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Diet Reconstruction of Wild Rio-Grande Turkey of Central Utah Using Stable Isotope Analysis

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ABSTRACT

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The wild turkey is endemic to North America and has played a role in human cultures past and present. However, with the turkey's elusive behavior some aspects of its ecology are challenging to understand. Diet is one of these difficult aspects to study. The purpose of this study was to determine the diet selection of wild turkeys in central Utah using non invasive stable isotope technology. We hypothesize that turkey diet is highly specific, that consumption of specific plant species correlates with the needs of the individual turkey, and that stable isotope analysis will reveal patterns in annual dietary intake. Vegetative forage, turkey feces, and feather samples were collected from the Salt Creek area east of Mt. Nebo during 2007 and 2008. Feces samples were identified to bird sex and forage samples were identified to family or growth form (grass, forb, and shrub) when species could not be determined. Carbon isotope analysis of turkey feces and dietary forage using a mass spectrometer revealed that composition of turkey diet changed seasonally and yearly. Isotope analysis of dietary forage according to vegetative growth form revealed that turkey diet for the spring of 2007 contained approximately 46.0% grasses, 30.0% forbs, and 24.0% shrubs and trees. The summer diet for 2007 consisted of 39.0% grasses, 31.0% forbs, and 30.0% shrubs and trees. During spring 2008, grasses comprised 10.3% of the diet whereas forbs and tree/shrubs constituted 53.0% and 36.7%, respectively. Turkey summer diet for 2008 was found to consist of 13.1% grasses, 48.5% forbs, and 38.4% shrubs/trees. Isotope analysis of turkey feathers revealed no significant patterns in isotope signatures in relation to vegetation type and season of year. Stable isotope signatures resulting from fecal analysis reflect opportunistic foraging behavior as birds utilized a wide variety of forages throughout the year. Our findings suggest habitat structure and type play a more major role in wild turkey survival then food type. These findings also strengthen the need to rigorously evaluate turkey habitat prior to reintroduction with respect to vegetative composition and structure and their relationship with wild turkey behavior and life processes.

Keywords: diet, Rio Grande, stable isotopes, Utah, wild turkey

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LITERATURE REVIEW

Wild Turkeys and North America Human Societies

The wild turkey has played a major role in the history of North America. With five known distinct subspecies, Eastern (*Meleagris gallopavo silvestris*), Merriam's (*M.g. merriami*), Rio Grande (*M.g. intermedia*), Florida (*M.g. osceola*), and Gould's (*M.g. mexicana*), the wild turkey occupied habitats reaching from the Northeast to the Southwest (Flake et al., 2006). Native Americans such as the Navajos in the Southwest, the Tonkawas of Texas, and the Pontonatemicks of the Lake Superior region used the wild turkey as a source of food and as a materials source to make cloths, tools, awls, and spoons (Kennamer et al., 1992; Wright, 1915). The Cheyenne were called the "striped-arrow people" because they used the barred-wing feathers from the wild turkey to feather their arrows (Kennamer et al., 1992).

With the arrival of European adventurers and settlers in North America the future of the wild turkey was forever altered. This New World bird was taken to the Old World by the Spanish conquerors in the early 1500's (Kennamer et al., 1992). With the aid of merchants such as the Jewish poultry merchants (who gave this new bird the name "tukki", which means peacock in Hebrew) the turkey was established across Europe by 1541 (Kennamer et al., 1992). Interestingly the establishment of domesticated turkeys as we know it today in the Americas was not obtained from the wild stock living in North America, rather by the relocation of European domestic varieties beginning at Jamestown Virginia, in 1607 (Kennamer et al., 1992).

Expansion of European settlers across North America signaled the decline of the wild turkey from many of its historically populous regions in North America. Wild turkey habitats found in South Dakota to New York, and from Florida to Texas experienced population declines due to over harvesting and habitat loss (Kennamer et al., 1992). By 1920, the wild turkey was extirpated from 18 of the original 39 states of its ancestral range, as well as from its ancestral range found in the Canadian province of Ontario (Mosby and Handley, 1943). Total populations reached their lowest range wide numbers in the late 1930's (Mosby, 1975).

The historic occurrence of wild turkey in the Intermountain West and throughout the western United States is not well documented. Native American records exist but are not conclusive as to wild turkey abundance and distribution. Evidence from explorers, trappers, and traders of the region shed some light on the existence of wild turkey in this part of the country. In 1833, Maximilian, Prince of Wied, records that turkeys were shot 1730 km (1075 mi) from the mouth of the Missouri river, but adds that turkeys were seen intermittently even farther up the Missouri river system, even on the Yellowstone River (Wright, 1915). During his trip to Oregon in 1833, Nathaniel Wyeth shot a wild turkey on the 25th of September just west of Black Snake Hills and Rubideau Fort, near what is present day St. Joseph Missouri (Wright, 1915).

Like many western States the history of the wild turkey in Utah is largely unknown. When Europeans entered northern and north-central Utah, the wild turkey was not reported (Utah Wild Turkey Harvest Management Strategy, 2001). However, archeological evidence such as pictographs, petroglyphs, turkey feather blankets, and turkey bones document that turkeys (the Merriam's subspecies) were present in the southern part of the state and were used by Native cultures of the area (Utah Wild Turkey Harvest Management, 2001). Evidence provided from the

Great Basin region of central Oregon suggests that wild turkey may have been located or transplanted by native peoples to many areas of the west, including Utah (Hilderbrant, 2008).

Turkey Morphology and Life History

Wild turkeys are gallinaceous birds with many unique morphological and life history traits (Pelham and Dickson, 1992). Strong feet and legs allow turkeys to unearth forage which, in turn, is obtained with their short, stout beaks (Pelham and Dickson, 1992). Turkeys also have short, rounded wings and a well developed tail that limits flight to less than 1.6 km (1 mi) with considerable gliding (Flake et al., 2006). Musculature, wing structure, and shape prevent turkeys from maintaining continues flight for a substantial period of time. Repeated wing beats rarely last for more than 200 meters (210 yards) (Pelham and Dickson, 1992). When repeatedly flushed in quick succession, wild turkeys can be physically exerted to the point of death (Flake et al., 2006). Therefore, rather than flying, wild turkeys generally escape danger by running (Flake et al., 2006).

Wild turkeys have excellent eyesight. With the eyes positioned laterally a turkey has what is known as monocular periscopic vision (Pelham and Dickson, 1992). Head turning and tilting enables turkeys to determine relative distances. Tilting also provides a 360˚ field of vision (Pelham and Dickson, 1992).

Feather coloration in wild turkeys is generally dark intermixed with light iridescence and barring on the primaries and secondaries of the wing and tail feathers. Wing feathers have white and black barring while the tail feathers have black and brown barring. Feather coloration and shape is key to determining subspecies, estimating age, and determining gender (Flake et al., 2006). The five subspecies of wild turkeys can be quickly identified by tail feather coloration. For instance, the Merriam's subspecies have light buff to white color in the tips of the tail coverts and tail feathers, the Rio Grande have a light buff color, and the Eastern are dark brown in these same feather tracts (Pelham and Dickson, 1992). Feather coloration aids in turkey sex identification. Male turkeys generally have breast, belly, side, and upper back feathers that are black-tipped giving males an overall darker coloration than females. Alternately, female turkeys generally have breast, belly, sides, and upper back feathers which are pinkish white to buff, giving the female a lighter coloration. These same feather tracts also help distinguish between subspecies. Contour feathers of the female Merriam's turkey have pinkish white to buff tips, Rio Grande females have buff to cinnamon, and Eastern females have brown to reddish brown tips (Flake et al., 2006).

Adult male turkeys are called toms and adult females hens. Besides differences in coloration other physical differences can be used to identify sex of wild turkeys. These differences generally include the presence of a beard, spurs, and the lack of feathers on the head and neck. Although female turkeys often have a more feathered head and neck, in some instances they can possess a beard. According to Flake et al. (2006), 19% of adult hens in the Black Hills have beards.

Behavior also differs among gender in wild turkeys. Sexually mature male turkeys strut, tail fan, gobble, and drum during the breeding season. Mature female turkeys will occasionally strut and fan the tail (Schleidt, 1970; Lehman et al., 2003). When identifying the sex of wild turkeys in the field it is important for the observer to rely on a suite of established behavioral and morphological differences and not depend on one particular trait.

The breeding season for wild turkeys begins as daylight increases in March. This correlates with an increase in daily mean temperatures. Unseasonably cold weather can postpone the initiation of courtship and breeding. Latitudinal control of breeding onset has been documented (Healy, 1992). For example, breeding begins in February in Texas but not until April in the more northern, colder portions of their range.

The initiation of nest building by wild turkey hens is influenced by latitude, altitude, and weather (Flake and Day, 1996; Shields, 2001). Additionally, nest initiation also varies with female body condition (Flake et al., 2006). Once nest initiation occurs, a hen will lay an egg daily, occasionally skipping a day (Flake et al., 2006). Egg laying will last from 10-15 days and results in hens laying an average of 9-12 eggs (Flake et al., 2006). Once the last egg has been laid, or the day after, a 28 day incubation period begins (Flake et al., 2006; Williams et al., 1974).

During incubation hens do not constantly sit on the eggs, but rather leave nests for short periods. On average, these absences occur every 1.9 days during which time hens may be gone for a few minutes or up to a few hours (Hillestad and Speake, 1970; Williams et al., 1974). Reasons for leaving nests include defecation, feeding, and drinking (Healy, 1992). Hens often lie motionless when approached, relying on camouflage to keep from being detected. However, hens will abandon nests if threatened, and if the nest has been depredated they often construct a new one (Keegen and Crawford, 1993). Hens continue nesting activity past five years of age (Schorger, 1966). The average life span of a wild turkey is said to be around six or seven years with some reports of birds living up to ten to twelve years (Schorger, 1966).

Social Behavior

Turkeys are social birds that primarily communicate vocally. It has been found that turkeys communicate with up to 28 unique calls. Each call has a specific meaning such as warning, gathering, and contentment, but variations in delivery allow transmission of complex messages (Flake et al., 2006; Healy, 1992). The most widely recognized call by humans is the gobble produced by males.

Vocal communication is essential for survival and begins early in life. As chicks begin the hatching process they perform a clicking vocalization within the egg. In response the hen replies with soft clucking (Healy, 1992). This communication works to synchronize the hatching process, and to allow chicks to imprint on their mothers (Hess, 1972). Poults raised in captivity and subsequently imprinted on humans were able to distinguish the voice of their human "hen" from that of other humans (Healy, 1992). However, this process does not work in reverse as hens do not imprint on their chicks as it has been observed that domestic hens respond with equal intensity to the calls of poults in other broods (Kimmel, 1983).

