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Adapting to change: transitions in traditional rangeland management of Tibetan yak herders in northwest Yunnan

Michelle A. Haynes · Yongping Yang

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Abstract Tibetan yak herding practices in northwest Yunnan, southwest China have maintained remarkable biological diversity. To learn more about local cultural adaptation to policy changes, we interviewed 37 households in Deqin County on their traditional knowledge, and the changes they have observed in ecological conditions, livestock health, and land management. These villages varied in proximity to main roads, farmland quality, and livelihood options. Herd sizes in Deqin have quadrupled since the 1950s, due to commune era policies and subsequent privatization of livestock. The practice of burning shrubs increased during the communal period but has since decreased due to a burn ban. Herders report that the increase in shrublands invading alpine meadows has reduced livestock forage, reducing the productivity of alpine rangelands and yak health. Butter production has declined by 30 % over the last two decades. Herders are shifting to diversify sources of income when available, but villagers in remote and protected areas continue to depend on livestock for much of their livelihood. Scientific data confirm herder reported ecological changes including increased temperature, decreased snowfall, and accounts of increased erosion (which deserves further study). Climate, policy, and economic incentives have interacted to increase pressure on shrinking alpine meadows and reduce dairy production.

Keywords Tibetan rangelands · Yak herding · Climate change · Burn ban · Traditional knowledge · Shrub encroachment

M. A. Haynes (✉)
Department of Botany, University of Wisconsin-Madison, 430 Lincoln Avenue, Madison, WI 53706, USA
e-mail: michelleahaynes@gmail.com

Present Address:
M. A. Haynes
U.S. Fish & Wildlife Service, National Conservation Training Center, 698 Conservation Way, Shepherdstown, WV 25443, USA

Y. Yang
Kunming Institute of Botany, Chinese Academy of Sciences, 132 Lanhei Road, Heilongtan, Kunming 650201, Yunnan, China

1 Introduction

For forty centuries, Tibetans have herded yaks in the Tibetan Plateau (Miller 1999), making it important to understand how historic land use and current socio-economic shifts are affecting traditional patterns of livestock grazing (Ma 2003; Tsundue 1999; Yeh and Gaerrang 2010). Approximately 94 % of all yaks in the world are located in China; reaching over 13 million distributed primarily in Sichuan, Tibet, Qinghai and Gansu (with smaller dispersion in Xinjiang, Yunnan, and Inner Mongolia), 15 % of which are hybrids with local cattle (Weiner et al. 2003). Northwest Yunnan, situated on the eastern and southern edge of the Tibetan Plateau in the Hengduan Mountains region, is traversed by historic trade routes (Tea Horse Road or Southern Silk Road).

1.1 Regional history

The most northwest of Yunnan's counties, Deqin County (Fig. 1) has changed political regimes several times over its history (Deqin Almanac 1997). Before its establishment as the Diqing Prefecture Autonomous Government in 1957, this ethnically Tibetan area shifted between being included in western Sichuan and eastern Tibet (currently the Tibetan Autonomous Region) jurisdiction from 1372–1665 to 1719–1726. The Mu clan chiefs of the Naxi ethnicity based in Lijiang, Yunnan, took over and ruled from 1665 to 1717. The county contains three temples (in Hongpo, Shusong, and Deqin) which converted to the Gelukpa sect of Tibetan Buddhism in 1676. Between 1727 and 1907, control primarily came from Weixi (Yunnan). From 1934 to 1949, Deqin established a government station. Since its official formation, Deqin County has been divided into 8 townships (Deqin 1997). The 7,504 km^2 county is currently home to 14 ethnic groups and is 80 % Tibetan.

