Midwest Deer Metrics: What, How and Why We Measure

Robert E. Rolley[1], Daniel J. Storm[1], Kevin B. Wallenfang[1] and Michael J. Tonkovich[2]

[1] Wisconsin Department of Natural Resources, [2] Ohio Department of Natural Resources

INTRODUCTION

Among the core principles of the North American Model of Wildlife Conservation are that wildlife resources are a public trust and science is the proper tool to discharge wildlife policy (Organ et al. 2012). The Public Trust Doctrine holds that certain natural resources, such as water, fish, and wildlife, are held in trust by the government for the benefit of the people (Batcheller et al. 2010, Smith 2011). As managers of the public trust, state wildlife agency professionals are responsible for monitoring populations and harvests; biological and human dimensions research; and public communication, education, and engagement (Smith 2011). Sound management of public trust resources requires decision-makers having access to the best available information about the size of the resource and the potential to grow the resource (Jacobson et al. 2010, Smith 2011). Equitable distribution of the proceeds of the trust to the beneficiaries while maintaining the corpus requires population surveys and research into population dynamics and human dimensions (Organ et al. 2012, Smith 2011).

While state wildlife agencies have common responsibilities for population and harvest monitoring, the methods used vary among states. An understanding of the survey methods used by states is needed to determine whether data can be compared among states (Rupp et al. 2000).

In 1979 the Midwest Deer and Wild Turkey Study Group in cooperation with the North Central Section of The Wildlife Society sponsored a symposium at the Midwest Fish and Wildlife Conference on white-tailed deer population management (Hine and Nehls 1980). The symposium included presentations on deer population estimation, reproduction, harvest estimation, estimation of illegal harvest and non-harvest mortality, and deer impacts on society. These presentations highlighted the various methods used by states in the region to monitor deer demography.

Nearly 20 years after the Midwest symposium, Rolley and McCaffery (1998) resurveyed states in the Midwest about deer monitoring methods. Their focus was on methods used to estimate harvest, population size, and trend; the spatial scale of population monitoring; and assessments of accuracy and precision of monitoring methods.

Our objectives were to update previous assessments of deer monitoring methods to better understand what data Midwest states collect, the methods used to collect these data, and how states use the data to inform management decisions. We broaden our assessment beyond population metrics to include impact metrics in recognition that population size is an incomplete measure of the myriad of public benefits associated with deer resources (Decker et al. 2014).

METHODS

We developed a 9 page questionnaire that asked about what population parameters states measured and methods used to measure those parameters. Parameters assessed included deer harvest size, sex and age composition of the harvest, nutritional condition, population size and trend, reproduction and recruitment, non-harvest mortality, hunter effort and satisfaction, and deer impacts. We inquired as to the spatial scale used to make deer harvest management decisions and the scale used to monitor deer population trends. We also asked whether states had specific performance goals for their deer management programs, how those goals were expressed, who was involved in setting goals, and what data was used in goal setting.

We e-mailed the questionnaire to deer program managers in the 13 states within the Midwest Deer and Wild Turkey Study Group. Multiple follow-up e-mails were sent to deer program managers to ensure a complete response. Additional follow-up e-mails were sent to clarify answers to several questions.

RESULTS

Completed questionnaires were received from deer program managers in all 13 states within the Midwest Deer and Wild Turkey Study Group.

The spatial framework for deer harvest management decisions varies among states in the Midwest. Seven of 13 states use counties as the basis of deer harvest management and 6 states use deer management units (Table 1). The number of management units per state varies from 18 to 128 with a mean of 82 (median = 88). The average size of management units varies from 337 to 4,300 mi^2 and averages 1,237 mi^2 (median = 613). States with fewer, larger units (Kansas, Nebraska, and North Dakota) tend to be western states with lower deer populations and hunter densities.

All states estimate deer harvest size annually. Nine of 13 use electronic mandatory registration (telephone or internet) and 4 (Kansas, Michigan, North Dakota, and South Dakota) use hunter surveys to estimate harvest. Of those states using electronic registration, 5 still maintain some in-person registration stations to facilitate collection of biological samples (including CWD surveillance samples) or for hunter convenience.

In the 4 states that use hunter surveys, the number of questionnaires sent to hunters ranges from 12,800 to 59,000, which represents from 10% to 50% of the hunter population. Response rates vary from 38 to >70%, resulting in sample sizes of 8,100 to approximately 30,000 returned surveys. States with smaller hunter populations sample a higher proportion of hunters in order to estimate harvest with a desired level of precision.