The ability to vocally communicate allows turkeys to form interactive social groups which are age and sex dependent (Williams, 1984). During late fall and winter, wild turkeys commonly form two distinct groups comprised of juvenile, yearling, and adult hens in one and males in the other (Williams, 1984; Flake et al., 1996). Group identity breaks down in winter as large flocks form near winter food sources (Flake et al., 2006). In spring, smaller sexually segregated social groups are reformed (Flake et al., 2006). During the breeding season, flock structure becomes transient with dominant males doing most of the breeding (Flake et al., 2006). Once breeding is completed, females disperse on an individual basis to nest. After nesting and hatching is completed, brood groups form consisting of 2 or more females and their young of the year (Healy, 1992). During the breeding season small groups of jakes (year old males) usually avoid the mixed female and dominant male flocks and often remain together throughout the breeding season and summer (Flake et al., 2006).

Diet

Wild turkeys eat high-energy foods and digest it rapidly and efficiently (Pelham and Dickson, 1992). One can gain insight regarding turkey diet by studying gizzard and crop content but these studies are seasonally biased. Wild turkeys are elusive, thus making direct observation of food consumption a challenge. Consequently, accurate studies of the annual diets are lacking and comprehensive studies of turkey diet using current technologies are sparse.

Turkeys are classified as omnivorous birds (Hurst, 1992). The timing of feeding fluctuates seasonally but generally occurs during the morning and late afternoon with a rest period in the middle of the day. However, feeding can occur at any time (Schorger, 1966). Young birds, on the other hand, are found feeding almost constantly except for a midday inactive period (Hurst, 1992). Typically feeding involves scratching and pecking to access food sources beneath organic debris. Some foods are obtained from the branches of bushes and trees such as berries and nuts (Hurst, 1992). Turkeys have been observed wading into water to obtain plant and animal matter (Hurst, 1992). During times of deep snow turkeys have been found to follow deer paths and feed where deer have pawed the snow and exposed food items (Schorger, 1966).

The sense of taste is thought to be underdeveloped in wild turkeys. Compared to mammals, turkeys have fewer taste buds but are believed to be able to detect the presence of simple tastes known as salt, sweet, acid, and bitter (Pelham and Dickson, 1992). It has been found that some birds exposed to corn soaked in tranquilizing drugs can select the corn that has not been treated if exposed again (Pelham and Dickson, 1992). Some report, however, that wild turkeys will select foods based on shape and color, not taste (Pelham and Dickson, 1992).

Most food consumption is a result of birds pecking and scratching as they walk. Consequently, feeding birds are seldom motionless (Hurst, 1992). The rate of feeding in wild turkeys varies. One study found a flock of birds consuming food while they covered ground at rates ranging from 327 m/hr to 3.218 km/hr (Mosby and Handley, 1943; Lewis, 1973).

Turkeys consume a variety of foods including nuts, seeds, fruits, flowers, and leaves of grasses, forbs, and shrubs (Flake et al., 2006). Turkeys also forage on animal and insect matter, including grasshoppers, beetles, spiders, lizards, snakes, and even crawfish (Schorger, 1966). In South Dakota, 10 of 31 wild turkey crops from both sexes contained animal bones and 5 contained snail shells (Beasom and Pattee, 1978). In another study it was found that of 146 turkey crops, 28.7 % of the content was grasshoppers and beetles (Litton, 1977).

The utilization of different food sources by wild turkeys is sometimes reported as being specific to the needs of the individual bird. For example, age is one attribute that has been found to influence turkey diet. The diet of poults' (name given to birds from the time of hatch to 12 weeks post-hatch) relies heavily on insect consumption to satisfy a 28% dietary protein requirement needed for muscle and feather development (Flake et al., 2006; National Research Council, 1977; Robbins, 1983). Merriam's turkey poults, in the Black Hills of South Dakota, were found to consume 81.4% invertebrate matter at 0–3 weeks old, 76.5% at 4–7 weeks old, and 61.1% at 8–12 weeks old (Rumble and Anderson, 1996b). The decrease found in insect consumption shows that the percentage of the diet in insects declines each successive week (Hurst, 1992). At the 8th week, (8th week of growth signals the completion of feather development), protein requirements of poults decrease and energy requirements increase (National Research Council, 1977). Juvenile (name given to turkeys from the 12 week period to the second breeding season) and adult (turkeys two years and older) diets are very similar as both will consume a variety of food sources (Flake et al., 2006). However, differing from poult diets, juveniles and adults consume a majority of plant matter with insect and animal matter comprising only a small portion of the diet (Hurst, 1992). Hens that are in the process of egg laying consume more snails than pre or post laying hens, correlating with the hens increasing calcium requirements to produce the egg shells . In Rio-Grande hens, hens that are in the process of laying eggs consumed 9 times more snails then pre-laying and post-laying hens (Beasom and Patee, 1978). In one study snails were found to make up more than 50% of the laying hens diet (Beasom and Patee, 1978).

Time of year also influences turkey diet. Juvenile and adult diets are largely comprised of plant material but as seasons change this changes too. Just prior to breeding, hens increase their consumption of insects and other high protein food sources such as new green vegetative growth (Rumble and Anderson, 1996a; Robbins, 1983). This is believed to allow the hen to meet the energetic demands of egg production. From early summer to late August arthropod consumption increases (Rumble and Anderson, 1996a).

Wild turkeys take foods that are available, palatable, and capable of supplying the physiological needs of the bird (Korschgen, 1967). While selection of the most productive food may not be a conscious decision of wild turkeys, returning to specific sites with seasonally available foods is. For example in Arizona, Merriam's turkeys returned to sites where baiting had occurred the previous winter (Shaw, 2004). This also occurred with the Rio Grande subspecies in Utah. In preparation for winter, some turkeys travel up to 45 miles to areas where winter foods are known to be found (Flake et al., 2006).

Turkey behavior is important in understanding turkey diet. Dietary behavior is directly correlated with gender (physiological needs) and the habitat in which the bird is located. Female and male turkey diet may vary as a result of preferred habitat types. Diets of hens and poults contain more insects than those of toms as they select areas with good vegetative cover and thus more insects (Rumble and Anderson, 1996a). Such areas include forest and meadow edges (Rumble and Anderson, 1996b).

Water requirement by wild turkeys varies temporally. Studies have suggested that available water is important during the winter months (Kilpatrick et al., 1988). However, during other times of the year, turkeys can meet their water requirements from available food sources (Hurst, 1992). It has also been suggested that water availability may be a factor in the selection of roost, and nest sites (Kilpatrick et al., 1988). Hens have been observed nesting near open water. This suggests that their dependency on water varies with the availability, type, or quality of food. Therefore, the seasonal use, or dependency, on open water sources may be the result of the seasonally fluctuating water content of food sources.

Digestion

Wild turkeys have a digestive system that is comparable to other gallinaceous birds. Consumed food will pass through nine different organs, including; the mouth, esophagus, crop, proventriculus, gizzard, small intestine, ceca, large intestine, and the cloaca (Blankenship, 1992). In one study, food passage in young egg laying hens took 2 hours and 27 minutes (Hillerman et al., 1953). Digestion begins as forage enters the birds mouth. To swallow, a turkey must raise its head and extend the neck relying on negative pressure to force the item downward (Blankenship, 1992). The continued movement of food throughout the rest of the digestive system relies on organ motility (spontaneous motion of organs) (Blankenship, 1992).

The crop functions as a storage chamber, expanding to accommodate large amounts of food (Figure 1). Large gobblers are known to have crops that are capable of holding up to a pound of food (0.45 kg), within as much as 23.6 cubic inches of volume (Schemnitz, 1956; Mosby and Handley, 1943). The crop is not only a storage area but also initiates digestion through bacterial activity (Blount, 1947). Leaving the crop, food enters the proventriculus where gastric digestion is initiated by the secretion of pepsin. Food then enters the gizzard, where a low pH (2 to 3.5) and grinding action continue to break the food down (Blankenship, 1992). The grinding action of turkey gizzards is known to flatten lead cubes and crush glass balls to powder (Schorger, 1966). The presence of hard objects such as rocks in the gizzard of wild turkeys is vital to digestion especially of hard mast (Schorger, 1966).

After the food passes the gizzard it enters the small intestine where enzymes and fermentation aid digestion. These actions are continued as food enters the ceca where microbial activity facilitates crude fiber digestion. Moving from the ceca, food enters the large intestine where little or no digestion takes place but where some water is absorbed. In the cloaca additional water absorption occurs before residual food waste is combined with urinary waste (Blankenship, 1992). The combined feces and urea waste are excreted from the body in distinct shapes which can be differentiated by sex (Bailey, 1956). Fecal droppings of males are generally dropped in an L or J shape, while female droppings are generally in a curl or a clump (Flake et al., 2006). Male fecal droppings are also longer and larger in diameter than those of hens (Flake et al., 2006).

Figure 1: Winter crop content of wild turkey hen

Research on dietary requirements and metabolism is needed. Winter months are often used to help determine baseline requirements of turkeys. During winter months with an average daily temperature of 0˚C (32˚F), turkeys are required to consume about 0.26 lbs/day (0.118 kg) of food to maintain body status at healthy levels (Haroldson et al., 1998). With every 10˚C (50˚F) drop in air temperature below 10.9˚C (51.6˚F), a turkey needs to increase its consumption of food by 20 grams (Haroldson et al., 1998).

Distribution

There are 5 distinct subspecies of wild turkeys distributed throughout North America. The Eastern (*M.g. silvestris*), the Florida (*M.g. osceola*), the Merriam's (*M.g. merriami*), the Rio Grande (*M.g. intermedia*) and the Gould's subspecies (*M.g. Mexicana*) (Kennamer et al., 1992). The eastern subspecies occurred originally in the eastern half of the United States and was named by L.J.P Viellot in 1817 (Kennamer et al., 1992). The use of the word *silvestris* is given to the eastern wild turkey because of its tendency to occupy wooded habitat (Flake et al., 2006).

The Florida subspecies was originally found in the southern half of the state. The Osceola name was given to the Florida wild turkey by W.E.D. Scott in 1890 in honor of the Seminole chief Osceola. The Merriam's subspecies was originally found in the mountainous regions of the western United States and was named by Dr. E.W. Nelson in 1900 to honor C. Hart Merriam, the first chief of the U.S. Biological Survey (Kennamer et al., 1992).

The Rio Grande subspecies was originally found in the south-central plains states and northeastern Mexico. It was named by George B. Sennett in 1897 and was given the name *intermedia* because of what George B. Sennett called, "the bird possessing a difference from the other wild turkeys by being intermediate" (Kennamer et al., 1992). The fifth wild turkey subspecies, the Gould's, was originally found in northwestern Mexico and parts of southern Arizona and New Mexico. The bird was named by J. Gould in 1856 (Kennamer et al., 1992).

