WHITE-TAILED DEER POPULATION MANAGEMENT SYSTEM AND DATABASE

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Maine Department of Inland Fisheries & Wildlife
Wildlife Division
Wildlife Resource Assessment Section
Mammal Group

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PART I. DEER POPULATION MANAGEMENT SYSTEM

INTRODUCTION

This document describes the system being used by Maine Department of Inland Fisheries and Wildlife (MDIFW) biologists to make recommendations for white-tailed deer population management. Included are the processes to translate available data into management decisions (Part I) and an evaluation of the techniques for estimating deer population attributes used in the decision process (Part II). Supporting information is provided in various appendices. There is a separate management system that guides decisions regarding protection and enhancement of deer wintering habitat in Maine (Lavigne 1991$_a$).

Management direction for white-tailed deer in Maine is accomplished through a strategic planning process. At intervals of 10 to 15 years, population status, habitat, management, and use of the deer resource are assessed and reviewed in a public process involving representative stakeholders. Following review, stakeholders recommend specific goals and objectives for deer populations. The Commissioner and his Advisory Council provide final authorization of recommended goals and objectives after internal review. Once approved, these population goals and objectives provide direction for deer management for the next 15 years. The current deer assessment (Lavigne 1999), goals and objectives, and resulting management strategies cover 2000 to 2015. Goals and objectives were established individually for our 30 Wildlife Management Districts (WMDs; Figure 1). In 2006 the Wildlife Management Districts were changed to form 29 Wildlife Management Districts; this modification will be discussed later in this document.

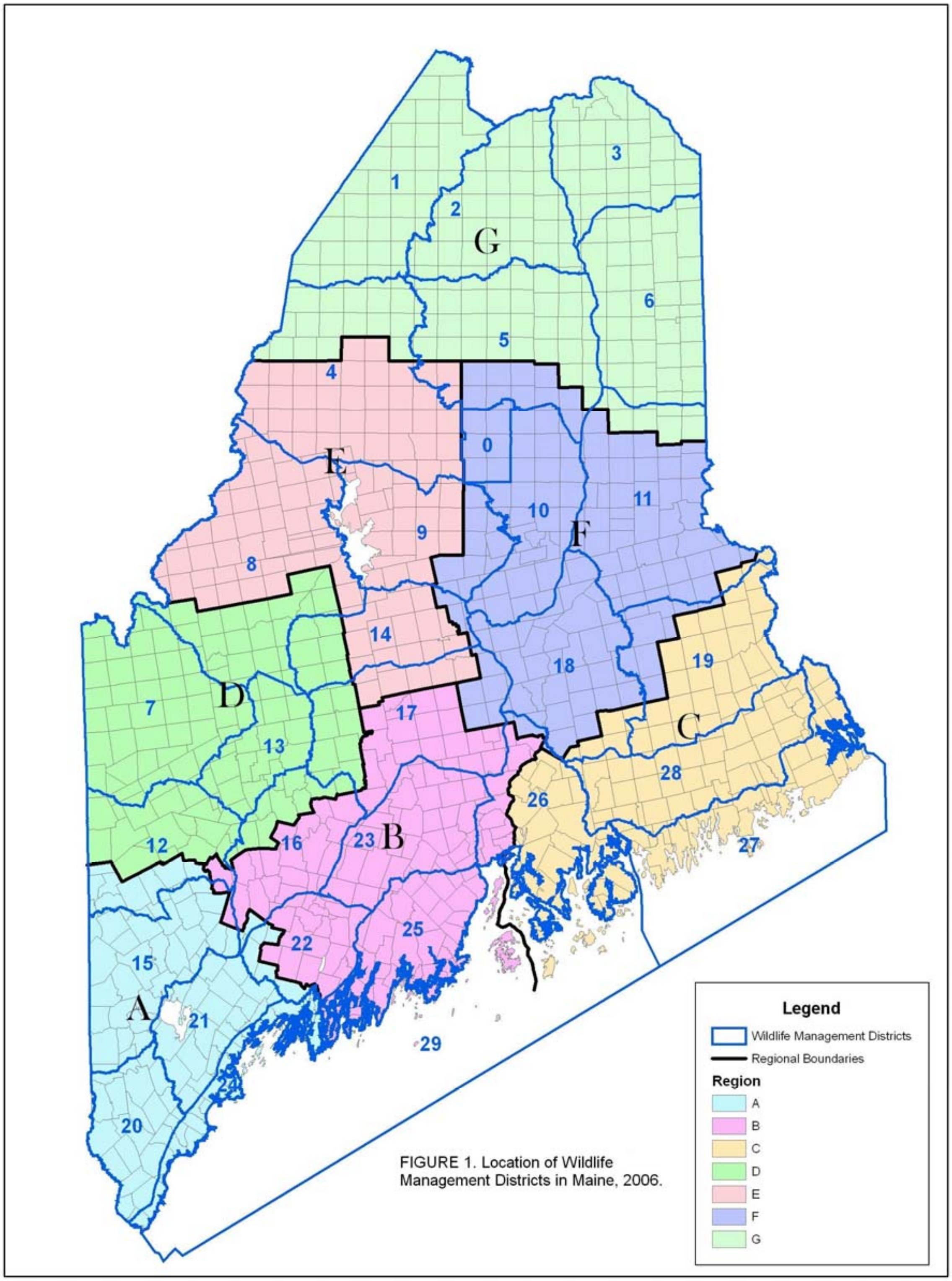


FIGURE 1. Location of Wildlife Management Districts in Maine, 2006.

Deer population management decisions relate primarily to regulating doe mortality as a means of attaining strategic planning goals and objectives. We accomplish this using recreational hunting in most areas, although other types of deer removals are employed where access or safety concerns limit the effectiveness of recreational deer hunting seasons. These non-traditional deer control methods currently include controlled hunts, depredation permits, and professional sharpshooting; they are employed sparingly and at limited land scales. Decisions concerning implementation of non-traditional techniques for deer control are guided by Department policy (MDIFW 2002; Appendix 1).

Maine offers 5 recreational hunting seasons for deer. A statewide 25-day firearms season that spans the rutting period in November draws the greatest number of participants (~170,000 hunters). A special muzzleloader season follows the firearms season; ~10,000 hunters participate in this 6 to 12-day (depending on location) season. We offer a 26-day statewide archery season during late September and October in which ~10,000 bowhunters annually pursue deer of either sex. Youths between the ages of 10 to 15 years can pursue deer of either-sex statewide during a 1-day hunt in October just prior to the firearms season; ~12,000 youths participate. The limit on deer is one per hunter in aggregate for the above hunting seasons. We established an 83-day expanded archery season that attracts ~5,000 participants in areas where residential sprawl precludes effective firearms hunting. Hunters are allowed to purchase an unlimited number of permits ($32 for bucks, $12 for antlerless deer, in 2006) to kill deer in areas open to this season.

Controlling the direction and magnitude of deer population change requires regulating doe losses. Preferably, doe losses are controlled using a method that offers flexibility to account for annual and spatial changes in deer population dynamics, including non-hunting mortality. Hunting mortality is often additive to other deer losses in Maine and hence, manipulation of the doe harvest can influence all-cause mortality rates.

We do not currently regulate the magnitude of doe harvests resulting from the expanded archery, statewide archery, or youth day deer seasons. However, we do regulate participation in antlerless deer hunting during the regular firearms and muzzleloader seasons. Give the current situation in Maine it would be highly unlikely that we would need the hunting effort of all of Maine's 170,000+ deer hunters to achieve needed harvests of antlerless deer. Consequently, we limit participation in antlerless deer hunting during the firearms and muzzleloader seasons using variable quota deer permits or "any-deer" permits. This document details how any-deer permits are calculated to regulate overall doe harvest and annual mortality in our efforts to attain Maine's deer population goals and objectives.

This is a technical report and it does not address social, political, or economic issues related to deer management in Maine. These issues were addressed earlier in the White-tailed Deer Assessment and Strategic Plan (Lavigne 1999).

REGULATORY AUTHORITY

As with all wildlife in Maine, white-tailed deer are a publicly owned resource that is held in trust for the benefit of all Maine people. The Maine Legislature has charged MDIFW with the responsibility to "preserve, protect, and enhance the inland fisheries and wildlife resources of the State; to encourage the wise use of these resources; to ensure coordinated planning for the future use and preservation of these resources, and to provide for effective management of these resources." The Wildlife Division within the Bureau of Resource Management is responsible for the Department's wildlife management programs. The Maine Legislature has defined "Wildlife Management" as "the art and science of producing wild animals and birds and/or improving wildlife conditions in the State". According to the State's definition of wildlife management, it specifically includes the regulation of hunting. Authority for regulation of deer populations is conferred to the Department by statute (State of Maine Inland Fisheries and Wildlife Laws 12 MRSA Part 10). In addition, MDIFW is authorized to promulgate rules under the Administrative Procedures Act to fine-tune regulations that may need to change annually or in various locations in Maine. Although most statutes and rules listed here apply to deer hunting, MDIFW is also empowered to address excessive predation on deer by coyotes and depredation losses to dogs through its Animal Damage Control Program and wildlife depredation statutes.

A synopsis of the various statutes and rulemaking activities that provide the context for deer harvest management in Maine is presented in Table 1. The statutes themselves

Table 1. Synopsis of statutory vs. rulemaking authority granted to MDIFW from the Maine Legislature.

STATUTORY AUTHORITY	RULEMAKING AUTHORITY
Time frame established within which all deer seasons must occur (early Sept. to mid-Dec)	
Five distinct hunting seasons are authorized, i.e. regular firearms, muzzleloader, youth day, statewide archery, and expanded archery	Season length and starting dates may be adjusted annually
Seasons may be closed on emergency basis	
State may be divided into hunting zones or management districts	Expanded archery zones and WMD boundaries may be adjusted as needed
Commissioner may regulate the sex/age composition of deer harvest during regular firearms and muzzleloader seasons. Deer of either sex legal for statewide archery	Any-deer and bonus any-deer permits are adjusted annually by WMD. Deer of either sex allowed during youth day.
Bag limit on deer fixed at one deer in aggregate for regular firearms, muzzleloader, youth day, and statewide archery seasons. Bag limit is separate and may vary for expanded archery	No bag limit on deer taken in expanded archery season. Hunters must purchase permit for each deer prior to hunt
Commissioner may initiate special hunting seasons to address deer overabundance	Details (timing, permits, bag limits, locations) established on a case by case basis
Commissioner may implement depredation hunts, sharpshooting, trap and transfer, or fertility control to address deer overabundance	Rulemaking not required
Game wardens may issue depredation permits to qualifying landowners to relieve deer damage to certain agricultural crops	
Landowners may kill deer while causing substantial damage to their property	
Hunters required to be licensed and to register harvested deer, enabling Dept. to monitor hunter participation and harvest	
Various statutes address safety, fair chase, prohibited acts	

are detailed in Appendix 1. Overall, the Department now has considerable authority and flexibility to address deer harvest management needs ranging from extreme scarcity to overabundance and at landscales varying from individual landownerships to aggregates of WMDs. The ability to regulate antlerless harvests using the any-deer permit system and the various types of controlled hunts and special seasons enhances our ability to attain deer population goals and objectives. Since most harvest authority resides within the Department, we are able to react quickly when major changes in non-harvest mortality (e.g., abnormally severe or mild winters) alter deer mortality/recruitment balances.

Despite ample regulatory authority to manage deer populations our efforts are to an increasing degree hampered by limited access for deer hunting. Land posting, municipal firearm discharge bans, and residential sprawl limit our ability to attain deer population objectives at local and more extensive landscales. This problem was identified during the assessment process; some strategies to deal with the access problem are being pursued.

MANAGEMENT GOALS AND OBJECTIVES

Deer population goals and objectives established for 2000 to 2015 (Table 2) are best interpreted in the context of those previously established. During the previous planning era (1985 to 1999) we sought to increase deer populations in all WMDs (Lavigne 1986). Deer populations had been declining since the late 1960s in response to severe winters, loss of wintering habitat, increased predation, and inadequate regulation of deer harvests. With more deer hunters (214,000) than deer (160,000) in Maine during the early 1980s there was a considerable unfulfilled demand for more huntable and watchable deer in most parts of the state. The only exceptions at that time were Maine's coastal islands and some urban/suburban environments where firearm hunting was precluded.

During the 1985-1999 planning era, deer population objectives were similar for all WMDs, i.e., to increase deer populations to 50% to 60% of maximum supportable population (MSP) and then maintain the herd at that level. MSP is defined as the maximum number of deer that can be supported without incurring starvation losses given current amounts of wintering habitat. MSP differs from "K" carrying capacity whenever the amount of wintering habitat prevents attainment of deer densities that could be supported on summer range alone. The probability that deer density at MSP will differ from density at K increases with increasing winter severity for deer.

Table 2. White-tailed Deer Management Goals and Objectives, 2000-2015.

Wildlife Management Districts 1-11

Short-term Goal:	Provide hunting and viewing opportunity for white-tailed deer, while preventing over-browsing of deer wintering habitat.
Short-term Objective:	Bring the deer population to 50% to 60% of the carrying capacity of the wintering habitat by the year 2004, then maintain at that level.
Long-term Goal:	Increase hunting and viewing opportunity for white-tailed deer, while preventing over-browsing of deer wintering habitat.
Long-term Objective:	Increase deer wintering habitat to 8% of the land base to ensure sufficient wintering habitat to accommodate a post hunt population of 10 deer/mi^2 by the year 2030 (or sooner), and then maintain as for the short-term objective.

Wildlife Management Districts 12, 13, 14 and 18

Short-term Goal:	Provide hunting and viewing opportunity for white-tailed deer, while preventing over-browsing of deer wintering habitat.
Short-term Objective:	Bring the deer population to 50% to 60% of the carrying capacity of the wintering habitat by the year 2004, then maintain at that level.
Long-term Goal:	Increase hunting and viewing opportunity for white-tailed deer, while preventing over-browsing of deer wintering habitat.
Long-term Objective:	Increase deer wintering habitat to 9 to10% of the land base to ensure sufficient wintering habitat to accommodate a post hunt population of 15 deer/mi^2 (when on summer range) by the year 2030 (or sooner), and then maintain as for the short-term objective.

Table 2. White-tailed Deer Management Goals and Objectives, 2000-2015 (cont.)

Wildlife Management Districts 19, 27, and 28

Short-term Goal: Provide hunting and viewing opportunity for white-tailed deer, while preventing over-browsing of deer wintering habitat.

Short-term Objective: Bring the deer population to 50 to 60% of the carrying capacity of the wintering habitat by the year 2004, then maintain at that level.

Long-term Goal: Increase hunting and viewing opportunity for white-tailed deer, while preventing over-browsing of deer wintering habitat.

Long-term Objective: Increase deer wintering habitat to 9 to10% of the land base to ensure sufficient wintering habitat to accommodate a post hunt population of 15 deer/mi^2 (when on summer range) by the year 2030 (or sooner), and then maintain as for the short-term objective.

Wildlife Management Districts 16, 17, 22, 23, and 26

Goal: Balance the desire for deer hunting and viewing opportunity with the need to reduce negative impacts of deer from browsing damage, collisions with motor vehicles, and potential risk of Lyme disease.

Objective: Bring the post hunt deer population to 20 deer/mi^2 (or no higher than 60% of Maximum Supportable Population) by 2004, then maintain.

Wildlife Management Districts 15, 20, 21, 24, 25, and 29

Goal: Balance the desire for deer hunting and viewing opportunity with the need to reduce negative impacts of deer from browsing damage, collisions with motor vehicles, and potential risk of Lyme disease.

Objective: Bring the post hunt deer population to 15 deer/mi^2 (or no higher than 60% of Maximum Supportable Population) by 2004, then maintain.

Deer population objectives for 1985-1999 were set at only 50% to 60% of MSP to assure that deer remained in good physical condition, were reasonably productive, and were less likely to over-utilize forage in either winter or summer habitat. At the outset, we anticipated that deer in central and southern Maine WMDs could attain higher densities at 50 to 60% MSP than deer in eastern and northern Maine WMDs because of more favorable wintering conditions (less reliance on deer wintering areas or DWAs), greater availability of DWAs, and higher recruitment rates (Lavigne 1986). In addition, we anticipated greater responsiveness of deer populations to changes in doe harvest among central and southern Maine WMDs because hunting mortality there was a greater contributor to all-cause annual losses.

Between 1985 and 1999 we attempted to increase deer populations by reducing doe harvests using the any-deer permit system. In most areas, we actually began curtailing doe harvests in 1983, using a combination of bucks-only and either-sex days. During the 1980s and 1990s we reduced doe harvests by >50% relative to harvests attained under deer of either-sex regulations during 1978-82 (Lavigne 1999). In eastern and northern Maine WMDs even greater reductions in doe harvest were achieved; buck-only regulations were nearly constantly implemented in eastern WMDs.

By the late 1990s we had succeeded in increasing the statewide herd from its nadir of 160,000 wintering deer during 1978-82, to nearly 300,000 deer during 1997-99.

As expected, central and southern Maine WMDs exhibited the greatest response to conservative doe harvesting, helped along by moderating wintering conditions. Among central and southern WMDs, we had attained wintering densities of 15 deer/mi^2 to >35 deer/mi^2 by 1999; up from 5 deer/mi^2 to 20 deer/mi^2 in the early 1980s. Yet despite these population gains, deer populations in central and southern Maine WMDs had not yet attained 50-60% MSP. Recent estimates of MSP in central and southern Maine range between 40 and >60 deer/mi^2 (Lavigne 1999).

During the 1980s and 1990s the impacts of growing deer herds were becoming increasingly apparent. Deer sightings and buck hunting yield increased in proportion to regional herd increase. However, so too did collisions with motor vehicles and complaints about browsing damage to crops and ornamental plantings. In areas that were favorable for survival of deer ticks, increasing deer populations were linked to increased human risk of contracting Lyme disease (Rand et al 2003).

During the 1980s and 1990s development for residential housing intensified in many locations within central and southern Maine (Lavigne 1999). This had the simultaneous effects of increasing potential conflicts between people and deer and of impeding efforts to control deer populations using recreational hunting with firearms. Overcoming obstacles to deer control posed by municipal firearms discharge bans, land posted against hunting, and safety zones in developed areas, has received increasing attention by MDIFW during the past 10 to 15 years.

At the statewide level there has been an ongoing change in hunter demographics that has the potential to affect deer management strategies. Since 1992, Maine has experienced a net loss of 46,000 deer hunters (Lavigne 1999) caused primarily by inadequate recruitment of new hunters to replace the loss of older hunters. This decline in hunter participation has been gradual. Although this trend may satisfy society's demand for more deer per hunter, it also poses challenges to our ability to achieve the deer harvests that are required to control populations. This latter fact necessitates greater flexibility and innovation in structuring deer hunting regulations.

During the 1985-1999 planning period we were largely unsuccessful in our efforts to increase deer populations in eastern and northern Maine, except in some transitional WMDs (e.g., WMD 7, 12, and 13). In many eastern and northern WMDs initial reductions in doe harvest did seem to result in positive herd growth. But by the early 1990s and thereafter, most populations had declined or remained stable at unacceptably low densities. By the end of the planning period, only populations in WMDs 7, 8, 9, 12, and 13 had attained the 50% of MSP population objectives established in 1985 (Lavigne 1999). In many of Maine's eastern and northern WMDs the very conservative doe harvest strategy we adopted between 1983 and 1999 seemed only to reduce the rate of decline in deer populations, instead of enabling herd growth to MSP.

We identified the ongoing loss of quality wintering habitat as a major limiting factor preventing significant, sustainable herd increases in the eastern and northern WMDs

(Lavigne 1999). Since the early 1970s, the proportion of the landscape supporting quality wintering habitat has declined from approximately 10% to <5% in the eastern and northern WMDs. Three factors have contributed to this critical loss of habitat: the spruce budworm epidemic of 1974 to 1988, increased logging of softwood forests, and widespread senescence of balsam fir stands. The short-term effects of excessive thinning or removal of the softwood-dominated forests that comprise wintering habitat for deer are increased snow depth and decreased mobility, which lead to higher rates of mortality to predation and malnutrition. The long-term effect is a reduction in carrying capacity for deer.

Exacerbating the ongoing loss in wintering habitat quality, northern Maine winters are currently increasing in severity for deer (Appendix 4). Average WSI (Winter Severity Index) during 1995-2003 (WSI = 87) was more severe for deer than during 1985-1994 (WSI = 83). Though still not as severe as the late 1960s and 1970s (mean WSI = 93), recent increases in severity are occurring at a time when wintering habitat quality is poorer and more limiting than during earlier decades. In contrast, except for an occasional severe winter (e.g., 2001), winters in central and southern Maine WMDs continue to moderate, relative to the 1960s and 1970s.

Based upon the November lactation index (see Part 2 for discussion of the limitations of this recruitment index), survival of fawns from birth to fall recruitment appears to have declined since the 1950s and 60s in Maine’s northern and eastern WMDs (Lavigne 1999). Moreover, recruitment in these districts is consistently less than that for central and southern WMDs. Diminished recruitment in eastern and northern WMDs appears to be related to poor survival of fawns, and not to density-dependent effects on in-utero productivity (Lavigne 1991[b]). Lower recruitment in northern and eastern WMDs poses a serious obstacle to increasing deer populations because it reduces allowable mortality for adults. Too often winter losses in deteriorated habitat exceed the level that can be replaced by available recruitment, even in the absence of legal doe harvest. The result is a population limited to a density which is well below MSP.

Achieving increases in early fawn survival in Maine's eastern and northern WMDs would improve our ability to achieve population objectives. This cannot be accomplished by regulating the harvest, but rather by addressing predation and other losses that fawns incur between June and November. To date, the Department has not developed effective strategies designed to improve early fawn survival. MDIFW's coyote control program (now suspended) does not directly address this problem over large areas.

In recent years, we have discussed the possibility that failure to achieve expected herd increases in northern Maine WMDs is the result of excessive stocking rates in DWAs. The combination of reduced availability of wintering habitat and reduced harvest mortality is postulated to have resulted in increased deer density within remaining wintering habitat. If true, this would result in over-browsing which would lead to density-dependent increases in malnutrition during winter, as well as diminished neonatal survival of subsequent fawns. Having reached or exceeded MSP based on existing availability of wintering habitat, deer populations would fail to increase, even with continued conservative doe harvests. This theory is explained in more detail in the Evaluation of System Inputs section (under YABD, page 47).

Another possible explanation for our failure to increase deer herds in northern WMDs is that current winters pose severe limitations on deer survival independent of density within DWAs. Under this scenario, deep snow and intense cold restrict deer to trails in limited areas for prolonged periods. Adequate forage is simply not accessible to deer and despite intense herbivory near trails survival is more dependent on stored fat reserves and ability to escape predators. Under this scenario a certain percentage of the population will be lost during winter regardless of herd density in DWAs. Hence, winter mortality rate is proportional to winter severity. Consistently severe winters combined with limited recruitment would limit deer at densities below MSP.

Questions surrounding density dependent vs. independent mortality in DWAs relate more to decisions about doe harvest than to attainment of population objectives. Overly conservative doe harvests may waste hunting opportunity where density-dependent winter mortality predominates. At the same time, it could lead to reduction in carrying capacity in DWAs over time. On the other hand, overly liberal doe harvests, where density independent winter mortality predominates risks extirpation of the herd. This occurs when additive hunting and winter losses combine to exceed recruitment over a prolonged period of time.

Stakeholders evaluating deer status during the 1999 strategic planning process left no doubt that considerable demand for deer hunting and viewing opportunities remained unfulfilled in eastern and northern WMDs. There was also substantial agreement that restoring deer wintering habitat was the most viable way of achieving sustainable herd increases. At the same time we considered it important not to overstock existing DWAs which would risk habitat damage and waste hunting opportunity.

Wintering habitat declined over a 30-year period (1970-2000) as noted above. As long as the land remains able to grow coniferous forests it is likely that historically used DWAs can again return to a species composition and stand class that provides winter shelter and forage for deer. However, re-growth could require 30 years or more and the forest should ideally remain in winter cover for several decades before being regenerated. Stakeholders agreed that restoring the entire DWA habitat base lost in eastern and northern WMDs was unrealistic. However, it may be feasible to double the current acreage in deer wintering habitat over the next 30 years. Consequently, the need to keep current deer populations in balance with existing DWA acreage while encouraging an eventual doubling in DWA acreage led to establishment of both short-term and long-term deer population objectives for WMDs in eastern and northern WMDs (Table 2). In each of these WMDs the short-term goal is to “provide hunting and viewing opportunities for white-tailed deer, while preventing over-browsing of deer wintering habitat”. The short-term objective called for bringing “deer populations to 50 to 60% of the carrying capacity of the wintering habitat by 2004 and then maintain at that level”.

Long-term population goals for eastern and northern Maine WMDs address the desire to increase hunting and viewing opportunities for deer, again, while preventing over-browsing of deer wintering habitat. Corresponding long-term population objectives specify increasing wintering habitat to 8% to 10% of the landbase by 2030 or sooner. This in turn, would enable us to maintain populations of 10 deer/mi^2 (WMDs 1-11) to 15 deer/mi^2 (WMDs 12-14, 18, 19, and 27-29), when on summer range. Methods and strategies that MDIFW are using to attain long-term increases in wintering habitat are detailed in the deer habitat management system update (to be drafted).

As currently estimated, a few WMDs are already at 50% to 60% of MSP (WMDs 7, 9, 12, and 13) and hence must be stabilized. The remaining eastern and northern districts' populations need to be increased to attain short-term objectives (Table 3). Overall, northern and eastern WMDs are currently estimated to be at 42% of MSP. Increasing each district's population to 55% of MSP would bring the regional population from 109,600 to 144,000 wintering deer or an increase of ~34,500 deer (± 31%). If the short-term objectives are accomplished, density on summer range would range from 3 to 15 deer/mi^2 among individual districts and would average 6.5 deer/mi^2 overall in eastern and northern Maine.

Attainment of long-term (habitat based) objectives in individual eastern and northern WMDs would allow us to maintain a population nearly 2 to 5 times as large as the

Table 3. Current vs. objective deer populations specified for the 2000-2015 planning period, by Wildlife Management District in Maine.

	2000 to 2002			Short-Term Objective			Long-Term Objective		
Wildlife	Wintering Population			Wintering Population			Wintering Population		
Management District	Percent of MSP	Number	Deer/Mi^2	Percent of MSP	Number	Deer/Mi^2	Percent of MSP	Number	Deer/Mi^2
1	42	5,148	3.6	55	6,774	4.8	55	14,170	10
2	31	2,705	2.3	55	4,830	4.1	55	11,760	10
3	34	1,738	1.9	55	2,803	3.0	55	9,310	10
4	35	6,400	3.3	55	10,000	5.1	55	19,590	10
5	43	7,972	5.2	55	10,221	6.6	55	15,430	10
6	34	5,053	3.7	55	8,150	5.9	55	13,780	10
7	50	9,905	7.2	55	10,884	8.0	55	13,630	10
8	48	9,797	4.8	55	11,261	5.5	55	20,410	10
9	50	3,792	4.0	55	4,167	4.4	55	9,480	10
10	41	3,426	3.9	55	4,568	5.2	55	8,860	10
11	37	8,275	5.0	55	12,350	7.4	55	16,660	10
12	46	8,777	9.4	55	10,449	11.2	55	14,055	15
13	54	8,532	15.1	55	8,706	15.4	55	8,475	15
14	49	4,605	5.8	55	5,174	6.5	55	11,910	15
15	46	15,637	15.7	44	14,940	15	44	14,940	15
16	43	17,017	23.7	36	14,360	20	36	14,360	20
17	40	32,167	23.6	34	27,260	20	34	27,260	20
18	41	7,843	6.0	55	10,457	8.0	55	19,500	15
19	37	3,498	3.0	55	5,221	4.5	55	17,490	15
20	47	9,616	16.0	44	9,015	15	44	9,015	15
21	46	8,963	18.4	38	7,320	15	38	7,320	15
22	43	12,209	23.4	37	10,420	20	37	10,420	20
23	39	27,451	30.0	26	18,260	20	26	18,260	20
24	42	7,314	26.5	24	4,140	15	24	4,140	15
25	41	8,809	18.2	34	7,260	15	34	7,260	15
26	41	14,237	23.0	36	12,380	20	36	12,380	20
27	38	6,971	8.5	55	10,103	12.4	55	12,225	15
28	37	3,015	3.6	55	4,500	5.4	55	12,450	15
29	34	2,208	4.5	55	3,561	7.3	55	7,305	15
30									
Statewide	42	263,080	9.0	46	269,534	9.2	48	381,845	13.1
N&E WMDs	42	109,660	4.9	55	144,179	6.5	55	256,490	11.6
C&S WMDs	42	153,420	22.0	35	125,355	18.0	35	125,355	18.0

current population. When held at 55% of MSP the northern and eastern WMDs could sustain densities of 10 to 15 deer/mi^2 (on summer range) and total >250,000 wintering deer overall (Table 3).

In Maine's more populous central and southern WMDs, deer population goals reflect a desire to reduce negative impacts of the growing populations we achieved by the late 1990s (Table 2). Accordingly, we sought a balance between hunters' and deer watchers' desire for an abundant deer resource with the practical reality that adverse impacts must be held to tolerable levels.

For the 2000 to 2015 planning period we set upper limits on deer density in Maine's central and southern WMDs rather than managing for a herd at 55% of MSP as before. Wintering herd objectives were set at 15 deer/mi^2 in our more populous WMDs (i.e., districts 15, 20, 21, 25, and 29). More rural districts we believed could accommodate slightly higher deer populations. Therefore, we established a wintering population objective of 20 deer/mi^2 in WMDs 16, 17, 22, 23, and 26 (Table2).

As currently estimated deer populations in Maine's central and southern WMDs vary from nearly 13 to 22 deer/mi^2; they collectively total nearly 115,800 wintering deer, and these populations are at roughly 50% of MSP (Table 3). To meet population objectives set for 2000 to 2015 deer populations need to be maintained near their current levels or increased to 125,000 deer at which time the regional population would be held at roughly 35% of MSP. Deer population estimates presented in Table 3 tend to be biased low in WMDs with inadequate hunting access (e.g., WMDs 24, 29, and portions of WMDs 20, 21, and 25).

For Maine as a whole, attainment of short and long-term population objectives during 2000 to 2015 would lead to an increase and an important redistribution of deer in the state. Fewer deer would occur in central and southern WMDs; northern and eastern WMDs would gain deer. This would minimize deer/people conflicts in urbanizing parts of Maine while improving the hunting-based economy in more rural WMDs. Overall wintering populations would increase from its current 212,000 to >380,000 deer when long-term objectives are met. At this time, potential deer harvest would exceed 46,000 deer, compared to current harvests of 25,000 to 38,000 deer (Lavigne 1999).

MANAGEMENT DECISION PROCESS

Management decisions relate primarily to determining annual doe harvests needed to attain deer population objectives. The decision process is applied to each individual WMD when data become available in spring. The decision-making process follows a series of yes or no answers to questions related to deer population status (Table 4). Responses to these questions are guided by rules-of-thumb (Table 5) that lead to specific recommendations regarding management direction (i.e., increase, stabilize, or decrease population). The decision process is flexible and dynamic enabling managers to accommodate changes in herd status, population growth, or environmental stressors (e.g., winter severity).

A major assumption involved in manipulating doe harvests is that hunting mortality is largely additive to other herd losses. If true, then a reduction in hunting mortality would not be offset by a compensatory increase in some other mortality factor. This in turn may allow the herd to increase, if total annual mortality is less than what the herd can replace with new recruits. The opposite effect, i.e., herd reduction, would result from an increase in doe harvest if this causes total annual losses to exceed available recruitment.

For this system to work we need to develop a working knowledge of the magnitude of hunting mortality relative to winter losses, all other herd losses, total annual mortality, and recruitment. Once these population attributes are understood, we gain some

Table 4. Decision process used to determine annual doe harvests needed to attain deer population objectives. Inputs include Yearling Antler Beam Diameter (YABD), HARPOP (a population model based on harvest rates), Buck Kill Index (BKI - bucks harvested per 100 mi^2), the Winter Severity Index (WSI; based on snow depth, sinking depth, and temperature), stabilization ratio (the number of does that must be harvested per 100 bucks to stabilize the deer population in a given Wildlife Management District [WMD]).

Questions	Inputs	Response	Management Actions
Is herd at target?	YABD or HARPOP	YES NO – Below Target NO – Above Target	Stabilize herd by issuing any-deer permits at stabilization ratio Increase herd by reducing any-deer permits Decrease herd by increasing any-deer permits
Is herd stable?	BKI	YES NO – Decreasing NO – Increasing	Calibrate any-deer permit allocations proportional to rate of change in population status
Have "normal" mortality recruitment patterns changed?	Achieved doe harvest	At Quota Below Quota Above Quota	No action needed Adjust any-deer permits upward in current year, if herd is at or above target; optional if herd is below target Adjust any-deer permits downward, if herd is below or at target; optional if herd is above target
	WSI	Within Threshold Above Threshold Below Threshold	No action needed Adjust any-deer permits downward to compensate additional winter losses, if herd is at or below target; optional if herd is above target Adjust any-deer permits upward to compensate additional winter survival, if herd is at or above target; optional if herd is below target Note: Adjustments to compensate additional winter mortality must be made for 2 years following the severe winter
	Stabilization Ratio	Adequate Too High or Low	No action needed Adjust harvest ratio to better reflect the contribution of hunting mortality to all-cause mortality/recruitment balance

Table 5. Rules-of-thumb that guide responses to questions regarding deer population status posed in Table 2.

Herd Status vs. Target	Herds in WMDs 1-14, 18, 19, and 27-28 will be considered at target (i.e., within 50 to 60% of MSP), if YABD averages 15.6 to 16.8mm. Herds in WMDs 15, 20, 21, 24, 25, and 29 will be considered at target if HARPOP posthunt density falls within 14 and 16 deer/mi^2. Herds in WMDs 16, 17, 22, 23, and 26 will be considered at target if HARPOP posthunt density falls within 18 and 22 deer/mi^2.
Population Stability	The deer population is considered stable if the BKI changes by ≤ 10% in the current year or has changed by an aggregate of ≤ 15% during the past 3 years. Alternatively, deer populations are considered to be increasing/decreasing if the BKI changes >10% in the current year or >15% in aggregate during the past 3 years.
Achieved Doe Harvest	If the doe harvest achieved by archers, youth day hunters, any-deer permittees, and Bonus any-deer permittees exceeds the prescribed doe removal rate by ≥ 2% of the pre-hunt doe population, then the harvest prescription in the following year will be reduced by a similar amount, when the herd is at or below target (optional when above target). If the doe harvest achieved by archers, youth day hunters, any-deer permittees, and Bonus any-deer permittees falls below the prescribed doe removal rate by ≥ 2% of the pre-hunt doe population, then the harvest prescription in the following year will be increased by a similar amount. When the herd is at or above target (optional when below target).

