Draft
December 14, 2001

Relationships between mule deer biology and federal environmental decisions on the Klamath Project

Jeffrey A. Manning and W. Daniel Edge, Department of Fisheries and Wildlife, Oregon State University

Introduction

Trade-offs between wildlife and the values of reservoirs, timber management, agriculture, and other land and water development activities commonly result from environmental regulatory and policy decisions. Confrontations also may arise between the conservation needs of threatened and endangered species and non-listed species that are managed, such as big game. The impacts on big game of the federal environmental decisions to restrict the allocation of water to farmers in the Klamath Basin have not been considered.

Because current federal decisions associated with the Klamath Project derive from procedural aspects of interagency consultation under Section 7 of the Endangered Species Act between the Bureau of Reclamation (BR) and the U.S. Fish and Wildlife Service (USFWS), state agencies provided comments regarding the effects of the decisions on big game. Here, we summarize the status and wildlife value of mule deer (*Odocoileus hemionus*) in the Klamath Basin and discuss how current federal environmental decisions for managing water in that area may influence this species.

Status of mule deer

Mule deer are the most sought big-game species in Oregon, with annual harvests since 1952 ranging from 16,000 to nearly 98,000 (Verts and Carraway 1998). They are one of five species of big game in the Klamath Basin. The other four are elk (*Cervus elaphus*), pronghorn (*Antilocapra americana*), cougar (*Felis concolor*), and black bear (*Ursus americanus*).

Estimated populations in North America increased from about a half million to 4.7 million between the 1920s and 1960s (Julander and Low 1976; Rue 1978). Between 1926 and 1933, estimates for National Forests in Oregon ranged from 28,654 to 55,570, suggesting that mule deer were abundant (Bailey 1936). They also were believed to be abundant in nonfederal areas during that time (Cliff 1939). McKean and Luman (1964) concluded that the mule deer population in Oregon had declined since that period. In 1990, the population in Oregon was estimated to be 256,000 (ODF&W 1990).

To manage game species, such as mule deer, the Oregon Department of Fish and Wildlife (ODFW) divided the state into 77 Wildlife Management Units (WMU). Seven WMUs lie within the Klamath Basin of Oregon. However, the majority of the Klamath Project lies within the Klamath Falls and Keno WMUs. Present management strategies differ by WMU based on buck:doe (male:female) ratios (ODFW 1990). Mule deer are present in all seven WMUs in the

Oregon portion of the Klamath Basin (ODFW 2001). Deer population trend estimates for the Klamath Falls WMU were 3.0 mule deer per survey mile in 1999 and 3.1 in 2000 (ODFW 2001).

Wildlife value

Mule deer evolved in North America before the presence of humans. Their prevalence throughout western North America makes them important in human subsistence, recreation, and nonconsumptive aesthetics. A total of 1,162 hunters purchased hunting tags for the Klamath Falls WMU, and 37 percent successfully harvested deer in 2000. No Oregon-specific data are available on the economic value of mule deer hunting. The average value of a deer-hunting trip to a hunter in California was estimated at $191, or $115 per recreation-visitor day (Loomis et al. 1989). Additionally, the general public in California derived an average value of $11 per trip on outdoor trips where they saw deer and $15 per trip on trips taken primarily to view deer (Loomis et al. 1989). In 1987, California deer hunters spent $184 million (Loomis et al. 1989).

Mule deer also contribute significantly to the structure and functions of ecosystems and are considered ecological indicators (Hanley 1996). They have large home ranges, often exhibit seasonal migrations, and require spatially diverse habitat elements such as food and cover. Mule deer are prey for various mammalian predators and birds of prey and substantially affect vegetation composition and basic ecosystem processes such as nutrient cycling, thereby functioning as a keystone species (Hanley 1996; Hobbs 1996).

Potential influences of current federal environmental decisions

ODFW and U.S. Department of Agriculture's Animal Plant Health Inspection Service, Wildlife Services (USDA, APHIS, WS) are primary sources of data on big game in the Oregon portion of the Klamath Basin. The Portland Office of the ODFW maintains a comprehensive database on damage by ungulate game species, from which we received information on deer, elk, and pronghorn. For each Wildlife Management Unit, ODFW maintains an annual tally of the number of kill and hazing permits issued, fence contracts completed, tree cages used, hay stacks protected, repellents and noise makers used, hazing efforts completed, trapping efforts completed, and times advice was given. ODFW also publishes "Big Game Statistics" each year, which contains population data and harvest survey information of big game harvested in Oregon. ODFW uses transects as an index to estimate trends in mule deer populations rather than attempting to estimate the population size per se. Trend counts also include herd composition data.

