DEER POPULATION GOALS

Population goals are one of the cornerstones of Wisconsin's deer management program. These goals, first established in 1962 (Doll 1962), guide both our deer harvest and habitat management programs. Administrative Code NR 1.15(2)(a) states:

> " The department will seek to maintain a deer herd in balance with its range and at deer population goals reasonably compatible with social, economic and eco-system management objectives for each deer management unit. Deer population goals are to be based on carrying capacity as determined by unit population responses to: (1) habitat quality, (2) historical records of winter severity, (3) the demand for deer hunting and viewing opportunities, and (4) ecological and economic impacts of deer browsing, deer herd health and disease transmission, and concern for deer-vehicle collisions."

Three different concepts should be considered in setting population goals: 1) the long-term maximum number of deer the land can support, 2) the number of deer that produce the maximum sustainable harvest, 3) the number of deer people are willing to tolerate.

The term **carrying capacity** has been used to describe each of these different population levels. The use of the term "carrying capacity," without qualification, to refer to different population levels has caused considerable confusion among wildlife managers and the public. Macnab (1985) stated "carrying capacity — rarely in the field of resources management has a term been so frequently used to the confusion of so many."

In an attempt to eliminate much of the confusion, this chapter starts out by defining the terms **Ecological Carrying Capacity**, **Maximum Sustained Yield**, and **Sociological Carrying Capacity**. Following the definitions is a section on estimates of ecological carrying capacity in Wisconsin, a discussion on the relationship of population goals to ecological and sociological carrying capacity, a description of current population goals in Wisconsin, a summary of the evolution of Wisconsin's goal setting process, and a discussion on alternative ways of expressing deer population goals. Lastly, the theory behind the concept of carrying capacity is reviewed in the Appendix 4A.

DEFINITIONS

Ecological Carrying Capacity: Ecological Carrying Capacity is the maximum population level of deer that can be sustained in the long-term for a given area. It is a stable equilibrium in the vegetation-deer system because the production of forage equals the rate at which forage is consumed. This population level has also been called **Biological Carrying Capacity**, **Environmental Carrying Capacity** and **K Carrying Capacity**. Throughout the rest of this chapter ecological carrying capacity will be abbreviated as **K**. Impacts on the ecosystem or on sensitive browse species can occur at deer population densities well below K.

Maximum Sustainable Yield: Maximum Sustainable Yield is the maximum number of deer that can be harvested from the population on a continual basis. The population level that produces the maximum sustainable yield is 50-60% of K (*Figure 4.1*) and has been referred to as **Economic Carrying Capacity** (Caughley 1979), or **I Carrying Capacity** (Macnab 1985). Range managers, whose objective is to maximize the sustainable yield of livestock from range land, have used "carrying capacity", without qualification, to refer to economic carrying capacity, contributing to the confusion surrounding the carrying capacity concept. Elsewhere in the chapter the maximum sustainable yield of deer will be referred to as **MSY** and the population level that produces MSY will be designated as $\mathbf{MSY_{deer}}$.