Of the 9 states that estimate harvest with mandatory registration, only 3 reported efforts to estimate compliance (Iowa, Kentucky, and Wisconsin). Iowa reported cross referencing deer that were sampled for CWD against their registration data base. Kentucky has used periodic telephone surveys of hunters conducted by Responsive Management to estimate compliance. Wisconsin used both warden field checks and questions on mail questionnaires to estimate compliance with registration.

Only 8 of 13 states attempt to estimate the sex and age composition of harvested deer beyond categories of adult male, adult female, and fawn (Table 2). In those 8 states, the most widely used method was aging at meat lockers (5 states). Two states reported using mandatory registration stations in some locations or seasons to facilitate classification of harvested deer, 2 used taxidermists, and 2 used hunter-supplied measurements of deer eye-nostril length and/or antler characteristics (beam circumference or inside spread). Missouri indicated they were planning to add hunter submitted measurements in 2016. Michigan reported using voluntary check stations and jaw aging events to age deer. The number of deer annually classified by trained agency personnel varied from fewer than 1,000 to approximately 29,000. Hunter-submitted measurements allowed classification of approximately 150,000 deer into a subset of age classes in Illinois. Most deer aged were associated with firearm season harvests but some bow season harvested deer were aged in a few states.

Approximately half of states responded that they attempt to monitor changes in the nutritional condition of deer populations (Table 3). Parameters measured included pregnancy rates (5 states), yearling antler development (3 states), fat deposits (3 states), lactation rates (1 state), body weight (1 state), serology and parasite load (1 state) and thyroxine levels (1 state). Mandatory and voluntary registration stations and meat lockers facilitated access to hunter harvested yearling bucks for assessment of antler development. Fat deposits and pregnancy rates were mainly assessed in vehicle-killed does in late winter. South Dakota used ultrasound and blood samples to estimate pregnancy rates of does captured for research studies. Kansas reported occasionally using herd condition protocols developed by the Southeast Cooperative Wildlife Disease Study in association with culling operations. Most states assessed nutritional condition on an annual basis, but Ohio only checked pregnancy of vehicle-killed deer periodically. Sample sizes varied widely among states and methods. Larger samples were associated with antler development of hunter harvested yearling bucks.

All states reported using a harvest index to monitor trends in deer population size (Table 4). Eight states also incorporate a measure of hunter effort into a trend index. Deer-vehicle collision data were used by 8 states. Six states reported using aerial surveys in some applications to index deer abundance. The scale of aerial surveys ranged from limited use in a few selected situations to selected management unit surveys to regional surveys. Six states indicated they used hunter, landowner, or staff observation surveys to monitor deer population changes. Hunter surveys usually relied on diaries of bowhunters, but included gun hunter observations in some states. Roadside surveys were used by 4 states, usually using a distance sampling framework. In Illinois, deer were recorded in conjunction with a furbearer survey. South Dakota was evaluating the utility of spotlight-distance sampling surveys in the Black Hills. Other indices of deer abundance used by Midwestern states included agricultural damage complaints and opinion surveys of agency staff, hunters, and production landowners. Kansas reported experimenting with trail cameras to monitor changes in deer abundance. All states reported using more than one index, with a mean of 3.3 methods/state (range 2-5).

Approximately one-half of Midwestern deer program managers indicated that they attempted to estimate deer population size (Table 5). Three states reported currently using accounting models and 2 reported using herd reconstruction techniques (sex-age-kill or Downing methods). Three states responded that they were developing integrated population models. Three states were using or evaluating roadside-distance sampling to estimate deer density and 2 states were estimating density with aerial surveys.

Most states in the Midwest attempt to monitor changes in deer population at the same spatial scale that they use to regulate harvest (e.g., county or deer management unit). The 2 exceptions were Iowa and South Dakota. Iowa reported monitoring deer abundance for 16 multi-county deer management units versus 99 counties and South Dakota had 11 data analysis areas that were aggregates of 81 deer management units.

Eight of 13 Midwestern states monitor changes in deer reproduction or recruitment (Table 6). The most commonly used methods were harvest fawn:doe ratios and winter fetal counts. Three states reported using observation surveys to estimate late summer or fall fawn:doe ratios. In two instances these were opportunistic surveys while in the third case fawn:doe ratios were calculated from data collected during roadside-distance sampling surveys. Additionally, South Dakota reported estimating neonatal survival from radio-collared fawns.

