SURVEYS USED TO MONITOR THE DEER HERD

Many of the recommendations that will be tackled by our group revolve around 'metrics'. What are 'metrics'? With respect to deer, metrics are anything that we can measure that provides information on the state of the deer population relevant to management; the size of the population relative to the capacity of the habitat, the size of the population relative to where stakeholders would like it, and the impact the deer population is having on nature and society. One of the tasks of this group is to provide input on what metrics should be collected in the future. In this section, I will describe the metrics that are currently used, metrics that have been used in the past, and some metrics that could be used in the future to meet the Deer Trustee Report recommendations and improve deer monitoring in Wisconsin.

The recommendations from the DTR that this section pertain to the most are:

- "Involving the public in data collection produces many benefits, including buy-in on management and harvest strategies and cost-efficiencies of data collection."
- "Each field biologist should be required to organize and conduct at least one field necropsy study each year, conducted along with cooperators and volunteers during late winter."
- "Develop a set of metrics to monitor progress towards the DMU goal of increase, stabilizing, or decreasing population density."

HARVEST REGISTRATION

Harvest registration is the most prominent way hunters help collect the data used by the WIDNR to monitor the deer herd. Mandatory, in-person, harvest registration began in 1953 and deer have been registered by management unit of kill since 1959. What do we get from harvest registration and what could we get in the future?

Harvest numbers*

The primary purpose of registration is to quantify deer harvest. Estimating the number of deer harvested is a critical need for population estimation and harvest management. There are currently 626 active deer registration stations spread across the state. Stations collect information on date, county, and deer management unit of kill, as well as whether the deer is antlered or antlerless. Information such as weapon type and age and sex of deer killed (adult buck, adult doe, buck fawn, doe fawn) has also been collected through mandatory registration. Deer sightings by successful hunters have also been collected via registration since 2009.

Age- and sex- structure of the harvest*

Aside from quantifying harvest, the age- and sex-composition of the harvest is estimated from a sample of registered deer. The primary objective of the deer aging survey is to document temporal and spatial variation in 1) adult buck mortality, 2) recruitment, 3) adult sex ratios, and 4) physical condition of herds. Long-term (5 or more years) yearling buck percents provide an estimate of adult buck mortality by unit. Long-term yearling doe percents provide an index to geographic variation in recruitment rates. Annual changes in yearling percents (especially does) reflect changes in recruitment. Ratios of buck and doe yearling percents are used to calculate adult sex ratios. Changes in buck yearling percents may also result from changes in buck harvest rates stemming from changes in hunting regulations, hunting pressure, or harvest selection.

Aging is not done in all units of the state. The survey is normally limited to those stations (113 in 2012) with a high volume of registrations during the opening weekend of the season with the final number of stations being tailored to the number of available personnel. Over 170 personnel, including volunteers, are annually certified and assigned to aging stations. Age information is obtained from 20,000-30,000 hunter-killed deer on an annual basis. Deer are aged at selected registration stations during the first 2 or 3 days of the firearm deer season. Deer are aged by trained observers using tooth wear and replacement criteria.

Physical condition and body measurements

Currently, antlers on yearling and older bucks are recorded as spike, fork (1" fork or more) or short-spike (less than 3" antler) as an index to physical condition.
A number of additional metrics could be obtained from deer at registration stations, including: antler beam diameter and the number of antler points of yearling bucks, dressed weights and hind foot length of yearling and fawns, thickness of fat at the base of the sternum. Except for fat thickness, these are measurements of growth and development, and are related to reproduction and survival, and therefore, population growth. Yearlings and fawns are used because the time period of growth and exposure to environmental variables is well-defined and not complicated by errors in age determination. Many of these metrics have been collected by the WIDNR at certain times and places, as have other state natural resource agencies. Research at the Sandhill

Wildlife Area showed that many of the growth measurements were related to one another, as well as to population growth.

Disease Surveillance

Since the discovery of chronic wasting disease (CWD), check stations have been used for CWD surveillance. The network of registration stations has made for efficient collection of tissues needed for disease sampling.

SUMMER DEER OBSERVATIONS

Since 1960, recorded observations of does and fawns, during July, August, and September and tallied the number of fawns per doe observed. This is an index of deer recruitment and is a function of both reproduction (pregnancy rates and litter sizes) and the early survival of fawns. Beginning to 2010, the DNR discontinued recording observations during July based on recommendations from the SAK Review Committee. Operation Deer Watch was created so the public could be involved in collecting fawn:doe ratio data.

The following link describes Operation Deer Watch in more detail, including survey instructions and reports based on this data.
http://dnr.wi.gov/topic/WildlifeHabitat/summerdeer.html

WINTER SEVERITY INDEX*

The Wisconsin DNR uses a winter severity index (WSI) based on the number of days with a minimum temperature of 0°F or below as a measure of winter air-chill, and the number of days with 18 or more inches of snow on the ground to estimate the snow hazard. These are added together from 1 December through 30 April to obtain the WSI. Days with both a minimum temperature of below 0°F, and with 18 inches or more of snow on the ground add 2 points to the WSI. Winters are considered "mild" if the calculated WSI is less than 50, "moderate" if it is between 50 and 80, "moderately severe" if it is between 80 and 100, and "very severe" if the WSI exceeds 100. The 30-year average is 67. There are currently 42 active WSI stations, all in approximately the northern 1/3 of Wisconsin.

The number of dead deer found in conjunction with pellet surveys between 1965 and 1975 showed a strong direct relationship to the WSI (*Figure 1*). Approximately 10% of the winter population died when the WSI was less than 80, 10 to 15% died when the index was between 80 and 100, and 20% or more died when the index exceeded 100. The most severe losses occurred in winters with at least 9 weeks of 18 or more inches of snow on the ground.

Conversely, fawn production has shown a strong inverse relationship to the WSI when deer densities have been at or below goals (*Figure 2*). Generally, fawn:doe ratios have been about 20% lower after severe winters than after mild ones. Production in years when deer densities were substantially above goals has tended to be lower than predicted based on winter severity.

There also has been a very strong relationship between the WSI and subsequent buck kills (*Figure 3*). Generally, the buck kill has increased around 30% when the WSI was less than 50, remained relatively stable when the WSI was between 80 and 100, and fallen as much as 25% when the WSI greatly exceeded 100. Therefore, the WSI has become an important tool for predicting the status of the next year's population and buck kill in the Northern Forest. An annual report on WSI is published in the *Wisconsin Wildlife Surveys.*

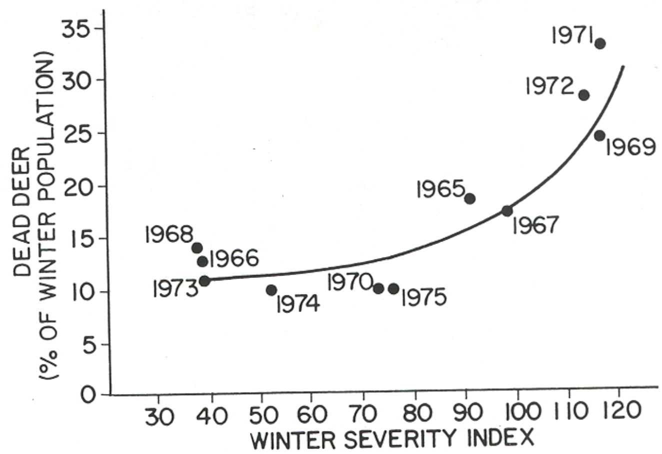

Figure 1. **Relationship between winter deer losses in Northern Wisconsin and the winter severity index, 1965-75.**

