A Review of Deer Management in Michigan

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Introduction

White-tailed deer (*Odocoileus virginianus*) are important to the people of the state of Michigan. The expectations, concerns, and values associated with deer by Michigan residents are diverse and complex making successful management of this natural resource challenging. The Michigan Department of Natural Resources (DNR) is responsible for the management of deer in this state and uses a scientific approach when considering the biological, social, economic, and political aspects of deer management.

Although wildlife management recommendations and decisions are based on best available biological science, they are nearly always determined within a social context where stakeholder values and priorities must be addressed. The integration of social considerations into scientific examination is necessary to move wildlife management recommendations and actions forward, especially in an environment where public knowledge and inquiry regarding management of public resources is significant.

This document is a review of scientific information pertaining to deer, deer-related issues, and deer-management options in Michigan and summarizes the best available biological and social science relevant to these topics. It is not intended to provide management recommendations for white-tailed deer in Michigan. The information presented in this document was obtained from published scientific literature, agency and university reports, unpublished agency data, and personal communication with deer experts. The purpose of this review is to present general information on deer and specific information relevant to deer management in Michigan. This document will be used by the Michigan Deer Advisory Team to develop recommendations to aid in the completion of the Michigan White-Tailed Deer Management Plan.

Biology of White-Tailed Deer

Distribution, Taxonomy and Physical Description

Deer are probably the best recognized and most widely distributed large mammal in North America. The white-tailed deer is found in nearly every state in the United States. Deer can be found throughout the southern provinces of Canada, in tropical forests of South America, and in the midst of an urban location in Michigan. White-tailed deer successfully live across a wide range of habitats and can be found in every Michigan county (Baker 1983). Deer are creatures of the forest edge and thrive in agricultural areas interspersed with woodlots and riparian habitat. They favor forest stands in early succession in which brush and sapling browse are within reach. Dense forest cover is used for winter shelter and protection.

White-tailed deer are ungulates, or hoofed mammals, belonging to the family Cervidae. The white-tailed deer's coat and color change semi-annually. Deer are more reddish-brown with a thin coat during summer months. Deer shed their summer coat in late summer or early fall and replace it with a thick, brownish-grey winter coat. The underside of the tail, belly, chin, and throat are white year round. The winter coat consists of both a short underfur and hollow, outside guard hairs that provide additional insulation and protection during the winter. The winter coat is shed in mid- to late-spring. Hair color is alike in both sexes. Fawns are born with white spots in the upper coat which provides excellent camouflage. They shed their spotted coats in 3 to 4 months and it is replaced with a brownish-grey fall and winter coat.

In Michigan, adult deer typically weigh between 125 to 225 pounds live weight and stand 32 to 34 inches at the shoulder. Female deer (does) tend to be smaller than males (bucks) of the same age from the same area. Deer weights vary considerably, depending upon age, sex, diet and the time of year the weight is checked. Deer are extremely agile and may run at speeds of up to 30 miles per hour. White-tailed deer are also good swimmers and often enter rivers and lakes to escape predators or insects. Deer can bleat, grunt, whine, and when alarmed or suspicious, make loud "whiew" sounds (referred to as a “snort” by many deer hunters) by forcefully blowing air through their nostrils. Does whine to call their fawns and fawns bleat to call their mothers.

Life History

Reproduction

Deer productivity rates (fawns produced per doe) generally are highest in regions with an abundance of nutritious food. Thus, deer occupying fertile farmland regions typically have higher productivity rates than deer in heavily forested regions. Likewise, deer living in areas with low annual snow accumulation tend to be more productive than those living in regions where snow covers available food for months at a time and inhibits deer movement to food sources. In southern Michigan where winter conditions are relatively mild, a high percentage of fawns and almost all yearling and adult does breed each year. Productivity rates also vary with age of the doe. Adult does have the highest productivity rates, and yearlings (deer that are 1 year old) have higher productivity rates than fawn does (less than 1 year old). In addition, the health of a doe, often a function of habitat quality, influences her reproductive capacity as females from the best range produce more fawns than those from poor range. Adult females (3 years and older) usually produce twins, and triplets are not uncommon.

In Michigan, the deer mating season typically occurs during late October through December. Peak mating activity is in November. Does are in estrus for 24 hours every 28 days. If not bred does will cycle 2 or 3 times until bred. One buck may breed several does. A doe may be bred by more than one buck. Gestation is about 200 days, and the peak of fawn drop is mid-May to mid-June. Fawns weigh 7 to 8 pounds at birth and are able to walk shortly thereafter. For the first couple of weeks, does leave their fawns in a hiding place for several hours at a time, returning briefly to nurse them. This strategy reduces the likelihood of predators locating the newborn fawn. Fawns begin to follow their mother on her foraging trips at about 4 weeks of age. White-tailed deer fawns are nursed for 8 to 10 weeks before they are weaned.

In southern Lower Michigan, where habitat for deer is excellent and winters are relatively mild, about 30 to 50 percent of females breed as fawns and produce a fawn themselves when 1-year old. In northern regions of the state, particularly in the Upper Peninsula (UP), only about 5 percent of 1-year-old does produce a fawn. Pregnancy rates for does 2 years and older typically are very high, ranging from 80 to 95 percent. Pregnant one-year olds usually produce a single fawn, whereas older does usually produce twins, with singles or triplets possible depending upon their age and nutritional status.

Food Habits

The diet of white-tailed deer changes with the seasons. Succulent herbaceous plants, such as ferns, wild strawberry, dandelions, and goldenrod are preferred by deer during the summer months, and these "forbs" are supplemented with berries, mushrooms, new leaves from trees, and aquatic plants. A wide variety of agricultural crops are also eagerly consumed by deer, including corn, soybeans, oats, barley, alfalfa, pumpkins, and potatoes. In the autumn, deer continue to make use of available agricultural crops but turn to hard mast crops that are high in energy, such as acorns and beechnuts, as well as soft mast such as apples and other fruits. They also consume hay and clover at this time. During winter, deer abruptly change their diet in northern areas to stems and buds of woody plants. Favorite winter "browse" species in Michigan are white cedar, maple, birch, aspen, dogwood, and sumac, as well as many shrubs. Deer in northern Michigan typically enter a "negative energy balance" during winter and lose weight even when browse is present and abundant.

Causes of Mortality

A deer's life expectancy in Michigan is influenced greatly by hunting pressure and hunting regulations. Simply put, Michigan has a large number of deer hunters who are very effective at harvesting deer. In 2007, an estimated 683,000 hunters spent 9.7 million days afield and harvested nearly 484,000 deer. Statewide, 48 percent of hunters harvested a deer, about 24 percent took an antlerless deer (doe or fawn) and 35 percent took an antlered buck. About 16 percent of deer hunters harvested two or more deer. Poaching, or illegal taking of deer by people, is also a cause of mortality.

Vehicle-deer collisions are another major source of deer mortality in the state. According to State Farm Insurance research, Michigan ranks 2nd in the nation in reported vehicle-deer collisions. During 2008, there were 61,010 reported collisions with 12 motorists killed and 1,648 injured (Michigan Traffic Crash Facts 2008). Crashes occurred most often in Michigan's southern, heavily populated counties. Vehicle-deer crashes occur during all months of the year, but they are especially prevalent during autumn (October-December) when roadways offer the last green forage of the season, corn fields are being harvested, the deer mating season ("rut") is in progress, and daily commute occurs around dawn and dusk, when deer are most active.

White-tailed deer are prey for several large predators in Michigan, including gray wolves, black bears, coyotes, and bobcats. Fawns less than 2 weeks old are the most vulnerable to predation, but older deer are also killed, particularly if they are suffering from injury including wounding during the hunting season, disease, or malnutrition. Sometimes predators attain a competitive advantage during the winter months if the snow pack is crusted and supports the predator's weight while deer crash through with each step. While deer mortality due to predation can be significant, deer have evolved physical and behavioral mechanisms to coexist with predatory animals and have been doing so successfully for thousands of years.

Deer have adapted to survive winter weather like that which occurs in portions of Michigan, but winters of long duration with heavy snowfall and low temperatures can result in over-winter mortality. Deer attempt to reorganize in the worst winter weather by moving to habitat that provides shelter from wind and snow and provides food sources to maintain energy reserves to counteract the effects of low temperatures. In northern Michigan, these seasonal movements to winter habitat complexes, also known as deeryards, usually occur in December and can involve distances of 40 miles. Wintering complexes typically contain a high proportion of conifer tree cover, such as northern white cedar, hemlock, or spruce-fir forest. These trees intercept snow and block wind, but hemlock and spruce-fir do not provide adequate nutrition, nor does mature, closed-canopy cedar without browse available in the understory. Deciduous browse is required around such wintering sites. If deer cannot take in enough calories to supplement the fat reserves on hand, they begin to lose weight. During especially severe winters, significant numbers of deer may die of malnutrition or increased susceptibility to predators due to poor health. About two-thirds of the deer dying each year in severe winters are fawns (8 to 11 months old). During the winter of 1995-96, an estimated one-third (about 200,000 deer) of the winter herd perished in the UP. Even in mild winters, a loss of 10-15 percent of the winter herd is not uncommon in the UP. Such losses are usually much less in the Lower Peninsula (LP).

In Michigan, white-tailed deer are susceptible to a host of diseases and parasites. Many parasites and some diseases may weaken infected animals or use them as a host but generally are not fatal. Others can be deadly to individuals and may potentially effect local or even statewide populations. In recent years, several significant disease outbreaks in Michigan's deer herd have stimulated public concern and driven deer management decisions as real and perceived threats are realized.

Bovine tuberculosis (bTB), caused by *Mycobacterium bovis*, was first diagnosed in free-ranging Michigan white-tailed deer in November 1975 (Schmitt et al. 1997). Since that time, the extent and characteristics of the outbreak, as well as its ongoing management by the DNR, have been extensively described (de Lisle et al. 2002, Hickling 2002, O'Brien et al. 2002, O'Brien et al. 2006, Schmitt et al. 2002). Bovine tuberculosis is primarily of concern because of its ability to infect a wide variety of species (Oreilly 1995), including humans (Wilkins et al. 2003, Wilkins et al. 2008), and the resulting economic costs of infection for the livestock industry due to herd condemnations and closure of markets (Morris et al. 1994). After more than 13 years of surveillance and research, white-tailed deer remain the only proven reservoir of infection for cattle besides other cattle (Corner 2006).

Surveillance and control activities for bTB in free-ranging Michigan white-tailed deer have now been underway for over a decade. Significant progress has been made, lowering apparent prevalence in deer in the core area by less than 60 percent, primarily via reduction of deer densities through hunting, and restrictions on public feeding and baiting of deer. These broad strategies of the DNR, implemented with the cooperation of Michigan deer hunters, halved the deer population in the portion of the northeast LP known as the TB area. Yet formidable challenges remain, and evidence suggests that eradication of bTB, if it can be achieved, will take decades.

Chronic Wasting Disease (CWD) is a Transmissible Spongiform Encephalopathy (TSE), caused by mutant cellular protein, that affects four species of North American cervids (Sigurdson 2008, Williams 2005, Williams et al. 2002), including white-tailed deer. The clinical features, pathology and epidemiology of the disease have been well described in areas where the disease is endemic. Both simulation modeling (Gross and Miller 2001, Miller et al. 2000) and field research (Miller et al. 2008) suggest that once established, CWD can build to high prevalence in infected deer populations, resulting in marked decreases in survival of infected deer and likely causing substantial population declines over decades. Where the disease has become established, no management agency has thus far been able to control its spread, let alone eradicate it.

Following confirmed diagnosis of Michigan's first case of CWD in a captive white-tailed deer in a Kent County facility in August 2008, the DNR's intensified surveillance was implemented per the Michigan Surveillance and Response Plan For Chronic Wasting Disease of Free-Ranging and Privately-owned/Captive Cervids (Michigan Department of Natural Resources/Department of Agriculture. 2002). In 2008, 9,151 free-ranging deer were tested for CWD statewide, including 1,523 from a nine township area surrounding the infected captive facility. All were negative. Since 1998, over 31,000 wild white-tailed deer have been tested statewide, and all have been negative.

Epizootic Hemorrhagic Disease (EHD) is an acute, infectious, often fatal viral disease of some wild ruminants. This malady, characterized by extensive hemorrhages, EHD has occurred in significant outbreaks in deer in the northern United States and southern Canada. Die-offs of white-tailed deer in Michigan occurred in 1955, 1974, 2006, and 2008. Total mortality in these events ranged between 50 and 200 deer. Because of its very high mortality rate, EHD can have a significant effect upon the deer population in a given area, reducing numbers drastically. There is no know treatment for the disease and there is no evidence that the virus can infect humans.

Eastern Equine Encephalitis (EEE) is a fatal viral disease of horses that can infect a variety of avian and mammalian species but seldom causes clinical disease. It rarely occurs, but white-tailed deer can be infected and the disease is fatal in affected animals. There have been single reports of mortality in deer in Georgia (Tate et al. 2005) and Wisconsin and multiple cases in Michigan (Schmitt et al. 2007). The die-off in Michigan occurred in 2005 in the southwestern portion of the state. Seven mortalities were documented in this outbreak. Due to a high mortality rate, EEE can have a significant effect on the deer population in a given area, but because it rarely occurs, it is not an important mortality factor to the state as a whole. Although it occurs rarely, humans are susceptible to this disease and it can be fatal.

Lyme Disease is an illness caused by a spirochete bacterium (*Borrelia burgdorferi*). This disease is transmitted to humans and animals primarily by the bite of the tick, *Ixodes scapularis*. The white-tailed deer is a host for the adult stage of this tick and therefore can be involved in exposing humans to the tick, and consequently, to the bacterium. White-tailed deer do not develop disease when infected with *Borrelia burgdorferi*, and therefore this disease is not an important mortality factor (Brown and Burgess 2001). This disease is of public health significance as the bacterium can affect the cardiovascular system and the neurological system and cause severe arthritis.

Social Structure and Behavior

The social organization of white-tailed deer is largely matriarchal with the most common social group being an adult doe, some of her female offspring from previous years, and all their fawns. Sometimes three or four generations of related does are present in a family group. When fawning season arrives in mid-May, adult does leave the family group and remain alone to bear and rear their fawns. Once a pregnant doe leaves the family circle to bear her fawns, her yearling offspring are left on their own for the summer. At this time, young males may disperse from their mother's home range. If siblings remain together throughout most of summer, yearling bucks will separate in September as the rut approaches and disperse from the mother's home range. Whether they disperse in the spring or fall, research has shown yearling bucks in southern Michigan travel about 6 miles on average (Pusateri 2003); however, distances of more than 20 miles are possible. Yearling does remain in the mother's home range and generally rejoin their mother and her new fawns between September and October. During the breeding season adult and yearling bucks tend to stay alone except when in pursuit of a female approaching estrus. After the breeding season, yearling and adult bucks form loose associations of small groups, anywhere from 2 to 6 animals, which remain together throughout most of the winter and summer months. These groups break up around September when the rut starts.

