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PROCEEDINGS OF THE TRANS-PECOS WILDLIFE CONFERENCE

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Plenary:
Managing West Texas Wildlife

TEXAS PARKS & WILDLIFE'S PRIVATE LANDS ASSISTANCE PROGRAM

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The Wildlife Division of the Texas Parks & Wildlife Department (TPWD) is known by many landowners and land managers in West Texas for its Wildlife Management Areas (Elephant Mountain, Black Gap, Sierra Diablo, Ocotillo), pronghorn permit issuance program, and responsibilities associated with game regulations. Considerably fewer land managers are familiar with TPWD's Private Lands Assistance Program. Through this program, TPWD biologists provide free technical assistance to landowners. Technical assistance may involve deer surveys (helicopter or spotlight), harvest management, wildlife habitat recommendations, cost-share and financial incentive programs, and assistance in applying for a wildlife management tax valuation. The technical assistance may involve a single ranch visit or, depending on the needs of the landowner, assistance may involve repeated ranch visits over several years. With regard to survey activities, the assistance effort is normally conducted on a one-time basis for educational purposes. The land manager is responsible for surveys in subsequent years, although the assisting biologist can continue to provide annual harvest recommendations based upon survey data and harvest records provided by the land manager. Depending on landowner preference, assistance may be in the form of verbal recommendations, written recommendations, or a written management plan.

Prior to entering a ranch and providing technical assistance, biologists must provide the landowner with a form that is to be signed by the landowner requesting assistance. This 1-page form simply provides written permission for the biologist to come onto the ranch and provide the type of management assistance that is of interest to the landowner. More importantly, the form describes (in bold print) a relatively new law enacted in September 1995 that concerns "privacy of information." This piece of legislation (HB 2012) has greatly assisted the landowner, and has indirectly assisted TPWD biologists. The important benefit of this law is that it provides for privacy of information that West Texas landowners value while providing the assisting biologist with a clear mandate regarding any information collected (e.g., survey data) and any plant or animal species observed. More specifically, any information collected in response to a landowner request for technical assistance is strictly "confidential and may not be disclosed." The only time this information could ever be used or released is through written permission by the landowner.

As a Technical Guidance Biologist for the Trans-Pecos, one of my primary responsibilities is providing technical assistance for private landowners across the 16 counties shown on the attached map. Assistance may involve big game surveys, harvest recommendations, maintenance of harvest records, and habitat recommendations that may involve water distribution, grazing management, predator management, supplemental feeding, brush management, riparian management, prescribed fire, and many other practices. In addition to their other duties, local TPWD biologists are available to provide technical assistance in their

areas of responsibility. Some of these additional duties include state wildlife surveys, harvest data collection, regulation development and revision, research, permit issuance, and public education. TPWD Private Lands Biologist, Philip Dickerson (Midland), performs many of these same duties and provides technical assistance on a district-wide basis concerning cost-share and financial incentive programs. These are described in detail in these proceedings in the manuscript "Landowner Assistance Programs for Habitat Improvement." TPWD Wildlife Diversity Biologist, Dave Holdermann (Alpine), provides technical assistance on a district-wide basis concerning rare species of animals and plants. Lois Balin (El Paso) is the Urban Biologist and provides technical assistance regarding urban wildlife issues. She also assists local state and city parks with habitat improvement projects. Mike Hobson is the District Supervisor and is stationed in Alpine.

TEXAS PARKS & WILDLIFE TECHNICAL ASSISTANCE

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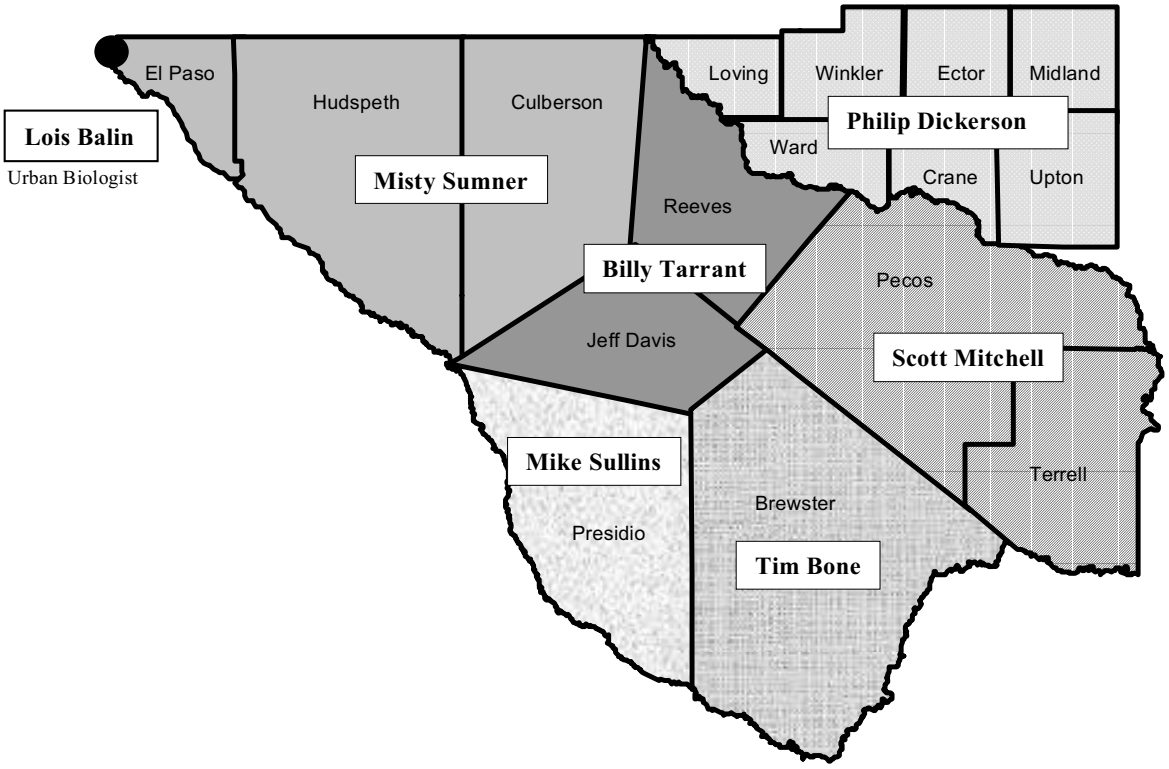

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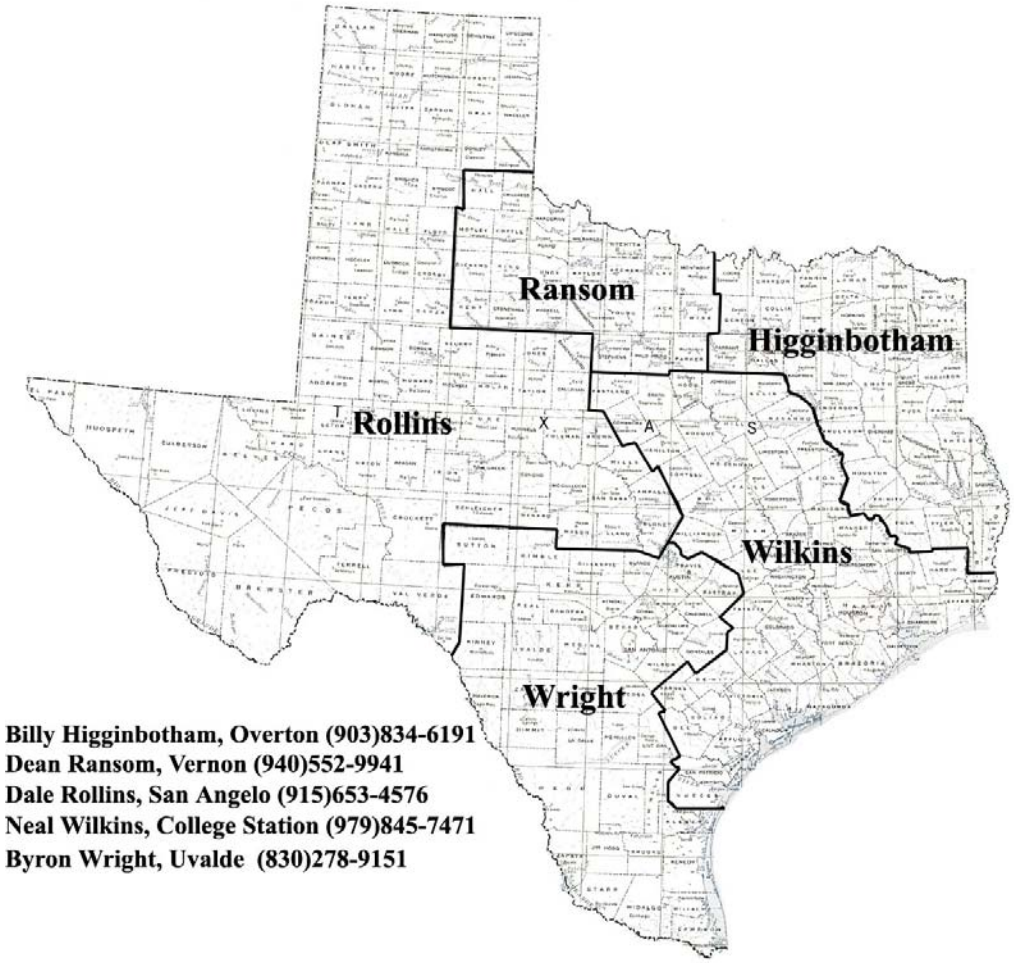

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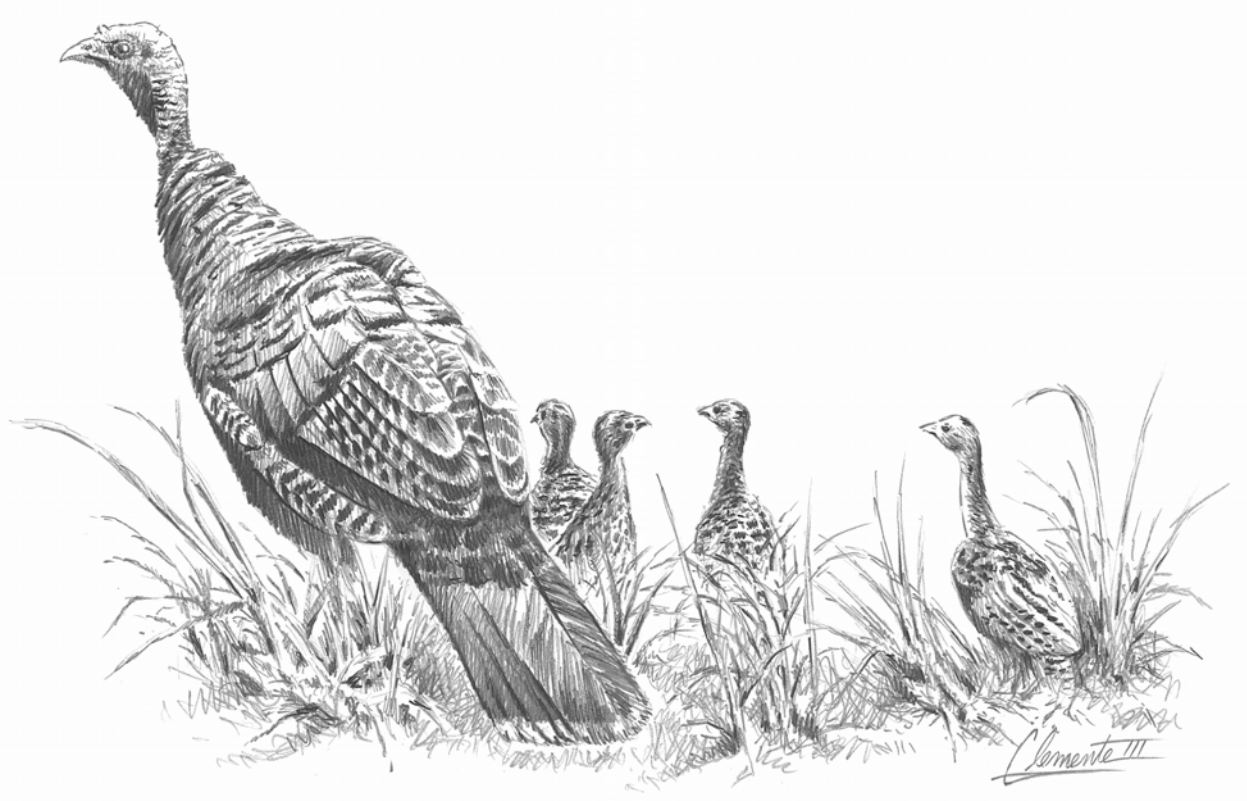

ECOLOGY AND MANAGEMENT OF GAMBEL'S QUAIL IN TEXAS

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The Gambel's quail (*Callipepla gambelli)* is one of three quail species found in the Trans-Pecos Region of Texas. Immediately recognized by its teardrop-shaped topknot (crest), the Gambel's quail is easily distinguished from its Trans-Pecos cousins, the scaled or blue quail (*Callipepla squamata*) and the Montezuma, Mearn's, or harlequin quail (*Cyrtonyx montezumae*). The scaled quail is the only other quail species that typically inhabits the mesquite, acacia, and creosote vegetative community that Gambel's quail call home.

Gambel's quail are found in the Mojave, Sonoran, and Chihuahuan Deserts of the southwestern United States. This includes the drier portions of Arizona, California, Utah, Colorado, New Mexico, and Texas. In Texas, the Gambel's quail is limited to the upper Rio Grande and associated drainages of the far western region of the State.

Adult male Gambel's quail have a gray back and breast, a black topknot, and a boldy colored black and white face. Females are less impressively colored with a gray topknot. Both males and females share dark chestnut flanks streaked with white.

Gambel's quail have a variety of calls they use to communicate with one another. Best known is a unique location call that can be best described as a nasal *chi-CA-go-go*. This sound often can be heard after a covey is flushed and the birds attempt to locate each other. Individuals also make a repeated *chip-chip-chip* sound when alarmed and a loud *squawk* when flushed. Male Gambel's quail also make a loud *kaa* call during April-June, apparently to attract mates. Males often can be seen in a characteristic erect posture, with upright crest, making this call from an exposed perch.

Male Gambel's quail chase each other and fight during the spring in order to establish a system of social dominance. Once pair bonds form, Gambel's quail are strongly monogamous, remaining together throughout the rest of the year. About April, the female lays 1 egg/day in a shallow depression on the ground that is typically concealed by grass until a clutch of 12-14 eggs is complete. The female incubates the eggs for 21-23 days while the male typically stands guard nearby. After the eggs hatch, young birds are up and running within hours. The first few weeks of life are most important for quail chicks. Mortality is typically high during this period due to starvation and predation. Young quail depend on a high protein diet of insects for survival and growth. The sporadic precipitation patterns associated with desert communities do not always guarantee that insects will be available during this critical period. Thus, few chicks may survive the first 4-6 weeks of life. Factors that reduce the availability of insects, such as a late spring freeze, can have a detrimental effect on chick survival. A late first freeze in the fall may allow insects additional time to lay eggs, thus increasing insect abundance the following spring and enhancing quail chick survival.

As they mature, young Gambel's quail begin to eat green leaves and other succulent vegetation and will eventually consume plant matter almost exclusively. Seeds typically make

up about 60% of adult quail diets. However, during periods of drought or when surface water is lacking, Gambel's quail often utilize the more succulent parts of plants. This provides an important source of moisture and minimizes their need for free water.

Coveys of Gambel's quail are typically composed of the parents and their broods that stay together through the winter. However, family groups sometimes combine to form a large covey. Single birds may organize into their own covey or join a family covey. Single birds or pairs are rarely observed during the fall and winter. With arrival of spring, coveys break down and pair bonds begin to form again.

BENEFICIAL HABITAT MANAGEMENT PRACTICES

Gambel's quail require a diverse pattern of vegetation to supply them with various foods they need throughout the year. This is especially true during droughts. In the Trans-Pecos region of Texas, critical periods for moisture typically occur from January-April. Both shrubs and forbs (native broad-leafed weeds) are important components of this vegetation diversity. Based on these characteristics, landowners and managers can implement the following practices to increase Gambel's quail abundance, distribution, and survivability:

- Implement a grazing system that provides planned periodic rest for pastures. Deferred-rotational grazing helps prevent overgrazing of forbs.

- Design fencing to facilitate deferred-rotational grazing. Protect riparian areas with fencing.

- Undertake practices to limit water from running off of property and increase soil moisture. These practices might include dike/levee construction, installation of diversion dams and berms, and gully shaping to hold rainfall and catch runoff.

- Use shallow winter disking on approximately 2-3% of the best quail habitat before the last freeze to stimulate forb production. Disking breaks the soil cap and allows for infiltration of rainfall. This practice should occur only on appropriate soils and topography so that erosion is limited.

- Distribute water facilities as appropriate for livestock, but remember that quail prefer free water at ground level. Some sort of drip or overflow system can allow some water to reach the soil. This will increase forb production and can provide insects during the spring when younger quail need them.

ECOLOGY AND MANAGEMENT OF MONTEZUMA QUAIL

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Abstract: The Montezuma quail (*Cyrtonyx montezumae*) is best known from studies conducted in the extreme northern edge of its range in central and west Texas, southern Arizona, New Mexico and Chihuahua, Mexico. Most of the literature on their life history (i.e., nest success, recruitment, habitat requirements, food preferences, etc.) is 20-30 years old. Montezuma quail are habitat specialists preferring the pine-oak woodlands with an understory of perennial bunch grasses and bulb producing forbs. Long claws facilitate their feeding behavior, which mainly involves digging for a variety of bulbs and tubers. There is a shift in diet from plant to animal (insect) food when insects become abundant after summer rains revive the vegetation. However, this shift in diet occurs only for a brief period (July-August). Montezuma quail have a late nesting season which coincides with the summer rains. These peculiar birds have declined in numbers and range over the past century. Researchers agree that heavy grazing not only destroys their food supply, but also reduces escape and hiding cover. This reduction in cover leaves quail vulnerable to predators and reduces potential quail habitat.

TAXONOMY

The Montezuma quail is a member of the class Aves and family Phasianidae. Members of this family are also called gallinaceous or game birds (Audubon). Male and female average weights are 194 and 175 grams, respectively (Leopold and McCabe, 1957). Leopold and McCabe (1957) also noted that the differential weight of sexes is unusual for North American quail.

DISTRIBUTION

Montezuma quail prefer the pine-oak vegetation zones (Leopold and McCabe 1957). Highest densities are attained in open pine-oak woodlands with an under-story of low shrubs and perennial bunch grasses (Leopold and McCabe 1957). The range of the Montezuma quail (*mearnsi* subspecies) includes the pine-oak vegetation zones of Mexico and extends into portions of southern Arizona, New Mexico, and west Texas (Brown 1982). Arizona's quail population is distributed from the Mexican border north to the Mogollon Rim and from the Baboquivari Mountains east to New Mexico (Yeager 1966). Major populations are located in the southeastern corner of Arizona in the oak woodland and grassland (Lowe 1964). In Texas,

Montezuma quail are found in isolated areas in the Edwards Plateau and Trans-Pecos regions (Albers and Gehlbach 1990).

HABITAT REQUIREMENTS

Pine, oak trees, and the elements of the under-story make the proper habitat for Montezuma quail (Leopold and McCabe 1957). Montezuma quail depend on underground bulbs and tubers for its food and water that are associated with the pine and oak scrub type of habitat. Grass cover taller than 0.3 m is the most critical component of feeding habitat, particularly on grazed land (Albers and Gehlbach 1990). The environmental factor most frequently limiting Montezuma quail is the lack of underground food reserves (e.g., tubers; Leopold and McCabe 1957).

BEHAVIOR

Movements

Initial defense mechanism of Montezuma quail is to ••freeze•• or crouch down and hold tight (Brown 1982). These birds will often flush only after being approached to within 1 m, and then only flush for short distances when adequate cover is available (Stromberg 1990). Leopold and McCabe (1957) observed average flushing distances of <50 m and noted that birds are reluctant to reflush after first flush or if paired up

Daily movements are typically small (15-60 m) for the majority of the year (Stromberg 1990). During midwinter, coveys use small areas (<6 ha), however, in late winter and early spring, coveys occupied areas as large as 50 ha (Stromberg 1990).

Foraging

Montezuma quail are highly specialized in their feeding behavior, which mainly involves digging for a variety of bulbs, tubers, and seeds (Bishop and Hungerford 1965). Their main diet consists of the bulbs of sedges (*Cyperus* sp.) and wood sorrels (*Oxalis* sp.) (Albers and Gehlbach 1990). A typical digging is a hole about 5.08 cm long x 2.54 cm wide x 5.08 - 7.62 cm deep (Leopold and McCabe 1957).

Other plant foods, including acorns and grains from cultivated fields, are consumed. Of these, acorns are the most abundant, nutritious, and available to quail (Leopold and McCabe 1957). Bishop and Hungerford (1965) suggest that the lack of other available food source during the summer forced quail to feed on acorns until the summer rains not only revived the plant foods but also brought forth the insects. Miller (1943) also agrees on the importance of acorns as food for Montezuma quail. Domestic grains are utilized as a food source, but it is not a common occurrence (Leopold and McCabe 1957).

Quail shift their diet from plant to insects when they become abundant. This typically occurs after summer rains, which provides green vegetation (Leopold and McCabe 1957). Leopold and McCabe (1957) noted that from June-August, animal food made up 68% of the overall diet. Bishop and Hungerford (1965) reported 49.7% animal food crop content in birds collected during the summer months in Arizona.

NESTING ECOLOGY

Nesting Season

There are few accounts of Montezuma nests and little information related to nesting ecology (Wallmo 1954). It is known that Montezuma quail are a late-nesting species, which is apparently timed to coincide with the summer rains (Leopold and McCabe 1957). In the range of this species, the rainy season typically occurs from July-August. The majority of the nest hatch during the rainy season (Leopold and McCabe 1957).

Nest Construction

Montezuma quail build nests on the ground. The nest of the Montezuma quail, unlike that of other members of this group, are domed (Leopold and McCabe 1957). The canopied construction of the nests may afford significant protection from the frequent rains during the breeding season. In nests where the canopy is flimsy or not present there is typically a dense over-story of broad-leaved vegetation which possibly serves as protection similar to that of a domed nest (Wallmo 1954). The dome-nest, as well as, the dense over-story may not only serve as protection from the rain, but also as shade (Wallmo 1954).

A scrape is made prior to nest construction. Captive birds (male and female) jointly construct the nest (Falvey 1936). The floor is typically lined with grass of leaves from surrounding vegetation (Leopold and McCabe 1957). Falvey (1936) stated that the hen covers the nest entrance after laying.

Eggs and Incubation

The eggs of Montezuma quail are chalky white in color and similar in appearance to those of bobwhite (*Colinus virginianus*) except that the apex is less pointed (Leopold and McCabe 1957). Leopold and McCabe (1957) also reported that clutch sizes vary from 6-16 eggs with and average of 11.1 eggs/clutch. The late start in nesting limits the possibility of a second nesting (Leopold and McCabe 1957). It is believed that both males and females incubate the eggs. Willard (1913) reported males incubating eggs in half of their nests examined. However, Wallmo (1954) never saw males at the nest. The incubation period, according to Leopold and McCabe (1957) is 25-26 days, which is 1-2 days longer than that of other North American quail.

Broods

Montezuma quail chicks can move at amazing speeds when disturbed, making it difficult to estimate brood size. Leopold and McCabe (1957) reported an average brood size of 8.4 chicks/brood, which is about 3 birds less than average clutch size. However, Wallmo (1954) counted groups in which young could be distinguished from adults and reported an average of 6.6 chicks per brood. Adult weights, defined as weight at the time when the bird is full-winged and in complete first winter plumage, is attained at 10-11 weeks (Leopold and McCabe 1957).

MANAGEMENT

Adequate cover is essential for Montezuma quail survival. This quail's initial reaction to danger is to crouch down and hold tight. This characteristic is highly developed that the quail will resort to crouching down even in the middle of the road (Brown 1982). This defense action

is effective when in cover, however, in the absence of adequate cover, this escape mechanism becomes useless.

Livestock grazing may be a factor influencing the decline of Montezuma. Leopold and McCabe (1957) observed that Montezuma quail declined when overgrazing destroyed their food supply. However, Brown (1982) noted that heavy grazing increased food but still caused a decline in quail numbers and speculated densities declined because heavy grazing reduced escape cover. Southern Arizona also experienced a drastic reduction in quail numbers due to removal of most available forage grasses by grazing animals (Brown 1982).

Apparently, if tall grasses are sufficient but quite patchy with respect to dense woody vegetation then more grass and fewer woody plants both predict feeding habitat (Albers and Gehlbach 1990). In the absence of grazing and the presence of more continuous grass cover, tall grasses are still important year-round but particularly in summer when feeding site selection is especially important. Special attention should be exercised to prevent overutilization of rangelands occupied by Montezuma quail to aide in their survival.

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IMPROVING WILD TURKEY HABITAT ON YOUR RANCH

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Abstract: Wild turkeys (*Meleagris gallapavo sp.*) will respond positively to habitat enhancements across their range. In the Trans-Pecos Region of Texas, Rio Grande wild turkeys (*Meleagris gallapavo intermedia*) benefit from riparian areas and associated uplands that provide sites for roosting, loafing, escape, bugging, feeding, and nesting. Merriam's wild turkey (*Meleagris gallapavo merriami*) require ponderosa-pinyon pine and oak woodlands that afford areas for the same activities. Productivity in both subspecies can be definitely influenced by the quantity, quality, and physical arrangement of natural foods, cover types, and surface water on the land. The use of planned grazing, prescription fire, selective management of brush and timber, and surface water augmentation are key habitat practices recommended to address limiting factors on a prioritized basis. Techniques like supplementation, predator control, and man-made roosts may temporarily increase or concentrate local turkey populations, but should not be viewed as a substitute for restoration and management of high-quality native habitat for wild turkeys and other wildlife.

Wild turkeys (*Meleagris gallapavo)* have historically demonstrated positive response to habitat management that provides for their life requirements across broad landscapes. In the Trans-Pecos Region of Texas, Rio Grande wild turkeys (*M. g. intermedia*) occupy riparian habitats in Jeff Davis, Presidio, and Brewster counties. They are more widely distributed in Pecos and Terrell Counties, with a general increase in numbers from west to east (Richardson 2001). Smaller numbers occur along drainages in Midland, Ector, Upton, and Crane counties. Wild-trapped Rio Grandes have been stocked in locations throughout the region in past years (personal communication, Mike Pittman, TPWD). In Texas, it is believed that Merriam's wild turkeys (*M. g. merriami*) naturally occurred in the Guadalupe Mountains of Culberson County (Schorger 1966), and a small population still exists there today. Merriam's have been introduced into the Davis Mountains (Jeff Davis County) by Texas Parks and Wildlife Department, beginning in 1984 (King et al. 2001). Their distribution seems to correlate directly with ponderosa pine timber occurring at higher elevations (Shaw and Mollohan 1992) throughout their range. To a degree, distribution and density of each subspecies is largely dictated by climate, elevation, topography, and vegetation. However, productivity can be definitely influenced by the quantity, quality, and physical arrangement of natural foods, cover types, and surface water on the land. There is much that wildlife researchers still do not know about the two subspecies mentioned here, especially as related to transplanted Merriam's wild turkey and possible hybridization with Rio Grandes in the region. Therefore, the following information is meant only as a basic primer for persons interested in considering the life requirements of wild turkeys within the context of comprehensive land and wildlife management planning for properties in the Trans-Pecos Region of Texas. As explained during this meeting, direct technical and monetary assistance for wildlife habitat enhancement is available to landowners on a voluntary basis from state and federal resource management agencies.

RIO GRANDE WILD TURKEY

Basic Habitat Needs

Rio Grande wild turkeys prefer large timber typically found along riparian areas for roosting sites, escape cover, and food production (Glazener 1967, Crockett 1973, Richardson 2001). They are adaptable and will readily utilize man-made structures for roosting (Kothmann and Litton 1975) in the Permian Basin and Trans-Pecos. Uplands and riparian areas containing a diverse mix of native grasses, forbs, legumes, insects, cacti, and shrubs are needed by Rio Grandes for loafing cover, escape cover, nesting cover, bugging areas, and food sources (Cook 1973, Porter 1980, Exum 1985). Well-distributed surface water (Davis 1996) is requisite for nesting hens and will help optimize conditions for turkeys in general. Insects are high in protein and very important as food for poults. Insects are also important to nesting hens as a source of calcium, phosphorus, and protein. Seeds of grasses and forbs (weeds), soft fruits, nuts, and acorns are relished as food items (Litton 1977). Agricultural crops located adjacent to other key habitat components (i.e., irrigated alfalfa in a riparian zone) are important where they exist by virtue of being readily utilized by turkeys for feeding and bugging. A natural interspersion (patchy effect) of all habitat components across a property is important in order for turkeys to maximize production in years of more abundant rainfall.

Habitat Management Recommendations

Management of riparian areas to retain and regenerate native timber like cottonwood, sycamore, walnut, western soapberry, and hackberry for use as roosting habitat, loafing areas, and feeding areas is strongly recommended as an excellent opportunity to benefit habitat for Rio Grande wild turkeys in the region. This may require employment of careful grazing schemes that only allow cattle into riparian areas for short periods and provide watering points away from creeks (Leonard et al. 1997). Retention of oaks, larger junipers, and large mesquites in areas immediately adjacent to riparian corridors is advised to provide additional roost sites for adult turkeys and young poults, especially if they contain lower limbs that are largely devoid of foliage (Haucke 1975, Richardson 2001). Careful planning is urged prior to <u>any</u> brush removal around known roost sites. In the case of invasive species like salt cedar (tamarisk), increasing brush densities may degrade the usefulness of the site by reducing ground visibility (>50% canopy cover or >50% visual obstruction at a vertical height of 30 inches above ground). In such a case, careful (surgical) brush management is warranted and recommended.

Retention of fruiting species like oaks, hackberry, walnut, mesquite, persimmon, littleleaf sumac, aromatic sumac, algerita, lotebush, tasajillo, prickly pear, and ephedra during brush management operations is recommended, especially where a natural mosaic effect is created with open grass-forb areas for bugging and feeding (Richardson 2001). Where possible, retention of at least 30% shrub canopy cover in uplands is recommended as a beneficial component of nesting habitat for shading and concealment of turkey hens.

Planned livestock grazing to provide residual herbaceous ground cover of 18-24 inches in height is recommended for optimal nesting cover (Cook 1972) and for production of turkey foods. Research in West Texas has shown that plains bristlegrass, rescuegrass, sand dropseed, panic grasses, Texas cupgrass, wildrye, and vine mesquite are important components in turkey diets. Important forbs in turkey diets include ground cherry, milkvetch, crotons, bladderpods,

and plantains (Litton 1977). Use of moderate stocking rates, frequent rotation of livestock to enable vegetative rest and growth response, or periods of no grazing may be necessary to achieve the desired vegetative effect on a property.

Judicious use of cool-season prescribed fire to stimulate native grass-forb plant communities for insect production (bugging areas) is recommended as a cost-effective management tool, and is very compatible with rotational grazing systems that feature periods of deferment for development of fine fuels. Advanced consultation and planning is advised with an experienced burn professional or land manager at least 1-2 years prior to initiation of burning operations, and pre/post-burn rest periods will be required to achieve the desired effect of this land management technique.

Provision of usable surface water at ½-mile intervals for general livestock and wildlife use is recommended to improve habitability for Rio Grande wild turkeys in the Trans-Pecos, especially to benefit nesting hens (Davis 1996).

MERRIAM'S WILD TURKEY

Basic Habitat Needs

We have a general overview of Merriam's wild turkey habitat needs from work done in the major portion of their range (outside of Texas). They are definitely tied to stands of mature ponderosa pine for roosting and loafing. In the Davis Mountains, they may also use white pine as roost timber (personal communication, Mike Pittman, TPWD). Merriam's turkeys often fly down from the roost into openings located within 50 yards; therefore, most researchers feel that good interspersion of grassy areas is an important habitat feature in all seasons. These birds are very dependent on associations of pinyon pine, alligator juniper, and oaks for feeding (Shaw and Mollohan 1992). Fruiting shrubs like aromatic sumac can be an important seasonal component of their diet. Mixed tree-shrub-grass-forb plant communities have the potential to serve as key areas for loafing, bugging, and feeding due to the availability of grass seeds, forb seeds, insects, and fruits. Merriam's turkey hens tend to nest on grassy slopes steeper than 30% in association with shrubs or a dense stand of low vegetation (Lockwood 1987). Research has shown that some hens return to the same area each year to nest, and that they locate nests on slopes very close to water sources. However, others suggest that a wide range of distances from water is possible (Shaw and Mollohan 1992). Open meadows near nest sites and corridors of timber seem to be important as brood range for young poults and for courtship display by adult gobblers. Usable surface water in the form of livestock water points, spring seeps, creeks, tanks, and man-made water holes is important for Merriam's turkey (Scott and Boeker 1975), especially in the dryer portions of their range.

Habitat Management Recommendations

Merriam's wild turkeys have been studied extensively in Arizona, New Mexico, Colorado, and other northwestern states; however, information on life history and ecology of the bird in Texas is limited (King et al. 2001). Therefore, the following habitat recommendations are tentative and subject to refinement.

Planned timber management treatments to regenerate mature ponderosa pine stands and associated woodlands for roost sites and food sources is critical, especially when this specialized habitat type is so limited in the Trans-Pecos Region. This is not to suggest that a timber harvest may necessarily be needed on a particular property. However, consultation with a trained forester is highly recommended for purposes of forest inventory and development of individual treatment prescriptions. Timber stand improvement (TSI) work with hand crews and prescribed burning may be appropriate to maintain habitat health for Merriam's turkeys by preventing certain areas from becoming excessively brushy.

Retention of mature ponderosa pine timber in clumps, particularly where turkeys are known to roost, at no less than 80 square feet of basal area per acre (BA) would be a general guideline (Shaw and Mollohan 1992). Researchers have found that hens with young poults use areas with much less timber and lower limbs; however, roost abandonment by Merriam's turkeys has also been documented where ponderosa pine was thinned below 73 BA (73 square feet of basal area per acre). On the ground, 80 BA would be approximately 57 trees per acre of a 16-inch diameter at breast height (DBH) in size, or 45 trees per acre of a 18-inch DBH in size. The resulting tree canopy would be partially closed, but still open enough to allow vigorous grass and forb growth which would require periodic management with cool-season fire.

Overall, Merriam's turkey habitat in pine-oak woodlands will generally benefit from treatment with cool-season fire in conjunction with a planned grazing program. In the Davis Mountains, some native grasses possibly beneficial for turkeys that would be stimulated by this type of management would include cane bluestem, sideoats grama, and blue grama. Some beneficial forbs would be Mexican sagewort, bush sunflower, and crotons (King et al. 2001).

Schemnitz et al. (1985) reported that Merriam's turkey hens with broods in New Mexico were strongly associated with earthen tanks during summer, and that watercress was an important food during winter. He emphasized the importance of open spring seeps and aquatic vegetation when other foods were unavailable. According to Scott and Boeker (1975), provision of water throughout drier portion of Merriam's turkey range in Arizona helped productivity and expansion of populations. Therefore, provision of usable surface water at no greater than 1-mile intervals for general livestock and wildlife use is recommended to improve habitability for Merriam's turkeys in the Trans-Pecos Region. Maintenance of natural water sources like springs or seeps in draws or riparian areas is highly recommended.

SUPPLEMENTATION, PREDATOR CONTROL, AND ARTIFICIAL ROOSTS

Landowners seeking to increase wild turkey populations often have questions about the need for supplementation, predator control, and creation of artificial roost sites (for Rio Grande turkeys). Therefore, some brief comments are appropriate here as they relate to an overall planned program of habitat improvement for wild turkeys and other wildlife on a property.

Supplementation

Wild turkeys will respond positively to supplementation in terms of being more visible and concentrated in certain areas, especially in arid regions like the Trans-Pecos. Whether or not this activity will result in net population gains, especially if key habitat components are lacking

over a large area during the nesting season, is a subject of debate among biologists and managers (Richardson 2001). For example, if quality nesting habitat that affords good concealment and screening cover is severely lacking and nest predators are plentiful across a broad area, no amount of supplementation will correct those deficiencies (limiting factors). Well-fed hens will likely be killed by healthy predators while attempting to nest "in all the wrong places." In fact, it is very possible to experience local population declines while spending large sums of money on supplementation, especially in drier climates where vegetation response (for nesting cover and bugging grounds) is heavily-dependent upon rainfall events and historical grazing practices. Landowners are therefore urged to concentrate management efforts on providing all key elements of high-quality habitat on the land, and to prioritize efforts by first identifying what factor(s) may be limiting for turkeys (Miller and Leopold 1992).

Predator Control

Wild turkeys are naturally subject to heavy predation throughout the year. There is no doubt that populations can be locally suppressed when nest predators like skunks, raccoons, opossums, snakes, bobcats, feral cats, coyotes, and feral hogs are able to exploit habitat deficiencies. Owls can be very effective in preying upon poults at night on the roost. However, while effects of predation on wild turkey populations is not yet fully understood, studies have shown that the birds have generally maintained good productivity in regions where high-quality habitat is maintained across broad landscapes (Miller and Leopold 1992).

Artificial Roosts

Landowners planning to develop man-made structures to provide roosting sites for Rio Grandes may instead wish to consider establishment of "pole plantings" with native willow and cottonwood stocks (Leonard et al. 1997). Suitable conditions for this restoration technique will not exist on every property; however, landowners are encouraged to contact local resource management personnel for information on techniques and persons having expertise with this practice in the Southwest.

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PANEL DICUSSION: CAN WE MAINTAIN BLUE QUAIL NUMBERS DURING DROUGHT?

Participants:
A. J. GALINDO, McElroy Ranch (Chevron-Texaco)
SHERMAN HAMMOND, Hammond Ranch Company
PETER BRIGHT, Double U Ranch
C. B. WATTS, Blue Diamond Ranch

McELROY RANCH: A. J. Galindo

The McElroy Ranch is about 87,000 acres and was acquired in 1990 by Chevron U.S.A. (now Chevron-Texaco). The McElroy Ranch is located immediately east of Crane, primarily in Upton County with a small portion in Crane County. We don't have a wildlife manager or biologist, and we don't have a budget designated for wildlife management or habitat improvements. We have mule deer, white-tailed deer, aoudads, javelinas, feral hogs, Rio Grande turkeys, blue quail, bobwhite quail, mourning doves and a few white-winged doves. We don't lease any hunting privileges but allow employees and special guests to hunt. Our quail numbers fluctuate from year to year, but we have been able to maintain good to excellent bird numbers during the prolonged drought that has extended over almost a decade on the McElroy Ranch.

Livestock Operation

We lease grazing rights primarily for the production of cattle. A limited number of Spanish goats are grazed in the pastures near the ranch headquarters. The ranch is operated under a deferred-rotation grazing system. The cattle are normally stocked conservatively at 8 animal units per section. Because of extended drought over the past 7 or 8 years, most of the ranch is stocked at 4-5 cows per section to insure adequate nesting cover and prevent damage to the forage plants.

Water Distribution

When we acquired the property in 1990, there were relatively few watering sites on the ranch, and several of those present were in need of considerable maintenance. Over the past 10 years, we established 20 new water wells, installed 30 water storage tanks, 40 new water troughs, constructed 30 earthen tanks, and laid 20 miles of new water line. There are 9 water pumps and 25 windmills on the ranch.

All water sources are maintained regularly. The additional sources of water have been a tremendous benefit to quail and other wildlife species on the ranch. Livestock watering sites have been enhanced to benefit quail and other wildlife by the development of numerous earthen tanks adjacent to water troughs. Some of the earthen tanks have been fenced to prevent trampling of the banks and to encourage growth of weeds and grass (nutritious greens and insects). Where we don't have earthen tanks, we often have a windmill or trough overflow (wet area that grows green grasses and weeds and supports insects). On some remote areas of the ranch, where we don't have windmills or access to electricity, we have installed 7 solar-powered pumps to provide permanent wildlife water.

Rangeland Restoration

We are trying to renovate some of our "badlands" (areas of capped soils, pure stands of creosote or tarbush where the grass has been lost). We are trying to get some rainfall infiltration by developing berms and rangeland ripping along the contour. This slows down the runoff, allows infiltration, and has started some grass and weeds growing. We have seeded some of these areas while on other areas, we allow the natural "seed bank" in the soil to begin the germination process. Chevron has constructed approximately 90 miles of fencing on the McElroy Ranch over the past 10 years to improve grazing distribution of cattle. This allows the grazing lessee to rest various pastures and allows for recovery of desirable forage plants.

Supplemental Feed/Food Plots

A minimal amount of supplemental feed (milo, corn, and scratch) is provided for quail and doves during times of stress (no feeders, just distributed by hand). Small food plots have been established in the deeper soils adjacent to the earthen tanks. Some plots have been planted with cool-season plants such as wheat and/or oats while others are planted with warm-season seed-producers such as sunflowers and sorghum. The food plots are fenced to exclude livestock and some are irrigated in the event of severe drought.

When well sites are abandoned, we remove the caliche, bring in top-soil, and seed these areas with grasses and forbs that will benefit quail and other wildlife. In the driest years, we don't get anything to germinate, but with the new topsoil, they provide pretty good quail feeding areas with just a little rainfall.

Chevron-Texaco leases surface rights to several petroleum companies. When surface damages occur, the responsible company must compensate us for the cost of the damage incurred. Rather than accepting direct monetary compensation, we incorporate habitat enhancement practices in the bio-remediation agreements such as earthen tanks, fencing, food plots, etc.