Most states reported some form of monitoring of non-harvest mortality. Ten states indicated recording reported cases of disease mortality, either EHD, CWD or meningeal worm. Five northern states (Michigan, Minnesota, North Dakota, South Dakota, and Wisconsin) reported using a winter-severity index (WSI) to estimate over-winter mortality. Most WSIs incorporated data on temperature and snowfall but the details of each state's WSI varied (e.g., different thresholds or time periods).

Virtually all states in the region monitor parameters associated with hunter participation, effort, and satisfaction (Table 7). Most monitor the number of licenses and/or permits sold, days hunted, and areas hunted, number of deer seen and ratings of hunt quality of hunter satisfaction. Approximately two-thirds of states track hunter's preferences for deer population trends. Mail surveys with or without internet supplementation were the primary method of collecting deer hunter data (Table 8). Frequency of hunter surveys varied from annual to every 5 years. Many states conduct multiple hunter surveys with different frequencies to address different questions. Sample sizes varied widely among states (range 3,000 - 59,000), with larger samples generally associated with states that rely on hunter surveys for estimation of harvest. States with smaller hunter populations generally contact a larger percentage of their hunters to obtain sufficient number of respondents.

All states reported monitoring agricultural damage caused by deer and most monitored deer-vehicle collisions (Table 9). Eight states indicated they conduct annual or periodic surveys of agricultural producers to assess deer damage. Three states indicated they have programs to appraise deer damage, while others indicated they monitor damage reports or permits issued to control damage. Most states (10) that monitor deer-vehicle collisions utilize crash data provided by their departments of transportation or highway safety. Three states reported that they use carcass removal data either in addition to or in place of accident reports. Kansas and South Dakota replied that they have conducted human dimension surveys of citizens to assess the impacts of deer-vehicle collisions. North Dakota previously tracked deer-vehicle collisions but their Department of Transportation discontinued providing these data.

Only 2 states responded that they were monitoring environmental impacts of deer. Illinois replied that some nature preserves were conducting browse surveys and Minnesota indicated using consultations with local biologists and foresters. Wisconsin responded that they were trying to develop an environmental impact metric.

Eleven of 13 Midwestern states responded that they had quantifiable performance goals that guide deer management decisions at the local level (Table 10). Indiana responded that they have a management plan that sets general directions for the program but did not have unit-specific goals. Michigan reported that they do not currently have unit-specific goals because hunters rejected proposed goals approximately 10 years ago.

The ways goals are expressed varies substantially among states (Table 10). Four states expressed goals in terms of desired population trend (increase, decrease, maintain). Minnesota responded that their goals were expressed in terms of population size and trend and Kentucky indicated their goals were expressed as desired population size. Performance goals in Illinois were expressed as a tolerable level of deer-vehicle collisions (accidents per billion miles travelled) and Iowa expressed their goals as a population size similar to that in 1995-1999. Goals in Kansas were expressed in terms of public desires. North Dakota expressed their goals as license sales and hunter success rates. Ohio recently moved from goals expressed in terms of population size to managing deer based on social tolerances of production landowners and hunters.

The frequency that performance goals are updated varies widely among states (Table 10). Iowa has not updated their goals since they were set over 15 years ago and Kentucky has not updated goals since 2005. Wisconsin regularly updates its goals every 3 years, North Dakota every 5 years, and Minnesota every 10 years. Four states reported updating their goals annually as part of their annual antlerless quota setting process.

The goal setting process varied substantially among states (Table 11). In Illinois and Iowa, initial goal proposals were developed by statewide advisory committees. Minnesota has used 15-20 multi-unit advisory committees to develop goal proposals. Wisconsin used 72 county advisory committees. In other states, initial goal proposals were developed by agency staff, usually the deer program staff. North Dakota indicated that initial goal proposals were developed by deer program staff in consultation with field biologists and 8 regional advisory committees. South Dakota reported that goal proposals were developed by regional managers together with local biologists and conservation officers. In most Midwestern states with goals, initial goal proposals received administrative review before being approved by the agency board or commission.

