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## **RESULTS OF ENVIRONMENTAL SCANNING APPLIED TO THE DESIGN OF A DEER MANAGEMENT DECISION SUPPORT SYSTEM (DSS) FOR THE UNITED STATES AND CALIFORNIA**

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### **ABSTRACT**

*Using freely available internet search tools for environmental scanning, information related to deer management was collected, categorized, and evaluated with the goal of providing public decision support. Key issues raised in the public debate discovered by the search are addressed with relevant information formatted as output for a decision support system – dashboard elements. A graph addresses contradictory reports about the current direction of the deer population; the trend since 2006 appears to be down. Another graph illustrates the approximate long-term population trend; the current U.S. white-tailed deer population is about the same as in 1500. A table summarizes profiles of state deer issues and strategies. Only eleven states are trying to reduce their deer population. A graph illustrates the rise and fall of the California population, the most dramatic population decline in the U.S. over the past 100 years. Hunting pressure and herd demographic management are found to be related to the decline, making these candidate variables for attention in the decision support system. This case application is designed to illustrate methods the author has learned in creating a variety of decision support applications for technology companies.*

**Keywords:** Environmental Scanning, Internet Search, Decision Support Systems (DSS), Deer Management

### **INTRODUCTION**

Many organizations, people, and animals have developed systems for scanning their environment to assess risks and rewards. Comparative advantages differ: sensitive noses for deer, advanced computer systems for the National Security Agency. Although there is extensive research on environmental scanning in the information systems literature, there are few documented applications [14]. As a project to build a public decision support system (DSS) for deer management, the internet has been scanned on a daily basis for four years to collect, categorize, and analyze data and information related to deer management. One goal is to identify important issues and to provide convenient access to information that can be used for decision support. Another goal is to use the combined expertise collected from the environmental scanning to identify variables and data that will improve a statistical deer population model, a more formal element of the decision support system that is under development. The approach reflects classical characteristics of decision support systems: “they attempt to combine the use of models or analytic techniques with traditional data access and retrieval functions [23].” The author has 30 years of high-tech industry experience producing decision support where the results are often proprietary. Methods developed from this experience are applied in this case to a public issue where all results are freely publishable.

Deer populations are typically managed by state and local governments using some varying degree of public input. The title of a famous book about the process in Pennsylvania, “Deer Wars” [10] gives a sense of the levels of interest among some of the stakeholders in the decision process. Information on the internet and in the media, with varying levels of reliability, will affect the decision making. Recent, significant, related information events include a fall, 2013, cover of Time magazine featuring a doe, a female deer, in a bucolic forest scene with the words “America’s Pest” written in red. The article in its title argues “It is time to cull the herd” and states that “Thirty million strong and growing, the population of white-tailed deer in the U.S. is larger today than it was when Columbus sailed the ocean blue, according to National Wildlife Research Center scientist Kurt VerCauteren [8].” At about the same time, the San Francisco Examiner reported on the 80 percent decline in the California deer population over the past 50 years and discussed some of the factors associated with the decline, issues currently under study at the University of California, Davis [24].

A few months later, a deer expert in Connecticut reported that the population had plunged in recent years as a result of increased predation from coyotes and bobcats [11]. At about the same time, the Wall Street Journal reported deer populations were soaring from Long Island to California [4]. During the deer hunting season of 2013-14, deer managers in Illinois, Maine, North Dakota, Iowa, Minnesota and Wyoming and other states were explaining to the

media why the deer population in their states was declining. Following a review of some of the environmental scanning literature in the next section, this paper presents figures and tables that are key information outputs for the deer management decision support system – elements of the system dash board.