1.2 Local ecology

Northwest Yunnan is part of the Three Parallel Rivers World Heritage Site and a hotspot of cultural and biological diversity (Yang 2004). Over one-third of Deqin County is designated part of the Baima Nature Reserve which was established as a National Nature Reserve in 1988 to conserve habitat for the Yunnan black-and-white snub-nosed monkey (*Rhinopithecus bieti*). Increasing domestic and international focus on the region's biodiversity has brought NGO conservation projects to the area. Growing development pressures for mass tourism, eco-tourism, infrastructure improvements, hydroelectric projects, mining, and non-timber forest product extraction now threaten ecosystem stability (Yi et al. 2007, 2008).

1.3 Local livelihoods

According to reports, the overgrazing of domestic livestock and accompanying shrub encroachment decrease biological diversity and the sustainability of yak herding livelihoods (Bao and Wu 2003; Harris 2010). The traditional practice of burning to reduce shrub encroachment is often mentioned (Baker and Moseley 2007; Buntaine et al. 2007; Chan 2003; Moseley 2006), but without detail or explanation of the practice. Such information gaps create challenges for land managers and animal husbandry officials (Yin et al. 2006).

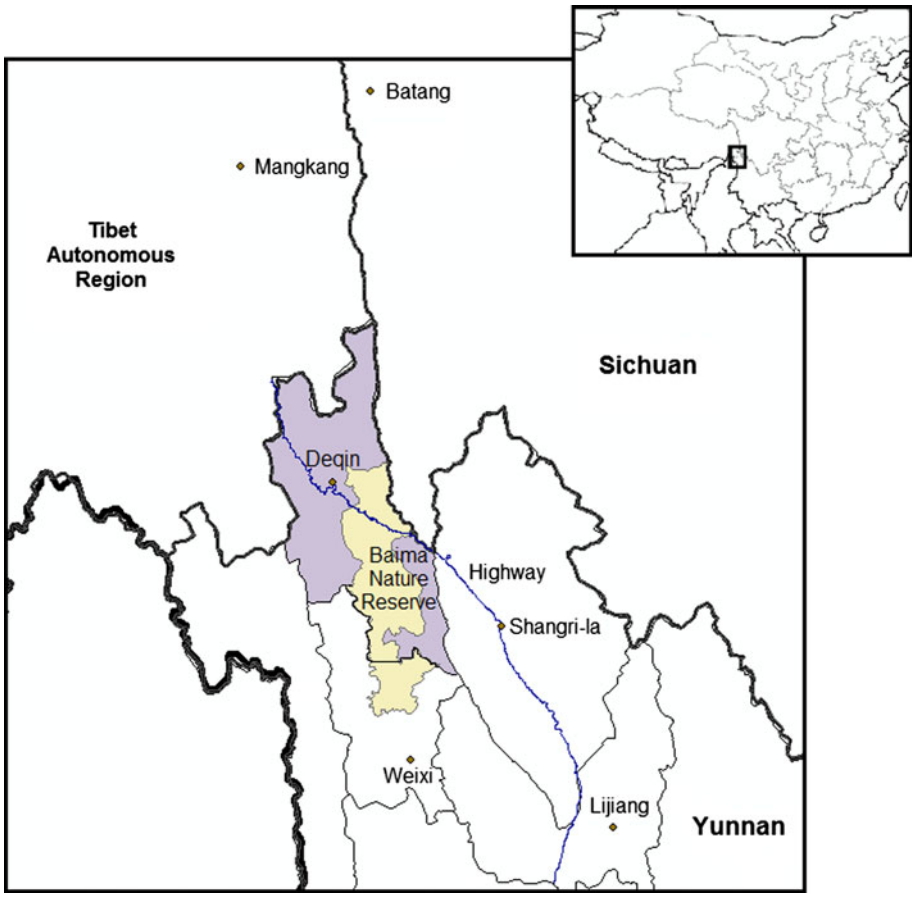

Fig. 1 Map of study region showing Deqin County (as located in southwest China), national highway 214, Baima Nature Reserve, and historical places of administrative management