As previously noted, wild turkeys have not been determined to be native to northern Utah. Since the 1980's birds have been released by state officials in hopes of establishing viable populations (Dennis Southerland, personal communication, January 12, 2008). Over the years Utah has seen the introduction of three subspecies of wild turkey including the Eastern (*Meleagris gallopavo silvestris*), the Merriam's (*M. g. merriami*), and the Rio-Grande (*M. g. intermedia*). It has been shown that the Rio-Grande subspecies displays a higher reproductive capacity and survival rate after translocations when compared with other subspecies (Keegan and Crawford, 1999). This fact has promoted the use of the Rio-Grande subspecies in many of the transplants occurring in Utah, resulting in Rio-Grande birds making up a majority of the states turkey population.

Currently Utah is listed has having two of the five subspecies of wild turkey, the Merriam's, and the Rio Grande. The introduction of wild turkey into Utah began back in the 1920's with the release of the Eastern subspecies (Utah wild turkey harvest statistics, 2000). These attempts to establish viable wild turkey populations were initiated using Eastern turkeys obtained from farm-raised stock, but were unsuccessful. The reason for failure is due to the many biological factors which cause a domestic raised bird to be incompatible with a wild environment. From a 1979 survey of 36 states it was found that the transplantion of 30,000 wild birds into 968 different locations resulted in 808 successful turkey populations (Bailey and Putnam, 1979). In contrast, the same survey found that by releasing 330,000 farm-raised birds into 800 different locations resulted in 40 successful turkey populations (Bailey and Putnam, 1979).

The biologically unsound management action of releasing farm raised birds into the wild persisted until the 1950's when the use of wild birds became the focus. For Utah this began by using wild turkeys trapped from source populations in Colorado and Arizona (Utah wild turkey harvest statistics, 2000). The Merriam's subspecies was used in these transplanting efforts and resulted in the establishment of flocks in Grand, Garfield, Kane, Iron, and Washington Counties (Utah wild turkey harvest statistics, 2000).

The 1980's marked a concerted effort by the Utah Division of Wildlife to increase turkey population and distribution throughout the state. A major management difference in the 1980's was the effort to use the Rio Grande subspecies in most, if not all, trapping and transplanting operations. Some Merriam's were used, but to keep with the available habitat and successful transplanting rate of Rio Grande birds, focus was given to the Rio Grande. Source populations for birds transplanted into Utah included Colorado, Kansas, Oklahoma, South Dakota, Texas, and Wyoming (Utah wild turkey harvest statistics, 2000). Today many wild turkey populations within the state have become successful and productive to the point of being used as source populations for trapping and transplanting.

Utah Population Dynamics

Currently, the total population of wild turkey in the state of Utah is estimated at approximately 30,000 birds (Personal communication with Dennis Southerland, Regional Biologist Central division, 2008), a conservative estimate according to state officials. As of 2001, the state of Utah established three goals dealing with wild turkey management. These goals were; 1) establish wild turkey populations in all suitable habitats throughout Utah, 2) minimize wild turkey impacts to agricultural interests, native vegetation and native wildlife, and 3) increase wild turkey hunting and viewing opportunities (Utah wild turkey harvest statistics, 2000).

Each of the three goals have specific objectives to facilitate accomplishment. To achieve the first goal, the first objective was to increase wild turkey populations by at least 10 per year through 2005. The second objective was to increase viability of at least three existing turkey populations per year through 2005. To establish the second goal the objectives of the state of Utah were to prevent conflicts between wild turkeys and agricultural interests through 2005, and prevent wild turkey impacts to native vegetation and native wildlife species. To achieve the last goal the Division of Wildlife for the state of Utah had objectives to; increase hunting opportunity for Rio Grande turkeys by 320 percent by 2005, maintain hunting opportunity for Merriam's turkey's through 2005, and increase public awareness and viewing opportunity for wild turkeys (Utah wild turkey harvest statistics, 2000).

Utah has many acres of land that could be used to support wild turkey populations. According to a Utah Geographic Approach to Planning Analysis performed in 1997, Utah has about 13,500 square miles of unoccupied turkey habitat. A majority of this potential habitat has been determined to be more suited for the Rio Grande subspecies (Utah wild turkey harvest management strategy, 2001). In 2001 the state of Utah designated 154 possible transplant sites for the Rio Grande, and a total of 12 possible transplant sites for the Merriam's (Utah wild turkey harvest management strategy, 2001).

Stable Isotopes

An isotope is an atom of a common element with the same number of protons and electrons but differing numbers of neutrons than the common form (Sulzman, 2007). Carbon (C), for example, normally has an atomic mass of 12. The most common isotope of carbon is C^{13} which has an additional neutron and thus an atomic mass of 13 (Sulzman, 2007). There are about

300 stable isotopes (Hoefs, 1997). Isotopes occur naturally, and organisms will sequester them in their tissues through the carrying out of natural life functions. For example, C is brought in to plants as CO_2, diffusing from the atmosphere into the plant through differing photosynthetic pathways (Marshall et al., 2007). Nitrogen (N) will come into the plant through detritus sources. As the isotope and natural element are brought in to the organism they are stored in particular ratios to one another. Using isotope ratio mass spectrometry (IRMS) the ratio of isotopes for a given element can be determined by separating the charged atoms on the basis of their mass-to-charge-ratio (Sulzman, 2007).

Different plant types, according to differing photosynthetic pathways, will have a unique isotope signature (Smith and Epstein, 1971). As animals consume these plant types the isotope signature of the plant will be stored in the fluids and tissues of the animal. These isotope signatures and ratios found with the application of isotope ratio mass spectrometry can allow relative diet and migratory patterns of animals to be determined (Hobson, 2007).

CONCLUSION

As an endemic species to North America the wild turkey has proved to be a dependable source for not only food and materials but for aesthetic and sport enjoyment. Many people and groups living in areas where turkeys exist, and or existed, have depended on them for hundreds, if not thousands, of years. However, with expanding human populations and habitat loss turkey biologists and wildlife managers are working to maintain existing habitat and to introduce populations of wild turkey into new areas. The wild turkey because of its strong physical characteristics and behavioral adaptations has proven to benefit from these management actions. To more fully benefit from such actions managers will need to continue to adapt and utilize new technologies and techniques. The use of technologies such as stable isotope analysis will allow managers and biologists to strengthen current knowledge and to address issues associated with wild turkey introductions.

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Diet Reconstruction of Wild Rio-Grande Turkey of Central Utah Using Stable Isotope Analysis

Abstract

The wild turkey is endemic to North America and has played a role in human cultures past and present. However, with the turkey's elusive behavior some aspects of its ecology are challenging to understand. Diet is one of these difficult aspects to study. The purpose of this study was to determine the diet selection of wild turkeys in central Utah using non invasive stable isotope technology. We hypothesize that turkey diet is highly specific, that consumption of specific plant species correlates with the needs of the individual turkey, and that stable isotope analysis will reveal patterns in annual dietary intake. Vegetative forage, turkey feces, and feather samples were collected from the Salt Creek area east of Mt. Nebo during 2007 and 2008. Feces samples were identified to bird sex and forage samples were identified to family or growth form (grass, forb, and shrub) when species could not be determined. Carbon isotope analysis of turkey feces and dietary forage using a mass spectrometer revealed that composition of turkey diet changed seasonally and yearly. Isotope analysis of dietary forage according to vegetative growth form revealed that turkey diet for the spring of 2007 contained approximately 46.0% grasses, 30.0% forbs, and 24.0% shrubs and trees. The summer diet for 2007 consisted of 39.0% grasses, 31.0% forbs, and 30.0% shrubs and trees. During spring 2008, grasses comprised 10.3% of the diet whereas forbs and tree/shrubs constituted 53.0% and 36.7%, respectively. Turkey summer diet for 2008 was found to consist of 13.1% grasses, 48.5% forbs, and 38.4% shrubs/trees. Isotope analysis of turkey feathers revealed no significant patterns in isotope signatures in relation to vegetation type and season of year. Stable isotope signatures resulting from fecal analysis reflect opportunistic foraging behavior as birds utilized a wide variety of forages throughout the year. Our findings suggest habitat structure and type play a more major role in wild turkey survival then food type. These findings also strengthen the need to rigorously evaluate turkey habitat prior to reintroduction with respect to vegetative composition and structure and their relationship with wild turkey behavior and life processes.

Key words: Diet, Rio Grande, Stable isotopes, Utah, Wild turkey

Introduction

Wild turkeys are not native to northern Utah and much of the western US. Since the 1980's birds have been released in Utah by state officials in attempts to establish viable populations (Dennis Southerland, personal communication, January 12, 2008). Over the years Utah has seen the introduction of three of the five subspecies of wild turkey. These three subspecies include the Eastern (*Meleagris gallopavo silvestris*), the Merriam's (*M. g. merriami*), and the Rio-Grande (*M. g. intermedia*). It has been shown that the Rio-Grande subspecies displays a higher reproductive capacity and survival rate after translocations compared to other subspecies (Keegan and Crawford, 1999). This fact has promoted the predominate use of the Rio-Grande subspecies in transplants occurring in Utah, resulting in Rio-Grande birds making up a majority of the state's turkey population.

The growing demand for turkeys in Utah, for both aesthetic and sporting purposes, has helped promote the gradual expansion of turkey in the northern regions of the state. However, turkey establishment has come with limited documentation as to the abiotic and biotic requirements and impacts turkeys have on their specific Utah habitats. Existing management strategies in Utah have been based mainly on documentations and studies performed in other states. These studies provide valuable information, but they often represent ecological and environmental conditions that are significantly different than those in Utah.

Diet is one important attribute of Utah turkey ecology that is poorly understood because of the turkey's elusive nature. Classified as omnivorous, wild turkeys have been documented eating a variety of foods ranging from seeds, fruits, grasses, insects, to some small vertebrates (Flake et al., 2006). The ability to consume a variety of foods may be misleading as wild turkeys have also been documented as being highly selective in utilizing the highest energy containing foods (Flake et al., 2006). One emerging technique for elucidating dietary intake of wild turkeys is the use of forage stable isotope signature and the subsequent signature of feces.

