IMPORTANCE OF NATURAL MINERAL LICKS TO UNGULATES

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INTRODUCTION

Natural mineral licks are commonly wet, muddy areas fed by springs where mineralized water and/or soil is consumed, but some licks are areas of relatively dry fine-grained soil. Licks are often heavily used in the spring and summer by ungulates and other herbivores. Lick use has been recognized as an important feature in the life history of many ungulate populations and has been studied in North America, including Alaska, as well as other parts of the world. Although no study as proven that mineral lick use is essential to any wildlife population, mineral elements commonly found in licks are essential to the health of wild ungulates. Elements and compounds found anomalously high in licks compared to nearby non-lick sites include sodium, potassium, magnesium, calcium, copper, iron, manganese, chromium, chloride, sulfate and bicarbonate.

LICK COMPONENTS AND IMPORTANCE

Identification of the source or sources of lick attraction is still a matter of debate in the literature. Many studies have shown that the essential macro-element sodium (Na) is relatively abundant in licks and is selectively sought by ungulates (Stockstad et al. 1953, Denton and Sabine 1961, Dalke et al. 1965, Knight and Mudge 1967, Hebert and Cowan 1971, Weeks and Kirkpatrick 1976, Fraser and Reardon 1980, Tankersley and Gasaway 1983). Few terrestrial green plants are known to require or store Na (Epstein 1972) which is an essential mammalian macronutrient important for acid-base balance, fluid volume, nerve impulse transmission, bone structure, and growth (Forbes 1962, Scoggins et al. 1970, Church and Pond 1974). Na is particularly important to ruminants because of its capability to buffer the acidic products of microbial fermentation in the rumen (Denton 1956, Denton 1957, Kay 1960, Church 1976). In addition, Na retention in herbivores may be aggravated by the high potassium (K) levels in new green growth during spring and summer (Hebert and Cowan 1971, Weeks and Kirkpatrick 1976, Weeks and Kirkpatrict 1978, Salter and Pluth 1980), and Na deficiencies are known to cause a Na-specific appetite in ruminants (Denton 1969, Church and Pond 1974).
Weeks (1978) also noted that artificial licks created solely with NaCl readily attract white-tailed deer (*Odocoileus virginianus*), and no differences in behavior of lick users

and seasonal timing of use occurs between natural and artificial licks.

However, not all licks have been reported to have relatively high levels of Na, or only Na. Some licks have relatively high levels of calcium (Ca), magnesium (Mg), or other essential elements (Murie 1934, Dixon 1939, Cowan and Brink 1949, Heimer 1973, Calef and Lortie 1975, Chamberlin et al. 1977, Tankersley 1984, Jones and Hanson 1985). Hanson and Jones (1976) originally hypothesized that sulfur may be a major lick attractant. However, as Weeks (1978) pointed out, sulfur is abundant in plant tissues and is not universally found in high levels in natural licks. More recently, Jones and Hanson (1985) submitted their "unified theory of lick use" that different licks may supply different minerals. Specifically, they promote the importance of Mg as well as Na, and to a lesser extent, Ca in licks to alleviate mineral deficiences in or caused by herbivore diets. However, selection experiments conducted with moose (*Alces alces*) and other ungulates at natural mineral licks containing high levels of Na, Mg and Ca showed no preference for Mg or Ca compounds, only Na (Stockstad et al. 1953, Fraser and Reardon 1980). Also, there is no evidence for a Mg appetite even in Mg-deficient animals (Denton 1982).

No other elements are currently being reported as major lick attractants. Explanations for reported lick content variability include primitive or incomplete sampling and analysis techniques, or contamination of samples (Fraser et al. 1980), and lick soil being sought not solely for mineral deficiencies, but also for relief from seasonal acidosis, plant poisoning, or buffering of excessive vegetative compounds (Kreulen 1985).