Deer activity is usually highest during fall because of breeding behavior and the need to increase food consumption while preparing for winter. Deer decrease their activity in winter when food is limited and their mobility is hindered due to snow. In Michigan deer "gear down" metabolically during mid-winter and spend many hours bedded, often in southern exposures to take advantage of mid-day sun. A marked increase in deer activity occurs during the spring and summer due to the high metabolic demands associated with fawning and antler growth. Deer tend to be most active at dawn and dusk but activity patterns will vary across seasons and can be affected by environmental conditions.

The size and shape of a deer's home range varies with deer density, sex, landscape conditions, habitat quality, and season of the year. In the UP, the average winter home range of migratory deer is about 4.4 square miles, and the average summer home range is 8.2 square miles (Van Deelen et al. 1998). In the northern LP, average winter home ranges of migratory deer were approximately 1.3 square miles and average summer home ranges were about 1.2 square miles (Garner 2001, Sitar 1996). Non-migratory deer in the southwestern LP of Michigan had an estimated annual home range size of 0.2–2.9 square miles (Pusateri 2003). Yearling and adult does in south-central Michigan had seasonal home ranges of 0.3-0.8 square miles (Hiller 2007). Deer occupying better habitats can fulfill all their necessary requirements in smaller areas whereas deer residing in poorer ranges may have to travel further distances to find suitable food and cover. Males generally have larger home ranges than females.

Antler Development

Male deer grow a new set of antlers each year beginning in March or April. The growing antlers are covered by a skin called "velvet" which contains nerves and blood vessels that supply nutrients. Antler growth is usually complete by late July. By late August or early September the velvet is shed, often hastened by rubbing on small trees. Polished antlers are carried throughout most of the breeding season and are shed during winter (usually in late December and January) as testosterone levels decline. Male fawns grow pedicles that are typically about 1 inch in length. Yearling bucks tend to grow antlers having 2 (spikes) to 8 points depending on nutrition and genetic qualities of both its mother and father. A deer may reach the maximum number of points early in life; however the mass of the antlers continue to grow, even though the number of points may not. Bucks will produce their largest antlers after reaching physical maturity at 4-5 years of age. Although a buck's antlers may decline with advanced age, few bucks in Michigan live long enough to show antler size regression.

Carrying Capacity

Carrying capacity is a term that refers to the maximum sustainable size of a population. Carrying capacity of a population is limited by any number of constraints, both biological (Biological Carrying Capacity) and social (Social Carrying Capacity). The effective and appropriate management of deer populations must consider both biological and social carrying capacities.

Biological Carrying Capacity (BCC)

Biological carrying capacity is defined as the maximum number of animals that a given area can support over a prolonged period of time (McCullough 1984). BCC is determined by the capability of the area to provide the habitat components of a wildlife species – food, water, cover, and space. As deer populations grow, individual animals compete for the resources that their habitat provides, with less of the 4 requisites being available per deer. In Michigan, healthy, well-fed does are capable of producing triplet fawns and routinely produce twins. Under ideal conditions, even fawns are able to breed and produce their first young when they are about 1-year-old. However, as populations near BCC, adult does raise fewer fawns, fawn survival decreases and fewer fawns are capable of breeding. Another impact when a deer population approaches BCC is antler development in yearling bucks may be retarded. In addition, more deer die from malnutrition. When BCC is reached, the number of deaths equals the number of births.

White-tailed deer thrive in areas with young forests, brush, and scattered openings that provide a variety of food resources. Food is harder to obtain in mature forests, where buds, twigs, and leaves grow out of reach, and closed canopies shade out understory plants. Winter food resources are also hard to reach when they are covered with heavy snows, and deer must burn more calories to stay warm in colder weather. Therefore, BCC varies throughout Michigan based on climate and the distribution of habitat. BCC may also change over time, if forests age without cutting or burning, and may fluctuate with annual variations in weather. Although these considerations mean that BCC cannot be exactly known in any given year, and is somewhat of a moving target over time (Macnab 1985), using it as a context in setting population management objectives is possible if long-term trends are used to establish average conditions and short-term perturbations are acknowledged as having periodic significance in population dynamics (Strickland et al. 1994).

Since white-tailed deer are highly productive, population growth can actually result in populations temporarily exceeding BCC before stabilizing (McCullough 1979). In addition, deer populations may exceed BCC for extended periods of time if food resources are artificially supplemented, or in some instances when new populations are established or dramatic changes in habitat conditions occur, resulting in a lag in time before resources and populations become balanced (McCullough 1984). When deer populations remain at or above BCC for extended periods of time, BCC may actually be reduced due to vegetation damage that can result from the sustained browsing pressure of high deer populations. This sustained activity may alter the plant species, structural composition, or successional processes of the landscape, resulting in negative impacts on the habitat, which can result in cascading effects on other wildlife species long before negative impacts on the condition of deer occur (deCalesta 1997).

Social Carrying Capacity (SCC)

The concept of SCC proposes the abundance of a wildlife species is limited by the human social environment or human tolerance for that wildlife species. This section discusses the social issues associated with establishing goals for deer abundance and distribution in Michigan. The SCC model used here is intended to organize an understanding of public attitudes regarding deer abundance and distribution in Michigan. The model proposes that some level of deer abundance must be acceptable to most stakeholders for a SCC to exist. Otherwise, any level of abundance will create conflict and threaten to disrupt a deer management program. The SCC is not simply the highest level of deer abundance that will be accepted. The abundance that different stakeholder groups prefer and the minimum abundance they will tolerate are also critical points in the description of an SCC. The model also identifies three management targets: (1) deer abundance; (2) deer–human interactions; and, (3) human attitudes and tolerances regarding deer. The model measures success by whether issues associated with the presence of deer are manageable, or whether they are disrupting attempts at management.

SCC is a notion proposing that human society represents a social environment capable of setting limits on the number and distribution of a wildlife species. SCC is defined by both the maximum and minimum population sizes society will tolerate. That is, Michigan society may not tolerate too many deer, but it may not tolerate too few either. SCC is also defined by the interactions between humans and a wildlife species. Issues and conflicts are created when stakeholders disagree on what level of interactions is acceptable. The status of such deer-related issues is a critical feature of the SCC model. Deer management can be less about management of deer than about managing the issues created by deer–human interactions and differences in stakeholder tolerances regarding those interactions.

Deer–human interactions can be negative or positive. Negative interactions can occur, for example, in the form of depredation of agricultural crops and vehicle collisions. Positive interactions, such as opportunities for hunting or feeding and viewing deer can lead to direct conflict between neighbors. Both positive and negative interactions are highly valued by stakeholders and an important component of their tolerances and preferences for deer abundance. In some cases, an interaction can be viewed as positive by some stakeholders and negative by others. Observing a large number of deer in an agricultural field may be a positive interaction to a hunter, but a negative interaction for a farmer experiencing crop depredation by deer.

When stakeholder tolerances are exceeded by too few or too many interactions, the resulting issues can disrupt planned management programs. Issue activity can be expressed as a demand for agency response to a perceived problem, but it can also be an action that seeks resolution through litigation or legislative means. It is in the best interest of all stakeholders and the natural resource for deer managers to seek resolution of issues before they become disruptive. This makes the concept of SCC an extremely important one.

A SCC for deer is defined by the level of abundance and interactions acceptable to enough stakeholders such that there is a low level of deer-related issues (Minnis and Peyton 1995). When deer abundance and interactions with stakeholders fall within a range that most stakeholders can accept, deer are being managed within SCC. If no range is agreeable to key stakeholders, a SCC does not exist and could only be created by shifting attitudes and tolerances of stakeholders. There is the potential to change SCC to support more or fewer deer, or to manage the abundance and distribution of deer to fit an existing SCC.

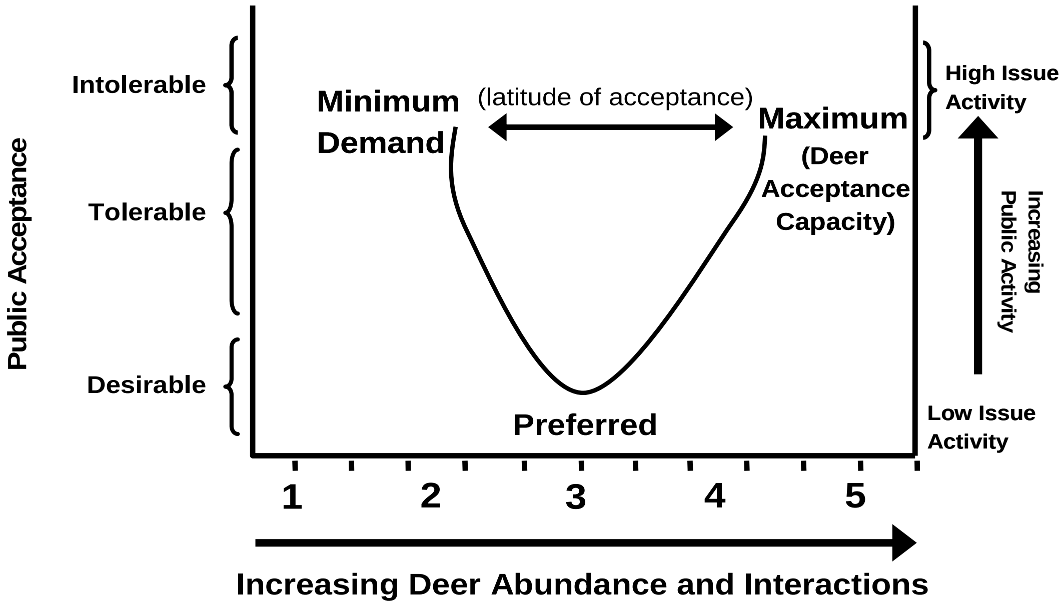

Figure 1. The three points (minimum, preferred, maximum) showing the preference and tolerances of a single stakeholder group for deer abundance and interactions.

Figure 1 shows the tolerances and preferences for deer of a single hypothetical stakeholder group. The x-axis could be either a range of 'deer–human interactions' or a range of 'deer abundance.' Both are used in this example. Stakeholders most often react to the 'interactions' with deer, but those interactions are linked to deer abundance. The figure suggests three hypothetical points for this group regarding deer population levels: the minimum level it will tolerate; the maximum level it will tolerate; and the level it prefers. The minimum level could be considered a 'minimum demand' for deer and the maximum is a 'deer acceptance capacity.' Between this minimum and this maximum is the range of acceptance for the group ('latitude of acceptance' in the figure). When the deer–human interactions are considered to be too low or too high by certain stakeholders, the interactions are outside their range of acceptance. At that point, if they place a high value on the consequences of the interactions, they are likely to become intolerant and engage in some issue activity (e.g., demand the agency adjust the deer population or they may take their issues to court). These stakeholders could be agricultural producers intolerant of depredation rates or they could be members of a deer hunting group intolerant of declining deer abundance.

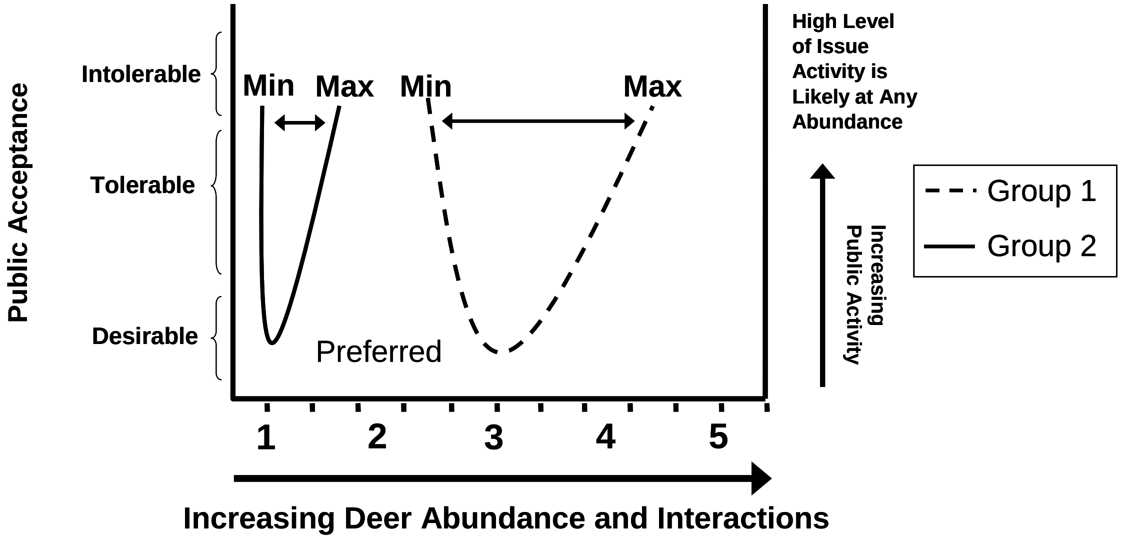

Figure 2. Points showing the preferences and tolerances of two stakeholder groups for deer abundance and interactions.

Figure 2 shows a situation in which two hypothetical stakeholder groups have ranges of acceptance that do not overlap. When key stakeholder groups do not have overlapping ranges of acceptance, management is difficult. For example, when the maximum number of deer that farmers will accept is below the minimum number that deer hunters will accept, conflicts are guaranteed. In fact, if stakeholder ranges of acceptance do not overlap, there is no SCC because there is no deer-population level that is agreeable. In this situation, any deer-population goal set by deer managers can be expected to generate political and/or legal opposition. Management is unable to resolve this issue, leaving the other two management targets to be addressed. One option is to shift the attitudes of stakeholder groups through education and outreach efforts to create some agreement. For example, if conflicting group tolerances are due to incorrect perceptions, education may be able to increase tolerance sufficiently to achieve some agreement among groups.

To illustrate, some stakeholders' intolerance of deer may be based on unrealistic perceptions of deer impacts on agriculture or the ecosystem. Other stakeholders with a demand for high deer abundance may have unrealistic perceptions that deer could have no impact on agriculture or the ecosystem. An effective education campaign might shift those ranges of acceptance to gain some overlap. A second approach is to address deer–human interactions that are creating intolerance. For example, a cost-effective means of reducing crop depredation or mitigating losses might increase farmer's tolerance of deer.