Stable isotope techniques use the natural ratios between isotopes of an element to establish a distinct signature for each plant type. For forage analysis the isotopes of carbon (C) and nitrogen (N) are most often used. This technique has been utilized to analyze, compare, and distinguish between the forage preference and selection of differing herbivores (Cerling et al., 1999). Stable isotopes aid in distinguishing between the consumers of C3 and C4 plants because of the differing photosynthetic pathways and differing carbon isotope storage methods in each type of plant (Smith and Epstein, 1971). The advantage of stable isotope technology is that it is a non-invasive approach to reconstructing the dietary habits of wild animals, alleviating the need to sacrifice the animal to obtain stomach content. Wild turkeys are easily disturbed by research activities, hence invasive techniques can alter turkey behavior and thus study results.

The purpose of this study was to determine wild turkey diet for season and year using non invasive stable isotope technology. This is the first time stable isotopes have been used to analyze turkey diet. No scientific literature exists regarding the use of stable isotopes for wild turkey diets. It is hypothesized that turkey diet is specific in its purpose, that foraging behavior correlates with the needs of the individual turkey and stable isotope analysis can reveal patterns in turkey annual diet.

MATERIALS AND METHODS

Study Location

The study was performed in Salt Creek canyon, located on the east side of Mt. Nebo (UTM 437726 E, 4397067 N, Zone 12). The Salt Creek population was selected because of its relative isolation from human influences. Our intent was to collect samples from turkey populations that do not utilize human food sources, thus allowing a study of “natural” turkey diet.

The Salt Creek area is located in the Uinta National Forest. With a steep elevation gradient ranging from 5,800 to 12,000 feet (1768 to 3658 m), the area has a mixture of habitat types including river and stream bottoms, sage-brush steppe, scrub oak, and high mountain aspen. Each habitat type has an understory dominant with native perennial and annual grasses and forbs as well as native shrubs. Annual precipitation is over 15 inches (38 cm) with most precipitation coming in the form of snow. Several wildlife species occur in this area, sharing similar forage species with turkeys such as elk (*Cervus elaphis*), mule deer (*Odocoileus hemionus*), and blue grouse (*Dendragapus obscurus*). Potential predators of wild turkeys include the bobcat (*Lynx rufus*), mountain lion (*Felis concolor*), fox (*Urocyon cinereoargenteus*), coyote (*Canis latrans*), great horned owl (*Bubo virginianus*), and golden eagle (*Aquila chrysaetos*).

Field Methods

Turkeys were bait trapped at the Salt Creek site during the winters of 2006 and 2007. Under the direction of the Utah State Department of Natural Resources Wildlife division (UDWR), birds were trapped using baited box live traps (Figure 2). Once trapped, the birds were transferred to cardboard holding boxes, specifically designed to hold an individual wild turkey for transport and safe release. Sex, age, weight and metatarsus, tarsus, and wing lengths were measured on each bird. Select hens were then fitted with radio backpacks or necklace style radio telemetry transmitters (Telonics, Model TMU-080; Mesa, AZ) prior to release. The decision to place radio telemetry units on hens was made so that additional information regarding nesting behavior and success could be obtained. Forty birds were fitted with radio collars from the Salt Creek flock.

Figure 2: Baited box traps used to capture wild turkey during winter months.

Monitoring consisted of monthly observations from September to the end of April and then daily observations from May to August. Daily monitoring was carried out to determine nesting initiation and brood rearing behavior. In the field, hen locations were determined by using triangulation with radio telemetry and nest site locations were recorded with the use of a hand held GPS unit (Vangilder et al., 1987).

When hens were stationary for three consecutive days, the site was documented as a potential nest location and the date of incubation initiation was recorded. Daily monitoring of the nest continued until the hens radio signal was found to not emit from the established nest area (Ransom et al., 1987). This signaled that a hatch had occurred, allowing the date of hatch to be recorded and additional measurements performed. Measurements recorded included counting the number of hatched and non-hatched eggs in the brood to determine hatching rates, and documenting nesting habitat data. Nest habitat data included measuring both horizontal and vertical vegetative cover, and types, as well as determining nest site aspect and slope

Horizontal vegetation cover was determined by using a one meter square portable cover board. This board was divided into 36 equal squares. To measure the visual obstruction around the nest sites observers would place the cover board in each of four compass directions at 3 different distances from the center of the nest. Distances used were 1.5, 5, and 10 meters, respectively. Measurements of horizontal (lateral) cover were obtained for each distance and in each compass direction by counting the number of squares obstructed from view at the predicted hen eye-level.

Daily monitoring and location of turkeys also improved the collection of fresh forage, feces, and feathers; however emphasis was given to collect fresh feces. Gender was determined from fecal deposits by shape. In April, when daily monitoring began, all feces found were collected to clear trails. This allowed for feces found concurrently on the same trail to be labeled as fresh.

When turkeys were seen actively foraging, or when a high concentration of feces was found in an area, all potential forage species samples were collected. Forage samples consisted of representative samples of every plant species within a 50 meter radius of collected feces or visually located turkeys.

Tail and primary feathers were collected when available or when found. During winter, feathers were collected from birds when they were trapped and fitted with radio transmitters. During spring and summer, feathers were collected when found on the trail. Primary and tail feathers were also collected from dead birds when located.

Lab Methods

Feces and forage samples were dried for 24 hours at 60°C (Flinders and Hansen 1972). Plants were identified to species when possible and to growth form when species was inconclusive. Growth form categories included grasses, forbs, and shrubs/trees. Plant and fecal samples were ground using a 0.425 mm mill (Wiley Minimill, Thomas Scientific, Swedesboro, NJ.) to produce a fine homologous sample.

Individual feather samples were sectioned at five centimeter intervals from base to the tip. A small sample was cut from the vain using a razor blade and placed in an eppendorf tube. A 2:1 chloroform/methanol solution was added to the small feather sample and the tube containing the feather and solution was placed into an ultrasonic water bath for 30 minutes, and then allowed to sit for 24 hours. Liquid was then removed and a 1:2 chloroform/methanol solution was added to the eppendorf and the tubes were then again placed in the ultrasonic water bath for 30 minutes. Upon completion, tubes were then again allowed to sit for another 24 hours. The 1:2 chloroform/methanol solution was then removed and five washes with HPLC water assured complete rinsing of chloroform and methanol. After rinsing, HPLC water was removed and the remaining water was extracted by spin vacuum over night. Feathers were then prepared for weighing by cutting the feathers in to small particles.

A microgram balance (Sartorius, Data Weighing Systems, Elk Grove, IL) was used to weigh sub-samples consisting of 600-700µg for all plants, 1700-2000µg for all feces, and 100-250µg for all processed feathers (Podlesak et al., 2005). Sub-samples were combusted using a Costech (ECS 4010, Cornusco MI Italy) elemental analyzer then passed through a Continuous Flow Isotope Ratio Mass Spectrometry system (Delta-V, Thermo Fisher Scientific Inc., Waltham, MA) to determine carbon and nitrogen isotope levels.

Feces and forage results were analyzed using the IsoSource (Phillips et al., 2005) computer model to estimate the percentage of each forage type found in the fecal samples. Before using the IsoSource computer model to analyze Salt Creek turkey diet patterns, we grouped forage samples according to family. Once IsoSource modeling had been completed plant species were further grouped according to growth form (grasses, forbs, and shrubs/trees). The use of the IsoSource computer mixing model takes into account all possible source contributions to isotopic signatures and produces a narrower source population from which analysis of turkey diet can be made (Phillips et al., 2005).

RESULTS

The Salt Creek flock yielded many forage, feces, and feathers samples. We observed that the Salt Creek flock used trails and roads to move around in their home range. The seasonal home ranges for the Salt Creek flock are presented in Figure 3. Summer habitat use was widespread with birds utilizing many of the available habitat types from sagebrush steppe to mountain aspen. Winter home range was confined to areas at lower elevations.

During the summer of 2007 a wild fire burned the winter range and a large portion of the summer range (see figure 3). The 2007 Salt Creek fire was an intense fire that consumed all understory vegetation and killed most of shrubs and trees located in wild turkey winter habitat. We observed turkeys using this winter habitat in 2008 for both roosting and feeding behavior. In late fall and early winter birds were often seen eating new grasses and forbs growing in areas cleared by fire (Figure 4).

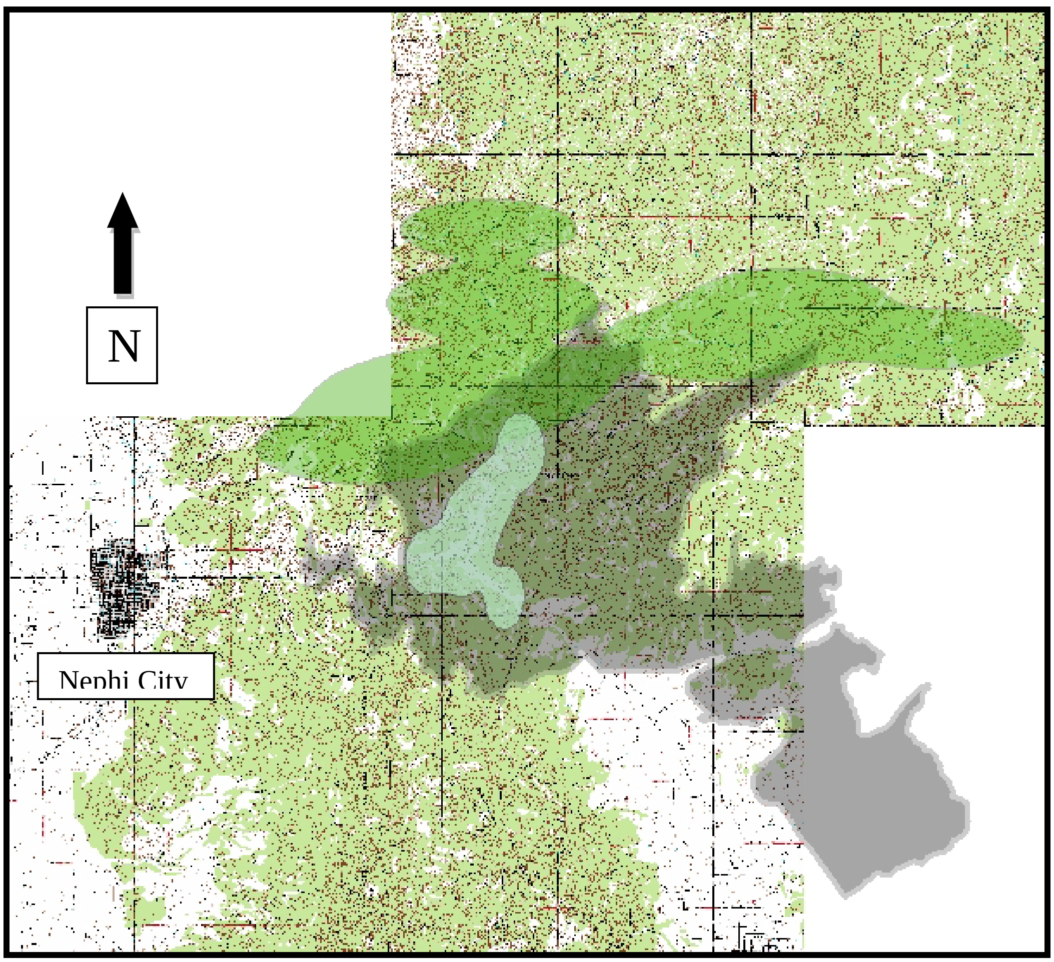


Figure 3: GIS construction of wild turkey seasonal home range for the Salt Creek Flock. Green area indicates summer habitat use, blue indicates winter habitat use. Gray area represents area burnt by the 2007 fire. The fire burnt a total area of 25,465 acres.