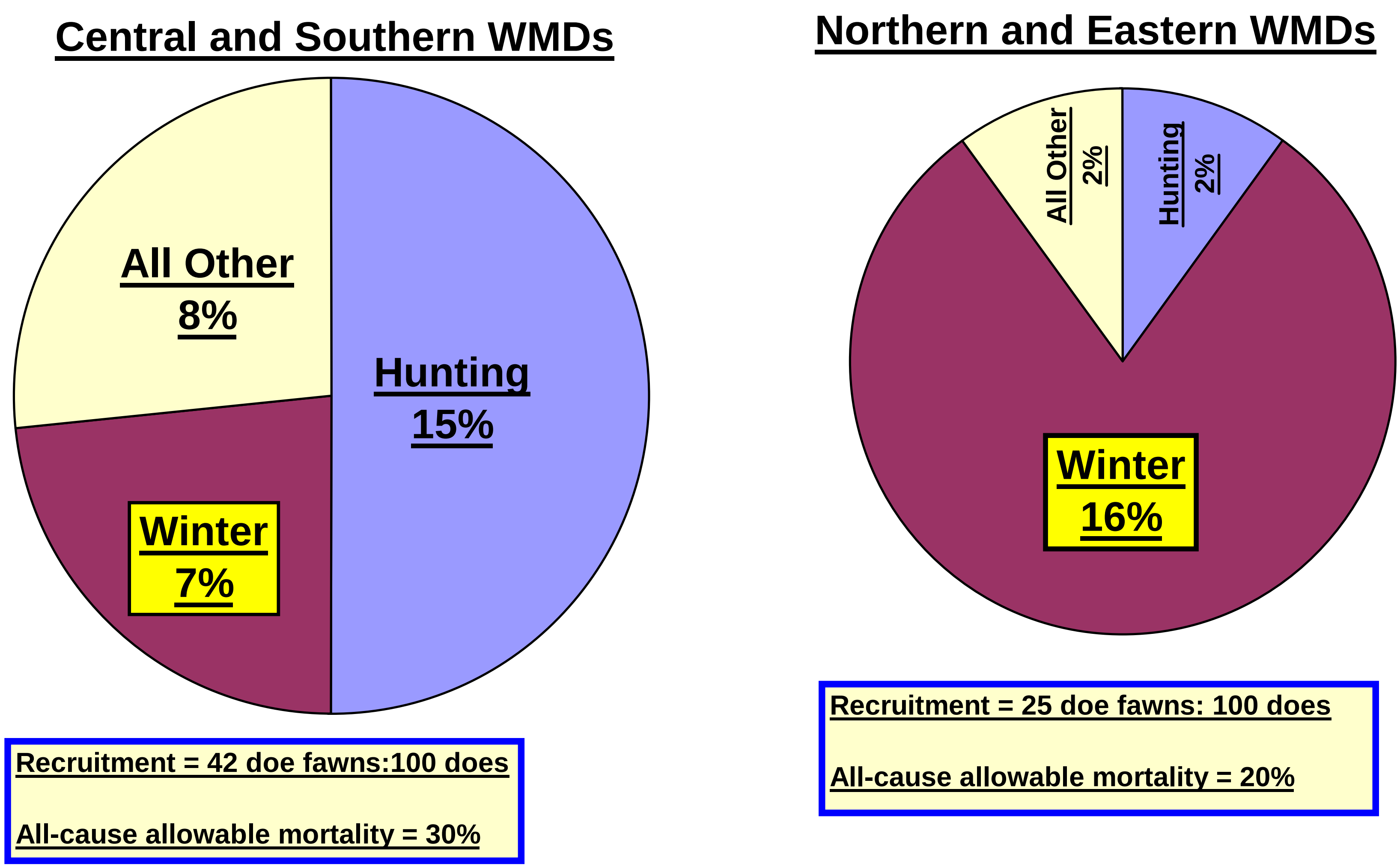
Table 5. Rules-of-thumb that guide responses to questions regarding deer population status posed in Table 2 (continued).

WSI	<u>Severe Winters</u> If the WSI for the current winter for a given WMD exceeds the long-term (1991-05) mean WSI threshold[1], then a deer population decline is assumed. A compensatory reduction in the doe harvest equivalent to the magnitude of excess winter doe losses is recommended to facilitate herd recovery when the herd is at or below target (optional when above target). During the second year following a severe winter, harvest adjustments of at least ½ the reduction in doe harvest imposed during the previous year will be implemented if the herd remains below target. [1] Associated with each WSI value is a predicted winter mortality rate (% of winter population dying). The threshold WSI is a range of WSI values that comprises the 1991-05 mean winter mortality rate ± 1% of the wintering herd (Appendix 4). <u>Mild Winters</u> If the WSI for the current winter is below the 1991-05 threshold, then a population increase is assumed. A compensatory increase in the doe harvest equivalent to the increase in winter survival rate is recommended when deer populations are at or above target (optional when below target).
Stabilization Ratio	If the current stabilization ratio fails to stabilize the population over a minimum of 3 consecutive seasons, after accounting for WSI adjustments, the ratio of adult does : 100 bucks in the harvest may be adjusted.

confidence in estimating the number of does that must by harvested to stabilize the population during years when <u>normal</u> levels of mortality and recruitment are operating in a given WMD. For convenience this stabilizing doe harvest or stabilization ratio is expressed as: adult does harvested: 100 adult bucks. Incorporation of buck harvest in this ratio ensures that a specific percent of the doe herd is removed, even when the population is empirically changing in either direction. Stabilization ratios have been defined for all 30 WMDs. They were initially estimated from population modeling (Chilelli 1988; MDIFW unpubl. data) during the 1980s. However, many of these ratios were modified using adaptive management as we evaluated the performance of past harvests since 1985. Currently harvest stabilization ratios range from 10 does:100 bucks to 90 does:100 bucks among WMDs and they represent removals of <1% to 20% of the adult doe population (Appendix 5).

There is a fundamental difference in the relative contribution of hunting mortality to total annual mortality between Maine's central and southern WMDs and the eastern and northern WMDs (Figure 2). Based on the November lactation index and population growth, we suspect the two regions differ in fawn recruitment and hence, in the total amount of mortality each herd can withstand. In central and southern districts during "normal" years there is sufficient fawn recruitment to sustain annual losses among adults of approximately 30%. In this area, winter and other losses (illegal, road-kill, disease, old age, etc.) typically amount to roughly 15% of the pre-hunt doe population. This leaves a substantial reserve in allowable mortality that may safely be allocated to hunters (i.e., 15% of the doe population; Figure 2).

Figure 2. Mortality/recruitment balances typical of "average" winters for the region.



In the eastern and northern WMDs diminished recruitment reduces all-cause allowable mortality to as little as 20% of the adult doe segment of the population (Figure 2). In addition, winter and other non-hunting losses comprise a much higher component of total annual doe mortality. During average winters for the region this typically leaves as little as 2% of the doe herd available to be allocated to hunters. Given current habitat and climatic conditions in eastern and northern Maine, doe harvests must be conservative if mortality is to balance available recruitment.

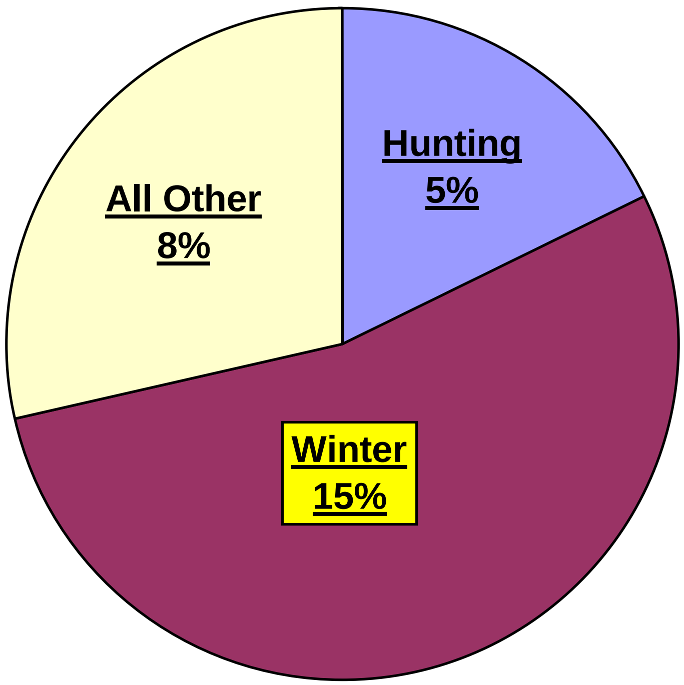
Stabilization doe harvests in Figure 2 assume relatively stable recruitment and mortality patterns. However, some deer losses (e.g., winter mortality) may fluctuate widely from year to year. Figure 3 illustrates how a severe winter would affect allowable doe harvest in Maine. Following severe winters fawn recruitment typically decreases, in turn, decreasing allowable mortality of adults for that year. For example, in central and southern WMDs following an average winter recruitment allows a 30% annual doe loss for the year (Figure 2). A severe winter more than doubles the winter mortality rate from 7% to 15% of the doe herd (Figure 3). Assuming the all-other category remained at 8%, hunting mortality must be reduced from 15% to a 5% removal of does to compensate the additional winter mortality. Severe winters are infrequent in central and southern WMDs, but when they occur, deer populations in this part of Maine are capable of rebounding quickly because of inherently higher recruitment and lower relative contribution of non-hunting losses to total allowable losses.

No such mortality cushion exists in northern and eastern WMDs, when winters of above-normal severity occur (Figure 3). At these times, all-cause allowable mortality decreases (as subsequent fawn recruitment drops), while winter losses dramatically increase. Even if the all-other loss category remains stable, total annual mortality in eastern and northern WMDs may greatly exceed allowable mortality. With hunting mortality able to compensate for only an increase in winter losses equivalent to 2% of the doe population, allowable doe harvest will need to be set at zero following most winters of above-average severity. Under these conditions, implementing bucks-only hunting regulations following severe winters in eastern and northern WMDs may only reduce the rate of decline in the deer population. Alternatively, continued doe harvesting at the stabilization harvest ratio or higher would intensify the herd decline and risk extirpation.

The first step in the annual decision process is to determine herd status in relation to population objectives established for 2000 to 2015 (Tables 2 and 3). For eastern and northern WMDs one must determine if the herd is at 50 to 60% of MSP. We currently use mean yearling antler beam diameter (YABD) as an index to population status in relation to carrying capacity or MSP (Table 4). It should be noted here that there may be limitations on the usefulness of the YABD index in some northern WMDs. A detailed evaluation of YABD and other indices used as inputs to this management system follows in the next section. When YABD averages between 15.6 to 16.8mm, the population is assumed to be within 50 to 60% of MSP or at target density for WMDs 1-14, 18, 19, and 27-28 (Table 5). WMDs with mean YABD >16.8 are assumed to be

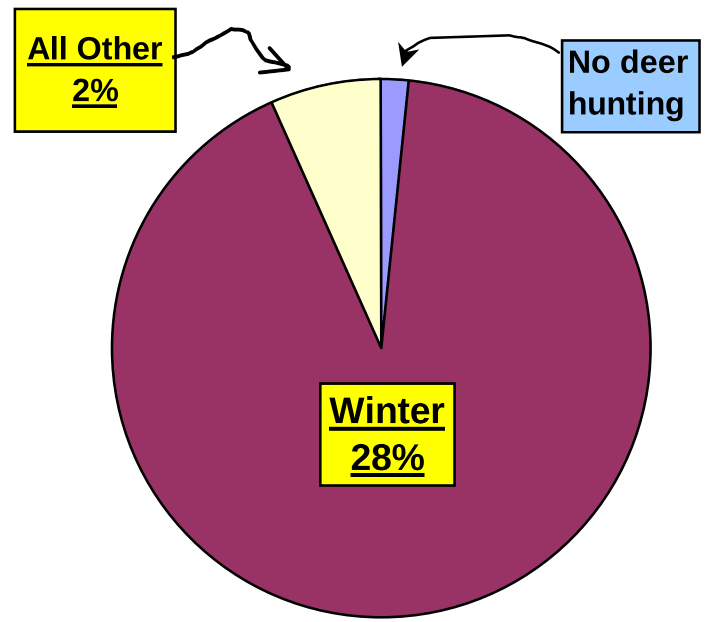
Figure 3. Mortality/recruitment balances typical of "severe winters" for the region.

Central and Southern WMDs



Recruitment drops to 38 doe fawns: 100 does
All-cause allowable mortality drops to 28%
Hunting mortality is reduced to compensate
higher winter kill / lower fawn production

Northern and Eastern WMDs



Recruitment drops to 18 doe fawns: 100 does
All-cause allowable mortality drops to 15%
Total annual mortality greatly exceeds allowable,
even in the absence of hunting

below 50% of MSP, while those with YABD averaging <15.6 are considered to be above 60% of MSP. Among central and southern Maine WMDs, current herd density will be evaluated to determine if the population objectives established for 2000 to 2015 (Tables 2 and 3) have been reached. For this, we use posthunt density estimated from the HARPOP model (Table 4). Because of inherent variability in the model (Appendix 3), and the impossibility of maintaining an exact density (e.g., 15 or 20/mi^2) from year to year, we have established a range of densities within which the herd in a given WMD would be considered at target density. Accordingly, herds in WMDs 15, 20, 21, 24, 25, and 29 will be considered at target if HARPOP posthunt density ranges between 14 and 16 deer/mi^2 (Table 5). For WMDs 16, 17, 22, 23, and 26, district deer populations would be at target density between 18 and 22 deer/mi^2.

For all WMDs considered to be at target, the management action would be to stabilize the herd using the appropriate doe harvest, if normal mortality/recruitment patterns are evident (Table 4). Recommended actions would be to increase the herd by reducing doe harvest for WMDs that remain below target. Alternatively, doe harvests would be increased when the population in any given year is above target.

As populations respond to management or to stochastic events (e.g., severe winters) it is desirable to monitor population trends over time. We use the buck kill index (BKI) to monitor population stability within WMDs over time (Table 4). The BKI is calculated as the harvest of antlered bucks per 100 mi^2. Because all licensed deer hunters are free to pursue bucks (and most prefer to kill bucks), changes in buck harvest tend to reflect changes in the population as a whole. (Limitations of this index are discussed in a later section). Rules-of-thumb guiding interpretation of BKI changes are presented in Table 5. The deer population is considered to be stable if the BKI changes by ≤10% in the current year or has changed by an aggregate of ≤15% during the past 3 years. The importance of evaluating population stability is two-fold. First, it allows us to monitor progress (or lack of it) toward attaining our population objectives. Second, it reveals the relative amount of change in doe harvest that is needed to accomplish our objectives. For example, a population that has declined by 30%, as indicated by the BKI, may require substantially more conservative doe harvests to recover than one that has declined only 5%.

The final question to be resolved in the decision process (Table 4) is whether or not “normal” mortality/recruitment patterns are operating. Mortality that falls outside of established norms require compensatory adjustments in doe harvest in order to achieve population objectives.

One factor affecting current mortality/recruitment status is past success or failure to achieve desired doe harvests. Over-harvest could lead to additive losses that exceed allowable total mortality for the year, resulting in unwanted herd reductions. On the contrary, failure to achieve a certain level of doe harvest could exacerbate unwanted herd growth, particularly when followed by a mild winter. Rules-of-thumb governing when we act to compensate for under or over-harvest during the preceding fall are presented in Table 5. If doe hunting removal rate exceeds 2% of the pre-hunt doe population in either direction we act to compensate for over or under-harvest within any WMD. However, these adjustments in subsequent doe harvest are optional, if the over or under-harvest lead to more rapid attainment of management objectives (Table 5).

Winter severity varies widely among WMDs (Appendix 4) with northern Maine WMDs experiencing consistently more severe winters than southern and coastal WMDs. Although winters may vary widely in relative severity for deer, average severity in a given WMD sets the long-term parameters for deer mortality/recruitment balances. Hence, when winter severity falls within a certain range (i.e., long-term norms), we can readily predict the likely population response to harvest management.

We monitor winter severity for deer using the Winter Severity Index (WSI). This index involves weekly measurements of snow depth, deer sinking depth and temperature that reflect relative deer mobility, and thermal stress. The WSI has proven to be a good predictor of winter mortality rate in Maine, based on correlation of WSI with dead deer surveys that were conducted annually throughout the 1970's -1980's (Appendix 6; Lavigne 1992).

We have established thresholds for WSI (e.g., WSI of 85 to 95) that represent long-term (currently 1991-2005) average or normal winter severity for a given WMD. When WSI for a given year falls within that threshold, no subsequent adjustment in doe harvest is needed (Tables 4 and 5). However, winters that fall outside these WSI thresholds require compensatory adjustments in subsequent doe harvests, except when that change in winter mortality leads to more rapid attainment of population objectives. We compensate for above-average winter losses for two years following a severe winter to better allow recovery of diminished cohorts within the population.

Finally, we monitor the harvest stabilization ratio to assess whether it actually balances total losses with recruitment (Table 4). Examination of population response to achieved doe harvests over a period of years can reveal whether established stabilization ratios are realistic. Of course, prior actions to compensate unusual levels of mortality must be taken into consideration. Our rule of thumb for evaluating stabilization ratios requires a minimum of 3 consecutive years of data for a given WMD (Table 5).

In addition, we routinely modify stabilization ratios when pre-hunt sex ratios are skewed. The number of adult does per 100 bucks in the pre-hunt population tends to increase when does are harvested conservatively. As a result, harvest prescriptions must be adjusted to compensate for the higher stocking rate of does. For example, in a population held stable at 150 does:100 bucks, a harvest of 50 does : 100 bucks would remove 12% of the pre-hunt doe population. However, the harvest of 50 does:100 bucks taken from a population with 200 does : 100 bucks removes only 9% of the doe population. Failure to adjust stabilization ratios when adult sex ratios are skewed will result in less precise doe removals. This could lead to systematic under or over-harvest (depending on direction of skewness) over time. Adjustments in the stabilization harvest ratio are made as needed using look-up tables provided in Appendix 5. These harvest and mortality schedules are also used to calculate mortality and harvest adjustments for over or under-harvest and winter severity inputs to the system.

When the decision-making process outlined in Tables 4 and 5 has been completed the manager is then able to recommend a doe harvest that will enable attainment of population objectives for each WMD. In doing so it is helpful to use worksheets such as the one depicted in Table 6. Each worksheet contains 3 sections. The first provides data about population attributes (e.g., age frequencies, adult sex ratio, mortality rates). The second provides a 6-year history detailing management inputs (e.g., YABD, HARPOP, BKI, WSI, stabilization ratio), harvest history (projected vs. actual), and any-deer permit history (expansion factors and permits issued vs. projected). The final section allows computation of the any-deer permit recommendations for the current year that comprise the primary output of this management system.

The actual process to compute any-deer permits is next described using data in Table 6 as an example. We begin with evaluation of the inputs and questions posed in Table 4. This leads to recommendation of one or more distinct management strategies to be applied in that WMD. When strategies are defined, the rules-of-thumb in Table 5 guide selection of a harvest prescription designed to achieve the management strategies that were selected. As with stabilization ratios, harvest prescriptions are defined as adult doe harvest:100 bucks harvested. When populations are to be decreased or when other excess mortality must be compensated harvest prescriptions call for lower doe harvests:100 bucks than that which stabilizes the herd. Higher doe harvests are

Table 6. Example worksheet for computing Any-deer permits.

Preliminary **Any-Deer Permit Recommendation** Date: March 31, 2003

WMD 16 Population Attributes Deer Habitat 718 Mi^2

All-Cause Annual Mortality: Bucks 46 Does 23 Allowable 30

Pre-Hunt Sex Ratio: Current 179 When Stabilized 153

		DEER MANAGEMENT HISTORY						
		1997	1998	1999	2000	2001	2002	2003
YABD [15.5-16.5]		16.9	18.2	18.1	17.9	17.6	17.9	
BKI (Buck Harvest/100 mi^2		166	153	173	223	167	201	
WSI [52-63]	Number	55	52	52	48	81	47	
	Rating	A	BA	BA	BA	AA	BA	AA
HARPOP (Post hunt/mi^2)		19.3	24.3	29.9	27.1	22.1	21.9	
Management Strategy			A	A, 3	B, 3, 6	B, 1, 7	C, 7	
STABTAR (STABCUR)			60(75)	60(75)	60(75)	60(70)	60(70)	60(70)
To Stabilize:	Doe Harvest		826	930	1,203	841	1,009	
	Permits		5,698	6,789	8,782	6,226	7,268	
Harvest Prescription	Desired		55	65	70	55	75	
	Achieved	53	49	52	58	58	70	
Adult Buck Harvest	Projected		1,230	1,200	1,400	1,440	1,320	
	Achieved	1,191	1,101	1,240	1,604	1,202	1,442	
Adult Doe Harvest	Quota		677	780	980	792	990	
	Achieved	635	542	642	934	692	1,005	
Expansion Factor	Applied		5.5	6.0	7.0	6.5	7.3	
	Achieved		6.9	7.3	7.3	7.4	7.2	
Permits Issued	Per 100 mi^2		521	652	947	711	1,004	
	Number		3,740	4,683	6,796	5,106	7,208	

2003 Any-Deer Permit Recommendations

Population Objective (Deer/mi^2) 20

Management Strategy Reduce herd; adjust for skewed sex ratio; compensate for severe 2003 winter

Stabilization Ratio 60 Adult Does:100 Adult Bucks Adjustment for sex ratio 70

Harvest Prescription 75 Adult Does:100 Adult Bucks Before WSI Adjustment

Revised Harvest Prescription 65 Adult Does:100 Adult Bucks After WSI Adjustment

Projected Adult Buck Harvest 1,370

Adult Doe Quota 891

Expansion Factor 7.3 Permits Per Adult Doe

Number of Any-Deer Permits Recommended 6,500 Per 100 mi^2 905 required to reduce the herd. Every harvest prescription (e.g., 65 does: 100 bucks) is associated with a certain removal rate of does from the population (Appendix 5). From the example in Table 6, we see that 3 management strategies were selected for WMD 16 in 2003: (1.) reduce the herd; (2.) adjust for skewed sex ratio; and (3.) compensate for the severe 2003 winter. By following Table 5, we concluded that a harvest prescription of 65 does: 100 bucks or removal of 13% of the pre-hunt doe population would satisfy management strategies for this district.

Once a harvest prescription has been selected it must be translated into a doe quota or a specific number of adult does to be removed from the pre-hunt population. To do this one must estimate the number of antlered bucks that will be harvested in the WMD. Recall that harvest prescriptions are ratios with buck harvest as the denominator. To select a buck harvest projection we evaluate the trend in the buck harvest in the past few years while modifying the projection to reflect current influences, such as winter severity, recent under or over-harvest of does, etc. From Table 6, we anticipated a slight reduction in buck harvest in WMD 16 due to the effects of the above average severity of the 2003 winter. Hence, we predicted that buck harvest would decline from 1,442 achieved in 2002 to 1,370 in 2003.

Having arrived at a projection of the buck harvest, one can compute the doe quota. In the example in Table 6, with a harvest prescription of 65 adult does:100 adult bucks, and a projected buck harvest of 1,370, the doe harvest quota is 891 (i.e., 1,370 x 0.65 = 891).

The final step is to estimate the number of any-deer permits that must be issued to achieve the doe harvest quota. Because hunter success is <100%, and because some hunters with any-deer permits will opt to take a fawn or a buck we must issue substantially more any-deer permits than the specified doe quota. In addition, some of the does may be harvested during the expanded archery, statewide archery, and youth day seasons. These harvests count toward the specified quota; they decrease the number of any-deer permits that need to be allocated.

To account for the above, we use a multiplier called an expansion factor (Table 6) to estimate any-deer permits required to complete doe quotas. We have learned since 1986 that the harvest of 1 adult doe requires from 3 to 9 any-deer permits among the various WMDs. Expansion factors are positively related to deer density, but may also be affected by illegal group hunting to fill any-deer tags, availability of tracking snow, and other factors. From Table 6, it is evident that expansion factors achieved in WMD 16 over the past 5 years have been rather stable, ranging from 6.9 to 7.4. For 2003, an expansion factor of 7.3 was selected.

Once an expansion factor is selected the requisite number of any-deer permits needed to achieve deer management strategies for the year can be computed. In the example in Table 6, a total of 6,500 any-deer permits was estimated to achieve the specified quota of 891 adult does for WMD 16 in 2003 (891 x 7.3 = 6,504 rounded to 6,500 any-deer permits).

EVALUATION OF SYSTEM INPUTS

WMDs

In a state encompassing 30,000 mi^2, with such wide variability in climate, land use, and carrying capacity, we need to tailor deer management to regional conditions. To meet this need the Department originally defined 30 Wildlife Management Districts based on winter severity, habitat quality, soils, land management, human population centers, and easily definable boundaries. These WMDs are large, averaging 1,000 mi^2 (range 276mi^2 to 2,041 mi^2). The large size of the WMDs, in some cases, resulted in considerable variability in the density of the deer population within an individual WMD (e.g., WMDs 26 and 27). For WMDs 26 and 27, the problem was fairly easy to correct by moving the boundary of WMD 26 eastward into towns now part of WMD 27 (Figure 1). For other towns, the problem may be more difficult to address. Because of restrictions on the use of firearms for hunting, and/or restricted access for any activity, local deer populations may differ greatly in density across limited landscapes. This is especially true in our more densely-developed WMDs (e.g., 20, 21, 24, and 25) where residential sprawl has created a diffuse patchwork of land that can or cannot be hunted with firearms. Within any given town there may exist separate deer populations that may exceed 50 deer/mi^2 (where access to hunting is prohibited or restricted) adjacent to populations that are limited at low density (perhaps <10 deer/mi^2) by intense hunting pressure.

Solving this fine scale disparity in population size within individual WMDs is more problematic. Increasing the number of any-deer permits to address overpopulated areas would be ineffective if those patches are closed to firearms hunting. Increasing the number of any-deer permits in these highly developed WMDs may only intensify hunting pressure in the firearms-open patches, where the local herds may already be at or below target density. A better solution would be to work with municipalities and landowners at the same geographic scale as deer home ranges (i.e., 500 to 1,000 acres) to find innovative ways to reduce deer populations to the target density for the WMD as a whole.

<u>YABD</u>

Direct measures of carrying capacity for deer are complex and prohibitively expensive for large landscapes. Yet, it is important to determine deer population status relative to carrying capacity in order to fulfill public expectations for maintaining harvest and herd quality or for minimizing conflicts with other land-uses. Fortunately, we are able to use readily-available indices that reveal deer population status relative to carrying capacity.

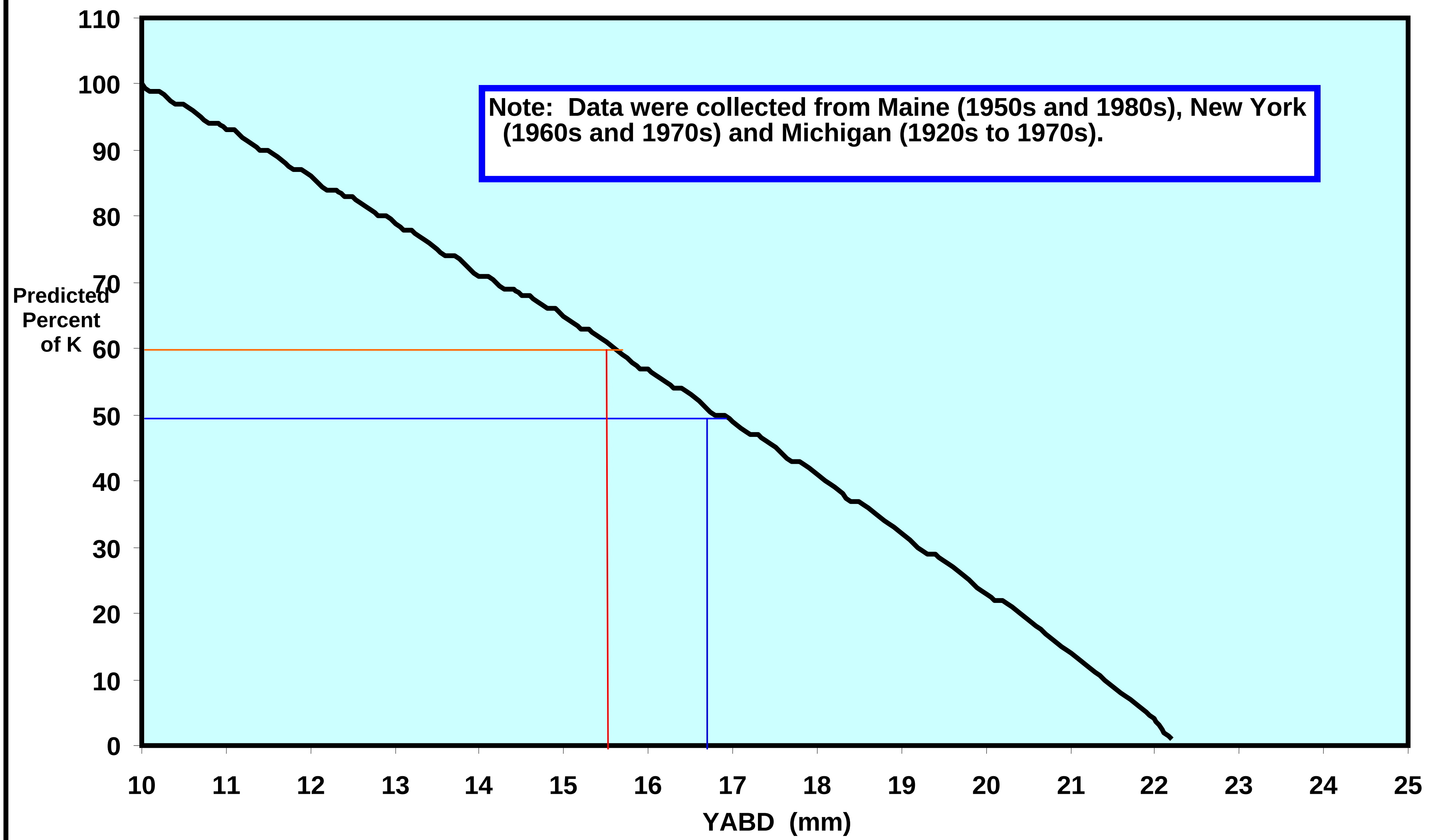
These indices rely on the fact that deer exert density-dependent impacts on their forage. At progressively increasing density deer alter the composition and quality of vegetation in their habitat. Diet quality is inversely related to deer density in a given area. As deer populations increase, diet quality declines and negatively affects net productivity, body size, and antler mass. It is the latter attribute that we use to index herd status in relation to carrying capacity in Maine.

Antler development is a physiological luxury for bucks; body growth takes precedence over antler development, particularly among immature individuals. Numerous studies throughout the deer's range have demonstrated that antler mass in yearling bucks diminishes with increasing density, if carrying capacity remains unchanged in a given habitat. Moreover, these changes in antler mass are correlated with density-dependent changes in body mass and net productivity.

There are several options available when measuring antler mass in deer. One could count antler points, measure antler beam length, estimate antler volume, or measure main beam diameter. All of these measurements are correlated, but some are more difficult to attain. In Maine, we use main beam diameter from yearling bucks (YABD) as the primary index to the herd's relative position to the carrying capacity of the land (see Part II of this document). We also record antler points as a supplementary index. We focus on the yearling cohort because these immature deer are producing their first set of antlers, are least dominant among bucks when competing for food, and they exhibit a strong tendency to first attain skeletal and body mass when diet quality is limiting.

We have developed a regression equation (Figure 4) that predicts deer population status relative to biological carrying capacity (K) in Maine.

Figure 4. Percent of K Carrying Capacity as Predicted from Mean YABD of Yearling Bucks



The YABD-K model indicates an inverse linear relationship between YABD and density relative to K. At extremely low densities, relative to K, yearlings would attain antler size commensurate with their genetic potential (i.e., mean YABD ≥ 22 mm). At the other extreme, yearling bucks from populations held near K would yield an average YABD closer to 10mm (Figure 4); when populations approach K as many as 1/3 of yearling bucks would fail to grow antlers >3 inches in length.

Interpretation of Figure 4 suggests that YABD would average between 15.6 and 16.8 mm when the herd is within 50 to 60% of K. This forms the basis for our rule-of-thumb for assessing when deer populations have met 2000 to 2015 short-term population objectives of 50 to 60% of MSP in our northern and eastern WMDs (Table 5).

It is important to note that YABD is an index to herd position on the carrying capacity continuum. It reveals nothing about the empirical magnitude of carrying capacity. Forage quantity and availability (e.g., effects of snow on restricting availability) vary tremendously among locations, and often between years. It is entirely possible for 50% of MSP to equal <10 deer/mi^2 in an area with extremely poor soils/vegetation or with extremely limited availability of winter habitat. At the other extreme, 50% of MSP may be >100 deer/mi^2 in highly productive agricultural areas with mild winters (Lavigne 1999). Regardless of density, YABD should average near 16mm if the population is impacting available forage in a density-dependent manner indicative of 50% MSP.

There is currently some doubt whether YABD accurately reveals population status relative to MSP in some of our northern WMDs. Although northern Maine deer populations did exhibit antler size, body mass, and other population attributes indicative of a herd near K (i.e. 12 to 14mm) in the 1950s (Banasiak 1964), more recent measurements in WMDs 1-6 consistently exceed 18mm.

In comparing the two eras, it's important to note that both summer and winter habitat quality has changed markedly in Maine's north woods. In the 1950's, northern WMDs had an abundance of quality winter habitat, but the summer range was of lower quality, being predominantly pole-stage mixed woods. The adequate quantity of winter habitat likely supported herd growth to levels that stressed vegetation on summer range (and also in DWAs). In other words, MSP and K would represent similar densities.