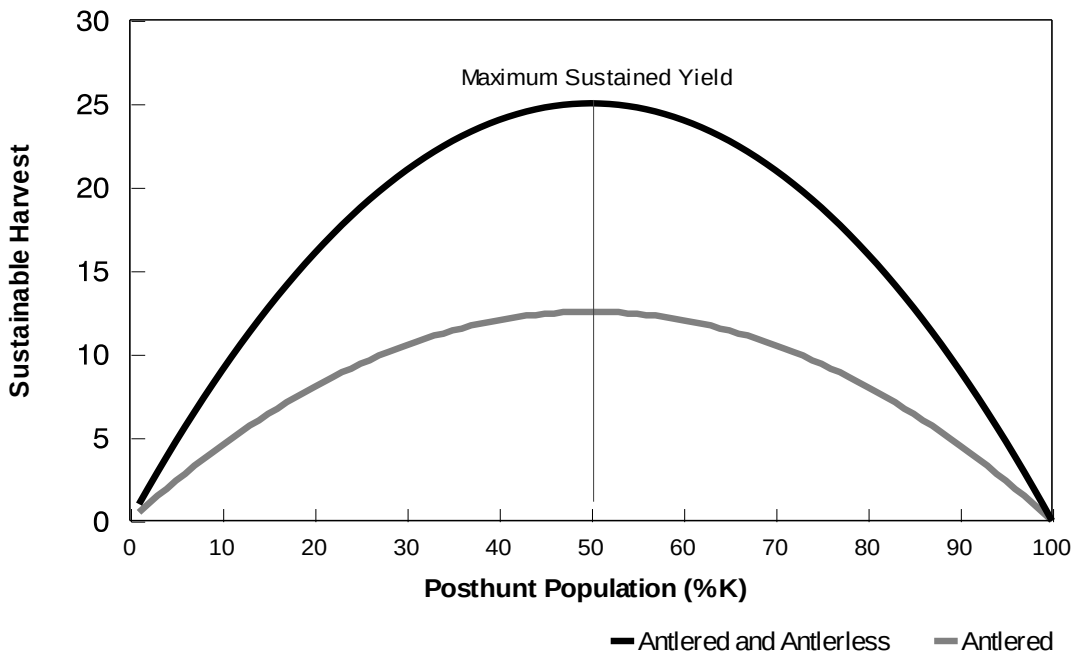

Figure 4.1. **Sustainable harvests of antlered and antlerless white-tailed deer as a function of population density relative to ecological carrying capacity.**

Sociological Carrying Capacity: Sociological Carrying Capacity is the maximum number of deer that can coexist compatibly with local human populations (Strickland et al. 1994). This population level has also been called **Cultural Carrying Capacity** (Ellingwood and Caturano 1988) or **Wildlife Acceptance Capacity** (Decker and Purdy 1988). Hereafter **SCC** will be used to refer to sociological carrying capacity.

ESTIMATES OF ECOLOGICAL CARRYING CAPACITY IN WISCONSIN

Estimates of K vary greatly across Wisconsin, and are considerably higher in the Southern Farmland than in the Northern Forest. This variation is the result of differences in food availability and the duration and severity of winter (McCown 1994).

Keith (1988) estimated mean carrying capacity for the Northern Forest based on 22 years of pre- and posthunt population estimates from 6 management units. He calculated the ratio of the prehunt population in year t+1 to the posthunt population in year t ($Lambda_2$, see Chapter 7). He then estimated the linear regression parameters for the relationship between the $Lambda_2$ and posthunt population density:

$$Lambda_2 = 2.04 - 0.04 \times \text{Posthunt Density} \quad (1)$$

Because the population would not increase from posthunt to prehunt when the population is at K, he set $Lambda_2$ in this equation to 1, and solved for the population density at K (26 deer/mi^2). McCaffery (WDNR unpubl. data) used the same procedure to estimate a K of about 675 or 54 deer/mi^2 for the Sandhill Wildlife Demonstration Area in the Central Forest Region of Wisconsin (*Figure 4.2*).

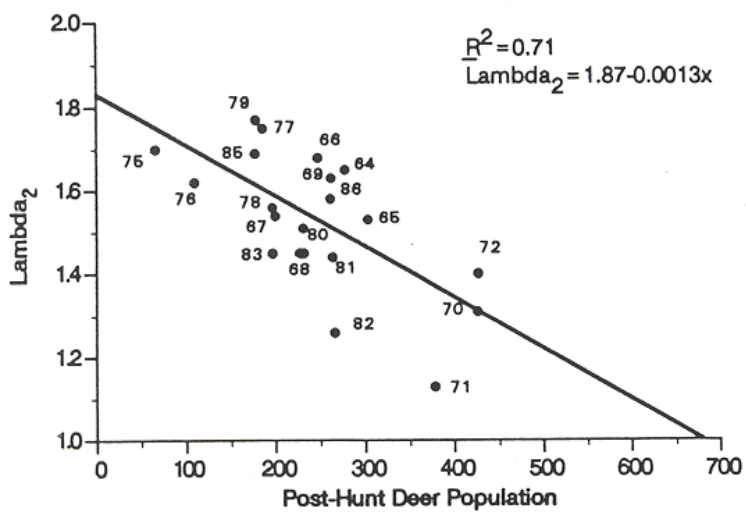

Figure 4.2. **Estimate of average ecological carrying capacity (K) on the Sandhill Wildlife Area. Note: Ecological carrying capacity occurs where $Lambda_2$ = 1.0, or at the intercept with the X-axis.** *(From Figure 9.9 of the Sandhill deer book).*