Figure 4: Turkeys eating vegetative regrowth after 2007 fire.

For the 2007 and 2008 nesting seasons 17 nests were found and documented (Table 1). UTM locations for visual contact and nest location were recorded and included when creating seasonal home range (Figure 3). Average nest initiation date was May 5th; hatch date was June 1st. Clutch size laid was 9.5 eggs, with 5.9 hatching. On average all nest were found to be located in areas with at least 93% total horizontal cover one meter above the ground (Table 2). In addition roost site location for these same years resulted in only a handful of documented sites. In general both nests and roost sites were located in areas with dens vegetation both horizontally and vertically. Nests were most often found in oak or maple woodlands with steep slopes. Roost sits were found in mature trees.

Table 1: Nest documentation and measurement

Bird Flock	Approximate Incubation Initiation Date	Approximate Date of Hatch (Within a day or two)	Clutch Size # Eggs	# Chicks Hatched	Slope in º	Aspect	Elevation (Feet)	Vertical Cover Index
Salt Cr	4/19/07	5/17/07	8	4	24.2	N	No data	50
Salt Cr	6/21/08	6/29/08	11	9	11.4	NE	7179	40
Salt Cr	6/9/08	7/7/08	11	11	16.2	N	6850	25
Salt Cr	6/9/08	7/7/08	9	6	12.4	S	7014	30
Salt Cr	6/2/08	6/30/08	10	6	6.8	NE	6740	25
Salt Cr	6/17/08	7/14/08	10	7	28.4	SW	6142	15
Salt Cr	6/10/08	7/7/08	8	6	16.7	NW	6850	40
Salt Cr	5/6/08	6/3/08	14	5	?	NNE	7196	15
Salt Cr	5/14/08	6/11/08	9	8	18.8	SW	7495	?
Salt Cr	6/2/08	6/30/08	8	0	25.6	NW	6410	20
Salt Cr	4/22/08	5/19/08	7	?	27.0	NW	6456	50
Salt Cr	6/24/08	7/22/08	9	6	11.3	SE	7103	20
Salt Cr	6/2/08	6/30/08	11	5	19.3	NE	7189	50
Salt Cr	6/2/08	6/30/08	8	5	25.6	NW	6830	15
Salt Cr	4/20/08	5/18/08	8	7	26.6	SE	6799	50
Salt Cr	5/6/08	6/3/08	10	10	6.8	NE	6740	25
Salt Cr	6/24/08	7/22/08	10	0	17.7	SW	7909	10
Ave	**5/5/2008**	**6/1/2008**	**9.5**	**5.9**	**18.4**		**6931.4**	**30**
St Dev			**1.7**	**3.0**	**7.3**		**427.6**	**13.5**

? = Values that were not obtainable. Vertical cover measured from Beaufort index.

Limited data before the 2007 fire makes it hard to determine if habitat use and home range during spring and summer was affected by the fire. For the 2008 nesting season two hens were found nesting in close relation to the fire line. One of these hens nested within the fires burn zone, but was unsuccessful in hatching. In general we observed both male and female groups avoiding spring and summer habitat affected by the fire.

Table 2: % Horizontal cover obtained with one meter cover board at nest sites.

Nest #	% Cover North	% Cover South	% Cover East	% Cover West	Total Average % Coverage	St Dev
1	100.0	87.0	100.0	85.2	**93.0**	**14.0**
2	100.0	76.0	98.1	98.1	**93.0**	**21.0**
3	100.0	100.0	100.0	100.0	**100.0**	**0.0**
4	100.0	100.0	100.0	100.0	**100.0**	**0.0**
5	100.0	100.0	100.0	100.0	**100.0**	**0.0**
6	100.0	100.0	100.0	100.0	**100.0**	**0.0**
7	100.0	100.0	100.0	100.0	**100.0**	**0.0**
8	100.0	100.0	100.0	100.0	**100.0**	**0.0**
9	100.0	100.0	100.0	100.0	**100.0**	**0.0**
10	100.0	100.0	100.0	100.0	**100.0**	**0.0**
11	100.0	100.0	74.1	97.2	**93.0**	**21.0**
12	100.0	98.1	100.0	99.1	**99.0**	**2.0**
13	100.0	98.1	100.0	96.3	**99.0**	**3.0**
14	100.0	100.0	82.4	100.0	**96.0**	**12.0**
15	100.0	100.0	100.0	100.0	**100.0**	**0.0**
16	100.0	100.0	100.0	100.0	**100.0**	**0.0**
17	100.0	91.7	100.0	100.0	**97.0**	**7.0**

Table 3: Botanical and isotopic composition by growth form, and plant family from Salt Creek for 2007

Growth Form	Botanical Families	# of species	δ15N ‰	δ13C ‰
Grasses	**Eragrosteae**	1	**-2.33**	**-27.55**
	Sporobolus cryptandrus			
	Poeae	1	**-3.25**	**-29.80**
	Poa bulbosa			
	Aveneae	3	**-0.38**	**-26.98**
	Phleum pretense		0.315	-27.80
	Avena fatua		0.03	-24.70
	Agrostis stolonifera		-2.19	-27.70
	Cyperaceae	1	**-0.11**	**-28.25**
	Carex geyeri			
Forbs	**Fabaceae**	3	**0.06**	**-27.77**
	Lupinus caudatus		-0.25	-27.25
	Unidentified		-1.23	-29.00
	Unidentified		0.53	-27.73
	Asteraceae	4	**0.04**	**-29.55**
	Taraxacum officinale		0.47	-29.30
	Achillea millefolium		-0.40	-29.80
Shrubs/Trees	**Aceraceae**	1	**-3.25**	**-28.20**
	Acer grandidentatum			
	Asteraceae	2	**0.54**	**-28.20**
	Chrysothamnus nauseosus		1.0	-28.10
	Artemisia tridentate		0.007	-28.30

Table 4: Botanical and isotopic composition by growth form, and plant family from Salt Creek for 2008

Growth Form	Botanical Families	# of species	δ15N ‰	δ13C ‰
Grasses	**Poeae**	5	**-0.93**	**-27.00**
	Poa bulbosa		-1.78	-26.50
	Bromus inermis		-0.31	-27.05
	Bromus carinatus		-0.36	-26.87
	Poa fendleriana		-1.59	-27.27
	Dactylis glomerata		-0.62	-27.30
	Aveneae	3	**-2.19**	**-27.70**
	Avena fatua		-1.38	-28.20
	Phleum pratense		0.32	-27.80
	Agrostis stolonifera		-2.19	-27.70
	Eragrosteae	1	**-2.34**	**-27.55**
	Sporobolus cryptandrus			
	Triticeae	1	**-0.61**	**-28.2**
	Agropyron intermedium			
Forbs	**Fabaceae**	3	**-0.97**	**-28.03**
	Lupinus caudatus		-0.41	-27.86
	Unidentified		-0.65	-27.56
	Unidentified		-1.86	-28.67
	Asteraceae	5	**-1.21**	**-29.16**
	Achillea millefolium		-0.70	-29.43
	Wyethia mollis		-1.34	-29.17
	Taraxacum officinale		-0.95	-29.29
	Senecio serra		-2.08	-30.10
	Unidentified		-0.99	-27.80
	Liliaceae	1	**-2.07**	**-28.90**
	Allium ascalonicum			
	Rununculaceae	1	**1.59**	**-26.5**
	Delphinium occidentale			
Shrubs/Trees	**Aceraceae**	1	**-1.15**	**-26.58**
	Acer grandidentatum			
	Ericaceae	1	**-4.57**	**-30.3**
	Arctostaphylos pungens			
	Asteraceae	2	**0.15**	**-28.37**
	Chrysothamnus nauseosus		0.89	-28.63
	Artemisia tridentate		-0.60	-28.10
	Chenopodiacea	1	**-0.76**	**-28.40**
	Ceratoides lanata			
	Caprifoliaceae	1	**-1.10**	**-28.40**
	Symphoricarpos occidentalis			
	Rosaceae	1	**-0.84**	**-29.20**
	Rosa woodsii			
	Fagaceae	1	**-1.25**	**-27.96**
	Quercus gambelii			
	Pinaceae	2	**-2.67**	**-26.90**
	Pseudotsuga menziesii		-3.49	-23.50
	Pinus monticola		-1.85	-30.30
	Salicaceae	1	**-0.89**	**-31.10**
	Salix exigua			

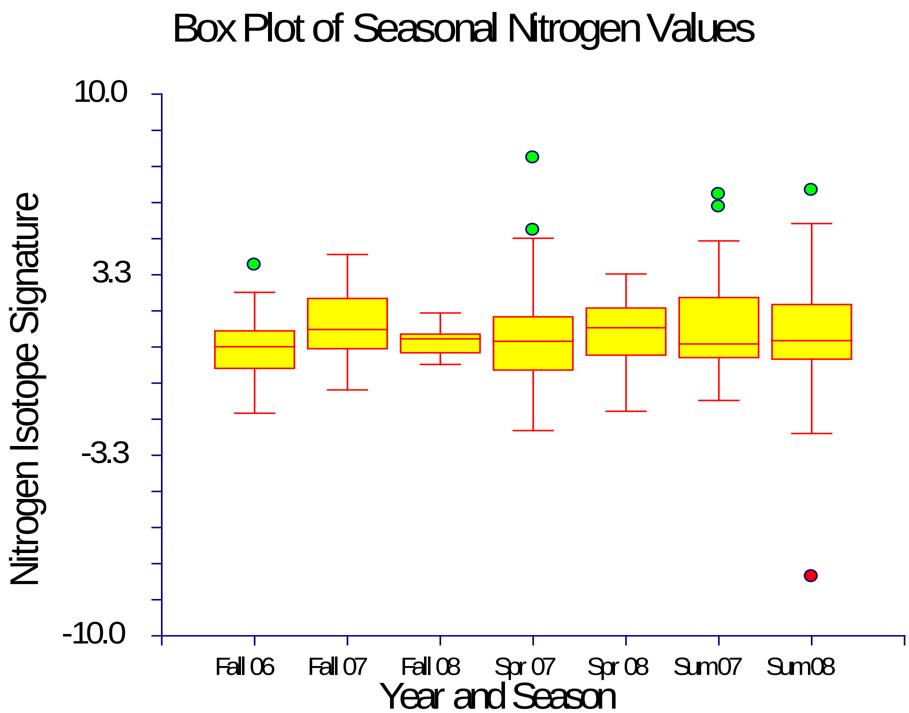
Mean δ13C and δ15N values for plant species type for the study year 2007 and 2008 are presented in tables 3 and 4. We found that values varied between plant species and plant growth form. Plants of the same species also had slightly differing isotopic signatures depending on varying conditions in climate, weather, and altitude.

