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Large-scale trapping features from the Great Basin, USA: The significance of leadership and communal gatherings in ancient foraging societies

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ABSTRACT

In the Great Basin, large-scale trapping features designed to capture multiple artiodactyls include fences or drive lines and corrals with associated wings. More than 100 of these features are known in the Great Basin. An experimental project confirms that these features must have been built through group effort. The marked concentration of large-scale trapping features in western and eastern Nevada may be explained by ecological factors such as the presence of migrating herds of ungulates, nearby toolstone sources, pinyon nuts, and water. The proliferation of large-scale trapping feature planning and construction beginning ca. 5000 to 6000 years ago is supported by studies of trap-associated projectile points and rock art. Initial construction of traps may have been sparked by human population increases that created new challenges and encouraged the development of new sociological and ecological adaptations.

1. Introduction

There is a stereotyped form of drive for rabbits, for mud hens, and for antelope. A leader or head-man, elected or chosen for each drive, is responsible for the direction of the undertaking (Park, 1938:62).

I had sent word to the old chief (White Horse) that I would make him a visit in a few days, and to make it interesting to me he planned an antelope catch…the killing was done with arrow and seldom missed piercing the heart. The catch was about twenty-five, mostly all bucks and does, there being only five or six yearlings in the bunch (Egan, 1917:238, 240).

Large-scale features designed to capture multiple artiodactyls in a single catch have been reported for nearly a century in the Great Basin (Egan, 1917). Hockett and Murphy (2009) Kelly (1943), Lowie (1924) and Arkush (in preparation) provide overviews of their distribution, abundance, age, and design features. These overviews discuss the who, what, where, and when of communal artiodactyl hunting in the Great Basin, and are necessary for exploring the possibilities of *why* these large-scale trapping features were built in the first place.

Artiodactyls most likely trapped or corralled in the Great Basin include pronghorn (or antelope, *Antilocapra americana*), mountain sheep (or bighorn, *Ovis canadensis*), and mule deer (*Odocoileus hemionus*). Bison (*Bison bison*) were present in the Great Basin throughout the period of human occupation, but were never abundant, even during climatic conditions most favorable to bison between ca. 1500–700 years ago (Grayson, 2006). Large-scale trapping features are defined as those that required group effort for construction. Single or multiple hunting blinds that might be each constructed by a family unit are not considered ‘large-scale’. Once built, however, large-scale features could have been used by individuals or individual families. “Communal” means multiple family members or groups working together for a common purpose or goal. Communal groups that constructed large-scale trapping features in the Great Basin could have included various members of multiple families or ‘men-only’ groups pooled from multiple families, as represented in ethnographic accounts (see Hockett and Murphy, 2009 for a review).

Three general types of large-scale traps were constructed prehistorically in the Great Basin: (1) drive lines or drift fences

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(hereafter referred to as ‘fences’); (2) corrals, enclosures, or pounds with associated wings (hereafter referred to as ‘corrals’); and (3) fences that terminated in a corral (hereafter referred to as ‘corral-fences’) (Figs. 1–3). Examples of fences that did not terminate in a circular corral include the Fort Sage Drift Fence (Pendleton and Thomas, 1983) and the Bob Scott Summit Fences (Thomas and McKee, 1974) of western Nevada. Corrals were sometimes constructed with matching wings that flared outward from both sides of the entrance, forming a funnel-shaped feature. The corrals constructed in northeastern Nevada and western Utah are typical of this construction technique (Raymond, 1982; Murphy and Frampton, 1986). In western Nevada, corral-fences were constructed at Whisky Flat (Wilke, 1986) and Huntoon (Parr, 1989).

Sparse mathematical modeling data are available on whether fences were constructed communally as has been richly documented in the ethnographic record for corrals. If corrals required communal effort to build, then corral-fences did as well. A better understanding of the effort required to build both fences and corrals is necessary in order to interpret the reasons communal artiodactyl hunting began in the Great Basin.

Two possible explanations for the development of communal artiodactyl hunting in this region focus on either economic/dietary or social/demographic concerns. While it is true that both the economic and the social aspects of human behavior are intricately intertwined, we are interested in exploring whether one of these two concerns provided the catalyst for the development of communal artiodactyl hunting in the Great Basin.

For example, if communal artiodactyl hunting represented a more efficient means to extract calories from the Great Basin ecosystem compared to hunting by smaller groups, then Darwinian

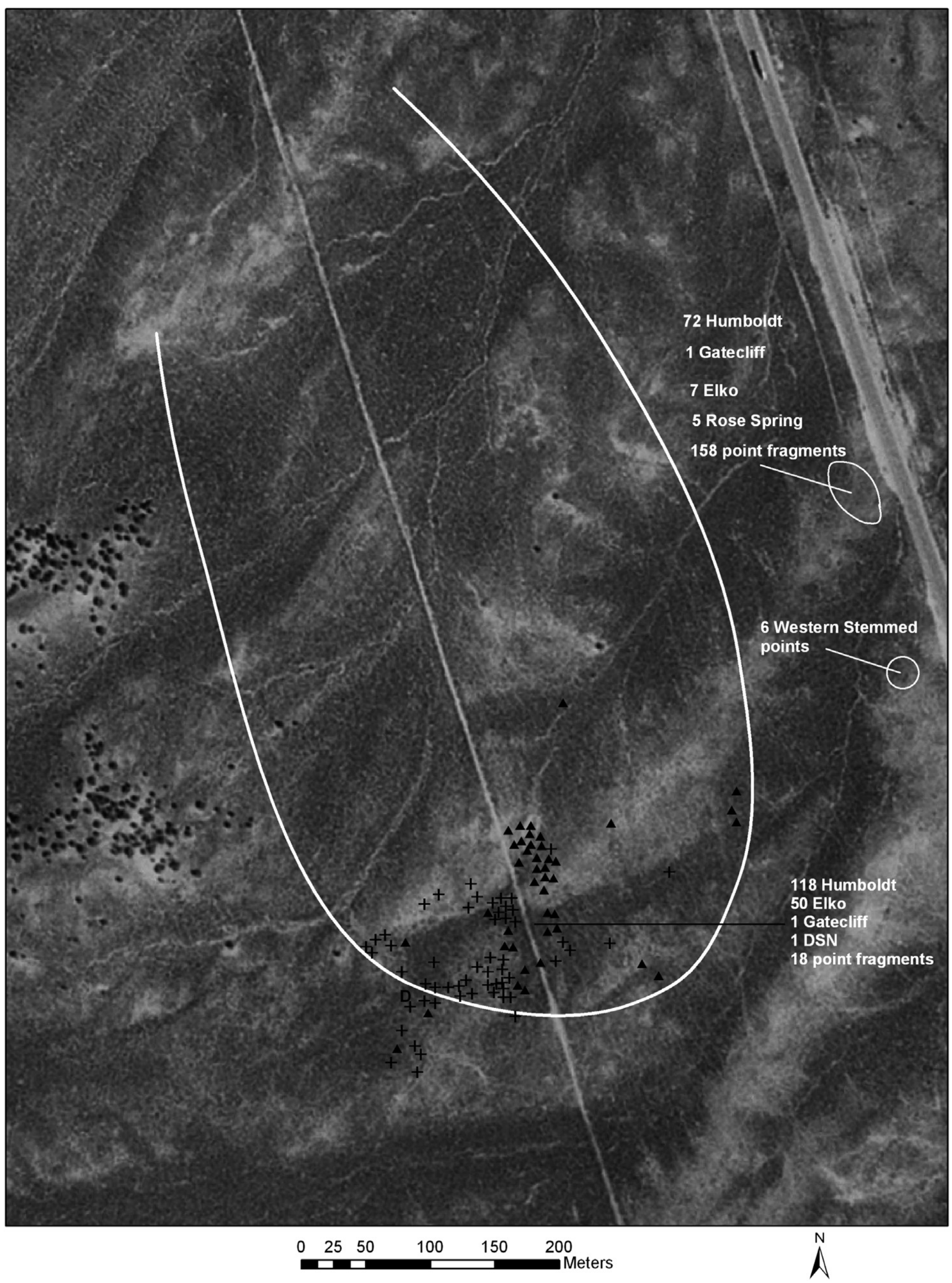


Fig. 1. The Valley Mountain pronghorn antelope corral, northeastern Nevada. Dense concentrations of Middle Archaic projectile points are located within and next to the existing corral, suggesting long-term use of the area for trapping artiodactyls.