Problems inherent in this type of data limit their use in making assessments of individual- and population-level responses by these species to the current federal environmental decisions. These data are based on broad geographic areas that encompass a variety of natural and human-modified habitats, weather conditions, and water sources. Within any one area, natural habitats may be converted to agriculture or houses, thereby encroaching into previously available habitats. Weather conditions are highly variable, and availability to natural and man-made water sources may vary depending on season, climate, and agricultural and domestic use by people. Additionally, increased complaints may be due to an increase in the human population rather than the status of big game populations. Furthermore, we suspect that big game damage would increase on farms that did receive water because the availability of green vegetation was limited. However, damage complaints actually declined in 2001 because so few farms produced a cover crop that attracted deer. Consequently, it is not possible to determine whether changes identified in the data are based on habitat conditions, loss of existing habitat, weather conditions, availability of water, or size of the wildlife population. Furthermore, precision of the available data both from the standpoint of variation among annual counts and the landscape scale at which it is collected makes it unlikely that changes in deer population can be contributed to changes in water distribution in the Klamath Basin.

The changes to the Klamath Project described in the 1992 and 2001Bureau of Reclamation's Biological Assessments have modified the timing and amount of water available across the landscape in the Upper Klamath Basin. Such changes, coupled with the current drought conditions, will likely increase distances among available water sources and reduce nutritionally rich irrigated forage crops, and may have direct and indirect influences on big game, such as mule deer. Direct influences include physiological stress on mule deer bucks after the rut, pregnant females during the winter, and young fawns during the spring and summer, and decreased survival and reproduction. Indirect influences may be shifts in local and regional distributions, increased risk of automobile collisions while travelling long distances, and crowding at remaining forage and water sources. Additionally, animal damage complaints from individual producers may rise due to increased foraging on ornamental plantings and irrigated crops by mule deer.

Weather

Given that recent drought conditions led to the Reclamation's modification to the Klamath Project, it is important to discuss the theoretical influences of the current federal environmental decisions on mule deer in light of weather conditions. Weather can directly affect wildlife by harming and killing individual animals, such as young that are often especially susceptible to severe weather. Weather can also indirectly affect wildlife populations by restricting movements; destroying, preventing access to, or reducing the production of food and cover resources; and it can influence the abundance of competitors, predators, and disease organisms (Bailey 1984).

Quantity and quality of forage production vary substantially among years depending on the amount and seasonal distribution of precipitation. Reproductive success in mule deer has been correlated with seasonal precipitation patterns (Shaw 1965), and improved forage conditions during years with extra moisture are one factor related to higher reproduction (Wallmo 1973; Anthony 1976). During drought periods, limited forage supplies may reduce small mammal populations, resulting in a shift of coyote (*Canis latrans*) predation to deer (Bailey 1984). Current federal environmental decisions, coupled with summer drought conditions, may result in decreased fawn and yearling nutrition, which in turn may cause poor physical condition leading to decreased winter survival.

Weather is a variable factor capable of large effects on wildlife and habitats. Because it is unpredictable, weather adds uncertainty to the predictions of wildlife managers and requires frequent review of management decisions. Extreme climatic conditions may override the effects of management on wildlife populations, perhaps requiring a reversal of management strategies (for example, see Severinghaus 1972).

Forage

Forage is necessary to animals as a source of energy and for growth and maintenance. Mule deer diets vary by location, season, sex, and other factors (Kufeld et al. 1973; Wallmo 1978; Main and Coblentz 1990). When given access to seasonally abundant, nutritious, herbaceous plants of high digestibility, deer will select those species over browse species of lower digestibility (Demarais and Krausman 2000). In the Klamath Basin, mule deer forage heavily on irrigated crops such as grains, alfalfa, and beets (Hainline, USFWS, pers. comm.). When natural vegetation is reduced during drought years, irrigated crops provide improved nutritional value for mule deer during autumn and winter. The reductions of water in the Klamath Basin will likely result in a reduction in the quantity and quality of irrigated crops available as forage to mule deer. Changes in the availability of natural and irrigated crops also will result in changes in the local distribution of mule deer as individuals move to forage in areas where irrigated crops are available.