Brush Management

We cooperate with Texas Parks & Wildlife and the Texas Cooperative Extension by installing demonstration plots for educational purposes. Some of these involve herbicide brush control while others involve mechanical brush control and grass restoration. At the same time, I use these same guys for assistance and I bounce my habitat improvement ideas off of them to get their perspective.

We work with Texas Parks & Wildlife, NRCS, and the Cooperative Extension Service to develop many of the practices that benefit livestock, quail, and other wildlife. We're interested in quality habitat and wildlife diversity but implement specific management practices for blue quail and other wildlife species.

HAMMOND RANCH COMPANY: Sherman Hammond

The Hammond Ranch is located in Pecos County , Texas between Fort Stockton and Alpine. It is approximately 33,000 acres.

Grazing Program

This ranch is a cow-calf operation. For the last 25 years, it has been historically lightly stocked. We have been in this drought since 1991. As of right now, we are stocked with 150 cow-calf pairs, and 60 2 year old heifers, and bulls. Before 1991 I felt as if I could run 10 animal units per section.

Water System

In 1979 we started an extensive water system program over the entire ranch. We have 40 water troughs, 26 earthen tanks (dirt tanks) , on the ranch that we pump water to that never go dry. Let me tell you, that in the last few years, we have had to pump a lot of water. These dirt tanks are supplied by an extensive pipeline system from 2" to 4" size pipelines. One thing that I think that is very important is to keep the water troughs full all the way. It doesn't hurt to let them run over some. This makes for a safe place for the birds to water.

Brush Types

The brush types on this ranch consists of mesquite, blackbrush, greasewood, catclaw, and a small amount of prickly pear.

Management Practices

In 1979 we started building diversions and food plots over the entire ranch to slow water down and also to try to stop some erosion. When it rained, all the water ran down the road like a river. We started putting humps or diversions in the road to divert water out of the roads and onto the pasture. Little did I realize what I was creating. Those areas where I was getting the material for the humps turned into food plots for quail. When we finished with the roads, we moved out into the pastures, and everywhere we find a wash, we build a diversion. We have literally built thousands of these things. When it rains, these areas are the first to green up and the last to dry up.

I think water--lots of water is very important in raising quail. I know everyone has seen quail a long way from water, but if you come to my place and wanted to see quail, I would take you to water.

Dry Years

In dry years and hard times, I try to treat quail like I would my cattle. If you are feeding your cows; then you need to be feeding your quail. Especially in cold icy conditions, and in March, April, and May when it is so hard. During dry years, if we don't have a good bird crop--we don't hunt! We save adult birds for breeding stock. We have also documented, and banded roosters that we know to be 5 years old.

Feeding Quail

I don't have quail feeders because I believe they just draw predators. I buy milo and spread it on all of the roads with a large 4-wheel fertilizer spreader that I pull behind my pickup. At about 15 mph, it will sling that milo 70' wide out into the brush so quail will be safer from predators.

Predator Control

We have a full time trapper for coyote and bobcat for approximately 8 years. I don't know what effect it has had on the quail, but we are having very good fawn crops again.

Management Practices Compared To Adjoining Properties

In good years, neighbors will have quail; we will have lots of quail. In bad years, neighbors no quail; we still have quail. I think the number one problem is overgrazing and predator problems.

Quail Survey

We did a 2 year quail study that was completed around 2 years ago. This was done through Dr. Dale Rollins. We learned a lot about blue quail that we didn't know. We have just started a 5 year study, "Texas Quail Index", that is going to be very informative. Some of the things we learned from the 2 year study was that 90 plus % of nests located were in tabossa grass. Their favorite loafing area is underneath catclaw. Not many predators can get a bird in catclaw. I strongly recommend not to eradicate catclaw.

Special Hunting Practices

Number 1--we abide by the laws.

Number 2--we don't try to harvest every bird in a covey.

Number 3--we age all birds harvested to determine the percentage of juveniles to adult birds.

Additional Information

I am very interested in the New Mexico Quail Study of Dr. Rollins to see what effect icy, cold conditions have on quail. In October 2000 we had cold, icy, freezing conditions in West Texas for several days. There was a big die-off during this period of time. I talked to people from Big Spring to Black Gap, they all said the same thing.

DOUBLE U RANCH: Peter Bright

The Double U Ranch is located in north Hudspeth County and is approximately 115,000 acres. It is located in a transition zone between two ecosystems-- short grass prairie and Chihuahuan desert. It is best known for its pronghorn antelope (the all-time State record and numerous Boone & Crockett bucks have been taken there), but the ranch also supports huntable populations of desert mule deer and scaled (blue) quail. We have been in a drought for so long that I've forgotten what our average annual rainfall is, but I suspect it is 10-12".

The ranch is a cow-calf operation and has historically been lightly grazed, particularly during drought years. The ranch has a series of troughs (drinkers) and tubs scattered throughout

the ranch. Water is maintained in the drinkers even when there are no cattle in the pasture. In addition, there are dirt tanks that seasonally catch water. The areas of the ranch that support quail consist of sacaton grass, prickly pear, tasajillo, cholla, mesquite, mountain mahogany, broomweed, lotebush, javelinabush and other typical Chihuahuan flora.

Supplemental Feeding and Predator Control

We have 42 feeding stations throughout the ranch and provide Purina® quail blocks for the birds on a year 'round basis. In addition, we are experimenting with a gravity flow feeder and are utilizing Purina® game bird conditioner in it (100# per month). We typically feed between 200-300 quail blocks in a year. The amount depends strictly on demand. During a drought, the utilization of the feed blocks increases.

We began experimenting with supplemental feeding of the quail with the hope that we could mitigate the damages of a drought and are convinced that it is effective. Supplemental feeding of quail in other areas or with different species, e.g., bobwhites, may or may not be beneficial on a long-term basis. In a Chihuahuan desert environment, especially during a drought, we are convinced that it is beneficial. In 2001, for example, our coveys were not as large as in the year 2000, but the number of coveys was the same. On some of the neighboring ranches in 2001, scaled quail were very hard to find. The difference, I believe, is the quality and consistent availability of the supplemental feed. In addition to the supplemental feeding, we have maintained a predator control program on the ranch for many years. The impetus for the predator control program was to enhance our pronghorn antelope and mule deer, but the spill-over effect has been to give the quail a little breathing room as well. The coyotes, foxes, bobcats, skunks and badgers that are caught in the traps will not eat any eggs or quail.

Wildlife Surveys

Our surveys of quail on the Double U are informal but thorough. We are in the field either hunting or servicing feeders all year long and are looking for quail while doing so. In addition, I hunt quail on the Double U (as do most of the guys on the lease) at least once a week every week during our 4-month quail season and am well-aware of our numbers of birds, numbers of hatches, etc.

Hunting Program

All of our bird hunting on the Double U is over pointing dogs. Hunters are not permitted to shoot birds on the ground or any other unethical practices. In a "wet year" we have a self-imposed limit of 10 birds per day per gun. In a dry or tough year, that daily limit may be 5 or 6. Our focus is to shoot birds over points and to hunt with dogs that we have personally trained, not "body counts."

Concerning information that can help us to better manage quail on the Double U, we are very interested in the research project that Dr. Rollins is currently conducting on the Armendariz Ranch in southern New Mexico and believe it may offer some concrete and constructive management practices for our area.

BLUE DIAMOND RANCH: C. B. Watts

The Blue Diamond Ranch is 13,200 acres and is located in Brewster County, 28 miles southeast of Marathon. The long-term average rainfall is about 12 inches. We've had relatively high numbers of blue quail for the past 6 years, despite the persisting drought conditions. We don't do anything fancy -- we are allowing the habitat to recover, provide lots of water and food, and are careful about how we harvest the birds. As a side note, during this same time we have seen a tremendous increase in the number of mourning dove and white-winged dove.

Habitat Types

Most of our country is low-elevation Chihuahuan scrub or chaparral. The vegetation consists of sotol, lechuguilla, mesquite, yucca, and creosote intermixed with grama grasses. There is a little redberry juniper scattered across the ranch, especially on the ridges. Some of the more productive areas are the dry creeks and draws which support desert willows, cottonwoods, sumacs, redbuds, whitebrush, and few oak species. We see quail coveys on all upland habitats with considerably less use of the draws and drainages.

Grazing Program

Prior to 1994, there was a herd of 125 cows, 125 calves, and a bull grazing on the south side of the ranch; the range condition was fair to poor. Early in 1994, we removed all livestock from this side of the ranch. Approximately 45 head of livestock continued to graze on the north side of the ranch until 2001. In 2001, because of poor range conditions, all cattle were removed from the north side of the ranch. At the present time, there are no livestock on the ranch. We applied for and were granted a wildlife tax exemption.

Water System

In 1996 we completed an extensive water system on the south half of the ranch. The system consists of 14 miles of water line and 17 watering locations (~ 1 watering site for every 380 acres). In 1998 we constructed and installed 4 small water guzzlers (operate from rainfall and hauled water). The watering locations are wildlife friendly and are accessible to quail, doves, songbirds, and small mammals. The water system now consists of 21 water locations on 10 sections (approx. 1 water location for every 300 acres).

A water system is planned for the north side of the ranch; however, it may be several years before it is completed. At the present time, there are 5 water locations on the north side--3 of 5 water facilities are the small guzzler type drinkers. Wildlife numbers on the north side are considerable lower than on the south half of the ranch. In 1996 the quail population was fair to good on the north side but has been poor since that time. Since the livestock were removed in 2001, there has been little improvement in rangeland conditions. It is interesting that we placed feeder locations throughout the north side, but we did not develop watering sites in association with these feeders. We have not seen an improvement in the quail, dove, or songbird population.

Feeding Program

In addition to our water system and grazing deferment (which is helping us to produce more food and cover for quail), we conduct a feeding program for quail and other wildlife. We provide feed for all kinds of wildlife but emphasize blue quail and mule deer. The feed ration is

provided in free-choice feeders and is a mixture of deer cubes (3/8"), corn, and milo. We also have constructed and installed numerous ground-level feeders strictly for birds. At these locations we place quail blocks and have constructed structures that allow birds access but prevent larger animals from getting to the feed blocks. Most of the feeding locations are on the south side of the ranch. In addition, the feeding sites have been placed in association with water locations.

Quail Surveys

We conduct informal surveys on a regular basis. These surveys relate more to location than numbers. The information is used to determine future feeding and water locations. In the future, we will use this information for habitat enhancement.

Effect of Drought

We understand that rainfall (or lack of it) has an influence on quail production; however, we believe that snow and severe cold can affect our quail numbers even more. In the year 2000, we had a severe and lengthy hard freeze. Up to that time, our quail numbers were high. After the long freeze in October, our quail numbers fell off significantly.

Predator Control

We have a predator management program that includes leg-hold traps, snares, and calling. Our program is focused on lions, coyotes, bobcats, and foxes. When we are "calling," we usually set up around feeding locations. This is an attempt to catch any predator that is working one of our feeding locations. We probably should include raccoons and skunks in our management program. We recognize that roadrunners are protected, but our personal observations indicate that they may be preying on quail chicks.

Hunting Practices

We do not hunt quail until February. In November we survey bird numbers, and at that time we determine how we will hunt in February. We continue to survey through January and make our final decision in late January. Our final decision is based upon the loss of birds due to severe weather conditions.

We do not hunt quail in November specifically because we still have young immature birds. December and January is used as a period of maturity and covey enhancement. In addition, we refrain from hunting until February because we feel that our deer are still in rut in January. We try to minimize disturbances to our mule deer during the breeding season.

While hunting as a group, we never shoot a covey to depletion -- partially because of lack of shooting skill, but mostly by choice. Of course, we stay within legal bag limits -- which, again, would be difficult to exceed because of the shooting skill that we display!

Big Game Management

FACTORS AFFECTING PRONGHORN ANTELOPE POPULATIONS IN TRANS-PECOS, TEXAS

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***Abstract*:** The primary factors influencing pronghorn antelope (*Antilocapra americana*) numbers in the Trans-Pecos at present are drought, overgrazing, barriers to movement, and degradation/loss of suitable habitat. Because these primary problems are generally prevalent throughout the region, predation (especially by coyotes) can be a limiting factor in pronghorn population growth. Drought and overgrazing have major impacts on nutrition, fawning cover, and quality of habitat. Barriers (i.e., fencing) can have a critical effect on nutrition, impede access to water and cover, and increase susceptibility to predation. Long-term changes in vegetation composition and structure adversely impact antelope populations by reducing or degrading suitable habitat and increasing vulnerability to predation. The combined cumulative effect of these factors (and possible others) has lowered the capacity of pronghorn range in the Trans-Pecos to support high numbers of animals at present. The quality and quantity of habitat available ultimately dictates the vitality and viability of antelope populations and is the prevailing influence over all adverse factors that impact population growth. Under favorable habitat conditions, pronghorn populations can increase rapidly.

Population fluctuations and the vast majority of population declines in native herbivores are the result of complex interactions of known and unknown variables. It is hypothesized that variations in climate, forage availability, predation, and habitat physiography are the major ecological selective pressures that have acted on the evolution of the pronghorn. (Bromley 1978) (Wilson 1975). Pronghorns have evolved keen eyesight and speed as defenses against predation, and require open, flat to rolling expanses where vision and movement are not obstructed. Pronghorn antelope are highly sensitive to environmental changes that inhibit defensive adaptations, restrict movements, or alter seasonal availability of forage and cover. Pronghorns are highly adapted to grassland/prairie ecosystems, and do not tolerate profound changes in their environment.

At the onset of the twentieth century, pronghorn occurred over all of Texas west of the 97th meridian (excluding the Hill Country of the Edwards Plateau). Their range encompassed approximately 72% of the state (Leftwich, Simpson 1978a). Pronghorn numbers in Texas were estimated to be as many as several million animals in the late 1800's (Bailey 1905) with the highest densities in the Trans-Pecos and Panhandle regions.

Today, pronghorn distribution in Texas is limited to remnants of former range in the High Plains, Rolling Plains, and Trans-Pecos regions. The highest numbers in the Trans-Pecos this century occurred in the 1980's with an estimated population of 17,000 pronghorn. Currently (2001) the estimated population is about 5,000 animals. The historic decline of pronghorn is

directly attributable to human activity. Anthropogenic pressures on both the animal and its environment have extirpated the pronghorn from three-quarters of its former range in Texas.

PRECIPITATION AND DROUGHT

The major annual limiting factor for pronghorn production and carrying capacity in the Trans Pecos is the timing and amount of rainfall received during the August-October period. Trans-Pecos rainfall data and population estimates indicate a direct relationship between the rainfall received during the August-October period and pronghorn survival over winter and early spring. The most stressful months of the year for antelope are February and March, when forage conditions are poorest. If late summer and fall rains are insufficient to produce adequate forage for the winter months, winter mortality is often high. Bucks that need to recover body condition after the breeding season will be susceptible to starvation. Fawn production is reduced when sufficient winter forage is not available. Antelope does that have been bred may resorb the fetus or produce single offspring when winter and spring forage conditions are poor. Below average late summer/fall precipitation also translates into insufficient fawning cover in late spring and early summer. Twelve to eighteen inches of herbaceous vegetation is required to adequately hide fawns from predators. Without adequate fawning cover, fawns are highly susceptible to predation. Low antelope fawn survival results in few replacement animals to antelope herds, suppressing population growth.

Winter/spring losses resulting from malnutrition are the greatest cause of annual population fluctuations of pronghorn in the Trans-Pecos. Successive years of below-average rainfall (drought) during the late summer/fall period can decimate populations. When drought conditions occur, the carrying capacity (amount of individuals the range is capable of supporting) is decreased. Land managers can remove, reduce, or feed livestock when conditions dictate. Pronghorns must use what is available, and when enough forage is not available, surplus animals die. Pronghorns will take supplemental feed, but the animals must be conditioned to take it. When the animals are already starving, it is usually too late.
Supplemental feeding should be considered for January-March when below average precipitation is received in the August-October period. Antelope population declines during drought conditions are the result of natural de-stocking of the range. Under favorable conditions, pronghorn populations can increase rapidly.

AVAILABLE WATER

Pronghorns require readily available water. Daily water consumption is about 1-2 gallons per day dependant upon conditions such as temperature and availability of succulent vegetation. The majority of current antelope range in the Trans-Pecos has good water distribution because most ranches have well-developed livestock watering systems. However, waters often are not maintained when pastures are de-stocked or deferred from grazing. Care should be taken to insure watering sites are maintained in all pastures to provide sufficient water for antelope on a daily basis. Ranch operations should include breaking ice on frozen troughs during extreme cold weather. Prolonged periods of cold weather put extra stress on pronghorns, especially when water is not available. Meeting the water requirements of pronghorns is critical to the proper management of the species and full utilization of available habitat.

ARTIFICIAL BARRIERS TO MOVEMENT

In the Trans-Pecos, artificial barriers consist of fences, railroad right-of-ways, highways, roads, municipalities, and areas of cultivation. Sheep-proof fencing can effectively restrict pronghorn movement and ultimately reduce viability of populations. There is ample evidence that barriers to movement have deleterious effects on pronghorn antelope populations. Pronghorn herds are susceptible to die-offs when the ability to move to better range or to water is restricted by fencing (Passey, Hicks 1970). In Wyoming, antelope killed themselves attempting to cross sheep-proof fences to reach water on adjacent range (Baker 1953). Although pronghorn in the Trans-Pecos do not migrate in the conventional sense (Autenreith 1978), movement from summer-fall range to winter-spring range and from dry to wet (green) areas is critical to survival (Hailey 1979). Anecdotal information suggests artificial barriers increase losses to predation.

Net-wire fencing and sheep-proof barbed wire fencing are relics of past large-scale sheep operations. Much of the present Trans-Pecos antelope range was once stocked with sheep but now cattle production is the primary use. This change in livestock operations eliminates the need for net-wire fencing on most ranches. Sheep-proof fencing continues to present serious obstacles to the free movement of pronghorns. Pronghorn can and do jump fences; however, they are appear extremely reluctant to do so, and typically will not jump fences even when pressured. In the Trans-Pecos, where not restricted by sheep-proof fencing, pronghorn moved up to 10 miles and movements appeared to be related to weather, fawning sites, and available forage (Buechner 1950). Pronghorn require a larger range in degraded habitat than pronghorn occurring in more optimal habitat. Female movements are more extensive than males, possibly because of greater nutritional demands, especially during lactation (Canon, Bryant 1997). Hailey (1979) recorded that for three consecutive years (1969-71) the average annual movement of pronghorns under study in the Trans-Pecos was approximately 2 miles and the maximum movement approximately 6 miles. Restriction of these movements during critical periods has resulted in periodic die-offs (Hailey et al. 1966) (Hailey 1979). According to a 1989 TPWD landowner survey, > 80% of ranches in the Trans- Pecos with suitable pronghorn habitat are fenced wholly or in part with net-wire fencing. (Clark 1989). Most net-wire fences in the Trans-Pecos are >30 years old and have deteriorated to a degree that allows some passage, or have been replaces with barbed wire.

The possibility that fences may work in favor of predators is real (Nelson 1925) (Knowlton 1968). Pronghorn antelope use eyesight and speed to evade predators. When the ability to run away at top speed is diminished by fencing, predators may gain an advantage. Fences that do not permit easy passage may help predators ‘corral’ their quarry (antelope-friendly fences should have the bottom strand of wire at least sixteen inches off the ground). Pronghorn may be more susceptible to ambush by predators when forced to use small passages in sheep-proof fence in order to move to adjacent pastures. Providing for free movement would likely mitigate the severity of losses during stress periods. Sheep-proof fences can be readily modified to permit passage by antelope without compromising the integrity of the fence for cattle.

HABITAT LOSS

Conversion of grassland and mixed prairie to brush or shrubland in the Trans-Pecos may be attributed to a combination of factors and variables; land-use practices, changes to historic fire regime, soil erosion, and possible long-term regional climate change (among other possible factors). As brush encroaches on grasslands and increases on mixed prairie, foothills, and in drainages, the habitat becomes less suitable to pronghorns. Pronghorn require open cover, grassland or mixed prairie interspersed with low shrubs where vision is not restricted by terrain or vegetation. Undulating topography, draws, and hills are also essential pronghorn habitat components in the Trans-Pecos affected by increased brush densities. Care must be taken when considering a brush control project, however, as removal of some heavily utilized browse species, particularly cane cholla (*Opuntia imbricata*) or prickly pear (*Opuntia* spp.) can significantly reduce the carrying capacity of the range for pronghorn.

GRAZING PRACTICES

Competition between antelope and cattle under normal conditions is marginal. Pronghorn typically utilize a small percentage of grasses in their diet. Pronghorn and cattle have little dietary overlap except on overgrazed rangeland (McKinnis and Martin 1987) (Schwartz and Nagy 1976). The degree of competition greatly increases when grasses are depleted and cattle begin heavy utilization of forbs and browse. Pronghorn can benefit livestock by eating forbs that are either poisonous to livestock or not palatable, such as groundsels (*Senecio* spp.), paperflower (*Psilostrophe* spp.), locoweeds (*Astragalus* spp.), and dogweeds (*Dyssodia* spp.). Livestock grazing has altered the type, quality, and composition of plant associations on most rangelands in the Trans-Pecos (Leftwich and Simpson 1978b).

When not severe, overgrazing by cattle may have little effect on pronghorn (Buechner 1950) and may be beneficial. Pronghorn are thought to do best in sub-climax plant associations where a greater variety of forage species may exist. Antelope co-evolved with large herbivores (bison, elk) and probably benefited from the relationship. Cattle production and pronghorn are compatible when proper grazing management is practiced. Long-term heavy stocking rates in arid and semi-arid climates can be detrimental to pronghorn by contributing to the conversion of grassland and mixed prairie to shrubland, eventually reducing suitable habitat available to pronghorns. Degradation and loss of suitable pronghorn habitat has impacted populations in the Trans-Pecos since the advent of large-scale grazing into the area.

Competition between antelope and sheep is severe and usually results in the loss of antelope where they occur together (Hailey 1979). Where confined by sheep-proof fences in heavily grazed sheep ranges, pronghorn are reduced to remnant populations or are eliminated within a few years (Buechner 1950). Heavy sheep grazing eliminates forbs that are necessary for pronghorn survival. Sheep may also disturb fawning sites (Einarsen 1948).

Good fawning cover is critical to fawn survival. Lack of sufficient fawning cover greatly increases possibility of fawn mortality by predation. Fawning cover usually consists of herbaceous vegetation (mid and short grasses such as sideoats grama, cane bluestem, green sprangletop, blue grama, black grama, and tobosa with few shrubs). As overgrazing occurs,

fawning cover is diminished. Pronghorn choose fawning sites where grasses are tallest. Fawning sites are typically located at the foot of low ridges and on the lower slopes of foothills adjacent to flats (Tucker and Garner 1983). Pronghorns also use shallow, wide draws where grasses are tallest. Landowners and managers should try to identify such areas and protect these areas from over utilization prior to fawning and if possible, exclude cattle during the fawning period (May-June). Proper management of fawning areas increases fawn survivorship during the most vulnerable period of the pronghorn's life (parturition to 4 weeks of age). Pronghorn does seek areas with good fawning cover prior to parturition and remain in these areas until fawns are capable of evading predators by flight (4-6 weeks). Cattle use of prime fawning areas during fawning season can pressure pronghorn does to select less suitable sites for fawning grounds. Use of sub-optimal fawning sites greatly increases the fawn's susceptibility to predation (Tucker, Garner 1983).

PREDATION

Predation is considered by many to be a major limiting factor for pronghorn and a major factor influencing population fluctuations in the Trans-Pecos (Einarsen 1948) (Hailey 1979) (Arrington and Edwards 1951) (Buechner 1950). The major influences on the degree of mortality attributable to predation are: (1) prey species abundance, and (2) quantity and quality of habitat available to prey species (Autenrieth 1978). The importance of predation as a limiting factor increases as habitat quality declines. Predation can have a greater influence on populations than other factors when habitat conditions are poor.

Marginal habitats will likely have the highest mortalities from predation. Under favorable conditions, pronghorn populations can increase rapidly but fawn mortality is still usually high, with most losses attributable to predation. In the Trans-Pecos region of Texas, fawn mortality was 90 percent (18 of 20 radio-collared fawns), with all deaths attributed to predation (Canon and Bryant 1997). Coyote (Canis latrans), bobcat (Felis rufus), mountain lion (Puma concolor), and golden eagle (Aquila shrysaetos) are important pronghorn predators in the Trans-Pecos (Yoakum 1980). Of these, coyotes are by far the major predator impacting pronghorn numbers, mostly fawns, especially newborns, with documented predation on adults less common (Hailey 1979). Bobcats are probably responsible for some losses, and mountain lions and eagles to a much lesser extent (Goodwin 1976) (Ockenfels 1984).

The effects of predation are obscured by other factors affecting pronghorn numbers, and requirements needed to establish cause and effect between predator densities and pronghorn densities are not well met in the literature. The correlation between climate conditions and population fluctuations is much closer to a cause and effect relationship than that of predation and population variations (Buechner 1950). Pronghorn antelope co-evolved with predators and have adequate defenses to cope with predation under normal conditions. Quantity and quality of habitat available, barriers to movement, and competition with livestock are the major determinants of the effects of predation on pronghorn in the Trans-Pecos.

Intensive coyote control can enhance fawn survival, especially when pronghorn populations are low (Buechner 1950) (Arrington and Edwards 1951) (Udy 1953) (Knowlton 1968) (Hailey 1979). When habitat conditions are such that predation has a greater influence

than other factors and predation is isolated as a major limiting factor suppressing pronghorn numbers, predator control may be considered. However, before any control program is initiated, these considerations and guidelines from Autenreith (1983) should be taken into account and followed:

Considerations

Predation is only one of many factors known and unknown that influence population trends; consider other influences on populations; predator control is not a panacea for all the problems in pronghorn management; predator control is seldom intensive enough or widespread enough to actually control predators, and compensatory reproduction, immigration, removal of dominant animals, etc. may result in more predators than when control was initiated; each herd of pronghorn is governed by known and unknown controls endemic to that herd and the habitat in which it lives; and most importantly, *the quantity and quality of habitat is the* ***overriding*** *influence on all adverse factors, including predation.*

Guidelines

Determine desirable herd parameters (total numbers, recruitment, herd age structure, etc.); determine population distribution year-round and habitat types used; consider cost to benefit ratio; if increase in numbers justifies cost, control should be practiced on herd units where documentation dictates predator reduction would meet management objectives; data on pronghorn and predators in control areas should be collected prior to, during, and after control efforts.

PARASITES AND DISEASE

The arid and semi-arid climate of the Trans-Pecos helps to prohibit the spread of disease and abundance of parasites. No evidence of brucellosis, leptospirosis or infectious bovine rhinotrachitis has been found in pronghorn in Texas. Hepatic fatty cirrhosis, common in livestock, has been found in pronghorn in the Lower Plains region. This disease is not fatal to antelope, but in combination with poor body condition and heavy parasite loads (a function of poor range conditions), it may be fatal. Parasites may contribute to mortality in an indirect way; pronghorn in very poor condition will have much higher parasite loads, hastening the demise of the animal. Healthy animals tolerate parasites with no obvious ill effect. Diseases and parasites are not significant factors in pronghorn mortality in the Trans-Pecos.

HUNTING

Humans are also predators on pronghorn. Pronghorn populations are closely regulated and hunting permits issued only after consideration of total estimated population, sex ratios, doe:fawn ratios, habitat conditions, and predicted population growth rate. TPWD regulates harvest through annual issuance of hunting permits designed to provide maximum sustained yield without deleterious effects on the resource. Low population growth (especially during drought) directly affects the number of hunting permits made available to qualifying landowners. Illegal hunting is considered very light in the Trans-Pecos because of low accessibility and landowner vigilance. Historically, over-hunting greatly reduced pronghorn numbers. Since

regulation of the resource began in the early 1900's, hunting has not been a significant factor in pronghorn population declines.

ROAD KILLS

Occasionally pronghorns are killed by vehicle traffic, primarily in spring and early summer when forbs are abundant on roadsides. Unfortunately, these losses are, for the most part, unavoidable; however, losses are minimal and do not effect pronghorn populations significantly.

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FACTORS AFFECTING MULE DEER NUMBERS IN WEST TEXAS

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Abstract: Desert mule deer (*Odocoileus hemionus crooki*) have evolved to survive prolonged dry spells. Man's influence upon the land is amplified during droughty periods and an understanding of these influences is necessary to provide sound desert mule deer management. As less revenue is being realized from livestock and more revenue being derived from wildlife, more importance is being placed on understanding and improving mule deer habitat and those factors affecting the number of mule deer in the Trans Pecos; drought, habitat degradation, reproduction, water distribution, and predator density.

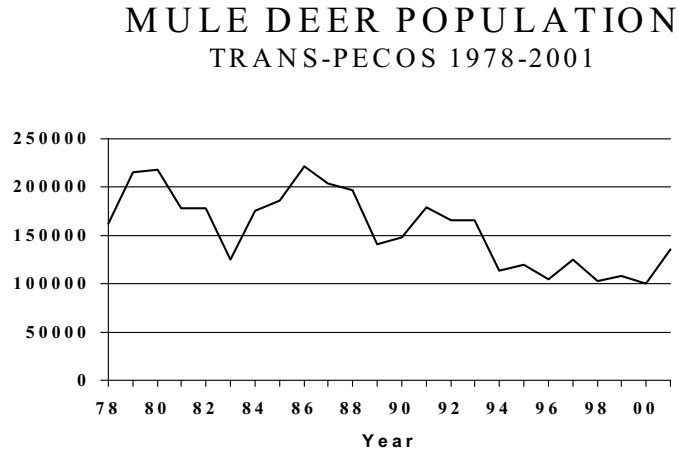

Figure 1. Mule deer population calculated by Texas Parks and Wildlife through 945 miles of aerial transects and 393 miles of spotlight surveys.

From 1978 through 2001 the Trans Pecos mule deer population has fluctuated from lows of fewer than 100,000 to a high of 221,220. Fluctuations in mule deer populations are normal but to manage mule deer well, we must understand the factors causing the fluctuations.

Ask anyone to list the factors affecting mule deer numbers and you will get the same list; drought, habitat degradation, reproduction, water distribution, and predator density. In addressing these issues it is difficult if not impossible to disconnect one factor from another.

DROUGHT

The major factor affecting mule deer numbers is drought. Wet years such as 1984, 1985, and 1986 produced good numbers of deer and surveys show an all time high number of deer in the Trans Pecos in 1986 of 221,952. The all time low of 99,790 in 2000 was preceded by 7 years of drought. Little grass is produced in droughty periods. This lack of grass production means less ground cover to provide mule deer does crucial hiding places for their fawns. Lack of fawning cover (grasses such as little bluestem, silver bluestem, side oats and other gramas) causes the fawns to be more visible and therefore more susceptible to predation. Forbs are dependent upon soil moisture and are nearly non-existent during a drought. Since forbs are the most highly preferred and nutritious part of a deer's diet, lack of forb production means lower deer herd nutrition. Drought may be the stimulus of habitat degradation, poor reproduction, and poor water distribution but mismanagement of the range is amplified during droughty periods.

HABITAT DEGRADATION

Droughty episodes not only provide less plant production, making fewer preferred plant species available to deer, but plants that do grow tend to be of poor forage quality. During these times mule deer are surviving on a less than desirable nutritional plane. Poor quality forage affects herd health. Poor reproduction over the past nine years has lead to a decrease in the mule deer population. To conceive and successfully raise fawns, does need good nutrition year-round. They need to be in good shape prior to breeding to facilitate conception, must have good nutrition throughout gestation to give birth to good birth weight fawns, and have good nutrition throughout lactation to raise healthy fawns. Poor quality forage not only leads to lack of recruitment into the population but also loss of adult animals in the herd. Low quality forage leads to nutritional stress and reduces a deer's ability to ward off parasites and disease. An unhealthy animal is more susceptible to predation.

Drought is not the only cause of habitat degradation. Mismanagement of the range, overgrazing, and subsequent brush encroachment, are other causes and are amplified during a drought. Over utilization of the range has contributed to brush encroachment over an alarmingly large portion of the Trans Pecos. Desert mule deer have evolved to survive in prolonged dry spells; however, this deer species, unlike white-tailed deer (*O. virginianus*), prefers more open rangeland. Brush encroachment makes mule deer more susceptible to predators as they depend upon their eyesight and their ability to quickly move away from danger.

REPRODUCTION

Common sense dictates that without recruitment the population will dwindle. The past 10 years have seen few years with a 60% fawn survival and more years with 40% or less. This too has confounding factors. It can be difficult to determine if poor nutrition or poor fawning cover has led to low fawn survival.

WATER DISTRIBUTION

The Trans Pecos is known for being cow/calf country. Figures from the United States National Agriculture Statistic Service show West Texas ranchers in a cow/calf operation to have steadily de-stocked from 1978 through 1986, increasing cattle numbers again after the drought broke and again de-stocking over time to the present. This mirrors the fluctuation of mule deer numbers in West Texas and draws attention to the natural de-stocking of mule deer on the range.

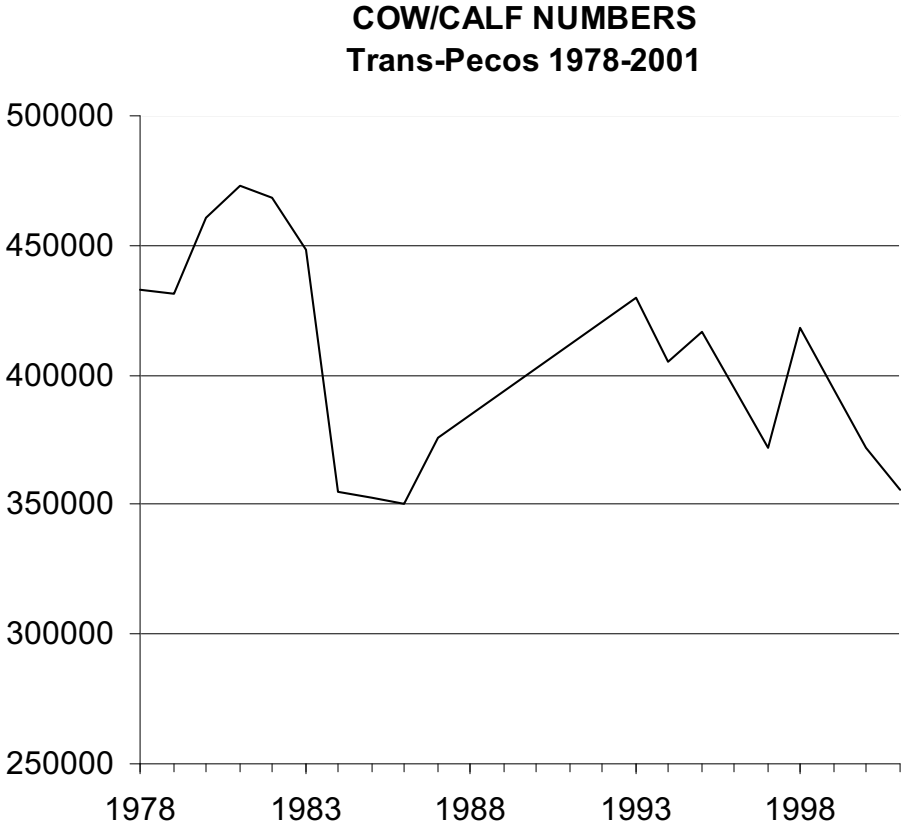

Figure 2. U.S. National Agriculture Statistic Service Trans Pecos Cow/Calf Numbers

Realizing the lack of cattle "habitat", West Texas ranches have been running fewer cattle and in some cases have completely de-stocked.

Lack of grass production to support livestock grazing has led to poor water distribution across mule deer range. Not only does the lack of infiltration and therefore ground water availability in springs and seeps affect water availability to deer and other wildlife but as cattle are removed from pastures water troughs and windmills are not maintained and an integral part of mule deer habitat, water, is missing.

PREDATOR DENSITY

Prior to the succession of cow/calf operations in the Trans Pecos sheep were the main livestock class. At that time predator control was intensively performed on a large scale. The change of livestock class to primarily cow/calf operations has led to less predator control being carried out on a large-scale basis and that, which is being done at a more local level. This had led to higher coyote and mountain lion numbers in most of the Trans Pecos. Predator control at the Black Gap Wildlife Management Area increased fawn survival and numbers of adult mule deer bucks in the herd. Other research indicates that low mule deer populations can be kept low or suppressed by high predator populations.

SUMMARY

Drought, habitat degradation, reproduction, water distribution, and predator density are factors affecting mule deer numbers. When attempting to increase mule deer numbers concentrating on one factor and ignoring the others will generate few results. As less revenue is being realized from livestock and more on wildlife more importance is being placed on the relevance of all the parts of habitat; food, cover, shelter, water, and space. Understanding the complexity of the relationship between factors affecting mule deer numbers is the beginning to understanding sound mule deer management.

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HISTORY, STATUS, ECOLOGY, AND MANAGEMENT OF DESERT BIGHORN SHEEP IN TEXAS

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Abstract: Desert bighorn sheep (*Ovis canadensis mexicana)* are an important part of the flora of the Chihuahuan Desert that were extirpated in the early 1900's. Restoration efforts for desert bighorns were initiated in 1954 and have resulted in a current population estimate of 450-500 sheep. Desert bighorns require vast, open, and rugged mountain ranges; a diverse and nutritious diet; and space with little interaction with humans and domestic livestock. Management for desert bighorns has concentrated on habitat and population management.

HISTORY

West Texas rock art provides evidence that desert bighorn sheep (*Ovis canadensis mexicana)* historically occupied most of the arid mountain ranges of the Trans Pecos region of Texas. Bighorn numbers during the late 1800s were estimated as high as 1,500 animals. By the early 1900s, Texas bighorn populations had declined or were extirpated from much of the historic ranges. These declines resulted from a combination of factors including: competition for forage with domestic livestock, introduced diseases from domestic animals, unrestricted hunting, and restriction of movements by net-wire fencing. Bailey (1905) estimated the population at 500 animals and described 16 mountain ranges that supported bighorns. Davis and Taylor (1939) reported sightings from only 11 mountain ranges and estimated the population at 300 animals. By the mid-1940s the population was estimated at 35 individuals (Carson 1945). The last documented sighting of a native Texas bighorn occurred in October of 1958 on Sierra Diablo WMA. It is believed that the last native Texas bighorns were gone by the early 1960s (Cook 1994).

Protective measures for bighorn sheep were initiated as early as 1903 with the enactment of a hunting prohibition. Further protective measures occurred in 1945 with the establishment of the Sierra Diablo Wildlife Management Area (WMA) to serve as a sanctuary for the last remaining Texas bighorns.

Restoration efforts were initiated in 1954 with the development of a cooperative agreement between the Texas Game, Fish and Oyster Commission, U.S. Fish and Wildlife Service, Boone and Crockett Club, Wildlife Management Institute, and Arizona Game and Fish Commission. Initial efforts focused on propagation of desert bighorn sheep in captivity to provide a source of stock for transplanting into suitable habitat. The first propagation facility was constructed on Black Gap WMA and was operational by 1959. Additional facilities were constructed on Sierra Diablo WMA in 1970 and 1983, and Chilicote Ranch in 1977.

Since 1959, 455 desert bighorn sheep have been transplanted to 7 mountain ranges in Texas. Of these, 146 have been transplanted to Texas from other states and Mexico, and 309 in-state desert bighorns have been transplanted between 1971 and 2000 (Brewer and Hobson 2000).

Bighorn restoration and management in Texas continues to be funded by hunters through the Federal Aid in Wildlife Restoration Program, Foundation for North American Wild Sheep (FNAWS) auction permits, and the Texas Grand Slam Hunt Program. Desert bighorn hunting was reinstated by the Texas Legislature in 1988 following an 85 year prohibition. Since then, 32 desert bighorn hunting permits have been issued including: 9 public hunting permits, 6 FNAWS permits, and 17 private landowner permits.

STATUS AND DISTRIBUTION

The Trans Pecos region of Texas currently supports 7 free ranging populations of desert bighorn sheep. These occur within the Baylor, Beach, Sierra Diablo, Sierra Vieja, and the Van Horn Mountains, and the Texas Parks and Wildlife Department's (TPWD) Black Gap and Elephant Mountain WMAs. Helicopter surveys conducted in August 2001 indicated an increasing population with 461 sheep observed during 45 hours of flight time. Restoration efforts have resulted in re-establishing bighorn sheep numbers to population levels of the early 1900s.

ECOLOGY

Desert bighorn sheep are social animals that remain in smaller groups much of the year. During the non-breeding season, males $\geq$3 years old live apart from females. Rams form bachelor groups and inhabit less suitable habitat than ewes and juveniles. Groups are largest during breeding season or rut as males and females aggregate (Bleich 1997). The length and season of the rut varies considerably with geographic location and may continue for extended periods of time in desert environments. Carson (1945) reported a rutting period of November-December in the original native Texas bighorn populations. However, July-September is a more appropriate description of the breeding season among present Texas bighorn populations.

Desert bighorn ewes and rams reach sexual maturity about 2 and 3 years of age. Ewes become solitary 10-14 days before lambing and remain so for a short time after. Lambing areas are selected on the basis of isolation, shelter and unobstructed view. Birth occurs following a gestation period of 173-185 days (Krausman and Shackleton 2000). Ewes typically produce a single lamb, although twinning occurs infrequently. Considerable variation exists in desert bighorn lambing seasons among years and geographic location. In Texas bighorn populations, newborn lambs have been observed as early as November and as late as June.