Fig. 2. A section of the Fort Sage Drift Fence, western Nevada.

selection may have favored communal hunting because those individuals left more offspring than those who did not communally hunt. The cultural transmission of large-scale trap feature use would then be passed on to the next generation via the behaviors instituted to support their construction. Economic concerns, molded by Darwinian selection, would be the driving force underlying their development. Social activities carried out during these gatherings, while anthropologically relevant, would be secondary (e.g., "disturbing causes" or "ancillary variables"; see Hockett, 2012a) to understanding why large-scale trapping features were built. One issue with this approach is that evolutionary ecology models typically emphasize individualistic behaviors and selection at that scale.

In contrast, if social or demographic concerns were the driving force underlying their construction, then the economic benefits of the communal capture of artiodactyls would have developed as a means to support these social institutions. Communal artiodactyl hunting would have been one of several possible approaches to meeting the economic or nutritional requirements of Great Basin foragers. Communal artiodactyl hunting would have developed primarily to place family groups together in the same location in order to provide opportunities to arrange marriages, exchange information, engage in social activities related to the arts/music, secure leadership positions, and engage leaders in conflict resolution. Procuring the amount of food necessary to support these gatherings required seasonally abundant and predictable resources such as occur during antelope migrations, years that witnessed abundant jackrabbit (*Lepus californicus*) populations, fish spawning runs, and the ripening of pinyon pine (*Pinus monophylla*) nuts. Changing population dynamics, such as increases in population densities in some regions of the Great Basin following the harsh conditions of the Middle Holocene drought (ca. 9400–6000 cal BP), may have encouraged the planning for, and development of, these new social institutions. Communal artiodactyl hunting may not have offered an optimal means for individuals to extract calories from the environment, but it served as an adequate means to bring the group together and provide for communal feasts.

Similarly, social dynamics may have led to the development of communal bison hunting in the northern Plains (Walde, 2006). Walde (2006) proposes that the rise of communal bison hunting approximately 2000 years ago in the northern Plains, and hence the beginning of the construction of large-scale trapping features in that region, coincides with the rise and spread of tribally-organized and more complex political hierarchies in horticultural societies to the east. Walde sees no compelling economic reason for northern Plains foragers to abandon smaller group size, lower levels of political hierarchy, and greater mobility just prior to 2000 years ago. Communal bison hunting did not develop as a mechanism to efficiently extract calories from the northern Plains environment. Rather, the change may have been driven by social concerns as small-scale foragers sought to counteract pressure from expanding horticultural groups by adopting similar but distinctive political hierarchies as a means to maintain social identity and culture (Walde, 2006).

Bamforth (2011), however, recently suggested that the large-scale trapping of bison on the Plains may have been driven by a desire to overproduce skins and other items in order to expand trading networks. In the western Sierra Nevada region and the western Great Basin at historic contact, trade networks were widespread and well-established. For example, the Central Sierra Miwok traded for shell as far south as southern California. Across the Sierra Nevada mountains into western Nevada, the "Me-Wok traded baskets, bows, shell beads, paint, arrows, acorns, manzanita berries, soaproot leaves, redbud sticks, and berries to the Washo and Paiute. The Washo and Mono [Paiute] in turn traded skin robes and blankets, salt, pine nuts, baskets, paint, pumice stone and moth caterpillars" (Davis, 1961:17, 42; Shelly Davis-King, 2006). The large-scale trapping of artiodactyls in the Great Basin also may have produced an overabundance of pronghorn, deer, or mountain sheep skins that could have been used in trading networks.

In order to address why communal large-scale traps were built in the Great Basin, we report the results of an experimental archaeology research project designed to model the time

Fig. 3. The flagstones that lie across the entrance of the Whisky Flat corral-fence.

requirements and work effort (in calorie expenditure) necessary to build rock-walled structures such as the Fort Sage Drift Fence. In addition, we provide an updated overview of the distribution, abundance, and design features of previously recorded large-scale traps in Nevada and surrounding east-central California and western Utah, and include complementary data sets that lead to a more complete understanding of these features, such as comparison of breakage patterns and degree of reworking of projectile point concentrations found at corrals and open-air camp sites. We also explore conceptual depictions of large-scale hunting features found in local rock art symbols, and whether these depictions represent the planning of communal efforts. These data provide the details necessary to judge whether communal artiodactyl hunting in the Great Basin may have been motivated primarily by economic or social concerns. Social concerns were the motivating factors behind the construction of large-scale trap features in the Great Basin.

2. Overview of large-scale traps in the Great Basin

More than 100 large-scale fences, corrals, and corral-fences have been discovered in the Great Basin between Mono Lake, California and the Bonneville Basin of western Utah (Fig. 4; Table 1). These features are not evenly distributed across the region. A majority of them are located in northeastern Nevada east of the Ruby Mountains, and in western Nevada between Walker and Mono Lakes (Fig. 4). Other traps are located in central Nevada. Interestingly, only one fence (Player Ridge) and no corral-fences have been found in northeastern Nevada. The remainder of the large-scale traps there are corrals, and are made of wood only, except for the D.C. Corral and the Wendover Trap. The northeastern Nevada corrals do not contain features known as ‘flag stones’ (Fig. 3), which consist of a linear row of flat rocks placed across the entrance to a corral. None of the corrals from this region are directly associated with rock art panels, except at Debs Canyon (see