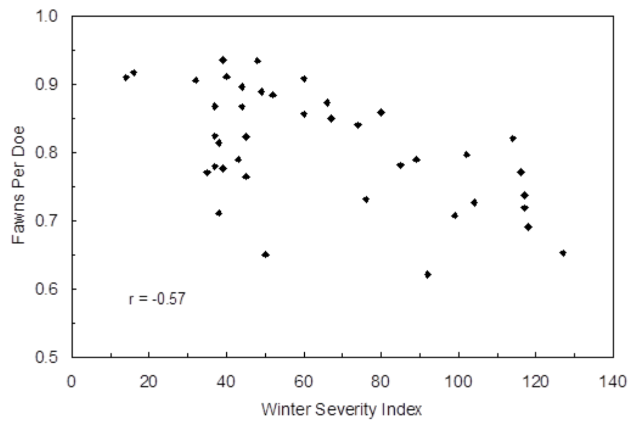

Figure 2. **Relationship between the winter severity index and subsequent fawn production in northern Wisconsin, 1960-2000**

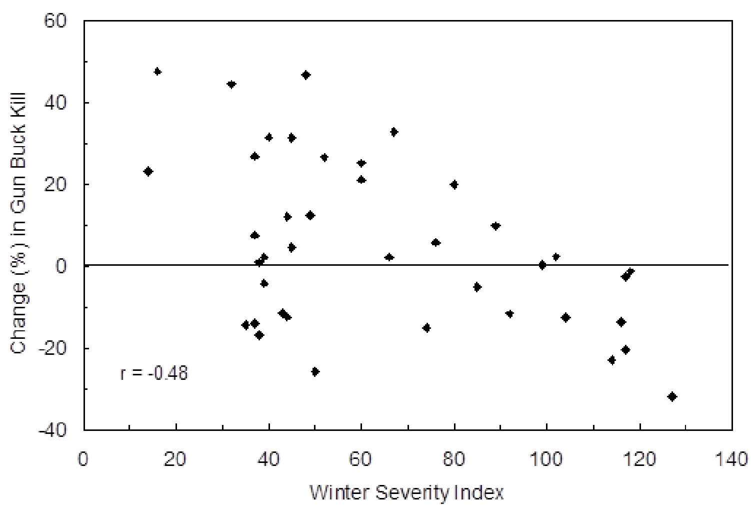

Figure 3. **Relationship between the winter severity index and subsequent change in buck gun harvest in northern Wisconsin, 1960-2000.**

HUNTER PRESSURE POLLS*

Gun deer hunters are queried annually on their gun deer hunting behavior. Hunters are selected at random from the current years' license sales in proportion to license sales for each county. Ten thousand questionnaires are mailed to hunters immediately after the close of the regular 9-day gun deer season. The questionnaires ask specific questions about the days and units in which hunters hunted during the season, attitudes towards season changes or revisions, satisfaction, and confidence in DNR herd estimates. A second mailing of 5,000 questionnaires is made to nonrespondents. The response rate for the 2011 gun deer hunter survey was 31%.

Archery deer hunters are surveyed on their hunting activities every fourth year. Participant's names are randomly drawn from the current year's archery and conservation patron license sales in proportion to license sales in each county. Ten thousand questionnaires are mailed to these people at the close of the archery season. A second mailing is made to 5,000 nonrespondents. Archers are asked to answer specific questions about their bow hunting activity, equipment, technique, and attitude about the season. The response rate for the 2009 archer survey was 49%.

Questionnaire results are presented to the DNR deer committee, wildlife managers, and the public through the *Wisconsin Wildlife Surveys* series and presentations. Results from the survey are used to estimate hunter density on the opening day of the gun deer season for all of the deer management units in the state. These data are important in evaluating hunter exploitation of bucks, and to track changes in hunting effort in the state's deer management units.

The data are also used to collect opinions on changes to season framework, evaluate changes in hunter techniques, measure hunter participation, gather information on hunter demographics, appraise hunter satisfaction, and determine attitudes about the DNR's deer herd estimate, and the hunter's opinions about deer population change. These data then assist in setting the next season's framework and permit levels. Hunter's opinions about population change. Figures 4-8 show time series of some of the survey responses for each deer management region.