1.4 Study aims

Due to the important ecological and livelihood changes in northwest Yunnan, we interviewed herders to (1) document traditional knowledge of burning practices; (2) identify changes in livestock health; (3) understand timing of transitions in rangeland management; (4) note perceptions of ecological change; (5) outline the local village history; and (6) ask herders about their expectations for the next generation. Specifically, we sought to determine the extent and frequency of burning to gain insight into the potential contribution of human disturbance from burning to the alpine rangeland system in northwest Yunnan. We investigated changes in rangeland management over the past six decades, searching for insights about the future of herding in the area. By examining the recent histories of Tibetan villagers, we illuminated anthropogenic land use changes and accompanying ecological impacts. Together, these lines of questions were targeted at knowledge gaps regarding on-the-ground changes in land management and specific impacts connecting to landscape level indicators of global system change.

2 Methods

In the summer of 2006, we established contacts with officials and local villagers and made an excursion into the core area of Baima Nature Reserve for house stays where we held open-ended interviews. In the summers of 2007 and 2008, we conducted preliminary interviews at the alpine rangelands. Ethnographic investigations were conducted in 2009, taking extended trips with Tibetan herders to alpine rangelands to discuss ecological and livelihood changes.

Interviews were conducted in January 2010 before the spring festival holiday during a time when villagers had a break from harvesting and had returned from herding in the distant summer pastures. During the winter months, livestock are kept in lower elevation pastures close to their homes. The survey instrument contained 7 sections: background of the interviewee, animal husbandry, burn history, village history, livestock health, ecology, and future expectations. In response to initial interviews, we modified the survey instrument to include additional sections on village history and detailed questions about traditional burning practices. Interviews lasted approximately 1 h. We interviewed 37 households in 6 villages during January–February 2010. Respondents were provided a small gift of food items but no financial compensation. No herders declined interviews. Some questions were omitted if not relevant to the interviewee's situation. We sampled households with experienced herders using the snowball method to gather information on the depth of knowledge from those with the longest history in rangeland management in the area.

Village leaders were also asked open-ended questions regarding decisions related to herding practices. To assess additional village-level characteristics and the history of administrative decisions, we also interviewed officials from the Grassland Monitoring Station and Animal Husbandry Bureau. Interviews were conducted in the local version of Mandarin Chinese (known as *Zhongdian hua*) or in the local Tibetan dialect and interpreted into *Zhongdian hua* by the local village host. Prior oral consent was obtained since most of interviewees were not literate (IRB Protocol SE-2008-0290). Historical records, county almanacs, statistical collections, and Animal Husbandry Bureau reports were also collected and reviewed for supplementary information.

3 Results

The average age of interview respondents was 60, with an average of 19 years herding (Table 1). The mean number per household of cows, yaks, and hybrids was 15.6 (3.3 cows, 2.8 yaks, 9.5 hybrids), of which 10.2 were milk-producing. Of those interviewed, one household had a female herder, as herding in this county is a predominately male activity.

3.1 Village description

Villagers residing within the Baima Nature Reserve are limited in resource extraction due to reserve policies. Sites along the roadside provide immediate access to markets where dairy products are sold to tourists. Villages near the Meili Snow Mountains are tourism and sacred mountain pilgrimage sites with National Park revenue potential. Other remote villages are outside of reserve boundaries and have not experienced tourism development. Some of those alpine rangelands are considered among the most remote and pristine in northwest Yunnan, with no current or planned protection in place. These sites capture the

Table 1 Summary of households interviewed on their herding experiences (SD = standard deviation)

Total household responses	Mean	SD
# in households	6.3	1.4
# herded	1.5	0.7
Age of interviewee	59.5	15.4
Years herded	19.3	11.4
Secondary herder, years herded	9.8	6.8
# cows and yaks	15.6	7.6
# yaks	2.8	2.3
# hybrids	9.5	6.6
# cows	3.3	2.8
# milk cows and yaks	10.2	4.5

Half of the households interviewed contained two generations of herders (presented in the row: secondary herder). In those cases, either the grandfather and father had herded or the father and son (hence the large deviations around age of interviewee and # of years herded)

variation in management regimes across northwest Yunnan as well as the diversity of conservation and development pressures in the county.