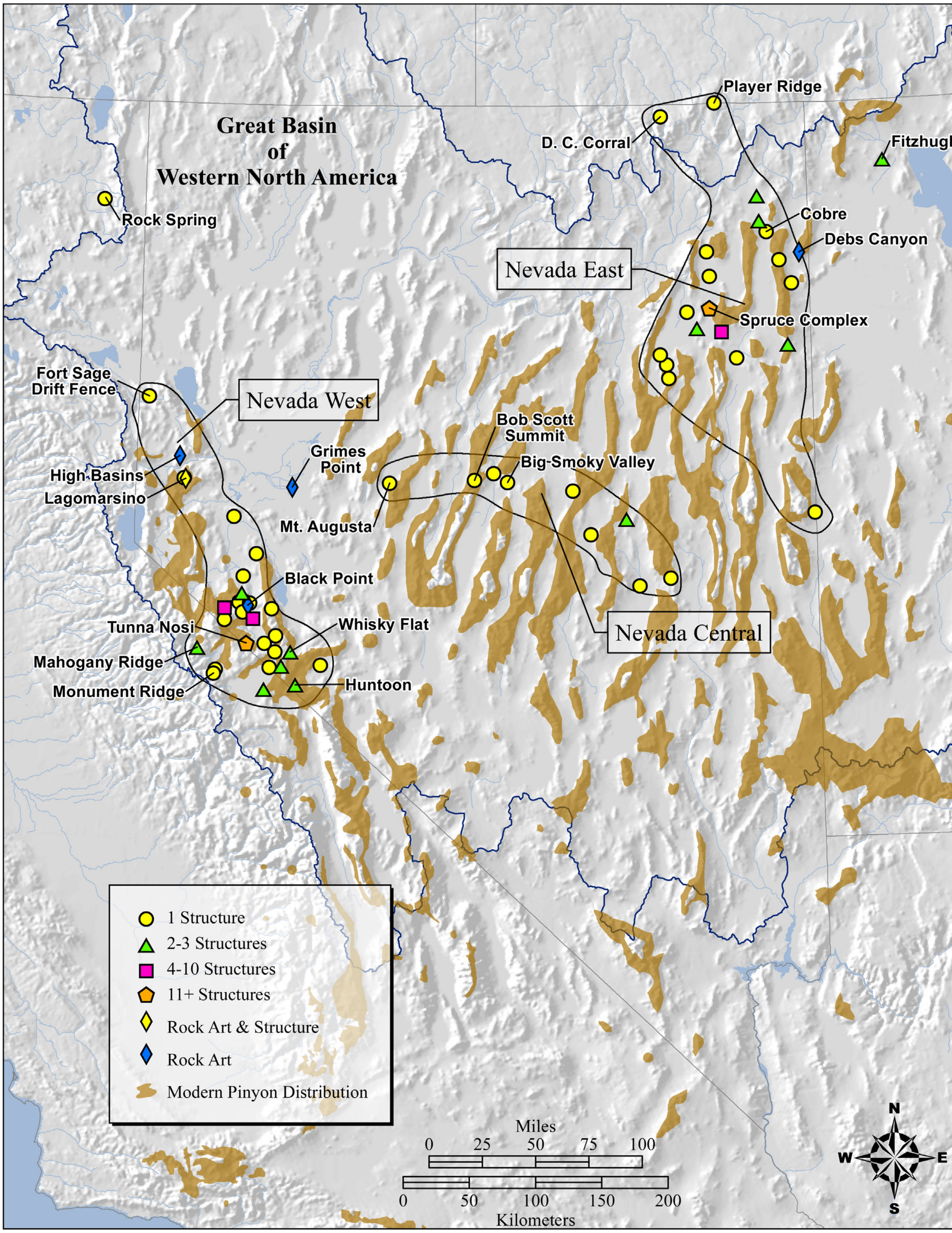


Fig. 4. The locations of the large-scale trapping structures and rock art sites discussed in the text. The correlation of the northern distribution of large-scale trapping features located within the boundaries of the Great Basin physiographic province and the northern distribution of pinyon pine is evident.

rock art section below). In contrast, corrals, fences, and corral-fences are all found in western Nevada. Most of the corrals and corral-fences from western Nevada consist of both rock and wood, or, in the case of some fences, rock only. Some of those made of only rock may have had wooden posts at one time, but are too old for any remnants of wood to have survived into the 20th and 21st centuries. Flag stones are found at a number of western Nevada corrals, such as Whisky Flat, Huntoon, Excelsior, Aldrich Grade, and Mono Lake. Many large-scale structures from this region are directly associated with rock art panels.

Table 1
Design features and associated projectile point concentrations of the large-scale trapping features of the Great Basin.[a]

Trap name	Type	Material	# Features	Point types associated	Notes
100	Fence	Rock	1		Rock art
Aldrich Grade 1	Corral	Rock/wood	1		
Aldrich Grade 2	Fence	Rock	1		Flagstones
Alkali Lake	Corral	Rock/wood	1	Late Archaic	Desert Side-Notched
Anchorite Pass 1	Fence	Wood	1	Middle Archaic	Humboldt, dart points
Anchorite Pass 2	Corral	Rock/wood	1	Middle/Late Archaic	Rose Spring, Elko points
Big Smoky Valley	Corral	Rock/wood	1		
Black Mountain	Fence	Rock	1		
Bob Scott Summit	Fence	Rock	2	Middle/Late Archaic	Rose Spring, Humboldt, Leaf-shaped points
Border	Corral	Rock/wood	1		
Borealis Mine	Corral	Rock/wood	1		
Butte Valley	Corral	Wood	1		
Cambridge	Fence	Rock	1		
Clover Valley	Corral	Wood	1		
Cobre	Corral	Wood	1	Early/Middle/Late Archaic	Desert Side-Notched, Rose Spring, Eastgate, Elko, Humboldt, Gatecliff, Large Side-Notched
Currant Mountain	Fence	Wood	1		high altitude; likely deer trap
Currie Hills	Corral	Wood	1		
D. C. Corral	Corral	Rock/wood	1	Middle/Late Archaic	High altitude; deer trap
Dry Lake Flat	Corral	Wood	2		
East Walker Lake	Corral	Rock/wood	1		
Easy Junior	Corral	Wood	2		Concentration of Elko/Rose Spring points nearby; likely an Early Late Archaic trap spot
Excelsior	Corral	Rock/wood	1	Early/Middle Archaic	Large Side-Notched, Gatecliff points; flagstones; bow stave trees
Fish Lake Valley	Corral	Rock	1		
Fitzhugh	Corral	Wood	2	1 unidentified	
Fivemile Draw	Corral	Wood	3		
Fort Sage	Fence	Rock/wood	1	Middle/Late Archaic	Desert Side-Notched, Rose Spring, Eastgate, Elko, Gatecliff
Garden Canyon	Corral	Rock/wood	3	Middle/Late Archaic	Desert Side-Notched, Elko
Hendry's Creek	Fence	Rock	1		
Hilton Ranch	Fence	Rock	1		Rock art
Huntoon	Corral	Rock/wood	2	Middle/Late Archaic	Desert Side-Notched, Rose Spring, Eastgate, Elko, Humboldt present; flagstones; bow stave trees
Lagomarsino	Fence	Rock	1		Rock art; points present but unknown
Locus 191	Fence	Rock/wood	1	Middle/Late Archaic	Rose Spring, Elko, Gatecliff
Mahogany Ridge	Corral/fence	Rock	2		
Maverick	Corral	Wood	1		
McCabe	Corral	Wood	1		
Mizpah Complex	Corral	Wood	4	Middle/Late Archaic	Desert Side-Notched, Rose Spring, Elko, Humboldt; concentrations of Elko, Gatecliff, Humboldt points nearby
Mono Lake	Corral	Wood	3	Late Archaic	Desert Side-Notched, Cottonwood nearby; flagstones
Monument Ridge	Fence	Rock/wood	1		
Mount Augusta	Fence	Rock/wood	1	Early/Middle/Late Archaic	Rose Spring, Elko, Humboldt, Gatecliff, Large Side-Notched; 125 rock cairns; high altitude probable mountain sheep trap
Mount Grant	Corral	Rock/wood?	1		
Mud Springs	Corral	Rock/wood	2	Middle/Late Archaic	Elko point
Murdoch Mountain	Corral	Wood	1		
Mustang Spring X	Corral	Rock	1		
Player Ridge	Fence	Rock	1	Early/Middle/Late Archaic	Rose Spring, Elko, Humboldt, Gatecliff
Railroad Valley	Corral	Wood	1		
Ring Lake	Corral	Rock/wood	1	Middle Archaic	Elko, Pinto; bow stave trees
Rockland	Corral	Wood	1		
Rock Spring	Corral	Rock	1	Middle Archaic	Dart/Spear points
Round Mountain	Corral	Rock/wood	1		
Ruby Wash	Corral	Wood	1		
Safford	Corral	Wood	1		
Silver Zone	Corral	Wood	1		
Spruce Complex	Corral	Wood	14	Early/Middle/Late Archaic	Desert Side-Notched, Rose Spring, Eastgate, Elko, Gatecliff, Humboldt, Large Side-Notched; dozens of concentrations of Elko, Gatecliff, Humboldt points nearby
Summers Creek	Corral	Rock/wood	1		
Thorpe	Corral	Wood	1	Late Archaic	Desert Side-Notched
Toano Draw	Corral	Wood	1		
Tobar	Corral	Wood	1		
Tunna Nosi (corrals)	Corral	Rock/wood	5	Middle/Late Archaic	Desert Side-Notched, Rose Spring, Eastgate, Elko, Gatecliff, Humboldt; rock art
Tunna Nosi (fences)	Fence	Rock/wood	9	Middle/Late Archaic	Desert Side-Notched, Rose Spring, Eastgate, Elko, Gatecliff, Humboldt; rock art
Wabuska	Corral	Rock	1		
Wendover	Corral	Rock/wood	1	Middle/Late Archaic	Desert Side-Notched, Rose Spring, Elko, Gatecliff, Humboldt