ARTIFICIAL LICKS

Although many studies have reported ungulate use of artificial salt (NaCl mixtures) sources (Table 1), replacement or supplementation of natural licks with artificial mineral sources has not always been successful. Approximately 50% of artifical licks established for elk in Idaho became inactive each year (Dalke et al. 1965). Also, elk (*Cervus elaphus*) preferred some natural licks to artificial salt grounds established nearby (Dalke et al. 1965). Similar situations occasionally occurred with big game in western Canada (Cowan and Brink 1949). Bison (*Bison bison*) in Montana and antelope (*Antilocapra americana*) in Colorado eat soil in preference to salt blocks (Jones and Hanson 1985).

Several factors may explain the unsuccessful results. It may take several years for an animal population to respond fully to a new source of minerals (Schneider 1956, Wiles and Weeks 1986). This may be due to the content or form of the lick. White-tailed deer ate the salty soil beneath a salt block in preference to licking the block itself (Chapman 1939). Elk which were familiar with using salt blocks for cattle consumed salt blocks before much use of salt-impregnated soil (Dalke et al. 1965). In a study of salty roadsides, moose often drank puddles of salty water, but rarely licked gravel; snowshoe hares (*Lepus americanus*) did the reverse; and white-tailed deer used both puddles and gravel (Fraser 1979).

Other factors influencing use of artificial licks include placement of salt (in correct habitat for desired species), competition from livestock, continued maintenance of salt supply, and discovery and access to a salt source (Dalke et al. 1965). Although mountain goats (*Oreamnos americanus*) may travel up to 24 km partially through forests to visit licks (Brandborg 1955, Hebert and Cowan 1971), Thompson (1982) reported a mountain goat population that used artificial Na sources had not used a natural lick high in Na 5.7 km from their normal range. He attributed this to their lack of discovery or avoidance of heavy recreational use in the area.

However, there are reports of ungulates finding and using new lick sites. Denali caribou (*Rangifer tarandus*) have heavily used overburden from the abandoned Dunkle coal mine as a lick (Boertje 1981). Mountain goats in Montana began using a new lick site probably created by river erosion near an existing lick about 1978 (Singer and Doherty 1985). In British Columbia, mountain goats began using new licks exposed by logging operations in an area of existing licks, even though use of one of the new licks required much further travel from normal summer range away from typical escape cover (Hebert & Cowan 1971). It was found that this lick had much higher Na concentrations than the main lick currently in use by that population. Moose first colonized Isle Royale in the early 1900's, and by 1983 were using 22 natural licks (Risenhoover and Peterson 1986).

Artificial licks may contribute to wildlife disease. Artificial sources of salt were implicated in an outbreak of contagious ecthyma among bighorn sheep (*Ovis canadensis*) and mountain goats in western Canada (Samuel et al. 1975).

AREAS WITHOUT LICKS

If licks are essential to ungulate populations, no one has adequately explained why some populations appear to survive quite well in the absence of licks. Botkin et al. (1973) and Fraser et al. (1982) stress the importance of Na-rich aquatic plants as substitutes for mineral licks for moose, although Risenhoover and Peterson (1986) disagree. In any case, not all lick-using ungulates feed on aquatic vegetation, so aquatics cannot substitute for licks for all species. Regional differences in soil mineral content can affect the mineral content of the vegetation. Moose from different areas of Alaska had significantly different levels of minerals in their hair (Franzmann et al. 1975b). Areas without licks may have soils high in mineral content and animals eating grasses or forbs may inadvertently ingest mineral-rich soil clinging to roots (Jones and Hanson 1985). Coastal rainfall and alkaline desert vegetation may be good sources of Na in some areas (Beath 1942, Blair-West et al. 1968), obviating the need for Na-rich licks.

The health of wildlife populations may suffer without the availability of licks or other mineral sources. Wild Australian rabbits had a substantial Na appetite and Na deficiency from areas with low environmental Na, but not in areas where Na was more abundant (Myers 1967). A copper deficiency was indicated for moose on the Kenai (Flynn et al. 1977), but few other examples of mineral deficiencies in wild ungulates have been documented. As Franzmann et al. (1975) pointed out, wild animals seldom show extreme barnyard-type deficiences as described by Franzmann et al. (1975) and Jones and Hanson (1985).

