks can be mounted end to end in areas of high snow levels.

Course Configuration: Stakes are set along a 180m transect at 20m intervals. The transect can be in any reasonable configuration as long as the minimum spacing is maintained and it does not pass within 40m of any clearing, lake, road, or other opening which could cause snow drifting.

Warning Signs: Plastic coated signs advise people of the snow course and help avoid disturbances. Place the signs in prominent locations if appropriate.

Course Maintenance: After leaf fall (mid-October) the following tasks should be undertaken:

1) clear obstructions such as logs, branches, and woody vegetation from within 2m of the stakes.
2) straighten and replace broken stakes and make sure metre sticks are flush with the ground.
3) remove young conifers, large logs, and excessive brush within 10m of the stakes.

■ When, What, and How to Measure

Measurements should be taken starting with the first accumulation of snow or on the first Monday of November if a snowfall has not occurred. Weekly measurements must continue until the following spring when no snow remains on the ground. If a week is missed (eg at Christmas or holidays), a record of estimated values must be entered for that week. If there are missing records, the calculation of cumulative winter severity indices becomes impossible. There must be continuous weekly measurements between the first readings and the last, even if they are estimated. Readings from nearby courses can aid in these estimations. It is important that measurements be taken once a week on the same day and at the same time (preferably Monday morning). It is recommended that information be recorded on WSI-1 report sheets in the field. WSI-1 and WSI-2 report sheets can be generated using the SNOW computer software. The measurements can then be entered using the SNOW data management program, and the information sent immediately to the central archive.

Snow Crust: A single value is used to describe the general crust conditions found along the snow course:
A = negligible or no crust, B = moderate crust,
C = crust capable of supporting a person on snowshoes.

Snow Depth: A snow depth measurement is taken at each of the 10 stakes to the nearest centimetre. If snow has built up around the stake, it should be removed to the level of the surrounding surface. If the snow has melted away from the stake, a ruler or stick can be placed across the gap to obtain a reading. The measurements from the 10 stations are averaged to give one weekly reading for the snow course. The SNOW data management program automatically calculates this value.

SPG (Pogo Stick): A measurement to the nearest centimetre should be taken in the undisturbed snow around each of the 10 stakes, at a distance of 20-30cm from the stakes or previous test holes. Place the SPG upright on the snow surface and depress the plunger until the collar barely touches the top of the copper tube. The sinking depth can be read on the outside of the copper tube. Under some conditions (eg. unfrozen leaf litter) the SPG reading may be greater than the snow depth reading, but for the purposes of calculating OWSI these should be given the snow depth value. The 10 measurements are averaged to give one weekly reading. The SNOW data management program automatically calculates this value.

Maintenance: The SPG should be kept at or below snow temperature prior to operating. Place the SPG upside-down to dry after use. Clean and lubricate the SPG at the end of the season, and store in its container.

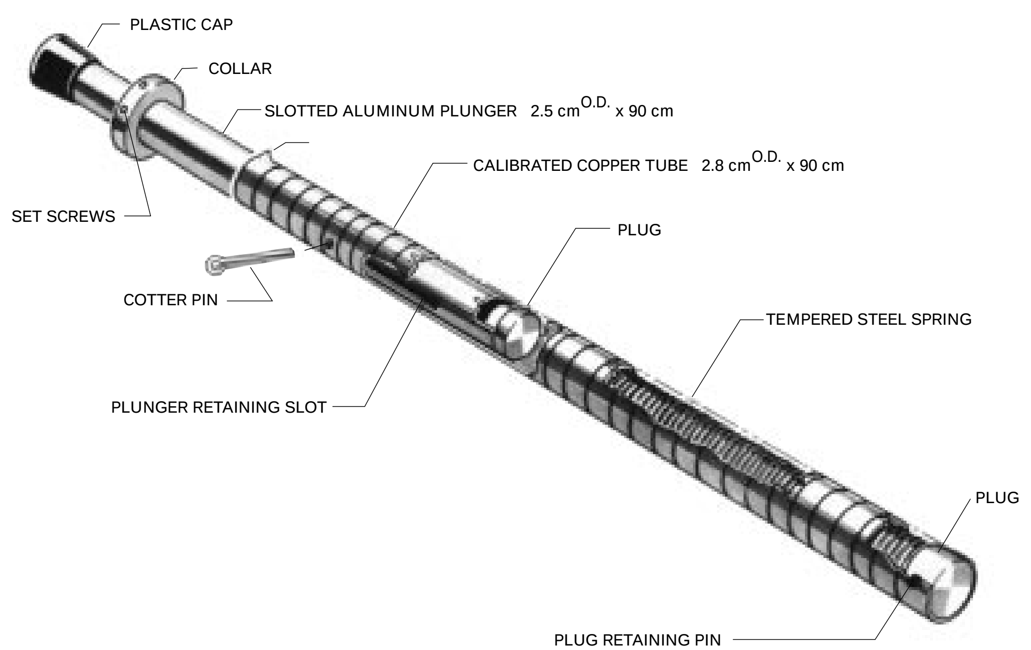
Chillometer: Chillometers should be placed in an area completely open to wind effects from all directions, at least 15m from buildings, fences, hedges, and trees. The chillometer should be plugged in and the hydro meter read on the last week in October and the first measurement or reading taken the next week. Readings should be taken at least until mid April or later if snow remains on the course. Record the number or needle position on each of the 5 hydro meter dials. The reading from the week before is subtracted from this value to give the kilowatt hours (kwh) used for the week. The SNOW data management program calculates this value automatically. Accumulated snow may act as an insulator and should be removed from around the pot.