The reproductive potential for desert bighorn sheep is considered low. Factors that influence the population dynamics of desert bighorns include environmental conditions, human disturbance, competition, and loss of habitat. Desert bighorns that survive their first year can be expected to reach 10-12 years of age.

HABITAT

Desert bighorn sheep are adapted to harsh desert environments including "rugged terrain, aridity, and sparse vegetation" (Krausman et al. 1999). Essential habitat components include topography, food, water, and space. Equally vital is the arrangement or placement of these individual components. Rugged terrain alone does not constitute suitable bighorn habitat. Likewise, “areas that provide unrestricted visibility and high quality palatable forage but lack escape terrain generally are not used.” (Krausman et al. 1999). Visibility, lack of competition for water, exclusion of domestic sheep, proximity to other suitable habitat, availability of unobstructed travel corridors, and protection from human intrusion are also important considerations.

Topography supplies important sources of cover for bedding, lambing, and escape. Escape terrain provides a means of escaping predators through hiding and climbing and is particularly important for ewes during lambing and rearing of young. Steepness, rugged, rough, rocky-outcrops, cliffs, broken terrain are common terms used to describe suitable escape terrain. Slopes >60% are considered important. The amount of habitat available to bighorn sheep is ultimately determined by the amount of escape terrain close to open landscapes.

Desert bighorn sheep are highly opportunistic and adaptable in their food habits. Season, availability, and the type of habitat in which the animal lives are the determining factors in the diet of desert bighorns. Quality, condition, variety, arrangement, and distribution, are also important aspects of the forage component. According to McCarty and Bailey (1994), “optimum bighorn forage occurs in a secure area, is abundant enough to support large groups, is palatable, has a high density of digestible nutrients and energy, provides large bite sizes, and is densely distributed at each foraging site.” Because bighorns are adapted to harsh, dry, desert environments, its foods are primarily of the desert lowland variety (Todd 1972). Desert bighorns are able to subsist on a variety of plants including desiccated and decadent forage (Krausman et al. 1999). Desert bighorns are considered grazers. However, woody plants and forbs are preferred in some areas.

Bighorn diets in the Chihuahuan Desert of Texas are dominated by shrubs. At Elephant Mountain WMA, desert bighorn diets consisted of 50% browse, 35% forbs, 11% grasses, and 4% succulents with a total of 91 plant genera identified (Brewer 2000). Fulbright et al. (1996) documented the forage habits of bighorns in the Baylor, Beach, and Sierra Diablo Mountains. Study findings revealed a diet of 40% shrubs, 34% forbs, and 26% grasses, with 35 plant genera identified.

Water may be the most important factor in the distribution and survival of desert bighorn. Water is available to desert bighorns from free-standing or running sources, condensation, a by-product of oxidative metabolism, and in forage (McCarty and Bailey 1994). Most biologists consider free-standing water to be an essential component of desert bighorn habitat. In contrast, a number of studies have documented the existence of healthy desert bighorn populations that do not have access to free-standing water. However, “the hypothesis that desert bighorn can exist without permanent sources of water is not widely accepted” (Krausman et al. 1999). Since the

mid-1950s, approximately 50 bighorn water developments have been constructed in Texas on both public and private land for a total combined storage capacity of 193,000 gallons.

The need for space or isolation by desert bighorns is well documented. Human encroachment played a key role in the extirpation of bighorn populations throughout the west. "With few exceptions, bighorn tend to be intolerant of humans and their activities" (Krausman et al. 1999). Abandonment of habitat by bighorns has been known to occur following increased human activity (Krausman et al. 2000). Protection from human disturbance is critical.

MANAGEMENT

Desert bighorn management in Texas is comprised of 2 primary segments including population management and habitat management. Since 1954, population management has been directed at restoring bighorns to historic habitat areas through translocation. Additional measures have included: conservative harvest strategies (<10% of total ram population each year); elimination of domestic sheep and exotic wildlife within bighorn habitat to prevent disease transmission and reduce competition for forage; selective predator control within bighorn restoration areas; and protection from human disturbances. Habitat management efforts have focused on: restoration of natural processes such as fire; maintaining open visibility within bighorn habitat; control of brush encroachment and elimination of manmade barriers to restore and maintain open travel corridors; and installation of water within strategic locations. According to Krausman and Shackleton (2000), "managers must ensure that habitat is protected, movement corridors remain open, livestock are separated from bighorn, and human disturbances are minimized to maintain and enhance viable populations of bighorn sheep."

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BASIC DEER NUTRITION

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Abstract: Deer like all animals require nutrients from 5 categories: (1) water; (2) energy: (3) protein; (4) minerals and (5) vitamins. Depending on habitat quality and population management, in addition to drought, any or all of these nutrients may or may not limit herd productivity. Although the importance of nutritional effects on deer productivity is well accepted, specific nutrient requirements of deer, especially mule deer, are not well documented, particularly in the area of nutrient requirements for antler growth. A deer's changing metabolic rate and feed intake throughout the year complicates the development and application of a herd nutrition program. Since most or all their nutrition should be supplied by the habitat, the key to optimizing nutrition is to improve and manage habitat for high plant species diversity. This allows deer to select a diet that provides nutrients needed to support growth, gestation, lactation, and antler development.

Nutrition is one of the major factors affecting productivity of deer, but it is one over which a wildlife manager can exercise considerable control. In order to make nutrition decisions which will result in a healthy, productive deer herd several factors should be considered: (1) seasonal forage availability and quality; (2) physiological state and nutritional requirements; (3) number and kinds of animal species; (4) livestock and grazing management practices; and (5) production goals. A complicating factor when planning a nutritional program for deer is their changing daily intake levels from winter to autumn. Daily dry matter intakes range from 1.5% of body weight in the mid winter to about 3.0% in the summer and autumn. While this difference in dry matter intake is caused by several things, a key factor is a shift in the metabolic rate. Deer have a high metabolic rate in the late spring to fall and a low metabolic rate in the winter (Moen 1976).

NUTRIENT REQUIREMENTS OF DEER

The nutritional requirements of deer should be considered on a seasonal basis since this corresponds both to the physiological changes in the deer herd (e.g., gestation, lactation, or antler growth) and the nutrient availability from the range resource. The amount of various nutrients needed by deer during one season may be influenced to a large degree by nutrients available during the previous season. Deer can survive for relatively long periods with little or no food if they have had an opportunity to store ample body reserves. How changes in daily feed intake may affect daily nutrient requirements has yet to be determined, and at this time, only subtle changes to accommodate age, sex and stage of production have been incorporated into nutritional requirement tables.

Deer require nutrients from five broad categories: (1) water; (2) energy (e.g., TDN, digestible energy and digestible dry matter); (3) protein; (4) minerals; and (5) vitamins. Research on nutritional requirements of deer has been limited mainly to protein, energy and minerals

(phosphorus and calcium) because these factors most often limit growth, reproduction, and antler development.

Water

One of the first things on the list of necessities for successful deer production is a dependable, year round water supply. Without a stable water source the viability of the deer herd is in jeopardy. Certain areas in the Texas have historically not had significant deer populations solely based on an inadequate water supply. Ambient temperature has a large impact on water needs of deer. Deer, like other ruminants need to consume about 3 lb of water for each lb of dry matter consumed. Without adequate water intake, dry matter intake is restricted, resulting in inhibited growth of fawns, lactation failure by does, low birth and weaning weights and an inconsistent fawning period. Water intake is especially critical during periods of high metabolic demand. This is especially important for growing fawns up to 18 months of age, bucks coming out of the rut and during antler growth and gestating/lactating does. Most data that I am familiar with indicate that in an area like west Texas a dependable water source every 1-1.5 miles is adequate for deer. If water is restricted during critical periods, overall productivity of the deer herd will be negatively impacted.

Energy

After water, energy is the nutrient that is required in the greatest amount in the diets of deer. Yet, many times wildlife managers consider only protein when evaluating deer nutrition. Energy requirements are cyclic and are influenced to a great degree by age, growth, gestation, lactation, locomotion, temperature, and antler development. Because of the wide fluctuations in energy requirements of deer in different physiological conditions and extremes in climatic variations from one part of the country to another, it is difficult to come up with specific requirements. However, there is enough available information to make general recommendations that will result in acceptable performance.

Mature does require about 25 Kcal of digestible energy (DE) per lb of body weight per day, which goes up to about 33 Kcal DE/lb during peak lactation (Ullrey et. al 1970). Since most ranchers think of energy in terms of TDN or digestible dry matter (DDM), which are essentially equivalent, these requirements correspond to a necessity of having plants available to the does that contain 55-60% DDM.

Fawns, because of their energy needs for rapid growth, have energy requirements on a body weight basis of about 70 Kcal DE/lb (Kirkpatrick et. al 1975). Generally; fawn nutritional needs are not a major problem if the doe is producing sufficient milk. It is because of their high nutritional requirements that fawn mortality is high when any factors such as drought, disease, etc. affect the health or nutritive status of the does.

Energy requirements of bucks are difficult to ascertain because food consumption drops about 50% during the rut and they generally will not eat enough to maintain body weight even if food is available. This is not detrimental to the buck if food of sufficient quality is available in the subsequent spring and summer to allow replacement of body energy stores. Generally an intake of about 50 Kcal DE/lb will allow maximum growth and allow energy to replenish body stores.

Protein

All protein consists of combinations of about 23 amino acids. The main function of protein is for the development of muscles, nerves and other tissues, such as the protein matrix in the growing antler. It also is involved in several body processes including normal digestive functions, is a constituent of blood, hormones, enzymes, body secretions and milk. Deer synthesize various proteins from amino acids in the blood which come from two basic sources: (1) Rumen microbial protein that is digested and absorbed in the small intestine and (2) Protein from plants or feed supplements in the diet.

Protein utilization in deer.--Once consumed by a deer, food protein is introduced to the rumen environment where most of it is digested by the rumen microbes, which include both bacteria and protozoa. After they have digested it into its component amino acids they then convert it into their own microbial protein. The microbial protein is then passed into the small intestine for absorption and utilization by the deer. A certain portion of the protein in the diet is not available to the microbes for digestion. This unavailable protein is called bypass protein. Bypass protein "escapes" breakdown by the rumen microbes and passes through to intestines. Too much bypass protein in the diet will starve the rumen microbes, reducing their efficiency and microbial protein output, and hence reducing animal productivity. Too little bypass protein and the microbes will produce adequate levels of essential and non-essential amino acids, but the animal may not be receiving enough "quality protein" or amino acids to optimize production of antler tissue. This area is the latest “cutting edge” research in deer nutrition. As a company we have been investigating this area for about 5 years. We have determined to our satisfaction that the right kind and amount of bypass protein has a very positive influence on antler growth.

Research from Pennsylvania (French et. al 1955) demonstrated the importance of protein in deer growth and antler development. Deer fed a 16% crude protein (CP) gained 108 lb the first year; deer on 13% CP gained about 100 lb; deer fed 9.5% CP gained 50 lb; and deer fed 4.5% CP gained about 25 lb. Antler development was directly related to protein intake. Deer fed 16% CP had antlers 12-15 inches in main beam length with 6-8 points. Deer fed 4.5% CP made little or no antler growth. Switching animals from a low to high protein diet the following year resulted in improved antler growth; however, animals fed low protein diets during their first year always had smaller antlers than animals fed the 16% CP ration their first year. Apparently, in the buck fawn, body growth has priority over antler development. Studies by the Texas Park and Wildlife Department at the Kerr WMA showed somewhat similar results. Therefore, a period of inadequate nutrition may adversely influence antler development for several succeeding years.

The main factors affecting protein requirements are the age and the physiological stage of the animal. Weaned deer require higher levels of protein than do adult deer. There are also maintenance and production protein requirements. Lactating does require higher dietary protein than does in early - mid gestation. A summary of available research data would indicate that deer require about 6%-8% CP to maintain life and rumen function. It appears; however, that CP content of the complete diet needs to be in the range of 14 to 18% (Magruder et. al, 1957) for successful growth, antler development and reproduction in deer. Michigan research (Ullrey et. al, 1967) has also shown that male fawns may have a higher protein (16-20%) requirement than female fawns (13%)

Minerals

Minerals that are required by deer are divided into 2 groups: macro and micro minerals. Macro minerals include calcium, phosphorus, magnesium, sodium, chlorine, potassium, and sulfur. These minerals are measured as a percentage of the diet. Micro or trace minerals include cobalt, copper, iodine, iron, manganese, molybdenum, selenium, zinc, and chromium. These minerals are measured in parts per million (ppm) or milligrams per kilogram (mg/kg) of feed. The difference between the macro and micro minerals is that macro minerals are usually required by the animal in grams per day, while micro minerals are required in milligrams per day.

Almost all research on mineral requirements of deer has been with growing fawns and very little is available on requirements of adult deer, particularly for maximum antler growth in mature bucks. A summary of the available research indicates that diets containing 0.40% calcium and 0.28-0.30% phosphorus will support acceptable growth and development in deer.

Vitamins

As far as I know, there has not been any research on the vitamin requirements of deer. However, data from other ruminant species can be used as a guide. Vitamins required by deer can be divided into two groups, fat soluble vitamins and water soluble vitamins. Fat soluble vitamins include A, D, E and K. Water soluble vitamins include all B vitamins, C and choline. All the vitamins are required for a myriad of body metabolic functions. However, those actually required in a deer's diet are limited to A, E and possibly D. Rumen microbes synthesize all the other vitamins most likely in sufficient quantities to maintain health and productivity. A possible and interesting exception may be the B vitamin, biotin. We do know that biotin is critical to the synthesis of a protein call keratin. This protein is the one that makes up the antler protein matrix. Biotin can be and is added to some deer feed supplements. However, the rumen microbes break it down so it may not actually get absorbed in amounts sufficient to do the buck any good. An area we are researching is the development of a bypass source of biotin to overcome this problem.

Some suggested deer nutrient requirements that I consider "close enough" are listed in Table 1. It should be recognized that these requirements are just an educated "guesstimate" of deer nutrient needs and are just targets to shoot for when developing a deer nutrition program.

NUTRIENT CONTENT OF DEER FOOD PLANTS

Table 2 shows how average nutritional content of several classes of south Texas deer food plants change during various seasons of the year. This data indicates that in south Texas, energy (DDM) may be a limiting nutrient, particularly in the summer when does are lactating and bucks are in a period of maximum antler growth. Although the protein level in browse appears adequate, I have done research that indicates that the digestibility of the protein in browse averages about 50%. Therefore, during the summer when deer diets in Texas may average over 90% browse, protein may be limiting for maximum antler growth. Forbs, when they are available, are good sources of CP, energy (DDM), and phosphorus during any season of the year. Prickly pear certainly has to be considered as an important factor in meeting the energy

Table 1. Estimated Nutrient Needs of Deer (Concentration in dry matter).

		Growth				Gestation		Lactation	
	Maint.[1]	Velvet	3-6 Mo.	6-9 Mo.	9-12 Mo.	Mid	ate	1st ½	2nd ½
Crude Protein (%)	7-10	16	18-20	16-18	12-14	12-14	14-16	14-16	12-14
DE (Mcal/lb)	1.00	1.10	1.40	1.30	1.20	1.10	1.20	1.30	1.25
TDN (%)	50-52	55	68	64	59	57	59	64	61
Calcium (%)	0.35	1.40	0.60	0.55	0.50	0.50	0.50	0.70	0.60
Phosphorus (%)	0.25	0.70	0.30	0.30	0.30	.040	0.40	0.40	0.40
Potassium (%)	0.65	1.0	0.65	0.65	0.65	0.65	0.65	1.0	1.0
Magnesium (%)	0.20	0.40	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Copper (ppm)	15	25	20	20	20	20	20	20	20
Manganese (ppm)	40	100	75	75	75	75	75	75	75
Zinc (ppm)	50	150	100	100	100	100	100	100	100
Iron (ppm)	50	200	200	200	200	200	200	200	200
Iodine (ppm)	0.30	1.0	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Cobalt (ppm)	0.10	0.30	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Selenium (ppm)	0.20	0.30	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin A IU/lb)	1500	2000	1800	1800	1800	2000	2000	2000	2000
Vitamin D (IU/lb)	250	500	450	450	450	500	500	500	500
Vitamin E (IU/lb)	10	20	15	15	15	20	20	20	20

[1] Maint. = Maintenance

needs of deer in south Texas, but it is low in protein and almost all minerals. These nutritional analyses indicate why most diet studies show that deer, particularly in south Texas, prefer forbs first, browse and prickly pear next and eat relatively little grass.

Little information is available on the mineral, especially trace mineral, content of deer food plants. However, there are limited amounts of data on range forage composition that may indicate potential problem areas. Mortimer et. al (1999) summarized analyses of over 700 forage plants from all over the US. They found that over 70% of the samples were marginal or deficient in copper for cattle (< 10 ppm) and over 80% of the samples were marginal or deficient in zinc for cattle (< 30 ppm). My personal opinion is that 10 ppm copper and 30 ppm zinc are not nearly enough for deer to support maximum antler development. An interesting question also is “Of the minerals in a plant, how much is actually digested and available to the deer?” I have a limited

TABLE 2. Average Seasonal Nutritional Content of Four Classes of South Texas Deer Food Plants (Concentration in dry matter).

Plant class	Spring	Summer	Fall	Winter
	----------% Digestible Dry Matter ----------			
Browse	51.2	47.2	46.0	48.1
Forbs	64.9	60.2	61.9	72.4
Grasses	49.5	45.4	42.1	48.3
Prickly pear	86.0	79.0	79.1	82.3
	----------% Crude Protein ----------			
Browse	21.5	18.1	18.5	16.9
Forbs	16.8	14.0	16.1	21.4
Grasses	12.5	12.0	13.1	14.4
Prickly pear	13.3	5.6	10.3	5.4
	----------% Phosphorus ----------			
Browse	.22	.15	.16	.14
Forbs	.26	.20	.22	.29
Grasses	.22	.27	.23	.21
Prickly pear	.22	.08	.17	.09

amount of information to indicate that the digestibility of minerals in deer food plants varies from 12% -70% depending on the mineral and the l stage of maturity of the plant.
An astute manager will become familiar with those plants that are both palatable and most nutritious for deer and will realize the need to have a diversity of plant species. Deer, like all animals, will generally select the most nutritious plants first and it is these plants that disappear first under overgrazing and/or drought. Deer can reproduce under relatively poor nutritional circumstances. However, maximum body size and antler development can only be attained under optimum nutritional conditions. The key is to balance deer and/or livestock numbers so that deer have an opportunity to select a diet that is the highest in nutritional quality that the habitat is capable of supplying.

ANTLER COMPOSITION/NUTRITION RELATIONSHIPS

Antlers are one of the fastest growing tissues in the animal kingdom. Obviously, if required nutrients are in short supply during the antler growth period, several things, all bad, can happen: (1) Antler growth rate slows down. Since antler growth occurs only during a limited period of time, an antler growing at the rate of 5 grams/day is going to be larger at the end of that period than one growing at 3 grams/day; (2) Less antler mass and density. Less dense antlers will have less breaking strength; and (3) Desirable characteristics such as antler mass, number of points and beam circumference are negatively affected by poor nutrition.

Nutrients in the diet will always be used first by the buck to maintain body functions necessary for life. Only nutrients that are left over after these needs are met will be used for antler growth. Therefore, it is critical that the buck be consuming the most nutritious diet of the year during antler growth. Unfortunately, this is the time of the year in many parts of the country when forage is of low quality. This why during a drought especially accompanied by high deer and/or livestock numbers antler quality is the first thing that suffers.

Antlers are high in minerals (Table 3). This illustrates the importance of having adequate minerals in the diet. Phosphorus, which is deficient in most soils and plants in Texas, is particularly critical. Some trace minerals, such as zinc, also appear to be important. Even after they harden, antlers are over 35% protein. Obviously, a diet that is adequate in quantity and nutritional quality is an essential for maximum antler growth. A diet that is low or marginal in one nutrient, may limit antler growth even though other nutrients may be adequate.

TABLE 3. Average Composition of Deer Antlers (Content in dry matter).

Mineral		Organic	
Calcium, %	19.0	Organic matter, %	48.0
Phosphorus, %	10.1	Protein, %	36.3
Magnesium, %	1.1	Energy (Kcal/gram)	2.1
Sodium, %	0.5		
Potassium, %	0.1		
Iron, ppm	55.0		
Manganese, ppm	6.6		
Zinc, ppm	116.0		

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NON-NATIVE UNGULATES IN THE TRANS-PECOS REGION OF TEXAS

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Abstract: Non-native ungulates comprise a significant proportion of the ungulate fauna of Texas. Wildlife managers must take this into account when developing ungulate management strategies. Management decisions regarding both exotic and native species are, by nature, complex and subjective. Analysis of 16 previously published studies revealed that the diets of aoudad and mule deer significantly overlap, but that aoudad appear to be more flexible in their diet. Thus, they may have a competitive advantage for food resources where the 2 species occur sympatrically. However, evidence from the Palo Duro Canyon of Texas indicates that these 2 species may be able to partition habitat spatially and/or temporally, allowing both species to coexist. Managers must consider the overall herbivore population density when determining desirable stocking rates.

Non-native ungulates are a significant part of many Texas ecosystems. Approximately 118,000 non-native, wild ungulates, representing 124 species or varieties, were reported in Texas in 1994 (Traweek 1995). The population continues to grow despite concerns about possible negative consequences of native species. A realistic outlook requires that wildlife managers consider non-native species when developing wildlife management programs. In this paper, I will highlight some of the more contentious points of the "exotic" debate. These include the subjective, value-laden nature of wildlife management decisions, as well as ecological interactions between various wildlife species in Texas, regardless of their evolutionary and geographic origins.

WHAT IS AN "EXOTIC"?

Before discussing the ecology of "exotic" species, we should first address some basic principles about how we view wildlife species in general and "exotics" in particular. The very definition of the term "exotic" is subject to interpretation and not agreed upon universally. For instance, the legal definition (in Texas) of an exotic is an animal which, among other things, is "not indigenous or native to Texas" (Jefferson 2001). But what about animals that otherwise fit this definition, but have been granted "game" status — a term normally reserved for indigenous animals? Or native species that have been classified as "exotic?" And what about Texas species that now occur in parts of the state which lie outside their "native" range? Unfortunately, there is no clear-cut answer to the question "Exactly what is, and is not, an exotic?"

A commonly held view is that "exotics" are ecologically "out of place." That is, they violate the natural ecological order of a specific location. However, before we make this statement, we must consider exactly what the ecological system of a particular place, with all of its constituent plant and animal species, actually is. It is not a static collection of species, but a dynamic system, that changes over both short (ecological) and long (evolutionary) time scales. In essence, an ecosystem is an evolutionary unit. It changes very slowly, and in response to

selective pressures. The "native" system which confronted the first European explorers to Texas some 400 years ago did not simply appear fully developed in place. It has no mystical properties that make it the benchmark to which all good biologists should strive. Instead, it was the result of millions of years of evolution, as well as immigration and emigration of the constituent species.

COMPETITION BETWEEN NATIVE AND NON-NATIVE UNGULATES IN WEST TEXAS

The majority of non-native ungulates in Texas reside outside of the Trans-Pecos region. One species, however, the Barbary sheep or aoudad, is present in considerable numbers. Traweek (1995) reported >5,100 individuals in 1994. At that time, the Trans-Pecos also supported 5 native ungulate species: mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), bighorn sheep (*Ovis canadensis*), pronghorn (*Antilocapra americana*), and elk. By far the most numerous native ungulate was the mule deer, with approximately 100,000 individuals present (D. Humphries, pers. comm.). Because both of these species sometimes occur in similar habitats (Bird and Upham 1979, Krysl et al. 1979), some wildlife managers are concerned about possible competition for resources between them. I will limit my comments to mule deer–aoudad interactions for 2 reasons: 1) this is the most common interaction between native and non-native wild ungulates in the Trans-Pecos and 2) there is limited time and space available. However, one should remain aware that interaction issues exist among all native and non-native species. Problems may be particularly acute regarding sensitive species such as bighorn sheep. Many biologists have expressed concerns about competition for food and habitat space, aggressive social interactions between the 2 species, inhibition of bighorn sheep breeding behavior by aoudads, and possible disease transmission from aoudad to bighorn sheep. Landowners concerned with bighorn sheep on their properties and their interaction with non-natives (especially aoudads) should consult a biologist for additional assistance.

Competition can be defined as "any interaction that is mutually detrimental …between species that share limited resources " (Smith 1986). One area of ungulate resource utilization that has received particular attention is diet. There is a considerable body of published literature on the subject. By assessing the diet of different species, it may be possible to get some idea of the degree of potential competition between the species for food resources.

Two components of ungulate diets are of interest when discussing competition. The first is the degree of overlap in forage selection between 2 species, which indicates if the 2 species are selecting the same type of food items. We can determine this by observing what types of food are consumed and the similarity of the 2 diets. The second component is the "plasticity" of an animals diet, or the degree of flexibility a species has in selecting food items. Diet plasticity is an indicator of how versatile a species is (with respect to feeding) and, thus, how easily it can adapt to different conditions as they change through time and space.

To determine diet overlap and plasticity, I examined the results of 11 published mule deer diet studies, representing 14 locations across the southwestern United States. I also examined 6 studies of aoudad diets, representing 5 locations in the southwestern United States and 1 in the Canary Islands. I compared the annual and autumn diets of the 2 species reported in the

literature. I selected autumn because 3 of the aoudad studies addressed only autumn, rather than annual diets. For each species, I calculated the mean proportion of the diet composed of each of 3 forage classes: browse, forbs, and grass. I defined browse as the fruit, leaf, or stem of any woody plant, cactus, or succulent, and forbs as broad-leaved, herbaceous species. I then calculated 95% confidence intervals on the means for visual comparison. I acknowledge that weaknesses such as unequal sample sizes, different data collection procedures, and analysis of summary—rather than raw—data lessens the statistical rigor of my analysis. However, I believe that the results do provide some insight into the general diet selection patterns of the 2 species.

The mean diet composition of mule deer and aoudad show a similar pattern of forage selection, although mule deer seem to be somewhat more selective (Figs. 1–4). Both species appear to be primarily browsers, with forbs and grass making up a smaller percentage of the diet. Thus the data shows that there is considerable dietary overlap between the species, which could lead to competition for limited food resources.

More importantly, the 2 species exhibit very different patterns of variation in the diet (Figs. 1–4). The very narrow range of results for mule deer, from studies conducted in different areas and under different conditions, indicates that mule deer are quite specialized when it comes to diet composition, relative to aoudad. Under a wide range of conditions, mule deer appear to have very similar diets. This stands in contrast to the results of the aoudad analysis. In this case, aoudads showed a great deal of variability in diet selection, indicating that they are more generalized and have a greater ability to adapt their diet to local conditions, although the small sample size in the aoudad analysis may have inflated the confidence intervals somewhat relative to mule deer. Thus, while the average diet of mule deer and aoudad may be similar, aoudad appear to have greater diet plasticity than mule deer. Other authors have speculated likewise (Ramsey and Anderegg 1972, Mungall and Sheffield1994).

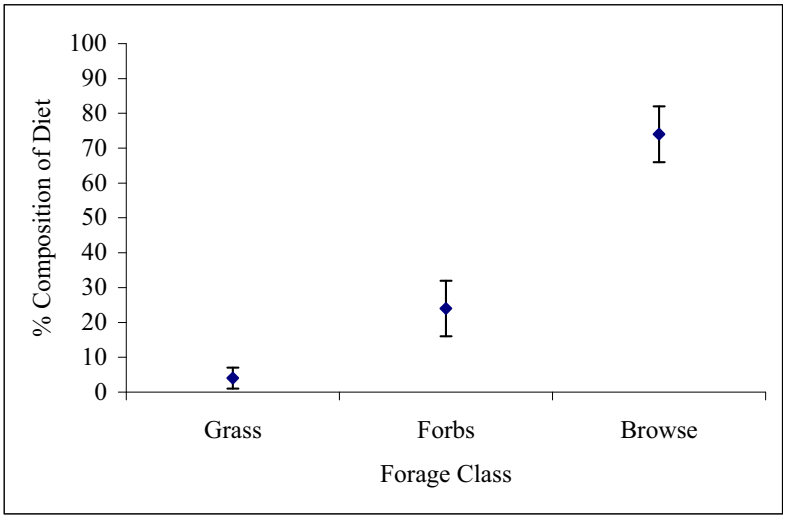
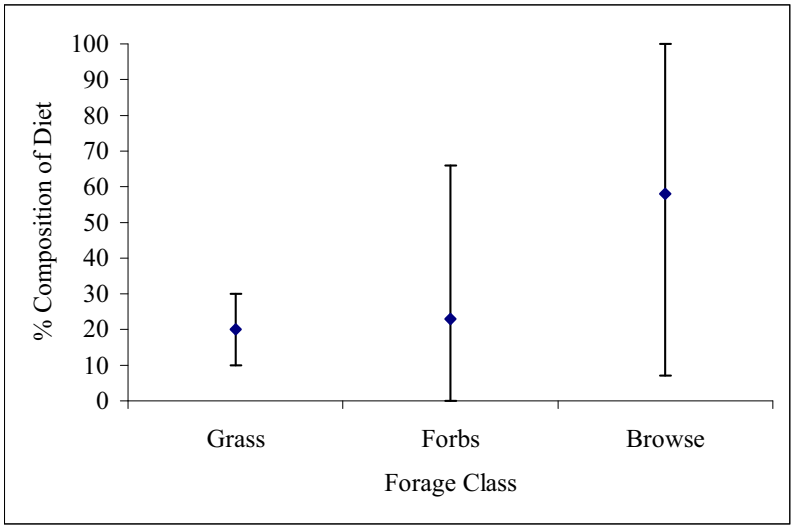


Figure 1. Percent of annual mule deer diet composed of three forage classes. Diamonds indicate mean of reported values. Bars indicate 95% confidence intervals on the mean. Based on data from Brown 1960, Anderson et al. 1965, Boeker 1972,

Keller 1975, Anthony 1976, Short 1977, Krausman 1978, Bird and Upham 1979,



Krysl et al. 1979, Leopold and Krausman 1987, and Krausman et al. 1997.

Figure 2. Percent of annual aoudad sheep diet composed of three forage classes. Diamonds indicate mean of reported values. Bars indicate 95% confidence intervals on the mean. Based on data from Bird and Upham 1979, Krysl et al. 1979, and Simpson et al. 1979.

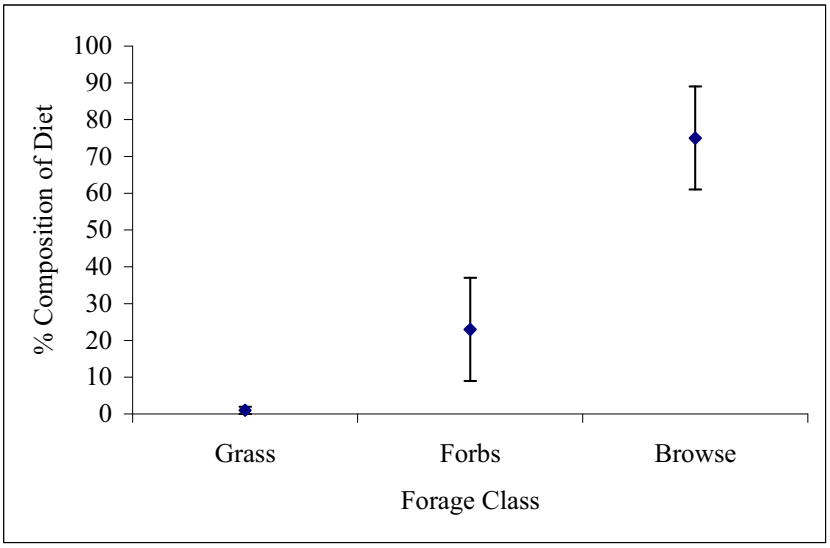


Figure 3. Percent of autumn mule deer diet composed of three forage classes. Diamonds indicate mean of reported values. Bars indicate 95% confidence intervals on the mean. Based on data from Anderson et al. 1965, Boeker 1972, Keller 1975,

Short 1977, Krausman 1978, Bird and Upham 1979, Krysl et al. 1979, Leopold and Krausman 1987, and Krausman et al. 1997.

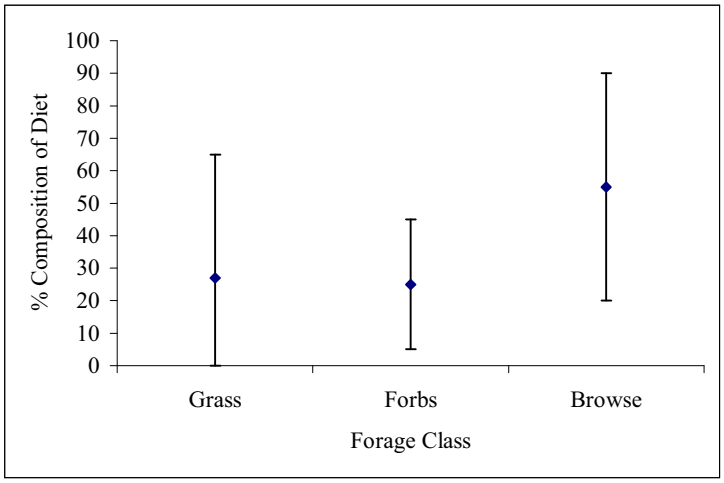


Figure 4. Percent of autumn aoudad sheep diet composed of three forage classes. Diamonds indicate mean of reported values. Bars indicate 95% confidence intervals on the mean. Based on data from Ogren 1961, Ferrel 1966, Bird and Upham 1979, Krysl et al. 1979, Simpson et al. 1979, and Pinero and Luengo 1992.

The combination of similar diets and dissimilar degrees of plasticity may have implications for competition between the 2 species. These implications are best viewed along a continuum of resource availability. When food availability exceeds the requirements of the mule deer and aoudad populations, forage is essentially unlimited and competition does not occur. As food becomes limited, due to environmental conditions (i.e., drought) or population increase by 1 or both species, the similarity of the diet composition means that the 2 species will begin competing for the limited resources. However, if food is limited enough, the high degree of plasticity in the aoudad diet may allow them to shift to alternate food sources. The results of the analysis indicate that mule deer are less capable of the shift. Thus, aoudad may find "refuge" in a heretofore unused food source, while mule deer are left to make do with the original, depleted forage base.

At a broader scale, where does the increasing population of aoudad in the Trans-Pecos leave native game like mule deer? It should be obvious that, if aoudad populations continue to increase, the range should be able to accommodate fewer mule deer, simply due to the resources consumed by aoudad. The extent to which this will occur, however, is less certain.

First, the above scenario assumes competition operating in a vacuum. On the contrary, we know that 2 species compete only in the context of the entire ecosystem. To make full use of its dietary plasticity, aoudad must have free access to alternate resources. But these resources may be limited also, and other species may compete with aoudad for them, thus inhibiting aoudad's ability to "evade" competition with mule deer.

Second, food is only 1 resource (albeit the most studied) for which aoudad and mule deer compete. Others include such things as water, cover, and space. To completely exclude mule deer from an area, aoudad must select for and outcompete mule deer for these other resources. Mule deer may be able to persist in habitats that are less suitable for aoudad.

Examples of this type of interaction have been documented. During 1949–1964, the Texas Parks and Wildlife Department restocked mule deer into Palo Duro, Texas, to augment a remnant population. During this same period, the Department introduced aoudad into the canyon. During 1977–1979, Simpson and Gray (1983) studied habitat partitioning between the 2 species. They found that aoudad and mule deer tended to use different habitat types, based mainly on topography, during certain seasons. During other periods, however, they occurred sympatrically. Simpson and Gray (1983) suggested that the occasional interaction between mule deer and aoudad during those periods when they occupied the same area might bring them into competition. However, Palo Duro Canyon, as well as other locales in the Texas Panhandle, currently support healthy populations of both species, suggesting that they have successful partitioned the available niches and can coexist (G. Miller, Texas Parks and Wildlife Department, personal communication).

CONCLUSION

It is clear that the question of how non-native ungulates fit into our current wildlife management scheme is a complicated one. We must remember that categories such as “native” or “exotic” are often arbitrary and bear little relevance to a species’ ecological role. A landowner’s decision to include non-native game in his management program is a personal choice based on his own goals and objectives, but one that has biological as well as social implications. For its own part, the Texas Parks and Wildlife Department has adopted a policy of not propagating or protecting non-native ungulates (except livestock) on most of its public land.

Non-native herbivores, such as aoudad, can be managed successfully alongside native game. However, the diets of many large ungulates overlap, resulting in potential competition for resources. Further, the more species of herbivores present—whether they be native or non-native, domestic livestock or wild animals—the more complicated the management becomes. Therefore, wildlife managers must be willing to balance appropriate population levels of both native and non-natives species in order to maintain productive habitat and good animal condition.

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COMPARISON OF DEER SURVEY TECHNIQUES IN WEST TEXAS

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Abstract: Periodic surveys are necessary to manage deer herds effectively. Fixed-wing surveys can be used to quickly obtain herd composition information and are less costly than helicopter surveys. However, fixed-wing surveys substantially underestimate deer and other wildlife numbers. The 2 most common deer survey techniques used in West Texas are helicopter surveys and spotlight surveys. Helicopter surveys are effective in obtaining accurate herd composition information and for monitoring population trends of deer and other wildlife species. They also allow managers to evaluate buck quality and provide a quick overview of ranch and/or habitat conditions. However, numerous studies have demonstrated that helicopter surveys underestimate deer numbers by 14-74%. In addition, helicopter surveys conducted on large ranches can be expensive. Spotlight surveys are less costly and tend to provide more accurate estimates of deer numbers when conducted according to the intended assumptions. Generally, spotlight surveys are good indicators of fawn survival but are less reliable in producing accurate buck to doe ratios. The spotlight method is time-consuming and will not provide reliable results on some ranches and/or under certain conditions.

To manage deer herds effectively, land managers must conduct periodic surveys to evaluate certain deer herd characteristics (numbers, sex ratios, fawn crop, buck quality). Because deer harvest is a primary factor affecting deer herds in West Texas and one of the few factors over which managers have control, it is important that deer surveys be as accurate as possible. The purpose of this paper is to assess and compare the accuracy of deer survey techniques commonly used in West Texas. In addition, potential sources of error associated with each technique are described. By understanding the sources of error associated with a survey method, land managers can make an effort to minimize these errors or at least account for them in their management decisions.

SURVEY TECHNIQUES

Two deer survey methods have broad applicability in the Trans-Pecos Region. These survey techniques are: 1) the mobile spotlight survey and 2) the helicopter survey.

A third method, the fixed-wing aircraft survey, has been used with limited success. Using a small, fixed-wing plane allows the observers to cover a large area in a relatively short period of time, and the method is less expensive than using a helicopter. However, fixed-wing aircraft are used infrequently compared to the other 2 methods. The major reason is that many deer are missed by the observers because of the speed and altitude necessary to safely conduct a survey (Caughley 1976). For example, when conducting fixed-wing research on the observability of livestock, Caughley (1974) observed 89% of a known number of cattle and only 74% of a known number of sheep in an open pasture. It seems reasonable that wild animals feeding and bedding among woody cover would be more difficult to observe. LeResche and

Rausch (1974) reported that during winter in Alaska experienced observers were able to detect 40-68% of a known number of moose in a relatively open area that had been burned. Inexperienced observers detected only 19-44% of the known population. In Colorado, a known number of mule deer in a 5,000-acre, high-fence enclosure were surveyed by fixed-wing aircraft (Super Cub), and only 34-49% of the deer were observed during 6 winter counts (Gilbert and Grieb 1957). Synatzske (1984) used fixed-wing aircraft to survey white-tailed deer at 3 sampling intensities in South Texas and observed 37-40% of marked deer on one study area and 25-46% of marked deer on a second study area. Burkett et al. (2001) observed only 46% (40 of 87) of radio-collared and marked oryx on White Sand Missile Range in New Mexico. Helicopter surveys also underestimate populations; however, in an aerial survey experiment Watson et al. (1969) observed a greater percentage of randomly located people from a helicopter (75%) than from a fixed-wing aircraft (65%). Rollins (1988) found that fixed-wing surveys in Pecos County detected about 50% of the deer that were observed from a helicopter.

The problem of overlooking deer is magnified with increasing brush canopy and ruggedness of terrain. As a result, deer surveys using fixed-wing aircraft generally result in lower deer density estimates than either of the two other survey techniques. Fixed-wing aircraft have their greatest applicability in relatively open and flat to rolling terrain. Fixed-wing aircraft surveys are relatively successful in obtaining accurate herd composition information (comparable to helicopter surveys).

SPOTLIGHT SURVEY

Method

The spotlight survey technique involves sampling a portion of a property to produce an estimate of the deer density on the entire ranch. Deer are counted at night from the bed of a pickup (or elevated seat), using two spotlights (200,000 to 500,000 candlepower is adequate). Two observers shine spotlights from each side of the truck while the driver maintains a speed of 8-10 mph (rough terrain will require slower speeds). Surveys should be initiated 1-3 hours after sunset (Progulske and Duerre 1964, Shult and Armstrong 1984, Fafarman and DeYoung 1986) and completed within 3 hours of the start time. Visibility estimates (distance that deer can be seen) on the right and left of the truck are taken every one-tenth of a mile for use in calculating the observed acreage. A maximum distance of 250 to 300 yards should be used, depending on light intensity and quality of optics (deer must not be confused with pronghorns, livestock, or exotics). Visibilities may be taken at night when conducting the initial count or during the day prior to the survey. If visibilities are taken during daylight hours, a laser rangefinder can help improve observer accuracy at the longer distances. The average width of the route is multiplied by the length of the route to calculate the observed acreage[1].