All states with goals reported obtaining input from various stakeholder groups to inform their goal setting process (Table 11). Most states indicated receiving input from hunters and farmers. Other stakeholder groups listed by some states included businesses, conservation organizations, transportation, tourism, Native American tribes, local biologists, foresters, and the general public. Various methods were used to solicit input from stakeholder groups. Eight states reported using human dimension surveys and 5 states received input from advisory committees. Many received input during public meetings, open houses or during public comment periods. South Dakota reported developing a phone app that their managers use to document opinions of the public they contact.

All states that set performance goals reported considering either hunter and farmer attitude data or data on crop damage complaints and hunter demand or success (Table 12). Six states reported that data on deer population trends were considered and six

states indicated that disease data were given consideration. Deer-vehicle crash data was reportedly considered by 4 states. Public input was noted by 4 states and local biologist input was listed by 3 states. Only two states reported considering data on habitat availability, 2 listed reproduction, and 2 states mentioned buck quality.

DISCUSSION

Big game harvest management strategies start with an inventory of the resource (Strickland et al. 1994). Inventory includes identification of spatial management units and estimation of population status within management units. With the exception of 3 states on the western edge of the Midwest region, deer managers are tasked with managing deer populations in 80 to approximately 130 management units. Monitoring deer populations at this scale presents significant challenges (Hanson 2011). Defining management units is always a compromise between the desires for local control of harvests with being large enough to facilitate the long-term collection of data with the needed precision for management decision making (Strickland et al. 1994).

There is no accepted industry standard for deer population monitoring; data collected among states vary widely (Wildlife Management Institute 2016). Our objective was simply to update our understanding what data Midwest states collect, the methods used to collect these data, and how states use the data to inform management decisions. A detailed discussion of the strengths and weaknesses of particular survey methods was beyond the scope of this manuscript, but see Keegan et al (2011) for a review of many of the methods.

All states in the Midwest use multiple indices to monitor trends in deer populations. Reliance on indices has been criticized because the relationship between the index and true population size is often unknown (Anderson 2001). By using multiple indices managers can have greater confidence of detecting true population change if multiple indices are positively correlated. A harvest index was used by all states. Trends in antlered buck harvest are commonly used to index population trends (Hanson 2011, Strickland et al. 1994). In Williamson's (2003) review of deer harvest management in the Northeast, he cautioned that variation associated with buck harvest rates complicates interpretation of a buck harvest index and encouraged managers to incorporate information about effort into their index or, better yet, to seek independent measures of population size.

Deer-vehicle collision data was widely used by states in the Midwest as an index of population trend. Likely, this is due to these data being inexpensive to obtain as they are often provided by other state agencies (e.g., departments of transportation or highway safety). However, because collection of these data are outside of the control of agency biologists, care is needed in interpreting them as variation in collision data may be unrelated to changes in deer population size.

Virtually all states in the Midwest monitor hunter participation, effort and satisfaction and many track number of deer seen and hunter desired population trend. Sample sizes in some states were sufficiently small to preclude estimation at spatial scales used for harvest management (e.g., county or DMU). Some state only measure hunter effort periodically which limits the utility of harvest/effort indices for anything other than long-term monitoring.

Riley et al. (2002) suggested that the essence of wildlife management is the management of wildlife-related impacts, i. e., the significant effects of interactions among humans and wildlife. In addition to monitoring hunter's ratings of hunt quality and satisfaction, all Midwestern states are monitoring negative impacts of agricultural damage and nearly all are tracking deer-vehicle collisions. More than half the states use annual or periodic surveys of agricultural producers to monitor deer damage to crops while the rest rely on tracking damage complaints and/or permits. With a few exceptions, monitoring of deer-vehicle collisions was largely dependent on information received from other state agencies. While this may be convenient for most managers, this leaves them vulnerable to administrative decisions outside of their control, as in the case of North Dakota. Although deer impacts to forests and the environment has received considerable research focus in recent years (e.g., Côté et al. 2004, Frerker et al. 2014. Rawinski 2014, Webster et al. 2005), there is currently limited data on environmental impacts available for deer management decision making at local scales. In the recent review of Minnesota's deer management program, it was recommended that better documentation of deer impacts on habitat be provided for setting population goals (Minnesota Office of the Legislative Auditor 2016).

There was relatively little consistency among Midwestern states in other parameters related to deer population status. About half of states attempt to estimate deer abundance, sex and age of harvest, nutritional condition, and reproduction or recruitment. There was considerable variation in the methods used to monitor these parameters. The number of deer examined for condition assessments were often too low to permit reliable inference at local scales.