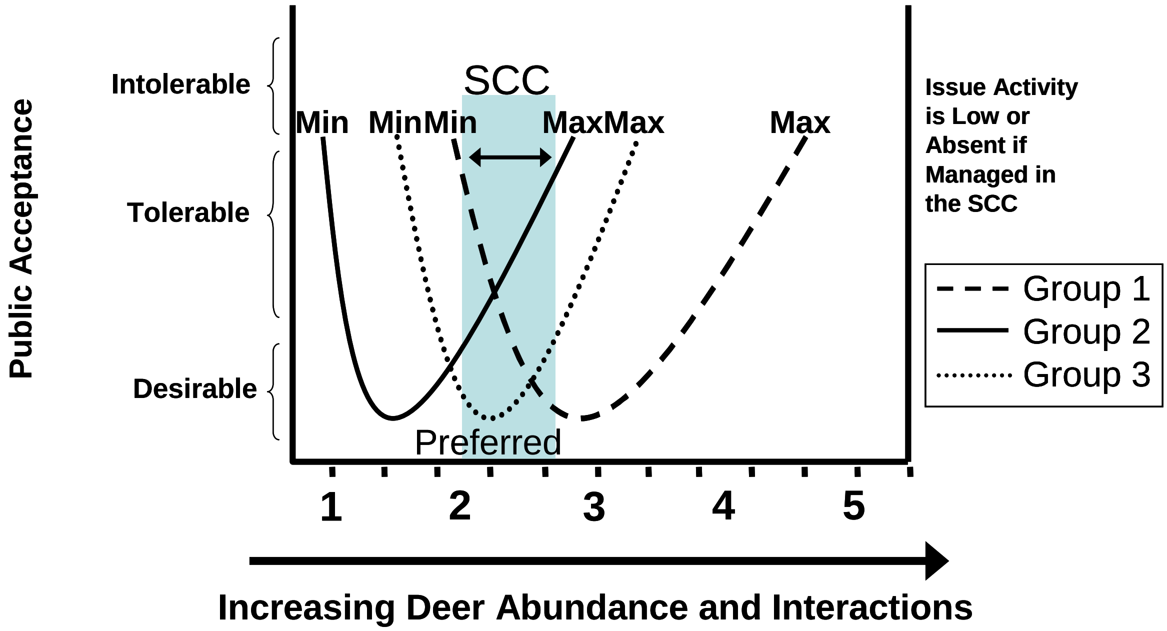

Figure 3. Points showing the preferences and tolerances of three stakeholder groups for deer abundance and interactions.

Figure 3 adds a third stakeholder group and shows some shift in tolerances of groups 1 and 2 to create some overlap in stakeholders' ranges of acceptance. This overlap defines a SCC; that is, it suggests a level of deer abundance and interactions that would be acceptable to most members of the three hypothetical stakeholder groups.

Assessment of Deer Populations

Successful deer management requires some form of population assessment so that population objectives and goals can be formulated. Management agencies assess deer populations using a variety of methods. Some methods, including counting of deer and utilizing intensive surveys to estimate populations or identify trends are often labor intensive and expensive. Other estimation methods are more easily implemented, yet perhaps less accurate, and may not provide the reliability or precision desired by some agencies and stakeholders. Other assessment techniques based on specific outcomes such as hunter and landowner satisfaction, or measurements of deer impacts on agricultural crops, forest regeneration or native plant communities can also be used. The Michigan DNR, like most agencies, relies on a suite of assessment methods to provide information needed to make management decisions.

Voluntary Deer Check

The deer harvest that occurs each fall through recreational deer hunting provides a tremendous opportunity for the DNR to collect data on Michigan's deer population. In recent years, the DNR has collected biological data (biodata) at over 100 voluntary check stations located throughout the state, where hunters can bring their deer. Michigan's voluntary check system gives the DNR the opportunity to collect biological and physical data from a sample of the harvested deer. This data is used in a variety of formats to monitor the size, composition, and health of the deer herd. The percent of harvested deer checked varies across years, seasons, and regions, but has recently averaged around 10 percent of the total deer harvest. Wildlife management agencies in some states utilize mandatory deer check or telephone or internet based deer check systems, but in many instances, little to no biological data are collected from harvested deer. At the check station, a trained DNR employee or volunteer records the age, as determined by the tooth wear patterns (Severinghaus 1949), and sex of the deer, the location and season of harvest, and the size of the antlers for bucks or the lactation status for does. Voluntary deer check stations also provide the opportunity to monitor the deer herd for diseases as some hunters are asked to submit samples to be tested for bovine tuberculosis and chronic wasting disease. As a secondary benefit, for many hunters, a visit to the deer check station represents a rare opportunity to discuss issues, share their thoughts and experiences, and ask questions as they directly interact with DNR personnel. Hunters receive a Deer Management Cooperator and Successful Hunter Patch for bringing in their deer. This interaction also provides valuable anecdotal information to DNR personnel regarding hunter opinions and impressions of deer hunting and management. Due to budget and staffing limitations, both the number of voluntary check stations and the hours of operation will be reduced in 2009. This will undoubtedly reduce the number of deer checked and the amount of data collected on harvested deer.

Mail Survey

The annual deer harvest mail survey uses a statistically based, stratified sampling design to develop estimates of the number of antlered and antlerless deer harvested, the number of hunters pursuing deer, and the number of days hunters spent pursuing deer. This information is collected by county, Deer Management Unit (DMU) and season. The survey is sent after the deer season ends to a randomly chosen sample of people who purchased Michigan deer hunting licenses. For the 2008 harvest, surveys were sent to over 51,000 license buyers and achieved a 59 percent response rate (Frawley 2009). The survey asks hunters to report where and for how many days they hunted and to report the number of antlered and antlerless deer they were successful in harvesting. Although only a sample of hunters receive the mail survey, all deer license buyers can report their hunting effort and results on the DNR web site. Unlike the biodata collected at voluntary deer check stations, the harvest survey is based on statistical design principles, but does not produce the breadth of information on the harvested deer that are provided by the biodata. The harvest survey data helps to assess the effects of regulations on hunting seasons and to assess the potential effects of the hunting season on the deer population.

Sex-Age-Kill (SAK)

One of the functions of the information collected from both the deer check stations and the mail survey is to determine an estimated deer population. The primary method for generating deer population estimates in Michigan is the SAK technique. This technique was originally formulated by Eberhardt (1960) in Michigan, and has been adopted for use in other states with various modifications (Creed et al. 1984). The SAK technique uses biodata gathered from hunter harvested deer at voluntary check stations located throughout the state and from mail surveys sent to a sample of hunters after deer season is over. This data is used to reconstruct the pre-hunt deer population. The key assumption for SAK is that the buck harvest tracks the buck population, meaning that the buck kill should go up when increases in the buck population occur and should go down when decreases occur. It is recognized that additional factors affect the buck kill, including weather conditions during hunting season, which can influence buck harvest rates by changing both deer (Zagata and Haugen 1974) and hunter (Curtis et al. 1972) behavior. In addition, potential biases have been identified in sex and age ratio data from the check stations. The buck to doe ratio is adjusted from that directly measured from the biodata because Michigan hunters tend to check a higher proportion of the antlered harvest (Cook 2001). Hansen (1998) determined that Michigan check station data revealed a higher proportion of yearling bucks and yearling does during the archery season than the firearm season. Maguire and Severinghaus (1954) and Roseberry and Klimstra (1974) both concluded younger males were more vulnerable than older males early in hunting periods. To minimize effects of these assumptions and biases on SAK population estimates, local biologists may adjust standard SAK estimates based on local knowledge of hunting conditions and generally only biodata collected from deer harvested within the firearm season is used.

Adequate samples of biodata must be collected from within each sampling unit to generate a reliable SAK population estimate. The minimum recommended sample should include data from 100 antlered deer and 200 antlerless deer. These sample sizes were determined using a standard equation for calculating sample size (Thompson 1992, Hansen 1998). Those units in which antlerless harvest or biodata collection is limited may use other indicators in place of check station data to generate estimates of sex and age ratios, such as results of camp or spotlight surveys. Data from the archery season may be included, or biodata may be pooled over several years or over larger geographic areas, in whatever manner the local manager feels provides a more cohesive image of the deer population (e.g. pooling over years when local deer populations are perceived to have been fairly stable over time, or pooling over larger areas with similar habitats and deer densities when significant annual changes in the population are suspected).

A significant benefit of using SAK as opposed to other survey or census techniques to estimate the white-tailed deer population in Michigan is that it utilizes biodata and harvest survey results that are already collected for the individual benefits each source of information provides. Population estimate scan be generated for any DMU in which adequate biodata are collected, or at the Management Unit, regional, or statewide level. Other population estimation techniques or indices used locally in Michigan and in other areas that could be applied in Michigan rely on significant additional time invested by DNR personnel (e.g. camp and spotlight surveys). Although such efforts can provide valuable local information, and can be used to develop trends to validate or even contribute to missing data necessary to generate SAK estimates, they cannot generate the large, statewide information that is collected annually during hunting seasons and through ongoing mail survey operations and incorporated into SAK calculations. Other techniques that are used in some states including mandatory deer check or telephone or internet based deer check may result in large sample sizes but provide less reliable data. In 2006, a panel of deer biologists from around the country evaluated the SAK model used by Wisconsin. The Executive Summary of the panel's report stated that "reconstruction methods such as the SAK provide a cost effective method for broad-scale demographic assessments" (Millspaugh et al. 2007).

Winter Severity Index (WSI)

Relationships have been established between the severity of winter weather and deer movement, survival, productivity, and physical condition in Michigan (Verme 1968, Verme and Ozoga 1971, Ozoga and Gysel 1972, Langenau 1996, Panken 2002). Deer have evolved in areas with harsh winter conditions and display a number of behavioral and physical adaptations for survival in snow and cold temperatures (Moen 1976, Telfer and Kelsall 1984). These adaptations allow deer to survive harsh mid-winter weather, however, when severe conditions persist into late winter and early spring (Verme and Ozoga 1971, Langenau 1996) or when cumulative effects of several winters (Mech et al. 1987) occur, physical conditions decrease and starvation can be significant.

The Michigan DNR implemented a technique to index the severity of winter weather conditions starting in 1964 in the UP and 1986 in the UP. This WSI was composed of air chill and snow hazard ratings. Air chill was indexed by using a specially designed chillometer to measure the energy required to maintain a sealed tank of water at a constant temperature, and snow hazard was assessed by tracking snow depth and utilizing a compaction gauge to assess snow pack (Verme 1968). The WSI proved useful for assessing potential impacts on deer populations and comparing relative severity of winter conditions over space and time (Verme and Ozoga 1971, Langenau 1996). However, challenges to maintaining a large network of data collection stations prompted the Wildlife Division (WLD) to develop an automated system for calculating a revised version of the WSI (Cook 2001, Chadwick 2002). The current WSI uses data collected hourly at automated weather stations located throughout Michigan and the surrounding area and reported by the National Climatic Data Center. Temperature, wind speed, and precipitation data are downloaded and calculations performed on a weekly basis from November 1 through April 30. The WSI values from individual stations can be averaged together to give a regional perspective on winter severity. Weekly index values may be plotted to identify the pattern of severe weather events throughout the winter season (such as the very early or very late peaks in severity that tend to have the greatest impact on deer) or they may be summed throughout the year to track the cumulative effect of the winter weather on deer (a less informative approach).

Although the WSI provides information on the potential effect of winter conditions on the deer herd, there are many other factors that play a role in determining impacts of winter weather. These factors include population density, quality and quantity of habitat, and previous winter or summer weather conditions. Due to the complexity of the relationship between the deer population and winter conditions, no single index can be used to predict over-winter mortality, fawn production, or deer physical condition and many factors must be considerd in addition to the WSI. Using the WSI as a tool to qualitatively evaluate winter weather severity, winters that have the potential to severely impact the deer herd can be identified. Especially in the northern regions of Michigan, WSI, in conjunction with other information on the deer herd and periodic visits to deer wintering complexes, is used to assess the deer population, adjust annual harvest quotas and make other management recommendations.

Pellet Surveys

Hunters frequently use the presence of pellet groups (deer scat) to assess whether areas are occupied or unoccupied by deer or as a measure of deer abundance. The pellet group survey is a formal extension of this common technique. The use of pellet counts to assess deer abundance was one of the survey techniques of primary focus in the 1930s and 1940s (O'Connell et al. 1999). Bennett et al. (1940) reported on the use of pellet group density estimates as an index of deer abundance or to compare deer use on different areas. However, wildlife managers were interested in generating estimates of deer density, rather than just relative indices of deer abundance. McCain (1948) was the first to describe the conversion of pellet group counts to an estimate of population density. By searching a representative sample of areas, counting pellet groups, and performing calculations based on measurements or assumptions regarding these relationships, an estimate of deer abundance may be calculated for sampled areas.

There are, however, numerous sources of error and variability involved in the field methods and assumptions required to perform the calculations of population estimates using pellet survey data. Pellet surveys are best used as an index for tracking annual changes (increases or decreases) in deer density and to help evaluate other population indices and estimates. Pellet surveys previously conducted in much of northern Michigan on a regular basis have become less frequently implemented over fewer areas. The most recent implementation was limited to use in the western UP to assess trends identified by other methods.

Observations, Spotlight Counts and Aerial Surveys

Various population assessment methods utilize direct observations of deer in order to estimate sizes, trends, or sex or age ratios of populations. While some methods may appear ideal for collecting data directly related to population abundance or composition, deer habitat use and behavior affect the rate at which bucks, does, and fawns may be observed throughout the year. The ability to detect deer also varies among different habitats, weather conditions at time of observations, and observers. Therefore, while observations of deer by DNR employees during summer and early fall regular daytime work activities were formerly recorded and compiled on an annual basis, accounting for the influence of such variables was not possible. This seriously limited the ability to infer how observations related to changes in deer populations throughout the years or across various areas within Michigan, so this survey was discontinued. Spotlight counts and aerial surveys, however, offer several advantages over daytime observations. These methods are sometimes implemented in surveys in order to assess trends in local populations. Rather than being conducted as highly structured, formal surveys, these efforts often complement other sources of knowledge or information. They allow biologists to draw inference regarding distribution of deer on different land ownerships or distinct areas within a larger area at which other data are summarized.

Deer are often less reclusive at night, and the eye shine produced when light is reflected by their tapetum can make them more readily observed than during daytime. McCullough (1982) found that different times of the year appeared to offer optimal conditions for using spotlight counts to generate estimates of population trends (October and November), sex ratios (July), and fawn to doe ratios (April). This variation is likely due to differences in feeding and bedding times among bucks, does, and fawns (Downing et al. 1977). The feasibility of generating any of these estimates for a given area would be limited where any considerable amount of dense vegetation occurs that deer utilize as escape cover (McCullough 1982). However, the amount of visible area in various habitats may be estimated by evaluating distances at which deer may be reliably seen at different points along a spotlight route. Whipple et al. (1994) found that accuracy of estimating deer densities using such a technique was influenced by both the ability of observers to detect deer and to estimate visibility distance in different habitats. These factors tended to offset and produce fairly accurate density estimates in open habitats, but compounded to generate considerable underestimates in dense cover. Collier et al. (2007) concluded that variation in deer detected by different observers and along different routes severely limited the ability of spotlight surveys to estimate abundance or index population trends except when population changes are substantial. Their greatest concern was that spotlight routes can only be run where access exists (along roads and trails), and thus cannot provide a widely distributed, representative sampling of deer habitat.