(*continued on next page*)

Table 1 (*continued*)

Trap name	Type	Material	# Features	Point types associated	Notes
Whisky Flat	Corral	Rock/wood	1	Late Archaic	Desert Side-Notched; flagstones; rock art
White Horse Pass	Corral	Wood	3		
Wichman	Corral	Rock/wood	1	Late Archaic	Desert Side-Notched, Rose Spring; rock art
Wylie	Fence	Rock	1		

[a] Data based partially on: Rudy (1953), Thomas and McKee (1974), Murphey (1980), McCabe (1982), Raymond (1982), Pendleton and Thomas (1983), Murphy and Frampton (1986), Wilke (1986, 1988), Parr (1989), Hall (1990), McGuire and Hatoff (1991), Simms (1993), Arkush (1995), Arkush (1999a,b), Hockett (2005), Jensen (2007), Hockett and Murphy (2009), Young (2010), Giambastiani and Sibley (2011), Nissen (1975), Nilsson et al. (2012), Patsch et al. (2012), Pellegrini and Shipley (2012), Scott and Oyarzun (2012) and Shaw (2012a,b).

The topographic locations of the large-scale trapping features in Nevada suggest that pronghorn, deer, and mountain sheep were captured communally. In eastern Nevada, most of the corrals are located in valley bottoms or on gentle slopes just above the valley floor. This suggests that pronghorn was the targeted species. Two eastern Nevada outliers are the D.C. Corral, located in the uplands of the Jarbidge Mountains, which was used to capture herds of deer (Simms, 1993), and the Player Ridge fence, which was likely used to drift mountain sheep (Nilsson et al., 2012). In central Nevada, upland fences such as Mt. Augusta and Bob Scott Summit are located in environments frequented by mountain sheep. The western Nevada/eastern California traps are located on valley bottoms suggesting pronghorn capture, as well as in upland environments along known deer migration corridors.

Projectile point concentrations associated with wooden corrals in eastern Nevada consist of Late Prehistoric types manufactured at historic contact (e.g., Desert Side-Notched, ca. 700–150 years ago), early Late Archaic types (initial bow-and-arrow technology, e.g., Rose Spring and Eastgate; ca. 1500–700 years ago), and earlier Middle Archaic types (atlatl and dart/spear technology, e.g., Gatecliff, Humboldt, and Elko types; ca. 5000–1500 years ago) (Table 1). Two corrals (Cobre and Hill) from eastern Nevada contain concentrations of Early Archaic types (e.g., Large Side-Notched; ca. pre-5000 years ago). These point concentrations likely represent the remnants of now-decayed large-scale trapping features, and suggest long-term use for the past 5000 years or more in this area of the Great Basin (Petersen and Stearns, 1992; Hockett, 2005; Hockett and Murphy, 2009; Arkush, in preparation).

Similarly, the traps of western Nevada show evidence of relatively recent use during the past 700–800 years at sites such as Whisky Flat and Mono Lake (Wilke, 1986; Arkush, 1995), and also earlier use during the Middle Archaic at sites including the Fort Sage Drift Fence, Wichman Corral, Mud Springs Corrals, Anchorite Pass Fence and Corral, Bob Scott Summit Fence, Huntoon Corral, and those at Tunna Nosi (Thomas and McKee, 1974; Pendleton and Thomas, 1983; Parr, 1989; Hall, 1990; this report). Further, Early Archaic use is indicated at the Mt. Augusta Fence (McGuire and Hatoff, 1991), and a concentration of catastrophically shattered Large Side-Notched points was located near the wall of the Excelsior Corral during a recent (June, 2012) visit to the site. These data from eastern Nevada and western Nevada/eastern California suggest that communal hunting began in the Great Basin by 5000 years ago, during the latter part of the Middle Holocene, and continued to historic contact about 150 years ago.

3. Were rock-walled fences and wood/rock corrals in the Great Basin large-scale trapping features?

The fact that the construction of wooden corrals required multi-family effort is aptly documented in the ethnographic literature (see reviews in Arkush, 1986; Hockett and Murphy, 2009). No ethnographic examples of fence construction are known; significantly, this may mean that the fences of the Great Basin were constructed prior to the Late Prehistoric Period (before ca. 700–800 years ago). Indeed, relatively few Desert Side-Notched points are associated with rock-walled fences. Instead, the points associated with them generally consist of early Late Archaic, Middle Archaic, and Early Archaic types (see Table 1).

Nevertheless, few mathematical models have generated data on the human work effort required to construct large-scale fences or corrals, nor have models estimated the number of animals that would need to be captured in order to equal that work effort and feed the group. These baseline or 'first-order' data also are significant because previous research on rock drive lines or fences in the Arctic regions (e.g., Benedict, 2005; Brink, 2005; Fox and Dorji, 2009) suggest that less than 10 people constructed these features in a matter of a few hours.

Did the fences and corrals of the Great Basin require communal effort? If so, could they be constructed in a matter of a few hours? In order to answer these questions, we built an experimental section of fence mimicking the Fort Sage Drift Fence (FSDF). Eleven volunteers spent 2 h building an experimental section of FSDF. The fence was built to the specifications of a typical section of the FSDF: (1) 1 m in height and 1 m in width; and (2) rocks greater than 30 cm in diameter were used to form the two outer walls of the fence, with smaller rocks (generally 5–20 cm in diameter) used as middle "filler" to form a singular 'block' of rock wall (Fig. 5).

3.1. *How many days would it have taken to build the FSDF by an individual in a single event?*

The experimental fence was constructed by 11 people (seven men and four women) who ranged in age between 20 and 66 years. Working nearly continuously for 2 h, we constructed a rock fence measuring 14.5 m in length, or an average of 7.25 m of fence per hour. This translates to an average of 0.66 m of fence per person per hour. Using this figure as an estimate for the time it took to construct the FSDF, and given that 1093 m of rock wall was constructed prehistorically, it would have taken one person 1656 h to construct the FSDF. This translates to about 69 days, or nearly 2 1/2 months working 24 h per day.