During the survey, total numbers of observed deer are recorded while binoculars are used to identify bucks, does, and fawns within about 150 yards of the truck. Attempting to identify sex and age of deer beyond that distance will result in errors or biased data (spike bucks recorded as does, or fawns mistaken for does). In areas where white-tailed and mule deer coexist, observed deer should be recorded by species. The observed acreage divided by the total number

[1] [Length of route (miles) x 1,760 yards/mile] x [Avg. visibility right (yards) + Avg. visibility left (yards)] divided by 4,840 square yards/acre = Acres Observed

of deer observed provides an estimate of the deer density (acres/deer). Deer identified as bucks, does, and fawns are used to calculate the sex ratio and fawn crop. Daytime observation of additional deer is usually necessary to increase the sample size and improve accuracy of the sex ratio and fawn-crop estimates. Because of differences in average fawning dates for the 2 deer species, the best fawn crop estimates can be obtained in September-October for white-tailed deer and during October-November for mule deer.

To obtain a reliable count using the spotlight technique, it is extremely important to establish the route through each habitat type on the property. On larger ranches, more than one route may be necessary to adequately sample the various habitat types. Because it is a sampling technique, the route should be established through various habitats or vegetation types in approximately the same proportion that they are present on the ranch. Conducting the survey in areas where most of the deer are normally seen can result in a biased (too high) population estimate. A soils map, topographic map, and/or aerial photograph of the ranch can be valuable tools when evaluating an appropriate location for the survey route(s). Because of variability in deer movements from night to night, spotlight surveys should be conducted on three separate nights. The best time to conduct a spotlight survey in West Texas is during September through November, when bucks have hardened (conspicuous) antlers and fawns are old enough to be following does.

Strengths and Weaknesses

One of the strengths of the spotlight survey method is its ability to provide fairly accurate estimates of deer numbers (provided that the technique is conducted within the intended assumptions). At night when most deer are up and feeding, it is very easy to detect deer within spotlight range because of the reflective nature of their eyes. Another advantage of spotlight surveys, when compared to aerial surveys, is their relatively low cost. Costs associated with spotlight surveys include 2 spotlights, binoculars, truck operating expenses, and labor (~3 hours x 3 people x 3 nights).

The spotlight technique also is a fairly good estimator of fawn crops, provided the sample size is adequate and the surveys are not conducted too early (before all fawns are old enough to be following the does). However, spotlight surveys tend to be less accurate in their estimates of sex ratios because bucks are often underrepresented (McCullough 1982, Fafarman and DeYoung 1986, Richardson 2001, unpubl. data--see Table 1). Primary reasons for the inaccuracy are differences in behavior and movement between bucks and does, and the typically low sample size associated with most deer counts in West Texas. Daytime observations conducted by the ranch manager can increase the sample size and help to improve the reliability of sex ratios and fawn crops. A potential source of error during nighttime observations, especially with inexperienced observers, is the tendency to “miss” small antlers such as “spikes” and classify these deer as does. It is important to use quality lights and optics when attempting to classify deer as to sex or age. First-time observers are encouraged to “look for spikes on every deer." A general rule that will help to minimize errors is to only classify deer within a certain distance of the vehicle (150 yards or less). Deer beyond that distance should be recorded as “unidentified”, because classifying deer beyond this distance will invariably result in errors. It may be fairly easy to identify a 10-point as a buck at 200 yards, but the survey will be biased if all large bucks are identified, and all other deer are recorded as "unidentified."

Table 1. Comparison of helicopter, spotlight, and daytime observations by ranch in West Texas (Richardson 2001, unpubl. data).

County	Ranch	Ranch Acreage	Date	Method[2]	Intensity[3]	Estimated Density[4]	Estimated Does per Buck	Estimated Fawn Crop
Terrell	A	5,000	Oct-00	H	100%	40.5	1.5	62%
Terrell	A	5,000	Oct-00	S	2	20.4	2.0	70%
Terrell	B	7,500	Oct-01	H	75%	120	1.6	46%
Terrell	B	7,500	Oct-01	S	1	76	5.0	80%
Pecos	C	21,000	Oct-01	H	80%	40.9	2.2	66%
Pecos	C	21,000	Oct-01	S	1	24.5	2.8	53%
Terrell	D	25,000	Oct-00	H	49%	130[5]	1.5	49%
Terrell	D	25,000	Oct-00	S	1	24.8	3.5	67%
Terrell	D	25,000	Sep/Oct-00	D			2.0	75%
Terrell	D	25,000	Oct-01	H	50%	92[5]	3.8	42%
Terrell	D	25,000	Oct-01	S	1	17.1	6.0	67%
Terrell	D	25,000	Sep/Oct-01	D			4.5	71%
Pecos	E	60,000	Sep-99	S	3	13.3	2.3	100%
Pecos	E	60,000	Sep/Oct-99	D			2.1	104%
Terrell	F	3,000	Oct-01	H	100%	35	2.1	40%
Terrell	F	3,000	Oct-01	S	1	16.6	0.8	80%
Terrell	F	3,000	Sep/Oct-01	D			1.5	67%
Upton	G	75,000	Oct-00	H	20%	135	1.3	85%
Upton	G	75,000	Oct-00	S	2	85.5	1.0	83%

[2] H= Helicopter survey, S= Spotlight survey, D= Daytime observations for herd composition only
[3] Percent of ranch coverage for helicopter surveys or number of spotlight surveys conducted
[4] Acres per deer
[5] Helicopter surveys extended through midday.

One of the basic requirements of a spotlight survey is a good road system on the ranch. The survey route should traverse most pastures and sample representative portions of each habitat type. When selecting an appropriate route, a general "rule of thumb" to remember is that at least 10% of the ranch acreage should be observed during the survey. Another basic assumption is that deer are randomly distributed within a particular habitat type. Naturally, deer will be attracted to certain habitat types more than others, and this fact is unimportant if each habitat type is proportionately sampled. The point of caution concerns deer concentrations. For example, reliable spotlight counts are generally not possible when deer are concentrating in an orchard or on crop fields such as wheat or alfalfa. The survey results will be biased high if the deer concentrations are counted and will be biased low if the concentrations are avoided. The best and perhaps only way to obtain a reliable count is to conduct the survey, if possible, prior to crop emergence.

During drought, deer tend to concentrate in the general vicinity of watering sites. The survey will tend to overestimate deer numbers if the route is established near most or all of the watering sites. If the water locations are completely avoided, deer numbers will tend to be underestimated. Although the deer herd will immediately redistribute following precipitation and the emergence of fresh green growth, waiting for rain in the Trans Pecos is seldom fruitful. The next best option is to establish the route near a few water locations (proportional to the ranch acreage observed) while avoiding most. The location of the survey route relative to watering sites is generally irrelevant under favorable forage conditions (deer will be widely distributed).

Because the spotlight survey method is a sampling technique that includes only a small portion of the ranch (usually 10-15%), it usually does not work well in areas with very low deer numbers. The low precision inherent in the spotlight survey technique requires 3 repetitions in areas with moderate to high deer numbers. In areas of low deer densities, 4 or 5 repetitions may be required to obtain an acceptable estimate of deer numbers.

HELICOPTER SURVEY

Method

The helicopter survey technique may involve surveying the entire ranch or sampling only a portion of the property (e.g., 50% or 33%). Partial (or percentage) counts have provided estimates similar to total ranch counts (Evans 1975, Beasom 1979, Synatzske 1984, Teer et al. 1985), and can be extrapolated to the entire ranch. Small, 2-seater helicopters commonly used for game surveys in West Texas include the Robinson R22, Schweizer 300, and Enstrom F28. These relatively small helicopters have excellent visibility and maneuverability, with a survey crew consisting of the pilot and the observer. Larger jet helicopters are often used in mountainous terrain. They have the advantage of carrying additional observers, but they are much more expensive to operate ($450-550/hour compared to $210-250/hour for small helicopters) and visibility is sometimes limited.

Aerial surveys should be conducted during early morning and late afternoon when temperatures are cooler and deer are most active. Most deer will be bedded from mid-morning through mid-afternoon, and surveying during this time will result in a relatively poor count. Cool weather can extend the survey flight time, as deer will remain active throughout much of

the day. Some managers prefer to conduct winter surveys because a higher percentage of the deer herd can be counted (deer are more active in cooler temperatures and leaf-drop improves visibility). However, basing harvest recommendations on winter surveys can be risky because natural mortality rates between winter and the following deer season can vary tremendously from year to year in West Texas.

An altitude of 40-60 feet above the vegetation should be maintained. In relatively dense juniper or mesquite, the flight speed of the helicopter should be maintained at about 30-35 mph. In fairly open habitat that exists across much of the Trans-Pecos, the air speed can be increased to about 45 mph. Many deer will be missed if the flight speed exceeds 45 mph (Shupe and Beasom 1987), mainly because fewer standing and bedded deer will "flush".

Deer and other animals of interest (javelinas, feral hogs, turkeys, quail, predators, etc.) are counted within 100 yards of the flight path of the helicopter (a 200-yard observation strip). Ranches with dense brush and trees may require a narrower observation strip (e.g., 150 yards), while very open country may allow a wider observation strip (e.g., 300 yards). The use of a global positioning system (GPS) will improve the accuracy of transects and allow easier calculation of the observed acreage (72.7 acres/mile @ 200 yard strip-width). Deer are classified by species (whitetail vs. mule deer) and categorized as bucks, does, and fawns. Generally, bucks are further categorized into “age” or “quality” groups (e.g., spikes, small forked, medium forked, and mature).

Mountainous terrain can be surveyed more effectively by flying transects along the contour rather than maintaining linear transects. A common practice is to survey the “bottoms” first and gradually work up the mountain because most deer (especially white-tailed deer) tend to run down the mountain toward the brushy bottoms when flushed. Deer may be counted twice if lower and upper elevations are surveyed in reverse. Survey transects should be conducted parallel to major canyons and drainages rather than across them.

Strengths and Weaknesses

The helicopter survey technique is a very good indicator of the deer herd sex ratio and is a fair to good estimator of fawn production, especially if conducted several months after the peak of fawning (when fawns are following does). Leon et al. (1987) concluded that there was no sex or age bias during helicopter surveys in south Texas, but the youngest deer they captured and marked was 1 year old (fawns were not included in the study). During October and November helicopter surveys, Sullivan et al. (1990) undercounted the actual percentage of fawns in a high-fence pasture (observed fawn crop 22%; actual fawn crop 30%). The authors hypothesized that fawns were more difficult to observe because they are smaller. Richardson (2001, unpubl.data) observed low fawn crops during helicopter surveys compared to fawn crops obtained on the same ranches during spotlight surveys and daytime herd composition counts (Table 1). He hypothesized that the occasional low fawn crop estimates during helicopter surveys may result from 2 factors-- fawns are more difficult to detect because of their smaller body size but, more importantly, young fawns may instinctively lie down (or remain bedded) as the helicopter approaches.

Another advantage of helicopter surveys is that they allow an evaluation of buck age and/or quality because a large proportion of the herd can be observed. Helicopter surveys can provide population trends of other wildlife species (e.g., quail, turkeys, elk, javelinas, feral hogs, aoudads, and predators), some of which are difficult to survey by any other means. In addition, a biologist providing technical assistance can learn more about a ranch (water distribution, brush management needs, wildlife distribution, etc.) in a shorter period of time than by any other technique.

Helicopter surveys are less effective in determining accurate wildlife numbers, including deer. Numerous studies have demonstrated that only a portion of the deer in the transect strip are observed, which is largely dependent on the brush density and the canopy cover of trees and brush. Other factors that will affect deer sightability include ruggedness of terrain, "ground" color (green vs. tan), number of animals per group, and the altitude and speed of the helicopter. Three factors that influence deer movement (and thus sightability) are time of day, temperature, and wind. Bartmann et al. (1986) observed 63% of a mule deer herd on a somewhat calm day and 51% of the herd on a windy day (20+ mph).

Rice and Harder (1977) conducted 5 helicopter surveys of a snow-covered, 300-acre enclosure in northern Ohio and observed 51-70% of a known number of deer. Beasom (1981) concluded that traditional ranch counts in south Texas underestimated the deer population by at least 26%. Mackie et al. (1981) observed 67-74% of a mule deer herd during helicopter surveys in a Montana habitat with few conifers. When the helicopter technique was evaluated at different sampling intensities (10%, 25%, 50%, and 100% coverage) in South Texas (40-60% canopy cover), it demonstrated an accuracy of 26-34% on one study area and 26-40% on the second study site (Synatzske 1984, Beasom et al. 1986). In the same study, 2 high-fenced pastures (685 and 650 acres) were "walked-out" by 100 individuals to obtain a total count of the deer. Assuming that all deer were accounted for by the walkers, only 43% of the deer were observed by helicopter in each pasture. DeYoung (1985) observed 36-65% of marked white-tailed deer herds during 14 helicopter surveys on 2 South Texas ranches. DeYoung et al. (1989) concluded that helicopter survey accuracy in south Texas can be improved from less than 50% to approximately 60% by reducing the transect width. However, they noted that improved accuracy may result in reduced precision because of reduced sampling intensity. Bartmann et al. (1986) examined the accuracy of helicopter counts of marked and radio-collared mule deer in a Colorado pinyon-juniper habitat. The average proportion of mule deer observed ranged from 35-77% in the first year and 50-86% in the second year (overall average was 66%). The trend of population underestimation observed in deer surveys by helicopter has also been documented in numerous other species, including elk, caribou, feral horses and pronghorn (Frei et al. 1979, Samuel et al. 1987, Firchow et al. 1990, Unsworth et al. 1990, Pojar et al. 1995, Mahoney et al. 1998).

Low accuracy of helicopter surveys is the result of 3 major sources of error. The first error source is the result of observers missing visible deer on the transect strip (moving deer are seldom missed but standing deer are missed more often). While this is the least important error source, survey results can vary substantially depending on observer ability and experience (Caughley 1977, LeResch and Rausch 1974, Frei et al. 1979). A more substantial error source is the tendency of observing fewer deer (not visible) with increasing distance from the flight line.

The 2 primary reasons for missing deer with increasing distance from the helicopter include: 1) lateral screening cover is greater with increasing distance from the flight line and 2) standing and bedded deer are less likely to flush at increasing distances from the helicopter. Beasom et al. (1981) conducted helicopter surveys on 11 south Texas ranches (30-70% canopy cover) and subdivided the transect strip (100 yards on each side) into 2 intervals -- 0 to 50 yards and 50 to 100 yards. Of the total deer observed, they saw 68% in the first interval (0-50 yds.) and only 32% in the second interval (50-100 yds.). DeYoung et al. (1989) concluded that the number of deer missed during helicopter surveys on 2 south Texas ranches was at least 50%. However, they were able to improve survey accuracy by reducing transect width to 40 yards. When conducting helicopter surveys of mule deer in a pinyon-juniper habitat, White et al. (1989) observed 150% more deer in the 0-25 yard interval than in the 75-100 yard interval. The third error source is missing deer (not visible) that are directly on the flight path because they remain stationary (bedded or standing) and are obscured by vegetation canopy. For example, when observers restricted their search path to only 20 yards from the helicopter flight line, they still missed 42% of the deer (DeYoung et al. 1989).

While the accuracy of helicopter surveys has been debated by wildlife managers, the precision (similar results on repeated counts) of the technique has rarely been questioned. Undoubtedly, aerial survey techniques have demonstrated greater precision than the spotlight survey method. However, studies of helicopter survey precision have demonstrated that the technique may not be as precise as wildlife managers have presumed (Beasom 1979, Synatzske 1984, Beasom et al. 1986). Synatzske (1984) conducted 6 helicopter surveys on each of 2 high-fenced study sites. On study site 1 (6,378 acres), a complete coverage survey resulted in an average deer density of 33.8 acres/deer (range of 26.0 to 43.1), an average of 1.5 does per buck (range of 1.2 to 2.1), and an average fawn crop of 5.5% (range of 2.0% to 13.9%). On study site 2 (7,483 acres), a complete coverage survey resulted in an average deer density of 24.8 acres/deer (range of 20.7 to 30.9), an average of 2.3 does per buck (range of 2.0 to 2.7), and an average fawn crop of 10.2% (range of 6.9% to 18.8%). When the study sites were flown at 50% coverage, variability of survey results was generally greater for density, sex ratios, and fawn crops.

Because deer numbers are consistently underestimated using the helicopter survey technique, harvest recommendations tend to be conservative. This is generally not a problem in West Texas if land managers are simply interested in producing mature bucks and maintaining deer numbers. However, when land managers are attempting to improve their income through deer hunting, very conservative recommendations can translate to dollars lost. The opportunity to harvest mature bucks is foregone, and this opportunity is replaced by considerable natural mortality of adult deer. Underestimating deer numbers is also a problem where white-tailed deer herds commonly exceed the carrying capacity of the land. Conservative doe harvest recommendations will only result in perpetuation of the problem.

Costs associated with helicopter surveys (2-seater) include flight time ($210-250/hour), trailering fee ($1.00-1.50/mile one-way), and labor (1 observer x flight hours @ 2,000-3,000 acres/hour).

SUMMARY

Spotlight surveys are relatively inexpensive to conduct and can provide good estimates of deer numbers if conducted within the assumptions previously described. However, spotlight surveys are less precise than aerial surveys, and sex ratio estimates tend to be unreliable. This is partially because of the relatively low number of deer typically observed along the route and because of differences in behavior and movement between bucks and does. In addition, mountainous terrain can present some sampling problems that are related to deer concentrations and changes in deer distribution. Helicopter surveys produce more reliable estimates of buck to doe ratios, allow population estimates of other wildlife species, and allow the land manager to evaluate the age and/or quality of the buck segment. However, annual helicopter surveys can be expensive, and they underestimate the number of deer on the property. The survey technique that is most appropriate for a given ranch will depend directly on the type of information that is most critical to achieving the deer management objectives. Each survey technique has strengths and weaknesses in estimating certain herd parameters. But more importantly, the deer manager that is aware of the strengths and limitations associated with each survey technique can select the most appropriate method (or combination of methods) for their ranch and successfully use it to manage the deer herd.

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SEASONAL DEER FEEDING

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***Abstract*:** Many hunters and landowners are feeding deer with little or no knowledge of whether or not the practice is beneficial nutritionally or economically. An important part of seasonal deer feeding is to have a comprehensive plan that involves population management, genetic selection, and nutritional management. By taking forage samples and comparing estimated nutritional intake to nutritional requirements of the different classes of deer, a manager can more accurately supplement the nutrients deficient in the deer's diet and maintain or improve animal performance. Seasonal deer feeding involves targeting specific supplemental feeds at different times of the year to optimize feeding costs and generate the most economical returns.

Almost everyone seems to be trying to produce trophy deer. Some pursue this goal in hopes of bagging this trophy themselves, while others hope to be able to market trophy animals to hunters willing to pay high hunting fees. However, very few have an actual plan on how to achieve this goal of trophy deer.

Trophy deer and happy hunters are the result of good management practices. Probably first on the list of practices is population management. Keeping the number of deer in line with the habitat they live in it paramount to all other management practices. Included in population management is allowing bucks to reach a mature age of 5 years of age or better to allow realization of their genetic potential for antler growth. Also, maintaining a narrow doe to buck ratio helps to optimize your operational costs because more of the high market animals (mature bucks) are receiving the inputs of good management, and therefore have the opportunity to return revenue to the manager.

Somewhere in your operation genetic selection has to be included in your plan to improve the quality of deer harvested on your place. We can argue all day about whether to cull deer as yearlings or wait until they are three year olds, but the fact remains that unless you do some level of harvesting deer that you consider inferior for your operation, you will not make as much progress toward your goal than if you don't harvest them.

Finally, nutrition plays a major part of allowing an animal to develop into the full potential of antler production, or reproduction, that they are capable. However, a supplemental feeding program should be developed that is goal oriented. By goal oriented, I mean that you should have an idea of what you want to accomplish before you start. Your goal may be to produce the most trophy bucks you can on your place. It may be to increase the productivity of your doe herd. Or may be to just maintain your deer population through times of severe drought like you have been experiencing.

Your supplemental feeding program should also be convenient. If it is too hard, it won't get done. I have seen many hunters and landowners start on complicated feeding programs only

to quit within a year. Most hunters have places for the pleasure of being outdoors as well as hunting. If it takes ninety percent of your time to keep the feeders full and the feed pens repaired, the pleasure of being in the great outdoors is diminished. So develop a feed plan that can be accomplished without taking away too much of the pleasurable experience of being outdoors.

A successful feeding program should also be economical. Unless you have a lot of money to spend, feeding deer has to begin to pay off at some time. This is probably the greatest reason that I've seen people quit, or fail, with their feeding program. Before you start feeding, you should project out how much it will cost to feed to reach your goal. Then you can decide if your program is sustainable. This may or may not determine if you can follow through with the program, but it can help you to determine whether or not you may have to find ways to generate income to offset the cost of feeding.

And finally, a feeding program must be nutritionally based. Feeding corn when deer need protein, or vice versa, is a very inefficient supplemental feeding program. Do you have any idea what deer actually need in nutrient composition? Better yet, do you have any idea what the nutritional quality of your deer's diet is? To feed economically, you need an idea of the nutritional quality of the diet and the nutritional needs of the animal. The best way I have found to estimate the nutrient intake of deer, or livestock, is to physically take a forage sample from the area where the animals graze and browse.

Beginning in 1997, I began a project with a cooperative landowner in Tom Green County, near San Angelo, Texas, and Steve Nelle, Wildlife Biologist with the National Resource Conservation Service, in San Angelo, Texas, to try to estimate what plants deer are interested in eating during different seasons of the year and to sample the forages that show deer usage, or that we anticipate deer will eat in the near future. Samples were sent to the Dairy One Forage Testing Laboratory in Ithaca, New York for analysis. The data from the forage analysis was put into a computer model to developed to estimate the forage intake, estimate nutritional deficiencies, and predict the performance, of the different classes of deer (doe, mature bucks, yearling bucks, etc.).

I used my experience of estimating the diets of cattle, sheep, and especially goats since 1985 in order to develop more efficient supplemental feeding systems for livestock on native pastures, to develop the technique of sampling and computer modeling. Using this past experience and frequent forage samples for deer diets I have developed a concept that I call "Seasonal Deer Feeding".

In reality, Seasonal Deer Feeding is similar in concept to a livestock operator supplementing his animals to maintain, or improve, the performance of his animals in either gain or reproduction to improve the profitability of his operation. Deer, being a highly selective ruminant browser, are very similar in nutritional needs to goats, with the exception of antler production. Therefore, it was a small jump from developing supplemental feeding programs for deer from goats.

The nutritional data is shown on graphs illustrating the values by month and an average for all samples taken in each month. Also, I have plotted some values from forage samples taken from west of Valentine, Texas based on my perceptions of mule deer diets in that area. There are only four of these samples, so it is difficult to draw many conclusions from this data.

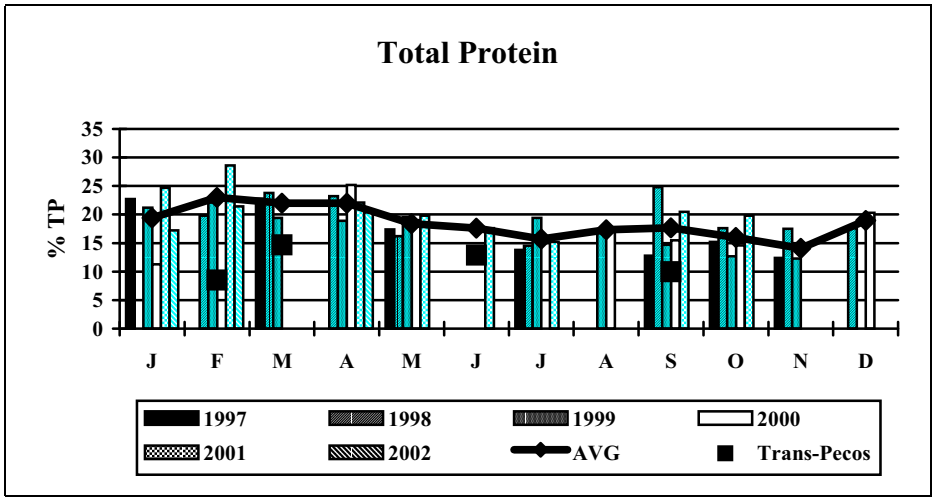

Figure 1

Figure 1 shows the protein content of the total forage samples taken on the cooperator's ranch from January 1997 until April 2002. The line connecting the diamonds shows the average protein value of the forages in the samplings each month. Black boxes on the chart represent the few samples of deer diets that I have taken west of Valentine, Texas based on estimates of mule deer diets. February, March, and April are the months with consistently higher forage protein content for deer. The summer months tend to have lower protein levels than other times of the year, except for November. Note that the protein levels of the mule deer diets in Brewster County were consistently lower than those from whitetail deer diets in Tom Green County. Remember these samples have been taken in this severe drought the country has been in for the last several years.

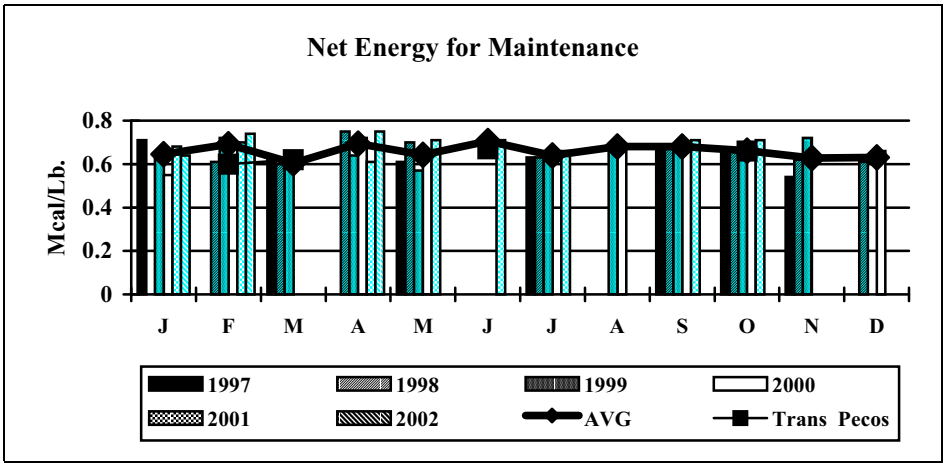

Figure 2

Figure 2 shows the energy values from acid detergent fiber levels in the forage samples. The energy values of the forage are more consistent than that of the protein value of the forages deer eat. This is most likely because of the selectivity of the deer for a diet that can be broken down and moved through the rumen rapidly. Deer seem to have a much faster rate of passage through their rumen than cattle, and to accommodate this, they tend to select only plants that have a low level of undigestible fibers. They also select broadleaf plant leaves, which have a net venation pattern of nutrient transport vessels in their leaves, over grasses, which have a parallel venation. The digestible material between the fibrous vessels in broadleaf plants is more readily broken down than that between the parallel venation of the grasses. Deer will forage on grasses in a very vegetative condition, since the fiber levels at that stage are very low. As plants mature, both broadleaf and grass, the fiber content increases and energy value, and digestibility, decline. This is why deer select the most tender, vegetative parts of the plants they eat.

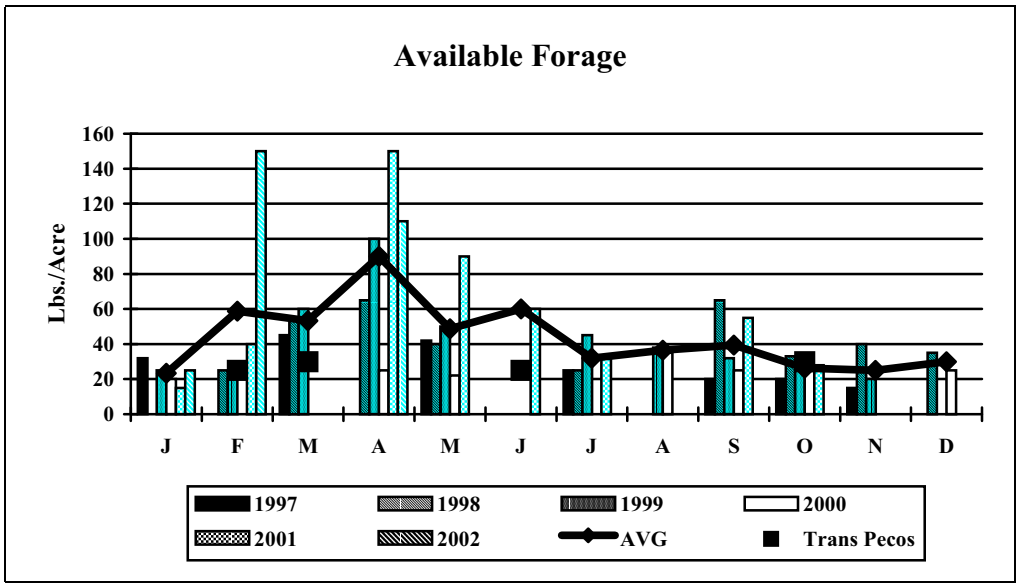

Figure 3

Figure 3 shows my estimate of the amount of forage available that a deer is willing and able to eat in the area from which I took the forage samples. This is a subjective assessment based on my experience with developing supplemental feeding program for livestock. The spring period of 2001 and 2002 have had the most forage available for the entire time I have been taking forage samples for deer. However, lack of rainfall has reduced the available forage amount greatly by the summer months. The mule deer samples are much lower for each month, except for the October sample, than the samples from Tom Green County, which should be normal, especially considering the much lower deer density in the Trans-Pecos than either the Edwards Plateau or Rolling Plains areas.

The importance of available forage is in estimating the forage intake of an animal in its habitat. There is a strong relationship for forage intake in relation to animal density and available forage. On a given area, if you increase the number of animals with a constant amount of available forage, forage intake will decrease. Also, if you maintain a constant level of animal numbers on a set area, but decrease available forage, forage intake will decrease.

This concept is important because knowing the protein, energy, or mineral levels of the diet of any animal, including deer, means nothing unless you can estimate how much they are eating. Animals need an amount of grams of protein, megacalories of energy, and grams or milligrams of minerals each day. The nutritional levels in the plants can be lower if a larger amount of forage is eaten a day. However, when diet is restricted, which in reality is most of the time in west Texas, nutritional levels must be higher in the plants to maintain productivity. It's the total pounds of nutrient intake that is important.

So keeping this in mind, I used the average monthly data in my computer model to estimate the nutritional intake of a mature doe and buck to compare the nutritional intake to the animal's requirements. Figure 4 illustrates this comparison for protein intake versus protein requirement for a mature doe with a single fawn production for the year. The arrows represent the periods and type of supplement to correct nutritional deficiencies in the diet of the doe.

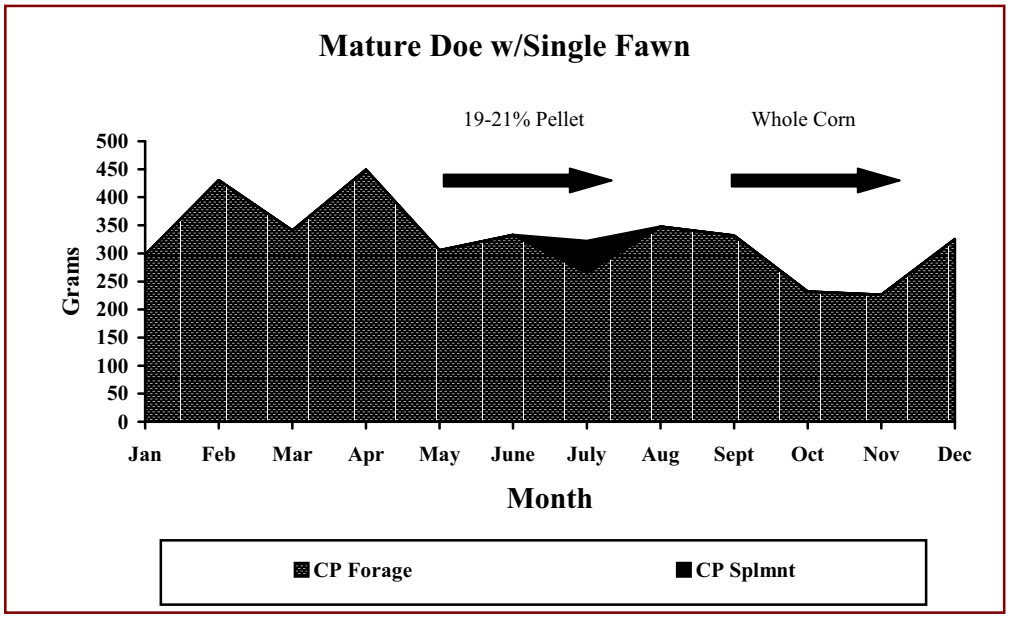

Figure 4

Because of low protein levels in the summer, the doe needs some protein to help maintain milk production to allow the fawn to get sufficient milk intake to grow and develop as well as he should. In the fall, due to colder temperatures, less forage available, and lower nutritional values in the forage, whole corn, or a lower protein deer supplement, will increase energy intake to correct energy deficiencies (chart not shown) and help maintain her body weight.

For a doe with twin fawns, both the protein and energy requirements are increased dramatically as is shown in Figure 5. In order to develop a plan to improve the reproductive rate and fawn survival, a higher level of protein and energy supplementation will be required, using the average forage values. Early in the year (January), an energy deficit can be corrected by feeding whole corn, especially if body condition is low on the doe. In February, a protein deficiency begins to develop that can be corrected with a mid-range (19% - 21%) protein deer

pellet because the protein content of the forages at this time is at its highest. As the late gestation period (the last 60 days of pregnancy) begins, the protein deficiency increases and a supplement with a higher level of protein (26% - 32%) will correct the deficiency more economically than the mid-range protein supplement. After weaning of the fawn, whole corn can be used to increase energy intake and maintain a good reproductive rate and body condition.

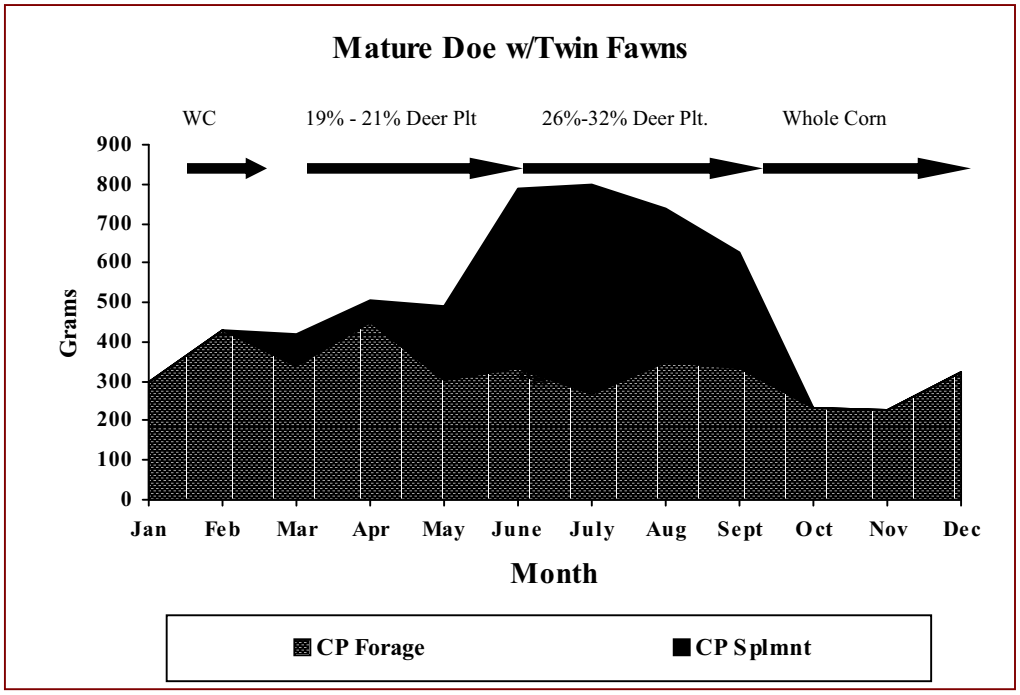

Figure 5

Antler growth does not seem to require a high-energy input, so feeding whole corn could correct the energy deficiency in a mature buck from low forage intake, high breeding activity, and lower energy values in the forage. However, when antler growth is factored into the requirements, a large protein deficiency develops. The practice of feeding protein supplements to bucks is justified to improve the antler development in mature bucks. While age is a major factor in a buck reaching his genetic potential for antler growth, supplementing with protein can improve the nutritional intake sufficiently to improve what the forage can provide alone in most years in west Texas. Figure 6 illustrates the protein deficiency between the nutrients provided by average forage conditions in Tom Green County and the buck's requirement for body maintenance and antler growth in a program designed to maximize antler growth.

To make the supplemental feeding program more economical, corn can be fed to help improve energy intake and improve body condition after the breeding season. Prior to antler growth, a moderate protein supplement should be fed to provide the protein intake not provided by the forage, even though the forage protein content is usually at its highest at this time. The amount of forage available in late winter-early spring many times is too low for the bucks to get all the protein they need. Then, as the summer months arrive and the plants are more mature, the protein and energy content decline. Switching to a higher protein supplement (26% - 32%

Protein) will help to correct the greater protein deficiencies at this time and allow antler growth to continue. After antler growth is complete and the protein requirement decreases, whole corn can again be fed as an energy supplement since protein deficiencies are low, or non-existent at this time, based on the average of the forage samples.

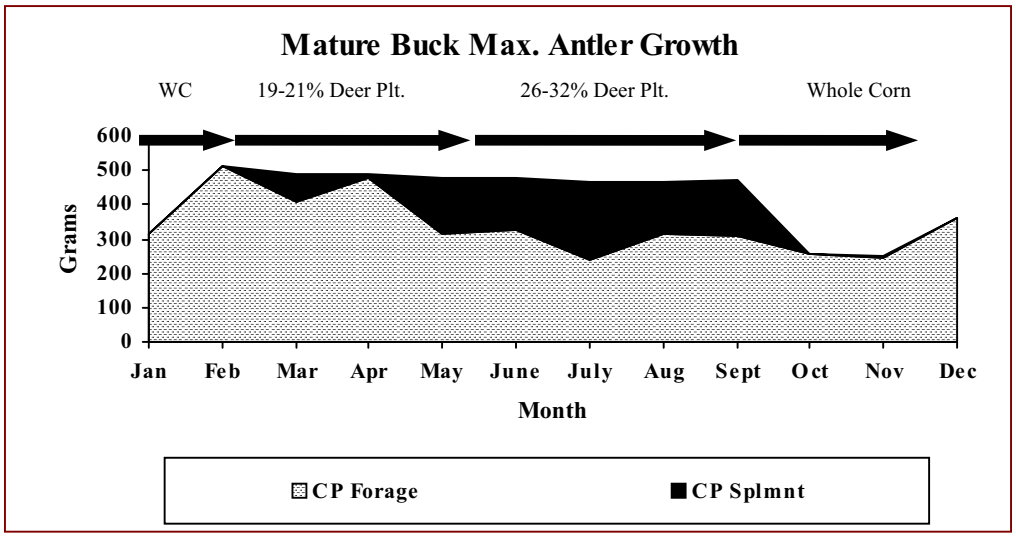

Figure 6

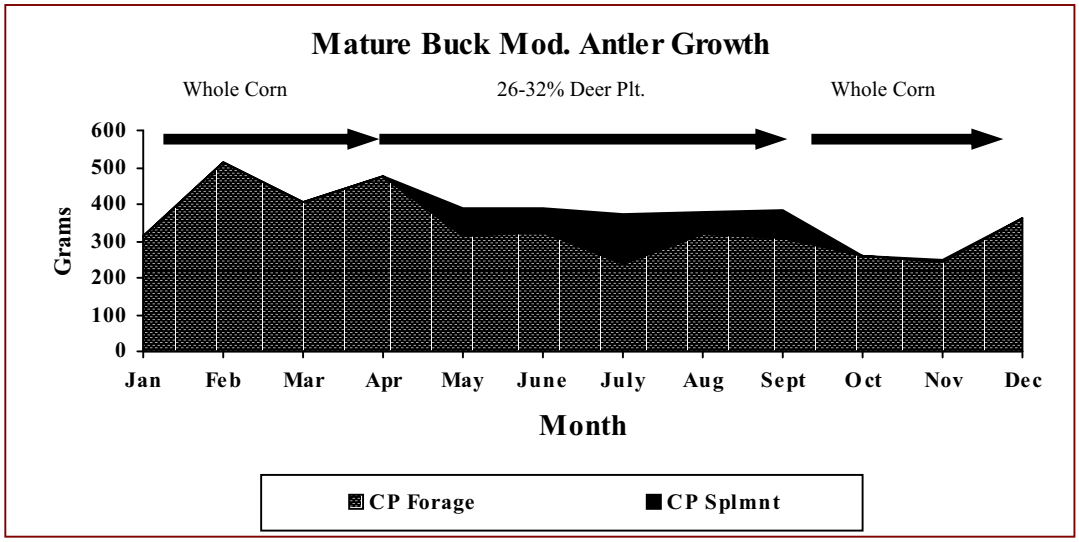

Figure 7

While this year-round feeding system is great for developing mature trophy bucks, it is costly and generally requires a marketing scheme to capitalize on the quality of bucks you are producing. If you cannot generate increased revenue from the increased feed costs of your supplemental feeding program, whether through more hunters, more trophy animals produced, or increased hunting fees, sustaining the program become difficult to justify. Many producers want

to increase the quality of their deer in both reproductive rate and antler growth, but not to the extent of the trophy deer type of program. For those, Figure 7 represents a supplemental feeding program designed to meet these goals.