In contrast, wintering habitat has greatly diminished in quantity and shelter quality in northern WMDs today. At the same time, extensive timber harvesting on summer range has dramatically improved diet quality on summer range. The net effect of recent changes in the northern Maine forest may be that summer K increased, while the carrying capacity in winter range decreased. There is simply not enough winter range to allow the herd to grow to the forage capacity of the summer range. This creates a disparity between summer K (60 to 80 deer/mi^2), and MSP (~ 20 deer/mi^2), based on availability of wintering habitat (Lavigne 1999).

This leads to the question: do current measurements of YABD in northern WMDs only reflect herd status in relation to summer K, only DWA carrying capacity, or both? In theory YABD should integrate both winter and summer elements. Buck fawns would be affected by forage availability in DWAs resulting in density-dependent changes in body mass over winter. Severe weight loss in over-crowded DWAs should place surviving buck fawns in a physiological state where they first need to recover body weight and grow skeletal mass during spring and summer in precedence to growing large antlers. In fact, wintering conditions in northern Maine WMDs typically persist 3 to 5 weeks beyond the time that bucks initiate antlerogenesis in early April, thereby extending the period that buck fawns (short yearlings) must subsist on sub-optimal diets.

However, once snow melts, bucks in northern WMDs would probably consume a high plane of nutrition since summer density (2 to 5 deer/mi^2) is so far below summer K (60 to 80 deer/mi^2). Remaining on high quality diets from mid-May to August (when antlers harden), yearling bucks in northern WMDs may more than compensate for negative impacts of poor winter diets. Hence, YABD as presented in Figure 4 may not adequately track herd density relative to winter carrying capacity. This would reduce our capability to detect when populations are at 50 to 60% of MSP where limited wintering habitat exists.

Perhaps a different paradigm is needed for YABD in northern WMDs. Conceivably, higher YABD thresholds (e.g., 17-18mm) may more accurately integrate diet quality on winter vs. summer range. Alternatively, we may need to directly monitor carrying capacity in key DWAs using browse surveys or other indices.

It should be noted that many other northern and eastern WMDs do exhibit changes in YABD that suggest density-dependent changes in carrying capacity on winter range. They include all WMDs below districts 4, 5, and 6 (Figure 1). Winters tend to be more moderate in WMDs 7-14, 18, 19, 27 and 28 than in WMDs 1-6. This leads to the possibility that differences in winter severity may be indirectly affecting the adequacy of YABD as an index to MSP. The more northerly WMDs (districts 1-6) may be governed by density-independent winter mortality, whereas the others may be more influenced by density-dependent losses. The rationale is this. In WMDs with extreme winter severity, deep snow obliterates most forage within DWAs. Except along trails, browsing pressure remains low and mortality rate depends largely on the length and duration of winter relative to an individual deer's ability to "wait out" the long period of food deprivation. During these deep snow winters, predators (e.g., coyotes) may be able to prey non-selectively with regard to age or physical condition. Hence, this type of mortality would tend to be density-independent as well.

In this scenario a relatively fixed percent of the population will die at a given WSI, regardless of the density of the herd entering winter. Along with this, deep snow may exert an intense selective pressure on fawns, with only the largest individuals surviving to spring. These larger fawns are likely to produce larger antlers during the ensuing growing season. If this theory were true, northern WMDs would exhibit high YABD and carrying capacity within DWAs would actually remain below MSP as long as winters remain very severe. However, this also means that winter severity alone would determine deer population relative to MSP. When very severe winters predominate deer density would remain low relative to MSP. Alternatively, a change to more moderate winters would result in higher survival and result in higher density the following year. If the second winter remained moderate, the increased deer population would then impact forage as limited snow depth enables deer to range widely off-trails.

At more moderate winter severity deer would be able to access more of the available forage in the DWA for a greater duration of the winter. This would lead to density-dependent impacts on the forage supply which would be expressed by density-dependent changes in over-winter weight loss among buck fawns. Assuming less rigorous “weeding out” of different-sized deer, one would predict density-dependent effects in DWAs to be reflected in YABD where more moderate winters predominate (e.g., WMDs 7-14, 18, 19, 27 and 28).

Between 1997 and 2000, we have conducted browse surveys in 4 DWAs along the border of WMDs 4, 5, 8, and 9. They have revealed variable browsing impacts ranging from 30% to 60% of available forage. However, we have yet to analyze YABD and other population attributes in relation to these browse removal rates. At this time, we do not have sufficient evidence to rule out use of YABD as an index to MSP in any of our northern and eastern WMDs.

Using YABD, generally, as an index to MSP requires some caution and interpretation. First, the index is assumed to represent deer/forage relationships across large WMDs. To avoid sampling errors, WMD sample sizes should exceed 30 yearling bucks. Using this standard, we rarely sample enough deer in our northern and eastern WMDs (see Part II). Yearling bucks should be sampled as they occur in the weekly harvest sequence, since mean YABD often varies significantly by week of the 4-week firearm season in November (Lavigne 1993). During early November (pre-rut) yearling antler size varies greatly, but small-antlered spikehorns often predominate. By the peak of the rut (3rd week of November), we usually note an increase in larger yearlings carrying 4 to 8 antler points. These larger individuals may be more actively participating in the rut than their small counterparts. This in turn may render larger yearlings more vulnerable to hunting mortality, as is the case for mature bucks. During the final week in November, antler size among hunter-killed yearlings again includes numerous small-antlered individuals. This probably relates to lower selectivity among hunters as the firearms season winds down.

In addition, we may introduce a bias toward larger antlered yearlings where any-deer permits are conservative. Yearling bucks that lack legal size (3 inch) antlers, or that possess small spikes would not likely be killed and registered. In addition, YABD may decrease slightly when an unusually severe winter occurs and increase following extraordinarily mild winters. Hence, it is beneficial to examine trends in YABD in each WMD over several years (e.g., Figure 5) to interpret herd status relative to MSP.

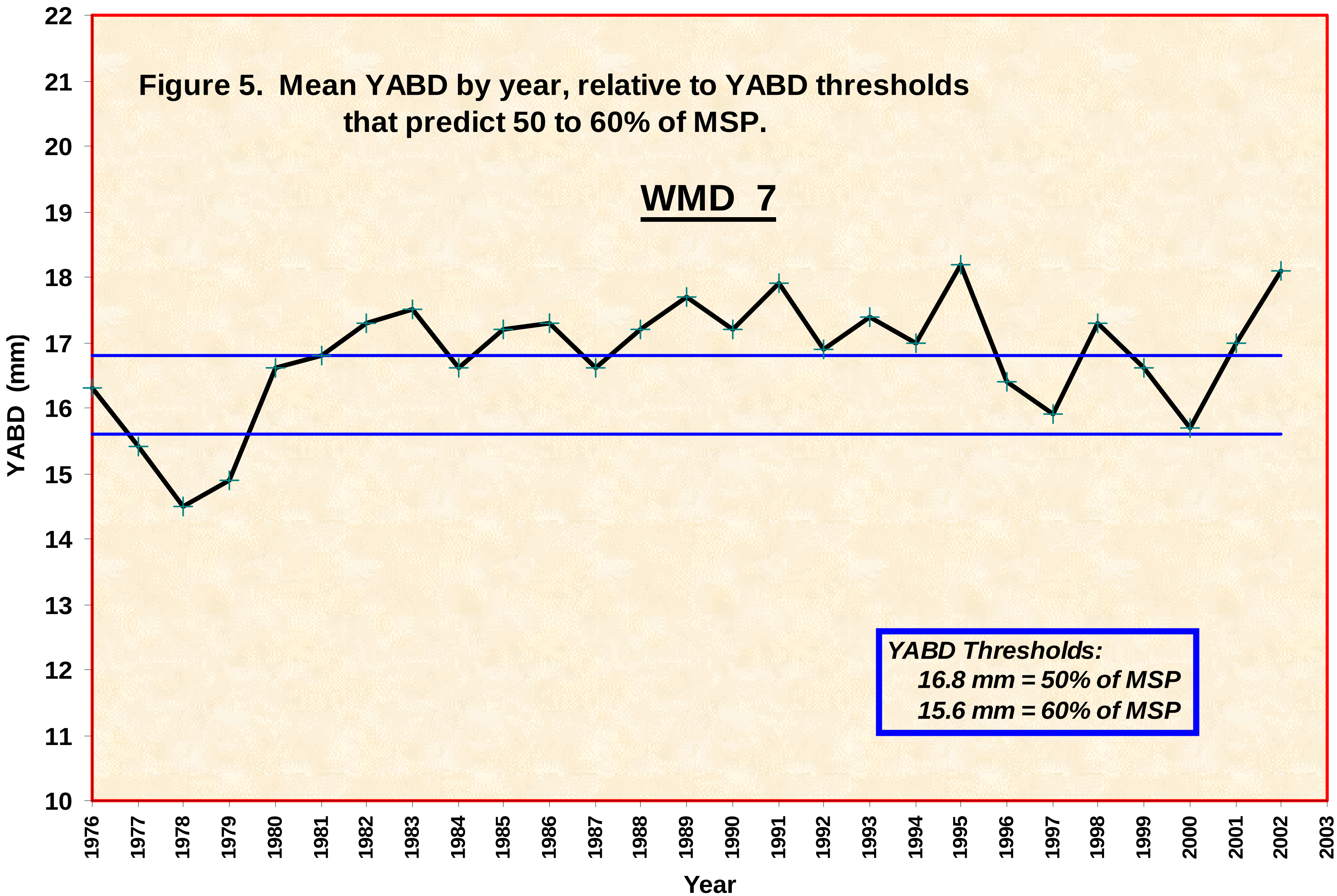


Figure 5. Mean YABD by year, relative to YABD thresholds
that predict 50 to 60% of MSP.
WMD 7
YABD Thresholds:
16.8 mm = 50% of MSP
15.6 mm = 60% of MSP
YABD (mm)
22
21
20
19
18
17
16
15
14
13
12
11
10
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Year

Finally, YABD must be measured accurately. With population means often varying by a few millimeters, it is critical not to introduce measurement bias into field measurements of YABD.

<u>HARPOP</u>

HARPOP is a variant of the standard sex-age-kill model that yields an estimate of population density from age-specific harvest data. Model inputs include harvest by sex and age, yearling frequency by sex, an estimate of hunting mortality rate for bucks, and an estimate of fawn recruitment. Most model inputs are derived from the registered harvest and the biological sample of the harvest (Appendix 3). Buck hunting mortality rate is predicted using hunting effort as the independent variable. This regression equation was derived using mortality rates resulting from population reconstruction of 1978 to 1982 harvest and biological data (Appendix 3). However, the regression was updated in 1997 from more recent data.

Based upon limited comparisons with deer pellet group surveys conducted between 1978 and 1988 (Appendix 8), the HARPOP model seems to provide reasonable estimates of deer density, if model inputs are carefully selected. I believe the model's greatest limitation is that it is very sensitive to the buck harvest. The model assumes that the size of the adult buck harvest is directly proportional to the size of the population as a whole. Consequently, perturbations in the buck harvest due to deviations in hunting effort, or hunting conditions (e.g., tracking snow or prolonged rain) will result in erroneous population estimates.

To overcome this bias in buck harvest, when it can be detected, one would need to provide a correction factor before inputting the buck harvest variable. For example, in 1998 and 1999, warm, rainy firearms seasons resulted in abnormally low buck harvests. In those years, I corrected for this bias using the rate of change in the road-kill index (see Population Trend Data, page 84). Unfortunately, this modification proved to have resulted in an over-estimate of density in most central and southern Maine WMDs based on more recent population estimates (Figure 6).

A far better correction for deviations in buck harvest caused by hunting effort or unusual hunting weather would be to use actual estimates of hunting effort and success. The statistic would be an annual estimate of buck harvest per 1,000 hunter-days in each WMD (i.e., catch per unit effort). We currently do not survey hunters to estimate effort; the last survey was done in 1996 (Appendix 2).

Under the 2000-2015 management goals and objectives, the Department was directed to maintain deer populations in southern and central Maine at certain densities. To evaluate whether progress is being made towards achieving these objectives we need accurate density estimates from HARPOP. Accurate density estimates require annual estimates of hunter effort. To achieve our management objectives, the Department needs to make obtaining information on deer hunter effort a high priority activity.

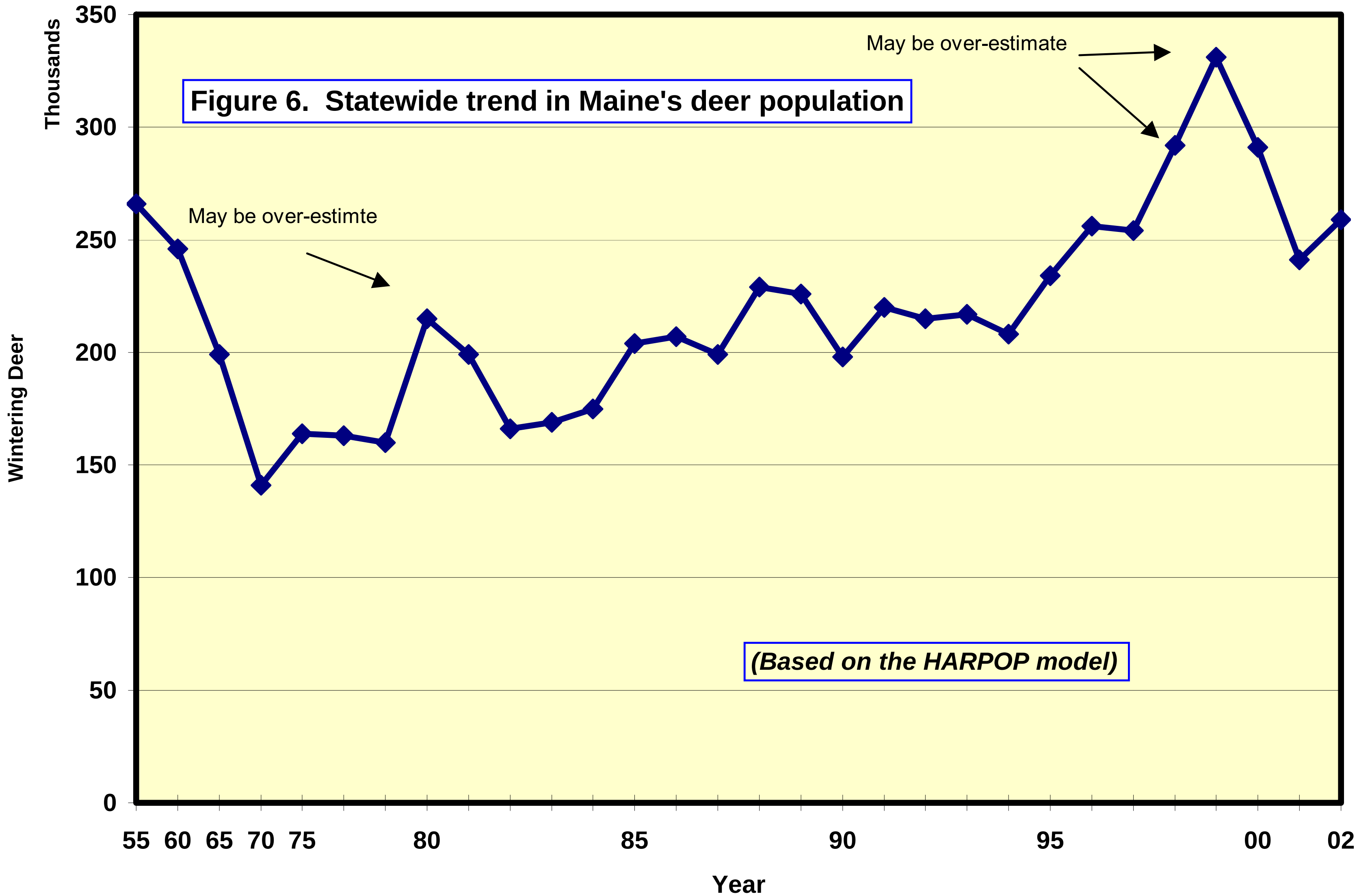


Figure 6. Statewide trend in Maine's deer population
May be over-estimate
May be over-estimte
(Based on the HARPOP model)
Wintering Deer
Thousands
350
300
250
200
150
100
50
0
55 60 65 70 75 80 85 90 95 00 02
Year

Since 2001, we have surveyed successful deer hunters to elicit annual moose and deer sighting rates among WMDs (Morris 2003). Unfortunately, only successful deer hunters are sent questionnaires for this survey. If deer hunting effort was calculated from these data it may be biased, since successful and unsuccessful hunters likely do not put in the same amount of hunting effort.

BKI

The buck kill index (BKI) is calculated as the harvest of antlered bucks per 100 mi^2 of habitat. With buck harvest standardized for area, this index allows comparison of buck harvest trends among WMDs. However, such comparisons are only approximate, since hunting removal rate for antlered bucks varies among WMDs.

The BKI is also useful for revealing trends in buck harvest, and presumably the population as a whole, over time within individual WMDs (e.g., Figure 7). This enables us to use the BKI to evaluate population stability (Table 5) over a period of years. It also provides a valuable tool to assess effects of past harvest management and/or stochastic changes in non-hunting mortality. For example, it is apparent from Figure 7 that our efforts to increase deer populations in WMD 16 certainly succeeded (when we restricted doe harvest between 1986 and 2000).

Unfortunately, the usefulness of the BKI is limited by the same biases described for the buck harvest variable in HARPOP. Changes in buck harvest due to random changes in hunter effort or hunting weather will produce variation in the BKI that may be unrelated

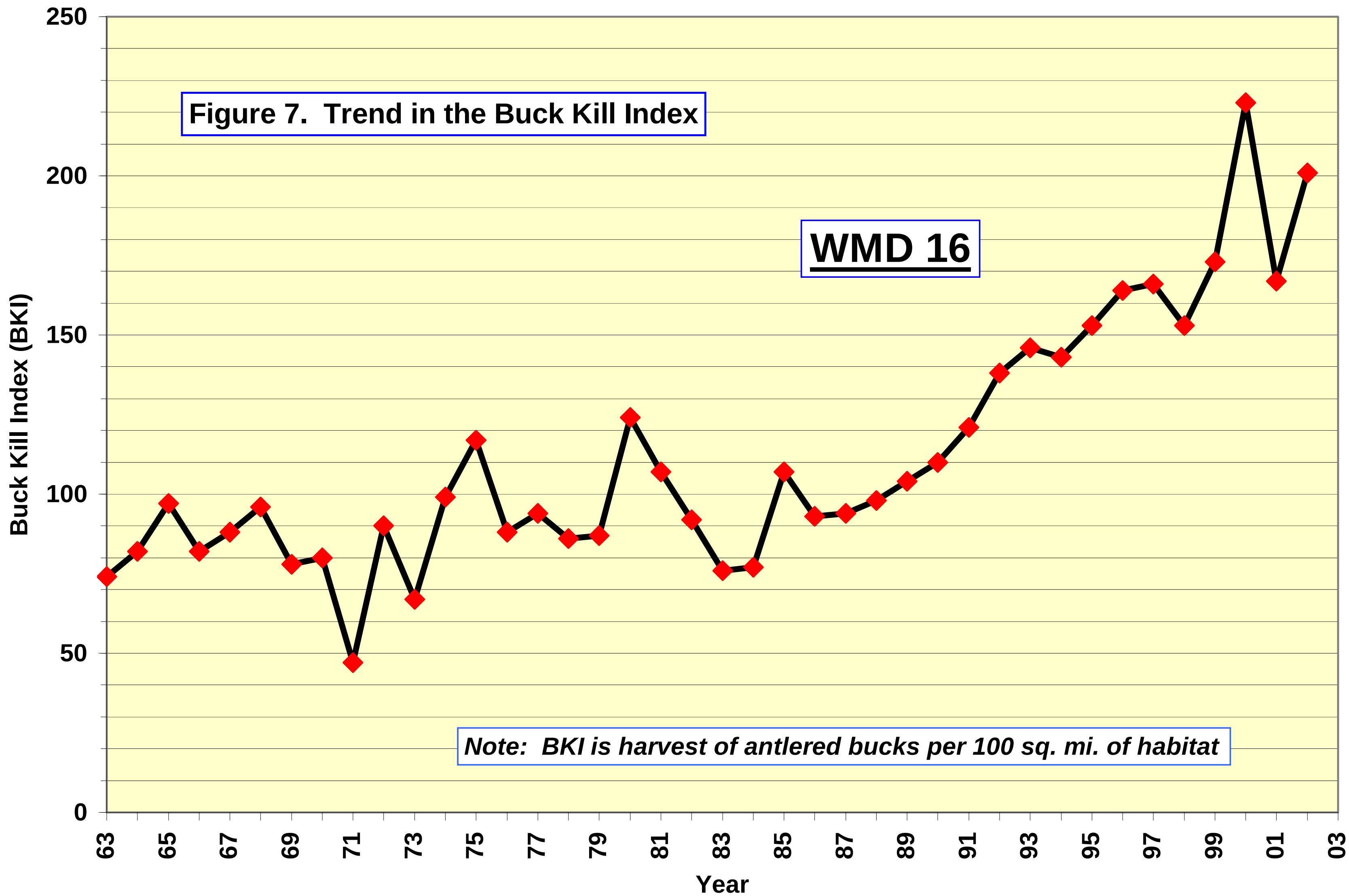


Figure 7. Trend in the Buck Kill Index
WMD 16
Note: BKI is harvest of antlered bucks per 100 sq. mi. of habitat
Buck Kill Index (BKI)
250
200
150
100
50
0
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
99
01
03
Year

to actual population changes. The bottom line is that we are unable to rule out the possibility that a change of ± 10% in the BKI may be caused by variations in hunting weather or effort and not actual population change. This bias can be accommodated under most situations, by accepting normal variation (e.g., ± 10% per year or ± 15% over 3 years), when interpreting the BKI (Table 5).

However, a more troubling bias threatens the utility of the BKI. Long-term changes in hunting effort, in either direction, will result in a corresponding increase or decrease in the BKI. For example, an influx of hunters over a period of years will result in an increasing trend in BKI. This will give the impression that the population is increasing. The herd may well be increasing, but it could also be declining. We simply cannot be sure if effort is changing incrementally and not being measured.

Considering the changes occurring in hunter participation over the past 30 years (fewer hunters but higher per capita effort; Lavigne 1999), we would be well served to more accurately monitor annual changes in hunting effort among WMDs. In addition, recent changes in bag limit for the expanded archery season and changes in hunter distribution caused by modifications to the any-deer permit application process are both likely to cause wider variation in deer hunter distribution among various WMDs. Unless these changes in effort are quantified, the BKI will become less useful as an index to deer population change.

Some states use BKI as the sole input to determine when the population is at target density. For example, they may consider the population objective to be satisfied if the BKI remains in the range of 150 to 160 antlered bucks per 100 mi^2. While this is certainly feasible for Maine and would obviate the need to use the HARPOP model using BKI has its pitfalls. The first involves the hunting effort and success biases described above. The second is that the buck harvest alone does not reveal any information about the position of the herd on the carrying capacity continuum. One could extract a harvest of 1,000 bucks, for example, from a herd held at 35% of K and one held at 68% of K (Figure 8). Although the magnitude of the buck harvest would be the same, the impact of the deer population on people living there may be dramatically different! Unless one also relies upon some index (e.g., YABD) that reveals the herd's status relative to K, use of the BKI alone may lead to increased conflicts with landowners and motorists in the long run.

WSI

The winter severity index (WSI) has been used to monitor winter mortality rate in Maine for over 30 years. The WSI is highly correlated with estimates of winter mortality, derived from pellet group and dead deer surveys in individual deer wintering areas (Appendix 4). The WSI also showed significant correlations with femur marrow fat in deer mortalities (Lavigne 1992), and with fetal mass in April and May (Lavigne 1991[b]). The latter measurements enabled us to estimate WSI effect on neonatal deer mortality in Maine as developed for deer in Michigan (Verme 1977).

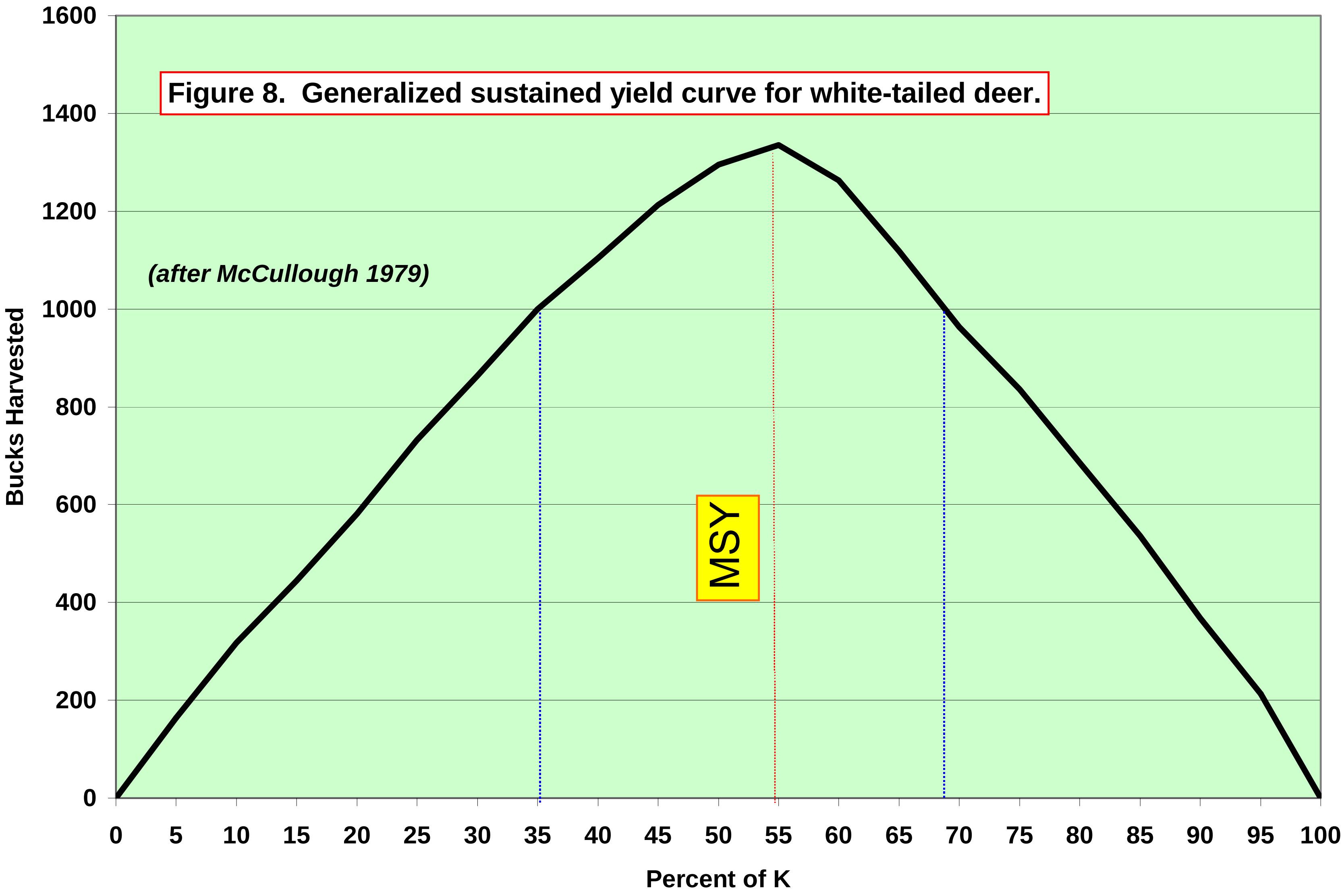


Figure 8. Generalized sustained yield curve for white-tailed deer.
(after McCullough 1979)
MSY
Bucks Harvested
Percent of K
0
200
400
600
800
1000
1200
1400
1600
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

At this time, I believe the WSI is adequate for our purposes. However, there may be some cost-savings to be achieved by simplifying the model to an energetics basis using deer sinking depth and temperature as the sole inputs. (Snow depth measurements could be dropped). Deer sinking depth could be measured by biologists or cooperators while performing other duties in wintering habitat. While model conversion was identified as a task to be performed during the past update of this management system (1989), other time and personnel commitments prevented its accomplishment.

Following review of the deer population management system in 1989, we ended collection of data (femur fat, reproductive status) from winter mortalities in an effort to save time and money. For the past 13 years, we have relied solely upon the WSI to predict nutritional condition of wintering deer and subsequent neonatal mortality. During the past 15 years we have also reduced time commitments for dead deer and pellet group surveys to only those which could be scheduled by the deer study leader. One notable exception were the 4 browse studies conducted in 1998-2000 in WMDs 8 and 9 by Region E biologists. These browse studies were paired with dead deer/pellet group surveys at the time.

This reduction in regional personnel commitment to deer study work came at a time when the relationship between WSI and winter mortality rate needed to be re-evaluated. In the mid-1980's, we discovered (from Chilelli 1988, and from our early experience in using the deer management system) that the WSI-winter mortality equation developed from data generated in the 1970s was likely under-estimating the impacts of wintering conditions on the population. This was logical, in view of the loss and deterioration of wintering habitat that was going on at the time. With limited personnel resources, we eventually generated enough data to revise the WSI-winter mortality equation by 1999 (Appendix 4). However, the model remains weak at both extremes of winter severity. Efforts should be made to fill in the gaps during the next few years.

Over the long-term, the quantity and quality of wintering habitat will change in Maine. The Department is currently engaged in an aggressive program to enhance the wintering habitat base. Moreover, other initiatives, such as conservation easements will likely affect future habitat availability. In addition, the spruce-fir resource will increase over the next decade or more simply from ingrowth of stands logged in earlier decades. On the other had the world demand for paper and lumber is not likely to decrease. How all of these variables will affect wintering habitat, winter mortality patterns, and deer density in the future is really unknown. Furthermore, the potential for introduction or immigration of gray wolves into Maine in the future adds to this uncertainty. In light of the above it would be a mistake to discontinue periodic re-evaluation of the WSI as an adequate index to winter mortality and natal mortality of Maine deer.

CHRONOLOGY OF DEER REGULATORY MANAGEMENT

The management decision process follows a distinct annual chronology which involves collection and interpretation of data, decision making related to any-deer permit allocations, implementation of management actions and evaluation of results (Table 7). During certain times of the year various facets of the management process may be operating concurrently with the simultaneous involvement of several divisions and/or sections within MDIFW.

Schedules for rulemaking and the any-deer permit application process are relatively rigid each year. As a result there is little leeway to accommodate delays in entering and compiling deer harvest, biological, and license data. Despite this there has been a trend toward later arrival of raw data from data entry personnel in Augusta. Compared to a decade ago these data now arrive 3 to 4 weeks later. Yet, the deadlines for initiation of rulemaking and application processes have not changed. This places a severe burden on WRAS personnel to adequately analyze and compile inputs to the population management system in a timely manner. Too often, regional biologists are given only a short time (< a week) to analyze data prior to meeting to recommend any-deer permits.

Table 7. Chronology of Deer Population Management System Activities.

September – November	Hunting seasons and harvest registrations Collect harvest biological data
December	Data entry of deer registrations and processing of biological data Begin winter severity monitoring Preliminary evaluation of harvest management actions (past fall)
January	Continue data entry of deer registrations and biological data Continue winter severity monitoring
February – March	Complete data entry. Perform analyses of harvest and biological data Evaluate current deer status and develop preliminary harvest prescriptions without winter severity adjustment Initiate rule making for proposed hunting regulations Continue winter severity monitoring
April	Hold public informational meetings re deer status and proposed regulations, if needed Conclude winter severity monitoring Adjust harvest proposal for winter severity, if necessary Advertise hunting regulation proposal and hold public hearings, if needed Begin pellet group surveys and dead deer surveys, if time allows
May	Deer hunting regulations adopted following Advisory Council meeting Continue pellet group surveys
June – September	Application period and drawing for any-deer permits

RECOMMENDATIONS

The following actions are suggested as ways of improving the deer population management system. Addressing some of these recommendations will entail additional research and survey work. Hence, incorporation of this work may entail modification to division work plans and budgets.

- Adopt the rule-of-thumb (Table 5) for central and southern WMDs that specify management for a range of densities (e.g., 18 to 22 deer/mi^2) rather than a single density (e.g., 20 deer/mi^2).
- Test the hypothesis that some WMDs in northern and eastern Maine are governed by density-independent mortality, rather than density-dependent mortality.
- Resolve the question regarding validity of using current thresholds for YABD (Table 5) as a predictor of MSP in northern and eastern WMDs.
- Improve the WSI-winter mortality regression by adding data points at very mild and very severe WSI.
- Improve the HARPOP and BKI indices by incorporating "harvest per unit effort" to correct for bias in annual buck harvest rates in individual WMDs.
- Test the validity of the HARPOP model using spring pellet group surveys.
- Test the validity of the recruitment estimate that is used as an input to the HARPOP model.

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PART II. DEER POPULATION MANAGEMENT DATABASE AND DATA COLLECTION SUMMARY

INTRODUCTION

The following section provides a brief evaluation of the data we collect to support the deer management system. It is from these data elements that we compile various models, indices, and system criteria that enable us to make informed management decisions. Detailed descriptions of deer management system models, indices and system criteria appear as appendices in this section.

DEER HARVEST REGISTRATION DATA

All deer harvested in Maine must be registered and tagged at one of the 450 registration stations operated by private cooperators throughout the state. At these stations, the following information is recorded: hunter name, residence, hunting license number, any-deer permit number, date and time of license issue, date, time, town and WMD of kill, and sex/age class (fawn or adult). Finally, a uniquely numbered tag (seal) is attached to the deer and recorded. Registration data are digitally compiled by town, county, WMD, and statewide by year and sex/age class. Total registrations are available at the statewide level from 1919 to the present; summaries of total harvest are available by town from 1939 onward, while registrations summarized by sex/age class for towns and WMDs are available from 1963 onward. Annual deer harvest has varied from 25,000 to >38,000 deer statewide over the past 2 decades (see Job III-302, Segment 18).

Major limitations of the deer registration data involve recording errors and inaccurate sex/age designation which occur because registration station operators receive no biological training. Occasionally, registration data are lost by district wardens or turned in too late for analysis.

Error rates inherent in the registration data are determined annually by comparing sex/age designations from a sample of 5,000 to 7,300 deer examined by biologists. Aging errors are consistent among years, and they range from 3% for antlered bucks, 10% for adult does, and 20 to 35% for fawns (see Job III-304, Segment 18). Corrected deer registrations are used to calculate buck kill indices (pp 57-60). In addition, sex and age specific harvest totals are an input into the HARPOP model, which provides estimates of post-hunt deer density (Appendix 3).

