# Seasonal grazing impact on cryptogamic crusts in a cold desert ecosystem

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## Abstract

Since settlement, cattle grazing has been a major cause of soil disturbance in cold desert ecosystems. The objective of this study was to determine the impact of cattle grazing in different seasons on cryptogamic soil crusts. This study was conducted adjacent to the Brigham Young University Skaggs Research Ranch, near Malta, Ida. Five areas of a crested wheatgrass pasture each interplanted with shrubs were evaluated. Each of the 5 areas was subdivided into 4 paddocks; a control paddock remained ungrazed, while the other 3 paddocks were grazed in either spring, summer, or winter. Each of the 1.2-ha grazed paddocks was grazed annually in the same season for 2 consecutive years by 10 cows for 4 consecutive days. Percent of the soil surface covered by litter, vascular plant bases, and cryptogams was measured using a 10-pin, point sampling frame. Mosses were the main component of the cryptogamic soil crusts under all grazing treatments. Winter grazing had no effect on the moss component of the crusts while spring and summer grazing reduced mosses. While winter grazing had significantly less impact on the lichen component of crusts relative to spring and summer grazing, there was a 50% reduction relative to the control plots. Total cryptogamic cover in the control paddocks averaged 27.6%; winter grazed paddocks 27.4%; summer grazed paddocks 14.4%; and spring grazed paddocks 10.6%. Controlled winter grazing has minimal impact on the total cryptogamic plant cover that protect soil surfaces on cold desert range ecosystems.

#### Key Words: lichen, moss, shrub, cattle, erosion control

Cryptogamic crusts consist of non-vascular photosynthetic plants, primarily algae, lichens, mosses, and cyanobacteria that live on the soil surface (St. Clair and Rushforth 1989). It has been suggested that the term cryptogamic be replaced by microphytic crusts in order to include bacteria and fungi, as well as the protozoan, nematodes, and mites that are associated with this microecosystem (West 1990). However, visual field estimates of the nonphotosynthetic organisms are not feasible, whereas green or colored cryptogamic components are often readily apparent (Beymer and Klopatek 1992).

#### Resumen

Desde que se ha establecido la colonización, el apacentamiento de ganados ha sido una deœ las causas principales de inestabilidad del suelo en los ecosistemas de los desiertos fríos. El objetivo de este estudio era determinar el impacto, en incrustaciones de suelos criptogramticos, del pastoreo que ocurre en diferentes estaciones. Este estudio se llevó a cabo en un terreno advacente al Rancho Experimental Skaggs de la Universidad de Brigham Young cerca de Malta, Ida. Se evaluaron cinco zonas de pasturas de agropiro crestado (agropirum crestatum) que estaban interplantadas con arbustos. Cada una de las zonas fue dividida en cuatro parcelas; una de las parcelas de control se dejó sin pastorear, mientras las otras se pastorearon en primavera, verano o invierno. Cada una de las parcelas de media hectárea fue apacentada anualmente por diez vacas en la misma estación, dos anos consecutivos, durante cuatro días seguidos. Se midió el porcentaje de la superficie del suelo cubierto por desperdicios, plantas basales vasculares y criptógamas en un bastidor tubular de diez barras. Los musgos eran los principales componentes de las inscrustaciones del suelo bajo todas las condiciones de pastoreo

El pastoreo invernal no tuvo ningún impacto en el componente musgoso de las incrustaciones, mientras que el realizado en la primavera y el verano lo redujo. A su vez, aunque el pastoreo del invierno tuvo menos impacto en los líquenes de las incrustaciones que el de la primavera y el verano, hubo una reducción del 50% respecto a los terrenos de control. La cobertura criptogramática total de las parcelas de control tenía un promedio de 27.6 %; las œ parcelas pastoreadas en invierno 27.4 %; las pastoreadas en el verano 14. 4 % y las de la primavera 10.6 %.

El pastoreo invernal controlado tiene un impacto mínimo en la cobertura criptogramática total que protege la superfice de los suelos en los ecosistemas de los desiertos fríos.

Cryptogamic crusts are common to arid and semi-arid ecosystems worldwide (Harper and Marble 1988). These crusts normally appear in the interspace between vascular plants and greatly enhance soil stability by reducing water and wind erosion (Fritsch 1922, Booth 1941, Blackburn 1975). They have also been reported to increase water infiltration (Loope and Gifford 1972, Harper and St Clair 1985) and improve seedling establishment and survival (Harper and St. Clair 1985). Significant amounts of nitrogen

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are fixed by some cryptogamic crusts under conditions common in cold desert ecosystems (Rychert and Skujins 1974, West 1981). Nitrogen fixed by soil crusts may be used by soil microorganisms, higher plants, and animals (Terry and Burns 1987). Other soil nutrients such as phosphorus, sodium, magnesium, and iron are more abundant in soils where cryptogamic crusts are present (Harper and Pendleton 1993).