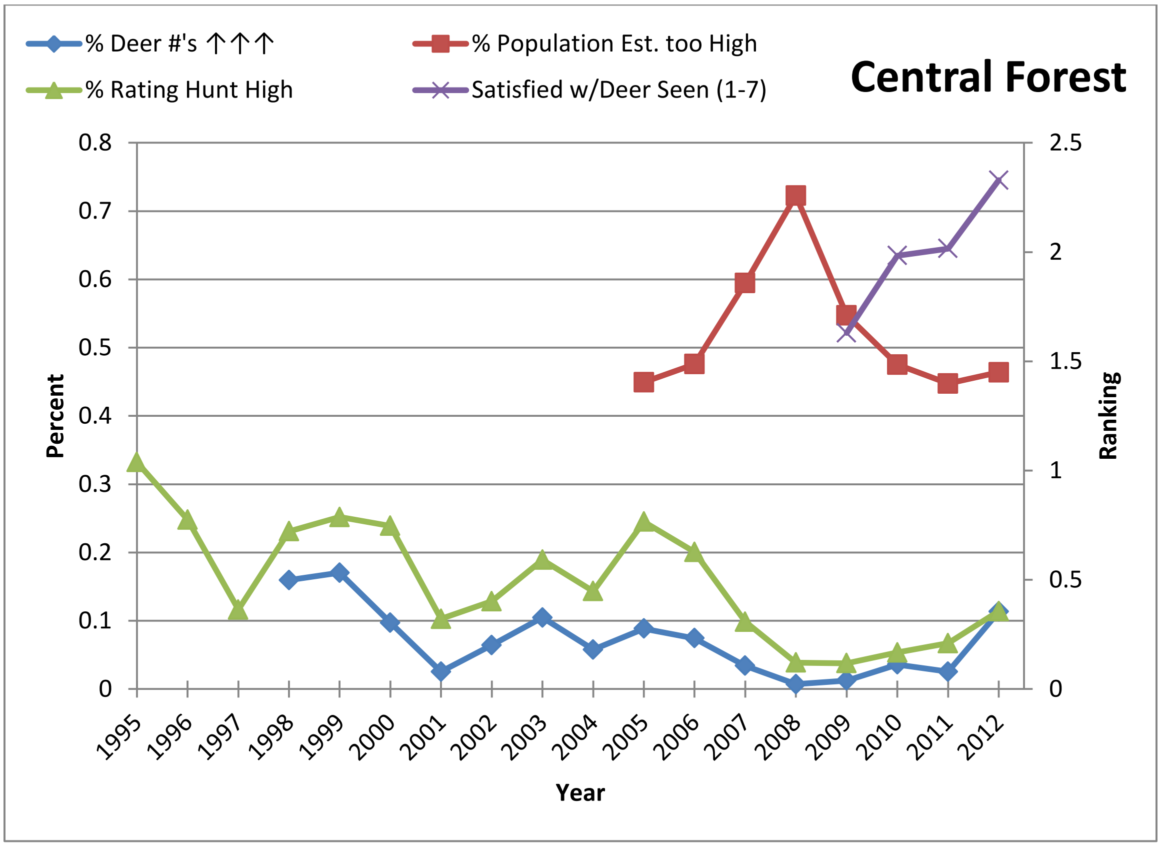

Figure 4. ***Data from the Deer Hunter surveys for the Central Forest region***

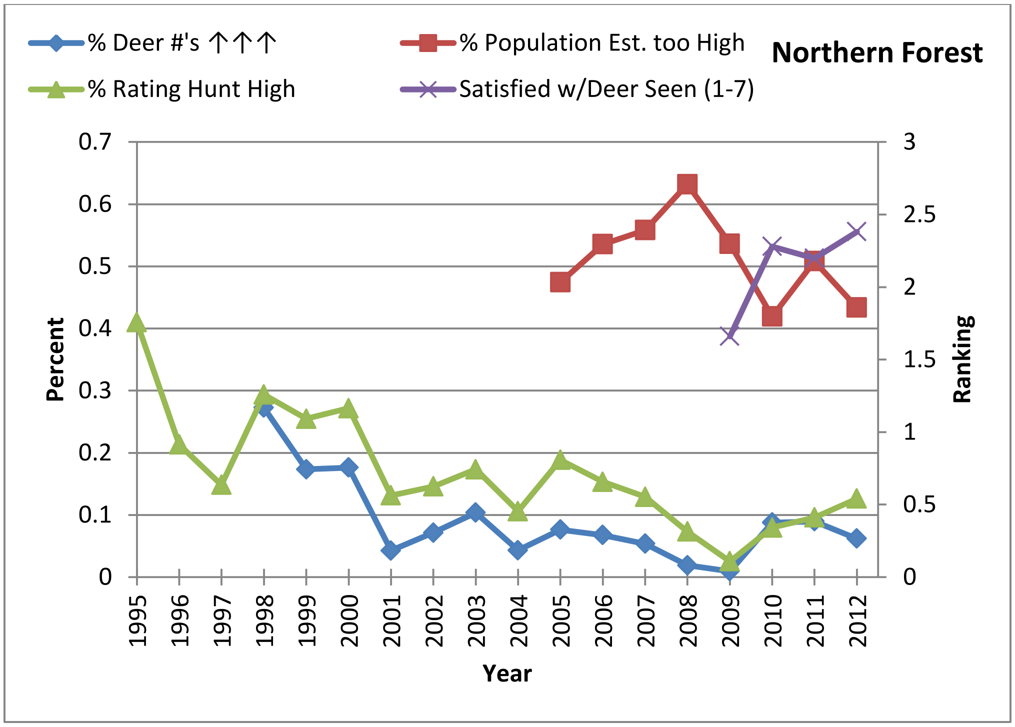

Figure 5. ***Data from the Deer Hunter surveys for the Northern Forest region***

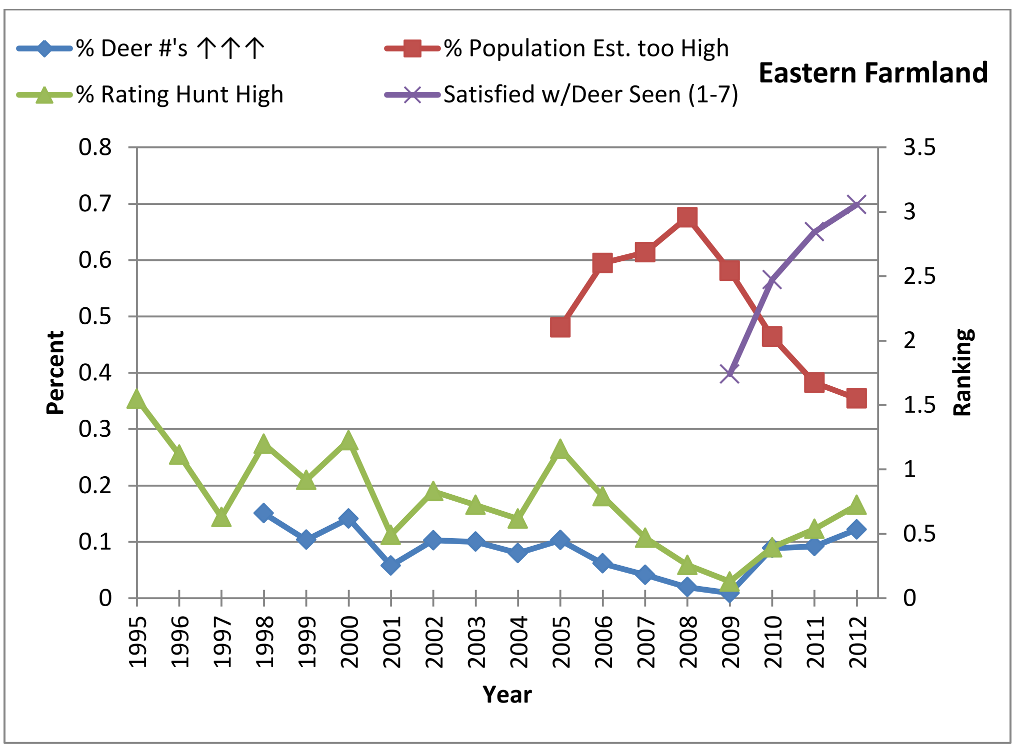

Figure 6. ***Data from the Deer Hunter surveys for the Eastern Farmland region***

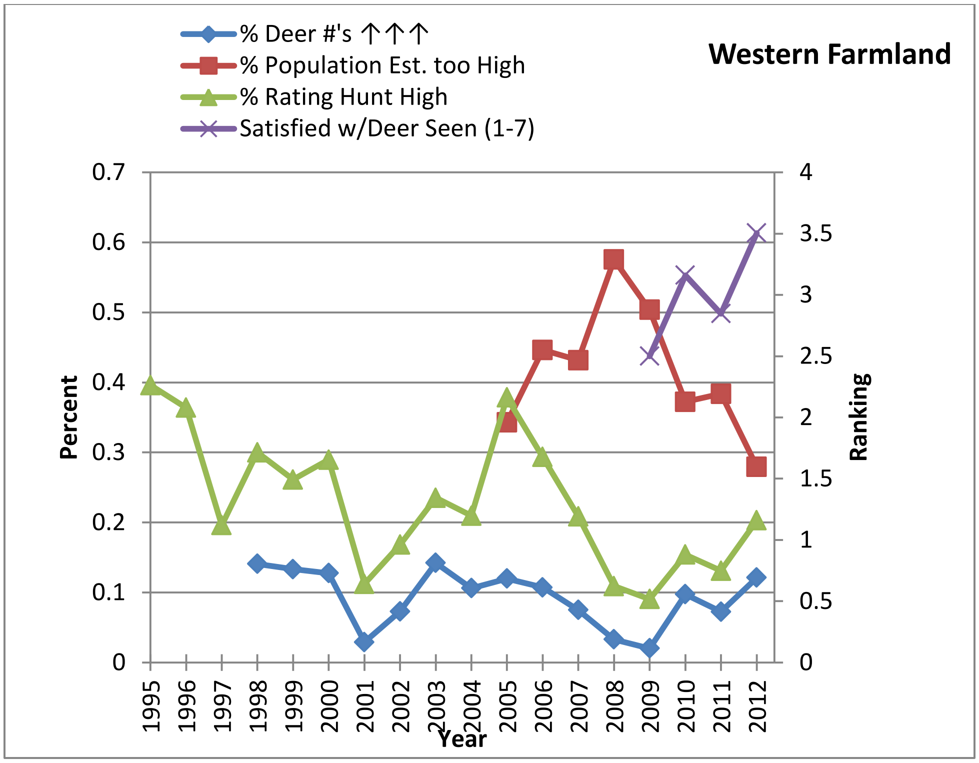

Figure 7. ***Data from the Deer Hunter surveys for the Western Farmland region***