As part of an environmental analysis of deer population goals (Vander Zouwen and Warnke 1995:185), unit-specific estimates of K were estimated in the Northern Forest Region using a process similar to equation 1. Long-term average $Lambda_2$s were used to estimate the relative population density (% of K [*Figure 4.3*]). Estimates of K were derived by dividing the mean posthunt density by the relative density. For example, if the mean $Lambda_2$ was 1.3 and the mean posthunt density was 20 deer/mi^2, then the posthunt population averaged 70% of K and K was estimated to be 20 ÷ 0.70 = 29 deer/mi^2.

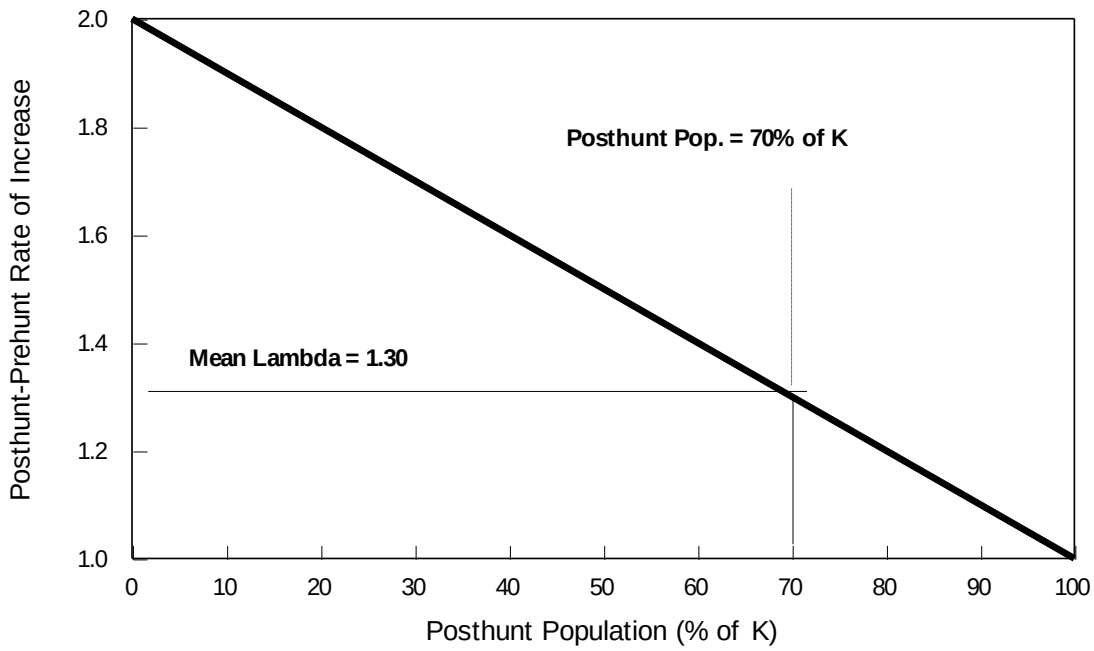

Figure 4.3. **Model of relationship of Lambda$_2$ and relative population density used for unit-specific estimates of ecological carrying capacity in the Northern Forest Region.**

Estimated long-term average K varied among Northern Forest deer management units from 15 to 53 deer/mi^2. These estimates corresponded closely to differences in forest composition among Northern Forest units (McCaffery 1987). Northern Forest units with the highest K are characterized by forests of aspen, oak, jackpine, brush, openings, or farm fringe. In units with the lowest K, forests are typically dominated by northern hardwoods, conifers, and swamps.

Outside of the Northern Forest, similar procedures were used to estimate mean regional K (Vander Zouwen and Warnke 1995). These estimates were 58 deer/mi^2 in the Central Forest, 68 in the Eastern Farmland, 66 in the Western Farmland, and 87+ in the Southern Farmland.