### **Environmental Scanning**

Wei and Lee [28] define environmental scanning as “the acquisition and use of information about events, trends, and relationships in an organization's external environment.” In his book *Information Management for the Intelligent Organization: The Art of Scanning the Environment*, Choo [5] concludes from a summary of literature “Decision makers ... must identify problems, search for solutions ... must actively search for the required information.” In a recent overview of related research, Rohrbeck and Bade [20] summarize over 250 articles and call for “a stronger linkage to adjacent research.” Welter and others [29] report that “As companies’ environment is becoming increasingly volatile, scanning systems gain in importance.” Abebe [1] concludes from an analysis of 90 manufacturing companies that “Environmental scanning is considered as one of the critical ingredients in the strategic formulation process.” Palomino and others [17] try to “optimize the collection of Web-based information” to assist decision makers, an approach similar to this deer management project. Babatunde and Adebisi [2] conducted an empirical study that concludes, “the use of strategic environmental scanning in evaluating environmental forces (opportunities and threats) helps in seizing the opportunities and avoiding threats and it leads to organizational profitability.” Through a series of executive interviews, Fabbe-Costes [9] concludes that environmental scanning can be used to design sustainable business supply chains.

### **RESEARCH METHODOLOGY**

A daily internet search, restricted to the previous 24 hours using both Google Alerts and Microsoft Bing, has been used to collect text and data related to deer management issues over the past several years. This approach allows for the capture of information that would be difficult to find using a single, intensive search process. Information sometimes drops off the internet in a few months. Another problem is that Google Search, for example, typically provides access to less than 1,000 of the millions of results it reports as found at the top of the page. Much of the information that shows up in a daily search will quickly drop so low in the Google page rank that it could only be found by using very specific search terms. A searcher would have to know the specific terms to use in order to find the information, or try by using many different search term combinations.

Google Alerts provides the option of restricting the search to a specific time range and then reporting the results to the user by email. In this case, in order to perform the most thorough search, the time frame was restricted to the minimum, the previous 24 hours, and the resulting email reports were evaluated manually each day. Google Alerts also provides the user with the option of identifying retrieved search items as “irrelevant.” By flagging results as irrelevant, the proportion of relevant searches is improved. Although manual evaluation of search results is somewhat time consuming, the researcher becomes acquainted with current issues by performing the evaluations. This learning process has been helpful in educating the researcher about trends and issues in the topic under investigation. More recently, a daily Bing search has been added to reduce the chances that information popping up on the internet will go unnoticed. Bing also provides the option of restricting search to new information appearing in the past 24 hours. Research on alternative approaches has revealed no better available method for conducting the environmental scan.

Search terms for the Google Alerts were determined by examining the volume of keywords searches using the Google Trends Tool, revealing that internet users often search for deer information by state, such as “Pennsylvania deer”. Also, since deer are managed at the state level, the decision support system and the information from search was stored by state and then by topic. A few search terms have been added over time that the researcher has identified as important based on review of the search results. More generally, based on text and data collected from the internet during 2013 and early 2014, deer management issues getting significant attention, but accompanied by contradictory factual information, suggest questions one and two below for detailed investigation. The effort to find variables that should be included in a statistical deer population model suggests question three. This paper is organized to address the following three questions:

Q<sub>1</sub>: What is the direction of the trend for the U.S. deer population, up or down?

Q<sub>2</sub>: How has the California deer population changed over time?

Q<sub>3</sub>: What are the influences on the population trend for each state that should be included in building a decision support system?

### ANALYSIS AND ANSWERS TO QUESTIONS DISCOVERED IN THE ENVIRONMENTAL SCANNING

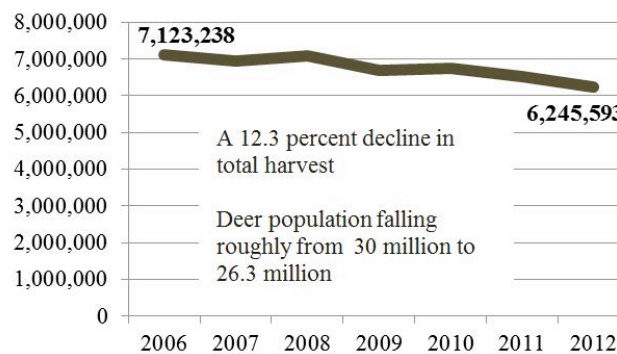
The following sections present some answers to these questions based on information collected by the environmental scanning. The figures and tables used to answer each question have become dash board elements for the decision support system, a common information system approach to provide users with a quick summary of key information. This format is also commonly used in Executive Information Systems where the goal is to provide summary information to assist with strategy and can support a drill-down allowing for closer examination of specific data.