DEER HARVEST BIOLOGICAL DATA

Each year roughly ¼ of the deer legally harvested in Maine are examined by biologists at roadside check stations or during visits to meat lockers, registration stations, homes or camps (see Job III-303, Segment 18). Most sampling occurs during the regular firearms and muzzleloader seasons, which annually account for ~90% of total deer harvests.

Harvested deer examined by biologists are assigned to fawn, yearling or adult age classes by tooth wear and replacement. Deer of uncertain age are assigned an age class based upon counts of cementum annuli in the lab. Antler beam diameter (YABD) and number of points are measured, primarily for yearling bucks. When feasible, dressed weight is determined for fawns and yearlings of both sexes. Does over one year of age are examined to determine if they are lactating. Finally, date, town of kill and seal number is recorded. Most biological data, at least at the statewide level, are available from 1954 to the present. Town and WMD level data are available from 1973 to the present.

Sex-specific age ratios (yearling vs. older bucks or does) tend to reflect prehunt population age ratios in WMDs that are adequately sampled. These ratios provide an index to sex-specific annual mortality rates. However, annual variations in recruitment may bias these mortality estimates. To overcome this, we calculate a running 7-year average for age ratio data. At current sampling intensity, sample sizes of yearling and older bucks are adequate to estimate all-cause mortality in all WMDs. Among does however, it is necessary to pool age ratio data among several WMDs, and/or extend the running average beyond 7 years to accumulate sufficient sample size (n = 100 does) where antlerless deer hunting is limited (e.g., eastern and northern WMDs). In a typical year biologists determine age class for ~4,500 bucks vs. ~2,000 does, statewide.

Measures of yearling antler size (YABD, number of points, and % spikes) provide an index to deer population status relative to ecological carrying capacity (Lavigne 1999). Mean YABD is used as a decision criterion in the population management system (pages 47-57). In addition, mean YABD is used as a predictor of age-specific reproductive rate in deer populations at the WMD level. Predicted reproductive rate, in turn, is used in the model allowing calculation of annual recruitment (Table 8). Statewide, we annually collect antler measurements from ~1,500 yearling bucks. Assuming a minimum acceptable sample size of 30 yearling bucks per WMD, our current sampling intensity is usually adequate in 2/3 of our 30 WMDs. In districts with lower sample sizes (primarily northern WMDs), yearling antler data are pooled among years before input into models or indices.

As with yearling antler size, mean hog-dressed weights among fawns and yearlings correlate with herd nutritional status relative to biological carrying capacity (Lavigne 1999). At the WMD level, sample sizes are rarely adequate (n = 30) to provide a statistically reliable estimate of mean weight of any sex-age class in most WMDs. Because of this limitation, we use mean dressed weight only as a supplementary source

Table 8. Age-specific reproductive rate (embryos per doe), as predicted from mean antler beam diameter of yearling bucks (YABD) statewide in Maine during 1954-2005.

			Predicted Embryos Per Doe[3]			
			Doe Age at Parturition			Wtd.
Year	YFF[1]	YABD[2]	1	2	3+	Mean
1954	29	16.8	-	-	-	-
1955	29	16.0	0.178	1.262	1.749	1.191
1956	29	15.0	0.090	1.148	1.705	1.120
1957	29	16.5	0.000	1.005	1.652	1.037
1958	29	15.2	0.145	1.220	1.732	1.164
1959	29	14.6	0.002	1.034	1.663	1.049
1960	29	15.8	0.000	0.948	1.631	1.015
1961	29	15.4	0.068	1.119	1.694	1.102
1962	29	16.0	0.024	1.062	1.673	1.066
1963	29	16.3	0.090	1.148	1.705	1.120
1964	29	15.9	0.123	1.191	1.721	1.146
1965	29	16.5	0.079	1.134	1.700	1.111
1966	29	15.3	0.145	1.220	1.732	1.164
1967	29	16.0	0.013	1.048	1.668	1.054
1968	29	15.9	0.090	1.148	1.705	1.120
1969	29	12.9	0.079	1.134	1.700	1.111
1970	29	16.9	0.000	0.705	1.546	0.921
1971	29	15.4	0.189	1.277	1.754	1.200
1972	29	15.8	0.024	1.062	1.673	1.066
1973	29	16.8	0.068	1.119	1.694	1.102
1974	31	17.7	0.178	1.262	1.749	1.160
1975	31	16.2	0.277	1.391	1.799	1.242
1976	31	16.4	0.112	1.177	1.716	1.106
1977	31	16.8	0.134	1.205	1.727	1.124
1978	31	16.6	0.178	1.262	1.749	1.160
1979	31	16.5	0.156	1.234	1.738	1.142
1980	31	17.8	0.145	1.220	1.732	1.133
1981	31	18.2	0.288	1.405	1.804	1.250
1982	31	17.4	0.332	1.463	1.827	1.287
1983	29	17.1	0.244	1.348	1.782	1.245
1984	29	17.4	0.211	1.305	1.765	1.218
1985	29	17.8	0.244	1.348	1.782	1.245

Table 8. Age-specific reproductive rate (embryos per doe), as predicted from mean antler beam diameter of yearling bucks (YABD) statewide in Maine during 1954-2004 (continued).

			Predicted Embryos Per Doe[3]			
			Doe Age at Parturition			Wtd.
Year	YFF[1]	YABD[2]	1	2	3+	Mean
1986	27	18.0	0.288	1.405	1.804	1.316
1987	27	17.7	0.310	1.434	1.816	1.334
1988	27	17.4	0.277	1.391	1.799	1.308
1989	27	17.4	0.244	1.348	1.782	1.281
1990	27	17.4	0.244	1.348	1.782	1.281
1991	27	17.6	0.244	1.348	1.782	1.281
1992	26	17.6	0.266	1.377	1.793	1.316
1993	24	17.7	0.266	1.377	1.793	1.351
1994	25	17.5	0.277	1.391	1.799	1.342
1995	24	17.9	0.255	1.363	1.787	1.342
1996	24	17.1	0.299	1.420	1.810	1.376
1997	24	17.4	0.211	1.305	1.765	1.308
1998	23	18.4	0.244	1.348	1.782	1.351
1999	23	18.0	0.354	1.491	1.839	1.436
2000	23	17.8	0.310	1.434	1.816	1.402
2001	21	17.7	0.288	1.405	1.720	1.419
2002	22	18.1	0.277	1.391	1.799	1.380
2003	22	17.5	0.321	1.448	1.822	1.428
2004	21	17.5	0.255	1.363	1.787	1.395
2005	20	17.5	0.255	1.363	1.787	1.395

[1]YFF = percent yearling does among yearling and older does. YFF may be used as an index of population age structure. Hence, in a population with a YFF of 25, does aged 1, 2, and 3+ would comprise 25, 19, and 56 percent, respectively of the does older than fawns.

[2]YABD = mean antler beam diameter (mm) of sample of yearling bucks, as measured 25 mm above the burr.

[3]Age-specific embryo rate predicted from mean YABD measured during the same year as conception using the following equations:

Embryos per doe age 1 = $-1.67 + 0.11\ YABD$
Embryos per doe age 2 = $-1.14 + 0.143\ YABD$
Embryos per doe age 3 = $1.03e^{0.0315\ YABD}$

Note: Current year predicted embryo rate is calculated from previous year YABD of information when assessing herd status relative to carrying capacity. We are able to record dressed weight of ~1,500 fawns and yearlings in a typical year, statewide.

Yearling and adult does that are accompanied by one or more young of the year maintain limited milk production to support social interactions as late in the autumn as mid-December. Hence, the presence of milk in harvested does can be used as an index to fawn recruitment (Table 9). While examining harvested deer biologists record the lactation status of does if udders remain on the carcass. Nipple length, the presence of milk, and active mammary tissue all support a conclusion that a given doe had a fawn at heel when she was killed. It is possible that lactation incidence may be under-estimated if hunters tend to completely excise milk-producing udders vs. retaining dry udders. However, this potential bias has not been objectively evaluated. The number of does we are able to examine for lactation status is inadequate in most WMDs, most years. Hence, it is necessary to pool WMDs and/or years to attain more reliable sample sizes (n = 100). As a consequence, estimates of lactation status and recruitment tend to reflect longer-term intervals rather than annual values. In a typical year we successfully examine 200 to 300 yearling and older does for lactation status.

Table 9. Calculation of the Lactation-embryo Index, statewide, for 1986.

Doe Age at Parturition	Proportion[a] Lactating in November	Embryos[b] Per 100 Does June	Fawns[c] Recruited Per 100 Does November	Pre-Recruitment[d] Fawn Mortality Rate (%)	Doe Herd Composition[e] Spring	Fall
Yearling	.061	39	2.4	94	.297	.265
2+ Years	.793	170	134.8	21	.703	.735
Weighted Total		135	100[f]	26	1.000	1.000

[a] As determined from examination of does in the harvest biological sample

[b] Predicted from statewide YABD from the harvest biological sample. Weighted total is computed from yearling:adult ratio (see footnote e).

[c] [Embryo rate] x [proportion lactating in November]. Weighted total is computed from yearling:adult ration in fall (see footnote e).

[d] 1-[Fawns recruited in November] / [June embryo rate]. Weighted total is computed from [1- ((November fawns:100 does) divided by (June fawns:100 does))] x 100 yearling: adult ratio in fall (see footnote e).

[e] Yearling frequency (%yearling among yearling and older does) and its complement in the harvest biological sample. Spring age ratio derived from 1985 harvest biological sample while Fall ratio was derived from 1986 harvest biological sample.

[f] Weighted total fawn recruitment estimate is the LER index value.

WINTER SEVERITY INDEX

The depth and duration of snow cover, along with low temperatures and wind chill (i.e., winter severity) exert a profound effect on deer survival. In parts of Maine that routinely experience severe winters, winter mortality may be the largest single mortality factor affecting herd dynamics (see pages 29-42). This is particularly evident in areas that lack quality wintering habitat. Even in parts of Maine that typically experience more favorable wintering conditions, severe winters periodically occur, temporarily altering normal mortality patterns. Accounting for annual changes in winter severity is essential to making reliable deer management decisions in Maine.

To monitor wintering conditions, we annually visit 28 deer wintering areas (DWAs) at weekly intervals from early December through late April (see Job III-305, Segment 18). We systematically measure snow depth in openings and/or hardwoods, while also measuring the depth at which deer sink in the snow pack. We also document the presence of crusts in the snow profile relative to their supporting quality for deer. At most of our sample DWAs, we continuously record air temperature in openings at deer height. Winter severity monitoring sites are strategically located to sample all of Maine's major climate regions, although a few WMDs do not have a monitored DWA within its borders.

Snow depth and deer sinking depth together are an index to relative deer mobility, and they are in turn strongly correlated with predation rates and winter nutritional status

(Lavigne 1992). These influences are further modified by low air temperature, since prolonged periods of below-zero cold increase demand for calories to maintain body temperature. Failure to meet that demand, as during times of poor mobility exacerbates nutritional deficits and predation losses.

Winter severity data are compiled into an index (WSI) that incorporates mean snow depth relative to a critical threshold for mobility (20”), mean sinking depth (relative to an 18” threshold), and air temperature relative to long-term norms. WSI values are calculated for the winter period by individual monitoring sites, WMDs, and statewide. They are also computed weekly and monthly. Statewide WSI is available from 1950 to the present; severity index values at the WMD and site levels are available from 1973 to the present.

WSI values for the entire winter are a good predicator of winter mortality rate, using individual sites, WMDs, or statewide level data (Appendix 4). However, refinements in the WSI-winter mortality rate algorithm are desirable at both extremes of severity (see Job III-313; Segment 15). The WSI is also an adequate predictor of late winter nutritional status, as determined from mean femur fat levels (Lavigne 1992); and as a predicator of nutritionally-related fawn losses at birth (Lavigne 1991). Because of the predictive capability of our WSI, we no longer routinely conduct post-winter deer mortality surveys, late winter femur data, or late gestation examination of deer fetuses.

We have developed a process that enables us to adjust for above (or below) normal winter mortality when recommending doe harvest quotas in the deer population management system (Appendix 4).

POPULATION TREND DATA

The buck kill index (BKI) and the harvest-derived population model (HARPOP) are discussed in detail in the main section of this document and in Appendix 3.

We also collect other trend data to supplement the major population indices. The numbers of deer-vehicle collisions, in theory, are positively related to deer density in areas with widely distributed roads. However, annual changes in traffic volume and consistency of reporting may greatly bias trend lines. In Maine, counts of deer/vehicle mortalities for which game wardens and police agencies issued a carcass tag provide an annual index to deer abundance. Because of probable regional and temporal variation in reporting by enforcement personnel, this road-kill index is of limited usefulness, except at the statewide level. Data are simply too variable to compare among WMDs in a given year, or between years in a given WMD (see Job III-318; Segment 18).

Two annual hunter surveys yield data on deer observation rates (Appendix 2). A mandatory questionnaire is issued to moose hunting permittees (n = 1,000 to 3,000) that asks them to report the number of deer they observed while on their (Sep. or Oct.) moose hunt. Data derived from this survey are compiled as deer seen per 100 hours of moose hunting. Although restricted to only those WMDs that are open to moose hunting (northern 2/3 of Maine), trend data are available for >20 years. Trends in deer sightings evident for various parts of the moose hunting zones appear to correlate with

BKI and HARPOP trends. Moreover, few other independent trend data are available for this part of the state.

A separate survey is sent to ~10,000 successful deer hunters, who are asked to report the number of deer they observed, the WMDs they hunted, and the number of hours they spent pursuing deer. This yields an estimate of deer seen per 100 hours of deer hunting averaged for individual WMDs and statewide. Complete datasets are only available for 2002 and 2003, which limits our ability to evaluate the usefulness of this index at this time. In 2006 we will incorporate this information into a hunter effort survey with the potential to estimate number of deer seen per unit effort.

Spring pellet group surveys, conducted on study areas encompassing 4 or more contiguous towns (~150 $mi.^2$) formerly (1975 to 1990) provided a useful supplementary check on posthunt density estimates generated from the HARPOP model (Appendix 3). The deer population management system would benefit from validation studies using deer pellet group surveys as a test of current estimates generated from HARPOP. However, current manpower limitations preclude widespread use of this technique (see Job III-318; Segment 18).

HUNTING EFFORT DATA

Attaining unbiased estimates of hunter effort is important for evaluating changes in buck harvest, particularly when buck harvest is used to index deer population change in the management system (pages 60-63). Prior to 1985, we conducted annual surveys of a random sample (n = 10,000) of deer hunting license holders. This yielded estimates of hunter density, hunter effort, and harvest per 1,000 hunter days at the regional (formerly 8 WMUs) and statewide levels (Appendix 2). Annual surveys were discontinued as a cost-saving measure and replaced by similar, but less frequent surveys. The most recent is 1996. Although some hunter effort and participation data can be estimated by extrapolation back to a 1996 baseline, this practice becomes less likely to accurately reflect current patterns of deer hunting effort with each passing year. In 2006 a new hunter effort survey will be introduced that should provide us with reliable estimates of effort and participation if response rate is statistically adequate.

FOREST RESURVEY DATA

The Maine Forest Service conducts periodic surveys to evaluate forest type, composition, volume, and growth. Forest survey plots are stratified by major forest type and region throughout Maine. Formerly, the forest re-survey followed a 10-year reporting cycle (e.g., Griffith and Alerich 1996). However, forest re-survey sampling is currently continuous, with regional sampling conducted on a rotating basis, using a 5-year cycle.

The forest re-survey, when recompiled to represent our 30 WMDs, provides a reasonable estimate of the extent of <u>major</u> forest types and their basic attributes (Chilelli 1998).

HUNTING ZONES, WMUS, DMDS, AND WMDS

The Department has long recognized the desirability of managing deer populations on a regional basis (Banasiak 1964). Maine varies widely in climate, physiography, vegetative cover, land-use, and human population. Each of these variables can influence deer survival, carrying capacity, and management needs (Lavigne 1999).

Initial attempts to provide regionalized harvest management usually involved a two-zone system (e.g., Figure 9) in which the length of our either-sex firearms hunting season varied for each zone. This level of management was featured for all years between 1893 to 1985 (Stanton 1963). During some years, we divided the state into 3 or 4 deer hunting zones, but these were the exceptions to the 2 zone tradition.

In 1968, the Department divided the state into 8 Wildlife Management Units (WMUs), using township boundaries to delineate ecologically distinct regions of Maine (Figure 9). Although the Department desired to regulate deer hunting seasons using WMUs, the Legislature rejected the concept in 1978 because they believed township boundaries are not sufficiently distinct to be practical in the field. At that time they passed legislation requiring hunting zone (or unit or district) boundaries to be readily recognizable landscape features, such as roads, rivers, powerlines, etc. Although precluded from regulating deer harvests using the 8 WMUs, the Department continued to organize deer data analyses using the WMU system between 1968 and 1985.

In 1986, the Department was authorized to regulate the harvest of antlerless deer using the any-deer permit system (Lavigne 1999, and main text of this document). Our legislative authority included implementation of a zoning system, if we used recognizable physical boundaries. Our initial implementation of that authority was the 18 Deer Management Districts (DMDs) that were used to regulate doe harvests between 1986 and 1997 (Figure 10). Although a definite improvement over the 8 Wildlife Management Units devised earlier, DMDs could still be improved upon as a vehicle for regional management of deer populations.

In 1998, the Department re-evaluated DMDs based on deer population response to harvest management at the township scale between 1983 and 1997. During all of these years, the Department implemented regulations intended to increase deer populations throughout the state (Lavigne 1985, 1999). Along with deer herd performance data, we also incorporated updated information describing Maine's climate, physiography, soils, vegetative cover, land-use, and human population. This resulted in an assemblage of the 30 Wildlife Management Districts (WMDs; Figure 11) in use until 2005. Beginning in 2006 the districts were reconfigured to better represent deer herd performance in Region C (WMDs; Figure 1). Since 1998, the Department has adopted the WMD system to regulate hunting and trapping seasons for all species.

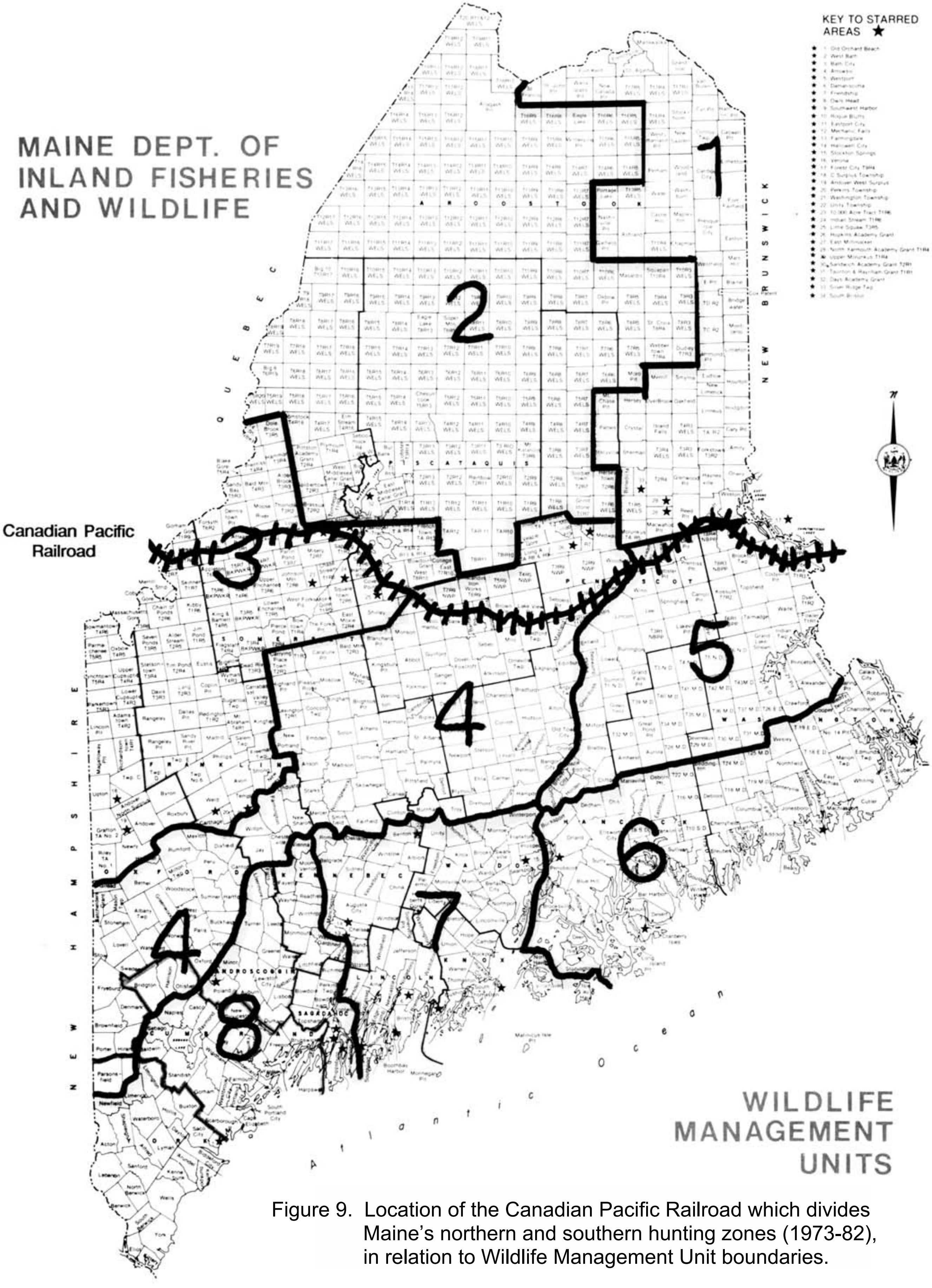

Figure 9. Location of the Canadian Pacific Railroad which divides Maine's northern and southern hunting zones (1973-82), in relation to Wildlife Management Unit boundaries.

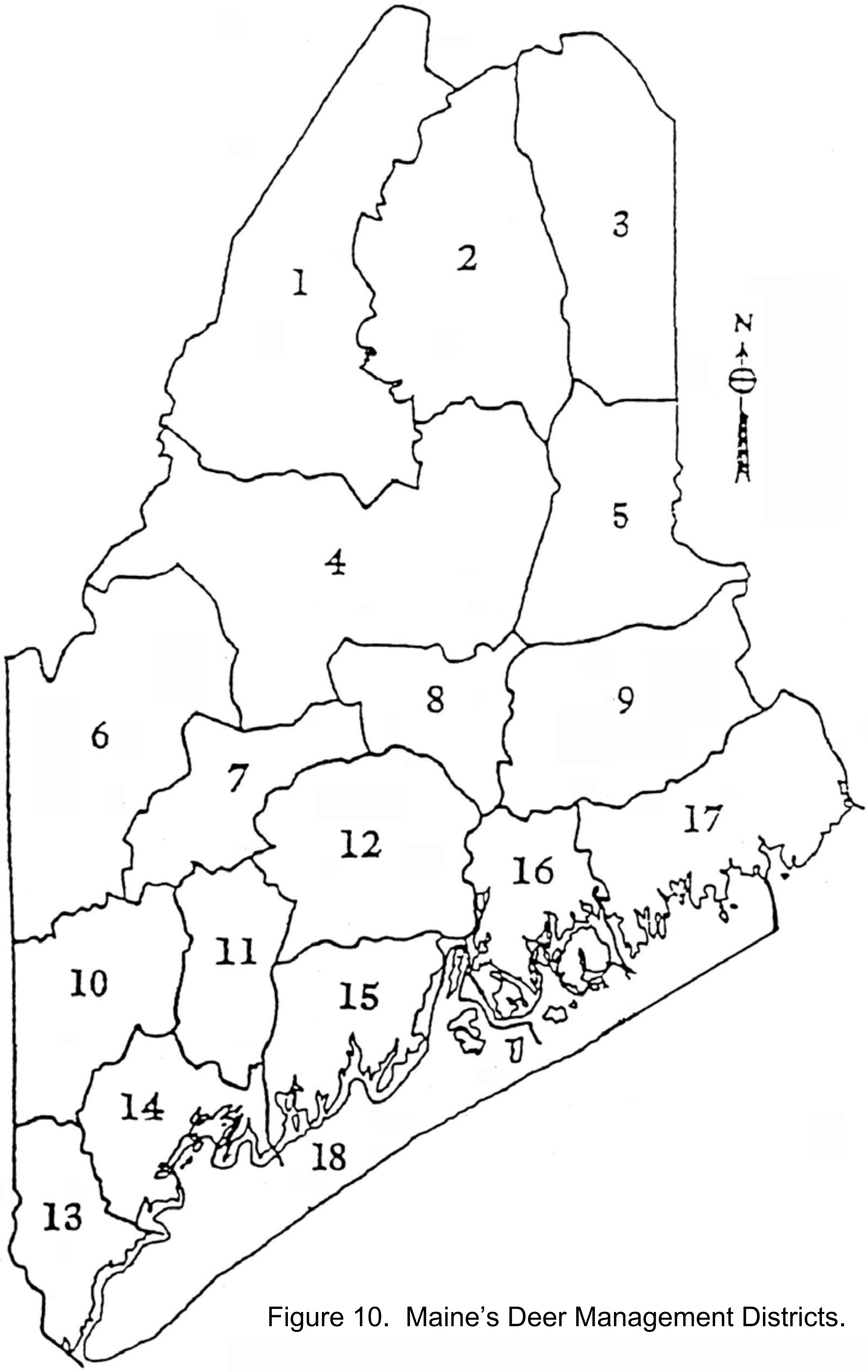

Figure 10. Maine's Deer Management Districts.

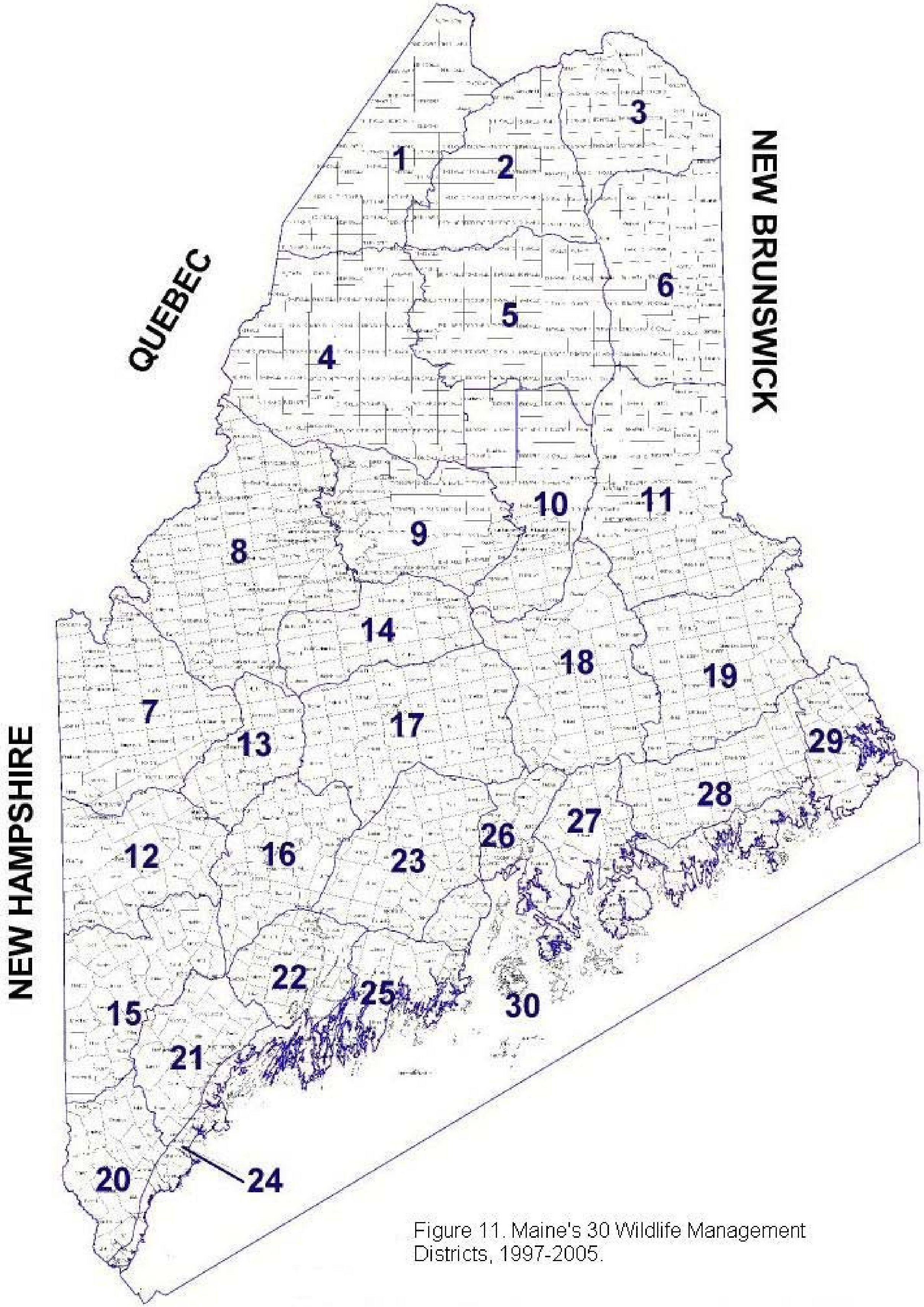

Figure 11. Maine's 30 Wildlife Management Districts, 1997-2005.

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PART III. APPENDICES

APPENDIX 1. STATUTORY AUTHORITY FOR DEER MANAGEMENT

Introduction

This appendix documents the Department's statutory authority for deer management, as vested by the Maine Legislature. In addition, each of the currently applied deer management options we currently use are defined and discussed in relation to purpose, appropriate landscale, and responsible entity (e.g., wildlife division vs. warden service), along with recent examples. A major intended outcome of this appendix is clarification and consistent use of terminology for the various deer hunts and non-traditional control options we currently use.

For example, the term "depredation hunt" is commonly used to describe a number of controlled hunts and deer culling activities that the Wildlife Division has implemented during the past 15 years. In fact, depredation culling of deer is only authorized in statute for narrow applications involving selected agricultural crops. According to statute, game wardens are the only department personnel authorized to issue depredation permits, as detailed later in this appendix. Controlled hunts and deer culling operations are authorized in a statute independent of the nuisance animal law.

Included in this appendix is the department policy (MDIFW 2002) describing when and under what circumstances various deer management control options may be employed. Deer hunting seasons along with our other deer control activities are summarized in

Table 10. The various permits we issue during deer hunting and control activities are explained in Table 11.

General Authority for Deer Management

The Maine Legislature has charged the Department with the statutory responsibility for wildlife management. Laws authorizing the Department to manage wildlife are contained in: State of Maine, Inland Fisheries and Wildlife Laws, Title 12 MRSA Part 10, Chapters 701 to 721. In addition, the Legislature has empowered the Department to regulate many of the finer details involved in wildlife management (e.g., season dates, or numbers of any-deer permits) in a timely manner through rulemaking under the Administrative Procedures Act (Title 5, Part 18).

White-tailed deer are a publicly-owned resource that is held in trust for the benefit of all Maine people. The Department has the statutory responsibility to “preserve, protect, and enhance the inland fisheries and wildlife resources of the state” (Chapter 702, Sec. 7011). The Department is specifically required to “encourage the wise use of these resources; to ensure coordinated planning for the future use and preservation of these resources and to provide for effective management of these resources”.

Table 10. Deer hunting seasons and other deer control activities currently utilized in Maine.

Season or Control Activity	Example	Statutory Authority	Rulemaking Required?	Responsible Personnel	Timeframe Allowed	Landscapes Applicable	Comments
Recreational Hunting Season	Regular Firearms	Ch. 707 Sch. III Sec. 7457-1E	Yes	Division Director	Nov. 25 days	Statewide; WMDs	Number of participants not limited. Any-Deer and Bonus Deer Permits issued.
	Statewide Archery	Ch. 707 Sch. III Sec. 7102A-6	Yes	Division Director	Oct. 26 days	Statewide	Number of participants not limited.
	Muzzleloader	Ch. 707 Sch. III Sec. 7107A	Yes	Division Director	Two wks early Dec.	Statewide; WMDs	Number of participants not limited. Any-Deer and Bonus Deer Permits issued.
	Youth Day	Ch. 709 Sch. III Sec. 7457-1J	Yes	Division Director	One Day	Statewide	Number of participants not limited.
Special Hunting Season	Bonus Deer Permits	Ch. 709 Sch. III Sec. 7457-1I	Yes	Division Director	Any Open Deer Season	WMDs	Bonus Deer Permit allows the recipient to kill an antlerless deer separate from regular bag limit in the designate WMD. Number of participants limited.
	Expanded Archery	Ch. 707 Sch. II Sec. 7102B	Yes	Division Director	Sep. to Dec.	WMDs; Towns; Multiple Ownerships	Number of participants not limited. Multiple bag limit by Expanded Archery Permit
Controlled Hunts	Swans Is. Hunts 2000-03	Ch. 703 Sec. 7035-3	No	Regional Biologist	Year Round	Town; Multiple Ownerships	Number of participants, timing, methods allowed, and bag limits set by biologist. Hunters issued Deer Management Permits.
	Sprague Estate Archery Hunt 1990-2003	Ch. 703 Sec. 7035-3	No	Regional Biologist	Year Round	Single Ownership	Number of participants, timing, methods allowed, and bag limits set by biologist. Hunters issued Deer Management Permits.
	Great Diamond Is. Hunts 1992-95	Ch. 703 Sec. 7035-3	No	Regional Biologist	Year Round	Multiple Ownerships	Number of participants, timing, methods allowed, and bag limits set by biologist. Hunters issued Deer Management Permits.

Table 10. (cont.) Deer hunting seasons and other deer control activities currently utilized in Maine.

Season or Control Activity	Example	Statutory Authority	Rulemaking Required?	Responsible Personnel	Timeframe Allowed	Landscapes Applicable	Comments
Deer Culling Operations	Professional Sharpshooting Peaks Is. 2001	Ch. 703 Sec. 7035-3	No	Regional Biologist	Year Round	Multiple Ownerships	Number of participants, timing, methods allowed, and kill quotas set by biologist. Sharpshooter issued Deer Management Permits.
	Deer Culling Operations Cliff Is. 2003	Ch. 703 Sec. 7035-3	No	Regional Biologist	Year Round	Multiple Ownerships	Number of participants, timing, methods allowed, and kill quotas set by biologist. Volunteer shooters issued Deer Management Permits
Depredation Culling	Smith's Strawberry Farm May 2002	Ch. 709 Sec. 7501, 7502-2	No	District Game Warden	Year Round	Single Ownership	Number of participants, timing, methods allowed, and kill quotas set by game warden. Volunteer shooters issued Depredation Permits. Targets only deer causing damage to specific crops.