Counting deer from aircraft allows more broadly distributed sampling than restricting observations to accessible ground routes. However, detection still varies widely within different cover types. Accurate aerial surveys of white-tailed deer have generally been restricted to mostly open habitats or defoliated deciduous forests with snow cover (Stoll et al. 1991, Beringer et al. 1998). Deer throughout northern Michigan migrate to wintering areas dominated by dense coniferous vegetation as persistent snow cover accumulates (Ozoga 1968, Verme 1973, Sitar et al. 1998, Van Deelen et al. 1998) severely limiting aerial surveys. Haroldson et al. (2003) evaluated the use of thermal imaging equipment for enhancing detection of deer during aerial surveys, in part to alleviate the need for specific weather conditions. They concluded that operator bias and inconsistent thermal contrast limited the precision and accuracy of implementing this technique.

Deer Camp Surveys

Many deer hunters in the UP return to the same “permanent” deer camps during the November firearm season. Camps are typically occupied by 5 to 10 individuals who hunt on the same parcels of land year-after-year. Deer camps tend to keep records of their deer sightings and kills over the years or are willing to do so if they believe the resulting information can help manage the deer herd. The DNR devised a cooperator deer camp survey that is distributed to select camps during the 16-day firearm season. The survey allows hunters to provide their assessment on local deer herd levels and the quality of hunting. This survey has been conducted in the western UP since 1994 and the eastern UP since 2003.

The deer camp survey has several objectives:

- Assess deer herd size compared to past years (more, same, less) based on the number of deer seen, harvested, and camp opinions of deer herd trend.
- Monitor doe-to-buck and fawn-to-doe ratios from hunter sightings.
- Assess the quality of hunting based on hunter success rates and their written comments.
- Monitor trends in sightings of select furbearer species by deer camps.
- Detect and address emerging deer management issues based on written comments submitted by camps.

The information resulting from this survey provides an early and localized view of deer herd size, trend, and hunter satisfaction. This survey, while hindered by small sample sizes in some deer management units, provides information immediately following the deer season. Thus, it fills a gap in information until other survey data are available.

Deer Tagging

Trapping and tagging deer (including radio-collaring deer) can provide valuable information on deer ecology that is useful to deer managers. Deer have been tagged for over 50 years in Michigan in efforts to document the seasonal migrations, movement patterns, and mortality factors of deer throughout the state. Trapping and tagging are generally done during the months of January through March when deer are most concentrated and natural foods are in short supply. Objectives of tagging studies include: determining the distance and direction of seasonal migrations; measuring home range size; determining habitat use and browsing effects of deer; investigating the role of winter weather and habitat quality on deer survival; as well as evaluating general deer population characteristics.

While deer tagging studies do not provide population estimates or indices they do provide important information on timing and use patterns of specific areas or habitat types. It is important for wildlife managers to know how deer use these areas to understand implications of antlerless quotas and how timber harvest and other land use activities may impact regional deer populations and habitats. In addition a basic understanding of deer migration patterns and home range size could be important in understanding how diseases like bTB and CWD may spread in a population.

Other Indicators

In addition to formal population estimates, indices and measures, other factors are considered when evaluating deer populations. Local wildlife biologists monitor deer-vehicle collisions, crop damage and forest regeneration issues as well as hunter satisfaction and hunter success rates. These indicators, when tracked over time and evaluated in the context of other changing factors can provide insight into local deer population trends.

In summary, precisely estimating population size of free ranging white-tailed deer at the local, DMU or statewide level is difficult. Conditions vary across the state and no known single population estimation technique can be successfully applied statewide. By applying a consistent technique (SAK), in combination with consideration of a variety of locally appropriate measures and factors, biologists in Michigan can provide a reasonably accurate population estimate that is useful when making deer management decisions and evaluating population goals and objectives.

Harvest Management

Legal Authority

The DNR has a public trust responsibility for the management of all wildlife species and populations. Primary legal authority for wildlife management and regulation comes from the Natural Resources and Environmental Protection Act, Public Act 451 of 1994. Part 401 of Public Act 451 gives authority to the Natural Resources Commission (NRC) and the DNR Director to issue orders (Wildlife Conservation Order) specific to wildlife management and hunting.

In 1996, Michigan voters supported a hunting ballot initiative requiring the NRC to use "principles of sound scientific management" in making decisions concerning the taking of wildlife. This legislation gave exclusive authority to the NRC over the method and manner of take for game species. Following passage of the initiative, it was codified as Section 40113a of Public Act No. 451 of the Public Acts of 1994, MCL 324.40113a. PA 451 can be found on the state Legislature website at www.legislature.mi.gov.

The regulations established by the NRC pursuant to PA 451 for the taking of deer in the state of Michigan are found in the Wildlife Conservation Order (WCO). The complete WCO may be found on the DNR website www.michigan.gov/dnr under Laws and Legislation.

Michigan Deer History

Deer have been a valuable resource in Michigan since the first Native Americans began to hunt them. Prior to European settlement, Michigan had an abundant deer herd in the south. The mixture of hardwoods, wetlands, bogs, forest openings and prairies was ideal for deer. There were few deer in the virgin forests of the north, which were inhabited mostly by elk and moose. These mature forests allowed little sunlight to reach the forest floor and deer browse was limited.

As farmers and settlers moved into southern Michigan in the 1800's, deer habitat was altered dramatically by removal of cover for crop fields. The shooting of deer for food was unregulated and deer were mostly gone from the southern LP by 1870. Logging of forests in the north produced the opposite effect. More openings, brush, and young forests provided cover and browse and the northern herd climbed to an estimated 1 million deer in the 1880s. As railroads developed and provided access into the wilderness, market hunters shot hundreds of thousands of deer. Early measures to control market hunting by restricting the time frame to take deer but not the number of deer taken, were not very successful. What followed were decades of ups and downs in the deer population resulting from changes in hunting regulations and available habitat.

The first regulation enacted to limit the taking of deer in Michigan occurred in 1859, when the state legislature limited the taking of deer to the period of August 1 through December 31. In 1887 the use of dogs or artificial lights became illegal. The state legislature shortened the season to 25 days with the first bag limit (5 deer) and created the first deer license in 1895, selling 14,477 licenses for 50 cents each with 22 non-residents paying $25 for a Michigan deer license. In 1909 the bag limit was reduced to 3 deer and market hunting and the selling of venison became illegal.

In 1914, Game Commissioner William R. Oates estimated that there were only 45,000 deer in Michigan and recommended changing regulations limiting hunters to 1 deer per season with the goal to increase the size of the deer herd. That year 21,061 resident licenses and 178 non-resident deer licenses were sold.

In 1921 the 3 inch rule was enacted limiting hunters to antlered deer only. The deer herd began to rebound. Some of the increase was due to habitat changes as logged-over areas produced abundant deer browse. In addition, shrubs and other deer foods developed in many areas that had been cleared for agriculture, but later abandoned.

By 1930, the abundance of deer was recognized and the first discussions of deer-vehicle accidents began. There was also a significant amount of winter starvation and over-browsing in cedar swamps where field investigators reported a shortage of food and cover for the growing herd. Mr. Ilo Bartlett, the state's first deer biologist, reported that there were 1.125 million deer in the state in 1937 and he began to talk about the "deer problem." About 1/3 of the deer at this time were in the UP and 2/3 in the northern LP- only a few deer were present in southern Michigan.

The deer population continued to grow and peaked at about 1.5 million deer in the late 1940s. Antlerless deer were once again allowed to be taken by hunters in an attempt to reduce the size of the deer herd. However, before that could happen, the habitat for deer collapsed, due to a combination of pressure from a large herd and an increase in forested areas as mature stands of timber once again began to develop on formerly logged lands. The deer population again dropped.

To address the habitat problem, the Department of Conservation (precursor to the DNR) developed a Deer Range Improvement Program (DRIP) in 1971 designed to acquire and manage critical deer habitat and with a goal of increasing the deer herd to 1 million deer for spring of 1981. The success of the DRIP, along with a series of mild winters and artificial feeding of deer by the public further propelled the herd to a new peak of 2.2 million deer in 1995. Signs of distress in the herd appeared again. State records for deer hunting were set in 1997 when 870,216 unique individuals purchased a deer license in Michigan and in 1998 when an estimated 582,000 deer were harvested (Figure 4). A complete listing of historical deer hunting regulations can be found on the DNR website at: http://www.michigan.gov/documents/dnr/deer_regulation_history_210705_7.pdf

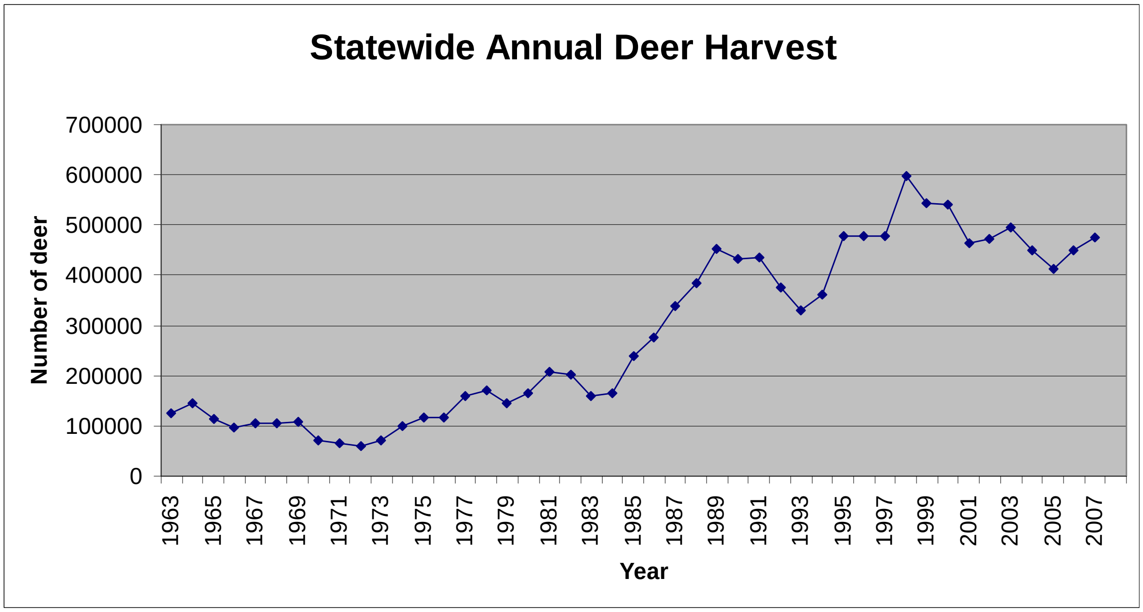

Figure 4. Estimated annual deer harvest 1963 through 2007

Deer Management Units

Michigan has two primary discrete deer populations, those of the UP and the LP. To facilitate management within these populations, DMUs have been established. A DMU is the geographic unit within which deer management is implemented. In the LP, each county, with a few exceptions, is a single DMU. The majority of LP counties have roads along their borders, thus helping delineate the DMU. The primary advantage of using counties as DMUs is the existing familiarity of the area and it's boundaries as a political unit. This familiarity allows hunters to be sure about their location when hunting and aids in collection and analysis of deer harvest and other hunting data since hunters are easily able to report the DMU in which they were hunting. In addition, counties provide reasonably appropriate geographic size for managing deer by balancing the benefits of providing sufficient population size, hunter harvest, and biodata with the desire of many hunters and deer managers to have relatively small units that allow management of deer at the appropriate scale. In the UP, counties often do not have roads delineating boundaries. Therefore, DMUs in the UP are defined by major, easily defined, linear geographic or constructed boundaries like rivers, power lines, railroad right-a-ways, and roads. These recognizable boundaries allow hunters to be sure of their location and to know which DMU they are in.

Population Goals

Deer population goals were established for each DMU in 1999 in order to guide management decisions and strategies. Population goals were developed for each DMU by local wildlife biologists and reflect biological as well as social considerations. Many factors associated with deer population size were considered in development of DMU population goals including: hunter satisfaction and success rates, land ownership patterns, habitat quality, climate, crop damage complaints, forest regeneration concerns and deer vehicle collisions.

Updated draft population goals were developed in 2005 for the 2006 - 2010 period. Public input on the proposed goals was solicited through a series of public meetings that were held throughout the state. While public opinions of the proposed goals varied across the state and among stakeholder groups, many vocal stakeholders questioned the accuracy of DNR population estimates and felt the proposed population goals for many DMUs were too low. The controversy over the proposed 2006 – 2010 goals was significant and the draft goals have not been approved and will be revisited in 2010.

Deer Seasons, Licenses and Bag Limits

The primary deer hunting seasons in Michigan have traditionally consisted of the archery season (October 1 – November 14 and December 1 – January 1), the regular firearm season (November 15 – November 30), and the muzzleloading season (dates vary each year and by Hunting and Trapping Zone* but occur in early to mid-December). In recent years, additional seasons designed to increase antlerless harvest or to provide special opportunities for young or disabled hunters have also been established. In 2009, the various seasons resulted in 100 days in which hunters could be deer hunting in Michigan:

- Early firearm season (September 17 – 21)
- Youth and 100 percent disabled veterans (September 26, 27)
- Archery Season (October 1 – November 14 and December 1 – January 1)
- Special Disabled firearm hunt (October 17 – 20)
- Regular Firearm Season (November 15 – 30)
- Muzzleloading Season: (Zone 1 (UP): December 4 - 13)
(Zone 2 (NLP): December 11 – 20)
(Zone 3 (SLP): December 4 – 20)
- Late Firearm Season (December 21 – January 1)

*For additional information on Hunting and Trapping Zones, go to:
http://www.michigan.gov/dnr/0,1607/7-153-10363_10913-31537--,00.html

The following information is a summary of deer license information. Additional rules apply and there are exceptions to the information provided here. Consult the Michigan Hunting and Trapping Guide or visit: http://www.michigan.gov/dnr/0,1607/7-153-10363_14518---,00.html for complete hunting license information.

Hunters are limited to purchasing two kill tags for taking an antlered (buck) deer. For hunting in the LP, hunters may purchase one archery license AND one firearm license (one kill tag each) OR one combination license (two kill tags). However, new UP buck hunting regulations in effect as of the 2008 hunting season place different restrictions on hunters depending upon the type of license purchased. Combination license holders have antler point restrictions (APR) for both licenses when hunting in the UP. To take an antlered deer in the UP with the regular combination license the deer must have at least one antler with three or more antler points, each at least one inch in length. The APR for the restricted combination license is unchanged (at least one antler with four or more points, each at least one inch in length). Both combination licenses are valid for an antlerless deer during the archery season. Hunters possessing both a firearm and archery deer license are limited to taking one antlered animal in the UP, all seasons combined. That deer must have at least one antler three or more inches in length. The archery license is valid for an antlerless deer during the archery season.