#### Q<sub>1</sub>: What Is The Direction of the Trend for the U.S. Deer Population?

Although accurate estimates of deer populations are difficult to achieve, most population estimates are based on hunting statistics: millions of hunters go out into the field each year following hunting rules that may be modified somewhat by government or private managers [13]. Population estimates are so controversial that the state of Wisconsin recently decided to do away with them; other states have made similar decisions. Nevertheless, management decisions often must address population issues and the phrase “deer population” is commonly used among internet users searching for information. Survey methods are also used to estimate population, including aerial, scat counts, and citizen scientists reporting their observations using the internet.

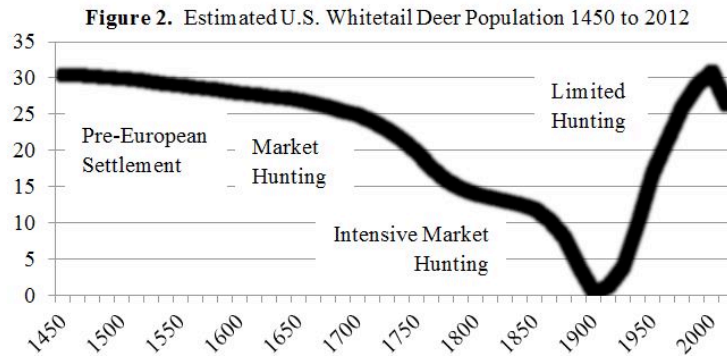
A relatively complete set of deer harvest data (deer killed by hunters) has been collected from each state over the period from 2006 to 2012. Data for the 2013 season is still incomplete. Some years for Florida and most years for Hawaii, with a very small deer population, were estimated. The harvest data from each state has a wide confidence level given the many problems of non-reporting. Some states rely on hunter surveys that have their own set of measurement problems. Given that, and other things being about equal, the deer harvest data will approximately track with the actual deer population. Figure 1 shows that the harvest data has declined over this period and this suggests also that the deer population has declined.

**Figure 1.** Total U.S. Reported Deer Harvest, 2006 to 2012



Although no agency appears to be making a yearly estimate for the U.S. deer population, there are some estimates discovered from publically available sources. For example, “Although estimates of pre-European deer densities are imprecise, reliable accounts document a geographically widespread decline of deer populations in the late 19<sup>th</sup> century [21].” VerCauteren [26] estimates that there were about 30 million white-tailed deer in pre-colonization area of the United States, around the year 1500, and that market hunting beginning in the 1600’s started a downward decline in the deer population that accelerated into the early 1900’s until few deer remained. Conservation efforts restored the population to about the same 30 million population level by 2000. Although there may be overly abundant deer populations in some areas, deer populations are below historical averages in other areas.

The estimated U.S. white-tailed deer population, the most common deer, in Figure 2 is based on VerCauteren [26] (the researcher earlier referenced as a source for Time Magazine), McCabe [15], and the University of Florida [6]. The harvest data from Figure 1 is used to update the information for the 2006 to 2012 period, so a few years in the early 2000’s are approximated. Of course, there is a wide error band on this estimate, illustrated to some extent by the wide line in Figure 2. Also, the harvest data used to estimate the 2006 to 2012 population trend includes non-white-tailed deer, about 10 percent of the total. A task for future research will be to separate these different deer populations for analysis. Non white-tailed deer generally reside west of the Mississippi river, were also hunted to very low levels during the early 1900’s, but in many regions the recovery of these populations peaked in the 1960’s and 1970’s and has been on a decline since.



*Answer to Q<sub>1</sub>*: The recent total U.S. deer population trend appears to be down. The total U.S. white-tailed deer population has been estimated to be comparable to the pre-colonization population in about the year 1500.

**Q<sub>2</sub>: How has the California deer population changed over time?**

Although there is an historical population graph available from the California Department of Fish and Wildlife (CDFW) on its website, it hasn't been updated for about 20 years and the graph does not track with historical harvest data [27]. The department's more recent population estimates from 1990 to 2013 show a steep decline, but are not included in the graph on the website.