Building the experimental FSDF was exhausting work, even for a fit group of people who regularly run, ride bicycles, hike, and swim. We think it unlikely that more than 2 h per day could have been expended prehistorically to build the FSDF, especially when accounting for the fact that these 2 h required approximately 900 extra calories per person to support the work effort. This is based on the number of calories expended by similar work efforts over a 2 h period, including carrying bricks (1086 calories), shoveling snow (817 calories), and vigorous weight lifting (817 calories) (www.prohealth.com/weightloss). If 2 h per day were committed prehistorically, then it would have taken an individual 828 days, or 2 years and 3 1/4 months to construct the entire FSDF. Four hours a day would have required an additional 1800 calories per day in addition to the base calories required for survival, and still would have taken a single person 414 days, or more that 13 1/2 months to construct the fence.

Fig. 5. The experimental Fort Sage Drift Fence.

3.2. How many people would be needed in order to build the FSDF in a communal effort in a single event, or over the course of several events?

Large-scale group events documented ethnohistorically in the Great Basin often involved 20 or more people, and some accounts state that 50 people were required to construct a juniper-and-sagebrush antelope corral and associated wings. These communal gatherings often lasted for two weeks or longer. Jensen (2007) places the numbers between 70 and 225 individuals, with a mean of 133 participants based on a review of the ethnographic literature. If we assume, first, a modest number of 40 individuals congregated in a 14-day communal event with 20 of those individuals involved in constructing the fence for 10 of those days, then this group could have constructed 13.2 m of rock wall per hour. Working 2 h per day, then, the group would have taken about 41.4 days to construct the FSDF. At this level of work, the fence could have been constructed in four 14-day sessions. Each building session would have resulted in the construction of about 275 m of wall.

3.3. How many calories were required to build the FSDF?

Constructing the FSDF wall would have required about 450 extra calories per hour (or 900 extra calories every 2 h per person), given current estimates of similar work effort. Our estimate that it took 1656 person hours to construct the rock fence, then, would require approximately 745,000 extra calories.

To state this another way, it would take about 208 person-days, working 2 h per day, to construct 275 m of fence, at the extra cost of one-quarter of the 745,000 total calories required to build the entire fence, or about 186,000 calories (Table 2). Over the 208-day period, then, the individual would expend about 520,000 calories in base energy needs plus the 186,000 calories spent in building wall, for a total expenditure of 706,000 calories (Table 2, row 1). In contrast, for 40 people gathering for 14 days, approximately 1.6 million calories would be required to support the group (Table 2, row 2).

Table 2
Calorie (cal) requirements for an individual or communal group to build 275 m of rock alignment (FSDF specifications) or one juniper-sagebrush corral in the Great Basin.

# Individuals	BMR forager cals[a]	PAL[b]	Daily cals + extra cals to build fence	Cals during gathering	# Pronghorn required to equal cal work	# Pronghorn eaten/person to equal cal work	# Pronghorn eaten/person without building; 14-day gathering
Fort sage drift fence – Rock Alignment[c]							
Individual 1 person	1400	1.8	(2500 cals × 1 person × 208 days) = 520,000 cals (base) + 186,000 cals (building)	706,000 cals	31 animals	31 pronghorn = 697,500 cals = 3370 cals/day/individual	n/a
Communal 40 people (20 people building)	1400	1.8	(2500 cals × 40 people × 14 days) = 1.4 million cals (base) + 186,000 cals (building)	1.586 million cals	70 animals	1.75 pronghorn/person = 39,375 cals/person = 2813 cals/day/person	62 animals
Juniper-Sagebrush Corral or Trap[d]							
Communal 50 people (35 people building)	1400	1.8	(2500 cals × 50 people × 14 days) = 1.75 million cals (base) + 145,000 cals (building)	1.9 million cals	84 animals	1.68 pronghorn/person = 37,800 cals/person = 2700 cals/day/person	78 animals
Communal 133 people (64 building)	1400	1.8	(2500 cals × 133 people × 14 days) = 4.655 million cals (base) + 145,000 cals (building)	4.8 million cals	213 animals	1.6 pronghorn/person = 36,000 cals/person = 2571 cals/day/person	207 animals

[a] BMR = Basic Metabolic Rate for an average forager.
[b] PAL = Physical Activity Level, expressed as a function of BMR, for an average forager.
[c] Assuming 450 calories/h expended during construction.
[d] Assuming 350 calories/h expended during construction.

3.4. How many pronghorn antelope would be needed to provide the number of calories required to build the FSDF?

Pronghorn weigh an average of about 55 kg (between 100 and 150 pounds). Their field-dressed weight is about 35 kg (77 pounds), and about 47% of this weight is edible tissue, or an average of 16 kg (36 pounds) per animal (Benson, 2010). Viscera and marrow would also have been consumed prehistorically. McCabe et al. (2004), citing Roll and Deaver (1980), suggest that a pronghorn would have contributed 45,000 total calories in meat and internal organs. However, this figure is probably in error. McCabe et al. (2004:20, Table 1) give a total edible weight for a pronghorn, including viscera, of 19.5 kg (43 pounds), which aligns rather well with Benson's (2010) 16 kg (36 pounds), the latter of which takes into account edible muscle tissue only. If we assume, then, that about 20 kg of edible food is available per average pronghorn, and each 100 g of pronghorn meat offer approximately 114 calories (US Dept. of Agriculture, 2012), then about 22,500 calories are available for human consumption per individual pronghorn.

Based on this estimate, about 70 pronghorn would need to be captured along the FSDF and consumed by the 40 people during a 14-day communal event (see Table 2, column 6). In contrast, an individual would need to kill 31 pronghorn over a 208-day period in order to construct 275 m of fence. This equates to about 3370 calories per day (Table 2). While this is a reasonable caloric intake, an individual would need to continuously stay at the FSDF for more than six months, killing and eating an entire pronghorn every six days to construct one-quarter of the FSDF.

3.5. Based on our model, was the FSDF likely constructed in a single event or in sections over some length of time? Was it likely constructed by an individual or by communal groups?

Using these figures for one-quarter of the total fence construction by an individual and by a group of 40, the costs in time and calories to build the FSDF in a single event may be estimated. Communally, it would require approximately six million calories and 35–40 days to construct the entire FSDF. This would equate to about 280 pronghorn. Capturing nearly 300 pronghorn may have been possible at times, especially when they herd together in winter (Einarsen, 1948), but 40 people staying in the FSDF area for more than a month is highly unlikely. Individually, it would require about 2.6 million calories and 828 days (more than two years) to construct the entire FSDF. This would equate to about 116 pronghorn.

The problem faced by both the individual and the group is not the number of calories *per se*, but the feasibility of camping along the FSDF for an appropriate amount of time given the availability of the resource. Pronghorn likely would have been available for capture during a relatively short period of time as they migrated through the region to spring/summer and fall/winter forage. A communal group of 40 individuals building 275 m of fence, camping there for 14 days while capturing and consuming 70 pronghorn seems reasonable. This communal group camping along the fence for more than a month in order to build the entire 1093 m of fence in a single event, while capturing and consuming nearly 300 pronghorn is less feasible. An individual camping at the FSDF for more than two years is simply beyond reason. Therefore, we conclude that the FSDF was constructed by communal groups, in sections, over some length of time.