The distribution and population density of some herbivores are determined by the availability of licks or other Na sources (Aumen and Emlen 1965, Weir 1972, Jones and Hanson 1985). Ungulate movements to licks in spring and early summer have been documented for several species (Dalke et al. 1965, Hebert and Cowan 1971, Heimer 1973, Best et al. 1977, Wiles and Weeks 1986), however the effect of lick or mineral availability on an ungulate population's year-round range is not well-documented. Salt was effective in influencing elk distribution only in spring and early summer. Vegetation was a more critical factor at other times of the year (Dalke et al. 1965).

SPECIES USING LICKS

All 11 native ungulate species in North America are known to use licks, at least in some part of their range (Jones and Hanson 1985). Studies in Alaska have documented lick use by Dall sheep (*Ovis dalli*), moose and caribou (Dixon 1938, Dixon 1939, Palmer 1941, Skoog 1968, Erickson 1970, Pitzman 1970, Heimer 1973, Boertje 1981, Tankersley and Gasaway 1983, Spindler 1983, Tankersley 1984). Black bears (*Ursus americanus*), porcupines (*Erethizon dorsatum*), woodchucks (*Marmota monax*), red squirrels (*Tamiasciurus hudsonicus*), raccoons (*Procyon lotor*), snowshoe hares, small rodents, birds and butterflies are also reported to use licks (Dixon 1939, Fraser 1985, Jones and Hanson 1985). Some species are known to share the same lick (Dixon 1939, Cowan and Brink

1949, Dalke et al. 1965, Carbyn 1975, Fraser and Hristienko 1981, Fraser 1985).

SEASONS OF USE

The great majority of studies have identified spring and early summer as the major peak of lick use (Jones and Hanson 1985). This indicates that most lick use is caused by a seasonal physiological need, not just a superfluous taste for minerals. Alaskan moose have lower levels of several elements in late winter and early spring (Franzmann et al. 1975b). A change in diet associated with leaf flush (vegetation high in K and water) has been linked to initiation of seasonal lick use (Hebert and Cowan 1971, Weeks and Kirkpatrick 1976, Fraser and Hristienko 1981, Thompson 1982, Jones and Hanson 1985). Declining lick use in mid-summer has been attributed to declining K in vegetation (Hebert and Cowan 1971, Weeks and Kirkpatrick 1976, Jones and Hanson 1985). The seasonal decline in lick use has also been attributed to the annual pattern of caribou migration (Calef and Lortie 1975), and the availability of aquatic plants high in Na for moose (Fraser et al. 1982), however, these reasons would not explain the decline for all ungulate species. Lower levels of lick use sometimes occur at other times of the year (Murie 1934, Chapman 1939, Knight and Mudge 1967, Skoog 1968, Watts 1979, Risenhoover and Peterson 1986), which may indicate a longer-term mineral imbalance.

EXTENT OF USE

Amount of Use

Different licks are used a variable amount, probably depending on seasonal availability of lick substrate, location, availability of alternate licks, tradition, and mineral content. In areas with more than one lick, some have reported that the lick with the highest Na content is used the most (Watts 1979, Tankersley and Gasaway 1983, Stark 1986). However, that is not the case for some licks used by moose on Isle Royale (Risenhoover and Peterson 1986) or Ontario (Fraser and Hristienko 1981). Bigger licks often have greater use (Tankersley and Gasaway 1983, Risenhoover and Peterson 1986, Stark 1986). Annual fluctuations of K in vegetation due to soil moisture content may influence the amount of lick use (Heimer 1987).

History of Use

Because of the size and network of trails radiating from some lick sites, paleontological studies at others, and many place names in the U.S. including the words "lick" and/or "salt", some licks may have been in use for centuries or thousands of years (Jones and Hanson 1985). Also, there are a few reports of former lick sites no longer being used (Watts and Schemnitz 1985, Risenhoover and Peterson 1986).