Table 11. Various permits allowing the taking of deer to support deer management activities in Maine.

Permit Type	Description
Any-Deer Permit	Issued by lottery to individual hunter, allowing the taking of a doe or fawn or buck in a specific WMD during the regular firearms season or muzzleloader season.
Bonus Deer Permit	Purchased by an individual hunter, allowing the taking of a second deer (must be antlerless) in a specific WMD during any open season. Bonus Deer Permits are made available when the number of Any-Deer Permits exceed the available number of applicants in a given WMD. They cost $12.
Expanded Archery Permit	Purchased by archer participating in the expanded archery season. Each permit authorizes the hunter to kill a buck ($32 permit) or antlerless deer ($12 permit).
Deer Management Permit	Permit authorizing an individual to take deer during controlled hunts or during deer culling operations.
Depredation Permit	Permit issued to a qualifying farmer or his agent(s) to remove specific deer observed damaging qualifying crops or orchard stock.

The Legislature designates the Bureau of Resource Management (Chapter 702, Sec. 7013) to be the bureau responsible for the management of wildlife resources within the Department. The Maine Legislature has defined “wildlife management” as: “the art and science of producing wild animals and birds and/or improving wildlife conditions in the state”. According to the State’s definition, wildlife management specifically includes the regulation of hunting (Chapter 701, Sec. 7001-43A).

In contrast, Maine municipalities are specifically prohibited from regulating hunting of any species (Chapter 703, Sec. 7035-1B). However, municipalities may enact ordinances regulating the discharge of firearms within their jurisdiction.

Recreational Deer Hunting Seasons

The Department annually administers 4 separate recreational hunting seasons for deer: regular firearms, muzzleloader, statewide archery, and youth day. The primary purpose of these seasons is to provide a variety of hunting opportunities to participants who enjoy sport hunting for deer. **The Department uses these recreational hunting seasons as the primary means of controlling deer populations over large areas of the state.**

There is a broad time frame during which all recreational hunting seasons must take place (Chapter 709, Sub. Chap. III, Sec. 7457-1A). Within that framework, the Department is authorized to determine the timing and length of each season. Firearms season typically occurs during 25 days in November (Sec. 7457-1E); muzzleloader season follows in early December (6 or 12 days; Chapter 707, Sub. Chap. III, Sec. 7107A). The statewide archery season extends for 26 days, primarily during October (Sec. 7102A-6), while the youth day occurs the Saturday preceding the start of firearms season (Chapter 709, Sub. Chap. III, Sec. 7457-1J).

There is no limit placed on the number of participants during recreational hunting seasons. However, hunters must be duly licensed and/or permitted to participate (Chapter 707, Sub. Chap. III, Sec. 7101, 7102A, 7107A).

The limit on deer is one per hunter for the regular firearms, muzzleloader, statewide archery, and youth day seasons combined (Chapter 709, Sub. Chap. III, Sec. 7458-1, and Chapter 707, Sub. Chap. II, Sec. 7102A), unless the hunter possesses a Bonus Deer Permit (Table 10). Deer of either sex may be taken during the statewide archery season and the youth day (Sec. 7102A and Sec. 7458-1). However, the harvest of antlerless deer is closely regulated during the regular firearms and muzzleloader seasons, using the any-deer permit system (Chap. 709, Sub. Chap. III, Sec. 7457-H, and Table 10).

Recreational hunting seasons are applied statewide (statewide archery and youth day) or they may be tailored to individual WMDs (any-deer permits), or aggregations of WMDs (muzzleloader season length). Season length and any-deer or bonus deer permit issuance is set annually by rulemaking.

Special Hunting Seasons

The Department is authorized to implement special deer hunting seasons for situations where the standard hunting seasons are inadequate for regulating deer populations (Chapter 709, Sub. Chap. III, Sec. 7457-I). Special hunting seasons can be applied at a variety of landscales ranging from statewide to partial towns. In designing these special seasons, the Department can regulate season duration and timing, designate specific hunting implements, and regulate the composition and size of the bag limits. In addition, we are authorized to limit the number of participants. Under Sec. 7457-I, specific details of a special hunting season are promulgated by the Department using its rulemaking authority.

To date, one type of special hunting season has been promulgated under Sec. 7457-I, i.e., bonus deer permits. After the 2000 update of the deer strategic plan we found it necessary to reduce deer populations in several southern Maine WMDs. This required a substantial increase in doe harvest and hence a dramatic increase in any-deer permits. By 2002, a situation arose in which the number of any-deer permits made available exceeded the number of applicants in some WMDs. Since we believed it was essential to allocate all permits needed to achieve desired doe harvests, we supplemented any-deer permits with bonus deer permits where warranted.

When the number of applicants for any-deer permits in a given WMD is less than the number of permits available we issue the requisite number of bonus deer permits to complete the permit quota in that WMD for that year. Currently, bonus deer permits are randomly offered to any-deer applicants who indicated an interest in receiving a bonus deer permit in that specific WMD. We charge $12 for bonus permits. A bonus permit enables the recipient to take an antlerless deer in the specified WMD during any open season on deer. This deer does not count against any other limit on deer. Rulemaking is required for the issuance of bonus deer permits; they are automatically promulgated during the any-deer computer lottery.

Another type of special hunting season was enacted in a separate statute, beginning in 1997. It is the expanded archery season (Chapter 707, Sub. Chap. II, Sec 7102-B). As currently configured, the expanded archery season spans about 80 days, from the first Saturday after Labor Day to the end of muzzleloader season. There is no limit on the number of participants, but hunters must possess a valid archery license. The expanded archery season encompasses WMDs 24 and 30, as well as small portions of WMDs 16, 17, 18, and 20 to 26. The latter locations focus on areas with intensive residential sprawl and/or portions of municipalities with firearms discharge bans. Expanded archery participants must pre-purchase permits (Table 11) to take deer: an antlered buck permit ($32) and/or an unlimited number of antlerless deer permits ($12 each). The price differential and the unlimited antlerless permits are intended to maximize doe harvest by archers in suburban environments.

Controlled Deer Hunts

Controlled deer hunts are authorized by Chapter 703, Sec. 7035-3. This statute states: “the Commissioner (or his agency designee) may issue permits authorizing persons to assist the Commissioner in the taking and destruction of wildlife". Under this broad statute regional biologists can implement controlled hunts to accomplish deer population control. **It is at this point where deer hunting strictly to provide recreational opportunity may transition into deer control specifically to address problem areas.** However, participants typically are pursuing deer using normal hunting practices. Controlled hunts differ from special hunting seasons in two ways: 1. there is no specified timeframe during which controlled hunts must take place; and 2. controlled hunts operate at smaller landscales.

Although winter or summer hunts are permissible, most controlled hunts to date have taken place concurrent with recreational deer hunting seasons. In addition, the Department is free to limit the number of participants during controlled hunts. Biologists are also authorized to designate hunting methods, implements, bag limits, and other provisions to ensure that the requisite number of deer are harvested. Deer killed during controlled hunts do not count against bag limits specified for recreational or special hunting seasons. Controlled hunts do not require rulemaking to be implemented. However, permit issuance by regional biologists, by policy, must be pre-approved by the Wildlife Division Director. Permits issued to controlled hunt participants should be termed: "Deer Management Permits" (Table 11).

Controlled hunts are particularly useful in places where deer are very numerous, but where residents are legitimately concerned about excess hunting pressure. These hunts are typically employed on multiple ownerships using archery and/or shotguns in the first phase of deer reduction programs on islands, or on previously unhunted portions of mainland towns. In designing controlled hunts, department biologists typically work cooperatively with a town government or their deer committees to address local concerns. Examples of controlled hunts implemented to date include:

- Great Diamond, Little Diamond and Cushing Islands deer control in Casco Bay, Portland 1992-95 (archery and shotgun).
- Sprague Estate, Cape Elizabeth, archery hunts ~1990 to present.
- Drakes Island / Laudholm Farm, Wells, archery hunts 2002 to present.
- Cranberry Isles, Hancock County, archery and shotgun hunts 1999 to 2001.
- Swans Island, Hancock County, archery and shotgun hunts 2001-2003.

Note: Many of the above controlled hunts have been erroneously termed “depredation hunts” and the permits that wildlife biologists issued to hunters were inaccurately called “depredation permits”. This is a misapplication of the statutes regulating the Commissioner’s authority to issue permits for the taking of wildlife, including controlled hunt permits (Chapter 702, Sec. 7035-3) vs. the law authorizing game wardens to issue permits to kill deer that are depredating certain agricultural crops (Chapter 709, Sub. Chap. IV, Sec. 7502).

For the sake of clarity, it should be Department policy to use the term “controlled hunt” in these control situations and to term the permits that biologists issue under Chap. 703, Sec. 7035-3 as “Deer Management Permits”.

Controlled hunts typically involve rules of pursuit that are similar to those in effect during recreational hunting seasons, e.g., time of day, limited driving, prohibition on baiting, etc. In contrast, deer control efforts in which participants are allowed to use methods that are considered illegal during recreational seasons are more accurately termed "deer culling". They are described in the next section.

Deer Culling Operations

There are situations where typical hunting practices would be ineffective for deer control due to excessive development or extreme deer density. Hence, the implementation of controlled hunts (even with liberal bag limits) would fail to achieve needed herd reduction or maintenance due, for example, to the presence of unhuntable refugia or difficult terrain.

In these situations biologists are authorized (Chapter 703, Sec. 7035-3) to issue Deer Management Permits (Table 11) to individuals to cull deer from a specific area. Note that this is the same statute that authorizes biologists to implement controlled hunts. **In these situations, however, permitted individuals may be authorized to kill a specific number of deer using methods considered unconventional for Maine.** These methods may include: hunting at night using night vision gear, use of sound suppressed firearms, use of attractant baits, or authorization to cull deer over protracted time frames until a specific quota is reached. Deer culling can be permitted to companies specializing in professional sharpshooting (at town expense) or to qualified local volunteers. Culling operations are more like nuisance animal control than sport hunting for deer.

In addition, the Department is authorized to cull deer using non-lethal means such as capture and translocation or fertility control. However, current Department policy (MDIFW 2002) prohibits the use of these options on the grounds that they are too costly and they lack proven ability to reduce and maintain deer populations.

Examples of deer culling operations in Maine include:

- Use of professional sharpshooters to extirpate deer from Monhegan 1997-1999.
- Use of professional sharpshooters to reduce deer density on Peaks Island, Portland from 230 to 25 deer/mi^2 during 2001.
- Use of local volunteers to cull 28 deer over several months from Cliff Island, Portland during 2003.
- Use of local volunteers to maintain deer at reduced density on Great Diamond and Peaks Islands since 1995 or 2002, respectively, using annual kill quotas and liberalized methods.

<u>Depredation Permits</u>

Our nuisance animal statute authorizes any person to “kill any wild animal night or day found in the act of attacking, or worrying, or wounding that person’s domestic animals, or domestic birds, or destroying that person’s property” (Chapter 709, Sub. Chap. IV, Sec. 7501). People who kill deer under this statute must report the kill to a game warden, as specified under Sec. 7502-3. In theory, a homeowner would be authorized under Sec. 7501 to kill deer "found in the act" of destroying ornamental shrubs or other "property". **However, Sec. 7501 does not authorize pre-emptive or post-damage culling of deer that damage ornamentals.**

The other provision of the nuisance animal law (Chapter 709, Sec. 7502) only addresses damage to specific crops or orchards. Except for grasses, clovers and grain fields, farmers "may take or kill wild animals night or day, <u>when wild animals are located within the orchard or crop</u>, and where substantial damage to the orchard or crop <u>is occurring</u>". **As with 7501, pre-emptive or post-damage culling from outside the time and place where damage is occurring is not authorized.**

Section 7502-2 specifies that a <u>game warden</u> may issue depredation permits authorizing farmers to employ agents to kill deer observed damaging qualifying crops or nursery and orchard stock. Depredation Permits typically specify a specific individual(s), a specific location and crop, and a specific number of offending deer to be killed over a specified time frame. Examples of depredation culling in Maine include:

- A commercial strawberry farmer in Bucksport was being seriously impacted by locally overabundant deer during spring and early summer 2002. After several non-lethal methods failed to provide relief, the district warden issued a depredation permit to remove up to 10 deer when they were observed damaging the crop. The depredation permit specified 2 volunteer shooters, who ultimately killed 8 deer using rifles during late afternoon and night between late May and early July. This activity reduced local deer density, alleviating the depredation problem.

- An orchardist in Newport had long-established an electric perimeter fence, aimed at keeping deer out of his apple orchard blocks. Over time, a growing deer population began breaching the fence during late winter. Although willing to tolerate deer damage to mature apple trees during dormancy, the farmer requested help when deer were seriously threatening a block of newly planted trees. The district warden issued a depredation permit enabling the farmer and 2 volunteer shooters to remove deer that breached the fence surrounding the new orchard block, during a 30-day period in late winter 2003. They killed two deer that had habituated to that site. Although permitted to cull more, no other deer caused damage sufficient to warrant their removal during the 2003 winter.
- A Christmas tree farmer in Sangerville established a stand of Frasier fir seedlings during 2003, roughly ¼ mile from a deer wintering area. During the ensuing winter, deer began intensively browsing the seedlings, threatening the crop. A number of factors combined to attract deer to this stand of coniferous trees, including winter logging in the nearby deer yard, deer attraction to a wild turkey feeding site near the Christmas trees, and low snow cover. Numerous attempts to scare deer away from the plantation using cracker shells and hazing ultimately proved ineffective at minimizing damage to the Frasier fir crop. At this point, the district warden issued a depredation permit enabling the farmer and a volunteer shooter to kill deer caught browsing in the Frasier fir stand. Over an 8-week period, 12 deer were killed, alleviating the problem for that winter.

Literature Cited

MDIFW. 2002. Actions to remedy nuisance problems resulting from locally high deer densities. Department of Inland Fisheries and Wildlife, Augusta, Me. 5pp.

Prepared by: Gerald R. Lavigne
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APPENDIX 2. DEER HUNTING PARTICIPATION, EFFORT AND SUCCESS

Introduction

This appendix describes the methods the Department has employed to estimate deer hunters, deer hunting effort, and success between 1968 and 2003. Some of the methods we used during earlier years (e.g., licensee surveys) are no longer available. This is regrettable, since reliable estimates of deer hunting participation, effort, and success provide useful indices that enhance interpretation of harvest and population trends. In addition, these statistics help us to place Maine deer hunting into economic, sociological and ecological contexts.

We estimate 3 categories of deer hunting participation: number of deer hunters, number of days of deer hunting effort (per capita and aggregate), and various measures of hunting success, including deer harvest per unit of effort. Attaining regional as well as statewide estimates is a priority from a deer management perspective. Sources and current availability of hunter participation data are summarized in Table 12. They are described below.

Number of Deer Hunters

Estimates of the total number of hunters pursuing deer statewide are calculated from surveys of hunting license buyers. Although data enumerating the number of licensees

Table 12. Source and availability of various measures of deer hunting participation in Maine, 1968 to 2003.

Statistic	Data Elements	Data Source	Data Availability	Comments
Statewide Deer Hunters	License Sales	Dept. records	Annually	
	Correction factor for non-deer hunters	Hunter surveys	Updated every 5 to 9 years?	Annual surveys prior to 1985. Updated in 1989 and 1996.
WMD Deer Hunters	Hunter reports of participation by WMDs	Hunter surveys	1984, 1989, 1996	1996 data used to extrapolate from DMDs to WMDs
	Or			
	Registered buck harvest by WMD and success rate of any-deer permittees that killed bucks	Any-deer permittee database	1987 to 2001	Changes to MOSES licensing system precludes use of this index after 2001.
Statewide Deer Hunting Effort	Total deer hunters	See above		
	Per capita effort	Hunter surveys	Updated every 5 to 9 years?	Most recent data are 1996, prior to initiation of expanded archery (1997) and youth day (2002) seasons.
WMD Deer Hunting Effort	Hunter reports of days expended deer hunting by WMD	Hunter surveys	1984, 1989, 1996	1996 data were used to extrapolate from DMDs to WMDs
	WMD deer hunter estimates	Hunter surveys or any-deer permittee database	1984, 1989, 1996 or 1987-2001	1996 data were used to extrapolate from DMDs to WMDs Change to MOSES licensing system precludes use of this index after 2001.
Statewide Hunter Success (total, by season, by residency)	Deer hunter estimates	See above	See above	Cannot directly estimate success for youth season or expanded archery season after 2001.
	Registered Harvest	Dept. records	Annually	
Hunter Success by WMD	WMD deer hunters	See above	No longer available since 2001	
Hunter Success among any-deer permittees or bucks-only hunters	Percent of any-deer permittees that tagged antlerless deer or antlered bucks	Any-deer permittee database	1987-2001	Changes to MOSES licensing system precludes calculation of these statistics since 2001.

(Table 13) are available each year, using these counts as a measure of deer hunter numbers would overestimate actual deer hunting participation. For example, individual hunters must purchase separate licenses to hunt with firearms vs. archery. In addition, most hunters purchase a license that allows small game, deer, bear, and moose hunting, but they may have elected not to pursue deer during any given year. Other hunters purchase a license intent on hunting deer, but for a variety of reasons, they never get into the woods that year.

To correct for license buyers that do not deer hunt we use data from hunting licensee surveys. Survey participants are typically asked if they hunted at all in a given year and those responding “yes” are asked if they hunted white-tailed deer. Responses to these queries have been remarkably similar over the years; roughly 85% of license buyers hunt deer somewhere in Maine each year. Estimated number of deer hunters in Maine, for 1919 to the present is presented in Table 14. Data prior to 1968 were taken from Department records and Banasiak (1964).

Between 1968 and 1984, the Department conducted hunting licensee surveys annually. Each survey consisted of a mailing to ~10,000 hunting licensees. In most cases, survey questions did not elicit attitudinal responses. Rather, hunters were merely queried about which species they hunted, how many days they hunted, how many of each game species they bagged and where they hunted.

Table 13. Sales of licenses that permit deer hunting in Maine, 1970 to 2003.

	Resident Hunting							Nonresident Hunting			Guide		Muzzleloader		Regular Archery		Expanded Archery	
	Combo	Hunt	C & H	Service	JR	Comp	Lifetime											
Year								All	Canadian	U.S.	Res	Non-Res	Res	Non-Res	Res	Non-Res	Res	Non-Res
1970	50,879	99,120	149,999	3,962	20,594			41,487			1,774	60			1,044	160		
1971	52,068	81,721	133,789	3,472	18,863			38,244			1,708	57			1,212	179		
1972	49,789	78,422	128,211	3,354	18,151			29,668			1,100	32			1,100	64		
1973	59,715	79,827	139,542	3,448	19,181			32,824			1,121	32			1,744	64		
1974	66,370	82,931	149,301	3,235	21,253			33,261			1,181	34			2,038	70		
1975	72,174	86,513	158,687	3,124	23,217			35,846			1,222	40			2,597	43		
1976	72,973	83,325	156,298	2,713	22,820			30,095	1,467	28,628	1,129	26			2,541	41		
1977	72,626	87,716	160,342	2,549	22,571	18,723		30,128	1,401	28,727	1,078	24			2,772	80		
1978	76,295	87,911	164,206	2,532	22,385	18,723		32,602	1,876	30,726	1,087	26			3,269	510		
1979	80,821	85,626	166,447	2,441	21,922	18,723		33,390	2,070	31,320	1,340	23			4,777	737		
1980	83,469	84,741	168,210	2,524	22,709	19,908		33,761	2,322	31,439	1,367	32			3,943	759		
1981	78,560	93,198	171,758	2,594	23,345	22,414		32,555	2,031	30,524	1,100	45	494	20	4,197	777		
1982	78,865	89,359	168,224	3,077	22,650	24,901		34,742	2,919	31,823	1,462	47	364	15	4,472	521		
1983	79,418	78,166	157,584	3,385	21,107	27,914		34,648	3,156	31,492	1,365	62			4,558	456		
1984	73,653	75,423	149,076	3,531	18,919	33,239		34,031	3,506	30,525	1,615	79			4,451	480		
1985	70,784	80,551	151,335	3,257	18,504	33,604		32,291	2,514	29,777	1,550	41	1,027	39	5,099	589		
1986	68,245	76,449	144,694	2,095	16,513	27,473		33,534	2,050	31,484	1,458	49	1,193	44	5,948	640		
1987	70,144	75,054	145,198	1,687	15,422	24,695		35,490	1,936	33,554	1,572	51	1,457	55	7,331	916		
1988	73,948	73,946	147,894	1,459	15,310	26,405		38,985	2,134	36,851	1,563	60	1,888	79	9,324	1,003		
1989	79,224	72,301	151,525	1,356	15,095	27,452		41,601	2,502	39,099	1,542	62	2,180	111	8,235	1,184		
1990	80,454	69,723	150,177	1,208	14,617	26,710		38,974	2,544	36,430			3,329	149	8,469	1,143		
1991	79,135	72,631	151,766	1,241	15,247	25,111		38,183	2,703	35,480			4,099	179	9,293	1,068		
1992	80,722	72,885	153,607	966	15,979	25,758		38,561	2,621	35,940			4,701	175	10,777	1,074		
1993	82,538	69,672	152,210	849	15,842	25,584		37,417	2,512	34,905			5,203	173	12,053	1,183		
1994	79,156	68,809	147,965	620	16,235	25,892		35,767	1,989	33,778			5,831	239	13,979	1,174		
1995	77,423	68,450	145,873	531	15,158	23,831		34,304	1,752	32,552			9,364	407	12,236	1,154		
1996	75,316	68,245	143,561	539	14,883	24,172		32,849	1,425	31,424			9,616	385	11,627	1,216		
1997	72,771	66,452	139,223	504	15,081	22,275		34,497	1,328	33,169			9,755	425	11,233	1,157	1,399	44
1998	75,569	65,706	141,275	511	15,413	22,325		34,450	1,005	33,445			11,387	403	10,583	1,052	2,495	81
1999	76,472	64,561	141,033	499	15,834	21,701		35,370	960	34,410			10,643	410	10,534	1,012	4,909	135
2000	77,902	61,848	139,750	373	16,097	22,649		36,407	895	35,512			10,767	454	10,329	1,111	5,249	151
2001	77,082	60,317	137,399	499	16,325	20,914	2,805	36,752	586	36,166			9,282	396	10,073	1,115	5,185	159
2002	78,263	54,931	133,194	1,139	17,084	20,900	3,552	35,973	520	35,453			9,089	488	10,968	1,130	5,521	176
2003	76,414	56,224	132,638	1,376	17,578	15,500	6,000	34,695	476	34,219			16,789	795	14,070	1,253		

Table 14. Summary of deer harvest and effort data statewide in Maine during 1919 to 2003.

Year	Registered Deer Kill	License Holders			Estimated Actual Hunters[1]	Hunter-Days Effort[2] (Millions)	Success Rate[3] (%)	Kill/1,000 Hunter-Days	Number Unsuccessful Hunters[5]
		Resident	Nonresident	Total					
1919	5,784	3,043							
1920	5,829	3,109							
1921	8,861	3,074							
1922	7,628	3,142							
1923		3,021							
1924		3,494							
1925	8,379	3,355							
1926		3,619							
1927	8,112	3,375							
1928	9,061	3,803							
1929	11,708	4,276							
1930	13,098	70,596	4,355	74,951	63,708	0.51	20.6	25.6	50,610
1931	14,694	91,743	4,215	95,958	81,564		18.0		66,870
1932	15,465	103,961	3,535	107,496	91,372		16.9		75,907
1933	18,935	99,519	3,476	102,995	87,545		21.6		68,610
1934	13,284	92,747	3,628	96,375	81,919		16.2		68,635
1935	19,726	98,633	3,716	102,349	86,997	0.70	22.7	28.2	67,271
1936	19,134	99,030	4,156	103,186	87,708		21.8		68,574
1937	19,197	92,927	5,055	97,982	83,284		23.1		64,087
1938	19,363	93,308	5,155	98,463	83,694		23.1		64,331
1939	19,187	92,920	5,070	97,990	83,292		23.0		64,105
1940	22,201	94,024	5,677	99,701	84,746	0.68	26.2	32.6	62,545
1941	19,881	99,521	6,115	105,636	89,791		22.1		69,910
1942	22,591	99,014	5,447	104,461	88,792		25.4		66,201
1943	24,408	102,411	7,191	109,602	93,162		26.2		68,754
1944	21,708	102,176	8,329	110,505	93,929		23.1		72,221
1945	24,904	102,343	11,478	113,821	96,748	0.77	25.7	32.3	71,844
1946	31,728	113,189	17,576	130,765	111,150		28.5		79,422
1947	30,349	101,520	11,906	113,426	96,412		31.5		66,063
1948	35,364	106,809	17,458	124,267	105,627		33.5		70,263
1949	35,051	138,467	16,348	154,815	131,593		26..6		96,542
1950	39,216	144,349	16,612	160,961	136,817	1.09	28.7	36.0	97,601
1951	41,370	145,872	19,777	165,649	140,802		29.4		99,432
1952	35,471	145,928	23,974	169,902	144,417		24.6		108,946
1953	38,609	146,031	23,265	169,296	143,902		26.8		105,293
1954	37,379	148,258	24,427	172,685	146,782		25.5		109,403

Table 14 (cont). Summary of deer harvest and effort data statewide in Maine during 1919 to 2003.

Year	Registered Deer Kill	License Holders			Estimated Actual Hunters[1]	Hunter-Days Effort[2] (Millions)	Success Rate[3] (%)	Kill/1,000 Hunter-Days	Number Unsuccessful Hunters[5]
		Resident	Nonresident	Total					
1955	35,591	145,087	24,925	170,012	144,510	1.16	24.6	30.7	108,919
1956	40,290	146,151	23,505	169,656	144,208		27.9		103,918
1957	40,142	151,295	24,039	175,334	149,034		26.9		108,892
1958	39,393	151,511	23,227	174,738	148,527		26.5		109,134
1959	41,735	151,469	24,061	175,530	149,201		28.0		107,466
1960	37,774	157,650	25,744	183,394	155,885		24.2		118,111
1961	32,747	147,182	25,687	172,869	146,939	1.18	22.3	27.8	114,192
1962	38,807	150,877	25,889	176,766	150,251		25.8		111,444
1963	29,839	147,205	28,518	175,723	149,365		20.0		119,526
1964	35,305	153,212	30,034	183,246	155,759	1.22	22.7	28.9	120,454
1965	37,282	152,665	33,143	185,808	157,937		23.6		120,655
1966	32,160	166,612	32,259	198,871	169,040		19.0		136,880
1967	34,707	165,847	33,464	199,311	169,414		20.5		134,707
1968	41,080	171,098	36,119	207,217	159,557	1.15	25.7	35.7	118,477
1969	30,409	167,267	38,622	205,889	158,535	1.15	19.2	26.4	128,126
1970	31,750	177,373	41,707	219,080	168,692	1.23	18.8	25.8	136,942
1971	18,903	159,044	38,480	197,524	154,666	1.11	12.2	17.1	135,763
1972	28,698	151,916	29,764	181,680	140,857	1.27	20.4	22.5	112,159
1973	24,720	165,036	32,920	197,956	149,143	1.23	16.6	19.5	124,432
1974	34,667	177,088	33,364	210,452	162,952	1.14	21.3	29.5	128,285
1975	34,675	188,847	35,929	224,776	182,285	1.46	19.0	24.0	147,610
1976	29,965	203,095	30,136	233,231	196,437	1.57	15.3	19.1	166,472
1977	31,430	206,956	30,208	237,164	199,590	1.60	15.7	19.6	168,160
1978	29,002	211,135	33,112	244,247	204,933	1.65	14.2	17.6	175,931
1979	26,821	214,310	34,127	248,437	207,286	1.68	12.9	16.0	180,465
1980	37,255	217,294	34,520	251,814	210,724	1.70	17.7	21.9	173,469
1981	32,167	224,308	33,332	257,640	215,485	1.74	14.9	18.5	183,318
1982	28,834	223,324	35,263	258,587	216,285	1.75	13.3	16.5	187,451
1976-82	30,782	214,346	32,957	247,303	207,249	1.67	14.9	18.4	176,467
1983	23,799	215,034	35,104	250,138	209,091	1.69	11.4	14.1	185,292
1984	19,358	208,710	34,551	243,261	203,273	1.92	9.5	10.1	183,915
1985	21,424	212,187	32,880	245,067	204,304	1.94	10.5	11.0	182,880
1986	19,592	197,089	34,175	231,264	192,469	2.02	10.2	9.7	172,877
1987	23,729	194,333	36,406	230,739	190,822	2.00	12.4	11.8	167,093
1988	28,056	200,806	39,988	240,794	197,903	2.21	14.2	12.7	169,847
1989	30,260	204,115	42,785	246,900	203,723	2.14	14.9	14.1	173,463

Table 14 (cont). Summary of deer harvest and effort data statewide in Maine during 1919 to 2003.

Year	Registered Deer Kill	License Holders			Estimated Actual Hunters[1]	Hunter-Days Effort[2] (Millions)	Success Rate[3] (%)	Kill/1,000 Hunter-Days	Number Unsuccessful Hunters[4]
		Resident	Nonresident	Total					
1983-89	23,745	204,611	36,556	241,167	200,226	1.99	11.9	11.9	176,499
1990	25,977	200,127	40,117	240,244	197,932	2.10	13.1	12.4	171,955
1991	26,736	203,303	39,251	242,554	199,389	2.12	13.4	12.5	172,653
1992	28,820	207,200	39,635	246,835	193,669	2.17	14.9	13.3	164,849
1993	27,402	206,846	38,600	245,446	191,636	2.17	14.3	12.6	164,234
1994	24,683	203,691	36,941	240,632	186,449	2.13	13.2	11.6	161,766
1995	27,384	199,688	35,458	235,146	183,183	2.11	14.9	13.0	155,799
1996	28,375	196,502	35,490	231,992	180,953	2.08	15.7	13.7	152,578
1990-96	27,054	202,480	37,927	240,407	190,459	2.13	14.2	12.7	163,405
1997	31,152	195,372	35,498	230,870	179,527	2.06	17.4	15.1	148,375
1998	28,241	196,077	35,563	231,640	179,713	2.07	15.7	13.6	151,472
1999	31,473	195,079	36,527	231,606	177,281	2.08	17.8	15.1	145,808
2000	36,885	193,119	37,769	230,888	176,778	2.06	20.9	17.9	139,893
2001	27,769	188,057	34,700	222,757	170,707	2.01	16.3	13.8	142,938
2002	38,153	192,406	35,973	228,379	173,739	2.08	22.0	18.3	135,586
2003	30,313	187,162	35,948	223,110	171,903	2.13	17.6	14.2	141,590
1997-03	31,998	192,467	35,997	228,464	175,664	2.07	18.2	15.0	143,666

[1]License buyers who did not hunt deer were estimated from respondents of Department's Game Kill Questionnaires, 1971-83, and the 1984, 1987 and 1996 hunting surveys. Data for earlier years were estimated assuming 15% non-deer hunters, overall, after Gill (1966), Banasiak (1964b) and Banasiak (1964a).

[2]Data for 1971-82 were derived from annual Game Kill Questionnaire. Data for earlier years assumes 8.1 hunting days for residents and 6.5 hunting days for nonresidents after Gill (1966) and Banasiak (1964). Data for 1983 to 1997 were derived from the 1984, 1987 and 1996 hunting surveys.

[3]Success rate derived as (registered kill/estimated actual hunters) X 100.

[4]Unsuccessful hunters estimated as (estimated actual hunters - registered kill).

Beginning in 1984, the Department included various attitudinal questions, but for budgetary reasons, discontinued annual surveys. Between 1985 and 2004, only 2 surveys have been conducted that could provide data on deer hunting participation: 1989 and 1996. Hence, the most recent survey providing a number of key inputs to our knowledge of deer hunting participation is now 8 years old. This survey preceded our change to WMDs (1998) and the additions of the expanded archery (1997) and youth (2002) deer hunting seasons. Between hunter surveys, I found it necessary to "estimate estimates"; never a desirable practice when attempting to manage such an economically important and high profile species as white-tailed deer. At the very least, the Department should conduct an appropriate hunter survey as soon as possible. Repeat surveys should be annual, or at most 3 year intervals, to detect changes in deer hunter participation.

The number of hunters pursuing deer varies regionally in Maine (Tables 15 and 16). Hunter density and effort directly impact deer survival; they are inversely related to availability of mature deer in the population. Regional estimates of hunter numbers cannot be determined by partitioning statewide estimates proportional to the size of regional units (i.e., WMUs, DMDs, or WMDs). Many hunters pursue deer in two or more areas of the state during any of our 5 annual deer seasons.

When surveys of hunting license buyers are conducted, regional hunter estimates are ascertained by querying respondents about the various locations (usually towns) in which they hunted for deer. These responses are then compiled for the regional

Table 15. Deer hunting participation and effort for 3 levels of regional characterization[a] of Maine between 1984 and 2001.