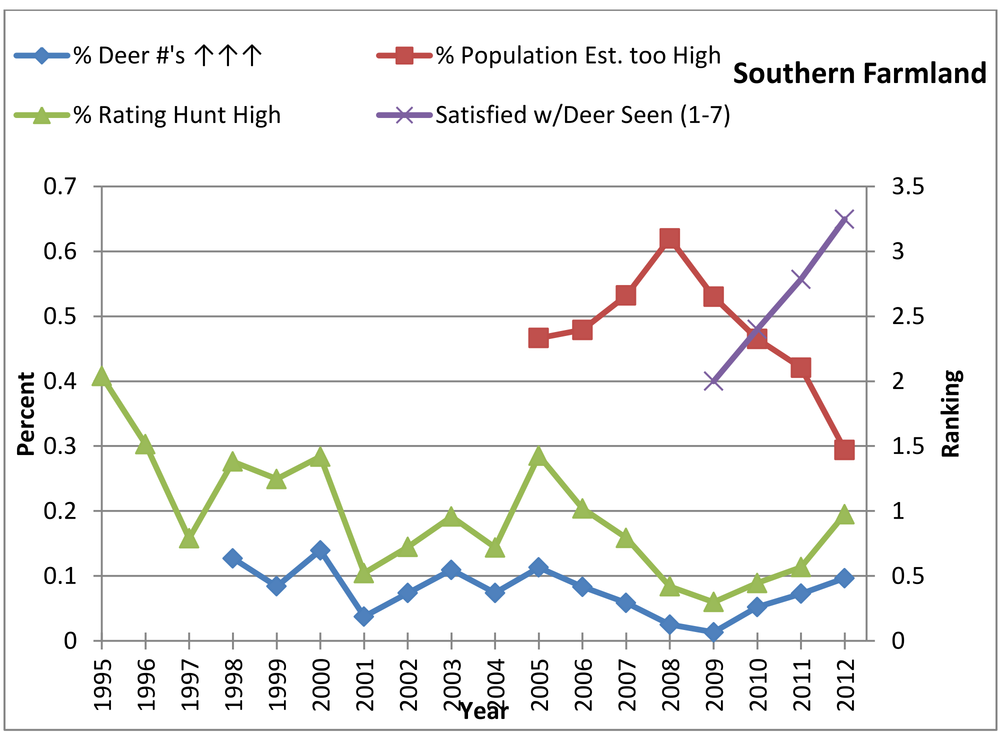

Figure 8. ***Data from the Deer Hunter surveys for the Southern Farmland region***

Reports based on these surveys can be found at :

http://dnr.wi.gov/topic/wildlifeHabitat/reports.html

DEER HUNTER WILDLIFE SURVEY

The deer hunter wildlife survey uses hunter observations of deer and other wildlife as indices to wildlife abundance. Wisconsin deer hunters are asked to voluntarily submit their observations using an online survey form. Figures 9- 13 show time series of deer seen per hour of hunting from submissions of the deer hunter wildlife survey and from observations of successful hunters, for each region.

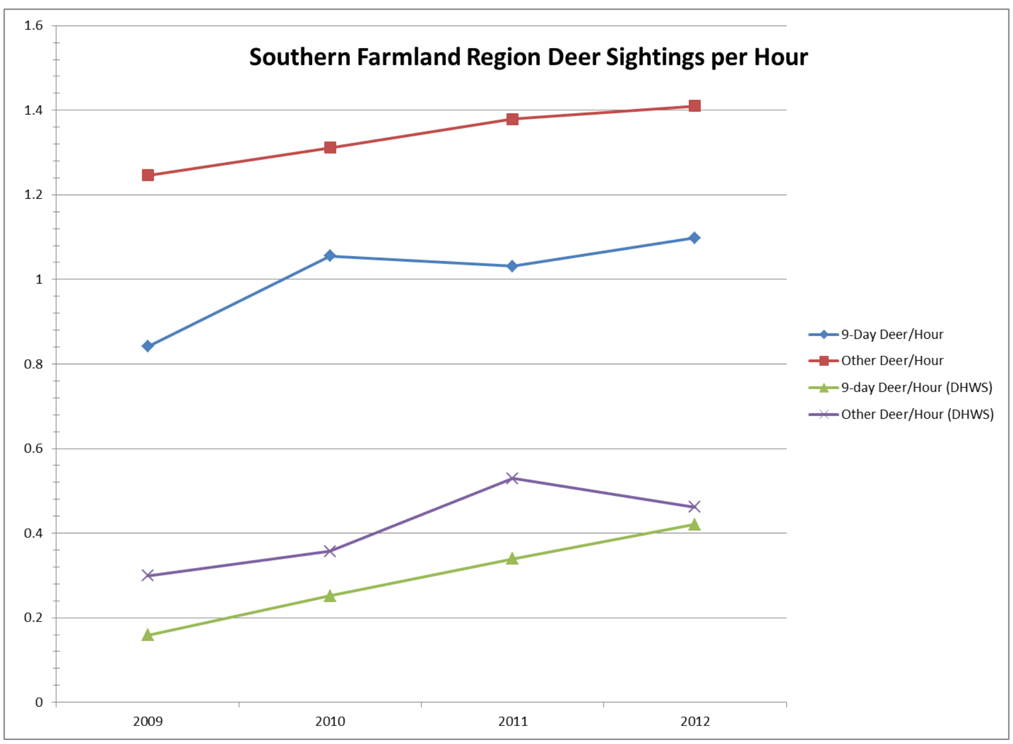

Figure 9. ***Data from the Deer Hunter surveys for the Southern Farmland region***