By factoring in a moderate antler growth, the protein requirement is lessened, which allows you to feed whole corn longer into the spring months. When protein supplementation is required, using a higher protein supplement (26% - 32% protein) will allow you to get more protein into the deer with fewer pounds of supplement. The post-antler growth period is the same as with the trophy buck program, because energy is the greatest deficiency for mature bucks going through the breeding season and winter. Again whole corn can correct this energy deficiency more economically than protein-type supplements.

While this type of supplemental feeding program won't create "monster" trophy bucks, it does have the potential to increase the productivity of the does, increase the weaning size of fawns, and increase the antler growth and winter survival of mature bucks, all of which can translate into greater revenue for your hunting operation. For hunters who lease land and want to develop a feeding program, this offers a compromise and economy and results that can fit their pocketbooks.

There is one other aspect of a good supplemental feeding program – food plots. While in arid west Texas, and even more so in the Trans-Pecos, successful food plots are difficult at best. If you can establish a foot plot, it can greatly enhance your deer productivity. If available, irrigation can be an economical possibility that can make food plots a much less risky proposition. The important principle concerning food plots is to have high quality forage available at times when the native forages are weak. Figure 8 shows the times of the year when protein is deficient for a mature buck and maximum antler growth. A combination of cool season food plots (wheat, oats, clovers, vetch, etc.) and warm season food plots (lab-lab, alfalfa, buckwheat, peas, beans, etc.) can fill in the nutritional gaps that develop during the course of the forage year.

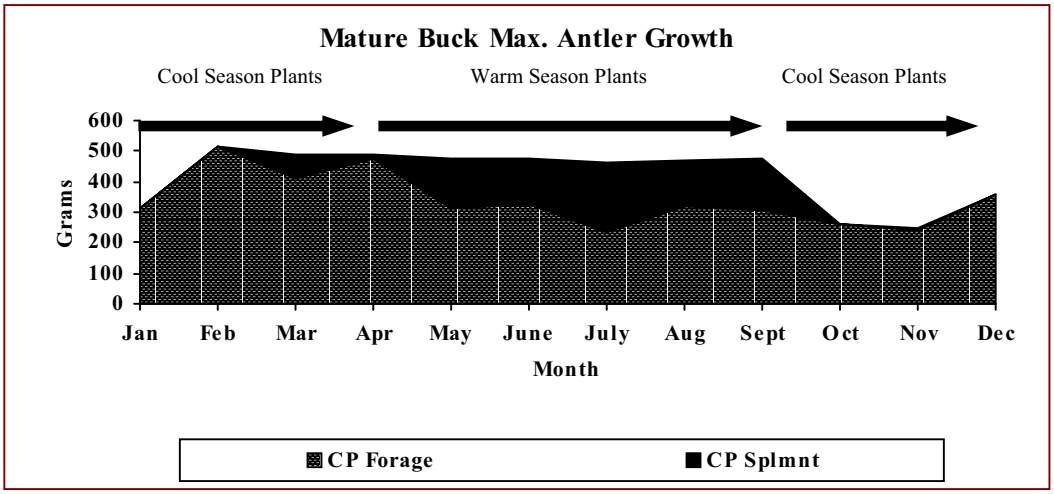

Figure 8

Improving the quality of your deer through a supplemental feeding program requires setting a goal for what you want to achieve, trying to determine the nutritional intake and requirements of your deer, and then developing a program that is goal oriented, convenient, and economical for your operation. Putting all of these attributes together will move you a long way toward reaching your goal of improved deer productivity and quality, and enhancing the enjoyment of your hunting experience and operation.

RANCHING IN THE DESERT

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Abstract: About 80% of the Trans Pecos is true desert. The desert was not regularly grazed by resident native large herbivores (bison). The combination of recurring drought and improper grazing has decimated the former grasslands and made the desert an even harsher place to ranch. The basic premise of sustainable ranching (a reliable surplus of grass) may not exist in the desert except during abnormally wet periods. The desert is poorly suited to ongoing cow-calf operations. During above average periods when there is adequate grass growth, grazing can be done in a manner consistent with conservation. Flexible grazing with stocker cattle, (or cows that can be easily liquidated) is the key. The desert is suited to the sustained management and production of wildlife. An increased emphasis on wildlife management may allow a faster and more complete recovery of ranges and more stable economics than a return to traditional cow-calf ranching.

Successful livestock ranching is based on the premise that there is a somewhat reliable supply of surplus grass produced each year. In most ranching areas, nature provides adequate rainfall and grass growth so that surplus grass can be grazed and converted into red meat and yet enough grass can be left ungrazed to protect and maintain the soil. This ungrazed residue of grass is essential for the perpetuation of the grassland and for the proper functioning of the water cycle. Across much of the Trans Pecos, it is very questionable whether or not this basic premise exists. The long-term wisdom of permanent and ongoing livestock ranching in the desert portions of the Trans Pecos will be challenged.

I have no first-hand personal experience that would qualify me to advise others how to successfully ranch in this desert region of Texas. However I have observed and listened and learned from others who have many years of first hand experience, which provides the basis for this paper. I would like to thank Chip Merrill, Wayne Seipp and Gary Valentine for reviewing this paper and providing helpful suggestions.

MOST OF THE TRANS PECOS IS A TRUE DESERT

The Trans Pecos region of west Texas is about 20 million acres in size and is considered part of the much larger Chihuahuan Desert. There are actually four zones within the Trans Pecos that differ in elevation, rainfall, vegetation and the ability to provide a stable livestock ranching environment.

The Desert Shrub zone (about 3 million acres) lies below 3,500 feet in a band along the Rio Grande and receives an average of 8-10 inches of rain. Most of Big Bend National Park lies in this zone as does the route between Lajitas and Presidio. This is the harshest, hottest and least productive region in the Trans Pecos and is typified by sparse desert shrubs and bare ground. Most of the zone now has little or no grass production and little or no realistic expectation for

recovery. Some areas that have little water and have not been heavily grazed still have desirable grasses.

The Desert Grassland zone (about 13 million acres) lies between 3,500 and 4,500 feet in elevation and receives an average of about 10-12 inches of rainfall. This zone encompasses the majority of Hudspeth, Culberson, Reeves, Pecos, Loving, Winkler, and Ward counties as well as portions of Brewster and Presidio counties. The drive from Sanderson to Fort Stockton to Pecos and on toward Carlsbad is representative of the Desert Grassland. This zone once supported stable grasslands along with a sparse density of woody plants. Heavy grazing and recurring drought over much of the area has reduced the desirable grasses, led to erosion of topsoil and allowed the increase of shrubs such as creosote bush and tar bush. Although large areas of the zone have lost most of its original productivity, there is still some potential for natural recovery through long term prudent grazing management. Brush management or other practices may be needed in some cases to allow the recovery of grasses to begin.

The Mixed Prairie zone (about 3 million acres) lies from about 4,500 to 5,500 feet in elevation and receives an average of about 12-15 inches of rainfall and snowfall. This zone encompasses much of Jeff Davis County as well as the northern portions of Presidio and Brewster counties. Along Highway 90 between Marathon and Valentine is a good example of Mixed Prairie. This is the most desirable ranching area within the Trans Pecos. The zone was originally an open prairie with desirable grasses and scattered shrubs. Much of the Mixed Prairie still supports good stands of desirable grasses. However, heavy grazing has caused a degradation of the grassland and the encroachment of brush in some areas. The composition and production of the grassland can be improved by good grazing management (proper stocking rates, rest and recovery periods and flexibility). This is the favored area for pronghorn in the Trans Pecos.

The Mountain Savanna zone (about 1 million acres) includes the areas above 5,500 feet in elevation that receive an average of 15-20 inches of rainfall and snowfall. Most of the taller mountain ranges in the region are in this zone including the Davis, Chisos, Guadalupe, Delaware, Sierra Diablo, Chinati, and Eagle Mountains. This zone supports a mixture of grasses, shrubs and trees and is valuable both for wildlife habitat and livestock ranching although roughness of terrain limits grazing accessibility.

If you are fortunate enough to own or operate land in the Mixed Prairie or Mountain Savanna zones, then ongoing livestock ranching can be an ecologically valid and hopefully profitable use of the land. These higher rainfall, higher elevation areas are not really a part of the Chihuahuan Desert. Even though these zones are not as harsh as the desert, they are still fragile and require good management. Extreme care and flexibility should be practiced when ranching here in order to maintain and conserve the resource.

The Desert Shrub and Desert Grassland zones that make up about 80% of the Trans Pecos should be considered true desert regions. Rainfall and grass growth is sparse, erratic and unpredictable and not well suited to sustained livestock production. Ranching in these zones is difficult even in good years. In poor years, or certainly in periods of prolonged drought there is not enough grass produced to provide even a small amount of grazing. These zones should not be considered stable ranching areas. Short term or seasonal grazing with stocker type animals

during above average periods is the most reasonable way to carry out livestock ranching in these desert regions. Some desert ranchers have been successful with extremely light stocking of cows, a variable number of stockers and the resolve to adjust or sell out early in a drought before the range is damaged. Even though these areas are not well suited to ongoing livestock operations, they are suited to wildlife habitat and the production of wildlife such as blue quail and mule deer.

LARGE GRAZERS DON'T THRIVE IN THE DESERT

In most ranching and grazing regions of Texas, there is ample evidence that these areas are naturally well suited to the production of surplus forage and grazing by large animals. It is a well-documented fact that large herds of bison were found across much of Texas, especially in the central and northern portions. In these areas that receive an average of 15-35 inches of rainfall and have an abundance of reliable natural water, the grazing of large animals is a natural part of the ecology of the land. Livestock grazing in these non-desert areas, when properly managed, can be carried out in harmony with the long-term health of the land.

In the Trans Pecos region, there is no similar evidence that bison were regular or common inhabitants of the desert. There are a few isolated records of bison west of the Pecos River, but not in large numbers nor on a regular basis. It would be logical to surmise that bison did wander into the desert in times of above average rainfall when water and forage were plentiful. However it is clear that bison did not live permanently in nor migrate regularly through the Trans Pecos. This fact argues against the practice of permanent and long term grazing of the desert portions of the Trans Pecos. Just as the bison presumably used the desert periodically during times of plenty, livestock ranching can simulate this pattern by the use of stockers during and after those times of plentiful rain and good grass growth. The maintaining of permanent breeding herds of livestock is not considered to be consistent with the wise and proper use of desert rangelands. The production of surplus grass is simply not reliable enough to justify ongoing cow-calf operations.

The Trans Pecos did support large wandering herds of pronghorn in historic times. These animals, however, have feeding habits very much different from cattle. The primary component of their diet is forbs (broad-leafed herbs or weeds) which make up well over half of their diet. Pronghorn also consume a large amount of browse (leaves, twigs and fruit of woody plants). Grass only contributes 5 to 10% of their diet. The historic presence of large numbers of wandering pronghorn does not provide support for the notion that the desert can support and sustain ongoing cattle ranching.

DROUGHT IS THE RULE IN THE DESERT

Prolonged periods of little or no rain and little or no grass growth are the ***normal conditions*** in the Chihuahuan Desert. The area is ruled by drought. Periods of generous rainfall and abundant grass growth do occur but are the rare exception. Even periods of so called normal rainfall are not very conducive to successful ranching. A normal year in the desert (if there is such a thing) might be described as 8-12 inches of rain, poorly distributed, with a substantial part of that as intense thunderstorms. Much of the rainfall is quickly converted to runoff. Some rain

soaks into the soil, but the series of 105 degree days that follow evaporates much of the moisture from the bare surface. Brush and/or weeds use their share of the limited moisture, leaving only a scant amount to keep grass plants alive and even less to allow for new growth.

THREE KINDS OF DROUGHT

There are at least 3 different kinds of drought that must be faced in the ranching business. The first kind might be called common drought. Common drought is the frequent but usually short-lived dry spells that occur as part of the normal climatic variation of a region. Common drought might be considered to be those below-average periods that seem to come along every few years. In non-desert regions, the good rancher can withstand these common droughts with timely adjustments in livestock numbers to match forage production. In the desert, where even an average year is poor, these common drought periods are more significant and may make ranching unprofitable. The advice usually given to help buffer a ranch from this kind of drought is to stock very conservatively with breeding animals (well below what you think the ranch will run) in order to have a built-in surplus of grass in all pastures. This reserve of grass is not only insurance against short-term drought, but promotes better grass health, builds a richer soil and promotes increased rainfall infiltration. Stocker cattle can be retained, purchased, or pastured to take advantage of good years.

The second kind of drought is man-made drought, sometimes called perpetual drought. Regardless of how much rain falls, the land still looks poor and grass production is never good. In years of good rainfall, the land grows weeds, not grass. This kind of permanent drought condition is the result of years and years of poor grazing management. Overstocking and continuous yearlong grazing causes the overgrazing of grasses. As grasses are repeatedly grazed and re-grazed and unable to recover adequately, they progressively become weaker and weaker. As the leaves continue to be grazed too short, too often, the root system becomes weakened and stunted and unable to extract soil moisture. The size and vigor of individual grass plants decreases. Grass cover decreases and bare ground increases. There is inadequate litter or old grass left to protect the soil. Erosion is increased and infiltration is decreased. Grasses subjected to this kind of grazing may stay alive during normal or good rainfall years, but cannot withstand a drought. A long term commitment to sound and conservative grazing management can help protect a ranch from this kind of drought.

The third kind of drought - catastrophic drought - is the most damaging of all and little can be done to mitigate its effects. Catastrophic drought occurs when a long string of back to back dry years hits. The damage to the land, the animals, ranch economics and the human spirit is devastating. Catastrophic drought may occur once or twice in 100 years. The "Drought of the 50's" was such a drought. The current drought that started in 1993 appears to be every bit as hard as the 50's and it's not over with yet. With such a drought as this, there's not much that can be done except hunker down and wait for the end. Since no appreciable grass has grown for several years, the holding on to cattle is unthinkable in the desert zones. Genetically valuable cattle might be pastured elsewhere until the drought ends, but even this might be economically questionable. Much grass has died in the past few years and it may take years and years of good rain and proper stocking to see any recovery. The effects of this drought will be apparent for many years after the drought has broken.

HOW TO SURVIVE A DROUGHT IN THE DESERT

Ranching in a desert is a hardship even in periods of normal rainfall. When a catastrophic drought hits in a desert region, the impact is so severe that livestock ranching is not a viable option. It is neither economically nor ecologically sound. If the rancher is to survive at all, revenue generated from wildlife may be the only hope. Although drought does affect wildlife and wildlife habitat, native wild animals are able to cope much better than livestock. Despite the ongoing catastrophic drought and the resulting decrease in mule deer numbers, huntable populations still occur over most of the desert and the quality of mature bucks remains good. Although mule deer numbers are currently well below the record high numbers of the 1980's, the population has maintained an amazing stability from 1994 to present. In general, hunters still seem to be willing to pay for hunting leases. Blue quail seem to be doing much better than what would be expected and have even rebounded in recent years.

It may seem strange to claim that cattle grazing should be curtailed in a drought stricken desert, while deer numbers are able to remain relatively stable. Cattle are dependent on large volumes of grass (about 10,000 pounds per year) and large volumes of water (about 5,000 gallons per year). Neither grass nor water is plentiful in a drought stricken desert. On the other hand, mule deer eat mostly browse and require only about 1500 pounds per year. One will almost always notice green leaves on shrubs, cactus and perennial forbs even when the grass is dry. Woody plants and perennial forbs are deeper rooted than most grasses and able to maintain green leaf during very dry periods. Mule deer, unlike cattle, are able to travel to remote and inaccessible areas in search of food. Although mule deer need daily water, their requirements are less than 500 gallons per year. Keeping permanent water locations maintained even in vacated pastures is essential for the well being of mule deer. Although the experts disagree, many ranchers and wildlife biologists will argue that water may also be critical for blue quail drought survival.

In a strange twist of irony, some have suggested that wildlife may actually thrive as well in a drought as during normal times of ranching. If livestock are removed from a ranch during a drought, then wildlife are able to have full access to all available food, cover and water. During normal times when livestock are present, there may actually be less nesting cover, fawning cover and food available for wildlife. This may be why mule deer and blue quail seem to be doing as well as they are during this drought.

SETTING A REALISTIC BENCHMARK FOR "NORMAL"

Human memory can be a poor record of what is normal. We tend to remember the good times and the bad times but not the in-between normal times. For many Trans Pecos cattlemen, the period of the 1970's and 1980's may be serving as a false benchmark of what is normal. The period of 1968 - 1992 was an unprecedented run of 25 years that experienced near normal to above normal rainfall and growing conditions. No drought occurred during this period. The harsh reality of ranching in a drought-prone desert was temporarily masked. Many of today's generation of ranchers were getting their start during this abnormally wet time. Possibly a false sense of security and optimism was built into folks who were ranching during these years.

During the preceding 70 years (1897 - 1968), generally one multi year drought of significant proportion occurred about every decade or so. These recurring droughts may have served as sobering reality checks for the previous generations of ranchers.

A new and more realistic sense of what is normal needs to be set into our minds. The blessings of the past were wonderful, but we should not presume that they will return. This drought will break some day like all others eventually have done. When it does, the land will need a long period for recovery to begin. Weeds will grow in abundance following the drought, and it will be tempting to restock and take advantage of it, but don't be fooled. Weeds are only the first wobbly steps of recovery and their bounty is fleeting. Whether the land and the grass ever will recover to the extent of previous eras remains to be seen. As stewards of the land, it is the responsibility of landowners to do everything reasonably in their power to help in the recovery process even if it means the sacrificing of some short term profits.

Returning to the days of ongoing cow-calf operations in the desert may not be in the best long-term interest of the land or the economic stability of landowners. No one can predict the future, but indications are that a greater emphasis on wildlife may be the best bet for economically sustainable ranching in the desert. With wildlife management as a primary objective and livestock production secondary, the land is more likely to improve, economic risk will be reduced and net profits maintained.

CONCLUSIONS

1. About 80% of the Trans Pecos is true desert.
2. The desert was not regularly grazed by resident native large herbivores (bison).
3. The combination of recurring drought and improper grazing has decimated the former grasslands and made the desert an even harsher place to ranch.
4. The basic premise of sustainable ranching (a reliable surplus of grass) may not exist in the desert except during abnormally wet periods.
5. The desert is poorly suited to ongoing cow-calf operations.
6. During above average periods when there is adequate grass growth, grazing can be done in a manner consistent with conservation.
7. Flexible grazing with stocker cattle, (or cows that can be easily liquidated) is the key.
8. The desert is suited to the sustained management and production of wildlife.
9. An increased emphasis on wildlife management may allow a faster and more complete recovery of ranges and more stable economics than a return to traditional cow-calf ranching.

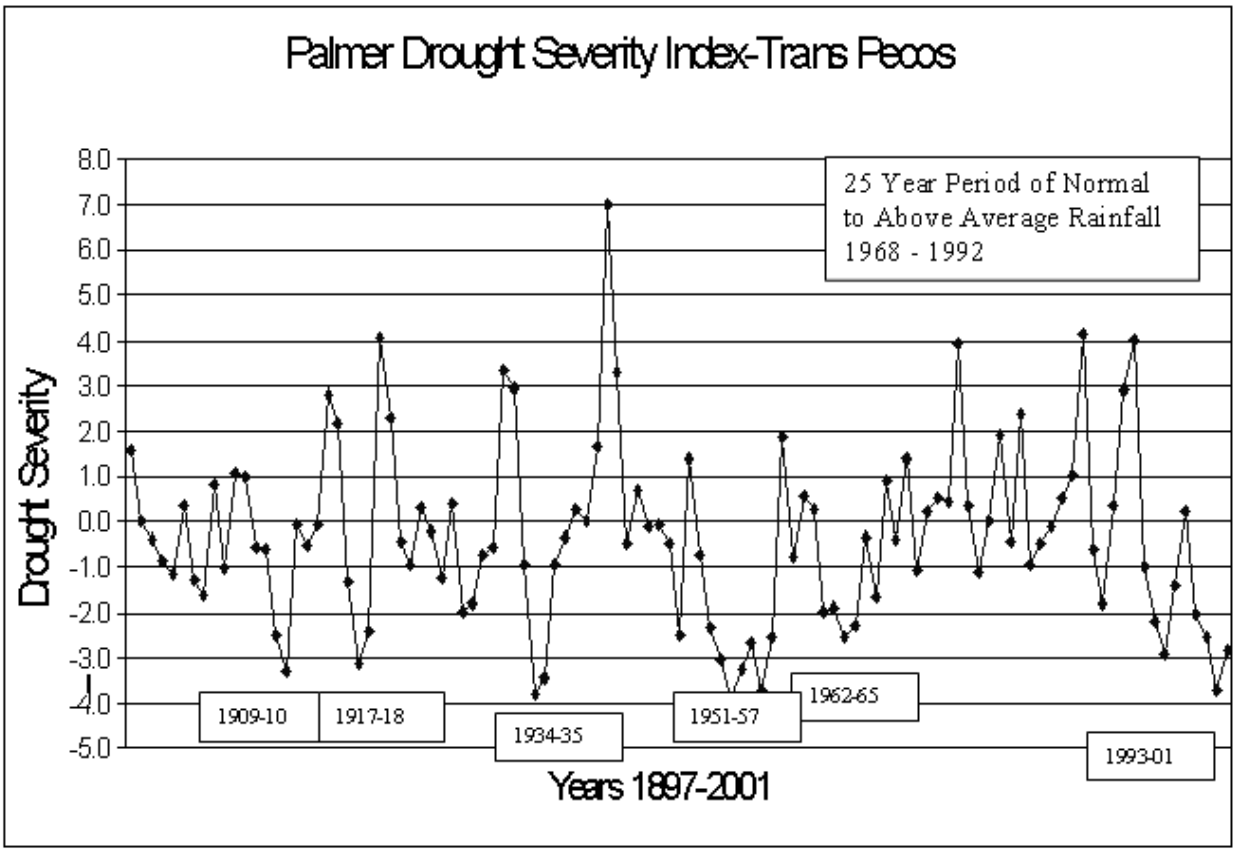


Figure 1. The Palmer Drought Severity Index for the Trans Pecos, 1897 - 2001
The PDSI is a comprehensive numerical rating, widely used in agriculture, to depict not merely rainfall, but also other factors that influence growing conditions. A rating of 0 is defined as normal. For practical purposes, the range of -1 to +1 should be considered the normal range. Any rating of -2 or below should be considered severe drought. Any rating of +2 or above is considered abnormally wet. The graph depicts the entire Trans Pecos region, not just the desert portions. There are areas within the Trans Pecos that have experienced even more severe drought than the graph indicates. There are also areas that have experienced more favorable rainfall that the graph indicates. Notice the following things about the climate of the Trans Pecos from the graph:

1. **Years rated below 0 are almost twice as frequent as years rated above 0.**
2. **Years rated below -1 are much more frequent than years rated above +1.**
3. **Years rated below -2 are much more frequent than years rated above +2.**
4. **The number of consecutive below normal years is often 2 to 4 years or longer.**
5. **The number of consecutive above normal years is usually only 1 or 2.**
6. **The exception to the statement above occurred from 1968 to 1992 when there was an unprecedented run of 25 years of near normal to above normal rainfall without drought.**

PANEL DISCUSSION: DEER AND SUPPLEMENTAL FEEDING-PRO'S & CON'S

Participants:
MIKE CAPRON, Six Bar Ranch
RALPH DONAHO, Rancho del Cielo
COLBY MANGUM, Barlite Ranch
C. B. WATTS, Blue Diamond Ranch

SIX BAR RANCH: Mike Capron

I work for H & K Construction, 6 Bar Ranch. It comprises 90,000 acres of Delaware Mountains and greasewood flats in the Delaware Basin. Rainfall will be 1/2 again as much in the mountains as the flats, but mule deer and livestock reside in both areas and the stocking rate will vary accordingly. Water is furnished throughout the land with wells, pumps and pipelines.

We started feeding the mule deer and surrounding wildlife in 1978 when Tony Kunitz purchased 44,000 acres of the Six Bar. Since that time the feeders have increased from 12 to the present 103 feeders on 90,000 acres. Tony has fed the deer during the dryer, harsher times and let the deer forage during the greener periods of the year. This ranch has had a good mule deer herd established for many years, and we have not seen an increase in numbers or horn size under the feeding program.

We do not feed year round or provide free-choice feed; however, we have fed for extended periods during a couple of years and feel that feeding year round/free choice would be far too expensive. We don't think year-round feeding would yield any benefit to the deer herd and would probably be detrimental to the whole ecosystem surrounding the deer feeders. It is natural for animals of all species (from birds to ground squirrels to coyotes to rattlesnakes) to take advantage of the free-choice meals which can cause undesirable changes and imbalances in all surrounding plants and animals. Conservation of harvest is the most critical factor to maintaining a natural balance among plants, animals and man.

We do not supplement cattle. We believe that the native raised cattle will properly harvest the available Chihuahuan desert plants of all kinds and produce an offspring at the most profitable end-of-year price. Periods within decades or even centuries and the types of habitation within these periods dictate the rules of production within each time frame. Only experience with each situation can help us to formulate proper management decisions.

All our surveys of the total ranch picture have been conducted through mental comparisons and written records. Each year has had many variations compared to circumstances in previous years. The whole Chihuahuan Desert moves very slowly in growth cycles and rejuvenation periods.

I feel that any method to cull, control or manage nature and God's plan would be as absurd as trying to run the U. S. Government by myself! Nothing but time, observation,

conservation and love will improve my ability to properly harvest the scarcities of the vast Chihuahuan Desert. Please understand that all of the above statements, ideas and facts pertaining to a small piece of the Trans-Pecos in the Chihuahuan Desert are of my own creation and mine only.

RANCHO DEL CIELO: Ralph Donaho

Cielo's grazing operation is basically a cow/calf with some stockers. Our goal is to not overgraze and to always maintain good wildlife habitat. In order to achieve this, we must have "drought flexibility" so therefore, we have greatly reduced the cow numbers and added stockers to our operation. With the cows and stockers today (June '02), our stocking rate is 133 acres/head. Shortly, our stocking rate will exceed 200 acres per animal unit and the ranch will be allowed to rest through the rainy season. We annually increase the number of water troughs and currently have approximately 1 per 1.25 sections. Twelve new troughs will be added in 2002. In addition to adding water, cross-fencing is another tool we have used to assist with grazing and habitat management. We keep very accurate rainfall records (by pasture; by month) over the ranch and use those records to assist us with stocking rate decisions.

We started feeding in 1990 by feeding the roads where we knew we had a good population of deer on the ranch. Once the deer started eating the feed, we went to self-feeders. At first our goal was to produce big deer, but that was in 1990. We have learned that feed alone won't grow big mule deer, so with the long drought our goal now is to maintain the herd, insure a breed-up, and a weaned fawn crop. Feeding has insured a fawn crop and if it ever rains, could rapidly cause an over-population. This will be a problem.

The most important success of the feeding program, in my opinion, has been fawn survival as well as mature deer survival. With the 10 years of drought we have experienced, we don't think we would have many deer here at Cielo if we hadn't fed. Our neighbors don't feed, and they don't have many deer left. We surely didn't feed all those deer into this ranch. Drought, overgrazing, aoudad, over-hunting, and predators are the mule deer's worst enemies. An indirect benefit to the rancher associated with feeding deer concerns land value. When selling a ranch here in the Davis Mountains, what it will bring (not what it is worth, but what it will bring) depends on the amount of wildlife (especially deer) it has on it. The more game it has, the more $$ it will bring and the faster it will sell.

There are some potential problems with providing supplemental feed. These include exorbitant feed costs, extra labor, impacts on vegetation, and feeding stations being used by predators as ambush sites.

We think it's important to monitor our deer numbers and herd composition. Texas Parks & Wildlife conducts an annual spotlight survey line on the ranch as part of their annual, regional deer survey and has for years. In addition, we conduct a helicopter survey each October with the assistance of TPW personnel. Harvest records are also maintained.

Types of information that we need to help us do a better job with our deer management program include the following:

1. More research on feeding.
2. Data from liver samples and femur samples to learn if the deer are utilizing the feed they are being fed.
3. Deer stocking rates.
4. Learn more about what deer are eating—feces studies.
5. Research on what impacts predators have on mule deer. (With the drought and little to no hunting and good grazing practices, our deer herd has maintained an even number over the past three to four years with tons of feed being fed. One would expect the numbers to have climbed with all the feed we fed.)

BARLITE RANCH: Colby Mangum

The main ranch I will be discussing is the Barlite Ranch, which is located approximately 15 miles southeast of Marfa. The other ranch where we feed deer is the Black Mesa Ranch, which is about 30 miles south of Alpine. Most of the Barlite is set up in a Savory Cell System, however the part of the ranch where we feed deer is not. These pastures in a normal year are grazed only once in the usually in a non-growing season, and usually receive at least 10 months of rest. Water is distributed very well with a pipeline and troughs on this part of the ranch.

The feeding program at the Barlite is going into its tenth year, about 6 year with the previous owner and about 4 with the current owner. We have 21 feeders distributed throughout the approximately 12,000 acres, which supply free choice high protein pellets. The main goal of the feeding program is to produce bucks with larger antlers.

The most obvious success with the feeding program is the fawn survival rates. We have also seen higher body weights. And the top end of the bucks harvested in the last 4 seasons have been above the average for the area. We do aerial game surveys on a yearly basis and weigh and score the bucks that are harvested. Bucks that qualify are entered in the Texas Big Game Awards.

The biggest problem associated with the feeding program has been the cost. The cost of the feed, labor, and equipment has not been proportionate to the number of trophy bucks harvested. We have a very high deer population (600+ on 12,000 ac) and yet harvest only a few trophy bucks each year. As some people believe that feeding draws deer off of the neighbors, we contend that due to our high numbers (due to fawn crop and survival), we actuall supply neighbors with replacements. We do employ a government trappers year round and are yet to see predators as a big threat.

Some questions that would be very helpful in our management program are as follows: What is happening to our mature bucks?? What is a cull? How many points should expect at what age? These questions are important but what good does all this information do without a long enough season to accomplish objectives.

In the above paragraphs I have described the program at the Barlite Ranch where feeding has been going on for a number of years. Given more time, we expect the Black Meas to be similar.

BLUE DIAMOND RANCH: C.B Watts

The Blue Diamond Ranch is 13,200 acres and is located in Brewster County, 28 miles southeast of Marathon. The long-term average rainfall is about 12 inches. Most of our country is low-elevation Chihuahuan scrub or chaparral. The vegetation consists of sotol, lechuguilla, mesquite, yucca, and creosote intermixed with grama grasses. There is a little redberry juniper scattered across the ranch but especially on the ridges. Some of the more productive areas are the dry creeks and draws that support desert willows, cottonwoods, sumacs, redbuds, whitebrush, and few oak species.

Grazing Program

Prior to 1994, there was a herd of 125 cows, 125 calves, and a bull grazing on the south side of the ranch; the range condition was fair to poor. Early in 1994, we removed all livestock from this side of the ranch. Approximately 45 head of livestock continued to graze on the north side of the ranch until 2001. In 2001, because of poor range conditions, all cattle were removed from the north side of the ranch. At the present time, there are no livestock on the ranch. We applied for and were granted a wildlife tax exemption.

Water System

In 1996 we completed an extensive water system on the south half of the ranch. The system consists of 14 miles of water line and 17 watering locations (~ 1 watering site for every 380 acres). In 1998 we constructed and installed 4 small water guzzlers (operate from rainfall and hauled water). The watering locations are wildlife friendly and are accessible to quail, doves, songbirds, and small mammals. The water system now consists of 21 water locations on 10 sections (approx. 1 water location for every 300 acres).

A water system is planned for the north side of the ranch; however, it may be several years before it is completed. At the present time, there are 5 water locations on the north side--3 of 5 water facilities are the small guzzler type drinkers.

Feeding Program

We have been feeding deer since 1994. Initially, we fed corn through spin-cast feeders. But we soon determined that in order to improve the overall quality of our deer herd, we needed to feed more generously and provide a better feed than just corn.

We consulted with Mr. Gene Bode at Bode Feed and Supply in Harper, Texas. Mr. Bode suggested a high-protein feed. We decided on a feed ration that consisted of 70% deer cubes (21% crude protein with vitamins and trace minerals), 20% whole corn, and 10% milo. We then removed the automatic feeders and went to free-choice feeders. Records are maintained regarding the consumption of feed at each location.

The results have been outstanding. Our deer herd has tripled in size. Our fawn crop has increased each year and their survival rate has also increased. Body weights and antler production has also shown a great increase. Although our initial and foremost concern was our deer herd, we have observed an increase in all forms of wildlife. While we firmly believe in the success of our feeding program, we won't deny that the livestock deferment and development of the water system have also played a significant role in the success of our wildlife program.

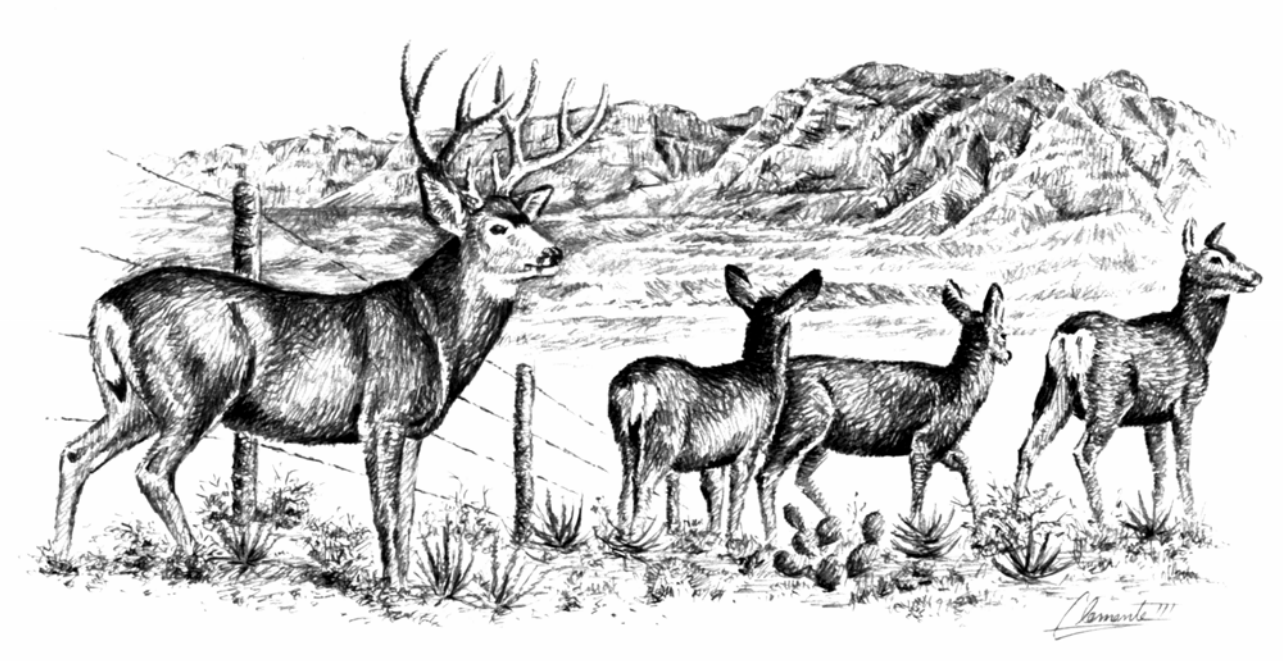
The costs and labor associated with the feeding program and the use of feeding locations as predator ambush sites present problems that we are constantly trying to overcome. We have a predator management program that includes leg-hold traps, snares, and calling. Our program is focused on lions, coyotes, bobcats, and foxes. When we are "calling," we usually set up around feeding locations. This is an attempt to catch any predator that is working one of our feeding locations.

We conduct 2 spotlight surveys each year. We conduct a recorded count (by sex and age) of all deer observed each day when we are conducting ranch business. The number of bucks to be harvested each year is based upon this information (as well as harvest records). We make our decision to harvest the selected number of bucks in late September after the surveys have been conducted. We may have a specific number in mind earlier that this, but the final decision is usually made at this time.

We are very careful about culling. We watch any potential cull buck for a couple of years before we make a decision.

We maintain harvest records of each buck that is harvested-- ages, weights, and antler measurements. This information is compared to previous years to evaluate progress and results associated with our management decisions. Some of our mature bucks are scoring in the 170's (B&C system) and body weights range from 175-230 lbs., which isn't too bad for south of Marathon in a long-term drought.

Habitat Management and Rangeland Improvements



WAS THE TRANS-PECOS A GRASSLAND? PAST, PRESENT, AND POTENTIAL

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Abstract: The Trans-Pecos region consists of the area of Texas that is west of the Pecos. The Trans-Pecos region was a savanna dominated by short grasses such as gramas, muhlys, and tobosa, with shrubs and trees ranging from pinons and oaks to creosote and ocotillo. Today much of the Trans-Pecos is a shrub land. To successfully reclaim an area and maintain it in a savanna architecture, every part of the ecosystem must be evaluated, including soil stability and productivity, plant cover, animal utilization, fire frequency, and position of water areas.

The Trans-Pecos region consists of the area of Texas that is west of the Pecos. The area contains several unique ecological areas including the Stockton Plateau around Sanderson, the mesa country around Fort Stockton, the plains around Marfa and Marathon, and the high elevations of the Davis, Chisos, Glass, Franklin, and Guadalupe mountain ranges. These differences in ecology have resulted in very different plant communities that make it difficult to actually categorize the Trans-Pecos as one particular vegetation physiognomy.

The trend today in natural resource management is one of conservation of resources and a much greater emphasis on the reclamation of range resources. As land managers begin the task of reclamation the first question that is posed is reclaim to what state? Some of the answers are easy. Range health is important, so at any state range hydrology, decrease in soil erosion, and plant reproduction should be primary goals. With this idea in mind, a rangeland can be healthy and not contain plants that were present at climax, or plants that are most useful to livestock and wildlife. On the other hand land managers want plants that are either the most beneficial for utilization needs or that reflect the climax community. This leads to the question of what is the climax community and what is the potential for a certain piece of rangeland. This has led to the question was the Trans-Pecos a grassland? The answer to the question is no, the Trans Pecos was never a grassland. The Trans-Pecos region is better characterized by the term savanna. A savanna is an open grassland dotted with trees or shrubs. This picture is very different from the shrub land that is prominent in many areas of the Trans-Pecos today, but it is also very different from the idea of thousands of acres of side oats grama waving in the wind without a creosote bush in sight. So what is the potential of our rangelands, with a view toward reclamation of, if not the species, but at least the savanna architecture that once prevailed in the Trans-Pecos? To answer this question, the questions of what the Trans-Pecos was and the agents that precipitated the change we see today must be answered.

PAST

The climate of the Trans-Pecos has undergone a major shift since the ice ages. Approximately 7,000 years ago a warming and drying trend changed the Trans-Pecos from a mesic landscape dominated by grasslands and woodlands to a semi-arid and arid landscape dominated by grasses and shrubs. It was during this time period that creosote first came to the Trans-Pecos. There were other vegetation shifts as well, with short grasses that were resistant to drought replacing the taller grasses that still characterize the plains of the United States, large trees giving way to smaller profile trees and shrubs (Barbour et.al, 1999). As the flora shifted to plants more adapted to the arid climate the animal community shifted as well. When the early Spanish explorers and the early Anglo settlers came to the Trans-Pecos they found an arid savanna dominated by short grasses such as gramas, muhlys, and tobosa, with shrubs and trees ranging from pinions and oaks to creosote and ocotillo. Antelope, deer, prairie dogs, and jackrabbits were the major herbivores that occupied this savanna. Buffalo also grazed these areas, although not in the number or with the massive migrations found in the buffalo in the plains. The balance between the herbivores and the plant life was one of moderate continuous grazing. Small mammals continuously grazed areas and large herbivores concentrated near permanent water and then radiated out into the surrounding landscape during wet seasons. Surface water was scarce so many areas did not see continuous grazing throughout the year (Green 1963, Casey 1981, Warnock 1980, Bray 1905).

Ranchers began bringing livestock to the Trans-Pecos in 1871 with the first herd of cattle arriving from Wilson county Texas and owned by J. D. Houston. By 1880 there were 89 cattle ranchers and one sheep man in what is now Reeves, Pecos, and Terrell counties. In 1887 the first wire fence was put up on the 7D ranch outside of Fort Stockton (Downie 1978). The early stocking rates were very high as land owners were driving stock from east Texas and were familiar with ranching in that area. Current recommendations for stocking rates range from 3 to 5 AUY per section. The Iron Mountain ranch was stocked with 27,000 head of sheep on 45,000 acres in 1881, a stocking rate of 65 AUY per section (Clayton, 1993). The Downie ranch was running 80,000 head of sheep, 20,000 head of cattle, 2,000 goats and 500 horses on 234 sections, a stocking rate of 61 AUY per section (Downie 1978). Stocking rates remained high through the 1920's when Sanderson recorded shipping 72,172 head of livestock and 1.5 million pounds of wool and mohair (Downie 1978). This stocking rate was possible due to the large amounts of grass that were available in the Trans-Pecos. Grazing had always been light to moderate with no grazing during dry years.