Interactions between forage and other aspects of mule deer biology also may influence deer survival. For instance, Bailey (1984) suggested that habitat condition, including forage quality, availability of water, and weather should not be considered as a population regulating factor without simultaneously considering predation. McNamara and Houston (1987) and Sinclair and Arcese (1995) reported an interaction between foraging and predation, and emphasized that it is meaningless to consider these factors in isolation. For example, better forage conditions enable deer to spend less time feeding, thereby lowering chances of predation (Kie et al. 1991; Kie 1999).

Physiology

Mule deer physiology can be broken down into growth, fat deposition and mobilization, water requirements, and thermal relationships (Demarais and Krausman 2000). All of these physiological factors inevitably influence survival. However, we suggest that fat deposition and mobilization and water requirements may be best for considering the influence of the Klamath Project on mule deer.

Fat deposition and mobilization. Generally, mule deer store fat in spring and summer and deplete it in fall and winter (Anderson et al. 1972, Wallmo 1981). Males reach their lowest point of fat storage following rut and into winter and early spring (Anderson et al. 1972). Females undergo a less pronounced annual cycle of fat deposition and loss compared to males, and reach a low point in their fat storage cycle during lactation because of high energetic demands for feeding fawns (Anderson et al. 1972). Adult females maintain greater fat reserves during critical winter periods than males, and have higher survival rates during these seasons. Reduced quantity and quality of irrigated crops available as forage to mule deer in the Klamath Basin may result in mule deer having poorer nutritional condition, decreased fat reserves, and subsequently may decrease survival rates. Increased winter-kill would be an indicator of such conditions. Poor nutritional condition also may result in low birth weights in fawns and subsequent higher mortality.

Water requirements. Mule deer that live in arid and semiarid environments are adapted to scarcity of freestanding water. Hazam and Krausman (1988) and Hervert and Krausman

(1986) reported that desert mule deer in Arizona visited sources of water on average once a day and consumed 5 to 6 liters of water per visit during the hot summer months, while visitation rates and amount of water consumed per visit declined during cooler seasons of the year. They also found that female mule deer drink more water than males during late summer. Females often are found closer to sources of water than males, presumably because of the demands of lactation, and may remain close to water sources year-round (Bowyer 1984, Fox and Krausman 1994, Boroski and Mossman 1996, Main and Coblentz 1996).

Mule deer are capable of obtaining water from a variety of sources. They can obtain water by consuming succulent plants, dew on the surface of plants, and through metabolic processes (Anderson 1981). Whether mule deer actually require freestanding water has been debated (Severson and Medina 1983). For instance, Lauteir et al. (1988) suggested that while mule deer may exist for periods of time without access to freestanding water, survival may be marginal during these periods. The current decision to reduce the amount of water allocated to farmers and national wildlife refuges in the Klamath Basin has reduced the availability of irrigated crops where mule deer may obtain dew from the surface of plants, and it may increase travel distances between freestanding surface water.

The abundance and spacing of water sources also can influence the distribution of mule deer in a local area. In northern California, mule deer averaged 1.19 to 1.55 kilometers (km) away from water sources, with a mean maximum distance of 2.46 km (Boroski and Mossman 1996). Female and male deer distribute themselves at different distances from water sources (Bowyer 1984; Fox and Krausman 1994; Boroski and Mossman 1996; Main and Coblentz 1996). This differential proximity to water led to recommendations for managing artificial water developments for mule deer in northern California, which included spacing the water developments less than 3.2 km apart with a maximum of 4.6 km (Wood et al. 1970; Boroski and Mossman 1996). The reduction of water provided to farmers and national wildlife refuges in the Klamath Basin may reduce surface levels, but likely will not eliminate water sources. Only in areas where irrigated crops are not receiving water or where secondary or tertiary canals are dry are mule deer likely to change distribution patterns. However, the presence of water in the major lakes, rivers, and canals of Klamath Basin will likely meet water requirements for mule deer.