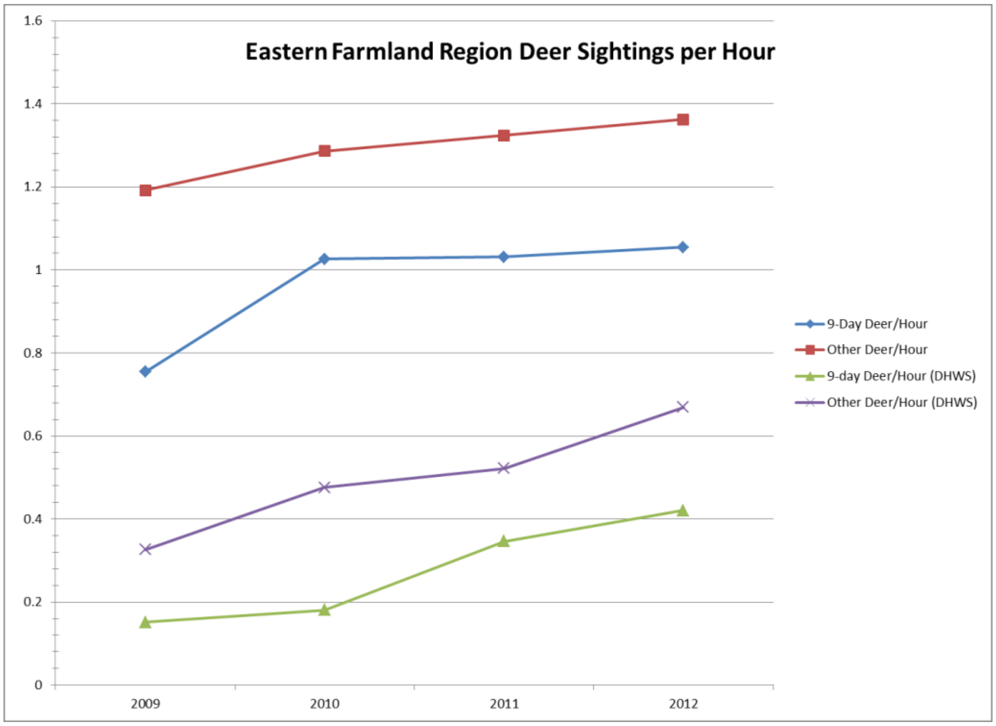

Figure 10. ***Data from the Deer Hunter surveys for the Eastern Farmland region***

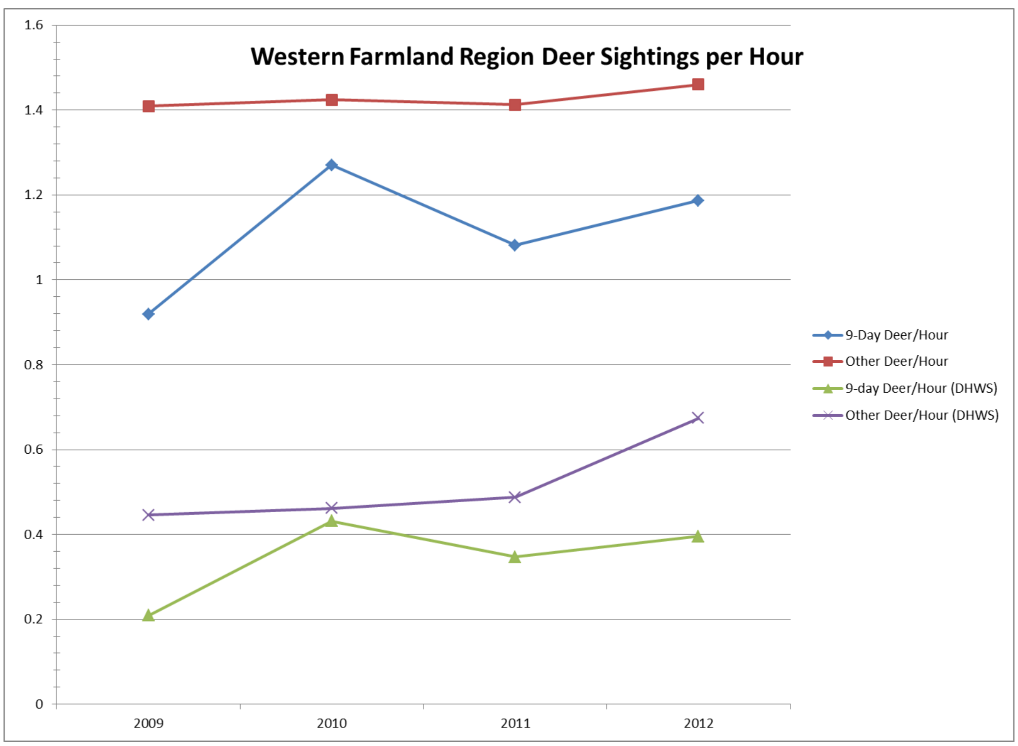

Figure 11. ***Data from the Deer Hunter surveys for the Western Farmland region***

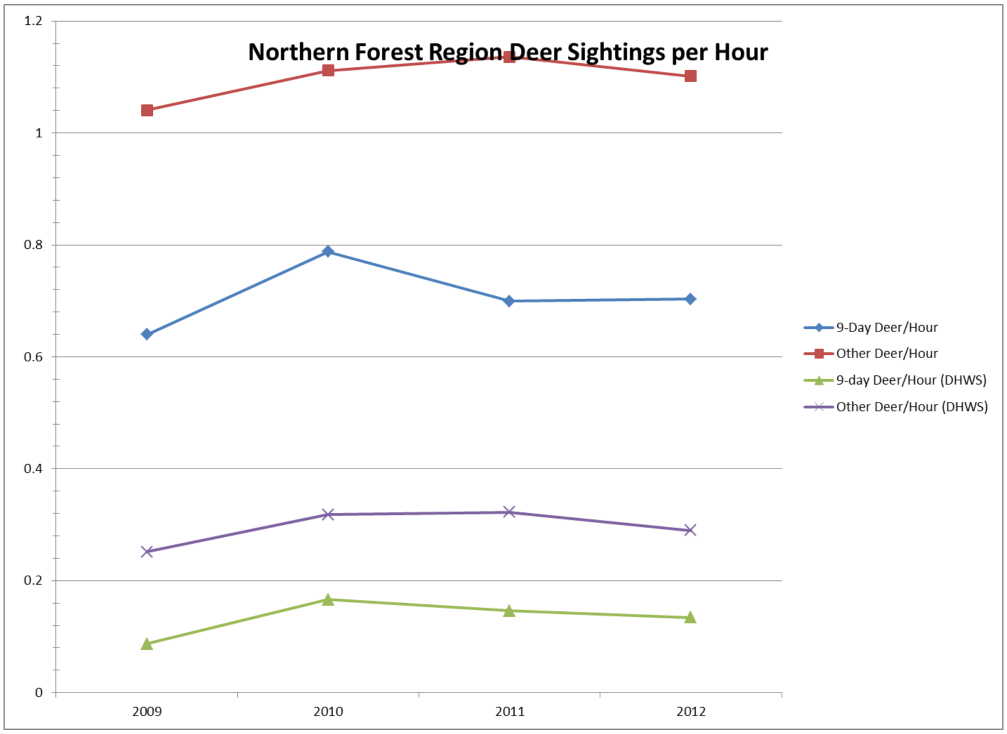

Figure 12. ***Data from the Deer Hunter surveys for the Northern Forest region***