1984						1996						2001					
Wildlife Mgmt. Unit	Deer Hunters /mi^2	Hunter-Days /mi^2	Buck Harvest /1,000 Hunter-Days	Deer Hunting Success (%)	Posthunt Deer /mi^2	Deer Mgmt. District	Deer Hunters /mi^2	Hunter-Days /mi^2	Buck Harvest /1,000 Hunter-Days	Deer Hunting Success (%)	Posthunt Deer /mi^2	Wildlife Mgmt. District	Deer Hunters /mi^2	Hunter-Days /mi^2	Buck Harvest /1,000 Hunter-Days	Deer Hunting Success (%)	Posthunt Deer /mi^2
1	15	101	6	8	3	1	2	8	34	16	10	1	3	30	5	6	3
2	3	19	12	14	5	2	3	14	21	12	8	2	2	19	5	6	2
3	6	40	5	5	3	3	4	23	8	6	3	3	1	15	5	6	2
4	14	111	6	8	8	4	4	26	14	11	7	4	1	15	5	6	3
5	8	62	6	7	5	5	5	31	14	12	9	5	3	29	6	8	5
6	8	68	6	5	5	6	4	29	13	10	6	6	2	28	6	8	3
7	17	136	9	12	12	7	14	109	12	14	17	7	5	54	6	8	6
8	21	171	5	5	4	8	13	106	11	13	15	8	3	40	5	6	4
						9	4	22	12	8	6	9	1	17	7	10	4
						10	11	84	13	16	13	10	3	29	6	8	4
						11	17	134	13	16	22	11	3	40	5	6	5
						12	16	125	14	18	23	12	7	79	6	10	8
						13	13	106	13	17	14	13	8	92	9	15	14
						14	18	143	12	17	17	14	8	88	4	5	5
						15	14	111	13	15	17	15	14	161	7	13	15
						16	10	80	14	14	15	16	16	187	9	20	22
						17	3	21	12	8	6	17	18	206	8	19	21
						18	UNK	UNK	UNK	32	UNK	18	7	85	3	5	5
												19	2	17	6	6	3
												20	14	164	8	14	15
												21	20	238	8	19	18
												22	19	219	9	21	22
												23	19	226	10	23	27
												24	24	283	11	24	22
												25	12	145	9	20	19
												26	12	143	11	21	23
												27	7	81	6	8	8
												28	2	24	5	6	3
												29	4	54	4	6	4
												30	UNK	UNK	UNK	UNK	UNK
State-wide	7	56	7	10	5	State-wide	6	47	14	15	10	State-wide	6	69	8	16	8

[a]Refer to Figures 9, 10, and 1 for depiction of WMUs, DMDs, and WMDs, respectively.

Table 16. Estimated number of people participating in deer hunting by Wildlife Management District in Maine, 1998 to 2003.

Wildlife Management District	Year					
	1998	1999	2000	2001	2002[b]	2003[b]
1	4,590	3,660	4,244	3,553	UNK	UNK
2	1,244	774	3,105	1,839	UNK	UNK
3	863	928	5,050	1,125	UNK	UNK
4	2,535	2,357	2,870	2,536	UNK	UNK
5	4,693	4,030	3,794	3,836	UNK	UNK
6	2,649	2,825	2,884	3,288	UNK	UNK
7	4,406	4,833	5,688	6,288	UNK	UNK
8	8,671	6,843	6,892	6,964	UNK	UNK
9	1,844	1,932	2,467	1,353	UNK	UNK
10	2,869	3,422	2,625	2,258	UNK	UNK
11	6,296	7,205	6,449	5,607	UNK	UNK
12	5,547	4,979	4,857	6,250	UNK	UNK
13	5,410	4,906	5,312	4,519	UNK	UNK
14	3,814	3,310	3,894	6,045	UNK	UNK
15	14,012	12,731	14,891	13,738	UNK	UNK
16	10,286	10,259	10,986	11,448	UNK	UNK
17	22,796	24,550	23,180	23,856	UNK	UNK
18	6,690	7,369	7,258	9,432	UNK	UNK
19	1,728	2,533	2,119	1,786	UNK	UNK
20	7,704	7,926	8,538	8,354	UNK	UNK
21	9,122	8,863	9,425	9,927	UNK	UNK
22	8,529	8,908	8,750	9,673	UNK	UNK
23	15,698	14,636	16,040	17,638	UNK	UNK
24	4,955	5,368	6,154	6,707	UNK	UNK
25	5,353	5,455	5,532	5,954	UNK	UNK
26	6,789	6,808	7,374	7,573	UNK	UNK
27	4,902	6,356	5,008	5,616	UNK	UNK
28	1,567	1,288	2,286	1,714	UNK	UNK
29	1,289	1,099	1,805	2,286	UNK	UNK
30	844	821	1,375	1,655	UNK	UNK
Statewide[a]	179,713	177,281	176,778	170,707	173,739	171,903

[a]Statewide hunter estimates may differ from the sum of hunters in each WMD, primarily because some individuals hunted in more than one WMD.
[b]Could not be estimated due to change to MOSES licensing system.

entities in use at the time. We have not yet been able to directly estimate hunter distribution among our 29 WMDs (Figure 1). To approximate this distribution for use in the deer strategic plan (Lavigne 1999), I extrapolated data from our 18 DMDs (Figure 12) using “best guess” technology, again “estimating estimates”.

I have also developed an alternate method to estimate deer hunters among DMDs (1987-1997) or WMDs (1998-2001) using any-deer permit data. Since any-deer permittees are allowed to choose to kill a buck or a doe or a fawn, the proportion of permittees that elect to take an antlered buck can be used to estimate total number of deer hunters. To begin with, I assumed that any-deer permittees and non-permittees would be equally likely to kill an antlered buck when they encountered one. In other words, no hunter passes on a chance to take a buck. If this assumption is true, then the buck hunting success rate of any-deer permittees would provide an index to the buck hunting success of all hunters pursuing deer in a given WMD. Calculating the number of deer hunters in the WMD then becomes a simple division of the registered harvest of antlered bucks by the buck hunting success rate of any-deer permittees in the district. For example, if 1,000 bucks are registered in WMD 23 by all hunters, and 10% of WMD 23 any-deer permittees tagged a buck, then 10,000 deer hunters are estimated to have hunted in district 23 (1,000/0.10 = 10,000). In WMDs where no any-deer permits are issued, buck hunting success rates were extrapolated from past years’ data or from adjacent or similar districts.

Regional-level estimates of hunter numbers are available from any-deer permit data for 1987 to 2001 and are presented for WMDs in Table 16. Note that the statewide estimate is not the sum of the WMDs, since some hunters travel to 2 or more WMDs to hunt deer.

Beginning in 2002, the Department implemented an automated licensing system (MOSES), that allows online purchase of licenses and electronic transfer of licensing information. While improving our capability of handling the licensing functions of the Department, the switch to MOSES inadvertently resulted in a loss of capability to track individual hunters. Now, a hunter is issued a different ID number every time he/she purchases an additional hunting or fishing “authority”. Unless the hunter purchases all “authorities” at once, he/she would be in possession of 2 or more “license numbers” by the time a deer is presented for registration. As a result, we can no longer match an individual any-deer permittee with the deer he or she registered. Hence, the Department is no longer able to calculate success rate of any-deer permittees. And with the loss of this capability, we cannot estimate regional hunter numbers.

<u>Estimates of Hunter Effort</u>

The amount of hunting pressure placed on individual deer populations directly impacts deer survival rates, and availability of mature individuals in the population. Assessment of deer survival and the contribution of hunting to all-cause mortality are important components to the deer management system. In addition, hunting effort is used in the HARPOP model to predict pre-hunt buck populations. Accurate estimates of relative hunting pressure are essential to generating realistic estimates of deer density from this model (see Appendix 3). Finally, expressing deer harvest as a function of relative hunting effort enhances interpretation of harvest and population trends, as explained later.

Estimates of hunting effort, expressed as hunter-days per unit area, are calculated by multiplying hunter numbers by an estimate of per capita effort. Hunter estimates were already discussed in the previous section. Per capita effort, expressed as the average number of days hunters pursued deer in a given year, can only be estimated from licensee surveys. Hence, the validity and availability of these data are subject to those same limitations (infrequent surveys, loss of ability to estimate regional deer hunters) as described for hunter estimates.

Per capita deer hunting effort is not static over time. Since the 1970's, mean hunting effort has increased from 8.4 days per hunter to 12.2 days per hunter (Lavigne 1999). In aggregate, deer hunting effort has increased from 1.6 to > 2 million hunter-days statewide (Table 14), despite a net reduction in the number of deer hunters over the past 25 years. During this time the Department has expanded deer hunting opportunity (more seasons and more available hunting days/season); individual hunters have responded by hunting more days per year.

Because we have not yet directly assessed per capita effort during the expanded archery and youth day deer seasons, estimates of aggregate hunting effort after 1996 are likely to be less accurate and probably biased low. Similarly, since we have yet to directly estimate hunter effort among WMDs 6 years after implementing WMDs, the accuracy of population estimates derived from the HARPOP model may have been compromised. I consider this a serious limitation, since the Department is now using HARPOP estimates to assess attainment of population objectives specified in the strategic plan.

There is an alternate survey of deer hunters (Morris 2003) that could potentially provide estimates of deer hunting effort. Each year since 2001, roughly 5,000 deer hunters have been surveyed to ascertain sighting rates of moose (the primary focus of the survey), and other game, including deer. As part of this post-season survey, deer hunters are requested to record the number of days they hunted for deer in various WMDs. This survey would be an ideal replacement for our periodic attitudinal surveys were it not for the fact that only successful deer hunters are contacted. Because per capita effort of successful hunters is likely to differ from unsuccessful deer hunters, use of this survey would lead to erroneous estimates of aggregate hunting effort for deer.

Hunter Success

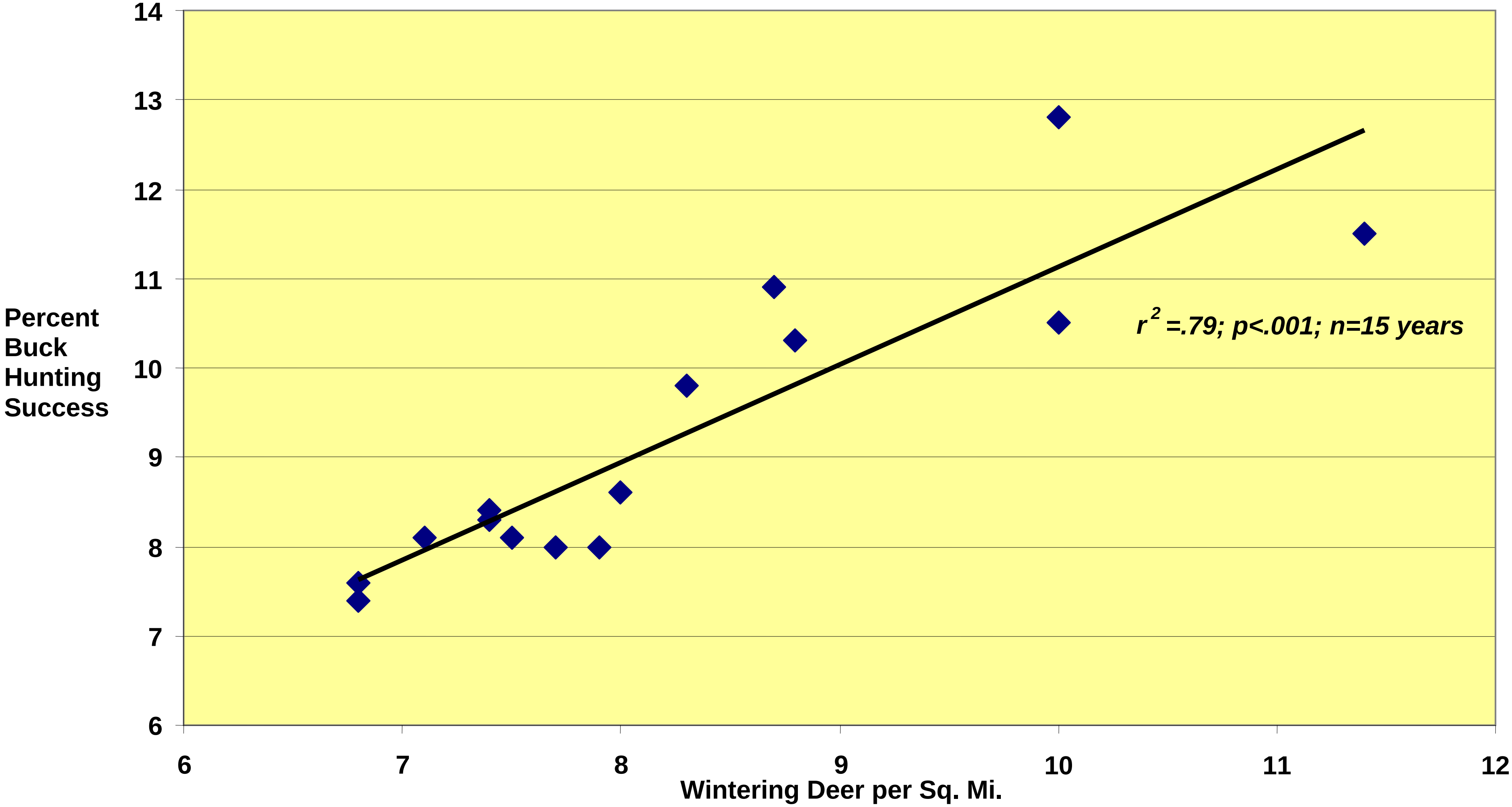
Hunter success is a useful measure of hunter satisfaction with the deer management program. For example, success rates tend to correlate with deer population trends (Table 14 and Figure 6). During times of declining deer populations, hunter complaints to the Department and to the Legislature tend to increase (Lavigne 1999). However, hunter success can also be influenced by annual variations in hunting conditions (wind, temperature, and precipitation, including presence of tracking snow).

Hunter success can readily be calculated as the percent of deer hunters that registered a deer, if we can generate reliable estimates of the number of hunters afield. In the past, we have been able to estimate hunting success by season, by hunter residency, by WMD, among any-deer permittees vs. bucks-only hunters, and for all seasons overall (Table 12). Unfortunately, the loss of our ability to estimate hunter numbers by WMDs, and our loss of ability to track success of individual holders of any-deer permits currently limits us to the more general statewide success estimates. And even these are partially dependent on outdated survey data.

Between 1987 and 2001, percent success among buck hunters statewide was a reliable index to deer population trend (Figure 12). Clearly, availability of antlered bucks was directly correlated with overall population size (Figure 6) in Maine. This relationship was also evident within several WMDs; districts with higher deer populations tended to support higher success rates among buck hunters (Table 15). Unfortunately, we can no longer monitor buck hunting success rate after the change to the MOSES licensing system in 2001.

Another expression of hunting success is harvest per unit effort (e.g., kill/1,000 hunter-days). Calculation of this statistic requires a valid estimate of hunting effort (e.g., hunter-

Figure 12. Relationship between buck hunting success and deer population density in Maine, 1987-2001



days), and an enumeration of harvest for the area in question. One can use total harvest in this calculation, particularly if deer of either-sex regulations are in effect. However, use of antlered buck harvest provides a less biased index to harvest trend in situations where antlerless harvest restrictions are implemented, and where these restrictions vary by year.

Kill/hunter-day data provide an opportunity to account for the influence of changing hunter participation on harvest trend. Ideally, an index such as antlered buck harvest/100 sq. mi. (i.e., our buck kill index or BKI) would reflect changes in deer population over time if hunting effort were reasonably stable. During times when hunter effort is changing actual BKI trends may be obscured by the change in effort. In addition, in-season variation in hunting conditions (e.g., heavy rain or snowfall) between years can also influence both hunting success and per capita hunting effort. Having the capability to assess hunter-days of effort could mitigate some of the bias caused by varying hunting conditions on BKI trends in our management system.

At this time, we routinely calculate deer harvest/1,000 hunter-days only for statewide overall harvest (Table 14). While this statistic does demonstrate relative success in harvesting deer since 1919, data since 1984 are only approximate because hunter-day effort is only an extrapolated value during years when licensee surveys are not conducted. During years when licensee surveys were unavailable, I estimated harvest/1,000 hunter days using hunter estimates by WMD, and an assumption of stable per capita effort (e.g., year 2001 in Table 15).

North Maine Woods Data

The North Maine Woods Association (NMWA) is an organization of industrial timberland owners located primarily in WMDs 1, 2, 4, 5, and part of WMD 9. They have established gated access to their collective ownerships, which exceeds 3.7 million acres. NMWA does not restrict access to their lands, but they do charge visitation fees and they monitor duration of visits. Since 1977, NMWA has compiled excellent data on number of hunters and per capita deer hunting effort. NMWA data nicely illustrates the benefits of using hunting effort to interpret buck harvest and population trends.

Hunter-day trends for deer hunting season on NMWA lands are depicted in Figure 13. These northwestern Maine WMDs experienced a net increase in deer hunting effort between 1977 and 1985. Effort took a particularly sharp jump in 1984 and 1985 when bucks-only regulations went into effect in eastern and southern Maine. Between 1986 and 1990, effort stabilized as WMDs in the NMWA jurisdiction were placed under any-deer permit system regulations. Between 1991 and 1995, effort spiked again as NMWA gained additional hunters from Quebec (after that province closed adjacent lands to deer hunting). Since 1993 hunter effort in NMWA has steadily declined.

Figure 14 depicts the buck harvest and buck harvest/1,000 hunter-days in WMDs 1, 2, 4, and 5. Note that the harvest fluctuated without obvious trend between 1977 and 1984, when NMWA was annually gaining hunters. In contrast, kill/unit effort steadily

Figure 13. Hunter-days expended pursuing deer within the North Maine Woods Area

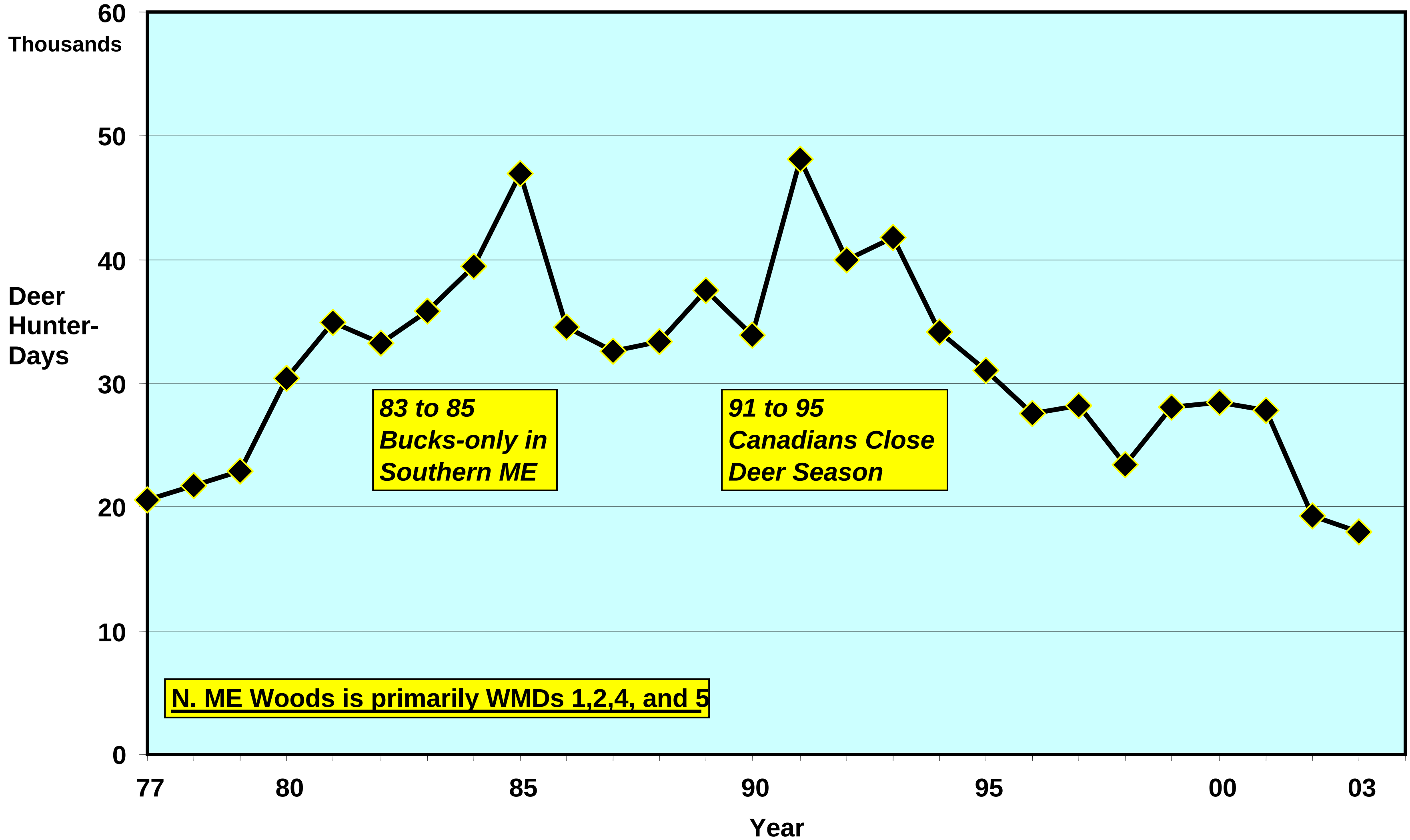
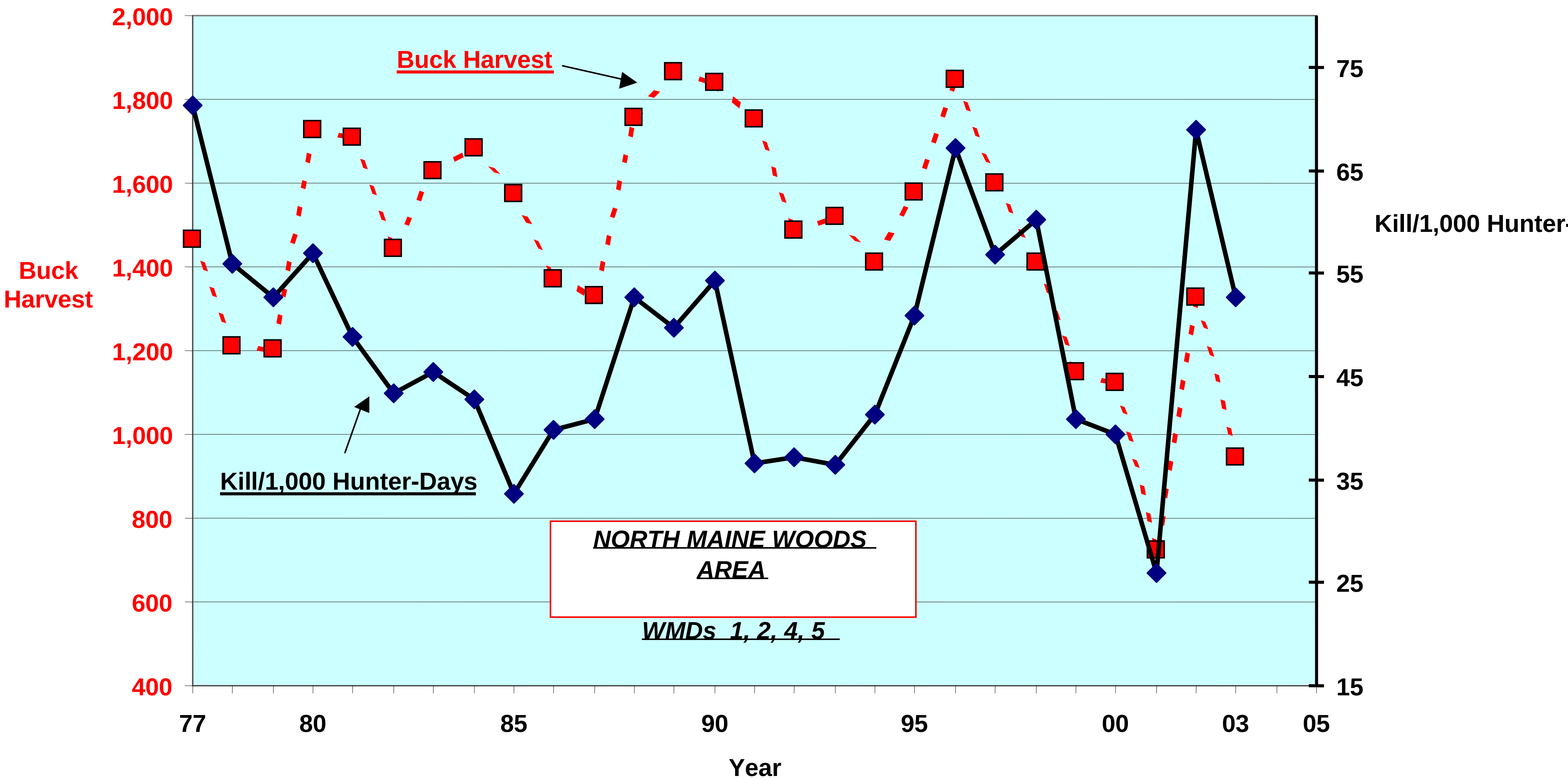


Figure 14. Buck harvest vs. kill per thousand hunter-days in the North Maine Woods Area of Maine, 1977 to 2003



dropped during that era. Using only the harvest trend, one would conclude that deer populations in WMDs 1, 2, 4, and 5 were fluctuating with minor changes in winter severity during the final years of either-sex hunting. But the trend for kill/unit effort suggests steadily declining hunter success indicative of a major decline in deer populations. Hunter input during that era reflected dissatisfaction with deer availability (Lavigne 1999) supporting a conclusion of herd decline.

Trend in kill/hunter-day between 1985 and 1990 suggests a recovery in deer population during the initial years of doe harvest restrictions under the any-deer permit system. Trends since 1990 show the effects of unusually severe winters in 1990, 1994, 1997, 1998, 2001, and 2003. In general, winters during the past 10 years have been increasing in severity in this part of the state (Appendix 4). Since 1995, both hunter effort and hunter success have declined sharply in the NMWA jurisdiction. One notable exception was 2002. In that year, unusually mild wintering conditions resulted in excellent deer survival. Both harvest and hunter success spiked despite a continued decline in overall hunting effort. Clearly, the availability of hunter effort data provides useful information when interpreting harvest and population trends.

Conclusions

Over the past 20 years, the Department has steadily lost the capability to adequately track deer hunter participation and success. This has led to less reliable data and a major limitation on the quality of decision-making in the management system. We need to find the means to reliably estimate hunter numbers and deer hunting effort at the

WMD level each year. In addition, we should at least periodically (3 year intervals) estimate hunter effort by season. Finally, the Department needs to restore our capability to monitor success rate of any-deer permittees.

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Prepared by: Gerald R. Lavigne
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APPENDIX 3. HARVEST-DERIVED POPULATION MODEL

Introduction

Accurate estimation of deer abundance serves a critical role in a management system driven by specific population goals and objectives. Ideally, it would be desirable to obtain reliable field estimates of deer abundance over large areas such as Maine's Wildlife Management Districts (WMDs; Figure 1). However, obtaining such estimates from large-scale pellet group surveys or aerial inventories is prohibitively costly and unjustifiable.

One solution to this problem involves the use of harvest data to model deer population changes. Several techniques have been developed utilizing deer harvest data to determine deer population size. One of the simplest involves the use of total harvest trend as an index to deer population change. This technique has serious limitations where variable quotas for antlerless deer result in marked annual fluctuations in hunting pressure on this segment of the population, or where buck hunting effort, hunting weather, season length, or deer vulnerability vary unpredictably. Trend of the registered kill of deer was used in Maine as the major index to population change until 1983, when deer of either-sex hunting regulations were abolished. The technique was not particularly effective in modeling deer abundance, primarily due to poorly documented increases in hunting effort and removal rates in certain parts of the State.

Trend in the harvest of adult bucks may be used to model deer population change. This technique is appropriate for hunting systems which allow all hunters to pursue antlered bucks, but restrict effort on antlerless deer. Buck kill index (BKI) is most effective in situations where removal rate of bucks remains stable from year to year, and hunter effort and season length for any given management area remain stable for several years. Where these conditions are met, BKI may be incorporated as a management objective and annual trend indicator. New York has successfully applied this approach for some time (Dickinson 1982). A buck kill index has been incorporated into Maine's management system for deer (see main text, page 60).

A more complex use of harvest data in modeling deer abundance involves population reconstruction (Downing 1980; Severinghaus 1969; Hesselton et al. 1965). In population reconstruction the size of the deer population is estimated by reconstruction of aged cohorts back to their year of recruitment. When accumulated for a large number of years reconstruction data provide a minimum population estimate, as well as estimates of total annual mortality and recruitment rates. A major assumption of the technique is that the proportion of hunting losses to total losses remains stable each year. In addition, population reconstruction most accurately reflects actual population size only when hunting is the predominant loss to the herd. When these assumptions are not met the results may be misleading.

Population reconstruction was used at the WMU level (Figure 9) in Maine between 1969-1982. Although resulting estimates of minimum population size were not incorporated into the existing (pre-1983) management system, sex and age-specific mortality and recruitment rates calculated from this technique were used for detailed population analysis for the years 1978-82 (Table 17). In this analysis, hunting mortality rate for adult bucks and does was estimated by the change-in-ratio (CIR) technique of Paloheimo and Fraser (1981). When combined, population reconstruction and CIR techniques enabled us to estimate population density, partition mortality into hunting and non-hunting losses, estimate recruitment and evaluate population stability for a fixed period of time in the past (1978-82). Both techniques had to be discontinued in 1983, when doe and fawn harvest restrictions invalidated the assumption of stable hunting removal rate. However, these data proved invaluable as a benchmark leading to estimation of allowable doe harvest when the Any-deer permit system was initiated in 1986.

In another type of population estimation model, pre-hunt adult buck population levels are estimated by population reconstruction of harvest data, but estimates for does and fawns are derived from sex and age ratios (e.g., yearling frequencies and fawn-doe ratios) evident in the harvest or from field observations. This type of model, usually referred to as sex-age-kill (SAK) analysis was an important part of Pennsylvania's deer management system (Lang and Wood 1976).

Table 17. Prehunt deer populations and hunting removals by Wildlife Management Units, 1978-82.

Item	Wildlife Management Units								Statewide
	1	2	3	4	5	6	7	8	
Deer Habitat (mi^2)	1,767	8,689	3,645	5,044	2,633	2,207	1,649	1,985	27,619
Mean Deer Kill									
Male Fawns	307	380	273	1,321	287	300	757	828	4,472
Male 1.5+	897	1,602	745	3,706	992	1,069	2,188	1,646	12,813
All Males	1,204	1,982	1,018	5,027	1,279	1,369	2,945	2,474	17,285
Female Fawns	289	366	226	1,190	286	257	668	665	3,993
Female 1.5+	550	832	480	2,999	650	652	1,767	1,636	9,536
All Females	839	1,198	706	4,189	936	909	2,435	2,301	13,531
All Deer	2,043	3,180	1,724	9,216	2,215	2,278	5,380	4,775	30,816
Kill/Mi^2 Habitat	1.16	0.37	0.47	1.83	0.84	1.03	3.26	2.41	1.12
Hunting Removal Rate									
Male 1.5+	0.219	0.124	0.163	0.228	0.177	0.204	0.249	0.412	0.204
Female 1.5+	0.119	0.056	0.081	0.146	0.116	0.122	0.189	0.343	0.139
All 1.5+	0.169	0.090	0.122	0.187	0.147	0.163	0.219	0.377	0.171
All Deer	0.164	0.081	0.117	0.177	0.141	0.153	0.197	0.349	0.162
Recruitment									
0.5 F/1.5+ F	0.390	0.375	0.321	0.349	0.381	0.377	0.457	0.509	0.402
Prehunt 0.5 M:F	1.059	1.037	1.207	1.110	1.084	1.134	1.133	1.029	1.120
Prehunt Population									
Male 1.5+	4,096	12,919	4,571	16,254	5,605	5,240	8,787	3,995	62,809
Female 1.5+	4,622	14,857	5,926	20,541	5,603	5,344	9,349	4,770	68,619
Male Fawns	1,909	5,778	2,296	7,957	2,314	2,285	4,841	2,498	30,895
Female Fawns	1,803	5,571	1,902	7,169	2,135	2,015	4,273	2,428	27,585
Males All Age	6,005	18,697	6,867	24,212	7,919	7,525	13,628	6,493	93,704
Females All Age	6,424	20,429	7,828	27,710	7,738	7,359	13,622	7,197	96,203
All Deer	12,429	39,125	14,695	51,922	15,657	14,884	27,250	13,691	189,907
Deer/Mi^2 Habitat	7.03	4.50	4.03	10.29	5.95	6.74	16.53	6.90	6.88
Sex Ratios M:100F									
All Age									
Prehunt	93.5	91.5	87.7	87.4	102.3	102.3	100.0	90.2	97.4
Hunting Kill	143.5	165.4	144.2	120.0	136.3	150.6	120.9	107.5	127.7
Posthunt	86.0	86.9	82.1	81.6	97.6	95.4	95.5	82.1	92.4
Adults (1.5+)									
Prehunt	88.6	87.0	77.1	79.1	100.0	98.1	94.0	83.8	91.5
Hunting Kill	163.1	192.5	155.2	123.6	152.6	164.0	123.8	100.6	134.3
Posthunt	78.6	80.7	70.2	71.5	93.1	88.9	87.0	75.0	84.6
Fawns:100 Does (1.5+)									
Prehunt	80.3	76.3	70.8	73.6	79.4	80.5	97.5	103.2	85.2
Hunting Kill	108.4	89.7	104.0	83.7	88.2	85.4	80.6	91.2	88.8
Posthunt	76.5	75.6	67.3	71.9	78.3	79.7	101.4	109.5	84.7

New Jersey (Burke and Snyder 1987) also employed a variant of this SAK model, as did Wisconsin (Creed et al. 1984). The use of yearling frequencies (Severinghaus and Maguire 1955) from adult buck and doe harvest data allows estimation of population sex ratios. This approach may be used with deer herds subjected to variable hunting removal rate, i.e., quota-oriented antlerless deer hunts. However, since several years are required for reconstruction of buck populations this SAK model is most accurate for historical data. The lag time required for population reconstruction is least for buck populations which are heavily hunted and therefore exhibit high turnover and limited longevity (e.g., Pennsylvania).

In lightly hunted populations (e.g., Maine), non-hunting losses exert an important influence on buck population dynamics (Chilelli 1988). Consequently, non-hunting loss rates should be incorporated into SAK modeling to achieve more reliable population estimates.

Model Overview

Another version of SAK models is currently being used in Maine. This version eliminates the lag time in reconstructing buck populations by utilizing yearling frequencies of harvested bucks to estimate total annual mortality rate. Buck populations are then calculated using the current harvest and estimates of non-hunting losses. As with other SAK models this version uses the relative yearling frequencies of bucks vs. does to estimate adult doe population size. Use of yearling frequencies in the harvest assumes long-term population stability in adult mortality rate for each sex. When this assumption is violated by fluctuations in adult mortality and/or recruitment, short-term changes in yearling frequencies may result in erroneous population estimates. Fawn populations are estimated from harvest or field-derived estimates of fawn:doe ratios. This SAK model provides the distinct advantages of allowing estimation of deer abundance in regions where: 1. hunting effort on bucks is light, and 2. antlerless deer are subjected to fluctuating levels of hunting removal.