When combining the average δ13C value for hen feces we obtained a mean value of -26.74‰ with a δ15N value of 1.4‰. Male mean values were found to be -26.71‰ for δ13C and 1.01‰ for δ15N. In comparing isotope values between male and female no significant differences were found (see table 5). Additionally no yearly or seasonal patterns or trends were discovered (Figure 5).

Table 5: : Carbon and nitrogen isotope ratios of all feces of Salt Creek flock. Values expressed as ‰.

Sample Type	**Feces Isotope Mean by Bird Gender and Age**									
	Male		Female		Adult		Female Poult		Male Poult	
Feces		Stdev		Stdev		Stdev		Stdev		Stdev
δ13C	-26.71	1.30	-26.74	1.10	-26.73	1.17	-26.30	.86	-26.40	1.20
δ15N	1.01	1.46	1.41	1.45	1.21	1.46	1.02	2.00	0.74	2.18

P-values: Adult Male and Female carbon = 0.886
Adult Male and Female nitrogen = 0.115



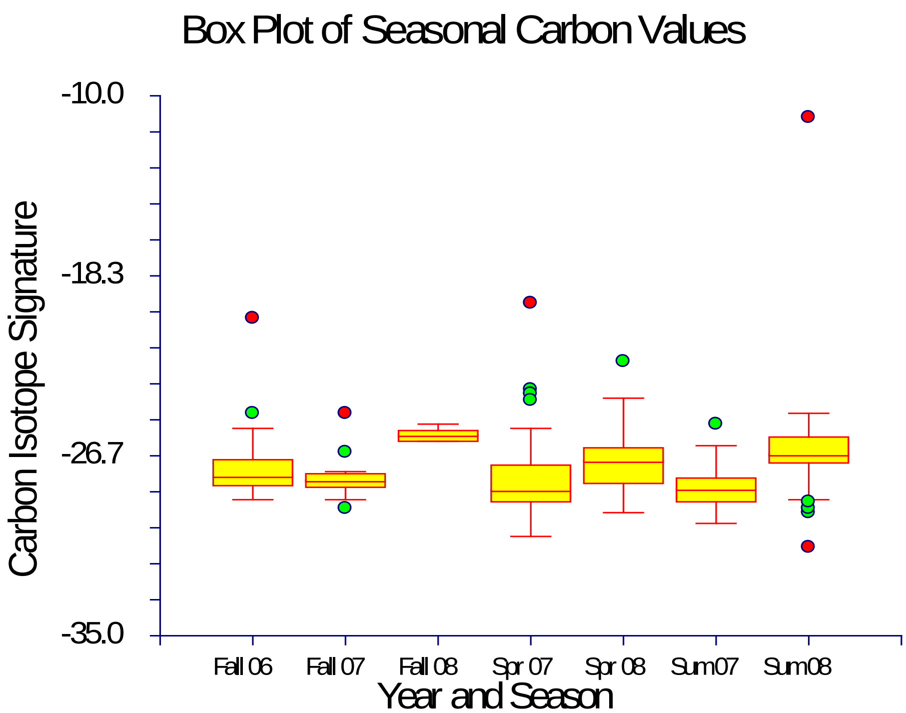


Figure 5: : Box plots showing seasonal and yearly variation in both carbon and nitrogen found in feces collected in the Salt Creek area.

It was found that turkey diet varied in the percent consumption by food type, forage class, season, and year (Figures 6 and 7). Values calculated for the winter months for 2007 and 2008 were compromised because of the decision to supplement wild turkey diet using corn and bailed oats. Isotope analysis of carbon picked up this artificial diet change. From the calculated % composition for turkey diet in the winter of 2008 it was found that 70% of the wintering turkey diet can be explained by the availability and consumption of supplemental feed (Figure 6). Percent composition for turkey diet in the spring and summer of 2008 and 2007 were found to vary. In addition δ values for nitrogen for the 2007 and 2008 study years were also found to fluctuate. However, δ values for nitrogen were found to be more consistent (Figure 5).

Isotope analysis of feathers revealed no significant patterns. As feather length increased there was a tendency for nitrogen values to become more negative or more depleted in δN15 (Figure 8 and Figure 9). When plotting nitrogen against feather length a negative correlation is found ($r = -0.17$) as well as a small R-squared ($r^2=0.03$). This shows that feather length reveals little to no significant variation in N uptake. C analysis on the feathers revealed no apparent patterns (Figure 8).

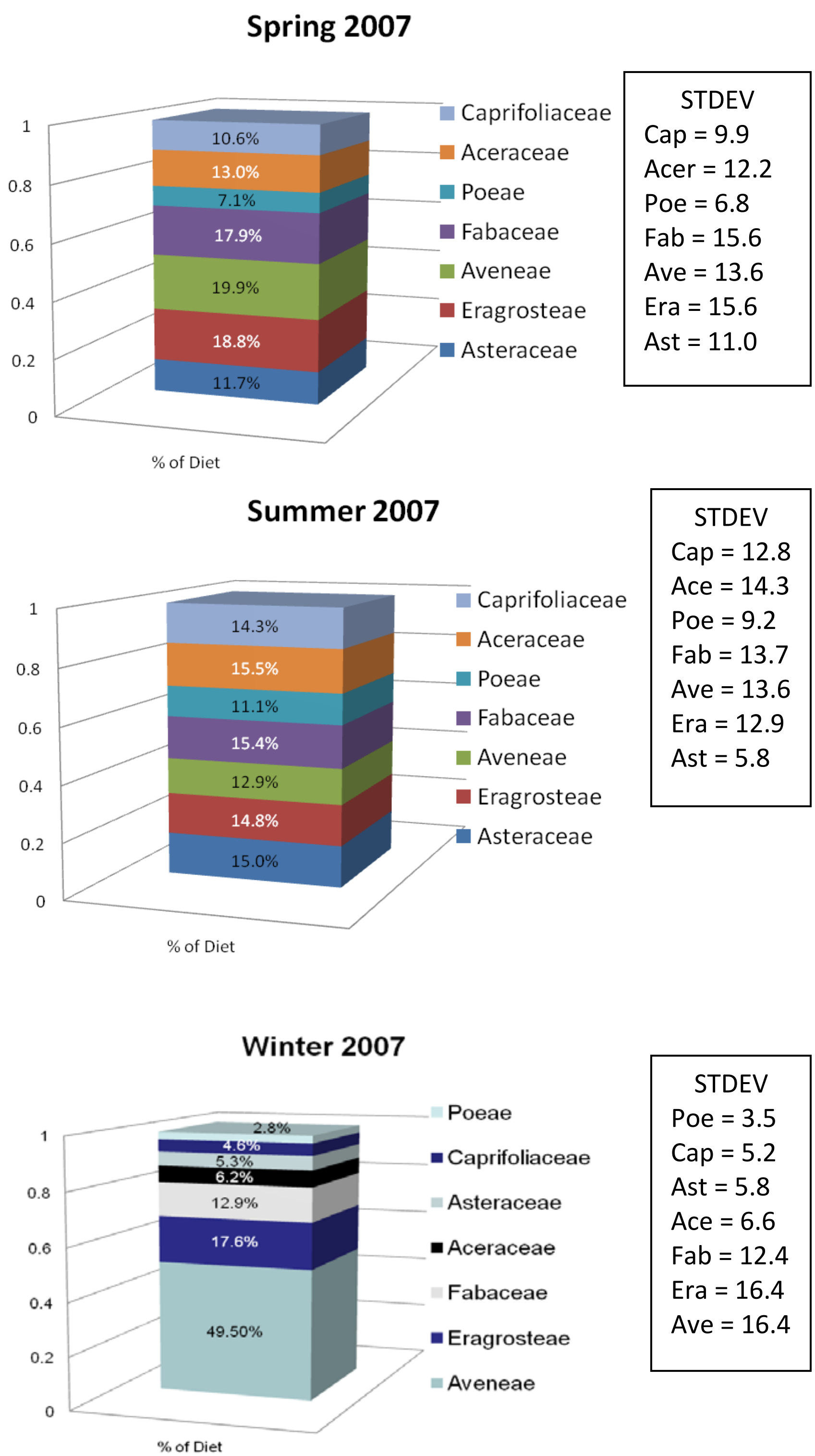


Figure 6: Comparing Salt Creek turkey % diet composition for spring, summer, and winter 2007