Reproduction

A change in the spacing and availability of freestanding water and reduction in quantity and quality of forage in the Klamath Basin may increase physiological stress and reduce reproduction in mule deer. The reproductive potential of mule deer is lower in habitats having poor-quality forage compared to those in habitats with high-quality browse (Taber and Dasmann 1957). Well-nourished females might breed at 17 months of age, whereas those in poor condition breed first as late as 41 months of age (Mackie et al. 1982; Anderson and Wallmo 1984). Timing and synchrony of reproduction are adaptations to long-term climatic patterns that help ensure that females have adequate nutrition during late gestation and parturition and that fawns are born at an optimal time of year (Robinette et al. 1977; Wallmo 1978; Bowyer 1991).

The ability to vary reproductive performance in response to environmental conditions may be of considerable adaptive importance for mule deer in the Klamath Basin, but abrupt depletion of water within the Klamath Basin may alter sex ratios in the mule deer population. Mule deer are polygynous and breed during the autumn (Thomas and Cowan 1975). Females usually breed for the first time at 17–18 months of age, and usually give birth to one young at 24–25 months; older females give birth to twins 64 percent of the time (Hines 1975). In most populations, adult females outnumber adult males by more than 2:1 (Robinette et al. 1957). Significantly more females can occur in heavily hunted populations (Mackie et al. 1982), and this appears to be the case in the Klamath Falls Management Unit (237 females : 27 males; ODFW 2001). Though it is not clear whether the reduction of water sources and associated irrigated crops used as forage by mule deer in the Klamath Basin will affect males more than females, increased losses to adult males could affect the existing sex ratios.

Adult female mule deer commonly give birth to two fawns in areas having adequate nutritional levels, while females breeding for the first time often will conceive only a single fawn (Anderson and Wallmo 1984). Adult females also are in poor condition following late gestation and lactation. Conversely, adult males are in poorest condition following rut, and consequently suffer greater mortality during winter (Flook 1970; White 1973; Kie and White 1985). Current decisions for managing water in the Klamath Basin, coupled with existing drought conditions, may decrease the numbers of fawns, the physical condition and survival of adult females after late gestation and lactation, and the physical condition and survival of adult males following rut.

Conclusions

The Klamath Project and current federal environmental decisions may potentially influence mule deer in several ways. First, the current weather conditions (drought) in the Klamath Basin, in combination with these decisions to reduce water, may alter habitat conditions to a level that causes a reduction in water sources and forage. Wild animals are well adapted to variable weather conditions within their environment (Kelsall and Telfer 1971). Nevertheless, weather extremes do cause mortality, and human-induced habitat losses and changes, such as managing water across the Klamath Basin, may cause population crowding, reduced reproduction, and physiological stress in mule deer in the Klamath Basin. However, the most likely effect of reduced availability of water in the Basin is a change in the distribution of mule deer, leading to increased use of irrigated crops.

Monitoring of mule deer in upper Klamath Basin should be conducted during and for several years following the period related to the current federal environmental decisions in the Klamath Basin to determine the extent of the influence on the mule deer population. This information, coupled with water allocations imposed by federal environmental decisions, would prove valuable in making harvest recommendations for mule deer that adjust harvest limits to current weather, habitat, water allocations, and herd conditions. The late winter herd counts will be the first opportunity to determine whether water withdrawals in the Klamath Basin have impacted deer populations. However, given the variability in those counts, it is unlikely that changes in population levels will be detected.

Acknowledgments

Comments on this chapter were provided by B. Coblentz of Oregon State University, Department of Fisheries and Wildlife; R. Hathaway, Oregon State University, Extension Service, Klamath Falls; and J. Mortenson from the Oregon Department of Fish and Wildlife.

Literature cited

Anderson, A.E. 1981. Morphological and physiological characteristics. Pages 27-97 in O.C. Wallmo, ed., Mule and black-tailed deer of North America. University of Nebraska Press, Lincoln.

Anderson, A.E., D.E. Medin, and D.C. Bowden. 1972. Indices of carcass fat in a Colorado mule deer herd. Journal of Wildlife Management 36:579–594.

Anderson, A.E., and O.C. Wallmo. 1984. *Odocoileus hemionus*. Mammalian Species 219:1–9.

Anthony, R.G. 1976. Influence of drought on diets and numbers of desert deer. Journal of Wildlife Management 40:140–144.

Bailey, V. 1936. The mammals and life zones of Oregon. North American Fauna 55:1–416.

Bakeless, J. 1947. Lewis and Clark: partners in discovery. William Morrow and Company, New York, 498pp.

Birgressen, B. 1998. Adaptive adjustment of the sex ratio: More data and considerations from a fallow deer population. Behavioral Ecology 9:404–408.