Remaining sections of Appendix 3 describe the development and implementation of the SAK model used in Maine. This harvest-derived population estimator (HARPOP) was developed in 1987 and incorporated into the deer management system in 1988.

HARPOP utilizes sex and age-specific enumerations of the legal harvest to estimate pre-hunt deer population size at the WMD or statewide level. When adjusted for estimates of crippling and illegal losses, in addition to known legal kills, HARPOP outputs pre-hunt, harvest period and post-hunt (wintering) population size and density, harvest mortality rates, and sex and age ratios for fawns, yearlings and adults.

HARPOP is a SAS program adapted to IBM Windows PCs. Model inputs include: year, WMD, area of deer habitat, adjusted registered harvest of fawns, yearlings and older bucks and does, yearling frequencies as a percentage of harvested yearling and older bucks or does, recruitment rate and sex ratio, illegal and crippling rate for bucks and antlerless deer, and hunter-days of effort per mi^2. Detailed discussion of model inputs is presented below.

The model may be divided into four components. The first three yield estimates of pre-hunt population size separately for yearling and older bucks, yearling and older does, and fawns. The fourth component calculates post-hunt and harvest period population parameters and outputs data files.

Model Inputs

Basic housekeeping variables are input to define the year and type of habitat unit being modeled. HARPOP is programmed to provide annual estimates of deer population parameters (e.g., Figure 6), although longer intervals (e.g., five-year means) have also been modeled at the statewide level. There is no limit to the size of study area that may be modeled provided that reliable input data are available, particularly for age and sex composition of the harvest. Intuitively, model accuracy would be greatest for large areas (>500 mi^2) such as WMDs. Population estimates were generated for smaller areas (e.g., proposed release sites for caribou during 1988), but age data for some of these 150-200 mi^2 areas had to be extrapolated from WMD-level data files. We occasionally use HARPOP to estimate deer density at the township level, providing the town is subjected to deer hunting activity.

Adjusted deer registrations summarized for areas being modeled by sex and age class (fawn, yearling and older deer) provide the basic data needed to estimate pre-hunt population size. A major assumption involved here is that age composition in the harvest accurately represents the actual age structure of the pre-hunt population for yearling and older bucks, and yearling and older does. This assumption is probably met given Maine's long deer hunting season and hunter selectivity patterns (White and Banasiak 1962). Maguire and Severinghaus (1954) also concluded that the harvest age structure for adults closely parallels population age structure separately for each sex in areas subjected to long hunting seasons. However, hunter selectivity and/or differential vulnerability may bias harvest sex ratios (White and Banasiak 1962) and harvest fawn:doe ratios (Coe 1980 and Banasiak 1964.). Fortunately, in HARPOP, these ratios are derived from other sources, i.e., sex ratios from yearling frequencies and fawn:doe ratios from the lactation index (Table 9).

Although harvest age structure is generally assumed to represent adult buck and doe age structures in the pre-hunt population, inadequate sampling may conceivably result in distorted age distributions which may lead to inaccurate population estimates (Lavigne 1993). To reduce sampling bias, effort is made to obtain an adequate sample distribution both spatially within WMDs and temporally throughout the firearm season. Nevertheless, when doe harvest quotas are particularly restrictive, even a 100% sample of the antlerless deer harvest may be inadequate to represent the true age structure of the herd. Multiple year means or extrapolation from other WMDs has been used to calculate yearling female frequencies. The importance of accurate and precise measures of this parameter cannot be overlooked and alternative techniques are being examined for possible use in the management system.

Yearling frequency (YF), calculated as the percent yearlings among yearling and older bucks or does in the adjusted registered kill provides an index to total annual mortality rate among adult deer. It has long been recognized (Severinghaus and Maguire 1955; Severinghaus 1969; Lang and Wood 1976; Creed et al. 1984; McCaffery et al. 1987) that YF is directly correlated with population turnover rate among deer >1 year of age. Increases in all-cause mortality rate are reflected in proportional increases in buck YF, with concurrent decreases in longevity (Table 18). Although extremely high all-cause mortality rates (70-90%) are biologically sustainable for adult bucks (Dickinson 1982; Lang and Wood 1976), adult mortality approximating 50% for does would exceed the genetic capability of the species to replace losses and hence would rapidly lead to population extinction (McCullough 1979). At the other extreme, all-cause adult mortality rates much below 20% are not biologically sustainable over long periods of time because survivorship for a large segment of the population would exceed the physiological limits for longevity (i.e., 18 years) of the species (Figure 15). In this situation, mortality rates among older deer (chronic mortality) would ultimately increase to compensate for reduced losses among younger cohorts. Stable deer populations not subjected to hunting or other additive sources of mortality could sustain a minimum doe mortality rate no lower than 18% (McCullough 1979).

That YF for bucks in Maine provides an adequate index to adult mortality rate is demonstrated by Figure 16. YF of bucks were significantly ($r^2 = .97$; $p < .001$) correlated with estimates of all-cause adult buck mortality rate derived from population reconstruction in Maine during 1969-82 (Table 5). Despite the strong correlation of YF with all-cause mortality rate, YF of bucks in this analysis tended to slightly underestimate all-cause mortality derived from population reconstruction (Figure 16

Table 18. Cohort size (% of total yearling and older deer population), given various all-cause annual mortality rates[1].

Age Class	All-cause Annual Mortality (%)								
	10	20	30	40	50	60	70	80	90
Yearling	10	20	30	40	50	60	70	80	90
2 ½	9	16	21	24	25	24	21	16	10
3 ½	8	13	15	14	13	10	6	3	<1
4 ½	7	10	10	9	6	4	2	1	0
5 ½	7	8	7	5	3	2	1	0	
6 ½	6	7	5	3	2	1	0		
7 ½	5	5	4	2	1	0			
8 ½	5	4	3	1	0				
9 ½	4	3	2	1					
10 ½	4	3	1	0					
11 ½	3	2	1						
12 ½	3	2	1						
13 ½	3	2	1						
14 ½	3	1	1						
15 ½	2	1	0						
16 ½	2	1							
17 ½	2	1							
18 ½	2	1							
19 ½	15	0							
Total	100	100	100	100	100	100	100	100	100
4 ½ +	73	51	36	21	12	7	3	1	0
10 ½ +	39	13	5	0	0	0	0	0	0

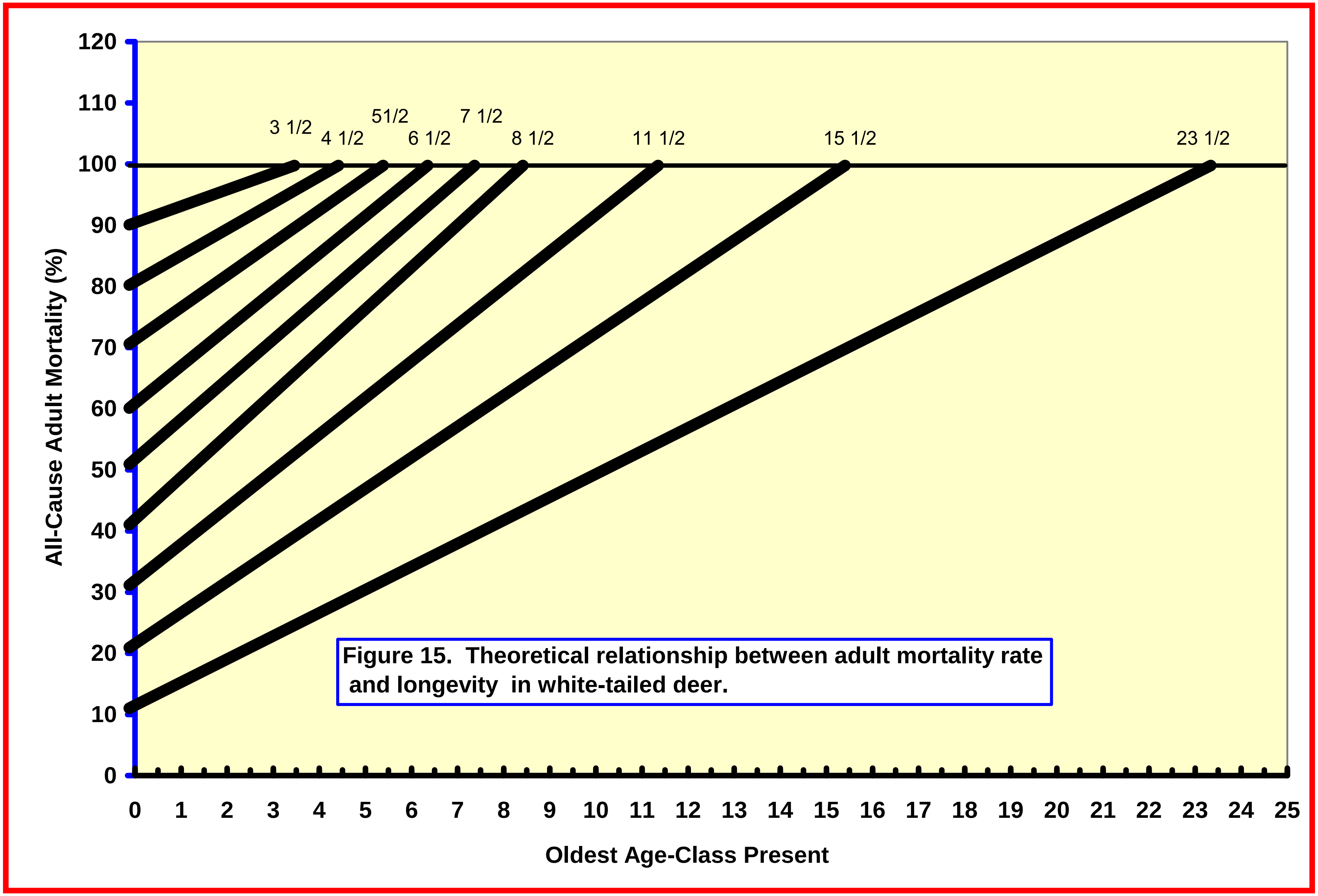

Figure 15. Theoretical relationship between adult mortality rate and longevity in white-tailed deer.

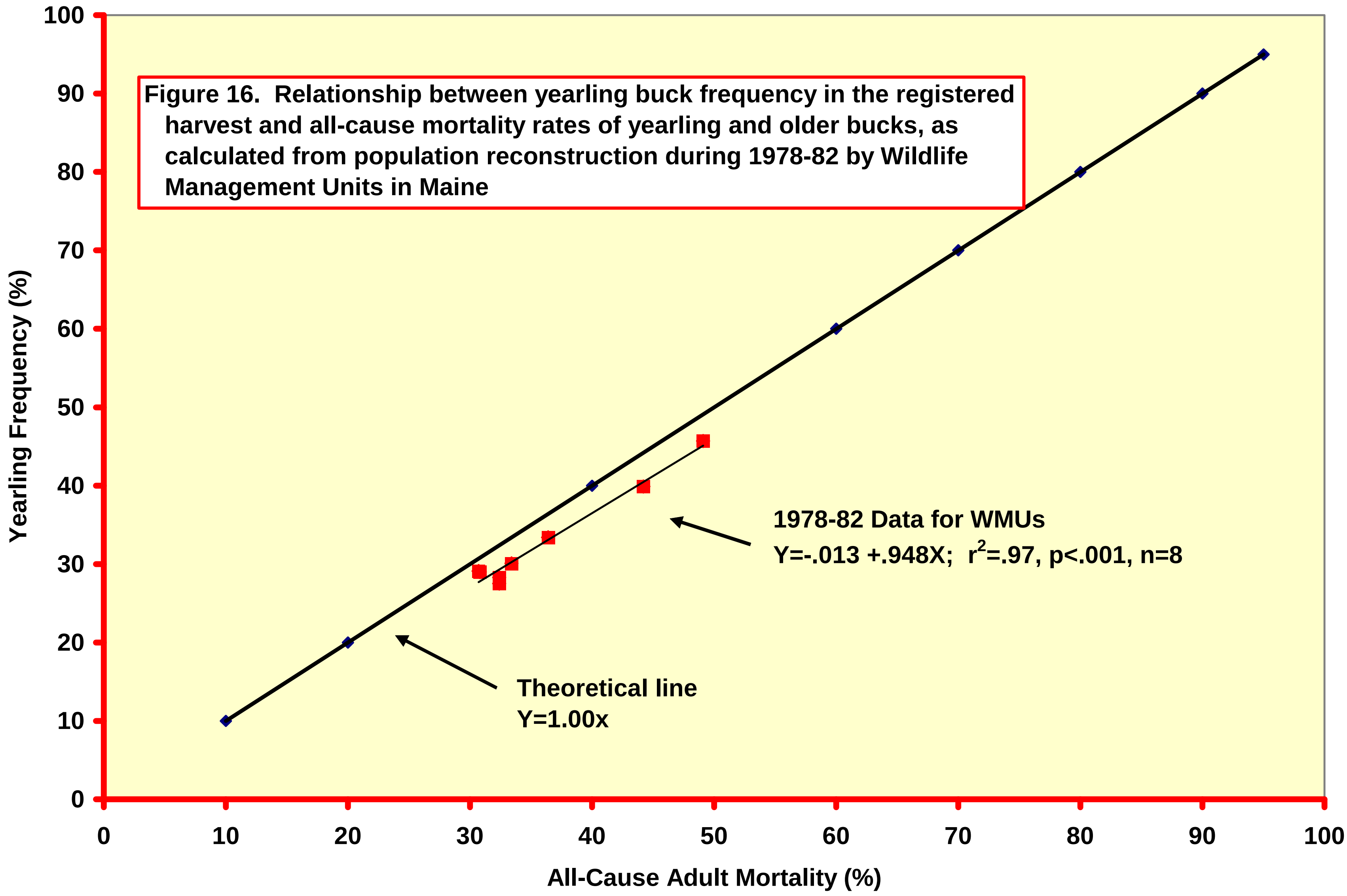
Figure 16. Relationship between yearling buck frequency in the registered harvest and all-cause mortality rates of yearling and older bucks, as calculated from population reconstruction during 1978-82 by Wildlife Management Units in Maine
1978-82 Data for WMUs
Y=-.013 +.948X; r2=.97, p<.001, n=8
Theoretical line
Y=1.00x
Yearling Frequency (%)
All-Cause Adult Mortality (%)
0
10
20
30
40
50
60
70
80
90
100

theoretical line). If this is generally true, then use of YF values in HARPOP may tend to yield slight overestimates of actual deer density.

YF values serve 3 functions in HARPOP. Yearling male frequency (YMF) is used to predict total annual losses of bucks. Secondly, YMF, along with an estimate of hunting effort, is used to predict the proportion of total losses attributable to the legal harvest (HPT). Finally, the relative magnitude of YMF vs. yearling female frequency (YFF) is used to estimate pre-hunt adult sex ratios (ASRP; Severinghaus and Maguire 1955). These applications of YF to HARPOP are discussed in greater detail in later sections.

Use of YF as an index to adult mortality rate is valid only when adult populations are reasonably stable. Large deviations in adult mortality rate or recruitment will result in short-term fluctuations in YF which lead to erroneous estimates of adult mortality rate (McCaffery et al. 1987). To minimize errors in predicting adult mortality rate, YMF and YFF are input as running 7-year averages instead of annual values. In the Wisconsin version of this model, YF is input as a 10-year running mean for the same reason (McCaffery et al. 1987). Nevertheless, during periods of rapid deer population change, it may be necessary to use personal judgment when inputting YF values in order to produce biologically sound estimates of adult mortality rates. In addition, YF of does must be estimated for WMDs subjected to bucks-only hunting for several consecutive years.

Estimation of pre-hunt fawn population requires an input which defines recruitment. This input is an estimate of the number of fawns:doe in the pre-hunt herd (FDRP). FDRP is derived from the lactation-embryo rate index (LER) illustrated in Table 9. Accuracy of recruitment estimates based on LER has not yet been validated. These estimates tend to yield lower fawn:doe ratios than those derived from population reconstruction data (Table 16). Underestimation of recruitment rates would bias HARPOP values on the low side. However, researchers have concluded that fawns tend to be more vulnerable than adult does in either-sex hunting systems (Banasiak 1964). Hence fawn:doe ratios calculated from either-sex harvest data would over-represent actual fawn recruitment.

Recruitment sex ratio (RSR) is expressed as the number of males:females at recruitment age, i.e., 6 months. RSR is currently derived from the sex ratio of fawns appearing in the statewide adjusted registered harvest. During 1978-82 this ratio was 112 males:100 females. Although minor fluctuations in sex ratio of harvested fawns may occur annually, statewide RSR values have approximated 112 males:100 females since at least the 1950s (Banasiak 1964; MDIFW unpubl. data). Whether the sex ratio of harvested fawns accurately reflects pre-hunt fawn and yearling sex ratios is unknown. However, minor deviations in estimated RSR from actual values would exert little influence on HARPOP population estimates.

Combined estimates of illegal kill and crippling loss for adult bucks (ILCM) and antlerless deer (ILCA) are also input into HARPOP. When added to the adjusted registered harvest, a reasonable approximation of total deer losses during November is available. These combined losses subtracted from pre-hunt population estimates enable computation of post-hunt population size for each sex and age class.

Actual rates of illegal kill and crippling loss are not available for Maine deer. However, because omission of these deer losses would result in less accurate estimates of wintering herd density (Chilelli 1988), “guesstimates” of illegal and crippling losses among bucks (ILCM) and among antlerless deer (ILCA) were input into HARPOP. Banasiak (1964) estimated illegal losses to be 20% of the registered kill while crippling losses represented 15%. These estimates were derived subjectively, yet appeared reasonable relative to other estimated losses. Lacking quantification of these loss rates, ILCM is currently set at 20% to 25% of the adjusted registered buck harvest. This yields an illegal and crippling rate for antlerless deer that is comparable to the pooled rates reported by Banasiak (1964) noted above.

HARPOP also requires an input which provides an index to hunting pressure. Hunter-days of effort (HDE) per mi^2, is used with YMF in a regression equation which estimates the proportion of total adult buck losses which are attributable to hunting (HPT). Derivation of HDE values for WMDs or statewide is detailed in Appendix 2. A major weakness of SAK models is the inability to estimate total annual buck losses solely from known harvest. Field estimates of the proportion of total losses attributable to hunting (HPT) vs. “all other losses” are generally lacking. Moreover, this proportion likely varies regionally and temporally. Pennsylvania and Wisconsin versions of SAK models assume a high and constant HPT value (Lang and Wood 1976; Creed et al. 1984). This assumption could not be considered valid under all field conditions in Maine (Table 19) during 1978-82.

Data collected in Maine during 1969-82 and 1992-96 clearly demonstrates that all-cause annual buck mortality increases with hunting effort (Figure 17). It is interesting to note that the Y-intercept differs significantly ($P < 0.05$) for the 1969-82 vs. 1992-96 data. This suggests that buck mortality during more recent times is higher (~33%) in the absence of hunting than during the 1970's (~25%). Although the actual source of this 8% additional mortality remains unknown, this non-hunting loss factor(s) is likely additive to the legal kill. Since it is also likely to be present among antlerless deer, this additional mortality must be (and has been) taken into account when prescribing doe harvests.

A major implication of the data presented in Figure 17 is that nearly all buck mortality above 33% (for 1992-96) is directly attributed to increases in hunting pressure. Because hunting effort and all-cause buck mortality are directly related, measures of deer hunting effort (HDE) can be used to predict the relative magnitude of hunting vs. all-other mortality as a percent of total annual buck losses. Figure 18 depicts the relationship between deer hunting effort (HDE) and hunting mortality as a percent of all-cause annual buck mortality (HPT) for 1969-82. Legal harvest comprised 40 to 80% of total buck losses during that era. In the HARPOP model, the equation in Figure 18 is

Table 19. Mortality rates, yearling buck frequency, and deer hunting effort among Wildlife Management Units in Maine during 1978-82.

	Mortality Rates[a] (% of Prehunt Population)					
WMU	All Cause	Legal Hunting	All Other	HPT %[c]	Buck[b] Yearling Frequency	Hunter-Days Effort Per Sq. Mi. Habitat[d]
1	32.4	21.9	10.5	68	28.3	83
2	30.7	12.4	18.3	40	29.1	12
3	33.4	16.3	17.1	49	30.1	30
4	36.4	22.8	13.6	63	33.4	99
5	30.8	17.7	13.1	57	29.0	49
6	32.4	20.4	12.0	63	27.5	65
7	44.2	24.9	19.3	56	39.9	156
8	49.1	41.2	7.9	84	45.7	192
Statewide	36.4	20.4	16.0	56	34.2	59

[a]All-cause mortality rates were calculated by population reconstruction of harvest data (Downing 1980).
Legal Hunting mortality rate was calculated using the change-in-rate estimator of Poloheimo and Fraser (1981).
All other mortality rate was calculated as (All-Cause)-(Legal Hunting) mortality rates.

[b]Computed as a mean for 1978-82 from adjusted deer registrations (Appendix IV).

[c]Calculated as (Legal Hunting/All-Cause)x100

[d]Estimated from annual Game Kill Questionnaires and averaged for 1978-82 (Appendix XIV).

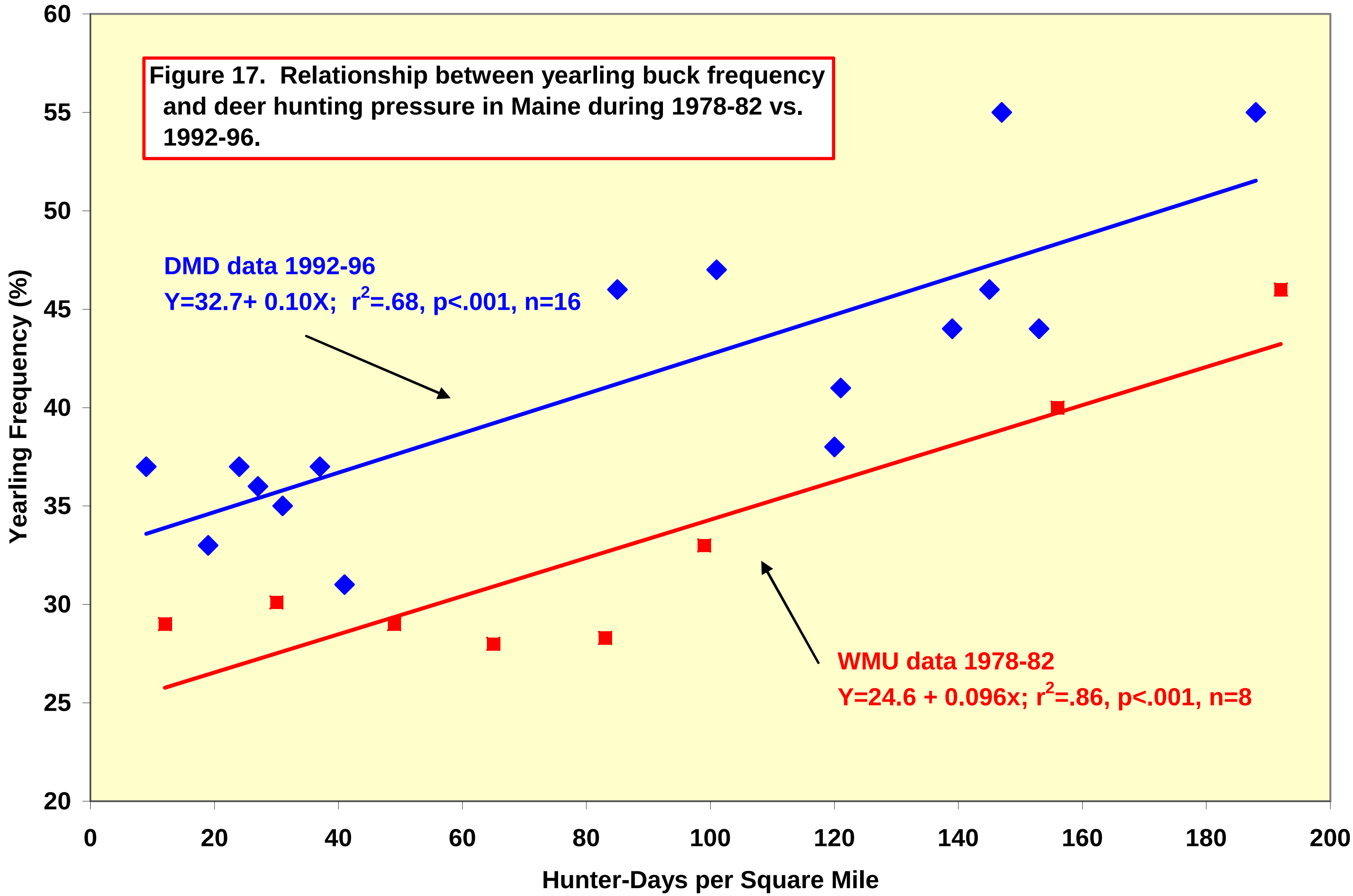
Figure 17. Relationship between yearling buck frequency and deer hunting pressure in Maine during 1978-82 vs. 1992-96.
DMD data 1992-96
Y=32.7+ 0.10X; r2=.68, p<.001, n=16
WMU data 1978-82
Y=24.6 + 0.096x; r2=.86, p<.001, n=8
Yearling Frequency (%)
Hunter-Days per Square Mile
60
55
50
45
40
35
30
25
20
0
20
40
60
80
100
120
140
160
180
200

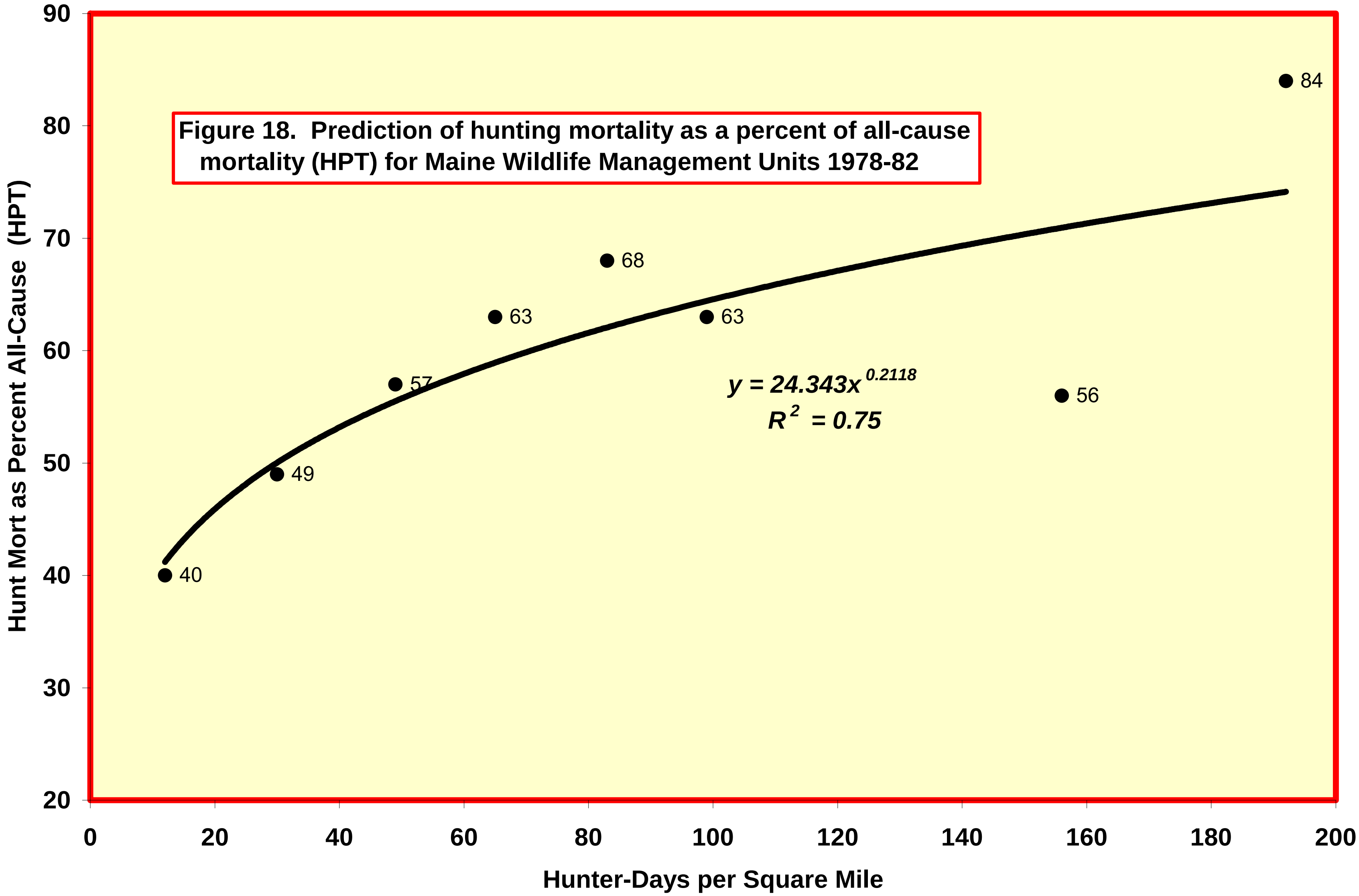
Figure 18. Prediction of hunting mortality as a percent of all-cause mortality (HPT) for Maine Wildlife Management Units 1978-82
Hunt Mort as Percent All-Cause (HPT)
90
80
70
60
50
40
30
20
84
68
63
63
57
56
49
40
y = 24.343x 0.2118
R 2 = 0.75
0
20
40
60
80
100
120
140
160
180
200
Hunter-Days per Square Mile

used to estimate HPT. This assumes that the effect of varying hunting effort results in the same proportional change in HPT currently as it did during the 1970s, despite higher total buck losses in recent times. This assumption is probably valid, since the slope of the regression equations in Figure 17 do not differ.

Model Components

Pre-hunt Buck Population

Pre-hunt population size for yearling and older (adult) bucks is calculated from the following equation:

$$YAMP = [YAMK \div HPT] \div YMF$$

Where YAMP = yearling and older buck pre-hunt population.

YAMK = adjusted registered kill of yearling and older bucks.

HPT = proportion of total annual yearling and older buck losses attributable to legal harvest.

YMF = percent of male yearlings among yearling and older bucks in the adjusted registered kill.

The first portion of the equation yields an estimate of total annual losses for adult bucks. The second portion uses this estimate to calculate the pre-hunt buck population from which those losses were drawn.

Pre-hunt Doe Population:

Pre-hunt population size for yearling and older (adult) does is calculated first by estimating the pre-hunt adult sex ratio (ASRP) using an equation adapted from Severinghaus and Maguire (1955):

$$ASRP = [(YMK \div RSR) \div YAMK] \div (YFF \div 100)$$

Where ASRP = yearling and older does:100 yearling and older bucks in the pre-hunt population.

YMK = adjusted registered harvest of yearling bucks.

RSR = male:female sex ratio at recruitment (into yearling age class).

YAMK = adjusted registered harvest of yearling and older bucks.

YFF = percent yearling does among yearling and older does in the adjusted registered harvest.

As proven by Severinghaus and Maguire (1955), the ratio of yearling bucks to does in the harvest reflects the pre-hunt population sex ratio of adult females to males after correcting for unequal sex ratio at recruitment into the yearling age class. Generally, the greater the divergence in YF of bucks vs. does, the greater the relative difference in population turnover rate, life expectancy, and standing crop between the sexes.

Once pre-hunt adult sex ratios are estimated, pre-hunt yearling and older doe population (YAFP) is estimated by multiplying the yearling and older buck population estimate by the pre-hunt adult sex ratio, i.e., YAFP = YAMP x ASRP.

Pre-hunt Fawn Population

The number of fawns in the pre-hunt population (TFP) is calculated by multiplying the pre-hunt yearling and older doe population (YAFP) by the recruitment rate (FDRP), i.e., TFP = YAFP x FDRP. As described in the model inputs section, FDRP is estimated from the lactation – embryo rate (LER) index, described in detail in Appendix 7.

FMP = TFP x [RSR ÷ (1 + RSR)]

Where FMP = pre-hunt male fawns.

TFP = total pre-hunt fawns.

RSR = male:female at recruitment.

FFP = TFP - FMP.

Where FFP = pre-hunt female fawns.

Miscellaneous Calculations and Output

Once pre-hunt population size and sex-age structure has been estimated, corresponding figures for the harvest and posthunt (wintering) population may be computed from existing data inputs and simple addition and subtraction. For example, wintering sex and age structure is computed by subtracting registered harvest and estimated illegal-crippling losses from pre-hunt population size for each sex and age class. Totals for various sex and age classes are computed by simple addition for pre-hunt, harvest and wintering periods. Sex ratios, age ratios and hunting mortality rates are computed for various sex-age classes. All population estimates are converted to densities by dividing the area of deer habitat (HAB).

HARPOP produces two types of output. One is a detailed listing of all computed population estimates and attributes by WMD for the current year. Included are values of all input variables used to generate population estimates.

The second output briefly summarizes pre-hunt and wintering estimates of total herd size and density, as well as total harvest by WMD for the current and all available past years. Output formats are easily adapted to other geographical areas or combinations of variables.

<u>Model Evaluation</u>

Population estimates produced by HARPOP appear to be realistic in light of deer density estimates produced by population analyses during 1978-82 (Figure 6 and Table 15) and for the late 1950s (Banasiak 1964). At the DMD level, HARPOP-derived estimates roughly parallel those derived from pellet group surveys during the late 1980s

(MDIFW unpubl. data). However, such comparisons have not been made since pellet group surveys were discontinued in 1990.

HARPOP should be more rigorously tested to determine sensitivity to input variables and verification of accuracy in predicting wintering herd estimates at the WMD level.

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APPENDIX 4. ADJUSTMENT OF ANY-DEER PERMIT ALLOCATIONS FOR WINTER SEVERITY.

Prepared by: Gerald R. Lavigne, July 11, 1995

Updates by: Lee E. Kantar, 2006

Introduction

Determination of allowable harvest of adult does within Maine’s 29 Wildlife Management Districts requires an estimate of the average or typical level of mortality annually sustained by the female segment of the herd. This mortality may be broadly divided into legal hunting (allowable harvest) and “all-other” causes of death. Since recruitment of fawns must equal adult doe mortality for a population to be stable, any major change in mortality rate in the “all-other” category must be compensated by a change in the legal kill. A major assumption here is that the various mortality factors are additive when the herd is <60% of K carrying capacity. Also, major changes in recruitment rate of doe fawns would also require a compensatory adjustment in legal harvest to maintain population objectives.