The grassland was maintained by this light grazing and by large fires that swept through the Trans-Pecos. Lightning caused fires were known to sweep 40 and 50 miles across the country. On the Cox ranch between Sanderson and Marathon, 6 fires have burned on the ranch since settlement in 1891. Three of these were started by the train, and one swept as far northward as the Big Canyon draw in Pecos County (Williams 1969). Fire kept the grasslands healthy and prevented shrubs dominating the land area. Shrubs and trees were often killed by fire and only roots left, giving the Chihuahuan desert the famous description "the land where you must dig for wood and climb for water" (Downie 1978). Other major disturbances in the natural ecosystems were the harvesting of Chino grass by the roots for use as hay, and the harvest of

Candelia for wax production. Both of these practices led to large areas of Presidio and Brewster counties with bare soil open to erosion and colonization by creosote and tar bush.
Water wells were also drilled across the Trans-Pecos, with the first well being a hand dug well down to 300 feet on the Downie ranch. This created permanent watering sources across the entire landscape, and enabled livestock to be grazed across the entire area rather than be driven to and from water each day, or drifted to the Rio Grande during dry spells (Downie 1978). Localized permanent water areas led to an increase in the wildlife and livestock.

PRESENT

Today much of the Trans-Pecos is a shrub land. The huge number of livestock minimized the standing crop of grasses and fires soon did not spread as they had historically. Grass was not allowed the three years that it takes to recuperate after fire or heavy grazing (Cottle 1931). This led to a dramatic increase in bare ground, decrease in grass basal cover and released the shrubs that were already present in these ecosystems. Comparison of photographs taken in the early 1900's and those taken in the present show marked increases in shrub cover (Cottle 1931, personal comparison). Stocking rates are maintained below 5AUY per section, and many ranches cannot sustainably graze that many livestock. Erosion is a massive problem with pedestals and gullies common on many ranches.

The landowner base is also changing, with fewer ranches being used for livestock production and more emphasis being placed on wildlife and aesthetics. This has led to the desire to reclaim the Trans-Pecos. In doing this there is a major push to reestablish grasses and eliminate shrubs.

POTENTIAL

Does the Trans-Pecos have the potential that it once had? Can we regain the grass production that once made the Trans-Pecos one of the most productive livestock areas in the state? The answer is yes and no. The potential of the Trans-Pecos is in the potential of its soils. There are some areas that still retain sufficient topsoil to support grasses; in other areas little topsoil is left. In these areas the soil may no longer be deep enough or have the organic material and nutrients that are necessary to support a savanna rather than a shrub land. Plant communities are a result of the complex interactions of soil, climate, biota, topography, and time. We have changed many of these in our use of the Trans-Pecos region. To regain the potential grass production we cannot simply remove livestock and hope things will get better. It took energy to change the state of the ecosystems of the Trans-Pecos and it will take energy to change them back.

To successfully reclaim an area and maintain it in a savanna architecture, every part of the ecosystem must be evaluated, including soil stability and productivity, plant cover, animal utilization, fire frequency, and position of water areas. The Trans-Pecos was once very different than it is today, a hands off policy will not return it to its potential state. Years of no livestock have not returned Big Bend National Park to a savanna. We must be active in the management of all areas of the rangeland ecosystem for a reclamation effort to be successful. Fire, grazing,

wildlife, and soil stability must be actively managed if there is to be a shift from shrub land back to savanna.

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DOES FIRE HAVE A ROLE IN THE CHIHUAHUAN DESERT?

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Abstract: Fire shaped the Chihuahuan Desert grasslands and is critical in their maintenance. Without periodic fire, grasslands generally revert to dominance by woody plants. For a fire to occur three components must be present: 1) an ignition source, 2) adequate fine fuel, and 3) the fuel must be dry enough to burn. Overgrazing, current landowner configurations, and liability issues are reason while large scale, naturally occurring fires are not common.

Vegetation varies greatly across the Chihuahuan Desert – from the Pecos River, the Mountain sky Islands of west Texas, New Mexico and Mexico, to typical black grama and blue grama grasslands. With the variety of vegetation there is also a wide variety of fire needs. Historically, fire shaped the Chihuahuan Desert grasslands, as fire shaped other grasslands of North America. Although fire is a vital component to healthy rangelands, fire is not the only process that has shaped the desert Southwest. Frequent drought, insects, diseases, rodents and rabbits all play role in maintaining the grasslands. Many people have attributed the vegetation changes of the Southwest over the past one hundred years to climatic variations; however there does not seem to be conclusive evidence that changes in precipitation or temperatures have been significant enough to influence the rapid shrub invasion (Van Auken 2000).

Fire is critical to the natural maintenance of desert grasslands. Fire size and frequencies have diminished greatly during the past century. Photos before 1880 indicate that shrubs were absent or inconspicuous in desert grasslands, which indicates natural occurring fires prevented widespread shrub establishment, since most desert shrubs are susceptible to fire as seedlings. Thus a fire return interval of 7-12 years would have maintained the Chihuahuan Desert in a relatively brush free grassland (McPherson 1995). Over the past 150 years, livestock grazing has reduced fine fuel amounts to the point where natural fires are rare, thus allowing brush species to increase.

For a fire to occur 3 components must be present: 1) an ignition source, 2) adequate fine fuel, and 3) the fuel must be dry enough to burn. In the desert there are plenty of ignition sources found in convection thunderstorms which frequently produce lightning, but no rain. When rainfall is adequate there is usually sufficient quantity and continuity of fine fuel present to support fire spread where grazing is not excessive. And to satisfy the third component, the low relativity humidity that results in fine fuel that is dry enough to burn. Recovery of desert grasslands generally occurs in 1-3 years and is dependent upon rainfall.

Without periodic fire, grasslands generally revert to dominance by woody plants. Therefore in order to maintain grasslands as grasslands we simply need to allow natural fires to burn (McPherson 1995). However today's land ownership configuration makes this impractical,

additionally with the demands placed on rangelands to produce vegetation for livestock, there is little fuel remaining for a fire.

An increasing concern in desert fire ecology is the presence of exotic species. Many invasive exotic species (grasses primarily) benefit from fire, thus increasing the fire frequency, possibly to the detriment of native grasses (Brooks and Pyke 2001). Thereby reducing the value to wildlife and usually reducing the quality of the vegetation to herbivores.

Over the past 100 years the grasslands of the Chihuahuan Desert have been degraded, most seriously degraded. This degradation has resulted from the removal of vegetation by livestock and the subsequent lack of naturally occurring fire. The excessive use by livestock generally results from a lack of knowledge of ecological processes. One example of this can be found in Arizona, during the early 1900's overgrazing was encouraged by forest administrators to reduce fire hazards and to promote tree growth (Griffiths 1910). The massive wildfires of the summer of 2002 have demonstrated what happens to these same Arizona forest following the lack of periodic fires. Therefore as we learn more about how the ecological processes work collectively to shape the desert grasslands the better we can manage for the future.

As landowners are aware, there is a decrease in grass production with an increase in brush densities. As we look at the cost of doing nothing we find that the longer we wait to control excessive brush densities the more costly to do so; added to the fact that there has been a continuous decline in grass production over many years. Today, prescribed fire is generally the most cost-effective broadcast method to treat large tracts of land ($1 to $15/acre). However very few areas of the Chihuahuan Desert have sufficient grass production to support an effective fire. An effective fire being a fire that results in the desired fire effects as opposed to just making the ground black. Understanding that much of the Chihuahuan Desert in it's current state cannot sustain a wildland fire, we must look at why and what to do about it. The simple fact is that there is not enough grass to support fires due to excessive grazing, drought or a combination of the 2. Therefore something has to be done to produce more grass, besides praying for rain. More than likely a number of tactics will be needed; reduced stocking rates, mechanical and/or chemical brush control and most importantly time. The degradation of much of the Trans Pecos has occurred over the past 130 years and the corresponding restoration will take time.

Timing of wildland fires has a dramatic influence on what happens next. Fires during the fall and early winter generally produce cool-season annuals and perennial forbs, most being beneficial to wildlife. Fires that produce an abundance of forbs attract a variety of wildlife. Wildlife are attracted to the nutritious forage and insects; insects are very important to the reproductive success of upland birds such as scaled quail and turkey (Richardson 2001). Whereas fires that occur in late winter, spring, and summer are more favored by perennial grass species. Timing of a prescribed fire is dependent upon your desired results. When producing a fire management plan for your property it is beneficial to alternate burning seasons over time, that is if you burned a particular unit the past 2 times in the fall, then it is a good idea for the next burn to be during the spring or late winter. This alternated burning regime will improve the diversity and production of Chihuahuan Desert ranges.

Burning may not be the first answer to improving range condition on much of the Chihuahuan Desert but, fire is a landscape process that maintained the Trans Pecos for tens of thousands of years prior to European mans arrival. We cannot turn back the pages of time to improve our range condition, rather we need to look to the future and decide, what do we want 10 years, 20 years, 50 years from now and begin working toward that goal today.

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WATER CONSERVATION FOR RESTORATION OF WILDLIFE HABITATS

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Abstract: Healthy rangelands are relatively efficient at conserving rainfall, but they may become dysfunctional in this regard as vegetative cover diminishes and aggregation of the surface soil layer is destroyed by overgrazing, drought, and establishment of excessive densities of low-value or noxious brush and weeds. Special water conservation treatments, such as contour ripping, furrowing, pitting, reseeding, or brush and weed control, may be necessary for restoration of rangelands and wildlife habitats that have deteriorated beyond a critical threshold in the downward desertification spiral. This paper describes these technologies and gives details of their utility for restoration of dysfunctional rangelands in arid and semiarid regions. Contour ripping of a degraded clay loam range site near San Angelo, Texas facilitated penetration of water from convectional thunderstorms to a depth of 48 to 54 in. compared to only 4 to 5 in.on adjacent, untreated rangeland. Over a period of 4 to 5 years, total herbage production on ripped rangeland was 1700 lb/acre compared to only 490 lb/acre on adjacent, untreated rangeland. Ripping increased the carrying capacity of the clay loam range site from 8.2 animal unit years (AUY)/section to 28.7 AUY/section.

Water is the trigger factor necessary for plant production in arid or semiarid regions where rainfall is erratic and unpredictable, but it must be effectively transferred deep into the soil reserve in quantities which exceed the minimum threshold necessary to generate pulses of plant growth (Ludwig et al. 1997). Healthy rangelands are efficient in conserving water, soil, and nutrients because the surface soil has good structure (aggregation) and because there is sufficient vegetative cover of perennial grass plants or grass colonies. Good soil structure facilitates rapid infiltration of rainfall while vegetative cover protects the surface soil aggregates from the energy of raindrop impact and provides resistance to runoff. Rangelands become dysfunctional, relative to the hydrologic cycle, mineral cycles, and energy flow, because of droughts, excessive grazing, and persistent infestations of low-value or noxious plants. Ecologically sound rangeland and wildlife habitat management involves working with the natural ecological processes of energy flow, the hydrological cycle, and mineral cycles (Whisenant 1999). Proper grazing management is the basic tool for restoration of degraded rangelands, but recovery of the resources often does not occur within a time frame acceptable to meet the objectives of resource managers. Ecologically sound practices that can expedite the restoration of dysfunctional rangelands and wildlife habitats include ripping, contour furrowing, pitting, reseeding, and control of undesirable weeds and woody plants.

HYDROLOGICALLY FUNCTIONAL RANGELANDS

Healthy rangelands have high rainfall infiltration rates because the soil surface has good structure, meaning that the soil particles are held together in water-stable clusters (aggregates) by roots, fungal hyphae, byproducts of organic matter decay and microbial synthesis, and resistant humus components (Boyle et al. 1989). These water-stable aggregates do not readily disperse during rainfall events; thus the silt and clay particles are not released to plug up the soil macropores as they move into the soil with water. Soil porosity (pore space) increases as the degree of aggregation increases, and rainfall infiltration increases as soil porosity increases. Healthy rangelands support a sufficient amount of vegetative cover, primarily perennial grass plants or colonies, mulch, and desirable shrubs or trees, to protect the soil surface aggregates from being dispersed by the energy of raindrop impact and to provide resistance to surface runoff. Vegetative cover also ameliorates the extremes of soil temperature, reduces evaporation of soil water, and provides a microenvironment favorable for decomposition of organic matter, which in turn contributes to the formation of water-stable soil aggregates (Thurow 1991).

HYDROLOGICALLY DYSFUNCTIONAL RANGELANDS

The direct and indirect effects of drought, excessive grazing, and/or excessive densities or cover of noxious or low-value plants can render rangelands dysfunctional relative to conserving water and nutrients and yielding the products and services needed by society (Thurow 1991). These effects seriously diminish the annual production of foliage and deposition of litter, the depth and branching of plant root systems, soil aggregation, and rainfall infiltration rates while increasing the losses of water, soil and nutrients from the landscape as surface runoff. As vegetative cover and the mulch layer decline, the kinetic energy of raindrops hitting bare soil causes the dispersion of soil aggregates and releases silt and clay particles which move with water into the large soil pore spaces. The clay and silt particles plug the pore spaces, thus reducing the capacity of the soil to absorb and store water. The result is drought-like conditions, even in years when rainfall amounts are normal. Over time the vegetative composition changes as the palatable, productive deep-rooted grasses die out and are replaced by smaller, less palatable, shallow-rooted plants (Archer and Smeins 1991, Briske 1991). These plants are less efficient in capturing the energy of sunlight, retrieving nutrients from deep in the soil, resisting runoff, and transferring rainfall into the soil reserve. The result is less microorganism activity, less aggregate formation, a harsher environment for seed germination and seedling establishment, more soil exposed to raindrop impact, fewer roots to exploit soil water and nutrients, decreased rainfall infiltration, and accelerated surface runoff and erosion. Weeds, woody plants and succulents (e.g., cactus) often increase or invade deteriorated rangelands and compete with the remaining desirable plants for space, sunlight, and the diminished supply of soil water and nutrients.

MANAGEMENT TO ENHANCE WATER CONSERVATION

Resource managers must learn to work with, rather than against, the natural ecological processes of energy flow, the hydrological cycle, and mineral cycles to manage vegetation and soils in order to achieve and maintain high infiltration rates and minimize losses of water, soil, and nutrients in surface runoff (Ludwig et al. 1997, Whisenant 1999). Proper grazing

management is the basic tool for achieving efficiency in water and nutrient conservation and utilization on rangelands. Control of excessive densities of low-value or noxious weeds or woody plants can increase the amount of water entering mineral soil and the availability of soil water for desirable plants. Mechanical water-conservation treatments, such as ripping, contour furrowing or pitting, may be necessary to reverse the downward spiral toward desertification on severely deteriorated rangelands, and reseeding may be necessary to re-introduce plants that can efficiently utilize the available soil water and nutrients.

Grazing Management

Excessive grazing affects plants directly by altering their physiology and morphology and indirectly by altering microclimate, soil properties, and the competitive interactions among plants (Archer and Smeins 1991). Without sufficient leaf surface area, plants cannot efficiently capture the energy from sunlight via photosynthesis, root growth is reduced, energy reserves are depleted, plant vigor and seed production decline, and plant mortality occurs. Over time, the composition of the vegetation changes; vegetative cover, plant production and rainfall infiltration decline (Figure 1); and surface runoff increases. Grazing management involves balancing the number of animals with the forage supply, selecting the appropriate kinds and classes of animals to be grazed, controlling the timing of grazing, and distributing grazing evenly across the landscape (Briske and Heitschmidt 1991).

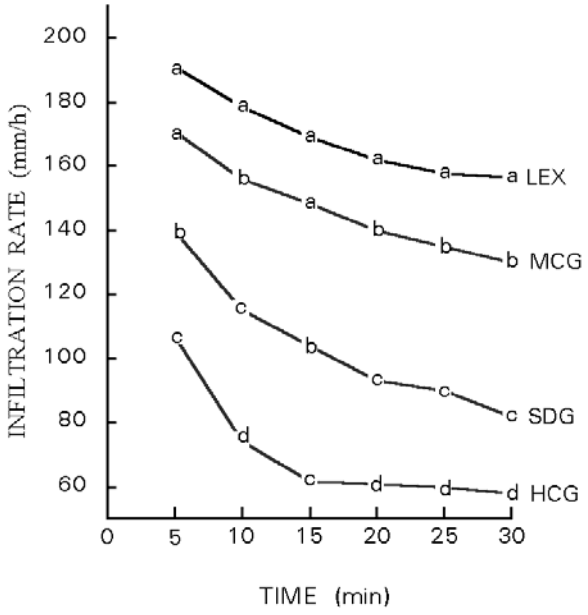

Figure 1. Mean infiltration rates for four grazing treatments six years after they were initiated on the Edwards Plateau, Texas. LEX = livestock exclosure; MCG = continuously grazed at moderate intensity; SDG = short duration rotation (14-pasture, 1-herd; 4 days on, 50 days rest) stocked at 1.75 times the moderate intensity; HCG = continuously grazed, stocked at 1.75 times the moderate intensity. Means within a time period with different letters are significantly different at P •• 0.05. [from (2)]. Reprinted from *Grazing Management: An Ecological Perspective* with permission from R.K. Heitschmidt and J.W. Stuth.

Achieving the proper level of utilization of forage plants and maintaining an acceptable minimum amount of litter is the most important management decision, regardless of whether rangeland is grazed continuously or in a complex grazing system. The minimum amounts of litter needed to sustain productivity of shortgrass, mid-grass, and tall-grass rangelands are 300 - 500, 750 - 1,000, and 1,200 - 1,500 lb/acre, respectively (White and McGinty 1992). "Take half and leave half" is the guiding principle for determining stocking rates. Under most management systems, 50% of the forage produced during the year should remain ungrazed. Twenty-five percent of the year's forage growth will be lost to trampling, insects and other animals, or rendered ungrazable due to livestock dung or urine. The remaining 25% of plant growth can be utilized by livestock (White and McGinty 1992). Rangeland vegetation and precipitation records should be continually monitored, and livestock and wildlife numbers should be adjusted annually or even seasonally to achieve proper use.

Proper grazing management is the "natural" and least-cost method for restoration of degraded rangelands and wildlife habitats. However, severely deteriorated rangelands, especially in arid and semiarid regions, often recover slowly or not at all after initiation of proper grazing management or the total removal of livestock because of the lack of vegetative cover, poor soil aggregation, low infiltration rates, and the resultant harsh environment for plant establishment and growth. The potential for range recovery is poor on many southwestern rangelands, even with the exclusion of livestock for 20 to 30 years (Dregne 1978). The rate of recovery following implementation of proper grazing management may be too slow to meet the management objectives of ranchers or resource managers on range sites which have deteriorated beyond a critical threshold in the downward desertification spiral. Mechanical water conservation treatments, reseeding, and/or management of persistent infestations of low-value or noxious vegetation may be useful to expedite restoration of these sites.

Management of Undesirable Vegetation

Excessive grazing, drought, climatic changes, a reduction in the frequency and intensity of fire, and perhaps the increasing concentration of atmospheric carbon dioxide predispose many rangelands to invasion by weeds, woody plants, and succulents that have little or no value to grazing animals or humans. These plants intercept or transpire large quantities of water that might otherwise be used by plants that have greater values for food and cover for livestock and wildlife. The efficiency of water use on rangelands can be increased by controlling undesirable vegetation (Ueckert 1979, Thurow and Hester 2001). Herbicidal, mechanical, prescribed burning, and biological control methods, or appropriately timed and sequenced combinations of these methods, coupled with proper grazing management can provide effective, cost efficient, and ecologically practical solutions to noxious plant problems (Hamilton et al. *in press*). Rangelands should be monitored annually for noxious plants, and control programs should be initiated before these plants mature, thicken, utilize excessive amounts of water, and cause deterioration of desirable vegetative cover (McGinty and Ueckert 2001).

Mechanical Water Conservation Treatments and Seeding

Mechanical land treatments such as ripping, furrowing, and pitting can expedite natural recovery of desertified rangelands (Valentine 1971, Whisenant 1999) by increasing resistance to surface runoff, shattering compacted soil layers, and thereby increasing rainfall infiltration and retention. To have a lasting effect, mechanical treatments must modify the soil surface

sufficiently so that rainfall is detained and stored in the soil (Branson et al. 1966). Mechanical treatments that effectively increase deep infiltration or percolation of precipitation in saline soils can leach soluble salts below the root zone and thus increase the availability of water to plants (Branson et al. 1966). The objective of using these mechanical treatments is to facilitate the establishment of dense patches or bands of vegetative cover that will persist and continue to conserve water and nutrients naturally, long after the soil disturbance has disappeared. The full potential of these practices will only be realized if treated areas are initially protected from grazing to allow the establishment of vegetative cover and afforded proper grazing management thereafter.

Ripping

Ripping (also referred to as subsoiling or deep chiseling) involves pulling one to three heavy shanks equipped with broad lifting tips 16 to 24 in. deep through the soil on the contour (Valentine 1971). Space between rips is variable, and usually depends upon the equipment available, slope of the land, and amount of vegetative cover present. Ripping fractures impervious soil layers (which increases porosity and the rate of infiltration), causes uplifting of the soil (which resists surface runoff), leaves a furrow in the center of the uplift (which will retain water), and the soil disturbance provides a seedbed for new plant establishment.

Forage production was 1405 lb/acre 10 years after ripper furrows were installed in a desert grassland in southern Arizona compared to 563 lb/acre on adjacent, unripped areas (Brown and Everson 1952). These rips were installed with construction-type rippers pulled by a crawler tractor. The ripper shanks were broad and the flat cutting tips were 3 to 4 in. wide. The rips were 18 to 24 in. deep and installed in pairs on 30-ft horizontal spacings. The treatment produced a furrow as deep, and ridges as high as an average lister furrow. Forage production on these ripped areas was 1.6 times greater than that on adjacent untreated rangeland after 24 years (Branson et al. 1966). Rips installed with narrow shanks and cutting tips have little lasting effect (Branson et al. 1966). In South Texas, subsoiling increased the production of coastal bermudagrass and buffelgrass by 2026 and 1167 lb/acre, respectively, compared to untreated areas; chiseling increased the production of coastal bermudagrass, kleingrass, and buffelgrass by 1412, 3539, and 1275 lb/acre, respectively, compared to untreated areas (Hanselka et al. 1993). Vibratilling to a depth of 18 in. with rippers spaced 39 in. apart near Post, Texas increased total herbage production to 1700 lb/acre compared to 1125 lb/acre on untreated rangeland (Bedunah and Sosebee 1986).

We initiated a study on rangeland ripping in late April 1995 on a very poor condition, clay loam range site northwest of San Angelo, near Carlsbad, Texas (Ueckert et al. 2001). The soil was a Tulia loam with 3 to 5% slope. Long-term average annual rainfall at the study site is about 20 in. The site appeared abused and overgrazed (90% bare ground) even though it had not been grazed by livestock during 1969-1985 and was grazed lightly with long periods of rest from 1985 until 1995. Visible evidence of a soil crust (platy structure at the surface) and excessive runoff led to the hypothesis that poor rainfall infiltration and the soil crust, which provided a very poor seedbed for grass seed germination and establishment, were the factors limiting herbage production and recovery of the site. A preliminary, small-plot experiment on ripping was installed in late April 1995. Rips were installed 15 in. deep on 22-ft horizontal spacings with a single-shank ripper mounted on the 3-point hitch of a 55-horsepower farm tractor in late April

1995 (Figure 2). At the end of the first growing season, the yield of grasses and forbs was 1760 lb/acre immediately adjacent to rips, compared to only 380 lb/acre on untreated areas. These promising results prompted us to install a larger experiment on the clay loam range site in the spring of 1996, in which similar rips were installed on 30-ft horizontal spacings. Additional treatments installed in 1996 included seeding Haskell sideoats grama, Lometa Indiangrass, little bluestem, and WW-Spar oldworld bluestem and transplanting fourwing saltbush seedlings in the rips.

Figure 2. Single-shank ripper used for restoration of a clay loam range site near Carlsbad, Texas in 1995 and 1996.

Rainfall from 1.5- to 2.0-in. spring and summer convection thunderstorms at the Carlsbad study site often penetrates to a depth of 48 to 54 in. along the rips, compared to only 4 to 5 in. on adjacent, unripped rangeland (Figure 3). However, this difference is not as great following gentle, soaking winter rainfall events. The total standing crop of grasses and forbs immediately upslope from the 1995 rips increased gradually through 2000, reaching about 5800 lb/acre by August 2000 (Figure 4). Dense stands of cane bluestem, a highly productive, warm-season midgrass, established naturally on the rips installed in 1995 and the production of buffalograss and three-awns increased substantially. The major change observed on the 1996 rips was a substantial increase in abundance of Texas wintergrass and increased production of buffalograss and threeawns. Seeding was of limited success in the 1996 experiments because of drought and below-normal growing season rainfall for several years. The only seeded grasses which established along the 1996 rips were Haskell sideoats grama and WW-Spar oldworld bluestem, and the number of live grass plants/100 ft of seeded row in mid August 2000 were only 39 and 28 for these two species, respectively. Survival of fourwing saltbush transplants in the rips averaged 25% and these plants averaged 20 in. in height and 14 in. in diameter after 5 growing seasons. By August 2000, the bands of perennial grasses visibly enhanced by ripping were 9.3 ft wide on the 1995 rips and 7.8 ft wide on the 1996 rips. Profiles of native plant yields in August 2000 across 1995 and 1996 rips that were not seeded are shown in Figures 5 and 6, respectively.

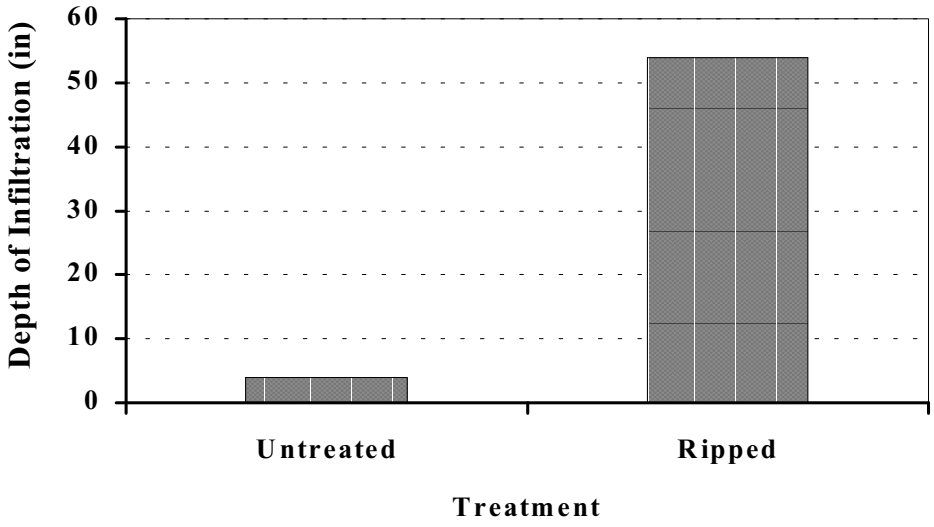

Figure 3. Depth of penetration of water from a 2-in. convection thunderstorm along rips and on untreated rangeland near Carlsbad, Texas.

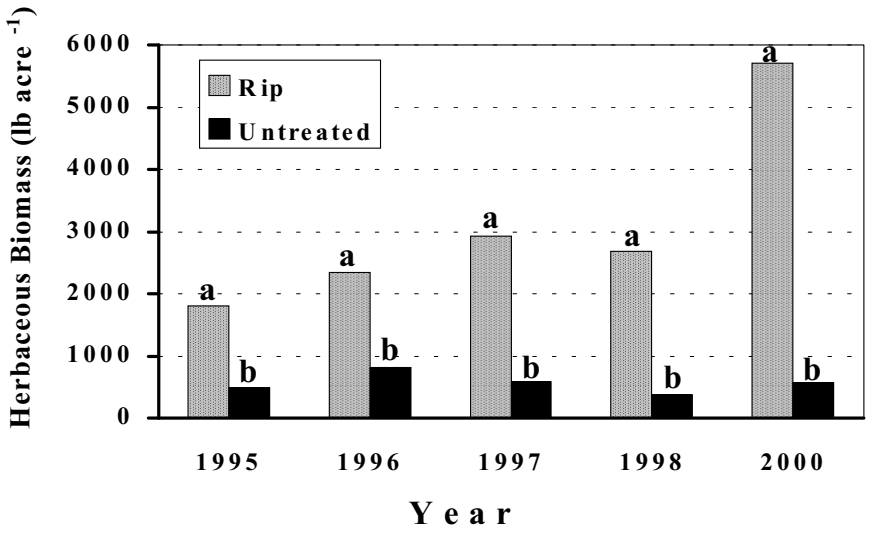

Figure 4. Herbage production during 1995 - 2000 immediately upslope from rips installed on a clay loam range site near Carlsbad, Texas in April 1995 and on adjacent untreated areas. Means within a year with different lower case letters are significantly different at the 5% probability level.

The rangeland ripped in 1995 and 1996 were substantially improved within 4 to 5 years in spite of the drought. Averaged over the two experimental areas, clipping data collected in 2000 showed that ripped landscapes that were not seeded yielded 1700 lb/acre of herbage,

compared to 490 lb/acre on unripped areas. Assuming proper use, i.e., grazing only 25% of the standing herbage, rangeland that had been ripped on 22- to 30-ft horizontal spacings had a carrying capacity of almost 29 animal unit years (AUY) of grazing/section compared to only about 8 AUY/section for unripped rangeland (Table 1).

Table 1. Effect of ripping in 1995 and 1996 on total herbage production, grazeable herbage, and carrying capacity of a clay loam range site near Carlsbad, Texas. (From data collected in mid August 2000).

Range Site Characteristics	Untreated	Ripped
Total herbage yield (lb/acre)	490	1700
Grazeable herbage (25% of total lb/acre for proper use)	122	425
Animal unit days of grazing/acre	4.7	16.4
Animal unit years of grazing/section	8.2	28.7

Above-normal cool-season precipitation during the fall-winter of 2000 - 2001 at the Carlsbad study site produced luxuriant growth of cool-season annual forbs. However, there was no effective precipitation on the Carlsbad study site during the growing season of 2001, and the cool-season forbs apparently utilized all of the deep soil moisture. Consequently, a high percentage of the perennial grasses currently appear to have died out. The loss of our perennial grasses has been extremely disappointing, but the presence of perennial grasses along the rips for a few years has improved the structure of the surface soil and some of the dead grass plants and mulch remain to resist runoff and to protect the surface soil from the energy of raindrop impact. We expect the perennial grasses to return whenever some effective growing season precipitation is received.

Ripping with the 55-horsepower farm tractor is relatively inexpensive. About 6.7 acres can be ripped/hr using the single-shank ripper on 20-ft horizontal spacings in 3rd gear and about 9.9 acres can be ripped/hr when rips are installed on 30-ft horizontal spacings. Assuming a labor cost of $10/hr and a cost of $ll.67/hr for the tractor, the cost for ripping on 20- and 30-ft spacings is $3.28 and $2.18/hr, respectively. Costs are somewhat higher than those shown in Table 2 for ripping in extremely dry and compacted soils because lower gears must be used. Rippers that can be mounted on the 3-point hitch of farm tractors can be purchased with one to several ripper shanks. We recently purchased a single-shank ripper (Bison SVH-1, Bison Equipment Co., Waco, TX) for $374. Ripping on 30-ft horizontal spacings with a small crawler tractor (Caterpillar D3C XL) equipped with a single-shank, construction-type ripper at a contract price of $45/hr cost about $6.75/acre. Performance of the crawler tractor was about 6.7 acres/hr.

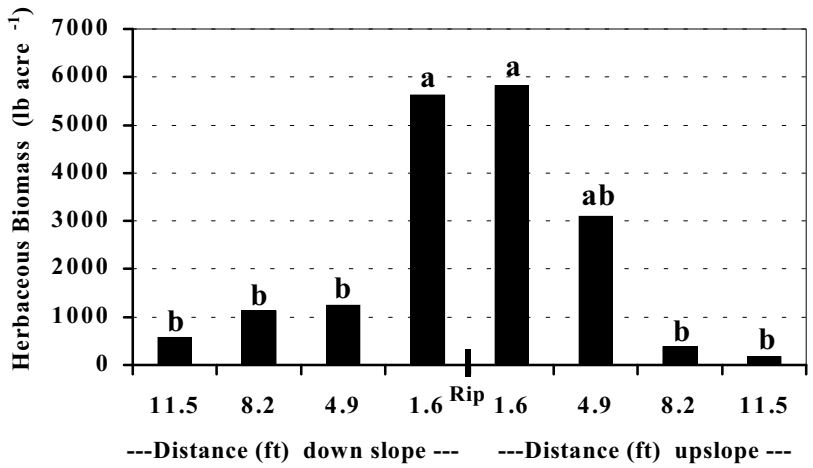

Figure 5. Profile of herbage production in mid August 2000 across rips installed in 1995 on a clay loam range site near Carlsbad, Texas. Values with different lower case letters are significantly different at the 5% probability level.

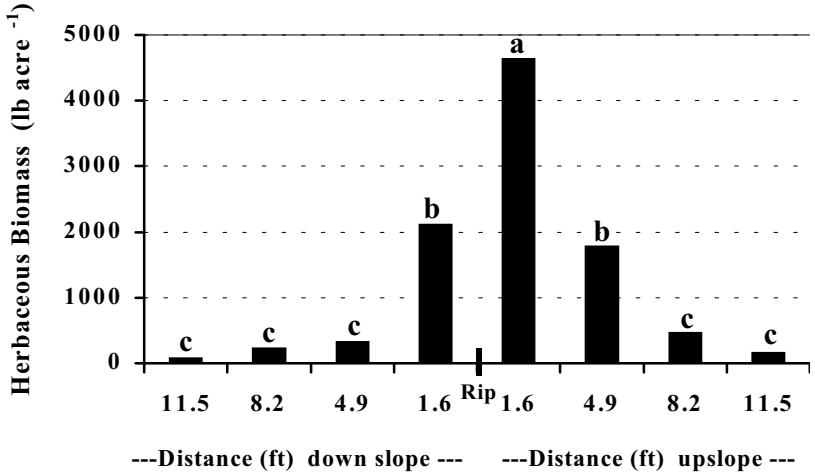

Figure 6. Profile of herbage production in mid August 2000 across rips installed in 1996 on a clay loam range site near Carlsbad, Texas. Values with different lower case letters are significantly different at the 5% probability level.

Wing ripping is accomplished by attaching shop-made wings or a furrow opener to the shank of ripping implements (Branson et al. 1966). The attached wings or furrow openers remove soil from the trench created by the ripper shank and flattened tip, resulting in a larger furrow for greater water retention capacity and larger ridges of soil for increased resistance to surface runoff. While installing water conservation treatments at 10 locations in western Texas during 2002, we found that ripping alone did not create sufficient uplifting or soil ridges or

furrows on soils with a low clay content. Wing ripping was accomplished by attaching 18.5-in.-wide wings made in the shop from 1/4-in. steel plate (Figure 7) or a standard furrow opener onto the leading edge of the the ripper shank. Brackets welded onto the back sides of the wings or furrow opener facilitate attaching these to the ripper shank with 5/8-in. bolts. The brackets and bolts also facilitate the vertical positioning of wings or furrow openers at the proper height to effectively create a clean furrow and shove the soil aside to create effective soil ridges. We found that the properly positioned furrow opener created a furrow with a depth of about 5 in. below the undisturbed soil surface, 24 in. wide at the top, and soil ridges about 5 to 6 in. in height on a sandy soil in Ector County. The overall depth from the top of soil ridges to the furrow bottom was about 10 in. Furrows made when the shop-built wings are attached to the ripper shank are slightly narrower and shallower.

Contour Furrowing

Contour furrowing involves pulling disk plows or other tillage implements, such as lister bottoms, to create depressions or grooves in the soil surface 4 to 8 in. deep, 6 to 30 in. wide, and 2 to 10 ft apart (Valentine 1971). These soil depressions increase on-site water retention and the ridges of soil adjacent to the furrow provide resistance to surface runoff. Furrowing implements can be designed with rippers in front of the disks and dikers that dam up the furrows at selected intervals. Diking of the furrows makes furrowing on an exact contour less critical than for furrowing without dikes (Branson et al. 1966). Seeders can also be attached that deposit seed on or into the disturbed soil during the furrowing process to establish plant species that can make beneficial use of the water retained in the furrows. Broadbase furrows are built with a road grader by pushing soil from a 6- to 8-ft-wide area downslope to form low dikes 1.5 to 2 ft in height. We bolt shop-built wings made from 1/4-in. steel plate or a lister bottom onto the shank of our single-shank ripper to create furrows (Figure 7) and attach a 1-row grass seeder to the ripper frame to facilitate seeding. The seeder, made by the Truax Company (Minneapolis, Minnesota), which has separate seed boxes for slick and chaffy seeds and is powered by a hydraulic motor, was fitted with a flexible seed tube that can be moved right or left by the tractor operator to strategically deposit grass seeds immediately upslope from the ridge of soil along rips or furrows (Figure 8). Log chains, pulled in a loop behind the seed tube, cover the seeds with soil.

Contour furrowing with the Arcadia Model B contour furrowing machine increased perennial grass production by over 500 lb/acre and broadbase furrowing increased perennial grass by almost 1500 lb/acre (Branson et al. 1966). Listing of rangeland near Spur, Texas increased perennial grass production 2.1 to 4.1 times compared to that produced on untreated rangeland (Dickenson et al. 1940).

Figure 7. A single-shank ripper (Bison SVH-1, Bison Equipment Co., Waco, TX) with shop-made wings.

Figure 8. A single-row grass seeder (Truax Company, Minneapolis, MN) attached to a single-shank ripper for strategic placement of seeds immediately upslope from the ridge of soil created by contour ripping or furrowing.

Pitting

The most effective rangeland pitting has been done with disk plows equipped with eccentric or deeply notched disks or disk plows with eccentric furrow wheels that alternatively raise and lower the disks. The pitting implements create thousands of small basins or pits across the landscape, which function similarly to contour furrows (Valentine 1971). Perennial grass production has been increased by about 200 lb/acre by eccentric disk pitting (Branson et al.

1966). Seeders can also be attached to pitting implements. Pits installed with implements that utilize spike teeth tend to fill in with soil within about a year. It is questionable whether spike-tooth or rotary pitters are of value as a land-treatment practice (Branson et al. 1966).

Seeding

Seeding of rangeland is an expensive and high-risk venture in arid and semiarid regions due to the erratic and unpredictable nature of rainfall. Seeding should be preceeded by seedbed preparation. Root plowing is normally used for seedbed preparation on rangelands infested with woody plants. Root plowing alone costs about $100/acre while a native grass seed mixture may cost $40 to $50/acre and roller chopping to cover the seeds and compact the seedbed may cost an additional $20 - $25/acre. Due to the high costs and risk and the low potential for recovery of costs, we have seen little root plowing and reseeding in arid and semiarid regions in several decades.

Seeding only within a 1-ft-wide band on the upslope side of the ridge of soil created by contour ripping or furrowing reduces the risks and the costs substantially. First, the amount of seed that would be necessary to broadcast or drill seed 1 acre will seed about 8.3 miles of rips or furrows. If rips or furrows are spaced 20 or 30 ft apart, the amount of seed necessary to drill or broadcast seed one acre will extend over 20 to 30 acres of rips or furrows. Because of this, our seeding costs have generally been less than $2/acre, averaged over the entire treated pasture or research plot. Strategically placing the seed immediately upslope from the ridge of soil created by rips or furrows reduces the risk of a seeding failure because this is the region where water will stand the deepest and most often following rainfall events of sufficient intensity to cause runoff. This seed placement strategy and leaving 20 to 30 ft between rips or furrows increases the probability that the soil immediately upslope from soil ridges will stay sufficiently moist for a sufficient duration to facilitate seed germination, seedling emergence, and seedling establishment. Seeding only on the upslope side of rips or furrows has its own inherent risks for two reasons. First, a good seedbed has not been prepared and often is not present. In some cases the surface soil may be too compacted for the drag chain to cover the seeds with soil, or the presence of dense stands of weeds may prevent seed coverage by the chain. Secondly, following effective rainfall events the seeded band may be rapidly colonized by annual weeds or low-value grasses which may out compete seedlings of the seeded species.

We do not feel that grass seed should be placed in the furrows created by ripping or contour furrowing because of the high probability that the small seeds will be covered too deeply as this extremely porous band of soil settles and as soil sloughs off the soil ridges into the furrow bottom during intense rainfall events. Grass seeds should generally be planted only about 1/8 to 1/4 in. deep and the soil should be firmed up so that there is intimate contact between the grass seed and the soil particles.

The plant species and varieties to be used in reseeding along rips or furrows should be carefully selected from among those known to be adapted to the climate and soils of the treated area. Local Texas Cooperative Extension or U.S.D.A. Natural Resources Conservation Service personnel are good sources of information on adapted species for use in rangeland reseeding projects.

CONCLUSION

Maintaining good vegetative cover, litter, and soil aggregation is critical for the efficient utilization of water on rangelands. Proper grazing management budgets about half of the annual plant production to be left to maintain healthy hydrological and mineral cycles and an acceptable level of energy capture via photosynthesis. Control of excessive densities of undesirable plants can decrease wasteful interception and transpiration of water and increase availability of water for beneficial plants. Mechanical water conservation treatments, such as contour ripping, furrowing or pitting, can effectively reduce surface runoff and increase infiltration of rainfall into the soil reserve, thus increasing the potential for plant production. Seeding, even in conjunction with mechanical water conservation treatments, is risky but can result in the establishment of plant species which have greater genetic potential than the resident plant species for effectively utilizing the available soil water. The long-term effectiveness of these mechanical water conservation treatments hinges upon the use of proper grazing management and periodic pasture rest to facilitate the establishment and maintenance of dense patches or bands of vegetative cover.