RELATIONSHIP OF POPULATION GOALS TO ECOLOGICAL AND SOCIOLOGICAL CARRYING CAPACITY

In the long-term, K is determined by habitat and climate and it is in this context that K is a useful reference point in the setting of population goals (Strickland et al. 1994). In the short-term, annual weather variation can significantly affect K. Deer populations can be maintained at a variety of possible goals below K by repeated harvesting. Selection of the goal is dependent on the management objective (Sinclair 1997, *Figure 4.4*).

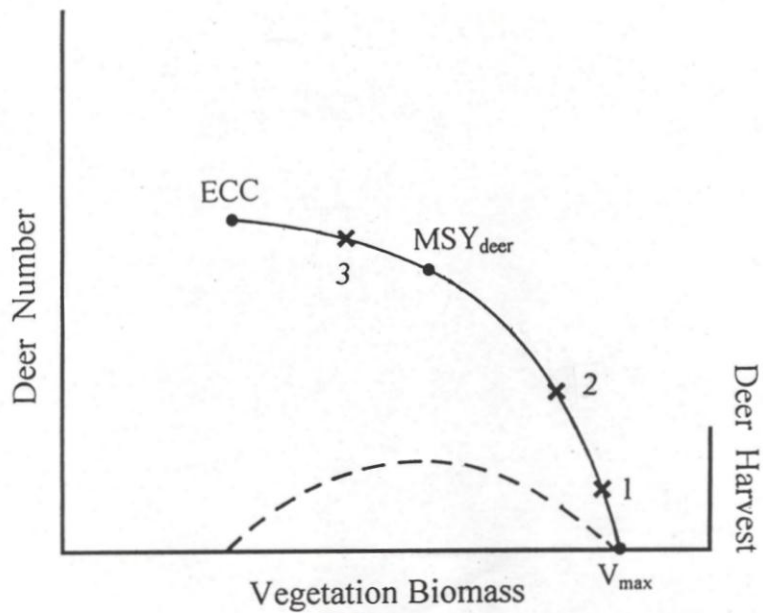

Figure 4.4. **Isocline at which both deer numbers and vegetation biomass are constant (solid line). A harvest rate (broken line) imposed on deer is necessary to maintain points on the isocline between ecological carrying capacity (ECC) and maximum vegetation (V_{max}). Other points on the isocline represent potential management goals for maximum sustained yield of deer (MSY_{deer}), to maintain viable population of sensitive rare plant species (1), at sociological carrying capacity (2), and for maximum hunter opportunity (3).** ***From Figure 23.1 in Sinclair (1997).***

If the objective was to harvest the MSY of deer, then deer numbers would be maintained at MSY_{deer}, 50-60% of K. However, Sinclair (1997) noted that hunters view the status of the deer population by the number seen and generally desire populations near K, presenting managers with a conundrum since populations cannot be at MSY_{deer} and K at the same time. He proposed that "hunter opportunity" is maximized somewhere between K and MSY_{deer}. Macnab (1985) also recommended maintaining populations between K and MSY_{deer}, because management for MSY was difficult in light of imprecise population estimates and the likelihood of overharvest, especially in areas with substantial environmental variability.

McCullough (1984) stated that population goals between MSY_{deer} and K are inherently self-correcting. If overharvest or severe winter reduced the population below goal, the smaller population would produce a larger number of recruits and therefore would quickly return to goal. Conversely, population goals below MSY_{deer} are unstable. An underharvest here would result in a larger population that produced a greater number of recruits while an overharvest results in a smaller population and a smaller number of recruits.

In areas dominated by agriculture or with a high density of people, human tolerance for deer (SCC) can be reached at densities much lower than MSY_{deer}. The most easily

recognized effects of deer on society include deer-vehicle accidents and damage to agricultural crops, nursery stock, and landscape plantings. In addition, concern has been raised about the role of high-density deer populations in the spread of Lyme disease in New England (Wilson and Childs 1997).