3.2 Village history

The villages can be compared across a gradient of farmland quality, roads and market access, tourism development, and type of protection designated. The peak densities of yak and cow livestock occurred at various times from 1990 to the present (Table 2). Villages with better cropland, access to markets, or tourism development show decreasing herd sizes since the 1990s. In contrast, those with less cropland, few roads to market, or lacking tourism reached the maximum herd size in the last few years or continue to increase their herd sizes.

The area has experienced substantial social changes over the last six decades. Prior to the 1950s, local landlords and monasteries served as the power-holding class, while most villagers were tenants who paid tribute to the local landlord with agricultural products. There were also traveling merchants, craftsmen, and servants. In places, wealthy local landlords held strong control, but in other areas, they were poorer and did not extract tribute. The three major monasteries in the county also had servants and received tribute from households in the area. Monasteries and landlords maintained herds of livestock and

Table 2 Village-level comparison for villages A-F, located within Deqin County, Yunnan, China

Village comparison	A	B	C	D	E	F
Quality of farmland	Low	High	High	Average	Low	Very low
Distance to highway	Far	Near	Near	Near	Far	Very far
Tourism development	None	Average	High	Low	None	None
Located inside nature reserve	No	No	No	Yes	Yes	Yes
Year of peak livestock density	2009	2000	1993	1990	2006	2010

Each interviewee was asked the year with the maximum number of livestock in the village, with the average shown. Note, village F responded with the current year, 2010, at the time of interviewing

could choose where to send them to graze depending on annual rainfall and productivity. Tenants did not have livestock to herd but might have a few plow or dairy animals kept near the house.

Human colonization of new areas has also occurred with expansion to more remote and higher mountainous areas over the last 150 years. For example, one village had only three households before the twentieth century but now has 22 (perhaps reflecting the absence of a local landlord there and indicative of population growth in the region). It remains remote and we were the first outsiders to visit.

Across villages, all respondents who had traveled to the summer pastures or herded for the local landlord reported that they had fewer and healthier livestock and that the grass condition was very good during those years (compared to the present). The yaks were big, strong, and seldom suffered from sickness. The overall situation prior to the 1950s was one of light grazing intensity with the flexibility to select the most favorable pasture locations based on rainfall for herding livestock.

During the commune period, roughly 1960–1980, people were organized into production teams and brigades. Livestock were collectivized at the commune level, and comrades were assigned to herd them. Burns that occurred during this time were organized by the production brigade leader in accordance with national policies to turn "wasteland into rangeland" and increase livestock production.

When herds were privatized in 1980, the mean number of livestock per household was 4.0 (1.3 yaks, 1.2 hybrids, and 1.5 cows). Many households did not begin herding their livestock immediately, instead leaving them in nearby pastures or grouping them together with other livestock for one person to take to the summer pastures. As additional livestock were purchased or added through natural reproduction, the herd size would increase to a level that the household deemed worthy of a person's work (usually around 8–10 head). According to county and prefecture almanacs, the number of livestock has quadrupled since the 1950s (Fig. 2; Deqin 1997; Le'anwangdui 2001).

3.3 Ecological changes

We also observed variation in local histories and worldviews among the six villages. For a village near the Meili Snow Mountains, a mountaineering expedition served as a historical

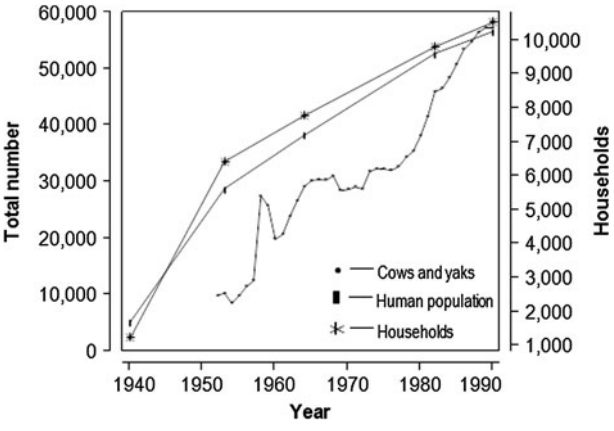

Fig. 2 Total number of cows and yaks, human population, and households in Deqin County, China (Deqin 1997)

pointer from which bad natural patterns emerged. A village near a monastery attributes weather changes to whether religious texts have been recited regularly or not. Such accounts exhibit diversity in perception from village to village.