In practice, if the long-term or typical doe loss rate (expressed usually as % of the post-hunt or wintering population of does) increases sharply during a given year, allowable legal harvest of does must decrease proportionately, if the balance between total mortality and recruitment is to be maintained. Conversely, if some factor in the “all-other” doe loss category decreases sharply below typical levels, allowable legal harvest of does could be increased proportionately to stabilize the population.

Many of the loss factors impinging on Maine's deer population cannot readily be measured. Gauging their magnitude and impact on regional deer populations has largely been accomplished through trial and error. This is an ongoing process. One category of mortality causes is related to the severity of winter weather. Winter severity, near the northern limit of the white-tail's range, is a major wild-card in deer management. One can never predict whether the effects of winter will be average or typical for an area, or whether severity will fall at the outer extremes for deer (extremely severe or extremely mild for a given area). Winter losses of deer take on many forms; all of them are directly related to the severity of wintering conditions (snow depth, deer mobility and thermal stress). Included among winter losses are malnutrition, disease (pneumonia among others), predation to coyote, bobcat and free-roaming dogs, and to some degree, collisions with motor vehicles (during and immediately after winter). Neonatal losses are also positively related to winter severity, as is fecundity rate of does (Lavigne 1992).

Maine experiences great regional and inter-annual variation in winter severity. In the past 45 years, winter's impact has caused loss rates ranging from <3% of the wintering herd during very mild winters to >35% during particularly severe winters. Although we cannot predict the severity of winter in advance, we have gained sufficient knowledge of its impacts to compensate for above (or below) average winters when they occur (Lavigne 1992). The procedures used by MDIFW to adjust the recommended allocation of Any-Deer permits for winter severity are detailed below. The process has 3 parts:

1. A winter severity index (WSI) and its corollary estimate of winter mortality rate (WMR) are computed for each WMD.
2. WSI and WMR for the current year are compared with a typical or normal range for a given WMD.
3. Any-Deer permits are adjusted downward (severe winter) or upward (mild winter) sufficiently to equal (and hence negate) the impact of that winter on doe survival and recruitment.

Winter Severity Index and Winter Mortality Rate

The monitoring program implemented by MDIFW since 1973 is described in Parts 1 and 2 of the Deer Management System and Lavigne (1995). The winter severity index (WSI) is computed for the December-April wintering period by WMD. Individual monitoring stations used to compute the index for each WMD appear in Table 20.

Estimation of Winter Mortality Rate (WMR) associated with a given level of WSI is accomplished using the following algorithm: $WMR = 2.29e^{0.0222WSI}$. This mortality curve predicts exponential increases in WMR with incremental increases in WSI. The equation was derived from research on the effects of winter severity on a population of deer wintering in good wintering habitat in western and north-central Maine during 1971 to 2000 (Lavigne 2001). The equation may underestimate actual winter loss rates at the mild and very severe ends of the spectrum. Predicted values for WMR at various levels of winter severity are presented in Table 21.

Comparison of Current vs. "Typical or Normal" Winter Severity Levels

Although it remains true that no two Maine winters are identical, long-term trends are evident in each WMD or group of WMDs (Lavigne 1995). For example, winters in northern Maine WMDs 1, 2, and 3 are typically severe, and hence deer in those districts typically sustain relatively high rates of winter mortality. In contrast, the opposite trend is true in southern WMDs 13 and 14; that part of the state rarely sustains more than a moderate level of winter severity. Consequently, WMRs in southern WMDs typically are low.

To characterize what is perhaps the typical or long-term trend in winter severity, mean WSI for the period of 1990-91 to 2004-05 were computed. This 15-year period encompasses that maximum life-expectancy of doe deer in Maine, and it includes the prevailing trends in winter severity for each WMD. However, it is a short-enough time span to reflect broad changes in winter severity as they occur. This 15-year mean is considered the Threshold WSI Level, specific to each WMD (Table 22).

> Rule of Thumb: Threshold WSI levels will be re-computed at 5-year intervals. Therefore, in 2010 the mean WSI for 1995-96 to 2009-2010 will become the new threshold for WSI.

Once threshold WSIs are computed, the long-term winter mortality rate associated with that severity level may also be computed (Table 22). To assess whether the current winter is less, more or similar in severity to the threshold level one could use either a point value for mean WSI threshold, or use a range of WSI values. At the lower extreme of WSI, WMR predictions change little with small changes in WSI, and it is debatable whether changes in WSI of 5 or more units is biologically significant. To account for this, I've opted for a range in threshold WSI which corresponds to a specified range in normal or typical WMR (Table 22).

> Rule of Thumb: Acceptable WSI Range is that series of WSI values which encompasses the 15-year mean WMR +/- 0.5% (one half of one %) of the wintering herd.

As detailed in Tables 3 current winters in which WSI falls within the Acceptable WSI Range are rated as Average; those falling below that range are Below Average in severity; and those which exceed the threshold are considered Above Average in severity.

Adjusting Any-Deer Permits for Winter Severity

The purpose of altering the number of Any-Deer permits is to regulate the magnitude of legal hunting mortality of does. When the various mortality factors are additive, altering the level of legal kill of does will affect the magnitude of all-cause mortality rates. In this way, manipulating the hunting kill enables the manager to achieve population increases if total doe losses are kept below the replacement or recruitment rate. Conversely, increasing the hunting kill of adult does would lead to population decreases, if this causes total losses to exceed recruitment. Clearly, this method of population regulation works best where hunting losses are a major source of total annual losses of does. This is the case in central and southern WMDs. Elsewhere, hunting is such a small component of total annual losses that herd response to doe harvest manipulations is slow, and rather tenuous, particularly when severe winters occur.

Above (or below) average winter losses are compensated by reducing (or increasing) Any-Deer permits by an amount equivalent to the difference between the threshold WMR and the current winter WMR.

> Rules of Thumb: If the WMR for the current winter in a given WMD exceeds the threshold WMR, then a deer population decline is assumed. Compensatory reduction in doe harvest equivalent to the magnitude of excess winter losses (mean threshold WMR – current WMR expressed as % of wintering population) is required when the herd is at or below the target population. When above target, compensation for winter losses is optional.
>
> If the WMR for the current winter is below the threshold WMR, then a population increase is assumed. A compensatory increase in doe harvest equivalent to the difference between mean threshold WMR and current WMR is required when the herd is at or above the target population. When below target, compensation for improved winter survival following mild winters is optional.
>
> If the WMR for the current winter falls within the range of WMR indicated by the acceptable WSI Range, compensatory adjustments in legal doe harvest for winter severity is unnecessary.

There is a time lag between onset of increase of doe mortality, and recovery of the standing crop of does to prior levels. This lag results from the time necessary for recruits to attain reproductive age (usually by age 2). Because of this lag effect, compensatory adjustments in doe harvest are to be implemented for a minimum of two consecutive years.

> Rule of Thumb: During the second year following a severe winter, harvest adjustments of at least ½ the reduction in doe harvest during the previous year will be implemented if the herd remains below target.
>
> During the second year following a mild winter, harvest adjustments of at least ½ the increase in doe harvest during the previous year will be implemented if the herd remains above target.

Translating excess winter mortality to a doe harvest prescription is accomplished using the look-up tables presented in Appendix 5. One example will illustrate the process: Suppose that the WSI for WMD 14 during 1995-96 is 80. This represents a substantially more severe winter than that southern Maine WMD normally experiences (Table 22). In fact, the acceptable WSI range for WMD 14 is 61 to 66, the threshold WMR range is 8.8 to 9.8% of the wintering herd, and this threshold averages 9.3%. At a WSI of 80 in 1995-96, WMD 14 experienced a computed WMR of 13.5% of the wintering population (Table 21). Subtracting the threshold mean WMR from that for 1995-96 yields an excess loss of 13.5 – 9.3 = 4.2% of the wintering population. Compensating for that excess loss requires a reduction in Any-Deer permits equivalent to 4.2% of the doe population.

It is at this point that the look-up tables for doe harvest are consulted. Table 23 is one of those tables from Appendix 5. We will assume that the WMD 14 population is heavily hunted (yearling buck frequency is 50%). The pre-hunt sex ratio of adults is 150 does:100 bucks; hence we will focus only on the “150” column. Assume also that the WMD 14 herd is stabilized when a harvest of 60 adult does was achieved for every 100 adult bucks harvested. The intersection of the AF:AM harvest ratio column at 60 and sex ratio column at 150 suggest a hunting removal rate of 17 percent of the doe herd when that harvest ratio is applied.

To compensate excess doe losses in 1995-96 amounting to at least 4.2% of the population we must reduce the adult doe:adult buck harvest ratio to 45. This would yield a hunting removal rate of 13% of the doe population and hence it fully compensates winter losses 17 – 13 = 4% of the doe population.

> Rule of Thumb: Reductions in adult doe:adult buck harvest ratios will be implemented in increments of at least 5 does:100 adult bucks.

Look-up tables are provided in DPMS Appendix 5 for populations exhibiting the full range of realistic sex ratios, and at all levels of hunting turnover rate (hunting intensity of bucks) likely to be experienced in Maine.

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Table 20. WSI stations as grouped to compute WSI values by Wildlife Management District, 2005-06.

Wildlife Management District	WSI Station Map Codes			
1	LBLA	6MIL		
2	LBLA	ARMS	6MIL	
3	ARMS	6MIL		
4	6MIL	GULL		
5,6	6MIL	MEAD		
7	SALT	DEAD		
8	GULL	SKYL	DEAD	
9	SIBE	TUSS		
10	SIBE	SEBO		
11	SHOR	SIBE	MEAD	
12	MTWI	DEAN		
13	MTWI	BARK	NOAN	
14	TUSS	BEAR		
15	DEAN	RAMS		
16	DEAN	SIBL		
17	BEAR	SIBL		
18	SEBO	TANN	CHIC	CROS
19	MUSQ	MOOS	CHIC	PASS
20	RAMS	SECO		
21	JIMI	RAMS		
22	JIMI	PEAB		
23	SIBL	PEAB		
24	SECO			
25	PEAB	WEST		
26	CHIC	WEST		
27, 28	CHIC	HADL		
29	MOOS	HADL		
30	Not represented by a WSI station			

Table 21. Estimates of winter mortality rates (WMR) of deer in Maine at selected values for winter severity indices (WSI).

WSI	WMR	WSI	WMR	WSI	WMR
30	4.5	66	9.9	102	22.0
31	4.6	67	10.1	103	22.5
32	4.7	68	10.4	104	23.0
33	4.8	69	10.6	105	23.6
34	4.9	70	10.8	106	24.1
35	5.0	71	11.1	107	24.6
36	5.1	72	11.3	108	25.2
37	5.2	73	11.6	109	25.7
38	5.3	74	11.8	110	26.3
39	5.4	75	12.1	111	26.9
40	5.6	76	12.4	112	27.5
41	5.7	77	12.7	113	28.1
42	5.8	78	12.9	114	28.8
43	5.9	79	13.2	115	29.4
44	6.1	80	13.5	116	30.1
45	6.2	81	13.8	117	30.8
46	6.4	82	14.1	118	31.4
47	6.5	83	14.5	119	32.1
48	6.6	84	14.8	120	32.9
49	6.8	85	15.1	121	33.6
50	6.9	86	15.5	122	34.4
51	7.1	87	15.8	123	35.1
52	7.3	88	16.2	124	35.9
53	7.4	89	16.5	125	36.7
54	7.6	90	16.9		
55	7.8	91	17.3		
56	7.9	92	17.7		
57	8.1	93	18.1		
58	8.3	94	18.5		
59	8.5	95	18.9		
60	8.7	96	19.3		
61	8.9	97	19.7		
62	9.1	98	20.2		
63	9.3	99	20.6		
64	9.5	100	21.1		
65	9.7	101	21.6		

*Estimated winter mortality rate, expressed as percent of wintering herd.
Calculated as: $WMR=2.29e^{0.222(WSI)}$

Table 22. Threshold WSI and associated estimates of winter mortality rate by Wildlife Management Districts in Maine during the 1990-1991 to 2004-05 period.

Wildlife Management Districts	Threshold (Mean 1991-05 Winters)				Acceptable WSI Range[b] (Threshold WMR +/-0.5%)
	WSI	WMR[a]	WMR +0.05	WMR -0.05	
1	90	16.9	17.4	16.4	89 to 91
2	85	15.1	15.6	14.6	86 to 83
3	83	14.5	15.0	14.0	85 to 82
4	78	12.9	13.4	12.4	80 to 76
5,6	79	13.2	13.7	12.7	81 to 77
7	68	10.4	10.9	9.9	70 to 66
8	69	10.6	11.1	10.1	71 to 67
9	67	10.1	10.6	9.6	69 to 64
10	68	10.4	10.9	9.9	70 to 66
11	62	9.1	9.6	8.6	65 to 60
12	58	8.3	8.8	7.8	61 to 55
13	63	9.3	9.8	8.8	66 to 61
14	63	9.3	9.8	8.8	66 to 61
15	57	8.1	8.6	7.6	60 to 54
16	56	7.9	8.4	7.4	59 to 53
17	58	8.3	8.8	7.8	61 to 55
18	62	9.1	9.6	8.6	65 to 60
19	55	7.8	8.3	7.3	58 to 52
20	51	7.1	7.6	6.6	54 to 48
21	53	7.4	7.9	6.9	56 to 50
22	52	7.3	7.8	6.8	55 to 49
23	50	6.9	7.4	6.4	53 to 46
24	48	6.6	7.1	6.1	51 to 44
25	51	7.1	7.6	6.6	54 to 48
26	50	6.9	7.5	6.5	54 to 47
27,28	53	7.4	7.9	6.9	56 to 50
29	48	6.6	7.1	6.1	51 to 44
30					
STATEWIDE[c]	62	9.1	9.6	8.6	65 to 60

[a]Estimated winter mortality rate, expressed as percent of wintering herd. Calculated as: $WMR=2.29e^{0.222(WSI)}$

[b]Range of WSI values which encompasses the estimated threshold WMR +/- 0.5% of the wintering herd.

[c]Statewide data are not used to evaluate Any-Deer permit allocations.

Note: Values based on 30 WMD System prior to 2006

Table 23. Estimated hunting removal rate of yearling and older does given varying population and harvest sex ratios and a harvest yearling frequency[1] of 50%

Harvest	Prehunt Population AFAM[2]													
AFAM[2]	80	90	100	110	120	130	140	150	160	170	180	190	200	210
5	3	2	2	2	2	2	2	1	1	1	1	1	1	1
10	5	5	4	4	4	3	3	3	3	3	2	2	2	2
15	8	7	6	6	5	5	5	4	4	4	4	3	3	3
20	11	9	9	8	7	7	6	6	5	5	5	5	4	4
25	13	12	11	10	9	8	8	7	7	6	6	6	5	5
30	16	14	13	12	11	10	9	9	8	8	7	7	6	6
35	19	17	15	14	12	11	11	10	9	9	8	8	7	7
40	21	19	17	16	14	13	12	11	11	10	9	9	9	8
45	24	21	19	17	16	15	14	13	12	11	11	10	10	9
50	27	24	21	19	18	16	15	14	13	13	12	11	11	10
55	29	26	23	21	20	18	17	16	15	14	13	12	12	11
60	32	28	26	23	21	20	18	17	16	15	14	13	13	12
65	35	31	28	25	23	21	20	18	17	16	15	15	14	13
70	37	33	30	27	25	23	21	20	19	18	17	16	15	14
75	40	35	32	29	27	25	23	21	20	19	18	17	16	15
80	43	38	34	31	28	26	24	23	21	20	19	18	17	16
85	45	40	36	33	30	28	26	24	23	21	20	19	18	17
90	48	43	38	35	32	29	27	26	24	23	21	20	19	18
95	51	45	40	37	34	31	29	27	25	24	22	21	20	19
100	53	47	43	39	35	33	30	28	27	25	24	22	21	20
105	56	50	45	41	37	34	32	30	28	26	25	24	22	21
110	58	52	47	43	39	36	33	31	29	28	26	25	23	22
115	61	54	49	44	41	38	35	33	31	29	27	26	24	23
120	64	57	51	46	43	39	36	34	32	30	28	27	26	24

[1] Percent of yearling bucks among yearling and older bucks in the biological harvest sample.
[2] Yearling and older does per 100 yearling and older bucks.

APPENDIX 5. DOE REMOVAL RATE LOOK-UP (example using YMF of 25%)

Table 24. Estimated hunting removal rate of yearling and older does given varying population and harvest sex ratios and a harvest yearling buck frequency[1] of 25%

Harvest AFAM[2]	Prehunt Population AFAM[2]													
	80	90	100	110	120	130	140	150	160	170	180	190	200	210
5	1	1	1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	2	2	2	1	1	1	1	1	1	1	1	1	1	1
20	3	2	2	2	2	2	1	1	1	1	1	1	1	1
25	3	3	3	2	2	2	2	2	2	2	1	1	1	1
30	4	3	3	3	3	3	2	2	2	2	2	2	1	1
35	4	4	4	3	3	3	3	2	2	2	2	2	2	2
40	5	4	4	4	3	3	3	3	3	2	2	2	2	2
45	6	5	5	4	4	4	3	3	3	3	3	2	2	2
50	6	6	5	5	4	4	4	3	3	3	3	3	2	2
55	7	6	6	5	5	4	4	4	3	3	3	3	3	3
60	8	7	6	6	5	5	4	4	4	4	3	3	3	3
65	8	7	7	6	5	5	5	4	4	4	4	3	3	3
70	9	8	7	6	6	5	5	5	4	4	4	4	3	3
75	9	8	8	7	6	6	5	5	5	4	4	4	4	4
80	10	9	8	7	7	6	6	5	5	5	4	4	4	4
85	11	9	9	8	7	7	6	6	5	5	5	5	4	4
90	11	10	9	8	8	7	6	6	6	5	5	5	4	4
95	12	11	10	9	8	7	7	6	6	6	5	5	5	5
100	13	11	10	9	8	8	7	7	6	6	6	5	5	5
105	13	12	11	10	9	8	8	7	7	6	6	6	5	5
110	14	12	11	10	9	9	8	7	7	7	6	6	5	5
115	14	13	12	11	10	9	8	8	7	7	6	6	6	6
120	15	13	12	11	10	9	9	8	8	7	7	6	6	6

[1] Percent yearling bucks among yearling and older bucks in the biological harvest sample
[2] Yearling and older does per 100 yearling and older bucks

APPENDIX 6. DEAD DEER SURVEY

Throughout the 1970's and 19080's, dead deer surveys were conducted in conjunction with deer pellet group surveys to provide an index to winter mortality rates. Hence, dead deer surveys served to corroborate data for winter severity indices.

Data Collection and Analysis

Personnel conducting spring pellet group surveys were instructed to record the number of dead deer they encountered along pellet group courses. Mortality data were compiled by WRAS staff for each Wildlife Management District in which a survey was conducted and pooled to compute a statewide mortality index. In addition, pellet group survey plot spacing was used to estimate the number of acres of deer habitat searched as follows:

Acres of deer habitat searched statewide =

Σ Survey areas [((number of pellet group plots) (L) (W)) ÷ 43,560]

WhereL = 132' distance between plots

W = 66' assumed search width

Dead deer survey data were then converted to a density per mi^2 of deer habitat searched as follows:

[((ΣDead Deer Found) x (640) ÷ (Σ acres searched)].

The resulting estimate of dead deer per mi^2 of deer habitat provides an index to relative deer mortality at the statewide level. These data are highly correlated with statewide winter severity indices. Limited sample size for acres searched in relation to deer mortalities encountered precludes use of this index at the WMD level. In addition, the assumed search width may not reflect actual visibility distance along pellet group survey lines. Consequently, this mortality index cannot be extrapolated to estimate actual winter mortality rates.

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APPENDIX 7. REPRODUCTIVE DATA

Within the Deer Management System, late-winter and embryo counts from road-killed does were used to estimate age-specific reproductive rate and neonatal mortality rate at the statewide level. Reproductive data from road-killed deer collected during the years 1980-1989 were used to characterize embryo rates among female age classes and are currently used in predicting reproductive rates and fall recruitment (Lavigne 1991). A third input, recruitment rate, is estimated from yearling antler beam diameter and the incidence of lactation among harvested does. This appendix provides details relating to the derivation and use of these inputs within the Deer Management System.

Data Collection

Embryo counts were performed on doe mortalities examined between February and early June by Wildlife Division and Warden Service (WS) personnel. When examined by WS personnel, embryos, middle incisors (or mandibles), and femurs were extracted from doe mortalities and forwarded to Wildlife Management Section (WMS) or Cervid Project personnel. Some WS personnel forwarded intact carcasses to the biological staff.

Data recorded for does included age class, town, and date of kill, and cause of death. If present, embryos were sexed, measured for crown-rump length and weighed to the nearest.1 kg. Conception and parturition dates were estimated from crown-rump length using a fetal aging scale developed from Cheatum and Morton (1946) and Armstrong

(1950) by the West Virginia Conservation Commission. Embryo measurements were made by either WMS or CP personnel, as needed.

Data Analysis

CP personnel compiled reproductive data from WMS and WS personnel. Data were entered onto a computerized database and analyzed using SAS programs.

Age-specific reproductive rate

Reproductive status was compiled for does <1 year old (fawns), does >1 year old but <2 years old (yearlings) and does>2 years old (adults). Pregnancy rate (% of does examined which carried at least 1 embryo), mean litter size (mean number of embryos per pregnant doe) and fecundity rate (mean number of embryos among all does examined) were computed for fawn, yearling, and adult age classes.

Sample sizes for doe mortalities examined since 1980 have ranged from 30 to 130, depending on winter severity. Fawn and yearling sample sizes were inadequate to detect possible changes in reproductive rate between years or between DMDs. Reproductive data for these age classes has been pooled for 1980-88 and are assumed to represent fawn and yearling reproductive potential for Maine given prevailing winter severity and relationship of herd to K carrying capacity.

Sample size for adult does was considered adequate to model annual changes in reproductive potential at the statewide level, but is not useful in detecting potential differences regionally.

Currently estimates of age-specific reproductive rate at the WMD level are derived using mean yearling antler beam diameter (YABD). The technique was first reported by Severinghaus and Moen (1983). Chilelli (1988) adapted the technique for use in Maine, utilizing 1980-86 embryo counts described above and comparable Maine data compiled during the 1950's (Banasiak 1961). Using this technique, mean fecundity rate is predicted from YABD utilizing separate regression equations for fawns, yearlings, and adult does (Chilelli 1988).

WMD-level estimates of age-specific fecundity rate are used to support calculation of the Lactation-Embryo Rate (LER) Index.

<u>Neonatal Mortality Rate</u>

Estimates of neonatal fawn mortality were derived at the statewide level using Verme's (1977) technique. Late winter nutritional deprivation of does is reflected in reduced embryo growth (Verme 1979) and increased fawn mortality (Verme 1977).

Neonatal fawn losses are estimated in several steps. First, mean fawn weight at birth is predicted by regressing mean weight of embryos dying in April and May on age of embryos (scaled on days preceding median birth date for all embryos collected).

Median birth date was estimated from parturition dates determined from crown-rump measurements for embryos examined between February and early June. Neonatal mortality rate is estimated from predicted birth weight using the equation derived from Verme (1977): $Y=8586.74e^{-2.11x}$ where Y=% of total fawn crop dying within 48 hours of birth, x=predicted mean weight (Kg) of fawns at birth and e=natural log. Confidence intervals are computed for mean fawn weight and associated neonatal mortality rate. Neonatal mortality rate may be predicted at the WMD level by substituting winter severity (WSI) values for fetal weight, since these inputs are highly correlated.

Lactation-Embryo Rate Index

The Lactation-Embryo Rate (LER) Index is an estimate of fall recruitment of fawns. As such, it serves as an input in estimating pre-hunt deer population size at the WMD level in HARPOP.

A version of the LER index was first compiled by Banasiak (1961) to verify harvest fawn:doe ratios during the mid 1950's. The first step involves determining the age-specific (fawn, yearling, adult) incidence of lactation from a sample of harvested does. Assuming that only does which were lactating during November successfully reared fawns, and that fecundity remains stable within age classes between June and November, then fall recruitment rate and summer fawn mortality rate may be computed as illustrated in Table 9.

Evaluation

Validity of the LER index needs to be tested. Applicability of this index at the WMD level is constrained by inadequate sample size for lactation incidence and at times yearling doe frequencies.

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APPENDIX 8. PELLET GROUP SURVEYS

Pellet group surveys were conducted in the spring to estimate over-winter deer density on selected study areas within each DMD (Figure 19) from 1978-1988. Survey results serve as corroborative data to deer density estimates derived from HARPOP (Appendix 3).

Data Collection and Analysis

Pellet group survey designs were adapted from various sources. Particularly helpful were the reviews of deer pellet group surveys by Neff (1968) and Ryel (1971). Statistical analyses were adapted from Caughley (1977). Pellet group surveys conducted in Maine prior to 1975 (MDIFW unpubl. data) were also reviewed for applicability to current survey needs.

Wildlife Management Section (WMS) personnel were responsible for conducting pellet group surveys, although Cervid Project (CP) personnel and temporary laborers were frequently utilized to accomplish field work. CP personnel were responsible for coordinating surveys, providing forms and materials, data analysis and reporting.

Pellet group survey areas consist of 4 to 6 townships generally comprising 120-160 contiguous mi^2. Selection of survey areas is subjective, with consideration given to road access and uniformity of hunter harvest relative to the DMD they represent.
For each survey, topographic maps of pellet group survey areas were gridded into mi^2 blocks. These blocks comprised the sampling frame for individual pellet group counts.

Blocks were stratified into those containing all or part of a deer wintering area (DY Blocks) vs blocks which do not contain wintering areas (NDY Blocks). Deer wintering areas were determined by aerial inventories when deer mobility was restricted by snow depths exceeding 12 inches.

Prior to the start of pellet group surveys, a sample of 40 to 60 blocks was randomly selected (with replacement). When winters were severe, the sample was stratified such that 2 DY Blocks were sampled for every NDY Block to account for high variability in pellet group deposition when deer were confined to DY Blocks. Following mild or moderate winters, sample block selection was not stratified, but consisted of a simple random sample (with replacement) of all available blocks on the survey area.

Pellet group surveys were conducted on courses run within each selected block. A course was shaped like three sides of an open-ended square, each leg of which was ½ mile in length. The starting location of a course within a block was generally randomized along a road that transversed a block. Pellet group counts were conducted on a total of 54 100 ft^2 (25'x4') rectangular plots located at 2-chain intervals along each course. The 18 plots comprising each leg of the course were located by pacing. In addition to the number of fresh (leaf fall to date of count) deer pellet groups, field staff also recorded date, cover type class, and location data.

The statistical datum calculated was the mean number of pellet groups per course along with associated 90% confidence intervals. Pellet group means were then converted to mean number of pellet groups per mi^2. Over-winter (posthunt) deer density estimates were then calculated from the following equation (after Ryel 1971):

Posthunt deer per mi^2 = [Mean pellet groups per mi^2] ÷ [(deposition rate)(deposition period)]

Where: deposition rate is assumed to be 13 groups/deer/day and deposition period = leaf fall to median date of counts

Pellet group data were adjusted for deer removed by legal hunting in November for survey towns. However, no comparable adjustments were made for illegal kills, crippling losses or winter mortalities.

Data analysis was facilitated by use of SAS programs adapted for the IBM-PC. Variance estimation correcting for stratification with unequal plot size follows Caughley (1977). Such corrections were necessary because natural obstacles (e.g. ponds) sometimes precluded searches of all 54 plots. Additionally, plots falling within developed areas (e.g. private homes, gravel pits, cemeteries, etc.) were not searched.

Pre-hunt deer density estimates and hunting removal rate estimates were calculated by adding known harvest removals from the registered kill records to posthunt population estimates for each survey area (Table 25).

Evaluation

Pellet group survey data provide the only existing "on the ground" method of estimating local deer abundance within the deer management system. While there have precision (observer error/standardization problems) and spatial limitations, pellet group surveys provide data which corroborate WMD-wide estimates of deer density derived from the HARPOP model (Table 26).

Given limited department resources and the importance of reliable data, alternate methodologies for estimating deer densities such as aerial surveys (Potvin) should be evaluated to consider the relative precision and accuracy of each method. A critical assessment of survey techniques is essential to developing a long term monitoring program while ensuring the collection of a robust data set to analyze changes in population densities.

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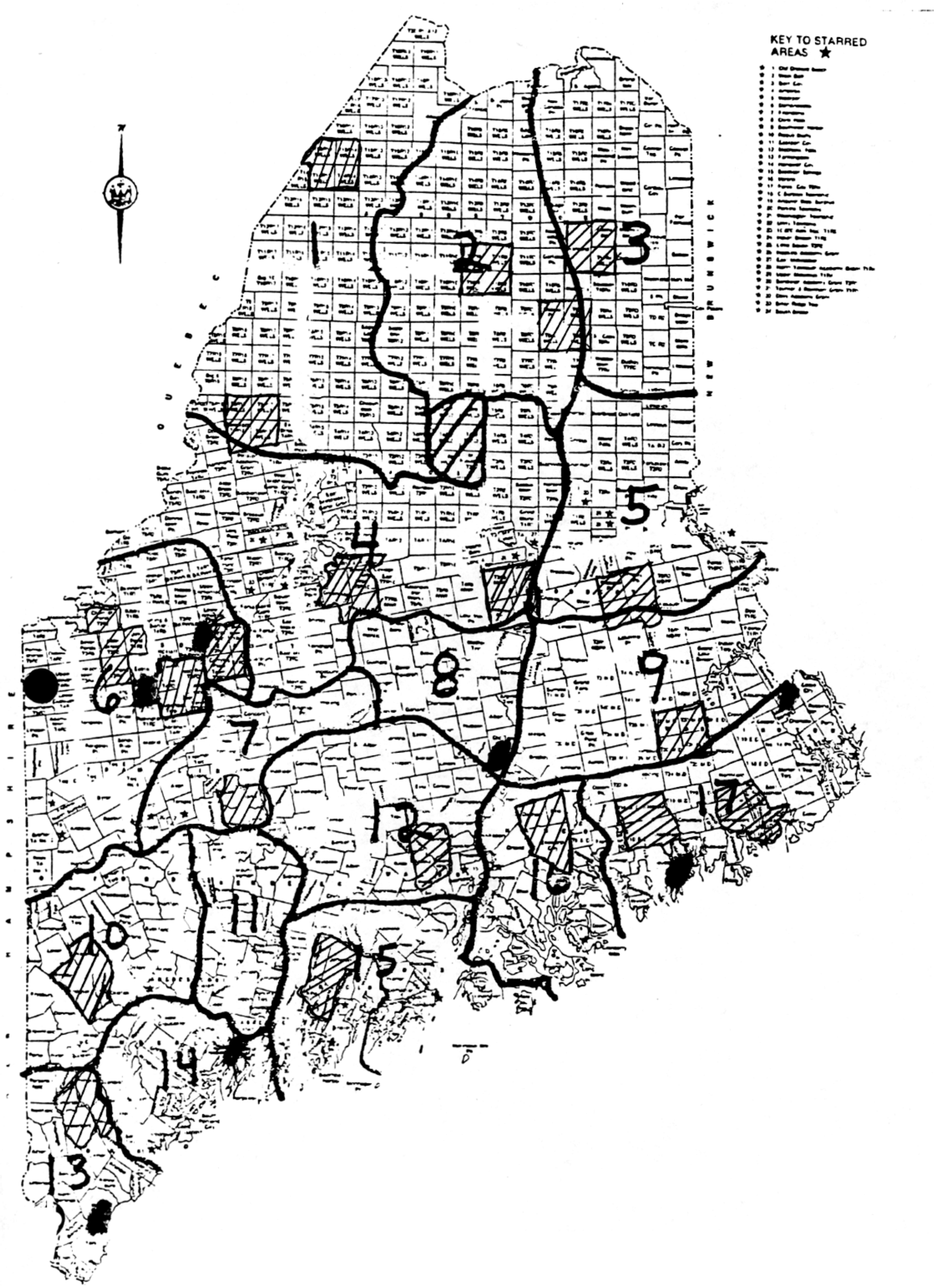

FIGURE 19. LOCATION OF DEER PELLET GROUP SURVEY AREAS, 1976-1988.

Table 25. Summary of deer pellet group surveys conducted in Maine during 1988.

Deer Management District	Survey Area	Posthunt Density/Mi^2 Mean	LL[1]	UL	Precision Level[2] %	Mean Harvest Rate[3] %
1	Comstock	4	2	6	±46	7
3	Ashland	5	2	8	±58	6
-	Baxter State Park	5	4	6	±24	-
4	Sebois Plt.	12	8	16	±34	4
6	Bigelow Mtn.	11	8	15	±33	-
7	Starks	7	5	10	±29	13
8	UMO	53	40	66	±25	-
9	T30 MD	3	2	4	±29	8
10	Bridgton	15	11	19	±26	6
13	Laudholm Farm					
15	Alna	8	6	11	±25	20
16	Ellsworth	9	3	14	±61	5
17	Petit Manan NWR	49	45	52	± 8	-

Table 26. Comparison of posthunt deer density estimates by DMD as derived from HARPOP, pellet group surveys and extrapolations based on the relative magnitude of buck harvest on pellet group survey areas vs DMD's as a whole.

Deer Mgt District	Pellet Group Survey Area	Buck Kill Per Square Mile			Post Hunt Deer Density Density Per Square Mile		
		DMD	Survey Area	Correction Factor[1]	DMD HARPOP	Survey Area	DMD Extrapolated[2]
1	Comstock	.19	.31	1.63	4	7	2.5
3	Ashland	.14	.30	2.14	4	5	2.3
4	Sebois Plt.	.29	.26	.90	6	12	13.3
7	Starks	.85	.66	.78	11	7	9.0
9	T30 MD	.39	.16	.41	8	3	7.3
10	Bridgton	.63	.64	1.02	10	15	14.7
15	Alna	1.18	1.11	.94	12	8	8.5
16	Ellsworth	.67	.30	.45	10	9	20.0

[1]Correction factor = Survey Area buck kill per sq. mi/DMD buck kill per sq. mi.
[2]Extrapolated DMD deer per sq. mi. = Survey area deer per sq. mi/correction factor.
Assumptions:

1. Hunting pressure on bucks is uniform within each DMD.
2. Wintering area distribution on survey areas similar to DMD as a whole, i.e., survey area not attracting deer from adjacent town and vice versa.