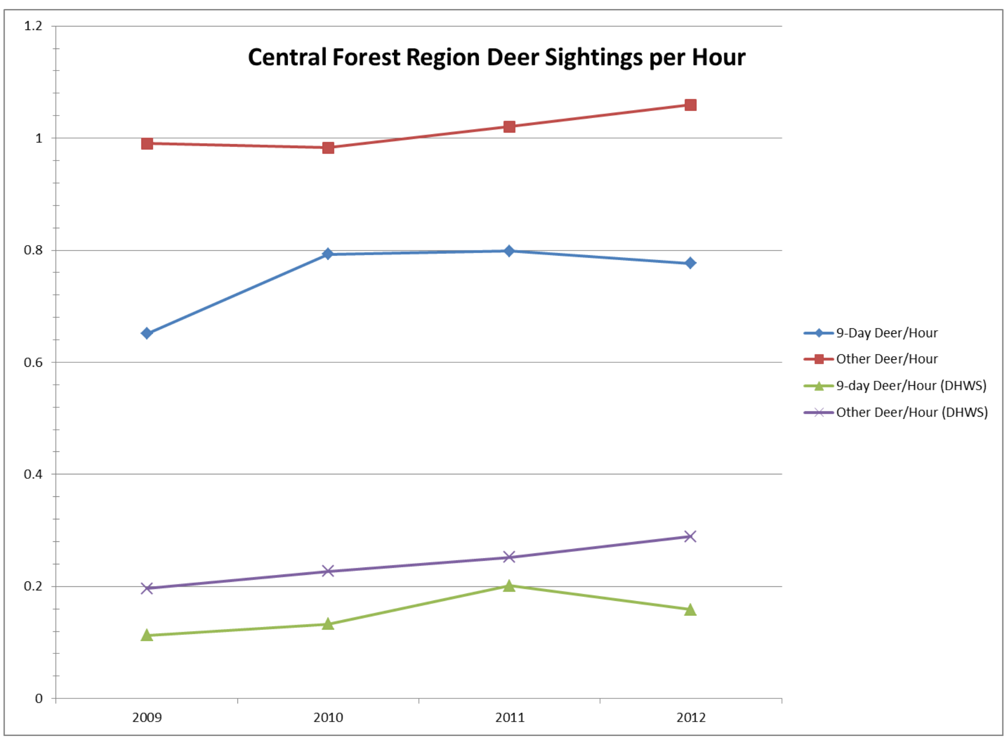

Figure 13. ***Data from the Deer Hunter surveys for the Central Forest region***

AGRICULTURAL DAMAGE

The WIDNR administers a wildlife damage abatement program, in which crop owners enroll to receive assistance. The number of crop owners enrolled and appraised damage is recorded annually at the state, county, and DMU level. In 2011, 644 crop owners received assistance for a total of $1,409,349.72. Damage program reports are found at:

http://dnr.wi.gov/topic/wildlifeHabitat/reports.html

A 2007 landowner survey only 5% of respondents had participated in the program but 44% of landowners report some crop damage, thus program participation in damage abatement programs is an incomplete a measure of damage.

DEER-VEHICLE COLLISION NUMBERS

Interest in alternative and supplemental tools for monitoring deer populations led us to assess the potential for deer-vehicle collision data to serve as a deer population index. In Wisconsin, there are several datasets related to deer-vehicle collisions, including reported vehicle crashes with deer (reports from law enforcement, data managed by the Wisconsin Department of Transportation) and deer carcasses removed from roadways (data managed by the Wisconsin Department of Natural Resources). These datasets were not designed to track deer populations, so the first step in this process is to simply understand the data: who collects the data, how is it collected, what influences data collection? An important feature of a population index is that it is collected the same way every year and every place. If data collection is not consistent, then we cannot be sure if changes in the numbers of deer-vehicle collisions are real or caused by changes in data collection procedures. For example, we found that sheriff departments vary tremendously in their policies for responding to deer-vehicle collisions and that some departments have changed their policies over time. This is an example of inconsistency in data collection that greatly complicates interpretation of deer-vehicle collision data. We also found inconsistency in the deer-carcass removal data. Most contractors are paid a flat fee on a monthly basis, however some contractors were occasionally paid per-deer instead. Large increases and decreases in the number of carcasses picked up by contractors coincided with changes in how contractors were paid (*Figure 4*). Possibly due to inconsistent data collection, correlations between deer-vehicle collision data and deer population estimates and buck harvest are weak or non-existent. In addition, the number of carcasses collected (adjusted for traffic volume) was poorly correlated to the proportion of reported accidents caused by collision with deer in most counties. It may seem intuitive that year-to-year changes in deer-vehicle collisions will reflect changes in deer abundance, however inconsistencies in data collection reduce the value of this data for purposes of monitoring deer populations.

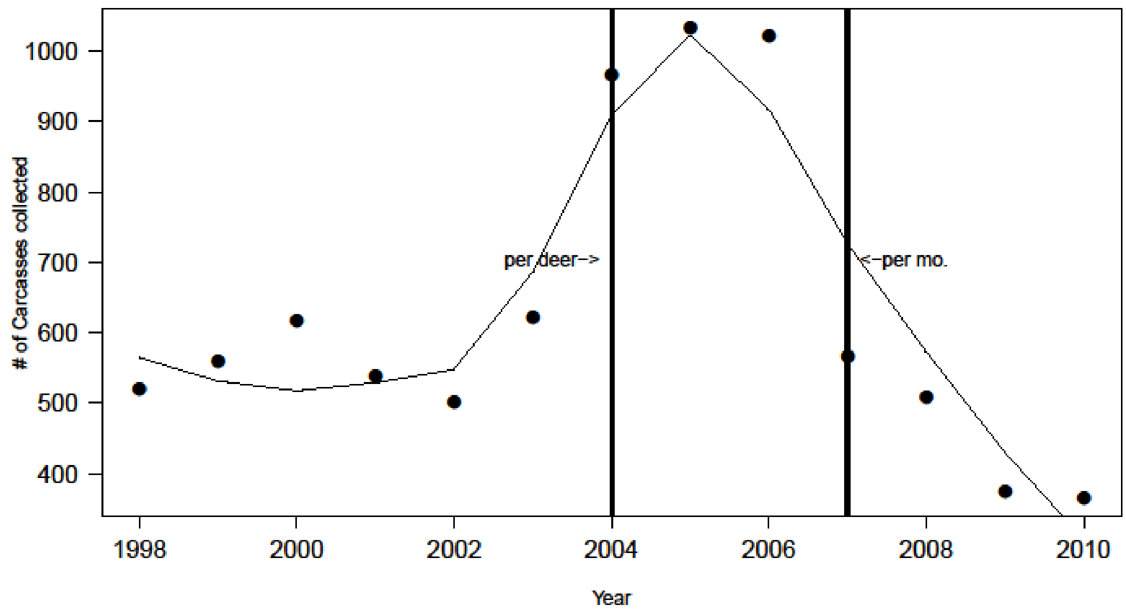

Figure 4. Number of deer carcasses collected by paid contractor from roadways from a county in Wisconsin, 1998-2010. From 2004-2006, the contractor was paid per deer picked up; the contractor was paid a flat fee during all other years.

REPRODUCTION AND NUTRITION FROM CAR-KILLED DEER

Many of the most relevant metrics can be taken from the deer themselves, and carcasses of car-killed deer are a ready source of numerous metrics, including reproduction, physical growth, and nutritional condition. In response to the Deer Trustee Report, we have initiated research on using car-killed deer to obtain metrics (described below). Metrics are informative if they relate deer demographics to habitat productivity, weather, and forage competition (deer density) and have predictable effects on rate of population change. The relationships described below are generalizations, based on extensive research on large mammals across the globe. By instituting our own monitoring effort, we will be able to quantify how the concepts described below relate specifically to white-tailed deer in Wisconsin. Increased understanding in this area will improve our ability to predict population change and set doe harvest quotas.