Archery Deer Hunting License
This license entitles hunters 10 years or older to take one antlered or antlerless deer during the youth and disabled seasons (if appropriate), or the October 1 – November 14 and December 1 – January 1 archery seasons with archery equipment. It is unlawful to purchase more than one archery deer hunting license.

Firearm Deer Hunting License
Hunters 12 years or older may take a deer with at least one antler three inches or longer during the youth and disabled seasons (if appropriate), November 15 – 30 firearm season or during the muzzleloading season. It is unlawful to purchase more than one firearm deer hunting license.

Combination Deer Hunting License
Hunters may purchase one Combination license with two kill tags (regular and restricted) for use during any firearm hunting season (regular firearm and muzzleloading), the archery seasons and the youth and disabled seasons. A hunter can use both kill tags in the firearm seasons, both in the archery season or one in each season. The regular combination kill tag can be used in the archery seasons to tag either an antlered or antlerless deer. The regular combination kill tag can be used in the firearm seasons to tag a legal (3 inches or longer antler) antlered deer of any size. The restricted combination kill tag can be used in the archery seasons to tag an antlerless deer or it can be used to tag an antlered deer during either the archery or firearms seasons if the antlered deer has at least one antler with four or more antler points each one inch or longer.

Antlerless Deer Hunting License
Hunters are entitled to take an antlerless deer or deer with antlers less than three inches in length. Antlerless licenses are valid during all deer seasons with hunting equipment appropriate for the season and hunting zone. There is a limit of five private land antlerless licenses per hunter of which no more than two are in Zones 1 and 2. There is no limit to the number of public land antlerless deer licenses a hunter can possess, however the need for an application and the limited quantity available usually limits hunters to one.

Antlerless Deer License Quotas

A regulated antlerless deer harvest allows biologists to manage deer populations by reducing the number of female deer in the population where appropriate. Antlerless deer licenses are generally issued to hunters in DMUs where harvest of antlerless deer will help achieve goals for maintaining or reducing deer populations or changing sex ratios. Antlerless license quotas are set each year when biologists determine the relationship of the projected October 1 population to the established deer goal for the DMU.

Generally, when the projected population is above goal, more antlerless deer licenses are offered in order to reduce the population. In many DMUs where deer populations are significantly over goal, especially in the southern Lower Peninsula (SLP), antlerless quotas are set high and are undersubscribed (some licenses remain unpurchased due to quotas exceeding hunter demand). When this occurs, it is difficult to maintain or lower deer populations. Even when projected populations are near goal or even slightly below goal, antlerless licenses are still offered to allow some antlerless harvest and keep the population in check. When populations fall well below population goals, antlerless quotas are set very low or eliminated for that DMU.

Since deer are not evenly distributed throughout a DMU and deer and hunter densities often vary across public and private lands, antlerless deer license quotas for each DMU are established separately for public land and private land. The number of private and public land antlerless licenses is based on the distribution of the deer population on these ownerships types and the impacts of these populations.

Management Strategies

The guiding principal for deer management in Michigan is Natural Resources Commission Policy 2007 on Deer Management, issued on April 14, 1994. Policy 2007 states:

> *The Department's goal is to manage the deer herd using management practices based on scientific research to:*
>
> > *1. Maintain healthy animals and keep the deer population within limits dictated by the carrying capacity of the range and by its effect on native plant communities, agricultural, horticultural, and silvicultural crops and public safety.*
> > *2. Maintain an active public information program designed to acquaint the public with the methods of deer management and the conditions needed to maintain a healthy, vigorous herd.*
>
> *The Department shall develop procedures to implement this policy.*

All regulations proposed and actions taken by the DNR regarding deer management are designed to help achieve the requirements of NRC Policy 2007. Effective management of Michigan’s deer herd requires consideration of many biological, ecological, social, economic, and political factors. The goal is to achieve the best possible long-term management outcomes for all involved while acknowledging that not everyone will be completely satisfied.

Current deer management strategies are aimed at maximizing recreational opportunities while maintaining healthy populations at appropriate levels. Hunters are legally allowed to harvest two bucks each year and antlerless quotas are designed to maintain deer populations at socially acceptable levels. These strategies do not specifically address sex and age ratios as desired by some stakeholders. Specifically, hunters seeking higher buck:doe ratios and a greater number of mature bucks in the population are requesting deer management designed to make these changes. Deer management strategies designed to alter buck:doe ratios and age structure in the buck population are often referred to as Quality Deer Management (QDM). QDM calls for adequate antlerless harvest, protection of young bucks and habitat improvement and may include: earn-a-buck (hunters must "earn" a buck tag by first harvesting antlerless deer), minimum antler restrictions, and a reduced annual bag limit of one buck per hunter. Another strategy, Trophy Deer Management advocates reducing deer densities to very low levels and protecting bucks from harvest until they reach the age where "peak" antler development occurs (e.g., 5 years of age or older). While many hunters appear satisfied with the current direction of deer management in Michigan, some hunters and land managers are expressing interest in making changes.

Regulatory Process

Establishment of Antlerless Regulations

Each year, biologists review deer population information including population data, mail survey information from hunters, crop damage complaints, winter mortality, deer-vehicle collisions, personal observations, and input from stakeholders prior to making recommendations regarding antlerless licenses. Recommendations are submitted by field staff regarding whether late antlerless seasons should be open, availability of antlerless licenses on public and private land, and antlerless license quotas for each DMU. Recommendations are reviewed by Management Unit Supervisors, the Statewide Field Coordinator, the Statewide Big Game Specialist, and the Species Section Supervisor. The Assistant Chief makes the final recommendation if there is not consensus between the Field Coordinator and the Species Section Supervisor. The final recommendation is forwarded by the Division Chief to all of the DNR Resource Bureau Division Chiefs for their approval. The recommendation is then reviewed and approved by the Resource Deputy Director and the Director before being forwarded to the NRC for consideration. The recommended proposal is listed on the NRC calendar for information for one month and then is listed again for another month before NRC action.

Natural Resources Commission Process

All the regulations governing the taking of deer in Michigan are found in either PA 451 or the WCO. Changes to PA 451 are the purview of the State Legislature. Changes (amendments) to the WCO are the purview of the NRC.

The NRC has an established process for review and approval of all Wildlife Conservation Order amendments. While a 60-day public review is built into that process, 30 days of public review are required by PA 451.

1) The process begins on the Monday following the regularly scheduled monthly NRC meeting when the Department submits a memo outlining the recommendations to the Director's Office. This action puts the recommendations on the NRC calendar for the following month and opens a public review period.
2) At the following month's NRC meeting, the Department typically makes a presentation "for information" on the recommendations, and questions from the NRC are addressed. At this time the public has an opportunity to speak before the NRC to voice their concerns, support, or opposition to the recommendations. The NRC does not take action to approve the recommendations at this meeting.
3) At the subsequent NRC meeting (approximately 60 days after the recommendation memo was submitted), the NRC typically takes action on the recommendations. There is another opportunity for the public to voice their concerns, support, or opposition to the recommendations. At the end of the meeting, most often the NRC votes on the recommendations, sometimes after changing the recommendation, yet can defer the decision to a later meeting following additional public comment. If approved, the recommendations become part of the Wildlife Conservation Order and the Department can take actions to ensure the approved recommendations are implemented.

All amendments to the WCO occur at the NRC monthly meetings which are open to the public. NRC meetings are typically held on the first Thursday on each month. The NRC Calendar is available on the DNR website or upon request from the DNR.

Habitat Management

High quality wildlife habitat produces healthy and abundant wildlife and habitat management is a vital component of deer management in Michigan. Seasonal habitat requirements of deer must be considered and are best addressed through manipulation of vegetation. Commercial forest management and agricultural activities have the largest impact on deer habitat but smaller scale efforts including non-commercial forest manipulations and food and cover plots established by deer hunters can have a cumulative impact as well.

Deer habitat varies greatly across the state as climate, land use, human population density, and other factors change dramatically as you travel from north to south. In northern Michigan, the main habitat factors limiting deer numbers are the availability of quality browse and thermal cover. Both these factors are related to vegetation and are particularly important in winter and early spring. In southern Michigan, where intensive agriculture provides an abundance of food for much of the year, winter conditions are tolerable, and predators are limited, habitat conditions are ideal and rarely limit deer populations except where agriculture is so intensive that escape cover is virtually non-existent.

Habitat management concerns and efforts vary not only from north to south across Michigan but depend on ownership patterns as well. Management goals and land use practices are much different on private, state-owned, and federally owned land. Private land owners, state land managers and federal land managers operate at different scales, with different levels of public input and under different management directives.

Private Land

The proportion of public and private lands varies across the state, with 96 percent of the SLP under private ownership, 74 percent of the NLP, and 51 percent of the UP. Statewide, about 79 percent of the land area is under private ownership (figure 5).

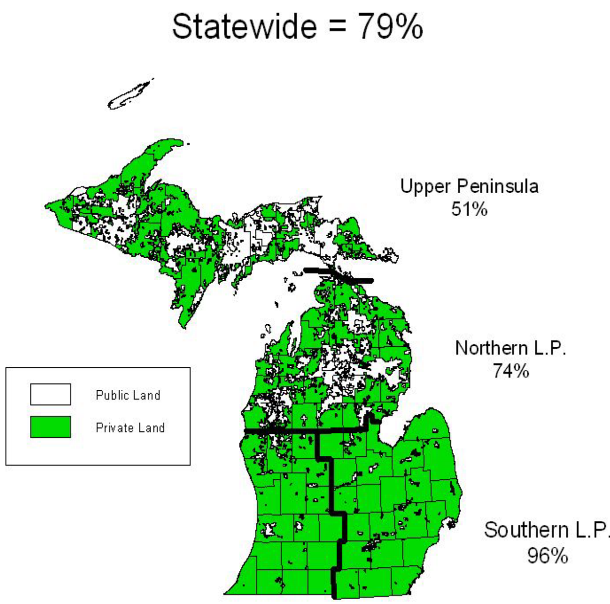

Figure 5. Distribution of public land in Michigan

Soil and land cover types in Michigan are not equally distributed between public and private lands. This inequitable distribution often results in higher quality deer habitat occurring on private land and out of reach of public land managers. Agricultural lands are almost entirely (99 percent) found on private land and the abundant nutritional forage provided by crops allows for tremendous deer productivity. Over 70 percent of the oak forests in Michigan are found on private land with the hard mast produced by these forests allowing deer to take on critical fat deposits as they enter the lean winter months. About 65 percent of Michigan's aspen forest is found on private land and deer benefit from browse available in regenerating forests, particularly those with aspen. In the UP, deer display seasonal migratory behavior where they seek out large lowland conifer blocks as thermal cover in traditional deer yards. More than 57 percent of the lowland conifer and 60 percent of the identified deer yards are found on private land. With the major portion of these cover types under control of private landowners, there is a large potential for habitat management activities on these lands to influence deer populations especially if land owners work together to identify regional habitat limitations and to address these limitations with appropriate projects.

Federal Land

There are three national forests in Michigan: the Ottawa, Hiawatha, and Huron-Manistee National Forests, accounting for about 3 million acres of public land. Although the DNR has legal authority for the wildlife found across the state, it does not dictate land management practices on these federal lands which are managed by the USDA Forest Service.

The Forest Service manages its lands with a diverse set of goals and objectives involving conservation and restoration of native plant and animal communities and opportunities for associated recreation. Forest Service efforts often focus on controlling and eliminating invasive species and providing quality habitat for rare species including the Kirtlands Warbler and Karner Blue Butterfly. Habitat management practices commonly used include timber harvest, tree planting and prescribed fire.

The Forest Service must comply with National Environmental Protection Acts (NEPA) and complete an environmental review for all proposed management. These NEPA requirements have opened the Forest Service to continued and lengthy litigation with various stakeholder groups. The result has been dramatically reduced timber management within these national forests. Forest Service plans call for reduced aspen harvests on all three national forests over the next ten years and may have a negative impact on deer and other wildlife that benefit from regenerating forests.

State Land

Northern Michigan

The state of Michigan has 4 million acres of state forest land, predominantly located in the northern half of the state. In 2006, the DNR sought and attained dual certification of State Forest lands under the Sustainable Forestry Initiative and the Forest Stewardship Council. Certification of our state forest system demonstrates to interested stakeholders and markets that natural resource management practices are sound and comprehensive. Management of the state forest is guided by planning efforts of the DNR eco-teams and is planned at the compartment level. Compartments are sections of forest that typically range in size from 500 to 3,000 acres.

The state forests are co-managed by the Forest, Minerals, and Fire Management Division and WLD. Management planning for state forest lands is done at the Forest Management Unit level. Management objectives for state forest lands are guided by the Michigan State Forest Management Plan, Ecoregional Forest Management Plans, annual Forest Management Unit analyses, and the Annual Plan of Work that is derived from the 10-year planning cycle for annual compartment reviews. The 10-year planning cycle requires that DNR staff visit 10 percent of the compartments each year to take inventory of forest stands and to identify opportunities for improving wildlife habitat. Proposed forest treatments that are considered during compartment review are guided by desired future conditions, goals and objectives contained in ecoregional management plans and from goals and objectives that are specified in the other listed plans. The most influential treatments that occur on state forest land are commercial timber sales, which can create a diverse array of wildlife habitat conditions. Deer benefit when felled tops are available during logging operations, particularly in winter when other forage is scarce, and again when new tree saplings regenerate the harvested stands. About 50,000 acres of timber sales (harvests) occurs on the state forests each year. Additional forest treatments include planting, seeding, burning and scarifying to regenerate the stands after harvest. In addition, wildlife managers prepare proposals for non-commercial treatments such as planting of oak seedlings, herbaceous planting in forest openings, prescribed burns to reduce woody encroachment, and roller chopping to create or limit brush growth. These treatments are frequently undertaken with public partners, such as conservation organizations or local sportsman groups.

Wildlife biologists and foresters evaluate habitat conditions of the forest and the needs of all wildlife species, including deer, are considered during the treatment planning process. This generally means planning for a diversity of forest types, grasslands, upland brush, and wetlands across the landscape. The management of cedar, hemlock and oak have been especially difficult as these stands have proven difficult to regenerate in some areas. Wildlife managers also seek to maintain and enhance habitat attributes required by species that are threatened or endangered.

Southern Michigan

In southern Michigan, less than 4 percent of the land is publicly owned. Public lands in southern Michigan consist primarily of State Game Areas (SGAs), State Parks, and State Recreation Areas. Parks and recreation areas are managed for a variety of recreational opportunities, while SGAs are managed primarily for wildlife and wildlife associated recreation. Plans for these areas are written to guide management activities and are designed to provide direction over a 10 year period. Biologists draft the plans for SGAs, which are reviewed by other divisions of the DNR, stakeholder groups and the general public.