The concept of SCC can be extended to consider ecological as well as economic and public health effects of deer. Deer, like all living organisms, affect the environment in which they live (Vander Zouwen and Warnke 1995). Deer affect not only the abundance of plants, but also, the species composition, feeding heavily on some species and less so on other species. Heavy feeding on preferred species can affect their survival and reproduction. Changes in the composition and structure of plant communities can have indirect effects on other animal species that are dependent on particular plant species or structures.

It was previously believed that population goals lower than 70-75% of K did not result in unacceptable levels of environmental alterations. Recently, some have argued that much lower deer density goals (<25% of K) may be needed to maintain viable populations of certain sensitive plant species (Alverson et al. 1988, deCalesta and Stout 1997). Sinclair (1997) concluded that the fundamental issue was whether there were more deer now than the original prehistoric plant community evolved to tolerate. This could occur especially where "modern" forests are fragmented into small patches surrounded by highly nutritious croplands. However, considerable uncertainty remains over presettlement densities of deer (McCabe and McCabe 1997). Additional research is needed to better understand the relationship between deer population levels and environmental effects. As we learn more about the effects of deer on the broader plant and animal community, it will be important for society to consider the ecological impacts of deer, in addition to the economic effects, when evaluating the costs and benefits of different deer population goals.

DEER POPULATION GOALS IN WISCONSIN

K is an especially important consideration in setting deer population goals in the Northern Forest due to high winter severity and the relatively low annual productivity of plants and deer. Current overwinter population goals in the Northern Forest range from 10-25 deer/mi^2 of deer range, averaging about 18 deer/mi^2 (*Figure 4.5*). These goals range from 46-76% of estimated K, averaging 62% of K. Seventy-five percent of Northern Forest Units have goals between 55-75% of K, in the range that would produce Macnab's (1985) "optimum sustained yield." Although yields at these goals are slightly lower than MSY, they are more stable in a variable environment and provide a more visible deer resource for both the hunting and non-hunting public. These goals will normally result in an annual recruitment equal to 30-40% of the posthunt population.