Herders tend to perceive their rangelands as better or worse than other locations. Those with less favorable views of their rangelands describe them by comparing them with previous times when their pasture had more grass, received more rain, or contained fewer livestock. Other indicators voiced for lower quality rangelands included road construction, burn restrictions, declines in milk production, and length of travel time required or difficulty involved in reaching the site. Rangelands designated as good quality were said to have plenty of grass, adequate water supply, and good quality and quantity of milk yield when livestock graze there.

The furthest site mentioned required a five-day walk, but most sites are accessed via 1–2 day (12–30 h) treks. Often, over 2,000 m are ascended between departure at the village and arrival at the summer pastures. Those with pastures farther away may only be at home 1 or 2 months a year. They discussed the difficulty and danger involved in the long transit, with the greatest risk for newborn calves.

When asked about erosion, 59 % mentioned noticing it. Of those, nearly half described erosion occurring more recently than in the past. They recalled erosion on trails, roadsides, pastures, and slopes around rangelands. They also noted the connection of erosion to rain. A few interviewees recalled large rainfall events spawning landslides and erosion in the early to late 1980s that have continued with each heavy rain.

Regarding plant composition changes, 65 % reported that shrublands have increased. Four interviewees from different villages noted, "thorny shrubs replaced the grass after landslides." Another mentioned, "more rocks in the grassland." Two interviewees did not mention plant community changes. The rest of responses mentioned dependence on weather, specifically regarding the amount of rainfall. One commented, "from 2002, I noticed that grass quantity depends on amount of rainfall, whereas before that, it was always good."

When asked about weather patterns, 74 % noted increases in temperature with the majority placing the onset of increase at 25–30 years ago (Fig. 3). Others remarked on increased wind speed, the hotness of the sun, changes in the onset of seasons, and the ability to grow crops not previously possible to grow. Five respondents mentioned warming specifically in winter. Respondents varied, however, on the onset of these changes, some placing them at 25–30 years ago, others more recently.

Some 78 % of respondents noted changes in rainfall with 97 % of those noting declines, though some mentioned change primarily in the seasonality of rain and quantity of the rainfall event. The described onset of rainfall changes mentioned occurred approximately 2.5 decades ago (Fig. 3). In addition, 84 % reported changes in snowfall, particularly in the last decade. Others reported that the snow melts earlier and faster than before. Some 27 % also noted shifts in the timing of flower blooming with some describing it as earlier, some as later, some as lower in quantity, or fewer blooming each year, and some as dependent on rainfall (with less rain meaning fewer blossoms).

3.4 Burning practices

Two interviewees specifically described religious practices regarding burning (fire is sacred, it takes the lives of creatures) as a limiting factor controlling the practice until the commune period where "superstitions" were "officially dispelled" and villagers were required to increase agricultural productivity. When asked whether the alpine rangeland was