One method used by deer managers to control deer populations is to change the ratio of buck to doe hunting licenses issued. Killing a large proportion of does will reduce fawn production in the following year, putting downward pressure on the population. Since one buck can impregnate many does, reducing the proportion of does killed and targeting bucks is typically used as a strategy to increase herd growth. Each buck can impregnate more than one doe. During the rebuilding of deer herds during the middle of the 1900's, many states employed a bucks only harvest to enhance population growth.

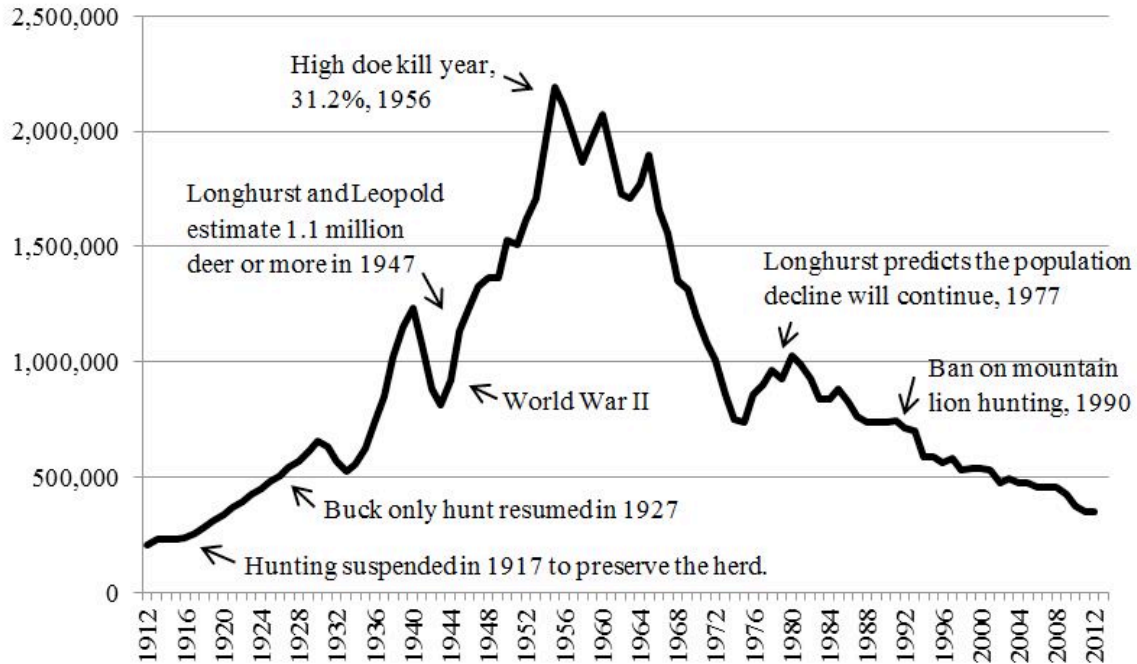
California is unique in that it is the only state that has pursued essentially a bucks only harvest for almost every year since 1927 when deer hunting was resumed after a 10 year hiatus designed to protect the herd from over hunting. A common method for estimating deer populations is to use "harvest" data, the number of deer killed each year by hunters and then adjust the number for variations in sex and age. California's sex and age distributions have generally been about the same. This first pass at building a state population model for the decision support system relies on the reported kill (harvest) to population ratio based on the CDFW population analysis for 1990 to 2009 (data from 2010 to current are reported as preliminary by the department so are not used in the analysis). Also used is a very thorough study of the 1947 deer population conducted by William Longhurst and Aldo Leopold [12] who is considered by many to be the father of modern wildlife management. Note that the estimated kill to population ratio for 1947 reported in Table 1 is within the range of the modern period, 1990 to 2009, so it is assumed this ratio has been relatively constant over time. See Webb [27] for a more detailed discussion of this data.