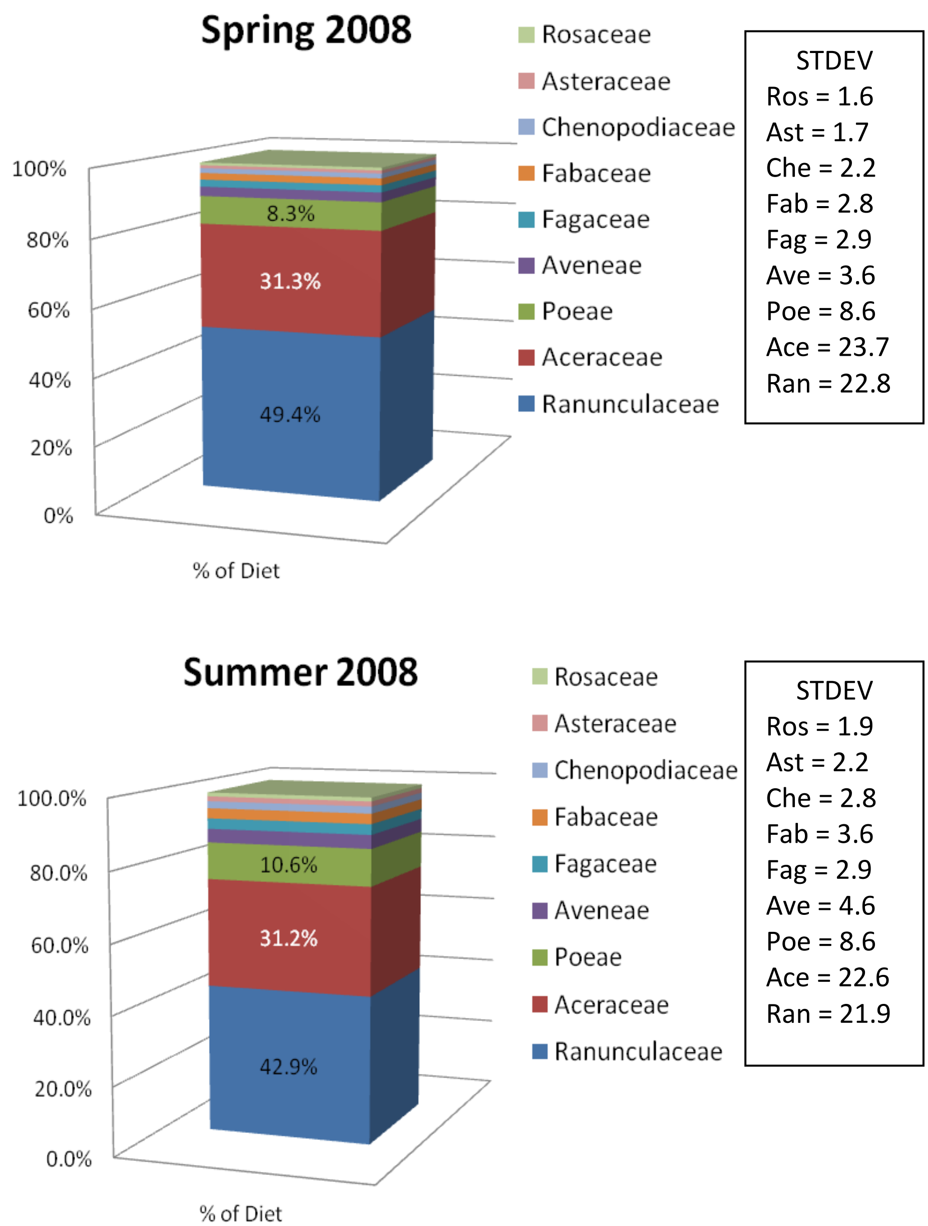


Figure 7: Comparing Salt Creek turkey % diet composition for spring and summer 2008

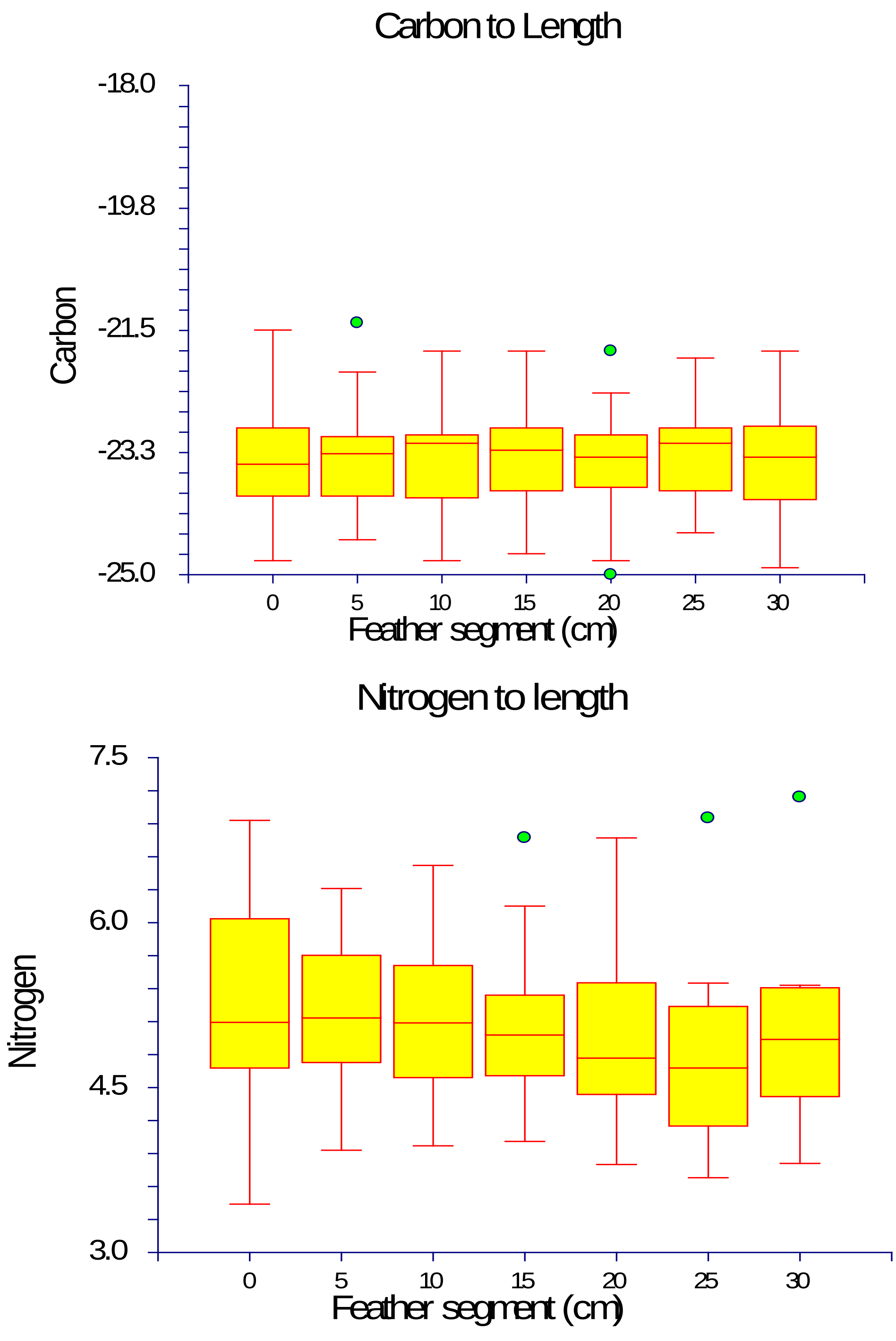


Figure 8: Box plots showing nitrogen and carbon isotope values plotted against feather length.

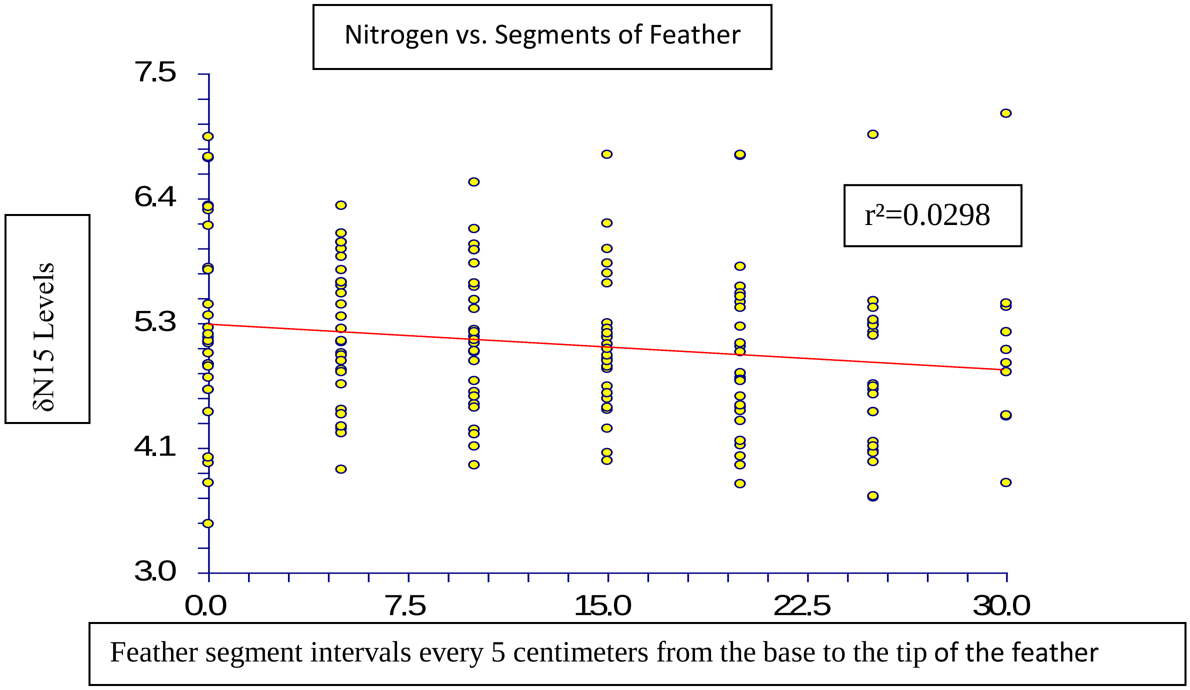


Figure 9: Scater plot showing linear relationship between Nitrogen levels and feather length. Horzontal axes is feather length segment, and vertical axes is nirtogen value.

DISCUSSION

Home range of wild turkeys is smallest during winter months and increases during the spring and summer seasons. Weekly home ranges for hens have been reported as less than 30 hectares (75 acres) during the brood rearing period but about 100 hectares (250 acres) during the summer months (Speake et al., 1975; Porter, 1980). Our findings support the findings of Speake et al. (1975) and Porter (1980).

Habitat use is dependent on time of year and bird sex. During late fall and winter, wild turkeys in South Dakota commonly form two distinct social groups. One group is made up of juvenile, yearling, and adult hens while the other group is mostly made up of males (Williams, 1984). Often the line between groups can be blurred during harsh winter months as both groups come together to form large flocks near winter food sources (Flake et al., 2006). We found that birds did segregate according to sex with females occupying areas separate from the males. During spring and summer months radio tagged hens spent most of their time in areas consisting of hard wood trees and intermittent mountain meadows. We did not find high values for hard mast in our isotope analysis but meadow edges are where high numbers of insects can be found (Rumble and Anderson, 1996). Hens and chicks may have been concentrating feeding in these areas to obtain the high protein diet chicks require. Our specific use of radio telemetry on hens was biased but in our collection of feces we never found substantial male feces mixed with female feces.

It has been found that as spring approaches and hens begin nesting behavior, they disperse from their winter range and actively avoid other hens while searching for a nesting site (Healy, 1992). Nests of hens in the Salt Creek flock were not located close together. Hens can be seen during the nesting season feeding with other hens and mating with gobblers but these behaviors take place 0.8 kilometers (0.5 miles) or more from the hen's nest site (Williams et al., 1974).