The biggest change in Midwestern deer metrics since Rolley and McCaffery (1998) has been the transition from in-person mandatory check stations to mandatory electronic registration of harvested deer. This transition has been driven by concerns over agency expense and inconvenience for hunters (Hansen 2011, Rupp et al. 2000), despite the fact that check stations were recognized for their ability to collect accurate harvest data within short time frames along with facilitating the collection of useful biological data and public relations values (Rupp et al. 2000).

Most deer program managers in Midwestern states who used check stations in 1998 felt that hunter compliance with regulations that mandated registration was high ($\geq$ 90%, Rolley and McCaffery 1998). The transition to electronic registration raises questions about whether compliance rates will be similar between techniques (Hansen et al. 2006). Three states indicated that they have recently attempted to estimate hunter compliance. While the reporting method differed (mandatory report cards), Rosenberry et al. (2004) observed that harvest reporting rates in Pennsylvania varied by type of deer, season segment, year and DMU. They cautioned that reporting rates estimated at the statewide scale may not accurately reflect local reporting rates. The Minnesota Office of Legislative Audit (2016) questioned the assumptions of constant compliance rates across DMUs and years in Minnesota.

Since 1998, the number of Midwestern states reporting use of harvest trends as an index of abundance increased (+3) while the number using population models or population reconstruction to estimate abundance decreased (-4) (Rolley and McCaffery 1998). No state reported using pellet group counts to index deer abundance in 2016 (-2 from 1998).

The greater emphasis on harvest trends and reduced emphasis on accounting models or population reconstructions may be driven by a desire for greater transparency with stakeholder groups. In contrast, recent advances in the computer-intensive modeling have led to several states developing integrated population models (IPM). The Wildlife Management Institute (2016) considered Bayesian IPMs to be the state-of-the art in population modeling. The Minnesota Office of Legislative Audit (2016) noted the challenge associated with the unique expertise required for deer population modeling and the need for clear communication of technical aspects of population estimation with citizens involved in goal setting processes.

Most Midwestern states have quantifiable performance goals for specific DMUs to help guide harvest management decisions. Many of these goals are expressed as desired population trends or size but a few are expressed in terms of impacts (e.g., tolerable levels of deer-vehicle crashes, hunter success rates, hunter/farmer desires). However, there is wide variation in the processes used in setting goals, how often the goals are updated, who provides input to the goal setting process and how input is provided and the types of information considered in the process. About half of states utilize quantitative human dimension surveys to collect stakeholder input while the remainder rely on less rigorous methods that may be less reliable and representative. Opinions of hunters and farmers are widely considered by Midwestern states when setting deer management goals but interests of other stakeholders may not be as well reflected. The Minnesota Office of Legislative Audit (2016) suggested the DNR consider expanding the range of interest groups surveyed as part of its goal setting process to include motor-vehicle drivers. Common types of data considered in goal setting processes include recent deer population trends, hunter and farmer attitudes, crop damage complaints, hunter demand and/or success, and disease concerns. Habitat quality, reproduction, and buck quality were listed as categories of data considered by only 2 states each.

Is there a need for greater consistency in deer metrics among Midwestern states? Deer management is a state responsibility and information needs vary among states. There is a wide variety of terrain, habitat and weather patterns across the Midwest. Winter severity is a concern for northern states in the region but not states farther south. Stakeholders in different states may have different expectations. Managers need to be cost-effective and design monitoring programs for state-specific needs. However, the lack of consistency does create challenges for regional analysis.

Widespread mule deer population declines starting in the late 1980s generated interest for greater interstate cooperation and coordination among western states (Heffelfinger and Messmer 2003). The Western Association of Fish and Wildlife Agencies chartered the Mule Deer Working Group to develop solutions to common mule deer management challenges. Among the many issues this group addressed was the collection and analysis of data. Carpenter et al. (2003) concluded that many questions about drivers of mule deer population change in the West could be better answered if data gathering approaches were more statistically sound, consistent, standardized, and continuous. Mason et al. (2006) argued that enhanced regional collaboration was critical for better understanding of management of western deer and elk populations. They believed there were substantial needs and opportunities to improve interagency coordination and collaboration in data-collection, data-sharing and analysis. They also believed there was a need to improve the rigor of data-collection and analysis strategies. Mason et al. (2006) stressed that states should strive to use common standards for obtaining population data; but they explained that "*by standardization we do not imply that all*

states use the same survey system but, rather, that all states should at least employ fundamental statistical aspects of random sampling and bias corrections when developing new or applying previously published survey techniques."