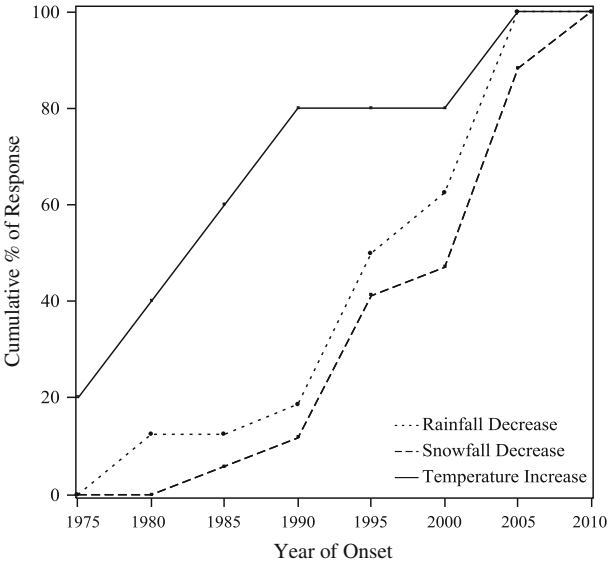

Fig. 3 Interviewees were asked if they had noticed any differences in climate, what type of differences, and the approximate year of onset of those differences. All interviewees described temperature increases and snowfall decreases along with earlier melting of snowfall. Shown here are the cumulative proportions and specific year of onset of the climatic changes they indicated

"traditionally burned," 22 % responded yes. Only 11 % of respondents said they had participated in, or heard of, burning prior to 1950. Most mentioned that there was no need to burn the pastures during that time due to the smaller herd sizes and better grass condition.

When asked if they had burned or heard about burning during the commune period, 54 % said yes. Some burns were organized by the production brigade (*dadui*) while smaller burns were organized by the production team leader (*xiaodui*). The number of people involved in the burn varied from a few people to a dozen or more, depending on the size of area to burn. Accidental burns were described by 11 % of respondents, most occurring during the 1970s.

Since the livestock were divided among households in the early 1980s, 40 % of interviewees mentioned burning, and of those, 22 % mentioned burning since the burn regulations. Of those that mentioned burning after the restrictions, 11 % mentioned continuing to burn. Many of those who practiced burning in the last decade have done so to improve the abundance of medicinal plants highly valued for collection in alpine meadows, such as the caterpillar fungus (*Cordyceps sinensis*) and *Fritillaria* spp. In some cases, the people collecting set the fires, not herders seeking improved rangeland forage.

Time of year for burn varied by respondent, and each month was mentioned except for June. Most said between October–December, when dry. Only one respondent described repeated burning at the same locale. Those who had participated in burning characterized the grass regeneration as good the first year and increased medicinal plants for collection in the second year. Only one account of poor regeneration was discussed. In that case the burn site was steeply sloped and suffered heavy rainfall just after the burn, washing away topsoil and leaving a substrate of rocks. Some respondents mentioned herding livestock on the burned pasture later in that same year, and others described waiting until the year after the burn to let livestock graze the site.

3.5 Livestock health and output

When asked about yak and cow health, 62 % reported increases in sickness, and 94 % of those stated that yaks were most likely to get sick (more than the yak–cow hybrid or cows). The next most likely were hybrids, then cows, and the cows were the fastest to recover from illness.

Of those that mentioned no change in health due to disease, some instead described problems, ranging from upset stomach to death, caused by consumption of poisonous plants. This was described by 11 respondents with an interesting distinction by village. It was only mentioned by herders in the reserve area, primarily the remote villagers. This was mostly in reference to dwarf rhododendrons which are eaten if nothing else is available and is eaten by newborn calves. Interviewees also described a sickness from the livestock coming down early or too quickly (57 %), with all (22 %) who responded about the altitude sickness saying it occurred in September and October when returning from the mountain and it was too hot.

Yak diseases were only mentioned in some areas and not in the most remote areas. There, respondents only described losing small calves washed away while crossing rivers to reach the alpine rangeland, the stomach sickness from eating noxious plants, and being eaten by wolves. Other sicknesses were also referred to with varying degrees of description and curability (colds, crazy disease, parasites, communicable diseases). When asked about dairy outputs, respondents provided estimates of butter production currently and when they began herding. This came out to a 30 % reduction in butter production. Respondents declared, "all livestock are getting smaller because the grass is less and livestock is more."

3.6 Future trends

When asked how many of their children will continue herding, most interviewees expressed uncertainty. A few remarked that their children would herd livestock, most responded that it depends on how their children perform in school, and if they are able to secure a job. Many said they wanted their children to go to school and get jobs and not have to continue the harsh lifestyle of livestock herding.