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BRUSH CONTROL STRATEGIES FOR SELECTED SPECIES IN THE TRANS-PECOS REGION OF TEXAS

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Abstract: Thousands of acres of rangeland within the Trans Pecos region of Texas are infested with dense stands of brush. Brush infestations in this area usually contain varying proportions of catclaw acacia, catclaw mimosa, whitethorn, whitebrush and mesquite. In addition, large areas are infested with a creosote-tarbush complex on the desert floor. Many of the riparian and sub-irrigated areas are becoming infested with dense stands of saltcedar. While a certain amount of brush may be desirable for feed and cover, brush density often reaches such levels as to severely reduce production of forage desirable for livestock or wildlife. Brush invasions can become dense enough to restrict the movement of man, wildlife, and livestock through the area. This paper is intended to provide an overview of research conducted on selected brush species within the Trans-Pecos region of Texas. Species addressed include creosote, tarbush, torreyana mesquite, catclaws, and saltcedar. Mechanical and chemical techniques including landscape level and individual plant treatment strategies are discussed. Additional information on projects presented in this paper can be found at: http://farwest.tamu.edu/rangemgt/demo.html.

Management of brush species in the Trans-Pecos region of Texas can be both a costly and risky proposition. Many management techniques used in other parts of Texas simply do not work as well due mainly to lack of rainfall. Quite simply, brush management in the Trans-Pecos is not as economical a practice as other parts of the state. However, proper techniques and targeted applications can improve wildlife habitat and grazing capacity in certain areas. This paper reviews management of selected brush species common in the Trans-Pecos with chemical and mechanical techniques. Much of the research supporting these strategies was conducted within the region.

CREOSOTE AND TARBUSH

Creosote bush (*Larrea tridentata*) is an evergreen aromatic shrub that can reach heights of 10 feet. Tarbush (*Florensia cernua*) is a leafy, much branched shrub that reaches a height of 6 feet. These two plants are typically found growing together but are also found independent of the other. In general, Creosote prefers the shallower soils while tarbush prefers the deeper soils. They both competitively invade rangelands in this region and present a serious problem to ranchers. Both plants are not eaten by livestock and are poisonous to some species. The creosote and tarbush complex is common to the Chihuahuan Desert.

Tarbush is resistant to foliar applied liquid herbicides. Current chemical control recommendations are with Spike 20P™ at a rate of 0.75 to 1.0 lbs. a.i./acre. Control can be very successful at >76% plant mortality. Individual plants can be controlled with Spike 20P™ at ½ oz. of pellets per 100 sq. feet. Both of these applications have the advantage of being applied

anytime of year with an optimum time of May through July. Additionally, Long-term study plots indicate that a treatment life of greater than 20 years can be expected.

Recently, interest has risen in a mechanical treatment with the Lawson Aerator that can minimize soil disturbance, aerate the soil surface, and destroy some existing brush. Little is known about the initial and long-term effect of this treatment in the dry region of the Trans-Pecos. Paired vegetation transects were established in treated and untreated areas to monitor brush characteristics over time following land treatment with the Lawson Aerator. Brush species densities and heights are being determined within belt transects. Percent canopy coverage of brush species is being determined by the line intercept method.

Two sites containing creosote and tarbush are being monitored. Comparisons on the WD Trap site indicate the treatment initially reduced average brush height by 46.3%, average plant density by 46.6%, and percent aerial cover by 70.4% (Table 1). Transects on the WD North site indicate an initial 50.7% reduction in brush plant height, 30.3% reduction in brush density, and 52.7% reduction in aerial cover of brush. One year after treatment very little growth had taken place on either treated or untreated plots. This is most likely attributable to low rainfall and drought conditions since the treatment was initiated. Creosote appears to increase in density slightly after treatment, although height and cover has not yet returned to pre-treatment levels. Tarbush density was initially reduced by 74.3% and has remained at or near that density for 3 years after treatment. It appears that reduction of tarbush density may be possible with this treatment.

MESQUITE

Mesquite is the most common noxious plant invading Texas rangelands. Mesquite densities can reach such proportions as to severely limit desirable forage growth by competing for nutrients, water and sunlight. In addition, large quantities of mesquite bean consumption over a period of time (several months) can be toxic to grazing animals. Small quantities of bean consumption can however be considered as a valuable forage.

Unfortunately, there is a variety of mesquite in the Trans-Pecos region of Texas that is resistant to aerial applications of herbicides. The variety is know as *torreyana* (torreyana mesquite), and is characterized by shorter height, smaller leaves and more basal stems as compared to variety *glandulosa* (honey mesquite), which is common throughout most of the rest of the state.

Table 1. Initial* and post-treatment vegetation transect measurements including vegetation height, plants per acre (density), and percent aerial cover taken on two sites in the Trans-Pecos after treatment with a Lawson Aerator and no treatment.

Site Treated	Plant Species		Treated			Untreated		
			Height	Density	%Cover	Height	Density	%Cover
WD Ranch trap	Creosote	Initial	10.1	659	2.2	17.1	951	4.6
		1 Year	10.3	902	2.4	16.1	878	4.0
		2 Year	11.4	902	3.6	17.1	805	3.3
		3 Year	11.5	1000	3.1	15.4	902	3.8
	Tarbush	Initial	9.1	171	0.2	20.2	707	2.8
		1 Year	9.2	220	0.0	21.8	732	2.8
		2 Year	6.0	49	0.0	15.6	707	4.4
		3 Year	8.0	122	0.1	14.1	707	3.3
	Javelina bush	Initial	6.8	122	0.1	11.2	122	0.8
		1 Year	7.3	98	0.0	10.8	195	0.6
		2 Year	10.4	171	0.0	9.2	146	0.8
		3 Year	6.2	122	0.0	9.3	98	1.5
	All Brush	**Initial**	**8.7**	**951**	**2.4**	**16.2**	**1780**	**8.1**
		1 Year	**8.9**	**1220**	**2.4**	**16.2**	**1805**	**7.3**
		2 Year	**9.3**	**1122**	**3.6**	**13.9**	**1659**	**8.5**
		3 Year	**8.6**	**1244**	**3.4**	**12.9**	**1707**	**8.6**
WD Ranch North	Creosote	Initial	13.1	878	3.9	20.8	707	3.8
		1 Year	10.5	1341	2.7	21.6	805	6.4
		2 Year	13.3	1122	6.6	21.1	780	3.8
		3 Year	13.6	1268	6.5	21.8	780	4.9
	Tarbush	Initial	8.0	244	0.5	22.1	902	5.3
		1 Year	4.1	171	0.0	22.0	1000	5.6
		2 Year	10.1	317	0.1	19.8	878	6.7
		3 Year	10.9	317	0.4	22.3	805	6.8
	All Brush	**Initial**	**10.6**	**1122**	**4.3**	**21.5**	**1610**	**9.1**
		1 Year	**7.3**	**1512**	**2.7**	**21.8**	**1805**	**11.9**
		2 Year	**11.7**	**1439**	**6.8**	**20.4**	**1659**	**10.4**
		3 Year	**12.2**	**1585**	**6.9**	**22.0**	**1585**	**11.7**

*Initial measurements were made immediately after land treatment with the Lawson Aerator.

Aerial application of ¼ lb. a.i./acre Reclaim™ + ¼ lb. a.i./acre Remedy™ herbicides on honey mesquite normally achieves 70-80% root kill with a single application. The same treatment on torreyana mesquite has generally resulted in less than 20% root kill. A study was designed to evaluate the use of rotary wing aircraft with varying rates of total spray volume with both a oil:water emulsion and a water:surfactant mixture. The standard ¼ lb. a.i./acre Reclaim™ + ¼ lb. a.i./acre Remedy™ mixture was used.

Three sites were selected in Brewster, Jeff Davis, and Pecos Counties. Applications were made on the Tinkler Ranch in Pecos County on June 4, 2001, the Jeff Ranch in Jeff Davis County on June 4, 2001and the Leary Ranch in Brewster County on June 5, 2001. All three sites are typical Trans-Pecos vegetation with a dominant over-story of torreyana mesquite. A series of eight treatments were established at each site. The study was designed to evaluate 1) four rates of total spray volume, and 2) use of diesel vs. surfactant. Treatments were made with a helicopter equipped with a 45 ft. boom and .016 accuflo nozzles (400-600 micron droplet). Surfactant used was Induce (90% active non-ionic) applied at 0.5% v/v. Sponto 712 emulsifier was used with diesel mixtures applied at a 1:7 oil:water emulsion rate.

Initial visual canopy reduction estimates were made one month after treatment (Table 2). These estimates were an attempt to characterize consistency of spray coverage and initial leaf mortality. These estimates are in no way estimates of plant mortality. Canopy reduction estimates indicate that the 15gpa rates, regardless of adjuvant, provided the highest and most consistent coverage averaging 85±5%. Canopy reduction increased with increasing gallons per acre through the 15gpa rate, after which the 20gpa rate decreased slightly. There was no initial difference in canopy reduction between diesel (• =55±25.2) and surfactant (• =57±27.0) averaged across all plots. These plots will be evaluated at one and two years after treatment and subject to analysis of variance to determine treatment effects.

Table 2. Initial canopy reduction estimates on test plots treated aerially with rotary wing aircraft for torreyana mesquite control.

Adjuvant	Gal./Acre*	Leary	Tinkler	McKnight	Avg.	STD
Diesel	5	15	15	45	25	14.14
Diesel	10	40	35	45	40	4.08
Diesel	15	75	85	85	82	4.71
Diesel	20	65	85	75	75	8.16
Surfactant	5	5	20	25	17	8.50
Surfactant	10	45	75	60	60	12.25
Surfactant	15	90	85	90	88	2.36
Surfactant	20	70	60	65	65	4.08

*Gallons per acre of total spray volume applied.

Individual plant leaf sprays can sometimes be used to control hard to kill plants. This increase in effectiveness occurs because the herbicide spray is targeted to specific plants. As a result, individual plant leaf sprays may use less herbicide per acre than broadcast sprays, although individual plants receive 2 to 4 times the amount of herbicide applied by these same broadcast applications.

In 1995 demonstrations were established to test the herbicides Remedy™ and Reclaim™ (½% + ½% v/v) for control of this hard to kill variety. This treatment usually provides over 70% root kill of the more common mesquite variety *glandulosa*. One year following application, the individual plant leaf spray of Reclaim™ and Remedy™ provided less than 16% control at demonstration sites in Culberson and Presidio counties. As a result, treatments were established in 1996-2000 that increased the concentrations of these two herbicides in the mixture.

Treatments were applied with backpack and ATV mounted sprayers equipped with adjustable X-8 cone-type nozzles. Water was used as the carrier and surfactant was added at 0.25% v/v concentration. Blue dye was included to reduce re-treatment of individual plants. A diesel oil and water emulsion was included in the 1997 treatments. The leaves of each tree were sprayed until they lightly glistened.

Apparent mortality estimates are presented in Table 3. One year mortality estimates ranged from 69 to 100 % and 84 to 100% two years post-treatment. An average of 94% root kill of mesquite variety torreyana three years post-treatment was accomplished with a 1+1% combination of Reclaim™ and Remedy™ herbicides applied as a foliar individual plant spray.

First and second year apparent mortality results from the ½+½ % mixture of Reclaim™ and Remedy™ are promising with an average of 91 and 96% respectively, across four sites and three years. It appears the failure of this treatment in 1995 may have been more related to environmental conditions.

Mechanical control methods for mesquite include individual plant grubbing and landscape level approaches such as chaining, root plowing, and roller chopping. Each of these has been used with varying success. The Lawson Aerator study also evaluated one site where mesquite was the dominant species. A comparison of initial transects on treated and untreated areas on the Long X site indicates that the treatment initially reduced average brush height by 27.8%, average plant density by 20.4%, and percent aerial cover by 76.7% (Table 4). These transects are read annually following treatment and again compared to untreated transects. Four years after treatment, mesquite plants on the treated area are about half the height of untreated plants. Density and percent aerial cover of mesquite on treated transects increased after the first two years while that on the untreated transect remained fairly constant. After four years, percent aerial cover of mesquite on the treated transect is near that of the untreated transect.

CATCLAW ACACIA, CATCLAW MIMOSA

Catclaw populations are particularly resistant to foliar applied liquid herbicides. Spike 20P™, a dry, pelleted herbicide does provide effective control at a rates of 0.75 to 1.5 lbs active ingredient per acre or greater. Unfortunately, control with this herbicide is expensive, as cost of

such an application would be as much as $45.00/acre plus application ($3.00 to $5.00/acre). As the amount of clay in the soil increases, rates must increase as well. Current recommendations for catclaws are primarily for heavier soils. A study was initiated to determine rates of Spike 20P™ for catclaw in deep sands.

Four application rates of Spike 20P™ were applied at three sites. Rates included 0.5, 0.75, 1.0, and 1.25 lbs. a.i./acre applied with an airplane. Applications were made on sites in Martin, Winkler and Andrews Counties on January 18, 2000 to 20 acre plots with fixed wing aircraft. To document catclaw mortality and treatment life, belt transects were established and permanently marked within each treatment. Transects were initially read to determine pre-treatment plant density, height, and aerial cover. Transects are read annually following treatment to determine percent mortality and treatment life.

Costs and rates for herbicide applications were calculated for each site and summarized in Table 5. Initial control data from these plots was determined at 18 months after application. The 1.0 and 1.25 lb.a.i./acre rates provided the lowest variability and greatest initial control at 96 and 83%, respectively. Only one of the three sites had adequate rainfall during 2000 or 2001. Control on lower rate plots should increase with more rainfall to move the herbicide further into the root zone. These plots will continue to be monitored for 3 years.

SALTCEDAR

Saltcedar (*Tamarix* spp.) is an ever increasing problem along waterways and drainage ditches in the Trans-Pecos region of Texas (Figure 1). There are seven species of *Tamarix* listed in Texas with *T. gallica, T. aphylla,* and *T. ramosissima* found in the western portion of the state. Saltcedar may grow as a short shrub or tall tree. It was introduced into North America in the early 1800's from Europe, Africa, and Asia. It has been recorded growing in 15 western states. In West Texas, it is typically found in dense thickets along major waterways but can also be a nuisance along drainage ditches, irrigation ditches, and frequently flooded or sub-irrigated areas. It is also invading areas such as CRP fields.

In addition to forming dense thickets, saltcedar is also an excessive water user and is commonly referred to as a "facultative phreatophyte." The plant is capable of growing in highly saline soils and can actually cause the soil surface to increase in salinity. Because of these reasons, saltcedar is considered a major threat to the conservation of waterways in Texas. Control of saltcedar in the past has been expensive and confined to mechanical removal of the plant. Treatments to effectively control saltcedar through mechanical means have cost in excess of $500 per acre. Recently, a new chemical treatment developed in New Mexico utilizes a combination of the herbicides Arsenal™ and Glyphosate.

Table 3. Average percent mortality estimates on mesquite var. torreyana plots 1 - 3 years after treatment with varying mixtures of Reclaim™ and Remedy™ herbicides.

	% Apparent Mortality														
Year treated	Lake Ranch			7V Ranch			Jeff Ranch			Cibolo Creek			Average		
	yrs after trt.			yrs after trt.			yrs after trt.			yrs after trt.			Yrs after trt.		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
½% Reclaim™ + ½% Remedy™ in water															
1998	91	89	91	95	97	97	96	98	96	X	X	X	94	95	95
1999	99	97		100	98		95	93		98	98		98	97	
2000	85			87			69			84			81		
Avg.	**92**	**93**	**91**	**94**	**97.5**	**97**	**86.7**	**95.5**	**96**	**91**	**98**	**0**	**91**	**96**	**95**
½% Reclaim™ + ½% Remedy™ in 1:4 oil:water emulsion															
1997	75	93	84	93	95	96	92	97	83				87	95	88
¾% Reclaim™ + ¾% Remedy™ in water															
1998	94	95	88	99	98	98	97	98	97	X	X	X	97	97	94
1999	98	95		99	95		94	93		97	97		97	95	
2000	97			85			70			88			85		
Avg	**96**	**95**	**88**	**94.3**	**96.5**	**98**	**87**	**95.5**	**97**	**92.5**	**97**	**0**	**93**	**96**	**94**
1% Reclaim™ + 1% Remedy™ in water															
1996	70	84	94	91	93	95	100	100	100	X	X	X	87	92	96
1997	86	99	88	95	98	96	90	98	88	X	X	X	90	98	91
1998	92	89	89	99	98	99	97	97	98	X	X	X	96	95	95
1999	X	X	X	98	91		93	88		99	99		97	93	
2000	96			X	X	X	83			80			86		
Avg	**86**	**91**	**90**	**95.8**	**95**	**96.7**	**93**	**95.8**	**95.3**	**89.5**	**99**	**0**	**91**	**95**	**94**
2% Reclaim™ + 2% Remedy™ in water															
1996	87	86	96	93	96	99	100	100	99				93	94	98
Site Avg.	89	92	90	95	96	97	90	96	94	91	98	0	91	95	94

During September 1997, four sites were selected for treatment of saltcedar with Arsenal™ and Glyphosate. Treatments were applied near FM 2217 along a drainage ditch in Hudspeth County on September 9, the Brantley Ranch along the Delaware River in Culberson County on September 10, the Foley Ranch along the Pecos River in Pecos County on September 11, and Highway 285 near Pecos in Reeves County on September 24. Two application rates of Arsenal™ and Glyphosate were made on all sites (Table 6).

Treatments were again established in 1999 at four sites. Plots were established September 10, 1999 in Martin County along County Road A3900 and in Howard County in a drainage ditch near Big Spring, on September 18, 1999 in Hudspeth County near Dell City, and on September 21, 1999 in Presidio County on the Presidio Valley Farms. Costs and rates are presented in Table 6.

Table 5. Treatment rates, costs, and average control of catclaw with Spike 20P™.

Spike 20P™ Rate Lbs a.i./ac	lbs. Material Applied/Acre	$/Acre*	1 Year % Apparent Mortality			
			Andrews	Martin	Winkler	**Average**
0.5	2.50	$26.25	24%	94%	68%	**62±36%**
0.75	3.75	$39.38	21%	96%	44%	**53±39%**
1.0	5.00	$52.50	92%	98%	96%	**96±3%**
1.25	6.25	$65.63	63%	95%	92%	**83±17%**

*Cost/acre for products only

Individual plants were treated using a trailer mounted high pressure (80 psi.) Bean sprayer equipped with a Gunjet® 43LA-AL spray gun, D6 orifice disc, delivering a maximum of 2.0 gal./min. This wand is capable of a maximum vertical throw of 33 feet. A total of 25-50 gallons of spray mixture was applied at each location. Each tank mix included herbicide, 0.25% non-ionic surfactant, Hi-Light blue dye and water. The mix was constantly agitated in the tank while spraying. Trees were sprayed until thoroughly wet but not to the point of runoff. Special care was taken to treat the terminal ends of branches. A good indication of this was when the tassels turned blue from the dye. Number of trees treated was recorded and the area treated was measured. Evaluations were made at one and two years post-treatment.

Percent apparent mortality at one and two years after treatment was evaluated by counting dead and live plants within each plot. Mortality averaged 79±30% on the low rate plots and 90±9.1% on the high rate plots averaged across years and sites one year after treatments (Table 6). Evaluations the second year after treatment indicate that some of the low rate plants had re-sprouted as mortality dropped to an average of 75±16.9%. Mortality on the high rate plots remained constant as estimates averaged 90±7.2% two years post-treatment. With the higher mortality and less variability between plots, the higher rate of ½% Arsenal™ + ½% Glyphosate appear to be the best choice and should justify the increased cost.

Aerial application of Arsenal™ alone or in combination with Glyphosate is also a viable option but somewhat expensive. During 1999, study plots were established to evaluate the use of fixed wing vs. rotary wing aircraft for application along a river system. Tank mixes of Arsenal™

and Rodeo™ were evaluated for efficacy in controlling saltcedar. Twelve study plots consisted of six replicated treatments. In each of the twelve plots, permanent transects were established and evaluated, in August 1999 and again in August one and two years post treatment.

The average percent mortality one and two years post-treatment for each of the six treatments is given (Table 7). The helicopter treatments provided nearly twice as much kill as airplane plots. Two year mortality estimates indicate the 1000 micron helicopter plots provided the highest and most consistent control of saltcedar.

Additional Aerial herbicide plots were established in Reeves County along the Pecos River near Pecos, Texas on September 16, 2000. Six treatments were applied to plots one mile long along the river between Business 20 and Interstate 20 and replicated on each side of the river. Treatments were applied with a helicopter delivering 15 gallons per acre total spray volume through a .027 accuflo nozzle (1000 micron) and 45 ft. variable width spray swath. Each treatment included 2 pints/acre of non-ionic 90% active surfactant (Induce™). Plots are evaluated one and two years post-treatment by counting live and dead trees within the plot boundaries

Preliminary percent mortality estimates were made on October 29, 2001. These preliminary estimates were made by counting 100 plants as live or dead within each treatment. A more thorough evaluation will be completed two years post-treatment in 2002. All initial mortality estimates fell below 50% control (Table 8). Initial estimates indicate that control was highest when at least 2 pints/acre of Arsenal™ are applied. When only 1 pint of Arsenal™ was included in the tank mix very little mortality was evident.

Table 6. Costs and apparent mortality (%) of individual plant treatments for saltcedar with a low rate (¼+¼%) and high rate (½+½%) of Arsenal™ and Glyphosate at various sites.

Site	Treatment*	Plants/Acre	Gallons of Spray/Plant	$/Plant	$/Acre	App. Mortality	
						1 Year	2 Year
1997 Treatments							
Hudspeth	Low	663	0.34	$0.33	$217.19	64%	54%
	High	833	0.50	$0.88	$735.47	82%	86%
Pecos	Low	187	1.67	$1.59	$298.63	95%	77%
	High	162	1.92	$3.39	$551.60	95%	85%
Reeves	Low	389	0.44	$0.42	$164.76	96%	95%
	High	293	0.59	$1.04	$304.33	92%	98%
Culberson	Low	89	3.13	$2.99	$265.45	98%	75%
	High	100	1.47	$2.60	$259.58	98%	94%
1999 Treatments							
Hudspeth	Low		0.22	$0.19		91%	X
	High		1.32	$2.02		X	X
Martin	Low	581	0.81	$0.68	$394.22	92%	92%
	High	1109	0.21	$0.33	$365.42	96%	96%
Howard	Low	426	1.14	$0.96	$407.36	X	X
	High	288	0.98	$1.51	$432.82	X	X
Presidio	Low		1.32	$1.11		16%	58%
	High		1.00	$1.54		75%	80%
Average	**Low**	**389**	**1.13**	**$1.03**	**$291.27**	**79%**	**75%**
	High	**464**	**1.00**	**$1.66**	**$441.54**	**90%**	**90%**
Std. Err.	**Low**					**30.0%**	**16.9%**
	High					**9.1%**	**7.2%**

***Low rate = 1/4+1/4%, High rate = 1/2+1/2%**

Table 7. Average density (# trees/ac) for August 1999 and average percent mortality one and two years post-treatment given for each of the six treatments. Mortality presented as % mortality ± standard deviation.

Treatment	Trees/Ac. Aug. 1999	1 Yr Avg. % Mortality	2 Yr Avg. % Mortality
1 (Control)	184	0	0
2 (Airplane, 4pts, 1 pass)	195	26.5±15.5	29.4±31.3
3 (Airplane, 4pts, 2 passes)	170	30.0±14.2	46.9±10.9
4 (Airplane, tank mix, 1 pass)	145	41.1±10.9	40.3±30.7
5 (Helicopter, 1500 micron)	248	78.6.±8.8	76.2±22.1
6 (Helicopter, 1000 micron)	256	87.6±3.6	93.8±2.2

Table 8. Percent apparent mortality of saltcedar one and two years after application of varying tank mixes of Arsenal™ and Rodeo™ herbicides applied with a helicopter.

			% Apparent Mortality	
Treatment	Herbicide	Rate	1 Year	2 Year
		(product/acre)		
1	Arsenal™+Rodeo™	2pints+4pints	47%	
2	Arsenal™+Rodeo™	2pints+6pints	40%	
3	Arsenal™+Rodeo™	1pint+8pints	17%	
4	Arsenal™+Rodeo™	1pint+6pints	17%	
5	Control		0%	
6	Arsenal™	4pints	48%	

LANDOWNER ASSISTANCE PROGRAMS-STATE

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Abstract: Landowners willing to enter into management agreements with private, state and federal conservation groups can accomplish range and wildlife improvements over large areas. The Trans-Pecos may be the driest region of Texas, but it is also the most ecologically diverse. This region supports more species of plants and animals than any other. However, there are several threatened, endangered and rare species of plants and animals here also. This presentation will discuss some of the cost-share options available to landowners that wish to protect these valuable resources.

LANDOWNER INCENTIVE PROGRAM

The Landowner Incentive Program (LIP) is a Texas Parks and Wildlife Program that assists landowners with the management of Threatened and Endangered or Rare wildlife species and their habitats. This program provides technical guidance and cost- share assistance directly to landowners interested in preserving these resources. Since its inception in 1997, landowners across the state have entered into agreements with Texas Parks and Wildlife to improve our natural resources.

WHAT ARE SOME OF THE PROJECTS ELIGIBLE FOR FUNDING?

All creative projects that are of benefit to rare plant species, animal species or special habitats are strongly encouraged. Examples of eligible projects include (restoring native vegetation, grazing management systems, preparing for prescribed burns, selective brush management, constructing exclosure fences and gating caves). Funds can also be awarded to help offset the cost of developing a conservation easement. Any project that accomplishes rare species/habitat conservation at a reasonable cost is encouraged and will be considered.

WHAT IS THE MINIMUM ACREAGE REQUIRED?

There is no minimum acreage requirement for a project to be considered for LIP funding. Some projects may require larger acreage than others to achieve the desired management objectives. While some projects can be implemented on an acre or less (i.e., protection of a bat cave), others may require more area (management of lesser prairie-chicken nesting habitat). Your local TPWD biologist can help you achieve your management goals.

WHAT ARE SOME OF THE CRITERIA FOR APPLYING?

The proposed action by the landowner must contribute to the enhancement of at least one rare species or habitat type in a significant way. Rare species also include those that are federally or state listed as threatened or endangered. The results of the action must be

measurable. A biologist will work with the landowner on the property for a pre-survey and return for periodic progress checks with the landowner at a mutually agreed time to assess the success of the project. The landowner and the biologist will develop a project agreement or management plan. Each management plan will be designed to meet the landowner's individual conservation and land use needs and objectives. The landowner's name and address will be required for accounting purposes. However, in regard to the landowner's right to privacy, the landowner can negotiate the kind and amount of information recorded by TPWD.

Inability to complete the agreed management action because of weather or other conditions beyond the landowner's control will be considered individually and rescheduled as necessary. Species and habitats deemed by TPWD to be of most concern within each ecological region of the state will be given priority during the selection process.

HOW WILL PROPOSALS BE SELECTED?

Submitted applications will be evaluated by TPWD for biological soundness. Applications and staff appraisals are then provided to the LIP Advisory Committee, which ultimately selects and recommends for funding proposals it feels are of greatest merit. This 11-person committee consists of landowner representatives as well as members from various resource agencies and conservation organizations.

The primary selection criteria will be based on the extent to which the proposed management action achieves actual sustainable rare species or habitat recovery or alleviates threats to the resource, balanced against the cost effectiveness of the proposed action. Landscape scale, innovation, impact, and sustainability are key considerations in selection. Applicants will be encouraged to allow their project to be used for mutually-coordinated demonstration purposes and field days for landowners. Additional weight in the selection process will be given to application from landowners willing to contribute cost sharing. The cost share may include labor and materials. While no duration limits exist for proposed projects, preference will be given to projects that show measurable results in 5 years or less.

Successful applicants will be notified and arrangements will be made to discuss and draft a conservation plan and the terms of the agreement. The TPWD staff will provide the landowner technical assistance, as needed, throughout the entirety of the project.

ARE THERE FUNDING LIMITATIONS?

Although $10,000 has generally been considered the funding limit for a project, larger projects will be considered. A minimum of 10% of the allotted funds will be retained until conclusion and final assessment of the project. Payment schedules will be negotiated with the landowner to meet the objectives of the management plan. Receipt of final payment will be contingent on the landowner's fulfillment of the agreement and project completion.

HOW DO I GET INVOLVED WITH THE LANDWONER INCENTIVE PROGRAM?

First, contact your Regional Wildlife Office for assistance, or call 1-800-792-1112, ext. 4799 or ask for LIP. A TPWD staff will contact you to discuss your options. If necessary, a site visit will be scheduled to further discuss appropriate management activities for your property. Finally, TPWD will assist you in completing and submitting the LIP application form which will outline the proposed management actions to be taken. Application forms will be provided by the TPWD staff member.

FOR FURTHER INFORMATION ON THIS PROGRAM PLEASE CONTACT THE NEAREST TPWD OFFICE.

West Texas (San Angelo, Regional Office)
915-651-4748

Ruben Cantu – Regional Director
3407-B S. Chadbourne
San Angelo, TX 76904
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Trans-Pecos - (Alpine District Office)
Mike Hobson – District Leader
109 South Cockrell
Alpine, TX 79830
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Midland, TX 79703
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200 N. Clark Drive
El Paso, TX 79905
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Kent – Misty Sumner
P. O. Box 3008
Kent, TX 79855
915-828-3413

LANDOWNER ASSISTANCE PROGRAMS-FEDERAL

WAYNE SEIPP, Natural Resource Conservation Service, Alpine, TX 79830

USDA RIPARIAN BUFFER PROGRAM - CRP
GENERAL INFORMATION FOR TEXAS

- Land adjacent to perennial and some seasonal streams on rangeland, may be eligible for enrollment in Continuous CRP. A Riparian Buffer is a band of dense native vegetation (grasses, shrubs and trees) along creeks, streams and rivers. A healthy riparian buffer will protect the banks, filter sediment and other contaminants, improve water quality, and enhance fish and wildlife habitat.

- Riparian areas along eligible streams that are currently not functioning properly are targeted for enrollment. Riparian areas that already have the appropriate kinds and amounts of vegetation are not eligible. Non functional riparian areas may have an inadequate cover of desirable grasses, shrubs and trees, or may have an excessive density of less desirable woody plants.

- Riparian Buffers will range from 35 to 180 feet wide on each side of eligible streams. This amounts to about 8 to 44 acres of buffer per mile of stream. The width of the Riparian Buffer will be based on the width of the active floodplain. This width is determined by observing soils, vegetation, topography and flood debris. Large streams will have wide buffers; small streams will have narrow buffers.

- Enrollment period will be 10 to 15 years with no grazing in the Riparian Buffer for the enrollment period.

- Cost sharing is available for the fencing of buffers and for development of alternative livestock water where needed. Total reimbursement for practice installation is 90%, including 50% Cost-Share and 40% Practice Incentive Payment.

- Other management practices that are needed to establish a properly functioning buffer will be required in addition to livestock exclusion. This management will be site specific and may include such practices as control of salt cedar or thinning of brush such as mesquite or juniper. Cost sharing is available for such initial management. Landowners will be expected to maintain buffers in proper condition.

- The buffer must have a certain minimum amount of desirable native shrubs or trees. In many cases these are already present but often in inadequate amounts. These desirable woody plants will usually increase naturally in the absence of grazing and with other necessary management. In some cases trees may need to be planted.

- Payments include a one-time, up-front SIP (Signing Incentive Payment) of $100 per acre for 10 year enrollment or $150 per acre for 15 year enrollment.

- Annual rental payments range from $16.80 to $49.20 per acre per year, depending on geographic location and whether the stream is perennial or seasonal. In addition, an annual maintenance payment of $7, $9 or $10 per acre per year is also paid depending on the kinds of maintenance required.

- This program is administered by the USDA Farm Services Agency and funded through the Commodity Credit Corporation, with technical assistance from the Natural Resources Conservation Service. Contact your local FSA or NRCS office for more details.

WILDLIFE HABITAT INCENTIVES PROGRAM

Overview

The Wildlife Habitat Incentives Program (WHIP) is a voluntary program that encourages creation of high quality wildlife habitats that support wildlife populations of National, State, Tribal, and local significance. Through WHIP, the Natural Resources Conservation Service (NRCS) provides technical and financial assistance to landowners and others to develop upland, wetland, riparian, and aquatic habitat areas on their property.

WHIP is reauthorized in the Farm Security and Rural Investment Act of 2002 (Farm Bill). Through WHIP, NRCS works with private landowners and operators; conservation districts; and Federal, State, and Tribal agencies to develop wildlife habitat on their property. Funding for WHIP comes from the Commodity Credit Corporation.

Benefits

Since WHIP began in 1998, nearly 11,000 participants have enrolled more than 1.6 million acres into the program. Most efforts have concentrated on improving upland wildlife habitat, such as native prairie, but there is an increasing emphasis on improving riparian and aquatic areas. The 2002 Farm Bill greatly expands the available tools for improving wildlife habitat conditions across the Nation.

Species that have benefited from WHIP activities include the grasshopper sparrow, bobwhite quail, swift fox, short-eared owl, Karner-blue butterfly, gopher tortoise, Louisiana black bear, Eastern collared lizard, Bachman' s sparrow, ovenbird, and acorn woodpecker.

How WHIP Works

Conservation districts convene local work groups to identify local wildlife habitat priorities. The local work groups then provide input to the State Technical Committee that advises the State conservationist in the development of a State WHIP plan. The State WHIP plan serves as a guide for the development of the State WHIP ranking criteria.

Persons interested in entering into a cost-share agreement with the U.S. Department of Agriculture (USDA) to develop wildlife habitat may file an application at any time. Participants voluntarily limit future use of the land for a period of time, but retain private ownership.

NRCS works with the participant to develop a wildlife habitat development plan. This plan becomes the basis of the cost-share agreement between NRCS and the participant. NRCS provides cost-share payments to landowners under these agreements that are usually 5 to 10 years in duration, depending upon the practices to be installed.

There are shorter-term agreements to install practices that are needed to meet wildlife emergencies, as approved by the NRCS State conservationist. NRCS also provides greater cost-share assistance to landowners who enter into agreements of 15 years or more for practices on essential plant and animal habitat. NRCS can use up to 15 percent of its available WHIP funds for this purpose.

NRCS does not place limits on the number of acres that can be enrolled in the program or the amount of payment made; however, some States may choose to establish such requirements. NRCS welcomes projects that provide valuable wildlife habitat and does not want to discourage any landowner who desires to implement practices that will improve habitat conditions for declining species.

NRCS continues to provide assistance to landowners after completion of habitat development activities. This assistance may be in the form of monitoring habitat practices, reviewing management guidelines, or providing basic biological and engineering advice on how to achieve optimum results for targeted species.

Applications are accepted through a continuous sign-up process. Applications may be obtained and filed at any time with your local USDA Service Center or conservation district office. Applications also may be obtained through USDA's e-gov Internet site at: http://www.sc.egov.usda.gov. Enter "Natural Resources Conservation Service" in the Agency field, "Wildlife Habitat Incentives Program" in the Program Name field, and "CCC-1250" in the Form Number field. Applications also may be accepted by cooperating conservation partners approved or designated by NRCS.

Eligibility

- Eligible lands under the program are: Privately owned land;
- Federal land when the primary benefit is on private or Tribal land;
- State and local government land on a limited basis; and
- Tribal land

If land is determined eligible, NRCS places emphasis on enrolling:

- Habitat areas for wildlife species experiencing declining or significantly reduced populations;
- Practices beneficial to fish and wildlife that may not otherwise be funded; and

- Wildlife and fishery habitats identified by local and State partners and Indian Tribes in each State.

For More Information

If you need more information about WHIP , please contact your local USDA Service Center, listed in the telephone book under U.S Department of Agriculture, or your local conservation district. Information also is available on the World Wide Web at: http://www.nrcs.usda.gov/programs/farmbill/2002/.

PARTNERS FOR FISH AND WILDLIFE

Initiated in Texas in 1990, the U.S. Fish and Wildlife Service's Partners for Fish and Wildlife (PFW) program restores and enhances fish and wildlife habitat on private lands. The PFW program initially targeted wetland habitat for restoration and enhancement work. However, the success of this landowner friendly program encouraged the Service to expand it to benefit habitats for all federal trust resources, including waterfowl, other migratory birds, and candidate, threatened, and endangered species. Projects generally involve wetland, native prairie, and/or riparian restoration activities. The PFW program provides cost-sharing and technical assistance to non- federal landowners, including private landowners, local governments, native American tribes, educational institutions, and other entities

Through 2000, the Service has entered into 646 partnerships with private landowners, covering approximately 103,000 acres in Texas. Approximately 50,000 acres of wetlands, 108 miles (2,000 acres) of riparian corridors, two miles of instream habitat, and 51,000 acres of native prairie and other upland habitats have been restored and/or enhanced by the PFW program in Texas. Throughout the State, the PFW program has also participated in projects seeking to educate the public regarding the benefits of wetland and other wildlife habitat by providing funds used to develop outdoor environmental classrooms.

The PFW program has been very well received by participating private landowners, known as Cooperators. In fact, many interested landowners remain on field office waiting lists at the end of each fiscal year. Several Cooperators have been honored as recipients of National and Regional wetland stewardship awards and also with local "Wildlife Conservationists" awards. A close working relationship often exists with personnel from the Natural Resource Conservation Service (NRCS), local Soil and Water Conservation Districts, Texas Parks and Wildlife Department, Texas Forest Service, other government agencies, and private organizations such as Ducks Unlimited.

APPLICATION AND APPROVAL PROCESS:

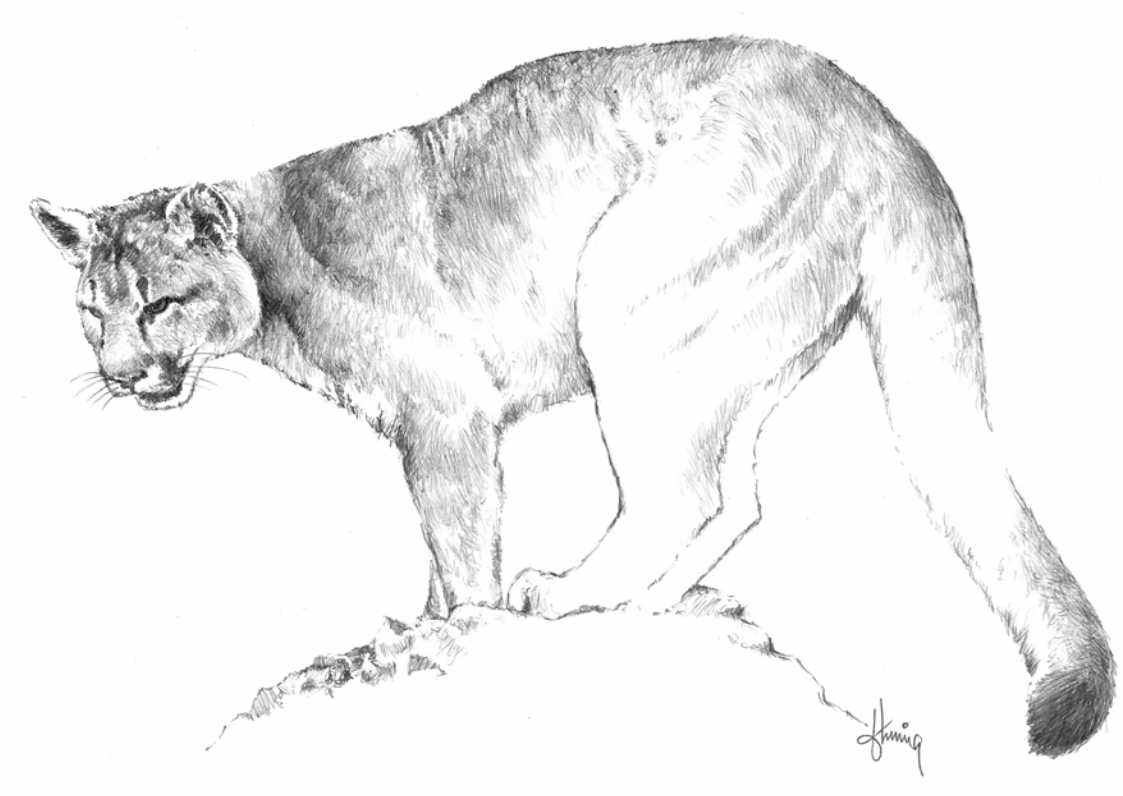
- Landowner, NRCS personnel, etc. contacts appropriate FWS field office.
- FWS conducts a site visit, often with NRCS representative.
- Proposed project developed with landowner, often with NRCS input -especially if engineering required.

- Private Lands Agreement which stipulates FWS/ landowner's cost-shares, project design, and management plan is signed by landowner and submitted to FWS field office.
- Once the project is approved at the field office level and based upon the availability of funds, the Agreement is sent to the Regional office (Albuquerque, NM) for final approval, archaeological clearance (if necessary), and other processing.
- Landowner receives signed agreement from FWS regional office; project construction may begin.
- Landowner reimbursed cost-share amount after project completed.