Boroski, B.B., and A.S. Mossman. 1996. Distribution of mule deer in relation to water sources in northern California. Journal of Wildlife Management 60:770–776.

Bowyer, R.T. 1984. Sexual segregation in southern mule deer. Journal of Mammalogy 65:410–417.

Bowyer, R.T. 1991. Timing of parturition and lactation in southern mule deer. Journal of Mammalogy 72:138–145.

Crouch, G.L. 1966. Preferences of black-tailed deer for native forage and Douglas-fir seedlings. Journal of Wildlife Management 30:471–475.

Crouch, G.L. 1981. Coniferous forest habitats: Part 1, Food habits and nutrition, Pages 423-433 in O.C. Wallmo, ed., Mule and black-tailed deer of North America. University of Nebraska Press, Lincoln.

Demarais, S., and P.R. Krausman. 2000. Ecology and management of large mammals in North America. Prentice-Hall, Inc. Upper Saddle River, New Jersey, 778pp.

Flook, D.R. 1970. Causes and implications of an observed sex differential in the survival of wapiti. Report Series Number 11, Canadian Wildlife Service, Ottawa.

Fox, K.B., and P.R. Krausman. 1994. Fawning habitat of desert mule deer. Southwestern Naturalist 39:269–275.

Hanley, T.A. 1996. Potential role of deer (Cervidae) as ecological indicators of forest management. Forest Ecology and Management 88:199–204.

Hazam, J.E. and P.R. Krausman. 1988. Measuring water consumption of desert mule deer. Journal of Wildlife Management 52:528–534.

Hervert, J.J., and P.R. Krausman. 1986. Desert mule deer use of water developments in Arizona. Journal of Wildlife Management 50:670–676.

Hoefs, M., and U. Nowlan. 1994. Distorted sex ratios in young ungulates: the role of nutrition. Journal of Mammalogy 75:631–636.

Hobbs, N.T. 1996. Modification of ecosystems by ungulates. Journal of Wildlife Management 60:695–713.

Julander, O., and J.B. Low. 1976. A historical account and present status of the mule deer in the West. Pages 3–19 in G.W. Workman and J.B. Low, eds., Mule deer decline in the West: A symposium. Utah State University, Logan.

Kie, J.G. 1999. Optimal foraging and risk of predation: Effects on behavior and social structure inungulates. Journal of Mammalogy 80:

Kie, J.G., C.J. Evans, E.R. Loft, and J.W. Menke. 1991. Foraging behavior by mule deer: the influence of cattle grazing. Journal of Wildlife Management 55:665–674.

Kie, J.G., and M White. 1985. Population dynamics of white-tailed deer (*Odocoileus verginianus*) on the Welder Wildlife Refuge, Texas. Southwestern Naturalist 30:105–118.

Kelsall, J.P., and E.S. Telfer. 1971. Studies of the physical adaptation of big game for snow. Pages 134–146 in A.O. Haugen ed., Snow and ice in relation to wildlife and recreation symposium. Iowa State University, Ames. 280 pp.

Kufeld, R.C., O.C. Wallmo, and C Feddema. 1973. Foods of the Rocky Mountain mule deer. USDA Forest Service Research Paper RM-111. U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Loomis, J., M. Creel,and J. Cooper. 1989. Economic benefits of deer in California: hunting and viewing status. Institute of Ecology Report 32, University of California, Davis.

Mackie, R.J., K.L. Hamlin, and D.F. Pac. 1982. Mule deer. Pages 862–877 in J.A. Chapman and G.A. Feldhamer, eds., Wild Mammals of North America—Biology, management, economics. Johns Hopkins University Press, Baltimore, MD.

Main, M.B. and B.R. Coblenz. 1990. Sexual segregation in ungulates: A critique. Wildlife Society Bulletin 18:204–210.

Main, M.B. and B.R. Coblenz. 1996. Sexual segregation in Rocky Mountain mule deer. Journal of Wildlife Management 60:497–507.

McCullough, D.R., D.S. Pine, D.L. Whitmore, T.M. Mansfield, and R.H. Decker. 1990. Linked sex harvest strategy for big game management with a test case on black-tailed deer. Wildlife Monographs 112:1–41.

McNamara, J.M., and A.I. Houston. 1987. Starvation and predation as factors limiting population size. Ecology 68:1515–1519.