3.6. What are the costs of constructing juniper-and-sagebrush corrals?

In a review of the ethnographic literature on communal pronghorn antelope drives, Jensen (2007) suggested that the average corral took 64 people to construct, with an average of 133 individuals in attendance. Jensen (2007) also suggested that an average-sized corral (1200 m of linear corral wall) would take about 1590 h to build, which is very similar to our estimate of 1656 h to construct 1093 m of linear rock fence (FSDF specifications). Corrals would have also required wing construction, which were generally less labor intensive and made of sagebrush, although they were at times over two miles in length. Based on our estimates, 64 people could construct a corral in 25 h, so this group could construct a corral in the same 10-day period as it took to build a 275 m section of FSDF if they also worked 2 h per day as was modeled for the FSDF. If we also assume that corral building required about 25 percent fewer calories per hour (350 calories expended per hour) compared to building a rock fence, then Table 2 (row 4) shows that approximately five million calories would be needed to sustain a group of 133 individuals over a 14-day period. This equates to 213 pronghorn captured and consumed to equal calorie expenditure.

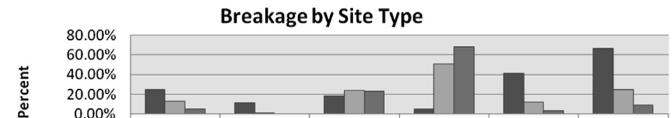
Several ethnographic accounts suggest that corral building was accomplished by less than 100 people, and one publication simply stated that at least 50 people were required (see Hockett and Murphy, 2009). If we model 50 individuals attending a 14-day communal gathering, with 35 people engaged in corral construction, then 84 pronghorn would need to be captured and consumed to equal the calorie expenditure (Table 2, row 3).

4. Analysis of projectile point concentrations

Projectile point concentrations associated with large-scale trapping features present a unique research opportunity, as they provide data specific to a single activity over time. Hockett and Murphy (2009) provided general projectile point breakage pattern data (e.g., numbers of tips, midsections, bases, and complete points present) for 13 sites containing greater than 20 points that were directly associated with corrals located in northeastern Nevada. Hockett and Murphy (2009) concluded that most of these point concentrations were "kill spots" rather than dehafting sites where foreshafts or arrows were retrieved following a kill made elsewhere. The Antelope Ridge B site, however, was interpreted as a dehafting site due to its large percentage of bases compared to complete points, tips, and midsections, similar to the Town Creek Site located to the north of the Spruce Mountain Trap Complex (Petersen and Stearns, 1992). The analysis below compares and contrasts point breakage data from concentrations located within existing trap walls, the Antelope Ridge B site (dehafting), and a campsite complex located in Pine Valley, northeastern Nevada in order to interpret whether point concentrations at trap sites differ from dehafting and campsites.

The Pine Valley campsite complex was originally excavated in 1984 by the Nevada Department of Transportation, and was selected for study because the point types encompass date ranges similar to those found at the Spruce Mountain Trap Complex. The Pine Valley complex was identified as a series of semi-permanent campsites based on the presence of groundstone, well-developed hearth features, and lithic manufacture and repair evidence.

The results are presented in Figs. 6–8. The Pine Valley campsites contained 46% complete points and an array of fragmented points consisting of 28% tips, 20% midsections and 5% bases ($n = 252$; Fig. 6). The antelope trap sites analyzed ($n = 185$) contain far fewer complete points than the campsites (12%), about one-half the percentage of tips (13%), but greater percentages of both midsections (24%) and, especially, bases (51%). In contrast, the Antelope Ridge B dehafting site ($n = 57$) has a high percentage of bases (68%) compared to both tips (5%) and complete points (4%), but midsections are as abundant as at trap sites (23%). The proportions of complete, tips, mids, and bases of each site type were examined



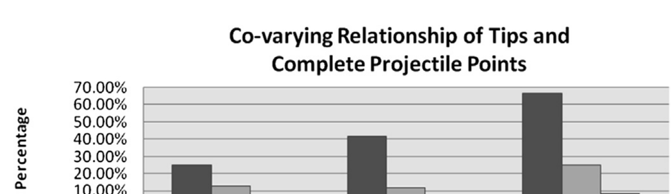
	Tips %	Lateral %	Mid %	Base %	Complete %	Tips&Complete
Campsite	25.00%	11.00%	18.00%	4.50%	41.50%	66.50%
Antelope Trap	13.00%	1.00%	24.00%	51.00%	12.00%	25.00%
Dehafting Site	5.00%	0.00%	23.00%	68.50%	3.50%	8.50%

Fig. 6. Projectile point breakage patterns from concentrations found at or near traps in northeastern Nevada, campsites from Pine Valley, and a dehafting site located within the Spruce Trap Complex.

using a chi-square test to determine if the difference in fragments is significant between the three site types. The differences were found to be highly significant $\chi^2 = 187.0428$, $p < .001$(df $= 6$, $n = 494$). Tips and complete projectile points co-vary at these sites (Fig. 7). The high overall percentage of complete points and tips at campsites likely results from tool manufacturing and butchering of carcasses at these longer-term occupation spots. The large presence of base fragments at the dehafting site is likely due to catastrophic failure of the points during hunting, and the lack of other activities being conducted on these relatively short-term sites. The more even distribution of all projectile point portions at trap sites (kill spots) can be explained by the catastrophic failure of many but not all points combined with a retrieval rate of less than 50% of foreshafts, as well as the fact that the campsites established during these communal hunts were located elsewhere.

Without wall features, then, how can large-scale traps be identified through the analysis of projectile points? The results of the breakage pattern study suggest they will be characterized by a relatively even distribution of complete points, tips, midsections, and bases compared to campsites and dehafting locales, as well as a spatial distribution pattern in a confined area on appropriate microtopography for trapping artiodactyls, as evidenced in Hockett and Murphy (2009).

Additionally, the degree of point reworking may also distinguish kill spots. The "use life" of projectile points, determined by the amount of reworking (Fig. 8), covers the span from newly made complete to heavily reworked points. Material sources used for the projectile points at the Spruce Mountain Trap Complex range from local sources such as Valley Mountain cherts (within one mile of traps) to distant sources such as Browns Bench obsidian (60 miles from the traps). Traps such as Cobre (Fig. 4) are located about equidistant between the Valley Mountain and Browns Bench lithic source areas. The traps located close to material sources such as the Spruce Mountain group reflect a higher percentage of "new" points with minimal signs of reworking, while the Cobre trap located further away from a material source has a higher percentage of reworked points. Nevertheless, as a group, the projectile points directly associated with the large-scale trapping features show



	Tips %	Complete %	Tips&Complete
Campsite	25.00%	41.50%	66.50%
Antelope Trap	13.00%	12.00%	25.00%
Dehafting Site	5.00%	3.50%	8.50%

Fig. 7. Relationship of tips and projectile points from trap, camp, and dehafting sites.

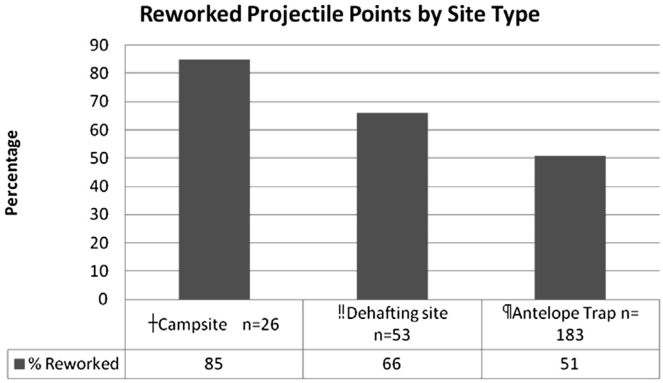


Fig. 8. Degree of reworking of the projectile points from trap, camp, and dehafting sites.

a much lower percentage of reworking compared to the Pine Valley campsites analyzed, suggesting that a general lack of reworking may be another characteristic that can be used to distinguish point concentrations created as a result of communal kills from those created through campsite activities.