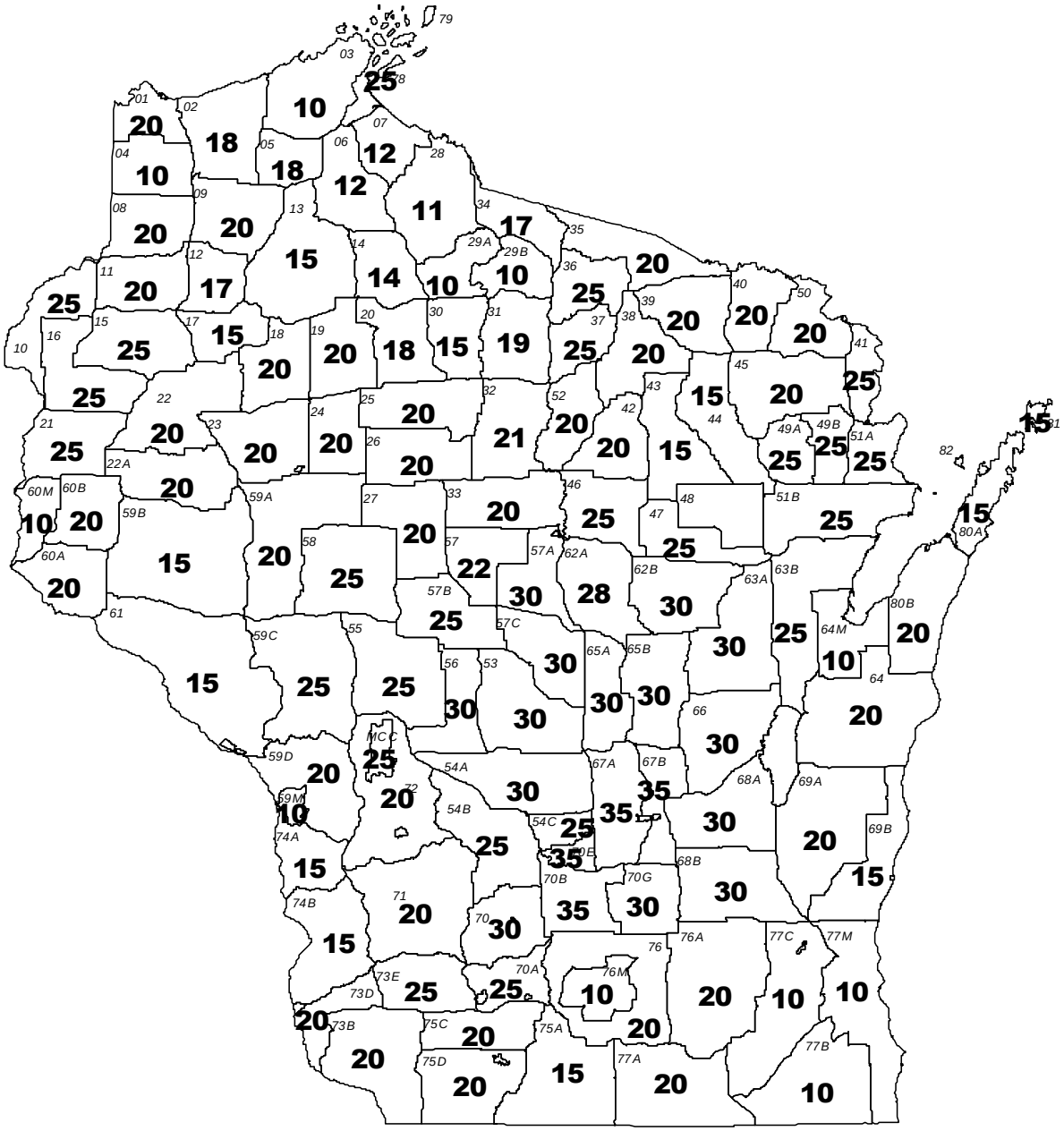

Figure 4.5. **Overwinter deer population goals for deer management units in 2000. Goals range from 10 to 35 deer per mi^2 of deer range.**

Overwinter population goals in the Central Forest range from 25-30 deer/mi^2. The current goals are approximately 50% of the estimated K. Annual recruitment averages 40-50% of the posthunt population. This allows an annual harvest very near MSY.

Overwinter goals in the farmland units range from 10 to 35 deer/mi^2 and average 22 deer/mi^2. These goals are less than 50% of our estimates of K. Annual recruitment results in 50-90% population increase between posthunt and prehunt. The lowest goals are based largely on local traditions of not having many deer and liking it that way. The upper density represents what appears to be the limit of human tolerance in agricultural units. During 1990-94, mean appraised agricultural damage was strongly related to population goals, markedly higher in units with goals of 30-35 deer/mi^2 (Stowell 1995). Crops receiving the most damage included corn, soybeans, alfalfa, orchards, Christmas trees, cabbage, and vegetables. In addition, the high density of deer-vehicle accidents in east central Wisconsin during 1991-92 was due to the higher population goals in this region (McCown 1994). Deer-vehicle accidents are also a major concern in the more urbanized counties of the state, and population goals in the metro units are among the lowest in the state (10 deer/mi^2).

Because of the natural instability of population goals below MSY_{deer} precise harvest management is important. Harvest management in farmland regions usually can be more precise than in the Northern Forest because significant winter losses are rare and recruitment and harvest exploitation are more predictable. However, overly conservative harvest quotas in 1993 allowed many farmland populations to grow substantially above goal, which led in part to the Zone-T hunts of 1996 and 1997.

GOAL SETTING AND PUBLIC INPUT

When population goals were first established in 1962, most Northern Forest units had a history of population estimates using pellet group surveys. Overwinter goals were set at the approximate mid-point in the range of historical population fluctuation. This procedure allowed deer themselves to tell us something about K. Conservative harvest management prior to 1962 had not exerted consistent control on the population, so deer populations may have reached K in most Northern Forest units.

In the farmland zones, deer populations were just becoming well established in many units in the 1960s. Little information about K or SCC was available when goals were first established. Most goals were initially set between 8 and 18 deer/mi^2.