In response to these demands for greater standardization in data collection, the Mule Deer Working Group produced a handbook titled *Methods for Monitoring Mule Deer Populations* (Keegen et al. 2011). The objective of the handbook was to thoroughly describe various monitoring methods and their advantages and disadvantages. Keegan et al. (2011) recognized that dramatic changes to state's ongoing monitoring programs were constrained by practical, political and economic factors. They acknowledged that different population management objectives influenced population monitoring needs; some management strategies require more intensive population monitoring than others.

While the 4 western states in the Midwest have populations of mule deer, white-tailed deer is the dominant species in the region. In contrast to mule deer, overabundance is a greater concern of many white-tailed deer managers (McShea et al. 1997, Warren 1997). While deer management is a state responsibility there are shared management challenges. Perhaps chief among them is conflict among stakeholders, appointed administrators, and elected representatives over goals for management (Woolf and Roseberry 1998). Diefenbach and Palmer (1997) recommended "marketing" the need for scientific deer management as an approach to overcome the political conflict associated with deer management. Will greater interstate cooperation, coordination, and data sharing help Midwestern deer managers address these challenges?

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Table 1. Spatial framework for deer harvest management.

	Type of area	N areas	Mean size (mi^2)
Illinois	County	102	349
Indiana	County	92	400
Iowa	County	99	566
Kansas	DMU	19	4,285
Kentucky	County	120	337
Michigan	DMU	80	700
Minnesota	DMU	128	613
Missouri	County[a]	115	561
Nebraska	DMU	18	4,300
North Dakota	DMU	37	1,910
Ohio	County	88	465
South Dakota	DMU	81	917
Wisconsin	County[b]	82	680
Mean		82	1,237

[a] Plus 1 independent city.
[b] Nine counties are split into forest and farmland parts.

Table 2. Methods used by Midwestern states to estimate sex and age composition of harvest, approximate number of deer examined annually, number of locations sampled, and timing of data collection.

State	Methods used[a]	Approx. N. deer examined	N. locations	Timing of collection
Illinois	MR, HM	5,000 (MR), 150,000 (HM)	10	firearm season (MR)
Kansas[b]	ML, TX	700		entire season
Kentucky	ML, TX	3,000	25	major firearm weekends
Michigan	VC, JA	29,000	80(VC) ,120 (JA)	entire season
Missouri[c]	ML, CWD	4,500	50	opening weekend (55%), entire season (30%), CWD (15%)
Nebraska	MR, HM	16,000	112	firearm season
Ohio	ML	7,000	73	firearm season
Wisconsin	ML	15,000	130	firearm season (82%), bow season (18%)

[a] CWD = CWD culling, HM = hunter submitted measurements, JA = Jaw aging events, ML = meat lockers, MR = mandatory registration stations, TX = taxidermists, VC = voluntary checkstations.
[b] Minor effort with occasional sampling.
[c] Planning to add hunter submitted measurements in 2016.

Table 3. Parameters measured and methods used to assess nutritional condition of deer populations by Midwestern states.

State	Parameter	Method	Frequency	N. deer
Illinois	Lactation	Mandatory registration	Annual	
Iowa	Fat deposits	vehicle-killed deer	Annual	100
	Pregnancy	"		
Kansas	Body weight	SCWDS[a] herd check	5-10 yrs	5-300
	Fat deposits	"		
	Lactation	"		
	Pregnancy	"		
	Serology	"		
	Parasites	"		
Michigan	Yrlg[b] antlers	Voluntary check		
		Meat lockers		
Ohio	Yrlg antlers	Meat lockers	Annual	1,200
	Pregnancy	vehicle-killed deer	10 yrs	
South Dakota	Pregnancy	vehicle-killed deer	Annual	200
	"	ultrasound research captures	Annual	550
	"	blood hormones fawn captures		
	Thyroxine	blood from research captures	Annual	600
Wisconsin	Yrlg antlers	Meat lockers	Annual	7,000
	Fat deposits	vehicle-killed deer	Annual	500
	Pregnancy	"		

[a] Southeast Cooperative Wildlife Disease Study
[b] Yearling (1.5 years old)

Table 4. Methods used by Midwestern states to monitor trends in deer populations.