5. Depictions of large-scale trapping in Nevada rock art

Depictions of zoomorphs and hunting objects such as the atlatl and nets in Great Basin rock art are well known and numerous (e.g., Steward, 1929; Heizer and Baumhoff, 1962; Nissen, 1982; Schaafsma, 1986; Quinlan, 2007). Particularly prevalent across western, east-central, and southern Nevada are depictions of individual artiodactyls or groups of artiodactyls. Heizer and Baumhoff (1962) noted that many rock art sites located in western Nevada are along large-game migration routes and deer and mountain sheep trails, and "very well situated for antelope drives" (Heizer and Baumhoff, 1962:216). They suggest hunters would have used blinds and rock ambushes, but also that several sites are associated with long rock walls where communal large-scale trapping likely occurred. Their interpretation was that rock art of the Great Basin was associated with "hunting magic" created by or under the direction of a hunting shaman or leader, and designed as spiritual aides to ensure a successful hunt or steady supply of game (Steward, 1941; Heizer and Baumhoff, 1962).

Whether we interpret rock art as hunting or settlement based, we deduce planning as an element of its production. A review of six of Nevada's petroglyph regions at High Basins, Black Point, Lagomarsino, Tunna Nosi, Debs Canyon, and Grimes Point (Ezra Mountain) (Figs. 9–12) provides examples of how specific rock art panels were used in the planning for communal construction of large-scale trapping features in some regions, but not in others.

East of the Spanish Springs area of Washoe County, Nevada, High Basins contains both a potential for a hunting landscape where pronghorn would have been prevalent in the past, and rock art images of bow and arrow (Fig. 9), atlatl, and artiodactyls. Among more than 1500 petroglyphs are specific panels that combine representational animals, hunting tools, and abstract images in the same areas where archaeological evidence supports residential activity (Quinlan, 2007).

At Black Point along the east Walker River in Lyon County, Nevada, researchers have long seen large-scale traps and hunting represented in the 800-plus images carved in a landscape well-suited to exploiting artiodactyls (Heizer and Baumhoff, 1962; Nissen, 1982; Young, 2010). For example, in the 1960s a hunter from Hawthorne, Nevada, reported to Heizer and Baumhoff (1962:212) that deer migrated "From the Wassuk Range across Whisky Flat to Garfield Flat and Huntoon Valley." This area contains known large-scale trap sites including Wichman, Camebridge, Whisky Flat, Huntoon, and Anchorite Pass, as well as the Black Point rock art site itself. Several game drive elements exist in the panels at Black Point, and support the relationship of large-scale hunting and rock art expression (Fig. 10).

The Lagomarsino site, located near Virginia City, Nevada, is adjacent to a large, perennial spring. A drift fence was constructed

Fig. 9. Petroglyph of an archer shooting a mountain sheep, High Basins, western Nevada. The bow string and arrow may postdate the original motif.

Fig. 10. Petroglyph of mountain sheep along a fence or corral wall at Black Point, western Nevada.

across the main drainage that contains the spring, and near the concentration of rock art panels. Baumhoff et al. (1958) published the first detailed descriptions of the Lagomarsino glyphs. More recently, the Nevada Rock Art Foundation (2012) finished a complete recordation of all the glyphs at Lagomarsino. The site is now known to contain 4600 motifs pecked into more than 2229 panels, which represents the greatest number of glyphs of any site known in Nevada (Nevada Rock Art Foundation, 2012). The vast majority of glyphs (80%) at the site are abstract images of unknown meaning. However, Lagomarsino contains five mountain sheep motifs, six representations of atlatls, and five motifs of hunting nets, some of which appear to have weights attached along the base (Nevada Rock Art Foundation, 2012:34, 50). The site also contains a panel of motifs representing corner-notched projectile points, as well as an unknown number of stylized mountain sheep horns first identified by Baumhoff et al. (1958).

Tunna Nosi, located near the historic town of Bodie along the California-Nevada border (Fig. 4), contains one of the two most numerous concentrations of large-scale structures known from the Great Basin. Rock art panels are found scattered throughout the region, but are particularly prevalent along known corrals and fences. Amongst the abstract images are depictions of mountain sheep horns, as well as possible large game trap structures.

Rock art sites are rarer in northeastern Nevada. One of the largest rock art sites known from the region, however, is the Debs Canyon site located in the Pilot Range near the Nevada-Utah border (Fig. 4). The site is located in the north–south trending ‘great corridor’ that contains all of the nearly 40 large-scale structures known from the region. The degree of patination of the motifs at the site range from deep black to nonexistent, suggesting a deep time range for their production. The glyphs at Debs Canyon are overwhelmingly dominated by hunting-related images, including

Fig. 11. Three figures all displaying pronghorn antelope horns, Debs Canyon, northeastern Nevada.

Fig. 12. Anthropomorph displaying mountain sheep horns, Debs Canyon, northeastern Nevada.

zoomorphs such as mountain sheep, pronghorn, deer, and bison, as well as several images of anthropomorphs (e.g., 'dancers', 'shamans', 'spirits') that are either half-human-half-artiodactyl or humans wearing artiodactyl headdresses (Figs. 11 and 12).

In contrast, at Grimes Point and other sites on Ezra Mountain east of Fallon, Nevada, images of the atlatl, but not of artiodactyls, are among the thousands of petroglyphs. This did not restrict Heizer and Baumhoff (1962:20) or Nissen (1982) from suggesting that enhancement of large game animal hunting was a primary reason for creating the images there, both for the post-4000 B.P. representational styles, and for the earlier abstract and pit-and-groove petroglyphs. However, the Grimes Point area now lacks artiodactyls, is not known to have served as a large game migration corridor, and is instead a consistent marsh-oriented environment. We do not see this landscape, which is presently "ill-suited for the ambush of game" (Nissen, 1982:382), as connected to large game hunting, and this is reflected in its rock art panels through a lack of representational images combining hunting weapons and artiodactyls.

We interpret that the planning for large-scale trapping through rock art symbols in western and northeastern Nevada allowed for transmittal of a construct beyond the verbal moment and likely maintained ownership or leadership of the concept for communal social benefits. The people that created the rock art held a mental image of what they wished to convey, they illustrated that image, and the illustration was within a shared social and cognitive construct among a larger community. We suggest that the expression of large-scale, community-based hunting through rock art influenced the opinion of the style and purpose of corral and wall construction, and provided leadership with a platform for instructing the group.

6. Discussion and conclusion

In the final analysis, the effort to construct large-scale traps leads us to conclude that social/demographic concerns were the driving force behind communal artiodactyl hunting. Whether the FSDF or juniper-sagebrush corrals were built individually or communally hinges on feasibility and functionality rather than calorie savings or surplus. It is simply not possible for an individual or a single-family to construct such features in the time necessary to have a successful hunt and procure the necessary animals to sustain human life. Working communally by pooling the labor of 7–10 families or more, however, allowed groups to build functioning large-scale traps that were capable of capturing the food necessary to sustain social gatherings.