Since 1962, goals have periodically been reviewed and revised. Public input has become an increasingly important part of the goal review process. The goal review process attempts to balance public demands for the positive benefits of deer (consumptive and non-consumptive) with the public's willingness to accept the economic and ecological effects of deer. Despite numerous reviews, goals in the forested zones have not changed much. However, because of public demands for higher deer populations, goals in the farmland regions have approximately doubled in the past 30 years. Concerns

about crop damage and car/deer collisions have kept most overwinter goals in farmland at no more than 30 deer/mi^2 of deer range.

Prior to 1994, public input into the goal setting process was limited to meetings between the local wildlife manager and representatives of the Wisconsin Conservation Congress and Land Conservation Committees. In 1994, the DNR expanded the public input process by conducting a series of 17 regional task force meetings following the deer season. Regional task forces consisted of 5-10 members drawn from various constituencies that use or are affected by deer including hunters, farmers, foresters, transportation officials, environmentalists, and insurance industry representatives. Prior to the meeting, task force members were provided with information to consider in setting population goals and a set of graphs, maps, and tables depicting trends in deer population size, harvest, and crop damage complaints for management units in their region. The regional task forces recommended slight changes to existing population goals. In addition, task forces recommended that unit goals be reviewed every 3 years.

The next review of unit population goals was incorporated into the Deer Management for 2000 and Beyond process (Deer 2000), a broad citizen planning effort to review Wisconsin's deer management system. Deer 2000 was led by the Conservation Congress at the request of the Natural Resources Board. Public meetings were held in every county of the state in September 1999 to gather input on a broad range of deer management issues, including population goals. The Deer 2000 Herd Size Study Group reviewed this public input, studied deer management issues in greater detail, listened to expert testimony, evaluated various criteria relevant to deer management unit goals, and recommended units for local reviews where existing goals raised significant social, economic and/or ecological concerns.

Local unit reviews were held in identified units in March 2000. These were open public meetings to allow for public education by the local wildlife manager, public discussion, and formation of recommendations. The local reviews were professionally facilitated and widely publicized to encourage attendance by a diversity of stakeholders. Recommendations developed at the local reviews were forwarded to the Deer 2000 Herd Size study group. The Herd Size Study Group then forwarded the local recommendations to Natural Resources Board along with their comments about the recommendations. The Natural Resources Board approved goal changes for 27 units, decreasing population goals in 14 units and increasing goals in 13 units.

Deer 2000 recommended that reviews of unit goals continue to be held on a 3-year interval, that all units have local review meetings, and that the same meeting format be used for the local public reviews. Deer 2000 further recommended that a diverse review committee be appointed to study relevant data and make recommendations to the Natural Resources Board on goal modifications. The Natural Resources Board would then consider input from the local public reviews, the review committee, and Department staff before deciding on population goals.

EXPRESSING GOALS

Population goals are legally established in Administrative Code and are expressed as a posthunt (January) deer population density (deer per square mile of deer range). Formally designating goals as a density has several advantages:

1) Density goals provide a "standard" for comparison between units;

2) They enable us to better appreciate and quantify the ecological and economic impacts of deer numbers; and,

3) They enable us to understand differences in habitat quality among our forested units.

While there are advantages to expressing goals as a density, density goals can be difficult for some to understand. Understanding requires not only an acceptance of population estimates but also assumptions regarding what constitutes deer range (Chapter 5). In the forested units, there is usually little argument about deer range. But, arguments may be common in the farmland.

Depending on the audience, managers may find it to be more effective to express population goals in alternative ways. Some individuals may find it easier to identify with a density goal if it is expressed as 2 deer/"forty" rather than 32 deer/mi^2. However, all density expressions may imply uniform deer distributions, which do not exist in the field.

Most hunters can easily understand a goal expressed in terms of a target kill of adult bucks. Such a performance goal requires similar annual hunting seasons and effort, accurate harvest data, and assumes no quota on adult bucks. It does not require a measure of deer range. A possible complication to this goal is the current trend in some units to reduce buck harvest exploitation in order to produce more older-aged bucks in the harvest. A second complication is that the same sustainable harvest can be obtained at two different points on the yield curve *(Figure 4.1).*

Population goals can also be expressed as the total population in the unit. Population goals require accepting deer population estimates, but area of deer range does not need to be argued. It is also easy to relate a harvest quota to a total population figure.