Taking this into account, they were next asked, "what will be the condition of rangelands in the future?" Nearly 20 % responded that there would be no change. Others remarked that it depends on rainfall, or that they would be rented to someone else to herd there. A few said they were not sure because they do not know whether the rangelands will be managed properly. They assumed the impact of grazing would stay the same as other households would take livestock to the rangelands.

In response to the question, "when is the best time in your lives or when were you most happy?" "Now" was the answer for 100 % of respondents. From the late 80s to the present, households have experienced increasing control over their livestock and livelihood opportunities. Respondents described multiple sources of income, good policies, self-employment, freedom of choice, moderate taxes, and improvements from earlier systems.

4 Discussion

Will changes in the nature and amount of regulation along with economic pressures drive communities to push their grazing systems across thresholds of resilience? Policy pressures in Sichuan, Qinghai, and Tibet threaten to further undermine stability by privatizing the

pastures (Yan et al. 2005). Northwest Yunnan has not undergone rangeland privatization yet, though some fencing initiatives have been attempted at lower elevations (primarily along roadsides). Further increases in herd sizes may be averted as herding families move to alternative sources of income including agriculture, non-timber forest products, or service/construction jobs. Factors like access to roads and markets, location within a nature reserve, agricultural productivity, and tourism development all affect when livestock numbers peaked (Table 2). Other variables not included in this analysis, such as annual household income for villages and abundance of marketable forest products might also influence when livestock quantities peaked.

Possible sources of error in this study include a potential cultural bias, reluctance to discuss certain topics with a foreigner or outsider, and language-induced error. Working with a local guide from each village and repeatedly visiting villages helped reduce hesitancy of respondents. Note that this study did not include any households that were members of the ruling class prior to the 1950s.

These interviews revealed a strong oral history of events and social changes even for periods before the 1950s. People are keenly aware of the class of family they descended from, whether they were landlords, peasants, traveling merchants, or servants, and their unique experiences provide valuable lessons in adaptation. Some traditional values appear to be in decline with the advent of pesticides in agricultural fields, the collection of plants from sacred mountains by laypersons instead of traditional medicine doctors, and shifts away from ancient practices rooted in religious beliefs.

The practice of burning shrubs to promote grass and forage regeneration in alpine meadows is less "traditional" than often implied in the scientific literature. The scale and frequency of burn instances have increased and decreased over the last 6 decades, peaking during the commune period of the 1970s. These results suggest that burning is not a regular disturbance mechanism in controlling shrub encroachment in grasslands. The correlations between shrub encroachment, climate change, and burn practice are explored further in Brandt et al. (2013). Among those who responded that alpine rangelands were traditionally burned, some described the burning as occurring prior to the 50s while others said it commenced during the commune period. One other respondent who affirmed traditional burning defined the practice as beginning after the 80s. Such dissimilarity shows the value of detailed investigation when assessing land use patterns, anthropogenic disturbance regimes, and policy recommendations (Wu and Richard 1999; Yeh 2003). Correcting misperceptions around the history of burn management plays a key role in informing policy analysis and conservation strategies.

Interesting parallels between traditional and scientific knowledge came to light during the interviews. Many of the ecological changes described by herders including warming temperatures especially in winter are confirmed in climatology reports (Haynes 2011; Li et al. 2010; Yu et al. 2010). Herders also described erosion occurring along trails, roads, and sloping areas, particularly after heavy rainstorms. Although less verified, such changes appear likely in light of known increases in precipitation and earlier melting. This topic deserves further investigation.

Declines in alpine meadow extent and quality reflect both increases in stocking and shrub encroachment (Fig. 2; Haynes et al. in press). Respondents describe the appearance of thorny shrubs (*Berberis jamesiana* and other species) after erosion or landslides providing insights into succession patterns in alpine meadows. These shrubs may colonize disturbed sites with soil and groundcover loss. Fang et al. (2010) identified *Berberis* spp. in a survey of pioneer plant species in northwest Yunnan.