Habitat management projects are designed to provide diverse plant communities that provide habitat for a variety of wildlife. Management activities include: commercial timber sales; planting of herbaceous vegetation for nesting, thermal and escape cover; maintenance of wetland habitats; and the application of prescribed fire, mowing, and herbicide. In some cases, food plots are planted to provide highly attractive food sources for deer and other wildlife.

Habitat on the limited amount of public land in southern Michigan does not have a significant impact on deer populations. In many areas, the habitat found on private land is more productive and attractive to deer than nearby public land. Because of this, and since deer are generally abundant here, habitat projects on public land in southern Michigan focus on needs of other species and are not designed specifically to increase deer populations.

Urban/Suburban Deer Management

White-tailed deer are an important part of the culture in Michigan. As white-tailed deer have expanded in number and adjusted to living in and around urban areas, they have taken up permanent or semi-permanent residence in many Michigan communities. With adequate cover and food available deer successfully navigate sidewalks, traffic and backyard fences, appearing quite comfortable with daily interactions involving humans, barking dogs and vehicles. Management of urban/suburban deer populations can be difficult. Similarly, as deer populations increase and conflicts with deer arise, different expectations, concerns, and values make addressing these conflicts problematic.

Deer populations in rural settings are managed nearly exclusively by recreational hunting with the exception of utilizing deer damage shooting permits for addressing specific situations. However, these lethal techniques face several challenges to application in many urban/suburban areas including: (1) real or perceived safety concerns, (2) conflicting social attitudes and perceptions about wildlife, (3) hunting and firearm-discharge restrictions, and (4) liability or public relations concerns (DeNicola 2000).

Urban/Suburban Deer Issues

As deer have lost their inhibitions of humans and densely populated areas, they have taken advantage of an environment that provides sufficient cover, an abundance of food, and freedom from natural and human predators (recreational hunters). Increasing numbers of urban car-deer accidents and excessive damage to landscaping are the most common problems associated with deer in these settings. In addition, concerns of disease associated with an abundant deer population living so closely with humans (e.g. bovine tuberculosis, Lyme disease) also arise.

Perhaps the most challenging aspect of deer management is the issue of how to deal with deer in urban and suburban areas where use of lethal control as a management tool has been unavailable. In most cases, community leaders must work together with stakeholders to gain acceptance of these highly effective, lethal techniques and utilize them in conjunction with a variety of non-lethal techniques to successfully reduce human-deer conflicts in these urban-suburban areas.

Urban/Suburban Deer Management Techniques

A variety of deer management tools, both lethal and non-lethal are available. Lethal tools are more effective than others but may be unacceptable in areas where social or safety concerns are an issue. Applying a combination of several techniques specifically tailored for each situation should prove to be more successful than utilizing a single tool.

Non-Lethal Deer Management Techniques

Non-lethal management techniques are generally well accepted by the public. However, limited effectiveness and high cost may prevent success when used exclusively to resolve human-deer conflicts. Non-lethal techniques are best used to supplement, not replace, deer population management.

<u>Habitat modification</u>-Deer are highly adaptable and will use a variety of landscapes, shunning only those areas that are devoid of cover. Removing woodlots and large patches of vegetation may cause deer to relocate. Suburbanites generally enjoy surroundings that

are landscaped or provide mixed vegetative cover; habitat modifications to discourage deer presence are rarely practical or acceptable to area residents.

Ban on deer feeding-Many people enjoy feeding deer in urban/suburban areas to increase viewing opportunities. This may attract deer to unwanted areas, especially during winter months. Feeding deer can also lead to crowding and increased potential for disease transmission. Inappropriate feeding locations can induce deer to cross roads, increasing the potential of vehicle accidents. The feeding of deer is prohibited in Michigan's LP.

Unpalatable landscape plants-While deer feed readily on a variety of plants, some varieties are less palatable than others. Careful plant selection for home and business landscapes, combined with the selective use of repellents may minimize damage due to deer browsing and make areas less attractive to deer. (Burroughs and Dudek 2008)

Repellants-Repellants are commonly used to reduce a plant's attractiveness and palatability to browsing deer. Use of repellants is often expensive and effects are temporary. Repellants work best in small orchards, gardens and on ornamental plants when an alterative food source is readily available.

Fencing-Deer proof fencing (10-foot high woven wire) is effective at excluding deer from specific locations to prevent or reduce deer access. Locations where landscape or horticultural damage is an issue are good candidates for fencing as are airports and along roads where deer-vehicle collisions are common.

Hazing and frightening techniques-Hazing or frightening deer can be an effective method for keeping deer out of specific areas, however, deer can quickly become accustomed to these techniques over time unless a variety of methods are used. Pyrotechnics, propane cannons, and visual, audible and ultrasonic devices triggered manually, by timers, or motion-sensing detectors have all been used effectively to frighten deer.

Dogs as a deterrent-Use of dogs, located within invisible fencing systems has been used effectively to deter deer from damaging crops. Success varies with the size of the area and the number and aggressiveness of the dogs. Dogs with restricted movement, such as on a chain, are not effective.

Approaches for minimizing deer-vehicle collisions-Roadside reflectors, wildlife warning whistles, warning signs, vegetation management, reduced speed limits, and efforts to raise public awareness have all been used to try and decrease the incidence of deer-vehicle collisions without much documented success. Construction of barrier fencing or wildlife overpasses or underpasses may be effective for addressing specific problem areas, but can be expensive to construct.

Trap and translocate-Capturing and moving deer from one area to another is often requested by people opposed to lethal techniques. However, it has been demonstrated to be impractical, stressful to the deer handled, and may result in high post-release mortality

(Beringer et al 2002). In addition, this technique is very expensive. Michigan will not issue a permit to translocate deer due to disease concerns.

Lethal Deer Management Techniques
Lethal deer population management techniques are not always well accepted by some portions of the public. However, when successfully implemented, they can be safe, relatively inexpensive, and highly effective at reducing deer populations.

<u>Controlled hunting</u>- Controlled hunting is the application of legal, regulated deer hunting methods in combination with more stringent controls or restrictions as dictated by landowners or government officials (DeNicola 2000). Regulated hunting has proven to be an ecologically sound, socially beneficial, and fiscally responsible method of managing rural deer populations. However, hunting has limited application in some urban/suburban areas because of safety considerations, competing land-use priorities, legal constraints, or social values (McAninch 1995, Warren 1997). This method, when used in a safe manner, is often the most cost-effective method for managing urban-suburban deer populations.

<u>Sharpshooting</u>- Lethal harvest of deer by sharpshooting through the employment of highly trained, experienced personnel can be a very effective technique. A variety of techniques can be used in sharpshooting programs to maximize safety, humaneness, discretion, and efficiency. This technique, while effective in reducing deer population, is generally more expensive than controlled hunting.

<u>Trap and euthanasia</u>- This method is seldom used, but is an option in areas where lethal techniques have been approved but hunting or sharpshooting are not possible due to safety concerns. It is an inefficient and expensive method as it is difficult to trap deer.

Experimental Deer Management Techniques
<u>Fertility control agents</u>- There has been a significant amount of research focusing on alternative, non-lethal population control techniques. Specifically, researchers have sought an effective, affordable immunocontraceptive that would be useful in areas where traditional hunting methods are not a safe or socially acceptable option. In spite of efforts to develop an effective immunocontraceptive for free ranging deer, such a program simply does not exist. Advances have been made in the methods through which fertility control can be achieved (Killian et al. 2008), but this technology does not overcome the intensive effort involved with treating a substantial proportion of deer to prevent population growth (Rudolph et al. 2000) and assessing deer movements in and out of the area in which management is being applied (Porter et al. 2004). Unfortunately, the lack of public understanding regarding the availability and practicality of fertility control has caused unnecessary delays in the implementation of effective management programs, because fertility control is perceived as the ideal solution (DeNicola 2000).

No Action
Implementing urban/suburban deer management is a difficult, costly, and time consuming undertaking. Communities may be tempted to ignore human-deer conflicts until the problem has escalated and become severe in nature. The eventual cost for taking no

action will likely be much greater than if the problem had been addressed when conflicts first surfaced. Deer populations, as well as frustration levels of residents, may have grown to the point where finding a successful solution becomes very difficult.

Comprehensive Deer Management Strategy

Communities often struggle to agree on which deer management techniques to employ when dealing with human-deer conflicts. Stakeholders often have very different values regarding deer and their impacts on urban/suburban areas. Disagreement and debate over many aspects of urban/suburban deer management including how much damage should be tolerated, which methods are most cost-effective, the ethics and morals of lethal versus non-lethal strategies, etc., can be expected. Solving human-deer conflicts in urban/suburban areas will likely involve changing stakeholder attitudes or behaviors (Decker et al. 1996) as well as modifying deer behavior and population size.

Local communities must identify the need for urban/suburban deer management before the DNR can provide expertise and potential solutions regarding human-deer conflicts. Since outcomes of co-management are usually perceived as more appropriate, efficient, and equitable than more authoritative wildlife management approaches (DeNicola 2000), a community-based task force with the guidance of a professional facilitator is often recommended for dealing with urban/suburban deer issues.

Complexities of suburban deer issues and the current limitations of available techniques make quick-fix solutions unlikely. Resolving conflicts associated with suburban deer often requires an integrated management program including short-term techniques which may relieve immediate problems and long-term approaches designed to maintain deer populations at target levels. Combining two or more techniques into a comprehensive deer management strategy may improve results and increase the acceptability of the program for a wider range of stakeholders (DeNicola 2000).

Economic Impacts

White-tailed deer are important to the economy of the state of Michigan. The millions of dollars spent by hunters and wildlife viewers as they enjoy hunting and viewing deer and the costs associated with deer-vehicle collisions, deer depredation on agricultural, horticultural, ornamental and forestry resources and the threat of disease transmission to livestock and people have far reaching effects on Michigan’s economy.

Hunting and Viewing

Based on the 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation Survey, Michigan’s deer hunters spent more than $710 million in 2006. These costs included money spent on food, lodging, transportation, equipment and licenses. The total economic benefit in 2006 from deer hunting expenditures that “rippled” through state’s economy was over $1.1 billion (Southwick 2007).

Revenues generated from the sale of hunting licenses and a federal excise tax on sporting arms and ammunition support most wildlife programs. More hunting licenses and sporting arms and ammunition are purchased by deer hunters than any other group of hunters (Southwick 2007). Therefore, deer hunters, through their purchase of hunting licenses, sporting arms and ammunition, support a majority of the DNR's wildlife conservation activities. Passage of the 1937 Federal Aid in Wildlife Restoration Act, which placed a federal excise tax on the purchase of sporting arms and ammunition (the Pittman-Robertson Program), was a huge step forward for America's growing wildlife management programs. In Michigan, Pittman-Robertson monies have been and continue to be used for the acquisition and maintenance of state game lands and to fund important wildlife management efforts including planning, population surveys, research, and outreach activities including hunter education programs.

Ninety percent of all hunters in Michigan are deer hunters (Frawley 2004). About 700,000 hunters pursue deer in Michigan each year (Frawley 2009). Michigan deer hunters accrued nearly 9.75 million hunting days in 2007. Over the last decade hunters harvested an average of over 450,000 deer annually. Deer hunting not only contributes millions of hours of outdoor recreation and field activity, but also provided tens of million of pounds of venison for the tables of Michigan households. Deer hunters, given their financial contributions and management assistance through hunting, have a tremendous impact on Michigan's wildlife management programs and in helping the DNR manage deer populations and habitat.

In addition to those individuals that spend money as they participate in deer hunting and deer hunting related activities, there are also many people who enjoy observing deer. These individuals contribute to the economy of Michigan as they spend money in their pursuit of deer watching opportunities. The National Survey of Fishing, Hunting and Wildlife-Associated Recreation estimated that 3.2 million people participated in wildlife-watching activities in Michigan in 2006 – approximately one third of Michigan residents. Activities mostly involve observing, feeding and photographing wildlife. The total economic effect from 2006 watchable wildlife recreation in Michigan was estimated at $1.6 billion (AFWA 2007). Deer are a popular species among wildlife observers (Conover 1997); thus, it is safe to assume that a good portion of those people spent time and money enjoying and observing deer.

Deer-Vehicle Collisions (DVCs)

As deer populations increase and development encroaches upon rural environments, DVCs have become more prevalent. While as many as half of all DVCs go unreported (Marchoux 2005), an estimated 1.5 million of these crashes occur each year on U.S. roads (Insurance Institute for Highway Safety 2005). During 2008, there were 61,010 reported DVCs in Michigan (Michigan Traffic Crash Facts 2008).

Deer Depredation

White-tailed deer are found throughout the state of Michigan at varying population densities and are considered overabundant in some parts of the state. Deer browsing causes significant damage to agricultural crops and ornamental plants in some locations, particularly the southern half of the LP and in the south central portion of the UP. Deer are opportunistic foragers and consume a wide variety of foods. Where agricultural crops and ornamental plants are present, deer have learned to utilize these highly accessible and nutritious food sources even when natural food is available. This adaptation often puts them at odds with their human neighbors as agricultural production and aesthetic values of ornamental plants are reduced.

Agriculture is big business in Michigan with economic impacts that spread throughout the state. In 2007, Michigan's 52,800 farms encompassed over 10 million acres and produced a net farm income of $1.53 billion. Michigan ranks 19th nationally in total cash receipts for agricultural products and is the leading producer of crops such as dry beans, blueberries, cherries, cucumbers and bedding and garden plants in the U.S. (USDA National Agricultural Statistics Service 2008).

Damage to agricultural crops occurs in every county in Michigan but, not surprisingly, occurs more frequently and intensively in areas where deer populations are high and agricultural crops are common. Over the last 30 years, high deer populations and intensive agriculture have become linked in Michigan as the bulk of the state's deer herd has shifted from the northern Michigan woods to the southern Michigan farm country. The abundance of highly nutritious food provided by agricultural crops, combined with the adequate cover found in adjacent woodlots and brushy areas results in ideal deer habitat where reproductive rates are high and natural mortality is low. Deer populations in Michigan are affected primarily by harsh winter conditions, especially in the northern portions of the state, and harvest via recreational hunting. In areas with significant agriculture, deer populations have increased even in the face of harsh winters and intense hunting pressure.

Many field crops can sustain moderate damage from browsing deer and still produce a viable harvest. Wheat and alfalfa can tolerate fairly heavy damage and still produce a decent crop. Corn and soybeans can tolerate some damage at certain stages of growth but for these crops, timing and extent of damage can determine whether plants will produce (MacGowan et al. 2006). Even minor damage to some agricultural products including many fruits and vegetables can completely prevent plants from producing a marketable crop. In addition, tolerance levels of deer damage to crops varies greatly among agricultural producers with some showing remarkable tolerance for damage and others unwilling to sustain any reduction in harvest. Currently, high fuel, fertilizer and commodity prices have farmers paying close attention to crop damage in their fields.