Use by Individuals

Many studies report lick use by individual ungulates for a few days during the lick use season, or at intervals throughout the summer (Heimer 1973, Carbyn 1975, Fraser and Hristienko 1981, Boertje 1981, Tankersley and Gasaway 1983, Risenhoover and Peterson 1986). There is a lot of individual variation in use (Fraser and Hristienko 1981, Singer and Doherty 1985a). A single annual trip to a lick area has been reported for some mountain goats (Hebert and Cowan 1971), presumably because of the distance involved. Other mountain goats in range only 3 km from licks made several trips to use them in one summer (Singer and Doherty 1985a). Licks used by Dall sheep away from alpine areas, may be unused for days even during the peak lick use season, because many individuals come and go from the lick at one time and storms may inhibit travel (Tankersley 1984).

Several studies indicate that licks are used by a significant proportion of an ungulate population (Best et al. 1977, Tankersley and Gasaway 1983, Tankersley 1984, Wiles and Weeks 1986). Heimer (1973) indicated that Dall sheep usage of the Dry Creek lick in the Alaska Range is quite high, with approximately 1500 individuals in 1972.

SEX AND AGE OF LICK USERS

Licks are used by both sexes, and by young and adult animals. Reported use by different sex and age classes has varied among studies. The sex and age composition of white-tailed deer using licks in Indiana was similar to that of the surrounding population (Weeks 1978). A disproportionately high lick use by bull moose (especially subadults) was reported by Tankersley and Gasaway (1983) and Risenhoover and Peterson (1986), however Murie (1934) reported just the opposite for moose on Isle Royale. The high frequency of use by females reported for several species (Chapman 1939, Heimer 1973, Calef and Lortie 1975) may reflect a greater abundance of females in the population, a greater physiological need due to pregnancy and lactation, or the timing of observations on populations with a seasonal difference between sexes in movements to licks, as noted by Hebert and Cowan (1971), Singer (1978), Fraser and Hristienko (1981), Tankersley and Gasaway (1983), and Tankersley (1984). Unweaned young are reported to make little or no use of licks in most cases (Peterson 1955, Jordan et al. 1973, Fraser and Hristienko 1981), but there are exceptions (Tankersley and Gasaway 1983).

BEHAVIOR AT LICKS

Diel patterns

The daily timing of peak lick use varies among species and study areas. Lick use by white-tailed deer in Indiana was largely crepuscular, with high use throughout the night, which paralleled their normal diel activity pattern (Weeks 1978). Tankersley and Gasaway (1983) also found peak lick use by moose to be at night (2200-0500 hours), however that was not similar to the normal diel activity pattern of moose in that area (Linkswiler 1982). Moose on Isle Royale had an early morning peak from 0400-0800, with a lesser peak from 1900-0100 (Risenhoover and Peterson 1986). Peak lick use by moose in Ontario was during 0700-1100 hours and 1700-2000 hours during one year, but was during midday in 3 other years (Fraser and Hristienko 1981). However, they did not observe the licks between 2200-0600 hours and may have missed significant nighttime use. Carbyn (1975) also noted midday peaks of lick use for elk and mule deer (Odocoileus hemionus), however his observations were only made during 0800-1730. Dall sheep in Alaska use the Dry Creek lick mostly from 0400-1100 (Heimer 1973), similar to sheep in the Sheenjek drainage (Curby 1981). Other Dall sheep in the Brooks Range use licks mostly during mid-day (Klingel et al. 1974, Spindler 1983).

Effects of Weather

The weather can affect timing and use of licks. Risenhoover and Peterson (1986) related low midday use of licks by moose to a reduction of activity during warm summer days. Carbyn (1975) found that high humidity (possibly corresponding to rainfall) was more important than temperature in reducing the number of lick visits. Heimer (1973) found that warming temperatures increased lick use by Dall sheep. Similarly, movements by mountain goats to licks occurred more often during clear weather (Singer and Doherty 1985a). Wind, not rainfall or temperature, was the only weather factor with a significant effect on moose licking activity in Alaska (Tankersley 1981).

Length of Lick Visits

Animals that travel some distance to licks may spend a few days in the lick area (Hebert and Cowan 1971, Heimer 1973, Tankersley 1984). Actual licking bouts are often brief, averaging about 30 minutes or less from a variety of studies (Weeks 1978, Salter and Pluth 1980, Boertje 1981, Fraser and

Hristienko 1981, Tankersley and Gasaway 1983, Risenhoover and Peterson 1986).