According to scientific reports, "the single most important factor influencing milk yield is the supply and quality of grass in the warm season of the year" (Weiner et al. 2003). Herders described grass and forb decreases, shrub invasion, increase in herd sizes, and diminished dairy production. Linkages between climate, policy, and economic changes negatively impact forage quantity, dairy outputs, and yak health (Fig. 4). Respondents expressed concern regarding yak health, with rising accounts of communicable and non-communicable diseases. Animal husbandry officials and local vets corroborated these reports (Haynes 2011), showing two-to-threefold increases in type of disease encountered, scale of disease, and amount of medicine disseminated.

Sustainability issues arose in discussions of the stocking level and vegetation quality. Responses like "before there was enough grass for livestock regardless of timing and amount of annual rainfall" suggest shifts toward decreased system resilience. Prior to the institutionalization of herding in northwest Yunnan, landlords chose among large swaths of alpine pastures and could rotate livestock depending on rainfall and vegetative production from year to year and month to month. Although herders currently rotate up and down the mountain to the village over the course of a year, they have few options regarding which pasture on which to herd livestock.

Changing climate, policy, and economic pressures simultaneously led to increases in shrub expansion and decreases in forage quantity. Herd sizes have grown, likely approaching a sustainability threshold in some areas, as alpine rangelands decline in forage production and livestock decline in dairy production. One respondent declared, "before, only the local landlord owned livestock and three tenant families lived in this house. Now

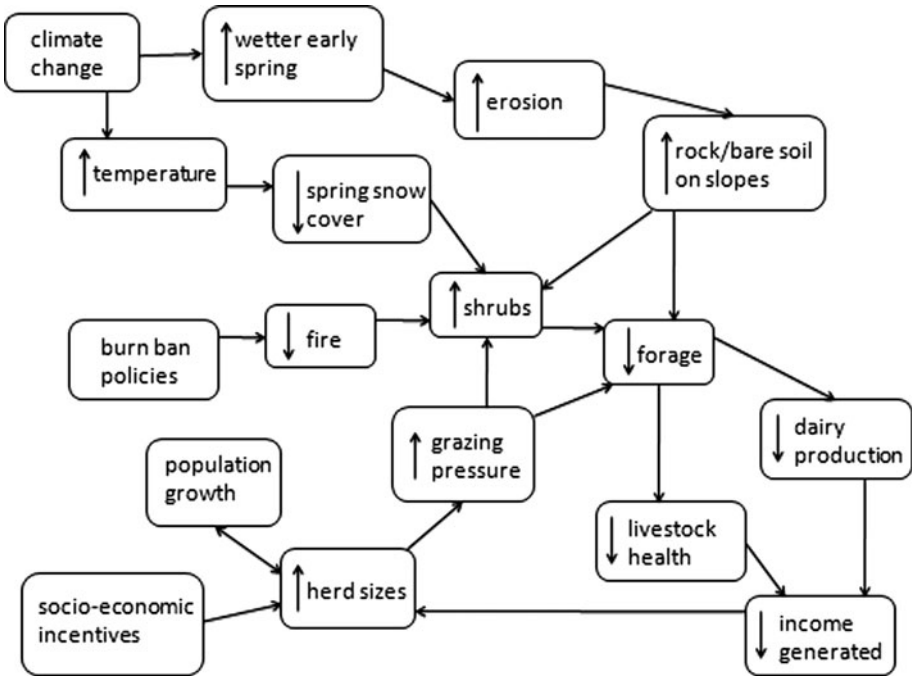

Fig. 4 Flow diagram showing probable links between climate change, rangeland ecology, burn ban policies and yak herding livelihoods in northwest Yunnan. Climate, policy, and economic incentives interacted to increase pressure on shrinking alpine meadows and reduce dairy production

we are like the local landlords! Only my family lives in this house and we have lots of livestock."

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