Reproduction (age-specific pregnancy rates and litter size)

During the 1980's, researchers in Wisconsin estimated reproduction using car-killed does. They found that age-specific reproduction (especially pregnancy rates of fawns) was lower in the northern forest region of Wisconsin than in other regions. This study provided valuable information on regional and age-specific variation in reproduction, however, not variation through time. Gathering adequate samples each year, over a number of years, is necessary to determine temporal variation and the impact of weather variables on reproduction.

In general, variation in reproduction of fawns and yearlings (especially fawns) is one of the demographic components that vary the most from year-to-year and place-to-place. Reproduction in prime-age adults is less variable; however it is thought to be more variable than adult survival. Reproduction is determined mostly by nutritional condition and body size at the start of rut. It is related to deer density, weather, and habitat productivity, and thus is an ideal metric.

Nutritional condition

Nutritional condition is another metric that relates deer density and environmental conditions to deer demographics. A downside of the reproduction metric is that it is not related to the severity of the winter in which it is measured (unless abortion or fetal absorption is common). However, fawn:doe ratios (our measure of recruitment) are related to the winter severity of the preceding winter. This means that a portion of the variation in recruitment comes not from reproduction, but from pre-weaning survival of fawns. Fawn survival is highly variable and sensitive to environmental variation. Fawn survival studies are usually restricted to small areas and short time frames, due to cost constraints. Pre-weaning survival of fawns is related to the nutritional condition of dams, which is related to winter severity, other weather variables, habitat productivity, and deer density. We can monitor nutritional condition of dams by assessing the fat reserves of car-killed dams. Thus by monitoring nutritional condition of deer, we can learn about the drivers of deer population growth.

Weight of deer fetuses

When car-killed dams are examined, we can weigh fawns (provided decomposition is minimal). One of the mechanisms through which maternal condition affects fawn survival is through birth weight; heavier fawns tend to have higher survival. Fetal growth is related to the nutritional condition of the dam during gestation. Thus by weighing fawns, we can increase our understanding of the mechanisms which underlie variation in deer recruitment

Physical growth

Physical growth metrics could include body length and length of the hind foot. Body size is important because it is related to reproduction and survival throughout life. Growth and body size depend on energy intake and expenditure, especially during gestation and early life. Thus like the other metrics, they are related to deer density and environmental variation. The dependence of growth on environmental conditions leads to so-called ‘cohort effects’, where conditions during development can have long-lasting effects on deer demographics. For instance, deer born following an especially harsh winter are expected to produce fewer offspring over the course of their lives than deer born following comparatively mild winters.

METRICS FOR MONITORING DEER IMPACTS ON PLANT COMMUNITIES

Deer impacts on plant communities can be evaluated by using woody seedlings, non-woody (herbaceous) plant communities and in optimum cases, both. Woody plant metrics include, 1) a simple count of seedling presence by species, 2) seedling height, and 3) the proportion of total stems browsed. In many cases, highly-palatable (easy to digest, high nutrient value) plants will be present in adequate numbers, but when height and percent browsed data are additionally analyzed, important context can be obtained, e.g. seedlings whose height is less than average snow depth show little browse while seedlings above average snow depth have severe browse damage. Large forest inventory databases like Forest Inventory Analysis or Wisconsin's continuous forest inventory will measure the proportion of woody seedlings browsed < 1.5m (~5 ft.) in height and categorize the level of deer browse damage to either; no browse, 1-25%, 26-50% or 51-75%, >75% stem browsed. In Wisconsin's northern hardwood forests, sugar maple browse index is an important and frequently used metric for deer browse analysis. Typically, this index is the proportion of terminal sugar maple twigs that have been browsed. Overall, browse indices have shown to be fairly robust when compared to ungulate abundance or density.

Measures of the herbaceous plant community can also provide relevant information regarding the level of deer browse intensity. The abundance of highly palatable plants such as varieties of Trillium, Canada mayflower, blue-bead lily or Indian cucumber may indicate lower browse stress, while the abundance of unpalatable species such as bracken fern, Pennsylvania sedge, jack-in-the-pulpit or mayapple may indicate high browse stress. Specific measures on a palatable plant can provide more in-depth information regarding browse intensity. Research has shown that *Trillium grandiflorum* height is a strong indicator of deer browse intensity. Other research shows that flower scape height on blue-bead lily was also an indicator of browse stress. However measuring species presence or absence may provide a similar index of browse intensity more efficiently than measuring specific features of individual plants.

While absence of highly-palatable plants may indicate intense browsing, other factors may also be at play. Therefore, experimental manipulation is important to separate deer browse from environmental factors like climate, available light and soil moisture. The first experimental manipulation would be to establish a deer-fence exclosure. A fenced exclosure can be constructed with a minimum of five foot high fencing. Even though a deer can jump five foot high fencing, if the fenced area is small enough (e.g. 16 ft. x 16ft.), deer will not typically jump into the area. By observing a fenced deer exclosure over the years, important information about the specific force deer exert in terms of plant diversity, reproduction, and production will be evident. These types of fenced deer exclosures have been utilized by Wisconsin DNR as well as university faculty across Wisconsin for decades. The 2012 Deer Trustee Report recently applauded the use of these types of exclosures and the data gathered from them. A second type of manipulation to explore deer browse intensity is through the use of transplants. This works by transplanting highly-palatable species into an area and monitoring the browsing rates on the transplants.

Overall, there are multiple techniques to measures deer browse intensity and the effects on plant communities. While all of the metrics listed above have been employed by scientists either in the past or currently to investigate deer browse, there is no special equipment needed. An average landowner who can correctly identify plant species and deer browse scars will be able to employ the techniques mentioned. However, it is important to note that rarely does a single group employ all the techniques at once. Choosing the correct metric to use will depend upon the specific question, along with the amount of available resources, mainly time. Whatever metric one chooses to utilize, it is important to have enough repeated measures to have some certainty in the final results.

Quantifying forest effects in relation to deer abundance.

Most of the information that I have provided above or the published articles that I provided links for typically look at relationships between estimated deer abundance and the level of deer browse. The scientific community has shown beyond reasonable doubt that with more deer there is greater browse intensity, though the relationship is not necessarily linear or equal across all species. However, most studies will not and cannot accurately provide a specific deer abundance or density that allows for the sustainable regeneration of forest and herbaceous plants, other than citing an estimated pre-settlement deer population, which is impractical considering current societal values. In order to provide the information needed, deer abundance would need to be quantified and controlled. Likewise long-term vegetation assessments would need to be conducted for enough years to capture changes in perennial species as well as to capture changes in succession. Therefore, to identify the shifts in species or succession over time with a known deer population would require a controlled deer-enclosure experiment. To date there only has been two replicated, controlled white-tailed deer density experiments. The first experiment was located in Western Pennsylvania and the second on Anticosti Island in Canada. With the publication of the 2012 Deer Trustee Report, the WDNR now plans to create and carryout a long-term replicated experiment with four levels of deer density. Our intention is to conduct a thorough investigation of forest regeneration, plant biodiversity as well as small mammal and avian community assessments. The goal of the experiment would be to identify how deer density affects forest regeneration, biodiversity and forest ecosystem processes. Thereby such an experiment could provide data to aid in decision making when trying to choose an appropriate deer density.

Links to research on white-tailed deer impacts on plant resources.