Competition and Aggression

Several studies have reported preferred licking sites within a lick, which usually were moister areas containing higher levels of Na and other elements and water (Hebert and Cowan 1971, Heimer 1973, Weeks 1978). Preference causes competition among lick users, with males being dominant (Weeks 1978, Fraser and Hristienko 1981, and Thompson 1982). Tankersley (1981) reported very few aggressive interactions between moose at licks, most probably as a result of a cow protecting a calf. However no obvious preferred licking sites were observed.

Urination in Licks

Ungulates using licks sometimes urinate or defecate in licks (Fraser et al. 1980, Thompson 1982). This can affect chemical anaylses of lick samples (Fraser et al. 1980).

TRADITIONAL USE OF LICKS

Movements to Licks and Access Routes

Several studies have reported ungulates traveling away from their typical home range to visit licks (Hebert and Cowan 1971, Singer 1978, Tankersley and Gasaway 1983, Tankersley 1984, Watts and Schemnitz 1985, Wiles and Weeks 1986). Dall sheep are known to travel up to 20 km out of their way to visit licks (Heimer 1973, Tankersley 1984). Moose are also known to take detours of 1-16.5 km to visit mineral licks (Best et al. 1977, Risenhoover and Peterson 1986).

There are often well-established access trails to licks (Cowan and Brink 1949, Calef and Lortie 1975, Chamberlain et al. 1977, Fraser and Hristienko 1981, Risenhoover and Peterson 1986, Wiles and Weeks 1986). Singer (1978) found that a trail to a lick used by mountain goats was discernable 10 km away. A temporary construction fence blocking one trail to a lick used by mountain goats was broken down by the first group encountering it, rather than it influencing their movements to an alternative access (Singer & Doherty 1985b).

Lick Fidelity

Heimer (1973) and Best et al. (1977) reported that individual Dall sheep and moose annually use the same licks. Dall sheep at the Dry Creek lick were estimated to have a high fidelity in returning each year, with ewe fidelity at 100%, and ram fidelity at 80%. This lick fidelity may be at the expense and risk of further travel from typical home ranges. Dall sheep in the Alaska Range traveled at least 9 km to a lick away from alpine habitat, even though another lick was located closer to their typical range (Tankersley 1984). Similar situations have been reported for bighorn sheep (Watts and Schemintz 1985) and white-tailed deer (Wiles and Weeks 1986).

Use of Alternate Licks

Some studies have documented use of more than one lick by an individual (Best et al. 1977, Fraser and Hristienko 1981, Wiles and Weeks 1986). Licks closer to an individual or population's home range may not necessarily be used in preference to one farther away (Tankersley 1984, Watts and Schemintz 1985, Wiles and Weeks 1986).

Abandonment of Licks

Despite indications of long-term traditional use of many licks, some licks have been documented as abandoned. Watts and Schemintz (1985) reported use of licks by bighorn sheep 4 km away from typical habitat and escape terrain and abandonment of 2 licks within typical range. This lick abandonment may be related to a large population decline from 150 to 25 individuals (Watts and Schemintz 1985). Moose on Isle Royale have also abandoned some licks for unknown reasons, but still use others (Risenhoover and Peterson 1986).

DISTURBANCE AFFECTING LICK USE

There are very few reports of the effect of disturbance on lick use. However, there are several indications that ungulates using licks can habituate to certain kinds of disturbances. Dall sheep in the Alaska Range have been trapped and observed from close proximity at lick sites for many years, and apparently have habituated to these activities (W. Heimer, ADF&G, pers. comm.). Bighorn sheep in Alberta use active natural gas well sites as licks, including ingesting material from drilling reserve pits and licking equipment washed with Na-rich fluids (L. Morgantini, pers. comm.). Mountain goats and white-tailed deer are known to use licks near busy roads (Singer and Doherty 1985, Wiles and Weeks 1986). However, mountain goats forced to cross a highway to use a lick may have skewed use to evening or nighttime hours (Singer 1978). During construction of a highway underpass for mountain goats in Glacier National Park, tolerance of the construction activities was attributed to the scheduling and location of construction away from seasonal and daily peaks in lick use and preferred access routes, slowing of traffic speeds to <8 kph, and the stopping of traffic for crossing goats (Singer and Doherty

1985b). Goat rarely responded to any construction or traffic noises other than blasts or drilling (Singer and Doherty 1985b), however mountain goats that are hunted or harassed may have more severe reactions to disturbances (Chadwick 1973).