**Table 1.** Historic Harvest (Kill) to Population Ratios

From recent 1990 to 2009 CDFW Model*	High: 0.0456 Low: 0.0273 Median: 0.348
From Longhurst Study of 1947 Herd	0.0422
* Harvest numbers from 2010 to 2013 are reported as preliminary by CDFW, so not used in this analysis	

The population estimate in Figure 3 was created by taking a weighted average of eight population scenarios, each using one of the four historic kill to population ratios reported in Table 1 applied against the total buck harvest and also against the total deer harvest. In most cases, these harvest numbers are nearly identical. On average since 1927 the doe harvest in California has been less than three percent of the total population. In one year, 1956, the doe harvest was 31.2 percent of the population. As a result the population estimate for 1956 may be a little high and is one issue under consideration as model development moves forward. To smooth out year to year anomalies that may be related to hunting conditions or other time specific issues, the population estimate is a three year centered moving average.

**Figure 3.** Deer Population Estimate for California, 1912 to 2012



As Figure 3 illustrates, the current California deer population may have fallen back into the population range of 1917 to 1926 when deer hunting was suspended in order to preserve the herd. This was at a time when many families relied on the deer hunt as an important source of food. The graph identifies the 1990 ban on mountain lion hunting because the environmental scanning has identified this as a widely suspected contributing factor to the decline of the deer population and the topic of other current research.

The significant difference in the population pattern over the past 100 years in Figure 3 as compared to the white-tailed population illustrated in Figure 2 demonstrates an important issue regarding the development of deer management information: deer population status varies widely across the United States. A goal of the environmental scanning described in this paper is to collect and present this information to decision makers, and to use the information to build summary graphics such as Figure 3 that will assist in the public decision making process.

*Answer to Q<sub>2</sub>:* The California deer population rose from around 200,000 in 1912, peaking at about 2,000,000 around 1960, then falling to less than about 400,000 in 2012. Numbers are approximate. This population decline is the most severe of any state in the past 100 years.

**Q<sub>3</sub>: What is the direction of and influences on the population trend for each state?**

Like many business organizations, state agencies compete for revenue. Resident and non-resident deer hunting license sales are a major revenue source. Deer hunting, breeding, and tourism is estimated to add billions of dollars to some state economies. Since states are generally allowed to charge higher prices for hunting licenses to non-residents, these sales can be a significant source of revenue. Each state implements a unique management strategy and faces a geographically dispersed set of challenges. Table 2 reports variables of interest for the decision support system, factors under study or reported as issues of concern by state deer managers or conservation groups.

**Table 2.** Variables of Interest: Reported Factors Related to Decline of Deer Populations

State	Issue	State	Issue
CA	Habitat loss and fragmentation, lions	MI	Coyotes, overhunting, sever winter, EHD
CT	Predation. First decline since early 1900's	NC	Coyote, mature forests
CO	Habitat, EHD (disease), energy development	ND	Drought, EHD, Habitat, energy development
FL	Flood, pythons	MT	Habitat, severe winter, Predation
GA	Coyotes, new to the region	SC	Coyote
IL	Overhunting, drought,	OR	Habitat, disease, population model
IA	Overhunting, drought, EHD	WY	Oil and gas development
MN	Habitat, coyote, sever winter, EHD	WV	Aging Forests

Competitor profiling, a common strategic management technique discussed at length by Michael Porter [18], provides the framework for Table 3 that summarizes current deer management practices and issues for each state.



**Table 3.** Results of Environmental Scanning for Deer Management

Explanation of Table Column Headings: *Goal*: Management Strategy for Population, Up, Down, or Stable.