The fragile nature of cryptogamic crusts makes them highly susceptible to severe damage or destruction by activities such as grazing (Poulton 1955, Kleiner and Harper 1972, Anderson et al. 1982b, Johansen and St. Clair 1986, Terry and Burns 1987), burning (Johansen et al. 1982, Callison et al. 1985), or off-road vehicles (Harper and Marble 1988).

Domestic livestock have grazed throughout the Intermountain region for more than 100 years. Grazing is known to disturb and compact the soil and damage cryptogamic crusts (Kleiner and Harper 1977, Belnap et al. 1994). While grazing damage to cryptogamic crusts has been observed, manipulation of the grazing seasons, animal densities, and general herd management in relation to the damage to cryptogamic crusts has not been widely studied. The purpose of this study was to determine if cattle grazing in different seasons would have different impacts on established cryptogamic crusts as well as variable impacts on the recovery of crusts from tillage disturbance in a cold desert ecosystem in southwestern Idaho.

# **Material and Methods**

#### **Study Site**

The study area is located approximately 14.4 km north of Malta, Ida. adjacent to the Brigham Young University Skaggs Research Ranch. The study site lies in the NE quarter of the NW quarter, Section 22, Township 11 South, Range 26 East (Salt Lake Baseline and Meridian). The topography of the study area is typical of the cold desert ecosystem of south-central Idaho with low lying valleys bordered with mountain ranges that run north to south. Stevens (1992) completed a soil analysis and description of the study site and classified the soils as Bahaem siltloam which is a fine loamy mixed mesic xerollic callciophid with a semi-impermeable hardpan at 40 cm. These are basic soils with a ph greater than 8 throughout the profile. This ecosystem is dominated by sagebrush-grass rangelands typified by cold, dry winters and hot summers with little precipitation. Average annual precipitation is 22.8 cm with most of the moisture falling as rain or snow in spring and late fall. Average daily temperatures range from -2 °C in January to 18.5° C in July. The elevation of the site is 1,342 m.

The study area was leased from the J. R. Simplot Company in 1985 for a period of 10 years and managed by Brigham Young University in cooperation with the USDA Forest Service, Shrub Science Laboratory. Pretreatment plant cover consisted of a seeded stand of crested wheatgrass (*Agropyron desertorum* (Fischer ex Link) Schult) intermixed with Wyoming big sagebrush (*Artemisia tridentata* Nutt. ssp. wyomensis Beetle and Young). This area had been grazed in the spring and fall seasons for several years prior to 1985 (Stevens 1992).

## **Study Description**

The response of cryptogamic soil crusts to 4 grazing and 2 tillage treatments were examined in a factorial arrangement in a randomized complete block design with 4 replications. The graz-

ing treatments consisted of spring, summer, or winter grazing and an ungrazed control, while the tillage treatments included 1-m tilled strips with 2.5-m untilled strips. Shrub seedlings were transplanted at 1.5-m intervals into the tilled strips.

The 20-ha study site was prepared beginning in the fall of 1985 by aerial spraying with 2,4-D ((2,4-dichlorophenoxy)acetic acid), a broad leaf selective herbicide, to remove all existing shrub species. The tilling treatment was imposed in 1986, when 1-m strips were tilled with a rear mount tractor powered tiller to a depth of 20 cm at 2.5-m intervals. In 1987, the area was subdivided into five, 4-ha parcels and shrub seedlings, of a single species per parcel, were transplanted at 1.5-m intervals into the tilled strips of each parcel. The 5 species of shrubs selected for transplanting were: Wyoming big sagebrush, prostrate kochia (Kochia prostrata (L.) Schrader), big rubber rabbitbrush (Chrysothamnus nauseosus (Pallas) Britt.), fourwing saltbush (Atriplex canescens (Pursh.) Nutt.), and winterfat (Ceratoides lanata (Pursh.) J.T. Howell).

A perimeter fence was constructed around each 4-ha parcel and cross fences within each parcel further divided it into 4 sections (hence referred to as paddocks). The 4 paddocks consisted of one, 0.4-ha ungrazed control paddock, and three, 1.2-ha grazed paddocks. Each 1.2-ha paddock was assigned a grazing season treatment applied in spring (first week of May), summer (third week of July), or winter (first week of December).

By 1991, the transplanted shrubs were mature in stature and ranged from 0.5 m to 1.5 m diameter and from 0.3 m to 1.5 m in height depending on species. Grazing treatments began in the spring of 1991 and continued to the winter of 1992. Ten cattle were allowed to graze in each paddock for 4 days (approximately 50% utilization of the crested wheatgrass) in their assigned season.

Therefore, the treatments represented 2 years of grazing on strips that had recovered from tilling for 5 years and on strips that had been untilled and ungrazed for the previous 6 years. The winter grazing period was preceded by 3 weeks of sub-freezing temperatures in both years, which froze the soil. In the 1991 winter grazing period, the ground was covered by a trace of snow, but in the 1992 winter grazing period the ground was covered by approximately 4 cm of snow.