State	Harvest index	Deer-vehicle collisions	Harvest/ effort	Aerial surveys	Roadside counts	Observation surveys	Other
Illinois	X	X		X	X		
Indiana	X	X	X				
Iowa	X	X			X	X	
Kansas	X	X	X		X	X	X[a]
Kentucky	X	X					X[b]
Michigan	X		X				
Minnesota	X		X	X			
Missouri	X		X			X	X[c]
Nebraska	X	X					
North Dakota	X			X		X	
Ohio	X	X	X	X			
South Dakota	X			X	X	X	
Wisconsin	X	X		X		X	

[a] Experimenting with trail cameras.
[b] Agricultural damage complaints.
[c] Opinion surveys of agency staff, hunters, and production landowners.

Table 5. Methods used by Midwestern states to estimate deer population size.

State	Accounting model	Sex-age-kill/ Downing	Integrated population model	Aerial surveys	Roadside distance sampling
Iowa	X		X[a]		X
Kansas					X
Kentucky		X			
Minnesota	X			X	
Missouri	X		X[a]		
South Dakota			X[a]	X	X[b]
Wisconsin		X			

[a] Integrated population models under development.
[b] Evaluating distance sampling for white-tailed deer in Black Hills.

Table 6. Methods used by Midwestern states to monitor deer reproduction or recruitment.

State	Harvest fawn:doe ratios	Winter fetal counts	Observation surveys	Other
Illinois	X	X		
Iowa	X	X		
Kansas	X		X	
Kentucky		X		
Missouri	X			
Ohio	X	X[a]		
South Dakota	X	X	X	X[b]
Wisconsin		X	X	

[a] frequency of approximately every 10 years.
[b] radio-collared neonates to estimate survival.

Table 7. Hunter participation, effort, and satisfaction parameters monitored by Midwestern states.

State	Licenses/permits sold	Days hunted	Units hunted	Deer seen	Rating of quality/ satisfaction	Desired population trend
Illinois	X	X	X		X	X
Indiana	X	X	X	X	X	X
Iowa	X	X	X	X	X	X
Kansas	X	X	X	X	X	X
Michigan	X	X	X	X	X	X
Minnesota	X	X	X	X	X	X
Missouri	X	X	X	X	X	X
Nebraska	X				X	
North Dakota	X	X	X	X		
Ohio	X	X	X	X	X	X
South Dakota	X	X	X		X	
Wisconsin	X	X	X	X	X	

Table 8. Methods used by Midwestern state to monitor hunter participation, effort, and satisfaction.

State	Survey contact method	Temporal scale	Sample size[a]	Comments
Illinois	Mail	Annual	3,000	Habitat stamp buyers, multiple species.
		3-5 years	3,000	Deer hunter surveys
Indiana	Mail	3 years	15,000	~8-10% of hunters
Iowa	Mail	Periodic	4,000	2% of hunters
Kansas	Mail & internet	Annual Periodic	10-15%	Hunter satisfaction Special issues
Michigan	Mail	Annual Periodic	59,000	10% of hunters As needed
Minnesota	Mail & internet	3-5 years	> 900 hunters/ permit area	Rotate among permit areas
Missouri	Mail	Annual	18,000	4% of hunters
Nebraska	Internet	5 years		
North Dakota	Mail	Annual Periodic	13,000	27% of hunters
Ohio	Mail, phone & internet	Annual 2 years	20,000	8-10% of hunters
South Dakota	Mail & internet	Annual Periodic	33,500	~50% of hunters occasionally ask number of deer seen and desired population trend
Wisconsin	Mail	Annual	10,000	2% of hunters # of deer seen estimated from successful hunters and web based hunter records

[a] number of surveys sent to hunters.

Table 9. Methods used to monitor deer-vehicle collisions and agricultural damage caused by deer in Midwestern states and the temporal scale of monitoring.