*% Peak*: Current deer harvest as a percent of peak harvest. *Peak Year*: Year of Peak Deer Harvest. *Hunter*

*Success*<sup>A</sup>: Percent success, a measure of hunting pressure. *Buck to Doe*: Buck Harvest Relative to Doe Harvest:

Less is less bucks than does, Balanced is approximately balanced, More is 60 to 80 percent Bucks, Most is 81 to

95 percent bucks, Only is all or almost all bucks

State	Goal	% Peak	Peak Year	Hunter Success	Buck to Doe	Other Issues
<b>AL</b>	Up	53	2000	80 – 90	Balanced	Coyote predation reduced the herd recently.
<b>AK</b>	Up	Stable	-	23	More	Nearly stable population fluctuates with harsh winter
<b>AZ</b>	Up	37	1961	25	Only	About 12 percent doe historically, buck only since 1991
<b>AR</b>	Stable	100	2012	70	Balanced	Also seeks to balance buck age distribution.
<b>CA</b>	Up	13.8	1956	8 - 17	Only	Average 3 percent doe harvest since 1927, most extreme of any state
<b>CO</b>	Up	33-50	1940s	44	More	Limited historical data, energy development concerns.
<b>CT</b>	Down	75	2012	24.7	Balanced	Seeks to balance buck age distribution. Reported hunter success rate
<b>DE</b>	Stable	97	2004	73	Balanced	Seeks to balance buck age distribution
<b>FL</b>	Stable	100	2012	100	Balanced	About one deer harvested for every hunt.
<b>GA</b>	Up	86	2004	140	Balanced	A leader in balanced demographics, coyote predation
<b>HI</b>	Down	100	2013		Balanced	Hawaii eradicating a few nonnative deer. Limited data
<b>ID</b>	Up	52	1989	100	Balanced	Balanced age and sex except a few years in 1970s
<b>IL</b>	Up	74	2005	45	Balanced	Goal was down for a decade until this year
<b>IN</b>	Down	92	2012	68	Balanced	Recent harvest declines may signal a goal change
<b>IA</b>	Down	47	2005	33	Balanced	Pressure to change goal to up
<b>KS</b>	Up	85	2000	48	Balanced	Concerns about drought and disease, EHD
<b>KY</b>	Stable	100	2012	77	Balanced	Trying to maintain balance while hunters want bucks
<b>LA</b>	Up	58	1999	75	Balanced	Data based on survey. Coyotes and hogs reduced herd
<b>ME</b>	Up	50	1958	53	More	Maine struggling grow herd, harsh winter, habitat loss
<b>MD</b>	Down	95	2009	45	Less	Stable population but some counties down 60 percent
<b>MA</b>	Stable	92	2002	20	More	Significant bow hunting, deer decline in west of state
<b>MI</b>	Up	69	1999	46	More	Harsh winters. Antler point restrictions
<b>MN</b>	Up	64	2003	35	Balanced	Harsh winters, goals have changed over 10 years
<b>MS</b>	Stable	85	2010	115	Balanced	1.15 deer per hunter. Floods, land use, coyotes, swine
<b>MO</b>	Up	78	2006	50	Balanced	Goal change in 2013 after 10 years of down

Table 1 continues on next page

<sup>A</sup>Hunter success rates are sometimes reported as percent of hunters who take a deer, or average deer per hunter.

**Table 3** (continued). Results of Environmental Scanning for Deer Management

Explanation of Table Column Headings: *Goal*: Management Strategy for Population, Up, Down, or Stable. *% Peak*: Current deer harvest as a percent of peak harvest. *Peak Year*: Year of Peak Deer Harvest. *Hunter Success*<sup>A</sup>: A measure of hunting pressure. *Buck to Doe*: Buck Harvest Relative to Doe Harvest: Less is less bucks than does, Balanced is approximately balanced, More is 60 to 80 percent Bucks, Most is 81 to 95 percent bucks, Only is all or almost all bucks