ODF&W. 1990. Mule deer management plan. Oregon Department of Fish and Wildlife. Unpublished document.

ODF&W. 2001. Big Game Statistics. Oregon Department of Fish and Wildlife. Unpublished document.

Pond, C.M. 1978. Morphological aspects and the ecological and mechanical consequences of fat deposition in wild vertebrates. Annual Review of Ecology and Systematics 9:519–570.

Robinette, W.L., N.V. Hancock, and D.A. Jones. 1977. The Oak Creek mule deer herd in Utah. Publication 15:1–48. Utah State Division of Wildlife Resources, Salt Lake City.

Robinette, W.L., J.S. Gashwiler, J.B. Low, and D.A. Jones. 1957. Differential mortality by sex and age among mule deer. Journal of Wildlife Management 21:1–16.

Rue, L.L. III. 1978. The deer of North America. Outdoor Life Books. Crown, New York.

Shaw,H. 1965. Investigation of factors influencing deer populations. Pages 125–143 in Wildlife Research in Arizona, 1964. Arizona Game and Fish Department, Phoenix. 251 pp.

Severinghaus, C.W. 1972. Deer weights as an index of range conditions in two wilderness areas of the Adirondack region. New York Fish and Game Journal 2:154–160.

Severson, K.E., and A.L. Medina. 1983. Deer and elk habitat management in the Southwest. Journal of Range Management, Monograph No. 2.

Short, H.L., D.R. Dietz, and E.E. Remmenga. 1966. Selected nutrients in mule deer plants. Ecology 47:222.

Sinclair, A.R.E., and P. Arcese. 1995. Population consequences of predation-sensitive foraging: The Serengeti wildebeest. Ecology 76:882–891.

Smith, B.L., R.L. Robbins, and S.A. Anderson. 1996. Adaptive sex ratios: Another example? Journal of Mammalogy 77:818–825.

Thomas, D.C., and I. McT. Cowan. 1975. The pattern of reproduction in female Columbian black-tailed deer, *Odocoileus hemionus columbianus*. Journal of Reproduction and Fertility 44:261–272.

Urness, P.J. 1981. Desert and chaparral habitats: Part 1, food habits and nutrition. Pages 347–365 in O.C. Wallmo, ed., Mule and black-tailed deer of North America. University of Nebraska Press, Lincoln.

U.S. Bureau of Reclamation. 1992. Biological Assessment of Klamath Project's continuing operations on the endangered lost river sucker and shortnose sucker. Final Biological Assessment of the Mid-Pacific Region's Klamath Basin Area Office, Klamath Falls, Oregon.

U.S. Bureau of Reclamation. 2001. Biological Assessment of Klamath Project's continuing operations on the endangered lost river sucker and shortnose sucker. Final Biological Assessment of the Mid-Pacific Region's Klamath Basin Area Office, Klamath Falls, Oregon. February 13, 2001.

Verts, B.J., and L.N. Carraway. 1998. Land mammals of Oregon. University of California Press, Berkeley.

Wallmo, O.C. 1978. Mule and black-tailed deer. Pages 31–41 in J.L. Schmidt and D.L. Gilbert, eds., Big Game of North America: Ecology and Management. Stackpole Books, Harrisburg, PA.

Wallmo, O.C. Important game animals and related recreation in arid shrublands of the United States. Pages 98–107 in Arid Shrublands, Proceedings of the 3rd Workshop U.S./Australia Rangelands Panel, Tucson, AZ.

Wallmo, O.C. 1981. Mule and black-tailed deer distribution and habitats. Pages 1–15 *in* O.C. Wallmo, ed., Mule and black-tailed deer of North America. University of Nebraska Press, Lincoln.

Wallmo, O.C., and W.L. Regelin. 1981. Rocky Mountain and Intermountain habitats: Part 1, food habits and nutrition. Pages 387–398 in O.C. Wallmo, ed., Mule and black-tailed deer of North America. University of Nebraska Press, Lincoln.

White, M. 1973. The whitetail deer of the Arkansas National Wildlife Refuge. Texas Journal of Mammalogy 15:72.

Wood, J.E., T.S. Bickle, W. Evans, J.C. Germany, and V.W. Howard, Jr. 1970. The Fort Stanton mule deer herd. Agricultural Experiment Station Bulletin Number 567. New Mexico State University, Albuquerque.