State	Deer-vehicle collisions	Agricultural damage	Temporal scale	Comments
Illinois	Accidents[a]	Farmer survey	Ann./periodic	
Indiana	Carcasses[b]	Appraised damage Farmer survey	Ann./periodic	
Iowa	Accidents Carcasses	Appraised damage Farmer survey	Ann./periodic	Ag. producers surveyed every 5 yrs.
Kansas	Accidents Citizen[c]	Damage permits Farmer survey	Ann./periodic	Ag. producers surveyed every 5 yrs.
Kentucky	Accidents	Damage permits	Annual	
Michigan	Accidents	Damage permits	Annual	
Minnesota	Accidents Carcasses	Farmer survey	Ann./periodic	Ag. producers surveyed every 3-5 yrs.
Missouri	Accidents	Farmer survey	Annual	
Nebraska	Accidents	Damage reports		
North Dakota[d]	Accidents	Damage reports	Annual	
Ohio		Farmer survey	2 years	
South Dakota	Citizen	Damage reports Farmer survey	Ann./periodic	
Wisconsin	Accidents	Appraised damage	Annual	

[a] Reported accidents from Department of Transportation/Highway Safety
[b] Deer carcass removal data.
[c] Human dimension surveys of citizens.
[d] North Dakota Department of Transportation formerly provided data on reported deer-vehicle crashes but no long does.

Table 10. Responses from Midwestern deer program managers to questions of whether their management program has quantifiable performance goals, how those goals are expressed, and frequency that goals are updated.

State	Have performance goals	Expression of goals	Update frequency	Comments
Illinois	Yes	Tolerable level of deer-vehicle crashes	2014	CWD takes precedence over other impacts
Indiana	No			Mgmt plan sets general directions
Iowa	Yes	Population level similar to late 1990s	> 15 years	
Kansas	Yes	Public desires	Annually	Deer committee and agency staff set general direction
Kentucky	Yes	Population size	Not since ~2005	
Michigan	No			No goals for ~10 yrs, hunters rejected proposed goals
Minnesota	Yes	Pop. Size & Trend	Every 10 yrs	
Missouri	Yes	Population Trend	Annually	
Nebraska	Yes	Population Trend	Annually	Informal process
North Dakota	Yes	License sales & hunter success	Every 5 yrs	
Ohio	Yes	Farmer and hunter desires	Periodically	Changing goal process
South Dakota	Yes	Population Trend	Annually	
Wisconsin	Yes	Population Trend	Every 3 yrs	

Table 11. Responses from Midwestern deer program managers to questions about the process of establishing performance goals, the role of agency staff, which stakeholder groups provide input to the process and how that input is provided.

State	Goal setting process	Stakeholder groups providing input	How is input provided
Illinois	Statewide advisory committee	Hunters, farmers, landowners	HD surveys
Indiana	No goals		
Iowa	Statewide advisory committee	Business, hunters, ag. producers conservation, public	Advisory committee, HD surveys, public input at meetings
Kansas	Agency driven	Hunters, landowners, general public	HD surveys, public meetings, individual comments
Kentucky	Agency driven	Hunters, farmers, landowners, biologists	"A blend of input"
Michigan	No goals		
Minnesota	15-20 multi-unit advisory comm.	Hunters, ag. producers, public	Advisory committees, HD surveys, public input at meetings
Missouri	Agency driven Deer program staff	Hunters, farmers, general public	HD surveys, public comment periods, stakeholder groups
Nebraska	Agency driven Deer program staff	Hunters, landowners	HD surveys, public comment
North Dakota	Agency driven Deer program staff + field input + 8 advisory comm.	Field staff, general public	Regional staff/advisory committee meetings
Ohio	Agency driven	Hunters, farmers	HD surveys
South Dakota	Agency driven Regional managers + field biologists and COs	Hunters, farmers, ranchers	HD surveys, advisory groups, public meetings, phone app
Wisconsin	72 county advisory committees	Hunters, farmers, foresters, transportation, tourism, tribal	County advisory councils, web survey public meeting input

Table 12. Types of data considered during performance goal setting processes in Midwestern states.

State	Hunter & farmer attitudes	Deer population trends	Disease	Crop damage complaints	Public input	Deer-vehicle crashes	Hunter demand/ success	Local biologist opinion	Reproduction	Habitat	Buck quality
Illinois	X		X			X					
Iowa	X	X	X	X		X			X		
Kansas	X	X	X	X	X	X	X	X			X
Kentucky	X			X				X			
Minnesota	X	X			X			X		X	
Missouri	X	X	X								
Nebraska	X	X	X	X	X	X	X				X
North Dakota	X	X	X				X	X			
Ohio	X										
South Dakota	X			X	X						
Wisconsin		X	X	X	X	X	X		X	X	