State	Goal	% Peak	Peak Year	Hunter Success %	Buck to Doe	Other Issues
MT	Up	64	2006	21	Balanced	Mule deer populations down 55% from 2007
NE	Up	60	2011	50	Balanced	Recent drought and EHD. Doe protection for mule deer.
NV	Up	35	1988	41	Most	Bucks 90 percent of harvest.
NH	Up	88	1968		More	Bucks 65 percent of harvest
NJ	Down	67	2000	63	Less	About half the deer are killed by hunting each year
NM	Up	27	1960s	45	Only	Buck only 1899 to 1931 and since 1983. Bucks must be fork antlered. Peak based on population estimates.
NY	Down	79	2002	35	Balanced	Harvest 56% bucks. Reducing harvest of young bucks. Success rate is deer kill divided by total hunters.
NC	Stable	100	2013	90	Balanced	Cherokee Indians having to restock tribal lands
ND	Up	32	2006	55	More	Harsh winters, habitat loss, EHD. Permits reduced.
OH	Down	81	2006	33	Less	Reducing harvest of young bucks to balance ages
OK	Stable	90	2006	69	Balanced	Also balances age distribution
OR	Up	26	1961	26	Most	Doe harvest 7.6 percent, 4 percent for mule deer. Minimum target of 12 bucks per hundred does. <sup>15</sup>
PA	Up	68	2002	37	Balanced	Reduced doe tags in 2014. Antler restrictions.
RI	Down	80	2008	26	Balanced	Using hunting pressure to reduce herd
SC	Stable	70	2002	90	Balanced	Habitat change and coyotes predation pressure herds
SD	Up	75	2010	44	Balanced	Change in goal from die off related to EHD
TN	Stable	69	1999	83	Balanced	Change in goal to up under consideration
TX	Stable	87	2010	60	Balanced	Pioneers in advocating for balanced herd demographics
UT	Up	22	1961	37	Most	Utah switched to buck only harvest in 1975 except in population control areas where does are also targeted
VT	Up	54	1980	84	More	Often uses balanced population, current goal is up. Use antler restrictions to balance buck age distribution.
VA	Stable	94	2009	80	Balanced	Population on target for past 10 years.
WA	Stable	65	1979	28	More	Bucks about 80 percent, down from about 88 percent in 1998. White-tailed antler restrictions since 1991. Peak % estimate approximate.
WV	Down	59	2002	45	Balanced	Rebuilding herd in some areas. Goal may change.
WI	Down	60	2000	45	Less	Goal may change to up after severe winter, 35% success rate for archery
WY	Stable	65	1970	68	More	Stable population over past 10 years. Bucks 71 percent of total. Mule deer half of peak. %Peak approximate

<sup>A</sup>Hunter success rates are sometimes reported as percent of hunters who take a deer, or average deer per hunter. Information in this table was collected from a variety of public sources available in Spring, 2014.

One of several problems associated with the hunter success rate as a model variable is that some states calculate based on reported data while others do surveys. The 8 percent success rate for California from Table 3 is reported data; the 19 percent rate is from surveys. Estimated data is typically about twice or more the reported data. In Connecticut, the reported number is somewhat low also in part because most hunters use bows which tend to reduce success rates.

As reported in Table 4, although there have been calls for moderating the deer population in the press, half of the states are currently employing a deer strategy designed to increase deer populations. Only 11 states, 22 percent, are trying to reduce populations and two of those states seem likely to change to an up or stable strategy in the next year.

**Table 4.** Summary of Table 3, State Deer Strategies

<b>Goal</b>	<b>Up</b>	<b>Down</b>	<b>Stable</b>		
Percent of Total	50	22	28		
<b>Buck to Doe</b>	<b>Less</b>	<b>Balanced</b>	<b>More</b>	<b>Most</b>	<b>Only</b>
Percent of Total	8	60	20	6	6
<b>Hunter Success Average: 55%</b>					

The modern deer management concept of maintaining balanced herd demographics to support herd health is commonly thought to have emerged in Texas during the 1940s and spread throughout the Southeast and then into other states in the east. Far western states have been the last to adopt this approach. Four of the eleven states currently attempting to reduce their deer population are following the “less strategy”, harvesting less bucks than does, one method of lowering population. Most states, 60 percent, are following a balanced strategy even though seven of these states have a goal of reducing the deer population. Only three states -- Arizona, California, and New Mexico – are following the buck only harvest strategy that was used by many states in the early to mid-1900’s when the goal was to restore deer populations. Of these states, California has pursued this strategy much longer than any other state with an average doe harvest of less than 3 percent since 1927 and with only one year having a deer harvest that would place it in the “Most” strategy. Arizona has been bucks only since 1991 and New Mexico since 1983; however, New Mexico has placed restrictions preventing the taking of too many young bucks to help balance age distributions.