If 50 to 200 pronghorn represents the typical number of animals captured during a 14-day communal gathering, then our modeling exercise suggests that the average group size that would result in a successful event would probably range between 40 and 75 people, with an average of perhaps 60 to 75 individuals in attendance. This would represent at least 7 to 10 families consisting of an average of 6–8 people per family group. If these were 'men-only' affairs, then more than 7–10 families would be necessary to pool enough males to build these structures and perform a successful capture. This does not rule out the possibility, however, that at times hundreds of artiodactyls may have been captured by 100 or more people attending a communal event. This, in turn, suggests that comparatively large population densities existed in what is now northeastern and west-central Nevada where these features are concentrated. For example, an 1860s census suggested that the population of Washoe, Paiute, and Shoshone in Nevada numbered approximately 8,000 (Train et al., 1941). Depending upon past population densities, then, it is possible that one percent or more of the entire population of present-day Nevada were present at some of these communal gatherings.

There is no compelling evidence that large-scale structures in the Great Basin would be built as optimal energy capturing devices, a conclusion also reached by McCabe et al. (2004) and Jensen (2007). In addition, modeling the amount of calories required during these communal gatherings without fence or corral construction does not change the number of pronghorn required to be captured and consumed in a significant way (Table 2, final column). Once built, the FSDF would still require over 60 pronghorn to be captured by 40 people over a 14-day period; similarly, almost 80 pronghorn would need to be captured and consumed by a communal group of 50 people reusing a corral. There is no way to determine just how many pronghorn were typically captured during these communal events. But these data suggest that less than 80 animals might result in a net loss of calories. Capturing a surplus of food to store for winter consumption does not appear to be the driving force behind their construction.

Consuming other food items during these communal events would be absolutely necessary from a nutritional point of view (e.g., Hockett, 2007, 2012a,b; Hockett and Haws, 2005), and would also serve to provide a buffer against low numbers of fence or corral kills. It may be more than coincidental that the northern distribution of large-scale traps in the Great Basin physiographic province strongly correlates with the northern distribution of pinyon pine trees (Fig. 4). This, in turn, may suggest that pinyon pine seed harvest was an important economic activity during these communal gatherings.

Structures such as the FSDF and juniper-sagebrush corrals were built communally to take advantage of predictable resources in greater abundance during specific times of the year, and to tie these natural events to social gatherings which were used to strengthen alliances (conflict avoidance), exchange information, and match-make for marriages. These social structures may be expressed in the "abstract" rock art symbols that occur alongside images of hunting-related behaviors at sites such as Lagomarsino, Tunna Nosi, and Black Point. These communal events did not require a complex political hierarchy – but it did require leadership skills that extended beyond single-family units. These leadership abilities also may have been codified in rock art symbols in the Great Basin.

The differences in construction materials and feature type between the large-scale traps of western Nevada/eastern California and eastern Nevada/western Utah inform on a sociocultural boundary break. These data suggest a long-standing cultural divide or separation of influence between the western and eastern Great Basin, with a north–south line drawn somewhere in the heart of the central Great Basin. The separation may be political, a reflection of the daunting topography of hydrographic sinks and high mountain ranges present in central Nevada, or both.

Large-scale trapping features are concentrated in northeastern Nevada and extreme west-central Nevada. Conspicuously rare are large-scale trapping features in southern and central Nevada, and as we have noted, the rock art of the central region generally lacks the imagery we interpret as planning for large-scale artiodactyl hunting. This may reflect where the largest concentrations of migrating herds of pronghorn, mountain sheep, and deer were consistently found in the Great Basin. Families could have traveled long distances to attend these communal affairs, so a dearth of features in one area of the Great Basin does not necessarily mean that those families did not participate.

This distribution may also reflect uneven population dynamics across the Great Basin, which in turn may help to explain the origins of communal large-game trapping in this region. Following the 3000-year drought of the Middle Holocene/Altithermal that began approximately 9,400 years ago (8300 ^{14}C BP) (e.g., Louderback et al., 2011), climatic conditions in the Great Basin began to ameliorate between 5000 and 6000 years ago. Sites that were largely abandoned during the Middle Holocene (e.g., Bonneville Estates Rockshelter, Hockett, 2007) were occupied with greater intensity, and many sites across the Great Basin were occupied for the first time (e.g., Swallow Shelter, Pie Creek Shelter, Lower South Fork Shelter). A population pulse is suggested for many, but not all, regions in the Great Basin 1000 to 1500 years prior to the onset of the cool and moist 'Neoglacial' phase (ca. 3500–2650 years ago) that expanded marshland habitats in western Nevada, creating the archaeologically visible "Lovelock Culture." Increased population densities across the Great Basin likely changed social dynamics among the region's foragers, including greater contact and interactions amongst family groups and leaders of those groups, and perhaps altered or strained subsistence boundaries. The kinds of social interactions and group size necessary for a successful communal trapping of large game through the construction of large-scale features, likely rendered impossible during the Middle Holocene, became possible at the end of the Middle Holocene and the beginning of the Late Holocene. Large-scale trapping of artiodactyls may have been one way to cope with new social constraints brought on by increasing population densities. One of the benefits resulting from communal hunting may have been conflict avoidance; indeed, there is scant evidence for deadly conflict at any time in most regions of the Great Basin.

Once established, large-scale communal hunting of artiodactyls became fixed in Great Basin prehistory. During the "good times" of the late Middle Holocene/early Late Holocene (including the Neoglacial) (Elston, 1982), large-scale trapping features were constructed and communal hunting occurred at places like Spruce Mountain in northeastern Nevada, Mt. Augusta and Bob Scott Summit in central Nevada, and Fort Sage, Anchorite Pass, and Tunna Nosi in western Nevada. It appears that both pronghorn (in the lowlands) and mountain sheep and deer (in the uplands) were targeted for communal capture throughout the Middle Archaic. Approximately 1500 years ago, bow and arrow technology entered the Great Basin, as did rather dramatic changes in culture and climate. Eastgate arrow points were manufactured along with Elko dart points, use of local toolstone sources signaled increasingly restricted territories, and the Neoglacial was replaced with a summer precipitation pattern that dried up marshlands but expanded grasses. Bison populations expanded in the Great Basin, but there is no evidence for the communal hunting of this animal. Instead, the communal corralling of pronghorn continued at sites such as Anchorite Pass in western Nevada and Spruce Mountain in northeastern Nevada. The summer precipitation pattern ended in the Great Basin, along with the "Eastgate/Rose Spring" archaeological pattern, between about 700 to 800 years ago. Toolstone from distant sources become more commonplace at individual sites, suggesting a broadening of foraging boundaries and/or trade. Bison largely disappeared from most regions as grass densities reduced. Desert Side-Notched points replaced the Eastgate/Rose Spring pattern. Communal large-scale trapping of artiodactyls, however, continued unabated, as corrals and fences continued to be used and new ones were constructed across the Great Basin.

Social interactions driven by population dynamics may have spawned communal large-scale trapping of artiodactyls in the Great Basin, but increasing population densities may not have been the reason for the continuance of the practice for more than 5000 years. Communal large-scale trapping transcended major fluctuations in climate and changing cultural identities in the Great Basin. The social interactions made possible by communal hunting, including conflict avoidance and alliance-building, match-making, and celebration, organized and executed by leaders, may have been one of the primary constants during an ever-changing social and ecological landscape in the Great Basin of North America.

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