In Michigan's UP, deer crop damage problems are most frequent in the south-central counties of Delta, Dickinson, and Menominee. Deer populations are higher there than in other locations in the UP due to milder winter weather, intensive timber harvesting that creates good winter food sources, and the presence of agriculture as a major land use. Most crop damage complaints received by the DNR pertain to corn, alfalfa, and potatoes, but complaints are also received for oats, barley, soybeans, pumpkins, strawberries, Christmas trees, and silage bags (during winter).

Deer crop damage problems in the NLP are similar to those in the UP. The more southern counties have relatively better soils, longer growing seasons, milder winters and, consequently, more deer and more crop damage complaints. A notable exception is the orchard country, primarily in Grand Traverse, Leelenau, and Benzie Counties. In spite of low deer numbers, significant damage occurs to young cherry trees and any-aged apple trees. Farmland is mixed with recreation land throughout the NLP and conflicting interests in deer protection and deer management objectives are often heard.

The SLP of Michigan provides the majority of the state's farming opportunities and agriculture dominates the landscape. Active farmland makes up greater than 50 percent of rural lands in most counties but is interrupted by forests, swamps and brushy areas that are unfit for farming as well as areas managed for non-agricultural purposes such as recreational hunting or wildlife viewing. This mosaic of farm and forest, combined with fertile soils and moderate climate, provides ideal deer habitat with enough food and cover to support deer populations at very high densities. In addition, winter conditions are more tolerable here with milder temperatures, less snowfall, and shorter winters than in the northern two-thirds of the state. Mortality inflicted by deer hunters and deer-vehicle collisions are the only significant factors limiting deer populations in this part of the state.

The Michigan DNR has attempted to minimize deer damage to crops through a variety of tools. While non-lethal methods including use of fencing, repellents, habitat alteration, dogs, etc. have shown some effectiveness, regulated shooting of deer is generally the most effective method. Liberalized hunting regulations in problem areas and provision of out-of-season shooting permits to affected landowners are tools frequently used to address excessive crop damage. In 2008, the various deer seasons (youth, early antlerless, archery, regular firearm, muzzleloader, and late antlerless) provided up to 100 days in some parts of the state during which hunters could legally harvest antlerless deer. While restrictions on antlerless licenses are placed on individual hunters (a limit of 5 per hunter and no more than 2 for Zones 1 and 2 combined), Deer Management Assistance Permits (DMAPs) are available to eligible landowners. DMAPs allow land owners designated by DNR field staff to purchase additional antlerless licenses. In addition, Deer Damage Control Permits (DDCPs) are available to approved landowners in problem areas. These permits are designed to harvest specific problem deer outside of the hunting seasons and to discourage deer from feeding on crops during the growing season. In 2007, the DDCP program provided 766 permittees with 5,899 out-of-season kill permits resulting in harvest of 3,527 deer in Michigan. Most of this harvest occurs during late summer (July and August) when crops are maturing.

While many landowners have successfully implemented antlerless deer harvest strategies designed to reduce deer populations, deer numbers remain significantly high in many DMUs. Hunter willingness and ability to harvest enough antlerless deer is often insufficient to make an impact on local populations. Farmers are often unwilling to mandate sufficient antlerless harvest strategies to their hunters, and guest hunters often choose to hold out for the big buck and neglect to harvest enough antlerless deer. Many recreational landowners, an increasing percentage of landowners in much of Michigan, do not perceive the need to reduce deer populations and choose not to harvest significant numbers of antlerless deer.

In addition to damage to agricultural crops, foresters in Michigan have identified deer depredation in forests as a serious problem across the state (Cook 2008). Deer browsing on seedlings and saplings is a major concern for the timber industry as deer can clear wooded areas of plants essential to the sustainability of the forest ecosystem. Excessive deer browsing can kill trees or retard their growth, and both scenarios represent economic loss to the timber industry. Further, many tree species that are valuable for commercial purposes including oaks, maples and aspen are preferred by deer, which can accelerate losses in revenue. Comprehensive assessments covering the entire 19 million acre Michigan forest are lacking, however, a large body of research exists for states and regions outside Michigan that has relevance to Michigan ecosystems (Latham et al. 2005, Cote et al. 2004, deCalesta 1994, Healy et al. 1997, Tilghman 1989). Much of this research demonstrates long-term negative impacts on forests (Cook 2008).

White-tailed deer have been identified as key regulators in the forest renewal process primarily through their browsing habits, which differentially alter the relative competitive abilities of young trees. Years of selective browsing by deer can render an understory to a near monoculture of highly resistant or unpalatable species (Sage et al. 2003)

Deer also consume ornamental vegetation found in residential areas and parks. Damage to ornamental plants continues to increase as deer become more accustomed to living in close association with people. This type of damage is generally associated with the following factors: increasing deer abundance, human population shifts to rural and suburban home sites, maturing of abandoned agricultural lands into deer habitat, landowner decisions to prevent deer hunting, and restrictions on firearm use in suburban regions (Burroughs and Dudek 2008). Along with the frustration caused by deer depredation to ornamental plantings, the cost of this damage could be in the thousands of dollars per home site.

Deer damage to ornamental plants often occurs in urban or suburban areas where recreational hunting is not an option. A variety of strategies can be implemented to minimize damage to ornamental plants including use of fencing and deer repellents to protect problem areas, stopping backyard feeding of deer, and the use of less palatable plants for landscaping. However, successful long term strategies likely involve lethal harvest of deer through highly regulated recreational hunting or hiring of sharpshooters. Where lethal harvest is implemented in urban or suburban areas it is critical that community leaders and adjacent business and homeowners are included in all aspects of the planning and implementation of the activity (DeNicola 2000).

Damage to ornamental plants occurs most often during severe winters and in locations where overabundant deer have over-browsed natural food sources. In addition, ornamental plants are often fertilized and irrigated making them especially appealing to deer. Since recreational hunting is not allowed in these areas, car-deer collisions are the only significant source of mortality and deer densities can be very high.

Disease Issues

White-tailed deer can potentially carry and spread diseases to other deer, other wildlife, domestic livestock and to people. Economic loss occurs when agricultural markets are effected (e.g. reduced market for livestock from infected areas, loss of ability to sell agricultural products as deer bait and feed, etc.), agencies commit resources to disease testing and monitoring, and hunting trips are cancelled (due to fewer deer and decreased interest in hunting 'diseased' deer). It has been estimated that due to the presence of bovine Tb, annual costs approaching $10 million in lost livestock sales and $10 million in state and federal funds used to implement increased regulations to manage the disease have been incurred by the people of the state of Michigan.

Ecological Impacts

Deer have the ability to alter their own habitat by over-browsing the very vegetation that sustains them. Over-browsing can result in reduced availability of adequate ground-level vegetation (herbaceous plants, seedlings, saplings, and shrubs) to provide for the immediate food and cover needs of deer. In addition, intense browsing activity can reduce the ability of forest tree seedlings to grow beyond the reach of deer, preventing the forest from regenerating itself and assuring the long-term sustainability of those forest features that support deer. High browsing intensity associated with abundant deer populations has been implicated in regeneration failure of several tree species, such as oaks, eastern hemlock, and white cedar, and modified survival and abundance of herbaceous plants. The complex nature of plant-animal interactions, and the variety of conditions required for the regeneration of some of these species makes a precise characterization of the role of deer herbivory in suppressing regeneration difficult to define. For example, Alverson et al. (1998) attributed the lack of regeneration of eastern hemlock and white cedar to high deer densities in northern Wisconsin and Michigan, although Mladenoff and Stearns (1993) suggest a variety of factors critical to hemlock regeneration may instead be to blame. Deer undoubtedly influence plant species dynamics. However, even where this relationship is intensively studied, site factors (such as soil types, lighting regimes, and the presence of competing vegetation) and time lags between deer population reductions and plant responses complicate the assessment of how deer population management may be conducted in a way to address these impacts (Augustine and Frelich 1998, McShea and Rappole 2000, Sage et al. 2003, Thompson and Sharpe 2005).

In addition to impacts on deer habitat, over-browsing by abundant deer populations can reduce the quality of habitat for other wildlife species. Deer are large herbivores, with the ability to out-compete smaller species for the same resource. Deer have the ability to alter the habitat, potentially denying other species the requisites for survival. There are numerous wildlife species that utilize ground level and mid-story vegetation of forests in Michigan that are negatively impacted by intense deer browsing. Deer also compete directly with turkey, ruffed grouse, squirrels and small mammals for mast.

Bird communities may be strongly influenced by impacts of deer herbivory on understory characteristics, as they are dependent on the structural complexity of habitats (MacArthur and MacArthur 1961, MacArthur et al. 1962). However, McShea and Rappole (1997) concluded that, in forests managed for timber production, logging practices may have a more substantial impact on understory composition and subsequent bird species diversity than browsing by deer. Deer herbivory may be more likely to reduce bird populations in unmanaged forests. Such areas generally display smaller-scale impacts (e.g. treefalls) on understory composition (Runkle 1982), and deer have been shown to prevent regeneration in such smaller mosaics of disturbance (Veblen et al. 1989).

Deer browsing impacts on natural communities can be significant. By foraging selectively, deer affect the growth and survival of many herb, shrub and tree species, modifying patterns of relative abundance and vegetation dynamics. Cascading effects on other species extend to insects, birds and other mammals. Impacts on rare plants, animals and communities are of special concern as years of over-browsing can threaten viability of local populations. In forests, sustained overbrowsing reduces plant cover and diversity, alters nutrient and carbon cycling, and redirects succession to shift future overstory composition (Cote et al. 2004).

Literature Cited

Alverson, W. S. 1998. Forests too deer: edge effects in northern Wisconsin. Conservation Biology 2:348-358.

Augustine, D. J., and L. E. Frelich. 1998. Effects of white-tailed deer on populations of an understory forb in fragmented deciduous forests. Conservation Biology 12:995–1004.

Baker, R.H. 1983. Michigan Mammals. Michigan State University Press. East Lansing, MI. 642 pp.

Bennett, L. J., P. F. English, and R. McCain. 1940. A study of deer populations by use of pellet-group counts. Journal of Wildlife Management 4:398-403.

Beringer, J., L. P. Hansen, and O. Sexton. 1998. Detection rates of white-tailed deer with a helicopter over snow. Wildlife Society Bulletin 26:24-28.

Beringer, J., L. P. Hanson, J. A. Demand, J. Sartwell, M. Wallendorf, and R. Mange. 2002. Efficiency of Translocation to Control Urban Deer in Missouri: Cost, Efficiency, and Outcome Wildlife Society Bulletin, 2002, 30(3):767-774.

Brown, R.N. and E.C. Burgess. 2001. Lyme borreliosis. In Infectious diseases of wild Mammals. ed. E.S. Williams and I.K. Barker. Iowa State University Press, Ames, Iowa. pp. 435-454.

Burroughs, J. P. and T. A. Dudek. 2008. “Deer-Resistant” Plants for Homeowners. Extension Bulletin E-3042, Michigan State University.

Chadwick, S. B. 2002. Automating a winter severity index for Michigan wildlife. Michigan Department of Natural Resources, Wildlife Division Report 3375, Lansing, Michigan, USA.

Collier, B. A., S. S. Ditchkoff, J. B. Raglin, and J. M. Smith. 2007. Detection probability and sources of variation in white-tailed deer spotlight surveys. Journal of Wildlife Management 71:277-281.

Conover, M. R. 1997. Monetary and intangible valuation of deer in the United States. Wildlife Society Bulletin 25:298–305.

Cook, B. 2008. Forester perceptions of deer depredation on the forests of Michigan. Michigan Society of American Foresters.

Corner, L. A. L. 2006. The role of wild animal populations in the epidemiology of tuberculosis in domestic animals: How to assess the risk. Veterinary Microbiology 112:303-312.

Cote, S.D., T. P. Rooney, J. P. Trembley, C. Dussault, and D.M. Waller. 2004. Ecological impacts of deer over abundance. Annual Review of Ecology, Evolution, and Systematics. 35:113-147.

Cook, S. L. 2001. An evaluation of the Michigan Department of Natural Resources' white-tailed deer field survey methodologies. Thesis, Michigan State University, East Lansing, USA.

Creed, W. A., F. Haberland, B. E. Kohn, and K. R. McCaffery. 1984. Harvest management: the Wisconsin experience. Pages 243-260 in: L. K. Halls, editor. White-tailed deer ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Curtis, R. L., Jr., H. S. Mosby, and C. T. Cushwa. 1972. The influence of weather on hunter-deer contacts in Western Virginia. Transactions of the North American Wildlife and Natural Resource Conference 37:282-285.

deCalesta, D. S. 1994. Impact of white-tailed deer on songbirds within managed forests in Pennsylvania. Journal of Wildlife Management 58: 771-781.

deCalesta, D. S. 1997. Deer and ecosystem management. Pages 267-279 in: W. J. McShea, H. B. Underwood, and J. H. Rappole, editors. The science of overabundance: deer ecology and population management. Smithsonian Institution Press, Washington, D.C., USA.

Decker, D. J., C. C. Krueger, R. A. Baer, Jr., B. A. Knuth, and M. E. Richmond. 1996. From clients to stakeholders: a philosophical shift for fish and wildlife management. *Human Dimensions of Wildlife* 1:70-82.

DeNicola, A.J., K.C. VerCauteren, P.D. Curtis, and S.E. Hygnstrom. 2000. Managing White-Tailed Deer in Suburban Environments: A Technical Guide. Northeast Wildlife Damage Cooperative.

Downing, R. L., E. D. Michael, and R. J. Poux, Jr. 1977. Accuracy of sex and age ratio counts of white-tailed deer. Journal of Wildlife Management 41:709-714.

Eberhardt, L. 1960. Estimation of vital characteristics of Michigan deer herds. Michigan Department of Conservation, Game Division Report 2282, Lansing, Michigan, USA.

Frawley, B.J. 2004. Demographics, recruitment, and retention of Michigan hunters. Michigan Department of Natural Resources, Wildlife Report 3426, Lansing, Michigan, USA.

Frawley, B. J. 2009. Michigan Deer Harvest Survey Report 2008 Seasons, Wildlife Division Report 3499, Michigan Department of Natural Resources, Lansing, Michigan, USA.

Frawley B. J. and B. Rudolph 2008. 2006 Deer Hunter Opinion Survey, Wildlife Division Report 3482, Michigan Department of Natural Resources, Lansing, USA.

Garner, M. S. 2001. Movement patterns and behavior at winter feeding and fall baiting stations in a population of white-tailed deer infected with Bovine Tuberculosis in the northeastern Lower Peninsula of Michigan. Dissertation, Michigan State University, East Lansing, USA.

Gross, J. E., M. W. Miller. 2001. Chronic wasting disease in mule deer: disease dynamics and control. Journal of Wildlife Management 65:205-215.

Hansen, K. M. M. 1998. Integration of archery white-tailed deer harvest data into a sex-age-kill population model. Thesis, Michigan State University, East Lansing, USA.