Ungulates are known to use active and abandoned mining or drilling sites as licks. Denali caribou (mostly cows) eat the overburden from the abandoned Dunkle coal mine (Boertje 1981). Moose on Isle Royale use water seeping from a abandoned core hole as a lick (R. Peterson, pers. comm.). Bighorn sheep in Alberta, which had used sump water and tailings from abandoned gas well sites for more than 20 years, currently ingest sump water, tailings, industrial wastes and "rig wash" placed on pipes (all high in Na), even though the sites are now currently being drilled and pumped for natural gas (L. Morgantini, pers. comm.).

MANAGEMENT OF LICK SITES

Seasonal, heavy nighttime and early morning lick use, especially in combination with typically brief visits, may lead casual observers to underestimate the importance of lick sites to ungulate populations (Fraser and Hristienko 1981, Tankersley and Gasaway 1983). Repeated heavy use, even from ungulates normally living far from lick sites, indicates the importance of protecting lick sites so that traditional use can continue. Heimer (1973), Best et al. 1977, and Tankersley and Gasaway (1983) recommended protection of mineral lick sites. Protection of lick sites from disturbance during spring and early summer is most critical, although some licks are used year-round. The uncertainty of the mineral attraction, the possibility that different licks can supply different necessary minerals, and the possible link between the health and distribution of a population and availability of mineral sources indicate that protection of natural lick sites from destruction is important, and creation of artificial licks may not serve the same function.

Creating artificial licks to mitigate for loss of lick use also may not be successful. Methods of lick replacement or mitigation for loss of lick use need to be tested, with consideration for accessibility for the affected individuals, location in proper habitat, similar mineral content, suitability of substrate, and maintenance. Also, artificial salt licks may contribute to the spread of disease.

Wildlife managers should also be concerned with protection of traditional access routes to licks. Wild animals often are traditional in their use of habitat, and sometimes do not develop new patterns quickly.

Recommendations (in order of preference):

1. Do not permit destruction of lick sites or disturbance of lick use. (Preferred alternative).

2. Allow activities near licks only during non-peak seasons. (Requires knowing annual fluctuation of use).

3. Mitigate for destruction of lick sites or loss of lick use with excavation of new natural lick sites with similar substrate along established access routes. (Requires soil and/or hydrologic studies, analysis of lick samples and non-lick comparison samples, and mitigation test trials).

4. Establish and maintain artificial licks with mineral supplements similar to anomalous natural lick compounds along established access routes and in areas closer to summer range. (Requires knowledge of movements, analysis of lick samples and non-lick comparison samples, mitigation test trials, and maintenance of artificial licks).

Table 1. Use of artificial Na-salt (e.g. salt blocks) by 8 ungulate species in North America.

Species	Use of artificial Na-salt sources
Moose (*Alces alces*)	Murie (1934) Fraser and Thomas (1982)
Wapiti (*Cervus elaphus*)	Rush (1932) Case (1938) Beeman (1957) Dalke et al. (1965) Pedersen (1977)
White-tailed deer (*Odocoileus virginianus*)	Chapman (1939) Seton (1953) Mattfield et al. (1972) Weeks (1978)
Mule deer (*Odocoileus hemionus*)	Rush (1932) Buss and Harbert (1950) Schneider (1956)
Bighorn sheep (*Ovis canadensis*)	Packard (1946) Cooney (1951) Blood (1971) Geist (1971) Rutherford and Schmidt (1973) Samuel et al. (1975)
Mountain goat (*Oreamnos americanus*)	Lentfer (1955) Shaw (1959) Holroyd (1967) Samuel et al. (1975) Thompson (1982)
Bison (*Bison bison*)	Rush (1932) McHugh (1958)
Pronghorn (*Antilocapra americana*)	Skinner (1922) Rush (1932)

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