PROGRAM CONTACTS:

- State PFW Coordinator: Don Wilhelm, Ecological Services Field Office, Arlington, 817-277-1100
- Northcentra11Northeast Texas: Don Wilhelm East Texas: Jeff Reid, Lufkin, 409-639-8546
- Texas Panhandle: John Hughes, Canadian. 806-323-6636; or Dave Haukos, Lubbock,806-742-2841
- Texas Coast: Dave Curtis (Texas Prairie Wetlands Project), Victoria, 361-576-0230
- Southeast Texas, South Texas, and Texas Coast: Ron Jones, Houston. 281-286-8282
- Central, West (Trans Pecos), and Southwest Texas: Tim Schumann, Austin. 512-490-0057

Predator Ecology and Management



INTERPRETING THE IMPACT OF PREDATION ON WILDLIFE

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Abstract: Predator control is a contentious issue, but especially so when the control of one wildlife species is proposed as a means of producing more of another for recreational purposes, i.e., hunting. When debating any issue, various "facts" and "statistics" are bantered about by the respective proponents/opponents for the purpose of persuading stakeholder opinions. Here I address some of the bones of contention related to predator management, and some of the misconceptions caused, or fueled, by the use and misuse of "facts" and "statistics." I offer some examples of how critical thinking skills can help understand such issues.

THE ROLE OF "SOUND SCIENCE"

We are a society inundated with various surveys, news reports, and other factoids designed to help us make good decisions. Whether it's the effects of salting our hamburger or controlling coyotes in Colorado to boost a mule deer population, we exhort science to tell us "the truth." But the truth seems to be an elusive, adaptive, and often cryptic, parameter. Mix these characteristics with politics and you're sure to have a cauldron of opinions, each clamoring to have science support their argument. The general theme of predator control and its impacts on game species has fueled many a college lecture and campfire debate.

Several years ago I was embroiled in a controversy surrounding a school enrichment curriculum called Predators in the Classroom. One side of the controversy (there's always at least two sides to every argument) attacked the curriculum's use of vocabulary like "balance of nature" and the inclusion of people as a "predator." After such experiences, I coined a new definition for "sound science." Sound science may be defined as "if the science *sounds* like it will support your respective argument, then it is by definition *sound science*; if not, it is simply somebody's misguided conjecture."

Before getting too deep into a discussion about whether predator control is or is not a useful tool for wildlife managers, a basic understanding of statistics, their uses, and perhaps more importantly their misuse, is warranted. Researchers use various statistics (e.g., means, standard deviation, correlation coefficients) to help them evaluate the response of some variable (e.g., nest success in quail) to some imposed treatment (e.g., predator control). The goal is to look objectively at two treatments and predict reliably (i.e., at least 95% of the time) whether any observed treatment response was attributable to the treatment or merely chance. By the careful application of an appropriate study design, methods, and analyses, we strive for objectivity. Leopold and Hurst (1994) outline appropriate study designs and considerations for predator-related studies.

Let me illustrate with a simple exercise that we use at the Bobwhite Brigade to introduce the concepts of experimentation and critical thinking. Here's a simple question that begs a

simple answer: who among us here today is the best shot with a .22 rifle? You may boast that you are, but I will beg to differ, just as many of our colleagues here today. So, how would you design an experiment to objectively (i.e., without bias) determine who's the best shot? Invariably someone will say set up a target and everybody shoot at it; closest one to the bullseye wins, right? How comfortable would you feel about just one shot? Okay, you say we'll each shoot three times and see who records the most bullseyes? Fine with me, I'll use my scoped Anschutz and you use your old Stevens with iron sights and a six-pound trigger pull. Oh, did I tell you that you would shoot offhand, and I'll fire from a bench rest? I'll shoot at 8:00 a.m. before the wind gets gusty, but you will shoot at mid-afternoon when the south wind gusts at 20 mph. This exercise illustrates how our seemingly simple question can become a nightmare to decipher. Further, it underscores the need for appropriate experimental procedures and design.

Science as a process is totally objective and unbiased. The scientific method implores its practitioners to observe, hypothesize, test, evaluate, and re-test. As scientists, we adhere to a philosophy that uses observation and experimentation to seek the truth. But then the situation often deteriorates as findings are taken out of context, embellished, or otherwise manipulated to support one's arguments. My intent here is to illustrate some examples of "sound science" and how one must exercise their critical thinking skills to differentiate fact from fiction and the degrees thereof. As a prerequisite to this discussion, I offer the following (mostly anonymous) admonitions.

1) "Get the facts first, and then distort them any way you like." - Anonymous

2) "There are three kinds of lies: lies, damned lies, and statistics." - B. Disraeli

3) "He uses statistics like a drunk uses a lamp post; more for support than illumination." - Anonymous

4) "Statistics are like a bikini; what they reveal is interesting, but what they conceal is vital." - Anonymous

5) "If I hadn't believed it, I never would have seen it with my own two eyes." - Wilson's Law

6) "Where you stand on an issue usually depends upon where you sit." - Anonymous

These acknowledgments reinforce that we have a tendency to put our own particular spin on a given set of data, and thus its interpretations. As an example of how people can look at the same data, but offering different interpretations, study Figure 1 and count how many squares you see. Now ask someone next to you what their answer was. I'll wager that the two answers are different. The lesson is two-fold: (a) people can look at exactly the same thing, but "see" something different, and (b) things get more complex the longer you study them. Predators and their management are the epitome of these conclusions.

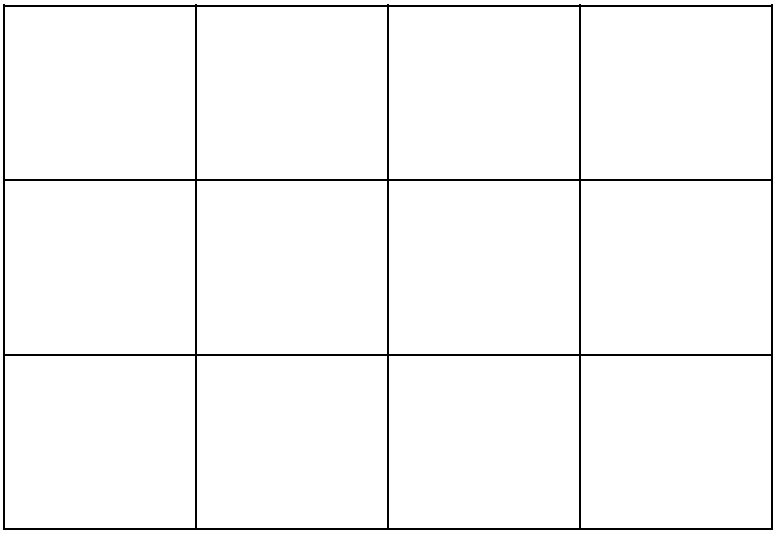

Figure 1. "Squaradigms" as they relate to predator management. Count the number of squares you see in this figure. Is it the same number that your neighbors see? Why or why?

As wildlife professionals, we measure the "worth" of our wares by publishing in "refereed" journals. A manuscript is subjected to anonymous reviews by (usually) three peers who challenge your methods, analyses, and interpretations. If it fails substantially any of these measures, it is unacceptable for publication in the professional journal. The system isn't perfect, but it does work well. The manuscripts presented here at this symposium may or may not have undergone such rigorous reviews, and I encourage you to challenge the author(s) on their statements (including mine). Such is the way of science.

SOME COMMON SOURCES OF CONFUSION

Researchers strive to minimize the effects of "extraneous" variables, i.e., those they are not interested in, by setting up controlled experiments. In a classical animal science experiment, one might use a number of steers of similar breeding (e.g., 30 angus steers) to test the effect of protein supplementation on average daily gain. An experimental design might place five steers in each of six different pens. The steers would be assigned randomly to one of the pens, and then three of the pens would be selected randomly to receive the "treatment" and the other three pens would serve as experimental "controls." Experimental diets would be similar except that one ration would be 12% crude protein and the other only 7% crude protein. To the degree possible, all other variables would be standardized (i.e., held constant across all replicates). At the conclusion of the trial, any differences observed in average daily gains should be attributable to the treatment.

In a perfect world, experiments relative to predator control would follow a similar protocol. However, in field ecology experiments, one rarely has the level of control over all variables as the animal scientist studying weight gains in a feedlot. Typically you are trying to

monitor a response that involves a nocturnal, elusive prey or predator species. Additionally, a suite of environmental variables may affect your experiment. And it's usually expensive to increase one's sample size of radio-marked bobwhites or coyotes to obtain the degree of accuracy you desire in whatever measurements are being recorded.

Some common problems associated with field experiments, including predator-prey studies, include (a) confounding, (b) spurious correlations, and (c) extrapolating beyond the context of one's study.

Confounding

When several variables are intertwined to such a degree that the scientist cannot separate the effects of Variable A from Variable Z, the results are "confounded." Consider the classic example of the Kaibab Plateau deer herd in Arizona. In 1906, Theodore Roosevelt proclaimed the Kaibab Plateau a federal game refuge for the sake of the mule deer herd. The Kaibab was closed to all hunting. Additionally, a predator control campaign was initiated that removed 20 wolves, 781 mountain lions, 4,889 coyotes and 554 bobcats from 1906 to 1931. The deer herd increased from an estimated 3,000 head in 1907 to a reported 100,000 head about 1924 (Figure 2; the numbers are disputable; see Burk 1973). A catastrophic die-off occurred about 1924 and the deer herd plummeted to pretreatment levels because of a depleted range. This incident is used in several ecology textbooks (e.g., Kormondy 1969) as the classical effect of "messing with Mother Nature" relative to controlling predators, and then subsequently releasing a deer herd that ultimately destroys its range.

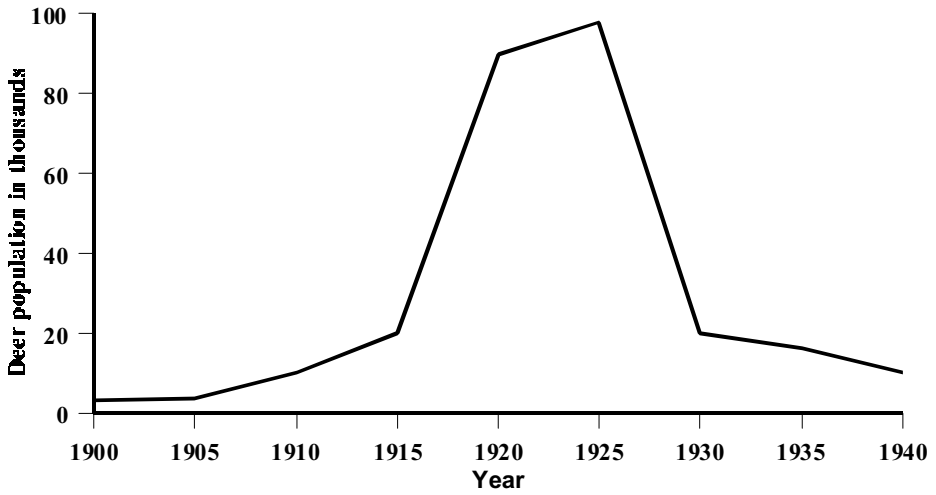

Figure 2. Deer population trends on the Kaibab Plateau, Arizona (from Rasmussen 1941).

While the popular interpretation of the Kaibab Plateau is to illustrate how predators kept the deer herd trimmed to fit the range's carrying capacity, other authors have attacked the interpretation (Caughley 1970, Burk 1973). Caughley stated that the "data on the Kaibab deer herd . . . are unreliable and inconsistent, and the factors that may have resulted in an upsurge of deer are hopelessly confounded." Confounded because in addition to the predator removal, some 195,000 sheep were also removed from the range during the early years. Thus, how does one

discern the population effects caused by removing predators from that of removing a competitor for forage?

One of my favorites is the case study of deer populations increasing over most of west Texas in the early 1960s. Most observers would be quick to credit the screwworm eradication program as the "treatment" that allowed deer numbers to multiply. But other factors were at play as well, including a targeted coyote control program using toxicants like strychnine and Compound 1080, a drought-induced destocking of livestock from much of the range, the breaking of the drought in 1957 and resultant forb flush, increased emphasis on law enforcement, and what I suspect was a reluctance of ranchers to allow hunting of the to-that-point low deer numbers. Which of these factors was not involved, at least to some extent?

Why have raccoons and other "mesomammals" apparently blossomed so over the last 15 years? Again, the intuitive response is the demise of the fur market in about 1986. But I can list two other factors that have surely contributed to the "release" including (a) emphasis on deer management, i.e., supplemental feeding, and (b) increased number of farm ponds. Both afford a mechanism for raccoons to increase in density.

Moral of the story is to beware of confounding factors. They are everywhere around us and cloud our ability to identify single causal factors.

Spurious Correlations

One of the most common pitfalls we step into is the inability to separate relationships that are "causal" (i.e., a "cause and effect" relationship exists) from those that are simply "correlated" (i.e., they vary together). Consider the relationship depicted in Figure 3 which illustrates a relationship between bobwhite abundance in the southeastern U.S. and what I refer to the moment as "Factor A." Study the graph, then answer the following questions.

1) Does an increase in "Factor A" cause the bobwhite population to decline?
2) Would you recommend controlling "Factor A" if your goal was to increase bobwhite numbers? What if such control would be politically incorrect; would you still lobby for it as a quail enthusiast?
3) What do you think "Factor A" really represents?
   (a) raccoon numbers
   (b) fire ant numbers
   (c) hunting license sales
   (d) hunting lease costs
   (e) Quail Unlimited membership

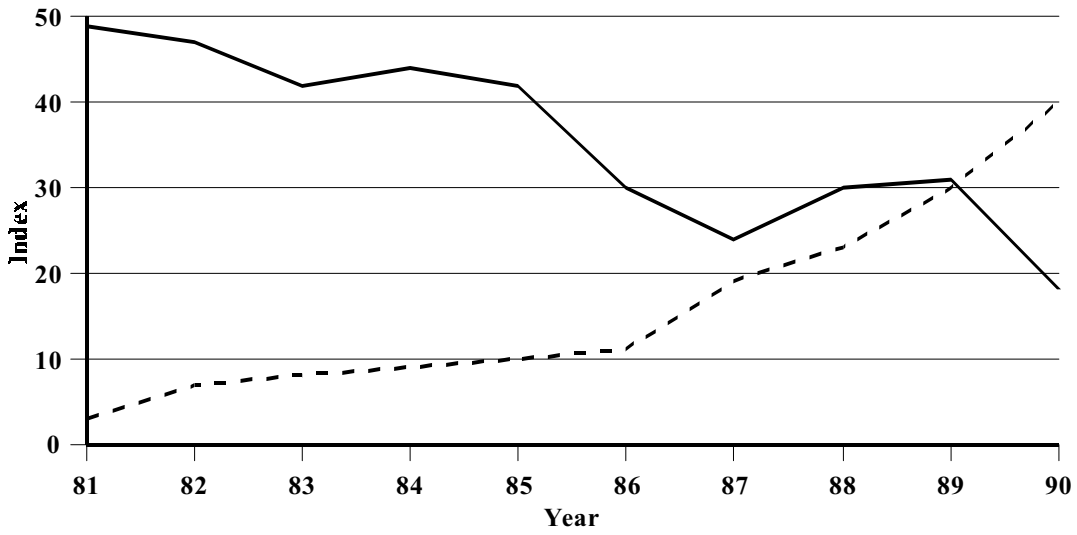

Figure 3. Bobwhite abundance in the southeastern U.S. (solid line) versus "Factor A" (dashed line). Adapted from Brennan (1991).

The correct answer is (e) Quail Unlimited membership! This illustrates that two variables may be highly correlated (either positively or negatively) and yet have little biological significance.

Similarly I could plot the number of churches in a city against the number of murders that occur in that city and have a highly significant correlation coefficient. Can I deduce then that an increase in churches causes a higher murder rate? Of course not. Population size is the independent variable that is driving both the number of churches and homicides.

Extrapolation

One of the standard caveats learned by any student of statistics (especially correlation analyses) is to never "extrapolate beyond the range of your data." Extrapolation means stretching whatever inferences may be gained from your analysis to points (or contexts) beyond which your respective data set applied.

For example, Frost (2000) removed approximately 1 mesomammal per 12 acres (mostly raccoons) from 600-acre study areas over a 30-day period just prior to the 1998 and 1999 nesting seasons in Tom Green County, Texas. Despite the removal of this number of potential predators, survival of radio-marked bobwhites and fate of artificial quail nests were similar on both trapped and nontrapped sites. So what do you conclude from such studies? That predator control failed to yield the desired result of more quail? Be careful about how you interpret your findings, especially as you use the phrase "predator control". Scent stations indicated that, at this scale and level of trapping (200 trap nights per acre), mesomammal abundance was not reduced even in the short-term. Thus no "control" was achieved, so one could hardly anticipate a treatment response in terms of increased quail or nest survival.

Interpreting Effects Of Predator Control

Connolly (1980) listed 31 studies where predators were implicated in controlling or limiting ungulate populations in North America, and 27 other studies where they did not. Connolly summarized that "a sufficiently selective review of the literature can reinforce any desired view on the subject of predation."

A question sometimes raised in the Edwards Plateau (i.e., sheep and goat country) is what impact predators (i.e., especially coyotes) would have on area deer densities "once the coyotes have killed off all the sheep." In other words, would (could) coyotes suppress deer populations? My take on the matter is this: deer numbers would decline somewhat but still remain fairly high. One has to look only at the Rio Grande Plains or the Rolling Plains to see that relatively high populations (perhaps two to five coyotes per square mile) can coexist with a healthy deer population. In fact, it would be interesting to graph coyote densities on the X-axis and the number of Boone and Crockett trophy bucks from a particular county on the Y-axis and see what kind of relationship exists. And would such a relation be simply correlated, or causal?

Once you get stimulated to study the "squaradigms" that surround predator management, there are a number of interesting relationships upon which to ponder. How do raccoons and coyotes vary? Coyotes and quail? Feral hogs and quail? Just remember that (a) even if everyone looks at exactly the same data, people will see different things and (b) the more you study what appears to be a simple question, it will inevitably become more complex.

For Additional Reading

See the proceedings of "The Role of Predator Control in Game Management" at http://texnat.tamu.edu for more detailed discussions. Printed copies are available by calling 888-900-2577 (telephone orders with Visa or MasterCard only), or by sending a check for $19 per copy payable to Texas Cooperative Extension. Send check to Distribution and Supply, P.O. Box 1209, Bryan, TX 77806.

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MANAGING COYOTE IMPACTS ON NATIVE WILDLIFE POPULATIONS

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Abstract: Coyote (*Canis latrans*) predation can negatively impact native wildlife populations when certain population, environmental or human caused events exist. Management of coyote predation is a specific process which involves identifying objectives, implementing management and monitoring results. This paper examines which conditions can lead to negative impacts to wildlife populations, and what measures are necessary to mitigate those impacts.

Coyote (*Canis latrans*) predation on native wildlife is a naturally occurring phenomenon which has, over time, helped shape the behavior and ecological roles of both the coyote and it's prey. Coyotes are highly adaptable and able to shift diet within a wide range of food, allowing them to exist in a variety of habitats, including all terrestrial ecosystems in Texas. While coyote predation is natural, the impacts can sometimes be excessive to certain populations. Coyote predation alone may not drive any species to extinction but, in concert with other environmental conditions, may be sufficient to cause severe declines in local populations. Numerous scientific reviews (Connolly 1978, Sinclair 1991, Skogland 1991, Ballard et al. 2001) have examined the role of predation as a regulator of prey populations and found a variety of impacts.

What, then, is the concern over coyote predation? When should predation management be implemented for the benefit of native wildlife? And how should predation management be implemented? The answers, like these questions, depend on the situation at hand.

PREDATION MANAGEMENT v. COYOTE CONTROL

Predator control has been described as a "…uni-dimensional approach to a multi-dimensional problem." (Armentrout 2001) This is an inaccurate view of the purpose and goals of modern predation management. "Coyote control" as practiced prior to 1972, involved suppressing populations of coyotes and, in some local cases, local eradication. "Predator control" has been replaced with *predation management*, with the goal of reducing to acceptable levels the negative impacts of predation. Predation management as a strategy reflects the true interests of managers in managing the impacts of predation without necessarily requiring predator population suppression.

Predation management requires an integrated method utilizing appropriate biological, cultural, chemical, and mechanical controls. For livestock protection, certain methods such as fencing, guard animals, scare devices and lethal control may be combined to effectively manage predation. For native wildlife, an understanding of all of the factors which affect predation is necessary.

FACTORS WHICH CONTRIBUTE TO NEGATIVE PREDATION IMPACTS

Numerous factors can contribute to coyotes limiting prey. Some factors are naturally occurring while others are human induced. When considering if predation management is necessary, an understanding of these factors is necessary.

Naturally occurring over-abundance of predators caused by an upswing in primary prey (a jackrabbit or rodent population explosion) or the long term availability of carrion followed by a sharp decrease in that feed can lead to negative predation impacts. Coyote populations, buoyed by the previous abundance of feed, can exert a negative impact due to an imbalance in predator:prey ratios. This can also occur with mountain lions where cattle provide an important food source, preventing a decline in lions and allowing them to impact deer numbers (Shaw 1981, Cunningham et al. 1995).

Changes in habitat can affect predation rates even with stable numbers of predators and prey. Certain habitats for prey animals are consistent across the landscape, allowing for even distribution of prey. Predation under these situations can be expected to be normal. However, other habitat features can make a prey species more vulnerable to predation, by concentrating predators and prey, and by making the habitat easier to hunt for the predator. Linear habitat features include strips of brush left from brush control, powerline rights-of-way, dikes, ditches and creek bottoms. These linear features are easily hunted by coyotes and prey that rely on them for escape may be easily impacted. Islands of escape habitat, either the result of brush manipulation or fire, are also easily hunted.

Concentrations of prey within the habitat can also lead to negative impacts. Fire can displace deer, pronghorn, or upland birds, concentrating them and making them more vulnerable to predators. Water development, so vital to the Trans-Pecos, also concentrates the predators with the prey, making predation inevitable. In some parts of the Trans-Pecos, water development itself has increased predator numbers, allowing coyotes and lions to establish home ranges where previously they were only occasional visitors. Changes in brush density, as a result of management or increases in brush density, can change the impacts of predation, especially in pronghorn habitat.

Population factors also can influence predation impacts. Most predation on deer and pronghorn fawns is from adult, territorial coyotes, which are feeding a litter of pups during the fawning season. Older coyotes (experienced and long term residents in the territory) likely have greater impacts on fawns than younger coyotes in the same territory. Increases in coyote numbers, through the cessation of management or a sudden increase in coyote habitat such as CRP, also contribute to increased predation impacts, as they will cause a crowding of territories.

Finally, low buck:doe ratios can increase predation impacts, due to extended breeding season and an extended fawning season. The more concentrated a fawning season, the more likely it is that some fawns will outgrow their vulnerability to predation.

PREREQUISITES TO PREDATION MANAGEMENT

Prior to implementing a predation management program, the manager must determine what is influencing predation and how to mitigate that impact. The first prerequisite is that a population objective must be established as a yardstick for how the prey population is performing. The objective needs to be realistic and based on the carrying capacity of the range.

The second prerequisite is that predation impacts must be evident and likely causing the population to perform below expectations. A population substantially below objective (50-60%), with low fawn:doe ratios (less than 50 fawns:100 does) and a stable to declining trend are good indications that predation management may be a useful exercise.

As an alternative, some other indication that predation is impacting native wildlife should be established prior to implementing a predation management program. Predation management may be necessary to mitigate some human caused habitat influence (protect the deer following a controlled burn or establish a protection area around a water source). Predation management may also be necessary to support the introduction of a depleted species, such as moving pronghorn back into an area. Some critical habitats, such as black-footed ferret reintroduction areas, are so critical they deserve long term protection. Finally, trophy deer or pronghorn management involves managing for 4-6 year old bucks. During drought, the combined pressure of lack of moisture and predation can lead to a complete loss of a fawn crop. Predation management may be justified to protect a cohort if trophy management is intensive.

RESULTS OF PREDATION MANAGEMENT

Overall results actually depend on where the prey population started and the intensity of management. To be effective, coyote predation management needs to be conducted prior to fawning (for deer or pronghorn) or nesting (for upland game). Predation management needs to be area specific, and must protect the native wildlife in the critical components of their habitat (key fawning areas, water developments, habitat corridors, etc.). To the extent practicable, predation management must effectively target that segment of the coyote population doing the damage. For deer and pronghorn, adult, territorial coyotes should be targeted with methods such as aerial hunting, denning, calling and shooting and seasonal use of ground equipment. Traps and M-44's may effectively target territorial coyotes when placed around key habitat and essential water sources.

Effective coyote predation management does not depend on the number of coyotes removed. Rather, effective predation management depends on reducing the overall impacts of predation. The number of coyotes which needs to be removed will depend on the habitat, the size of the coyote population, and the size of prey base. Two examples serve to illustrate strategies in predation management.

The Henry Mountains in southern Utah are a rugged range extending approximately 20 miles north-to-south and 12 miles east-to-west. The area was once famous for high mule deer populations, but despite conservative deer harvest management it has suffered from a decline in deer numbers for the past decade. Much of the mountain is covered in juniper habitat, with

brush management near the permanent water sources. Most of the mule deer fawn within these brush management zones, which range from 1000 acres up to about 3200 acres. Depending on the year, 1-2 pairs of coyotes will establish a territory which encompasses each of these brush management areas. To effectively protect the mule deer fawns, only these few coyotes need be removed to protect all of the deer fawns on the mountain. Such removals must be done prior to fawning, and must include the adult female of each pair. Killing only the adult males is the same as no coyote removal at all, as the female will continue to kill fawns to provide for the pups.

The Cisco desert, on the other hand, is a sprawling desert (about 450 square miles) which receives less than 9" of moisture annually. The Cisco desert has seasonal livestock grazing, with developed water catchments spread across the area. In years of adequate moisture, surface water is evenly distributed, and pronghorn fawning occurs throughout the desert. Coyote predation in these years is also evenly spread, and removals for pronghorn protection would need to occur throughout the desert (involving perhaps 200 coyotes). However, in dry years, water is concentrated on the north end of the desert and in any stock pond to which water is hauled. While these dry conditions make fawn survival difficult, the concentration of pronghorn at the water makes them very easy targets for coyotes. Coyote predation management, however, may involve removing only those coyotes using these water developments, and effective predation protection may be accomplished by taking 50 coyotes or less. Again, coyote removals must occur prior to fawning and must involve adult females.

One of the difficulties in determining the effects of predation management is trying to measure the level of predation avoided. Statisticians like treatment and no treatment studies and in laboratory conditions these provide an excellent way to estimate the benefits of a program. Unfortunately, field conditions rarely exist to effectively compare 2 dissimilar areas. Rarely are the environment, the predator population, and the prey population close enough in condition that an effective comparison may be made. An alternative to this analysis may be to compare a unit pre-management to itself post-management. A long-term (3-5 year) look at the unit may be necessary to mitigate weather effects within a single year. However, this type of analysis is better than a single snap-shot in time and allows for the overall population to be measured, which is after all the end product managers are after.

In practical application, if coyote predation management is specific (in locality, timing and targets the right portion of the population) and effective, mule deer fawn survival should double above pre-treatment levels. In 2 areas in Utah, fawn survival approached a 3-fold increase, but this was because pre-treatment levels were chronically low. Over time, the increase in the overall deer herd will reduce the measured benefit, but at some point it becomes unnecessary to protect the deer (because as they approach carrying capacity predation impacts become less limiting). Deer fawn survival never increased above 80 fawns per 100 does, so overall population growth will be slow. Still, a benefit:cost analysis of coyote predation management for mule deer showed a range of $11.4-$22.6 benefit per dollar spent on predation management.

Pronghorn protection is generally accepted as an effective way to increase fawn survival. Smith (1986) analyzed protection strategies and noted that non-selective coyote removals every other year yielded the best benefit:cost return, in the neighborhood of 2:1. Again, field

experience shows that predation management may double fawn survival, but only up to about 1 fawn/doe.

Upland game may be vulnerable to coyote predation, but the majority of opinions hold that such impacts are compensated by reductions in other mortality. The exception may be low density populations (such as Mearns quail) or species on the fringe of their range, such as pheasants in the south Plains. Prairie chickens in Texas are likely vulnerable to predation impacts due to the fragmented nature of their habitat combined with extreme weather conditions. While overall management of the habitat is a desirable and necessary goal, predation management may be necessary to prevent the populations from becoming extinct as habitat goals are achieved.

COYOTE POPULATION IMPACTS

Early coyote population models focused on the long term impacts of coyote removal on the coyote population itself, and were concerned with extinction (Connolly and Longhurst 1975). Those efforts indicated that coyote removals in excess of 70% of the population per year for 50 years were necessary to drive a population to extinction. Newer population modeling efforts have focused on impacts of coyote removals on coyote populations, using time to recovery as a better judge of impacts. The new Swarm Model (Pitt et al. 2002) includes more variables such as territoriality and natural mortality and relies on field data to represent real populations. The Swarm Model recognizes that coyote removals at 60% or less of the population allows the population to rebound within 1 year, and a removal of 90% in a single year still allows the coyote population to rebound within 5 years. Ultimately, the objective of coyote predation management is not to drive coyote populations to extinction, but rather to manage the negative impacts of predation. Using an integrated approach, it is possible to manage these negative impacts without negatively affecting coyote populations or the other roles coyotes play in the environment.

FINAL CONSIDERATIONS

Overall, whether or not to implement a predation management program to protect native wildlife will rest with the land managers, primarily the landowners in West Texas. Efficiency of predation management rests not only on the factors above, but increasingly on the actions of neighbors. Trying to provide effective predation management on small tracts of land is ineffective.

Much of the Trans-Pecos is cattle country, and wildlife may already benefit from predation management for livestock protection. An integrated program which protects livestock and wildlife makes greater ecological and economic sense than a program designed for one without consideration of the other. Where coyote predation management is in place for livestock protection, fawn survival rates for both mule deer and pronghorn are approximately double those for areas without any predation management. Spring calf protection, if conducted in pronghorn fawning areas, will benefit fawns if adult coyotes are targeted effectively. However, calving and coyote removals on the flats will do little to benefit mule deer in the mountains.

Further, while environmental conditions may dictate predation management during some years, there is some economic benefit to maintaining coyote population management. Even if coyote populations overall are not decreased, the decreased age structure in the population will likely benefit fawn survival if deer or pronghorn populations are below objective. Economic considerations, in concert with environmental considerations, will ultimately decide the level of predation management applied to much of the Trans-Pecos.

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MOUNTAIN LIONS, DEER AND PREDATOR CONTROL

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Abstract: Predator-prey relationships are complex, and not all parameters are well understood. The mountain lion *(Felis concolor)* is a high-class predator, and a controversial species. Mountain lions prey on all age classes of mule deer *(Odocoileus hemionus)* and white-tailed deer (*O. virginianus).* Combinations of factors influence the number of deer killed by mountain lions in a given area over a period of time. Climatic conditions, deer density, cover, the abundance and diversity of prey species and mountain lion density are all factors. To understand the effects of mountain lion predation on deer population's wildlife managers need to have a working knowledge on the ecology of both species before management decisions are implemented. In certain cases predator control is an effective wildlife management tool when benefits will be derived by control measures.

The mountain lion also known as cougar, puma and panther, has been an integral part of the Texas fauna for thousands of years as evidenced by the paintings and pictographs of Native Americans. Lions were once common throughout the state of Texas, but since Anglo settlement, they have been mostly confined to the isolated and rugged areas of the state. Lions now appear to be moving back into historic ranges in other areas of the state.

Mountain lions are controversial animals that often evoke love-hate feelings on the part of humans. Whatever one's perspective, mountain lions are fascinating and little understood predators that play an important role in ecosystems.

BIOLOGY

Mountain lions are high-class predators, and a basic knowledge of their biology is important in understanding their role as predator and deer as prey. Mountain lions are reddish brown to tawny in color, this coloration aids in camouflaging them as they stalk their prey. Mountain lions are solitary animals, and are active in the early in the early morning and at dusk (crepuscular) and at night (nocturnal). Normal weights of adult males in western Texas and northern Mexico average 100-150 pounds, and 55-90 pounds for adult female (McKinney 1996).

Adult males and females are together for a 3 to 5 day period during breeding season, then separate to resume their solitary lifestyle. Lions may breed at any time during the year, but most litters are born in the summer and fall. Females first breed when they are around 2 years of age. Intervals between litters average from 18 months to 2 years. Average litter size is normally 2-3 young. The gestation period is about 90 days. Female lions pick locations within their home range that offers cover and security for their young. Kittens may be left unattended for hours while the mother hunts. Females may leave their kittens in heavy brush, rockslides, caves or overhangs. The growing cubs stay with the female until they are 12-24 months old, at which time

they disperse and began the search for their home range. Dispersal of young lions depends on the distance to unoccupied habitat. Generally, sub-adult males disperse further than females.

The size of a lion's home range is determined by a variety of factors: diversity and abundance of prey, topography, habitat parameters and actual mountain lion density. Male home ranges average roughly 2.5 times larger than those of females. The male's range usually encompasses the range of several females. Recent research in western Texas indicated a degree of home range overlap in adult males; however in a literal sense males do not share home ranges (Pittman et al. 2000). The home range of an adult male may vary from 80 square miles (207 km^2) to over 200 square miles (518 km^2), while female ranges normally average 20 square miles (51 km^2) to as much as 100 square miles (259 km^2). Female ranges tend to have some degree of overlap with other females, yet they remain solitary.

HOW MOUNTAIN LIONS KILL

Lions are opportunistic, preying on a wide range of animals. As with any carnivore, it is impossible to predict what a lion will prey upon at a given time. Lions stalk their prey and kill by crushing their victim's esophagus, resulting in suffocation. Another killing technique is biting the neck, thus separating the vertebrate. In some cases, lions will bite through the skull.

Lions are meticulous about their kills compared to other carnivores. Once the kill is made the lion will drag the prey to a cache area. Lions cache their kills in areas of heavy cover. They often cover the kill with grass, leaves, dirt or other debris, but they do not bury their kills. Also often the internal organs are removed and covered at or near the kill site. Lions will uncover their fill and feed, then drag the carcass to another area and cover it again. The carcass normally remains intact as the lion begins to feed at the shoulders and ribs, eventually moving to the hindquarters and loin on subsequent meals.

IMPACTS ON DEER NUMBERS

Lions will predate on all age classes of deer. Newborn fawns are easy prey, and after the rut when bucks are recuperating from breeding activity they are particularly susceptible to lion predation. Groups of deer present more eyes and ears to alert them to danger than a solitary animal.

In an area where small mammals are abundant lions will have less impact on deer numbers. Smaller mammals act as buffer species thus reducing predation on deer. Wildlife managers should not over-harvest small game and nongame species that act as buffers. For example, mountain lions will prey on javelina (*Tayassu tajacu*), nine-banded armadillo (*Dasypus novemcinctus*), black-tailed jackrabbit (*Lepus califomicus*), porcupine (*Erethizon dorsatum*), skunks (*Mephitis* spp.), and wild turkey (*Meleagris gallopavo*). In areas where deer are the primary prey species and small mammals are not common lions will prey on deer more heavily.

In the yearly cycle there are "X" number of days the lion will hunt, and when the lion has made an adequate kill he stops hunting activity. An example of this is when a lion kills a javelina it may take him out of the killing cycle for up to two days.

A common myth relates that mountain lions will completely kill out a deer population. In all probability, the deer and lion evolved together and if the above statement were true lions would have extirpated deer many years ago. A look at our national parks where all species are left to their own means to survive is a good example of why this does not occur. Deer and mountain lions coexist in parks without manipulation by man, and deer populations tend to remain stable. What wildlife managers must recognize is the combination of hunter harvest and lion predation creates the situation where deer are unable to withstand natural predation and harvest combined. The result can be a significant decline in deer numbers.

In an area of low deer density mountain lions can suppress population increase. Resident lions have a higher impact on deer numbers than a transient lion. Transient and resident male lions utilize larger areas and deer kills will not be concentrated in one place. In retrospect, a resident female with a much smaller home range will make more kills in one area, particularly when she has kittens to feed.

Another factor that contributes to the rate at which a lion will make a kill is the weather . Depending on prey density lions may occasionally scavenge, but in general they prefer fresh meat. In cooler weather the meat doesn't spoil and this allows the lion to stay with the kill until he consumes it, which in turn lessens the number of deer killed. On the other hand, in hot weather a deer kill will spoil quickly. This necessitates the need for the lion to make another hunt. In essence, there are a number of factors that dictate and contribute to the mountain lion predation on deer herds.

PREDATOR CONTROL

When deemed necessary, predator control can help a dwindling deer population recover . One must understand that it requires a long-term commitment, both in man-power and money to obtain results. The integrity of the mountain lion population when fractured by removal of lions will for a short period of time increase. This may sound contradictory since you are removing lions, but in reality you are creating a vacuum effect. When you remove resident lions that have established home ranges you create a void, other resident lions that have home ranges that may overlap the individual you removed now find that territory empty. This allows them to expand their range, as well as create openings for transient lions to establish a new home range. Short-term predator control programs do little but aggravate the situation. Long-term predator control will show results.

Professions that have the knowledge and experience to effectively target the particular species that is creating the problem should handle predator control; non-target animals should not be affected in predator control efforts. Predator control is an effective management tool in situations where wildlife is being reintroduced.

SUMMARY

Deer populations are a numbers game. It takes numbers to make numbers. If by removing several mountain lions creating a situation where more bucks breed resulting in more doe's having fawns, and the survival rate of fawns increasing, then predator control can be a shot in the arm that a depressed deer herd needs. However, before predator control is implemented all of the aforementioned factors which effect deer herd numbers need to be considered. Predator control is an effective management tool when used properly. Eradication and extirpation are not the answers.

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PANEL DISCUSSION: PREDATION-THE PROBLEM OR A SYMPTOM?

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DEER–PREDATOR RELATIONSHIPS-A REVIEW OF RECENT NORTH AMERICAN STUDIES: Warren B. Ballard

In recent years mule (*Odocoileus hemionus*) and black-tailed (*O. h. columbianus*) deer appear to have declined in many areas of the western United States and Canada, causing concern for population welfare and continued uses of the deer resource. Causes of the decline have not been identified, but predation by coyotes (*Canis latrans*), mountain lions (*Puma concolor*), and wolves (*Canis lupus*) has been proposed as one of many factors. We reviewed results of published studies conducted since the mid-1970s concerning predator–deer relationships to determine if predation could be a factor in the apparent deer population declines and if there was evidence that predator control could be a viable management tool to restore deer populations.

Seventeen published studies were reviewed concerning mule deer. Only 4 published studies of the effects of predation on black-tailed deer existed. A larger database existed for white-tailed deer (*O. virginianus*); with 19studies examining effects of predation on white-tailed deer.

Study results were confounded by numerous factors . A deer population's relationship to habitat carrying capacity was crucial to the impacts of predation. Deer populations at or near carrying capacity did not respond to predator removal experiments. When deer populations appeared limited by predation and such populations were well below forage carrying capacity, deer mortality was reduced significantly when predator populations were reduced. Only one study, however, demonstrated that deer population increases resulted in greater harvests, although there were considerable data that indicated that wolf (*Canis lupus*) control resulted in greater harvests of moose (*Alces alces*) and caribou (*Rangifer tarandus*). The most convincing evidence for deer population increases occurred when small enclosures (2–39 km^2) were used.

Our review suggests that predation by coyotes, mountain lions, or wolves may be a significant mortality factor in some areas under certain conditions. Relation to habitat carrying capacity, weather, human use patterns, number and type of predator species, and habitat alterations all affect predator–prey relationships. Only through intensive radiotelemetry and manipulative studies can predation be identified as a major limiting factor. When identified, deer managers face crucial decisions.

Reductions in predator densities have only occurred on relatively small study areas (2–180 km^2) where predators were identified as a major limiting factor and deer populations were well below forage carrying capacity (an important criterion). Thus a problem of scale, methods used to kill predators, benefit:cost ratios, results to hunters, and public acceptance are primary considerations. Methods of predator control available to deer managers have been restricted severely and current methods may not be feasible over large areas when and if predation becomes a problem. Public acceptance of predator reduction programs is essential for predator–prey management, but may not be achievable given current public attitudes towards predators. We identified several recommendations and research needs based on our review of the literature given current social and political limitations.

TEXAS PARKS AND WILDLIFE DEPARTMENT: Jerry L. Cooke

Generally speaking, I hate people who answer a question with a question, despite the fact that I do it to myself on a regular basis. In my opinion, predation can be both a problem and a symptom of a problem but seldom will it be both at the same time. The role of predation on a particular property will depend on the answer to 5 relatively simple questions, and these are the same 5 questions that I ask myself whenever I am considering any treatment on the landscape:

1. **Cause vs. Effect** – Am I treating a process acting on the system, or am I trying to correct the result of a process. *Example:* Reducing the fever caused by malaria without treating the malaria itself is a waste of resources.

2. **Weak Link** – Am I treating that aspect of the system that is holding back the energy capture rate of the remainder. If not resources can be better spent elsewhere. *Example:* When your deer are starving it makes no sense to talk about the importance of genetics in a management scenario.

3. **Whole System Response** – When you treat any part of a system, the whole system responds. If the reaction of the system produces problems worse than the one that you were correcting, you probably shouldn't do it. *Extreme Example:* You can absolutely solve the fire-ant problem by using inter-locking nuclear-thermal devices, but there are system consequences to that treatment.

4. **Margin Dollar Response** – Good management makes money, poor management costs money (that's my definition and a useful one for most ranchers). If the return from a treatment is poorer than the return would have been from some other investment, then the treatment was a poor investment. *Supply your own example here.* If you think a minute I'm sure several will come to you…

5. **Social/Cultural implications of my treatment** - How will my treatment be perceived by those who observe it, or those who are expected to apply it? *Example:* It doesn't matter how logical, economical, or scientific my argument may be; I will not be able to convince The Navaho Nation to sell their sheep and raise chickens!

Hosts:

Chihuahuan Desert Resource and Development Area

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