In 1993, the season following cessation of the grazing treatments, percent ground cover was measured with a 10-pin, point sampling frame. The frame consisted of a 1.0-m wide upright frame with 10 sharpened pins placed 10 cm apart. For each frame placement, the pins were lowered individually and the cover type of each "hit" at the soil was recorded (Cook and Stubbendieck 1986, Bonham 1989).

Within each paddock data were recorded from 60 stratified random placements in the untilled strips and 40 in the tilled strips. The weighting accounted for the relative area of each treatment. Placement of the frame within the tilled strips were selected in conjunction with a randomly selected shrub within the strip, such that a portion of the points were located under the shrub canopy.

Five classes of soil surface cover were recorded as they occurred in all plots: litter, bare ground, vascular plant (by species), moss, and lichen. Absolute percent cover was calculated for each of the 5 cover types in each treatment level by dividing the number of "hits" on a particular cover type by the number of points sampled and multiplying by 100.

The 2-factor factorial design (4 levels of grazing treatment by 2 levels of soil tillage) was analyzed using the Number Cruncher Statistical System general linear models procedure to determine

the response differences in soil surface cover types by treatment (NCSS 1989). Mean separations were conducted using a protected Fisher's Least Significant Differences procedure (P = 0.05).

# **Results and Discussion**

The primary moss species encountered in this study were Tortula ruralis (Hedw.) Gaertn., Meyer and Schreb, and Bryum sp. Lichen species included Aspicilia fruticulosa (Eversm.) Flagey, Collema tenax (Sw.) Ach., Caloplaca tominii Savicz, and Caloplaca tiroliensis Zahlbr.

Cryptogamic cover composition was dominated by mosses in all paddocks, ranging from a high of 97% in spring grazed paddocks to a low of 87% in control paddocks. Total cryptogamic cover was affected (P < 0.05) by grazing and tillage. Response of cryptogams to the grazing season treatments differed with the tillage treatment (Fig. 1, P < 0.05). Total cryptogamic cover was significantly higher in the control and winter grazed paddocks on both the untilled and tilled strips relative to the spring and summer grazed paddocks. Cattle hoof action on softened and sometimes wet soils in spring and summer was sufficient to disturb the soil surface and reduce cryptogamic cover by nearly 50%. Breaking the soil surface structure exposed soil particles to both wind and water erosion. Frozen soils in the winter combined with some insulation of snow cover mediated hoof impact on the cryptogamic cover.

The response of total cryptogamic cover to grazing and tillage was largely influenced by moss (Fig. 1). Moss cover was reduced by as much as 50% with spring grazing. However, winter grazing had no significant effect (P > 0.05) on moss cover. Lichen cover was reduced (P < 0.05) by tillage and grazing in all seasons (Fig. 2), although winter grazing had significantly less impact on lichens than either spring or summer grazing.

Relative to the mosses, the crust formed by lichens tends to be thinner and more brittle in nature. Hoof impact is much more



Fig. 1. Total cryptogamic cover (mosses and lichens) in response to different seasons of cattle grazing and tillage treatment (interaction significant at P < 0.05). Variability in the data is represented by standard error bars.



Fig. 2. Total lichen cover in response to different seasons of cattle grazing and tillage treatment (interaction significant at P < 0.05). Variability in the data is represented by standard error bars.

likely to crumble this structure than the more spongy texture of the moss crusts. Bare ground was highest (P < 0.05) on summer grazed paddocks (39.2%) followed by spring (36.3%), winter (31.7%), and control paddocks (20.2%), respectively.

# Conclusions

Many studies have documented the negative impacts of ungulate grazing on cryptogamic crusts. The majority of these studies have been completed in desert ecosystems that do not sustain frozen soils for long periods (Kleiner and Harper 1977, Anderson et al. 1982b). For studies completed in cold deserts (Anderson et al. 1982a, Brotherson et al. 1983), stocking rates and specific timing are not available. Most of these areas are either winter grazed or have year-round use. Even in winter grazing, the season extends well into the period of the year when frost leaves the ground.

Both Anderson et al. (1982b) and Brotherson et al. (1983) indicate optimism about the compatibility of carefully managed and timed grazing with stable cryptogam communities. While this study has demonstrated that cattle grazing, even at traditionally accepted stocking rates, can adversely affect the cryptogamic soil crust in a cold desert ecosystem, it has also demonstrated that taking advantage of frozen soils in the winter as a protection mechanism allows managers to graze cattle at proper stocking rates without damage to the total cryptogamic soil cover. Leaving the crytogamic crusts intact protects the surface soils from natural wind and water erosion.

Grazed areas in the cold deserts of the Intermountain Region, where accelerated erosion can occur, benefit from grazing management practices that favor cryptogamic cover. Winter grazing with frozen soil conditions appears to be compatible with stable, moss-dominated, cryptogam populations. Continued repetitive summer and especially spring grazing may jeopardize long-term ecosystem stability in these fragile environments.

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