Maintenance: The water level and temperature should be checked monthly. At the end of the season, inspect the lid seal for damage, empty and clean the pot, and remove scale from the heating element and thermostat. Store the pot inside in a dry location.

■ Data Management

To ensure data uniformity and instant access to current and historical winter severity information, the SNOW data entry and management program was developed and distributed to each snow course manager. This software ensures that all weekly data is recorded in the proper format, automatically calculates all three winter severity indices mentioned above, and produces uniform weekly Winter Severity Index (WSI-1) reports in both hard copy and electronic form. The weekly data can then be sent automatically or manually via the OMNR computer network to a central archive. The central archive contains all of the winter severity data that has been recorded since the inception of the snow network in 1952, as well as summary graphs for all historical SDI data. The SNOW data management program also enables managers to access, search, filter, and import historical data from this central archive. Trends over many years or recent developments can be compared for a single course, area, or entire region. This tool can greatly benefit managers and biologists who must make wildlife management decisions based on current or past winter conditions by providing historical background and comparison data. Current winter conditions can also be compared to those at other course locations nearby or across the province.

OMNR SNOW PENETRATION GAUGE



The Snow Network for Ontario Wildlife:

45 Years of Team Effort

The field work, experiments and research behind this document were the results of the diligent efforts of hundreds of people over 45 years. In preparing this bulletin, the primary author, Rob Warren, an independent wildlife consultant, was assisted by two people in particular. Dennis Voigt, a Research Scientist with the MNR has long guided the SNOW operations and provided his expertise and knowledge for this report. Bruce Pond, a Statistical Analyst with the MNR has also played an important role in recent SNOW developments and lent valuable advice on content and layout.

Peter Smith has dedicated an immeasurable amount of time and effort to the SNOW as a Resource Technician for the MNR, acting as the SNOW custodian for many years, maintaining the network, equipment, and data.

Peter's work followed the original development of the network and snow studies by Robin Hepburn and Dick Passmore.

Field staff have diligently collected information and maintained SNOW for over 45 years. Dan McKenney and his colleagues at the Canadian Forest Service compiled and mapped provincial snow depth data which was the key to creating WMU and SNOW station correlations. Bryan Smith of Environment Canada provided cost estimates for the use of Environmental Services winter climatic data.

Al Bisset has helped advance and develop SNOW through various means for many years, and also provided valuable editorial comment and opinion on the appropriate acronym for this project.

Kevin Firth has made an invaluable contribution, producing the SNOW data management software which will vastly improve the way historical and current SNOW data can be accessed and used.

The SNOW has included many biologists, technicians, MNR District and Regional staff, and volunteers throughout the province. We wish to thank those who collected data, maintained courses, and provided support for the SNOW over the last 45 years.

Thanks also to those who have furnished editorial comments for this report, including Bruce Ranta and Jan McDonnell.

A special thank you to Greg Belmore, Diane Somers, and the staff at the MNR Fonthill office who greatly aided the production of this bulletin.

All photos were taken by Peter Smith and Dennis Voigt.

Additional Resources

For more information or technical support, the following additional literature is provided:

Snow Network Information System (SNIS) Data Management Installation Guide and User's Notes. 1994.

Standards and Guidelines for Measurement of Snow and Winter Severity in Ontario. 1989.

Guidelines for Winter Feeding of Deer in Ontario. 1997.

Deer Conservation in Winter. 1997.

White-Tailed Deer in Ontario. Background to a Policy. 1992

Ontario Deer Model (ODM) User's Guide

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