California is currently conducting research into what environmental factors are responsible for the decline of its deer herd. As Table 5 reveals, California has put more hunting pressure on its herd than any other state, as measured by hunter success. It has also maintained skewed demographics using a bucks only harvest for much longer than any other state and it has a relatively low proportion of mature bucks in the herd. A recent study from Spain supports previous studies that conclude a management strategy relying on skewed herd demographics is not sustainable [25]. These results suggest that herd management is a contributing factor to the decline of California deer and indicate further investigation is warranted. North Dakota’s severe decline is recent, attributed to several harsh winters and some aggressive hunting pressure that has been recently reduced.

**Table 5.** States With Lowest Percent of Peak Harvest

<b>State</b>	<b>% Peak</b>	<b>Peak Year</b>	<b>Hunter Success %</b>	<b>Buck to Doe</b>
CA	13.8	1956	8 - 17	Only
UT	22	1961	37	Most
OR	26	1961	36	Most
NM	27	1960s	45	Only*
ND	32	2006	55	More
NV	35	1988	41	Most
* NM relies on antler restrictions				

It is well known that at too low a level of the buck to doe ratio, the population becomes unsustainable because there are simply not enough bucks to impregnate available does. California relies on very rough estimates of regional buck to doe ratios in its management information system. In one case, for example, a detailed survey reported that only three percent of the herd was actually bucks [22]. Not enough to sustain a herd. Poor data about herd status may be another contributing factor to the population decline.

Geographic information among deer in herds is passed on through elders. Fewer elders make it more difficult for herd groups to retain the information, a disruption of the herd information system. Wildlife managers throughout the west are investigating the cause of the mule deer and black-tailed decline. This information problem presents an interesting hypothesis. Until recently, managers in Wyoming were unaware that the mule deer take an annual 150 mile migration, requiring much geographical information. The problem of harvesting too many elders to lead the group has recently been demonstrated for tuna [7]. The authors suggest their findings can likely be extrapolated to other animal species, although we find no evidence that this issue is being investigated as a cause for the decline of mule deer herds. The mule deer herds in the western Sierra of California have been decimated, although habitat fragmentation and degradation are two known causes contributing to the decline. Buck to doe ratios there are also very low and there are relatively few mature bucks.

*Answer to Q<sub>3</sub>:* The pattern of change for U.S. deer populations varies widely among the states and regions. Half the states are trying to increase their populations but face ecological constraints related to habitat, weather, and predation. Management practices resulting in skewed herd demographics may be contributing to the severe drop in the population of California deer. Aggressive hunting pressure appears to be a likely contributing factor, explaining why deer numbers in California have fallen so much more than in neighboring states. Predation, habitat loss and degradation, disease, and severe weather are all factors affecting deer populations.

### CONCLUSIONS

With regard to the three general questions raised by examining the public debate over deer management, the information indicates that since 2006 the deer harvest data is trending lower, suggesting that the U.S. population is trending down toward the bottom of the range estimated for pre-European levels of around the year 1500. The California deer population estimate shows a significant rise and fall over the past 100 years, putting current populations near levels where deer hunting was suspended to preserve the herd in the early 1900's and representing the most dramatic decline of any state over this time period.

A difference between California and other states evident in the state profiles is the significant hunting pressure in California, measured by hunting success. Also a persistent policy of hunting bucks only that skews population demographics may be contributing to the decline of the herd. Although there is a wide perception in the press about abundant deer populations, the herd size in many western states is significantly below the peak. Only 11 states have a policy to reduce the deer population. One of those states is New York, the geographic origination for two of the media reports about deer overpopulation. Many media reports generalize about deer populations when deer herd status varies dramatically by region.

In addition to data, the environmental scanning has provided context and ideas for future research. A dissertation published just as this article was undergoing final revision attempts to take a similar approach in using data from several states to conduct an analysis, the author comments that having "... detailed data ... for the majority of the states would enable white-tailed deer managers in every state to quickly interpret the data and make conclusions about what is occurring in other states, benefiting the deer manager in many ways [3]." Many public and private decision making processes could benefit from this kind of easy access to data and analysis.

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