Haroldson, B. S., E. P. Wiggers, J. Beringer, L. P. Hansen, and J. B. McAninch. 2003. Evaluation of aerial thermal imaging for detecting white-tailed deer in a deciduous forest environment. Wildlife Society Bulletin 31:1188-1197.

Healy, W. M., D. S. deCalesta, and S. B. Stout. 1997. A research perspective on white-tailed deer overabundance in the northeastern United States. Wildlife Society Bulletin 25: 259-263.

Hickling, G. J. 2002. Dynamics of bovine tuberculosis in wild white-tailed deer in Michigan. Michigan Department of Natural Resources, Wildlife Division Report 3363, Lansing, Michigan, USA.

Hiller, Tim L. 2007. Land-use patterns and population characteristics of white-tailed deer in an agro-forest ecosystem in south central Michigan. Dissertation, Michigan State University, East Lansing, Michigan, USA.

Insurance Institute for Highway Safety. January 3, 2005. Status report 40(1).

Killian, G., D. Wagner, K. Fagerstone, and L. Miller. 2008. Long-term efficacy and reproductive behavior associated with GonaCon use in white-tailed deer (*Odocoileus virginianus*). Pages 240-243 in R. M. Timm and M. B. Madon, editors. Proceedings of the twenty-third vertebrate pest conference. University of California, Davis, USA.

Langenau, E. 1996. The winter of 1995/96: a tough one for white-tailed deer. Michigan Department of Natural Resources, Wildlife Division Report 3251, Lansing, Michigan, USA.

Latham, R. E., J. Beyea, M. Brenner, C.A. Dunn, M.A. Fajvan, R.R. Freed, M. Grund, S.B. Horsely, A.F. Rhoads, and B. P. Shissler. 2005. Managing white-tailed deer in forest habitat from an ecosystem perspective: Pennsylvania Case Study. Report by the Deer

Management Forum for Audubon Pennsylvania and Pennsylvania Habitat Alliance, Harrisburg. 340 pp.

de Lisle, G. W., R. G. Bengis, S. M. Schmitt, and D. J. O'Brien. 2002. Tuberculosis in free-ranging wildlife: detection, diagnosis and management. Revue Scientifique Et Technique De L Office International Des Epizooties 21:317-334.

MacArthur, R. H., and J. W. MacArthur. 1961. On bird species diversity. Ecology 42:594-598.

MacArthur, R. H., J. W. MacArthur, and J. Peer. 1962. On bird species diversity. II. Prediction of bird census from habitat measurements. American Naturalist 96:167-174.

MacGowan, B. J., L. A. Humburg, J. C. Beasley and O. E. Rhodes, Jr. Identification of Wildlife Crop Depredation. Purdue University Cooperative Extension Service, Department of Forestry and Natural Resources, FNR-06-06.

Macnab, J. 1985. Carrying capacity and related slippery shibboleths. Wildlife Society Bulletin 13:403-410.

Maguire, H. F., and C. W. Severinghaus. 1954. Wariness as an influence on age composition of white-tailed deer killed by hunters. New York Fish and Game Journal 1:98-109.

Marcoux, A. 2005. Development of information and education programs to alleviate deer-vehicle collisions. M.S. Thesis. Michigan State University, East Lansing, Michigan, USA.

McAninch J. B., ed. 1995. *Urban Deer: A Manageable Resource?* 1993 Symposium of the North Central Section. St. Louis, Mo.: The Wildlife Society.

McCain, R. 1948. A method for measuring deer range use. Transactions of the North American Wildlife Conference 13:431-441.

McCullough, D. R. 1979. The George Reserve deer herd: population ecology of a k-selected species. University of Michigan Press, Ann Arbor, Michigan, USA.

McCullough, D. R. 1982. Evaluation of night spotlighting as a deer study technique. Journal of Wildlife Management 46:963-973.

McCullough, D. R. 1984. Lessons from the George Reserve, Michigan. Pages 211-242 in: L. K. Halls, editor. White-tailed deer ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

McShea, W. J., and J. H. Rappole. 1997. Herbivores and the ecology of forest understory birds. Pages 298-309 in: W. J. McShea, H. B. Underwood, and J. H. Rappole, editors. The science of overabundance: deer ecology and population management. Smithsonian Institution Press, Washington, D.C., USA.

McShea, W. J., and J. H. Rappole. 2000. Managing the abundance and diversity of breeding bird populations through manipulation of deer populations. Conservation Biology 14:1161–1170.

Mech, L. D., R. E. McRoberts, R. O. Peterson, and R. E. Page. 1987. Relationship of deer and moose populations to previous winters' snow. Journal of Animal Ecology 56:615-627.

Michigan Department of Natural Resources/Department of Agriculture. 2002. Michigan surveillance and response plan for Chronic Wasting Disease of free-ranging and privately-owned/captive cervids. Lansing, MI

Michigan Traffic Crash Facts. 2008. Vehicle-deer Crashes. http://www.michigantrafficcrashfacts.org/

Miller, M. W., H. M. Swanson, L. L. Wolfe, F. G. Quartarone, S. L. Huwer, C. H. Southwick, and P. M. Lukacs. 2008. Lions and Prions and Deer Demise. PLoS ONE 3(12):e4019. doi:10.1371/journal.pone.0004019

Miller, M. W., E. S. Williams, C. W. McCarty, T. R. Spraker, T. J. Kreeger, C. T. Larsen, and E. T. Thorne. 2000. Epizootiology of chronic wasting disease in free-ranging cervids in Colorado and Wyoming. Journal of Wildlife Diseases 36:676-690.

Millspaugh, J. J., M. S. Boyce, D. R. Diefenbach, L. P. Hansen, K. Kammermeyer, and J. R. Skalski. 2007. An Evaluation of the SAK Model as Applied in Wisconsin. Report to Wisconsin Department of Natural Resources.

Minnis, D. L., and R. B. Peyton. 1995. Cultural carrying capacity: modeling a notion. Pages 19-34 in: J. B. McAninch, editor. Urban deer: a manageable resource? Proceedings of the 1993 symposium of the North Central Section, The Wildlife Society. 175 pages.

Mladenoff, D. J., and F. Stearns. 1993. Eastern hemlock regeneration and deer browsing in the Northern Great Lakes region: a re-examination and model simulation. Conservation Biology 7:889-900.

Moen, A. N. 1976. Energy conservation by white-tailed deer in the winter. Ecology 57:192-198.

Morris, R. S., D. U. Pfeiffer, and R. Jackson. 1994. The epidemiology of mycobacterium-bovis infections. Veterinary Microbiology 40:153-177.

O'Brien, D. J., S. M. Schmitt, S. D. Fitzgerald, D. E. Berry, and G. J. Hickling. 2006. Managing the wildlife reservoir of Mycobacterium bovis: The Michigan, USA, experience. Veterinary Microbiology 112:313-323.

O'Brien, D. J., S. M. Schmitt, J. S. Fierke, S. A. Hogle, S. R. Winterstein, T. M. Cooley, W. E. Moritz, K. L. Diegel, S. D. Fitzgerald, D. E. Berry, and J. B. Kaneene. 2002. Epidemiology of Mycobacterium bovis in free-ranging white-tailed deer, Michigan, USA, 1995-2000. Preventive Veterinary Medicine 54:47-63.

O'Connell, A. F. Jr., L. Elyse, and J. Zimmer. 1999. Annotated bibliography of methodologies to census, estimate, and monitor the size of white-tailed deer populations. National Park Service Technical Report NPS/BSO-RNR/NRTR/00-2.

Oreilly, L. M., and C. J. Daborn. 1995. The epidemiology of mycobacterium-bovis infections in animals and man - a review. Tubercle and Lung Disease 76:1-46.

Ozoga, J. J. 1968. Variations in microclimate in a conifer swamp deeryard in northern Michigan. Journal of Wildlife Management 32:574-585.

Ozoga, J. J., and L. W. Gysel. 1972. Response of white-tailed deer to winter weather. Journal of Wildlife Management 36:892-896.

Panken, S. L. 2002. An examination of population-level quality indices as a measure of white-tailed deer condition in Michigan. Thesis, Michigan State University, East Lansing, USA.

Porter, W. F., H. B. Underwood and J. L Woodard. 2004. Movement behavior, dispersal, and the potential for localized management of deer in a suburban environment. Journal of Wildlife Management. 68:247-256.

Pusateri, J. S. 2003. White-tailed deer population characteristics and landscape use patterns in southwestern Lower Michigan. Thesis, Michigan State University, East Lansing, USA.

Roseberry, J. L., and W. D. Klimstra. 1974. Differential vulnerability during a controlled deer harvest. Journal of Wildlife Management 38:499-507.

Rudolph, B. A., W. F. Porter, and H. B. Underwood. 2000. Evaluating immunocontraception for managing suburban white-tailed deer in Irondequoit, New York. Journal of Wildlife Management 64:463–473.

Runkle, J. R. 1982. Patterns of disturbance in some old growth mesic forests of eastern North America. Ecology 63:1533-1546.

Sage, R. W., W. F. Porter, and H. B. Underwood. 2003. Windows of opportunity: white-tailed deer and the dynamics of northern hardwood forests of the northeastern US. Journal for Nature Conservation 10:213–220.

Schmitt, S. M., S. D. Fitzgerald, T. M. Cooley, C. S. Bruning-Fann, L. Sullivan, D. Berry, T. Carlson, R. B. Minnis, J. B. Payeur, and J. Sikarskie. 1997. Bovine tuberculosis in free-ranging white-tailed deer from Michigan. Journal of Wildlife Diseases 33:749-758.

Schmitt, S. M., D. J. O'Brien, C. S. Bruning-Fann, and S. D. Fitzgerald. 2002. Bovine tuberculosis in Michigan wildlife and livestock. Annals of the New York Academy of Sciences 969:262-268.

Schmitt, S. M., T. M. Cooley, S.D. Fitzgerald, S. R. Bolin, A. Lim, S. M. Schaefer, M. Kiupel, R. K. Maes, S. A. Hogle, and D.J. O'Brien. 2007. An outbreak of eastern equine encephalitis virus in free-ranging white-tailed deer in Michigan. Journal of Wildlife Diseases 43: 635-644.

Severinghaus, C. W. 1949. Tooth development and wear as criteria of age in white-tailed deer. Journal of Wildlife Management. 13:195-216.

Sigurdson, C. J. 2008. A prion disease of cervids: Chronic wasting disease. Veterinary Research 39.

Sitar, K. L., S. R. Winterstein, and H. Campa, III. 1998. Comparison of mortality sources for migratory and nonmigratory deer in the northern lower peninsula of Michigan. Michigan Academician 30:17-26.

Sitar, K. L. 1996. Seasonal movements, habitat use patterns, and population dynamics of white-tailed deer (Odocoileus virginianus) in an agricultural region of northern Lower Michigan. Thesis, Michigan State University, East Lansing, Michigan, USA.

Southwick Associates. 2007. Hunting in America: An Economic Engine and Conservation Powerhouse. Produced for the Association of Fish and Wildlife Agencies with funding from Multistate Conservation Grant Program.

Stoll, R. J., Jr., M. W. McClain, J. C. Clem, and T. Plageman. 1991. Accuracy of helicopter counts of white-tailed deer in western Ohio farmland. Wildlife Society Bulletin 19:309-314.

Strickland, M. D., H. J. Harju, K. R. McCaffery, H. W. Miller, L. M. Smith, and R. J. Stoll. 1994. Harvest management. Pages 445-473 in: T. A. Bookhout, editor. Research and management techniques for wildlife and habitats. Fifth edition. The Wildlife Society, Bethesda, Maryland, USA.

Tate, C. M., E.W. Howerth, D. E. Stallknecht, A.B. Allison, J.R. Fisher, and D.G. Mead. 2005. Eastern equine encephalitis in free-ranging white-tailed deer. Journal of Wildlife Diseases 41:241-245.

Telfer, E. S., and J. P. Kelsall. 1984. Adaptation of some large North American mammals for survival in snow. Ecology 65:1828-1834.

Thompson, J. A., and W. E. Sharpe. 2005. Soil fertility, white-tailed deer, and three *Trillium* species: a field study. Northeastern Naturalist 12:379–390.

Thompson, S. K. 1992. Sampling. John Wiley and Sons, New York, USA.

Tilghman, N. G. 1989. Impacts of white-tailed deer on forest regeneration in northwestern Pennsylvania. Journal of Wildlife Management. 53: 524-532.

U.S. Department of Agriculture. National Agricultural Statistics Service. 2008. Census of Agriculture. http://www.nass.usda.gov/census

Van Deelen, T. R., Campa H. R., Hamady M., and Haufler J. 1998. Migration and Seasonal Range Dynamics of Deer Using Adjacent Deeryards in Northern Michigan. The Journal of Wildlife Management 62(1):205-213.

Veblen, T. T., M. mermoz, C. Martin, and E Ramilo. 1989. The effects of exotic deer on forest regeneration and composition in Northern Patagonia. Journal of Applied Ecology 26:711-724.

Verme, L. J. 1968. An index of winter weather severity for northern deer. Journal of Wildlife Management 32:566-574.

Verme, L. J., and J. J. Ozoga. 1971. Influence of winter weather on white-tailed deer in upper Michigan. Michigan Department of Natural Resources, Research and Development Report 237, Lansing, Michigan, USA.

Verme, L. J. 1973. Movements of white-tailed deer in Upper Michigan. Journal of Wildlife Management 37:545-552.

Warren, R. J., ed., 1997. Deer Overabundance. Wildlife Society Bulletin 25(2). Bethesda, Md.: The Wildlife Society.

Whipple, J. D., D. Rollins, and W. H. Schacht. 1994. A field simulation for assessing accuracy of spotlight deer surveys. Wildlife Society Bulletin 22:667-673.

Wilkins, M. J., P. C. Bartlett, B. Frawley, D. J. O'Brien, C. E. Miller, and M. L. Boulton. 2003. Mycobacterium bovis (bovine TB) exposure as a recreational risk for hunters: results of a Michigan Hunter Survey, 2001. International Journal of Tuberculosis and Lung Disease 7:1001-1009.

Wilkins, M. J., J. Meyerson, P. C. Bartlett, S. L. Spieldenner, D. E. Berry, L. B. Mosher, J. B. Kaneene, B. Robinson-Dunn, M. G. Stobierski, and M. L. Boulton. 2008. Human Mycobacterium bovis infection and bovine tuberculosis outbreak, Michigan, 1994-2007. Emerging Infectious Diseases 14:657-660.

Williams, E. S. 2005. Chronic wasting disease. Veterinary Pathology 42:530-549.

Williams, E. S., M. W. Miller, T. J. Kreeger, R. H. Kahn, and E. T. Thorne. 2002. Chronic wasting disease of deer and elk: A review with recommendations for management. Journal of Wildlife Management 66:551-563.

Zagata, M. D., and A. O. Haugen. 1974. Influence of light and weather on observability of Iowa deer. Journal of Wildlife Management 32:220-228.