Rio Grande wild turkeys are similar to eastern wild turkeys in there establishment of a nest directly under shrubs (Lehman et al., 2003). Our results from the analysis of 17 nests show that the Rio Grande species making up the Salt Creek flock not only established nests with direct vertical cover but often establish nests at the base of trees. In addition Salt Creek hens also tended to select areas with steep slopes to establish nests (table 4). The average slope for a nesting area was 18.4º with hens establishing their nests somewhere within the sloping terrain.

We never found nests at the base of or at the beginning of a slope. This supports findings by Healy (1992). Northern aspects were also noted as being preferred by many Salt Creek hens. Salt Creek birds established nests with a northern aspect 64.7% of the time with southern aspects making up 35.3%.

Turkeys have been known to prefer nesting in areas that possess certain soil characteristics. Areas with high levels of calcium have been shown to attract higher populations of turkeys (Leopold and Dalke, 1943). Northern aspects may offer more optimal soil moisture temperature conditions for plant community development. The use of southern aspect slopes may be deceiving because of the rough terrain in this study location. A southern aspect may possess the same characteristics as a northern slope because it may be shadowed by an even larger raven or canyon ridge directly to the south.

Turkey hens often show strong nest site fidelity (Hayden, 1980; Liedlich et al., 1991). We observed hens nesting within a hundred meters of the previous years nest and some hens nesting more than a half a mile from their previous years nest. Considering the terrain in the study location, hens were found to express fidelity for a canyon with a certain slope, aspect and elevation.

We found nests located in thick vegetation with direct vertical and dense horizontal cover (Table 2). Wild turkeys require well-developed vegetation one meter above the ground providing cover for growing chicks that are unable to fly (Porter, 1992). Hens tend to avoid areas with low ground cover. In one study it was found that no hens, nests, or broods were seen in heavily grazed turkey habitat (Ransom et al., 1987). Wild turkeys have been known to nest in a variety of vegetation types with a variety of direct vertical cover aspects (Porter, 1992). A common requirement in most nests in all turkey habitats from the north east to the south west is horizontal or lateral cover immediately around the nest (Porter, 1992). In the Salt Creek flock hens were found nesting with a variety of direct vertical cover but with full immediate horizontal cover (Table 2).

The Salt Creek Fire of 2007 burned 25,465 acres (10,305 hectares) and was predicted to severely alter wild turkey populations. Our data collection for late 2006 and early 2007 found that turkey habitat and home range use was not drastically affected. The effects of the fire were seen mostly in the loss of winter habitat for the Salt Creek population (Figure 3). Wild turkey response to fire disturbance has been shown to be negative (Scott and Boeker, 1977). The negative response is a result of the loss of vegetative requirements such as ground cover and roosting trees. During the winter months of 2008 and 2009 birds in winter flocks were seen roosting in the burned-out cotton wood trees lining Salt Creek. The Salt Creek fire had the potential in some areas to alter turkey nesting behavior. In 2008 we found two hens nesting in and near the Salt Creek fire zone. The hen which nested in the burn area was unsuccessful in hatching, but the hen nesting at the fires edge produced a successful hatch. In comparing both nests, the main difference was only found in the amount and density of horizontal cover. The hen nesting at the fires edge established a nest in an area with more horizontal cover. Both nests were established at the base of a tree.

In general, wild turkeys are productive in habitats consisting of woodlands fragmented with grasslands and meadows (Porter, 1992). The 2007 fire in some places will help to create this mosaic of fragmented habitat as well as stimulating the growth of understory vegetation which will eventually benefit the wild turkey population.

Wild turkeys are able to select desired foods but annual fluctuation in availability results in a diverse dietary consumption (Flake et al., 2006). Our comparison of C isotope values of feces and forage support this statement and we found that the wild turkeys in the Salt Creek flock consumed a variety of foods with variation between season and year. We were not able to combine forage selection with forage availability because of our limited resources.

Stable isotope technology is a tool that does not measure the nutritive value of foods. Instead it is a tool that measures the difference between atoms by their mass-to-charge-ratio. An isotope is an atom of a common element with the same number of protons and electrons but differing numbers of neutrons then the common form (Sulzman, 2007). C for example has a normal atomic mass of 12. The most common isotope of carbon is C^{13} which has an additional neutron and thus an atomic mass of 13 (Sulzman, 2007). There are about 300 stable isotopes (Hoefs, 1997).

Because isotopes occur naturally organisms will sequester them in their tissues through biochemical pathways as dietary nutrients are metabolized. In plants for example, C is brought in to the plant as CO_2 from the atmosphere into the plant through differing photosynthetic pathways (Marshall et al., 2007). N will come into the plant through detris sources. As the isotope and natural element are brought in to the plant they are stored in particular ratios. When an animal consumes this plant material the animal takes on an isotopic signature specific to the plants species and growing conditions. Using isotope ratio mass spectrometry (IRMS) the element isotope ratio can be determined by separating the charged atoms on the basis of their mass-to-charge-ratio (Sulzman, 2007). The result of the mass-to-charge ratio is a number that can be positive or negative (Tables 1,). To understand the values reported it is important to remember that a positive “delta” (δ) indicates that the sample has more of the heavy isotope (ie. ^{13}C or ^{15}N) than does the standard and that a more negative value of “delta” (δ) indicates the sample being measured has less of the heavy isotope than the standard (Sulzman, 2007). In other words a more negative value is said to be depleted for the heavy isotope and a more positive value is said to be more enriched for the heavy isotope.

Our results determined plant family presence in turkey feces and thus diet based on isotope markers or particular mass-to-charge-ratios. In a study performed in the Black Hills of South Dakota, kinnikinnick (*Arctostaphylos uva-ursi*) seeds dominated turkey diets when the higher energy containing ponderosa pine seeds were scarce due to drought. When ponderosa pine seed production and availability were normal, ponderosa pine seed use was greater than kinnikinnick seed utilization (Rumble and Anderson, 1996).

The lack of any apparent patterns or trends in turkey diet as a result of feather isotope analysis may be due to the difficulty in determining time of growth and time of molt. Wild turkey adults molt each year taking 4 to 5 months to complete the process. The exact timing may differ according to geographic location and subspecies (Flake et al., 2006). Our results show that isotope analysis cannot be used to understand temporal turkey diet patterns through feather isotope analysis but instead highlight the importance of combining time of feather growth with food availability. It may be more useful to evaluate (or sample) different shed feather types. Feather growth could potentially allow for a record of turkey diet for a longer period of time than the three hours provided through fecal analysis. The growth of the eighth primary on a turkey hatched in June would not reach completion until the middle of December allowing for a 7 month record of diet during growth (Knoder, 1959). Our result of no apparent pattern may in fact be a pattern in its self.

Plant consumption by wild turkeys makes up a majority of their diet but the use of small animals and insects as a source of food is well documented (Hurst, 1992). In South Dakota 10 of 31 male and female wild turkey crops examined contained bones and 5 of these same 31 bird crop contents contained snail shells (Beasom and Patte, 1978). In another study it was found that after analyzing 146 different wild turkey crops, 28.7 percent of the content was grasshoppers and beetles (Litton, 1977). The analysis of insect and animal sources of food is lacking in our study but we did notice some turkey feces samples that exhibited abnormally enriched values of N. Normally, values of N in turkey feces were 1.41‰. We found some samples of turkey feces to show a N content of 5.5‰. When compared to other animal feces types collected in the same area such as Mt. Lion and coyote, the turkeys producing feces consisting of N isotope values of 5.5‰ or higher have diets that most closely resemble the diet of a Mt. Lion. Mt. Lion feces collected in the Salt Creek area were found to have a mean nitrogen isotope value of 6.06‰. Turkeys digest food fast with complete food passage in young egg laying hens taking 2 hours and 27 minutes (Hillerman et al., 1953). Our finding of a N signature of 5.5‰ in a turkey suggests that the turkey responsible for those feces had consumed a diet, within the past three hours, dominant in animal tissue. The large majority of turkey feces collected indicate that plant material is the predominant food source; these others with animal tissue N isotope signatures substantiates the fact that turkeys can and do eat small animals and insects.

Our findings support the theory that turkeys use a variety of food sources and are opportunistic when these foods are available (Flake et al., 2006). Like in plant analysis, the selection of animal and insect food sources is hard to determine because of the turkey's opportunistic feeding behavior. Future turkey diet studies should analyze both types of food sources so that relationships may be revealed. Flake et al. (2006) found, while studying a group of turkeys in South Dakota, that acorns were absent from turkey diet and grasshoppers made up 50 % of the diet. The following year acorns made up 56% and grasshoppers contributed only 3% of total diet.

We expected to see distinct differences in C and N isotope signatures between male and female turkey feces because of the tendency of males and females to occupy and use differing habitat types due to gender segregation (Healy, 1992). We did notice males occupying and spending time in different areas then females used. However, we found no apparent difference as P-values for C were found to be 0.886, and N was 0.115.

Water requirements of wild turkeys can vary according to the water content of available foods. Spring and summer forages have sufficient water content but winter forages may be too low in water content to meet metabolic needs (Exume et al., 1985; Kilpatrick et al., 1988). Throughout our research we repeatedly located hens with chicks in areas located some distance from open water sources. In one case a hen hatched her brood in a nest located near a running water source, but as soon as hatching was complete the hen moved her chicks up in elevation and away from open water sources during the summer months.

MANAGEMENT IMPLICATIONS

Wild turkeys have the ability to utilize many different food sources. As wildlife managers work to introduce and expand wild turkey populations throughout Utah and the Western US many questions will be raised as to how the turkey impacts its surrounding environments. With the ability to consume many different food sources the main source of conflict may not be in competition for food but competition for space both temporally and spatially. Turkeys require a combination of two specific habitat elements, which are trees and grasses, to be successful. Analysis of nest habitat data, and nest and hatching success will enable managers to better understand nest site selection and to determine hatching rates (Vangilder et al. 1987). A better understanding of why and how turkeys use their habitat will not only benefit turkey management but management of the range as a whole especially in areas where wild turkeys are new.

CONCLUSION

Dietary requirements of wild turkeys can be met through the consumption of many differing food sources. Our findings reaffirm that wild turkeys are indeed dynamic in their food consumption and that they are flexible in the types of foods eaten. This may be more true with turkeys in Utah and other similar parts of the Western United States which have seasonal extremes and are located at the fringes of known turkey habitat. Stable isotope analysis is proven to be beneficial in mapping a general reconstruction of turkey diet. The growing understanding of the ability of the wild turkeys of central Utah to be able to successfully utilize different food sources will help wildlife managers more successfully manage the state’s population and its impact on the surrounding environment. Habitat type and structure, not food types, appear to play more of a major role in giving turkeys the opportunity to survive and be productive in Utah.

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