Professor Don Waller from UW-Madison has been studying the effects of deer on plant communities in the Great Lakes Region, specifically Wisconsin for many years. His publications are available on his website below.

http://www.botany.wisc.edu/waller/publications/publications.html

Professor Tom Rooney, a former student of Prof. Don Waller, has numerous publications regarding deer browse, while his website lists his publications it doesn't include links. However, if you contact him directly, he may be able to e-mail a copy of any of his publications.

http://www.wright.edu/~thomas.rooney/publications.html

Professor Steeve Côté from University Lavel in Quebec Canada has written numerous publications regarding deer browsing on plant communities. The work from the Côté lab is mainly based in Canada's northern forests, which is applicable. Publications from Steeve Côté are listed on his website, which also supplies the direct link to the pdf . One publication of Côté that I highly recommend as a broad overview is: Ecological impacts of deer overabundance; Côté, S. D., T. P. Rooney, J.-P. Tremblay, C. Dussault and D. M. Waller. 2004. Annu. Rev. Ecol. Evol. Syst. 35 : 113-147.

http://www.chaireanticosti.ulaval.ca/en/publications/

The USFS Northern Research Station has conducted numerous studies on deer impacts to forest communities, though most of the work is based in Pennsylvania's Allegheny forest. By searching for articles online using "USFS" and "Deer Browse" will yield many results. I have provided links to some articles, though these are not peer-reviewed.

http://www.na.fs.fed.us/fhp/special_interests/white_tailed_deer.pdf

http://www.fs.fed.us/nrs/news/review/review-vol16.pdf

Dr. Alex Royo with the USFS is a lead investigator with the Northern Research Station who specializes in deer browse impacts. His publications are available on his website.

http://www.nrs.fs.fed.us/people/aroyo

The book "The Science of Overabundance; deer ecology and population management" edited by William McShea, H. Brian Underwood and John H. Rappole is terrific and there is a chapter specific to Wisconsin entitled *Deer populations and the widespread failure of hemlock regeneration in Northern forests* by William Alverson and Donald Waller.

Some scientific papers on deer browsing effects and metrics

ANDERSON, R. C. 1994. HEIGHT OF WHITE-FLOWERED TRILLIUM (TRILLIUM-GRANDIFLORUM) AS AN INDEX OF DEER BROWSING INTENSITY. *Ecological Applications,* 4**,** 104-109.

AUGUSTINE, D. J. & FRELICH, L. E. 1998. Effects of white-tailed deer on populations of an understory forb in fragmented deciduous forests. *Conservation Biology,* 12**,** 995-1004.

BALGOOYEN, C. P. & WALLER, D. M. 1995. THE USE OF CLINTONIA-BOREALIS AND OTHER INDICATORS TO GAUGE IMPACTS OF WHITE-

TAILED DEER ON PLANT-COMMUNITIES IN NORTHERN WISCONSIN, USA. *Natural Areas Journal,* 15**,** 308-318.
CHEVRIER, T., SAID, S., WIDMER, O., HAMARD, J. P., SAINT-ANDRIEUX, C. & GAILLARD, J. M. 2012. The oak browsing index correlates linearly with roe deer density: a new indicator for deer management? *European Journal of Wildlife Research,* 58**,** 17-22.
FRERKER, K., SONNIER, G. & WALLER, D. M. 2013. Browsing rates and ratios provide reliable indices of ungulate impacts on forest plant communities. *Forest Ecology and Management,* 291**,** 55-64.
KOH, S., BAZELY, D. R., TANENTZAP, A. J., VOIGT, D. R. & DA SILVA, E. 2010. Trillium grandiflorum height is an indicator of white-tailed deer density at local and regional scales. *Forest Ecology and Management,* 259**,** 1472-1479.
MORELLET, N., GAILLARD, J. M., HEWISON, A. J. M., BALLON, P., BOSCARDIN, Y., DUNCAN, P., KLEIN, F. & MAILLARD, D. 2007. Indicators of ecological change: new tools for managing populations of large herbivores. *Journal of Applied Ecology,* 44**,** 634-643.
ROYO, A. A., STOUT, S. L., DECALESTA, D. S. & PIERSON, T. G. 2010. Restoring forest herb communities through landscape-level deer herd reductions: Is recovery limited by legacy effects? *Biological Conservation,* 143**,** 2425-2434.

SOME ADDITIONAL THOUGHTS ABOUT THE ROLE OF METRICS IN DEER MANAGEMENT

It is worth considering not only which metrics to monitor, but also what role metrics will have in deer harvest management (i.e. DMU goals, antlerless quotas). The trustee report suggested replacement of population estimates and numerical deer population goals, in favor of measures of deer impact on society and nature, population indices, and physical metrics. Indeed, similar recommendations have been made in the scientific literature, based on the rationale that 1) acquiring unbiased and precise population estimates at relevant spatial scales is extremely difficult and costly, 2) what is relevant is not population size per se, but population size relative to carrying capacity. Some researchers suggested monitoring a set of 'ecological indicators', (e.g. physical metrics from harvested deer, habitat impacts) along with a population index (e.g. visual counts). Ideal metrics should respond predictably and sensitively to changes in relative deer density (but not changes in other factors). It is acknowledged that ideal metrics do not necessarily exist, thus they suggest simultaneous monitoring of multiple metrics may be necessary. Metrics are typically easier and less costly to obtain than population estimates. Measures related to social tolerance of deer (e.g. deer-vehicle collisions, agricultural damage, public opinion, etc…) and hunter satisfaction (e.g. permit success, deer seen, satisfaction ratings, etc…) could also be considered. An additional critical feature of metrics is that they are collected at the same spatial scales and time frames that harvest management decisions are made.

The relationship between indices and ecological and social metrics and deer abundance can only be determined through simultaneous estimation of both the metric and deer abundance, thus population estimates cannot be avoided altogether, unless one is comfortable assuming, without verification, that the metrics track changes in abundance. Use of indices has been roundly criticized in the wildlife literature, because of the very fact that they rely on numerous assumptions that are unlikely to be met.

As the end result of any deer monitoring program is informing harvest management, it is critical to have an idea how to adjust harvest to achieve desired response. For instance, say some metric is 20% higher than the stated goal. How many additional deer would need to be harvested in order to achieve that goal? If the metric is deer abundance, the needed deer harvest is easily calculated. If the metric is some ecological or social indicator, the needed harvest is not known. It is possible that the relationship between harvest and subsequent changes in metrics could be determined through time, but as harvest and monitoring occur on an annual basis, this process could take many years. Additionally, large variation in metrics and harvest are required to determine the relationship.

Many states do not estimate deer abundance, which raises the question of whether doing so is necessary. It is unknown whether this strategy leads to successful deer management (i.e. meeting goals) or if it is even possible to assess whether goals are met.

Setting goals based on metrics is sensible because population goals are inherently related to balancing the benefits and detriments of deer populations. However, it is an open question as to whether monitoring only metrics could lead to successful harvest management. Monitoring that includes metrics in conjunction with population estimates is the strategy most likely to result in successful harvest management because population responses to harvest are well-established, and it would allow for the greatest potential for learning about relationships between deer abundance and metrics and using harvest to reach metric goals.

*Content within sections with the * next to the paragraph heading is largely taken directly from ‘Management Workbook for white-tailed deer’, published by the WIDNR in 2001.