The Impact of Compression on Microphytic Crusts

Introduction

In the desert of the Great Basin, small organisms can be found in the crust of the earth's soil. These organisms are responsible for the construction of microphytic crusts, or cryptobiotic soil. For many years, some researchers and experts have cautioned hikers to avoid stepping on the fragile soil, reasoning that the crust may take hundreds of years to fully recover. The facts to back up this statement, however, have been scarce. In order to determine just how detrimental compressional force is to the cryptobiotic soil, we must first look at what it is, the functions it performs as a contribution to desert ecology, its physiological adaptations to its environment, and finally experimental data which compares and contrasts disturbed and undisturbed areas and recovery times.

Composition and Structure

Various concentrations of mosses, lichens, liverworts, algae, fungi and bacteria interact to form a layer of solid topsoil about 10 centimeters thick. Loose soil particles are joined together by filamentous cyanobacteria, which are usually surrounded by sticky mucilaginous sheaths. (www.gorp.com) Moss and lichen constituents of cryptogamic crusts are also important soil stabilizers. Thalli and small ventral rhizoids penetrate the surface, creating a highly irregular surface crust of raised pedestals (typically black) and intervening cracks. (Anderson, Harper, and Rushforth) Frost heaving, subsequent uneven erosion, and lack of surface plant roots also result in high pedicles. (www.soilcrust.org)

Edaphic Considerations

Correlative studies in arid to semi-arid regions have consistently shown more microphytic cover of the soil when the texture trended to finer particles. (N. E. West) Many mosses and lichens can occur on highly acidic soils, whereas cyanobacteria are generally found on saline soils and perhaps even require sodium for their best growth. (N.E. West) Due to the high alkalinity of the Great Basin soils, *Microcoleus*- and *Scytonema*-dominated crusts occur in relative abundance in southern Utah. (Jeffries, Link, Klopatek)

Distribution and Dispersal

Cryptobiotic soil can be found in deserts worldwide, with relatively similar compositions. Microphytes are dramatically more taxonomically similar between homologous environments on different continents than are vascular plants and animals due to the ease of diaspore transport in the atmosphere. (N.E. West) "Dust devils" and clear thermal vortices that frequent desert landscapes can carry particles less than 20 micrometers up to an altitude of 5000 meters. From there, the jet streams could carry them between continents. (N.E. West)

Functions

Crusts provide favorable sites for the germination of vascular plants and play important roles in water conservation, nitrogen fixation, and prevention of soil erosion. (D. N. Cole) The irregular soil surfaces break up the micro-patterns of wind flow, reduce windborne soil losses, and trap drifting soil particles. (Anderson, Harper, and Rushforth) Obviously these small organisms play a big role in desert ecology.

Physiological Adaptations to Harsh Environments

Microphytes are extremely resilient to large variations in climatic features.

They can become active during relatively cool conditions, but are also capable of withstanding very hot and desiccating conditions. (N. E. West) Rather than depending solely on rain, lichens and mosses commonly survive on dew or even air of high humidity. Microphytes have evolved rapid physiological responses and can use surface soil moisture that comes in pulses. (N.E. West) With all these adaptations to extreme climatic conditions, it is more likely that they will be more influenced by the indirect rather than the direct effects of climatic change, e.g. dust deposition, vascular plant litter, fire, trampling, etc. (N.E. West)

Effects of Compressional Damage on Soil Loss and Water Runoff

Physical disruption of cryptogamic crusts increased the average loss of water as runoff by 51% and increased soil loss by 686%. Complete removal of the crust resulted in the loss of 92% more water than was lost from control plots and 1,441% more soil loss. (Marble and Kimball) Breaking the integrity of the crust can result in crust burial, turning solidly anchored, crypto-covered gardens into drifting sand dunes. (www.4corners.net)

Severity of Compressional Disturbances Due to Timing

Microphytic crusts are especially susceptible to mechanical damage when dry and brittle. (www.gorp.com) Respiratory and photosynthetic activity for crusts of both *Microcoleus* and *Scytonema* begins to diminish rapidly at about twelve percent water content. (50% soil saturation) So, net photosynthetic activity of cryptogamic crusts in a blackbrush community would apparently be greatest during the wet spring, when soil moisture would be sustained at near soil saturation for extended periods of time. (Jeffries, Link and Klopatek)

Freedom from grazing in the late winter and spring allows soil moisture to permit some regrowth of cryptogams and may result in enough surface stabilization to significantly reduce runoff and sediment losses due to torrential summer rains.

Grazed

Treatment Early winter	Number of Cryptogamic species	Cryptogamic species as % of total	Treatment Early-late winter	Number of Cryptogamic Species	Cryptogamic species as % of total
1	1	7.1	1	2	15.4
2	1	7.7	2	2	15.4
3	4	28.6	3	2	16.7
4	2	20.0	4	1	11.1
Averages	3.8	15.9		1.8	14.7

Control

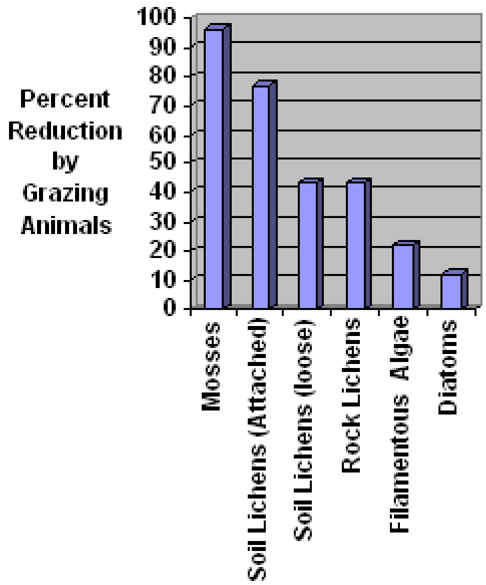
1	4	28.6	1	4	23.5
2	4	22.2	2	4	28.6
3	4	25.0	3	5	38.5
4	4	26.7	4	6	31.6
Averages	4	25.6		4.8	30.6
t-values	2.333	1.460		4.245*	4.940*

*Asterisked t-values denote significant differences between treatments and controls
+Table taken from Marble and Harper

A significant reduction in cryptogamic cover is associated with late winter grazing, while early winter grazing shows no significant difference in any cover type. (Marble, Harper) In fact, altering the season of grazing from winter long (15 Oct.-15 May) to early winter only (15 Oct.-15 Feb.) without a change in grazing intensity reduced water runoff by 23% and sediment release by 31%. (Marble and Harper) Moisture is usually the limiting factor in development of crusts, (Jeffries, Link and Klopatek) so crust crushed during the dry season may not be able to support new algal growth to restabilize the fragile surface.(Anderson, Kimball, Holmgren)

Effects of Compressional Forces on Nitrogen Fixation

Although trampling leaves an apparently sterile surface of sand, in reality, it is heavily inoculated with crustal organisms. (D. N. Cole) Mosses and foliose lichens appear to be more susceptible to livestock trampling than crustose lichens and the microscopic forms. (N. E. West)



*Graph taken from Anderson, Kimball, and Holmgren.

Although there is a large reduction in foliose lichen and moss cover in grazed areas, the average number of filamentous algae, diatoms, rock lichens, and loose soil lichens stay much the same or are only slightly reduced. Because crustose lichens like *Collema* and free-living cyanobacteria play the major roles as N-fixers, livestock grazing and other kinds of mechanical disturbances may not dramatically reduce that function, if applied in moderation. (N. E. West)

Recovery

Although cryptogamic crusts are highly fragile, they are moderately resilient. In

Israel, where unrestricted livestock use has occurred for centuries, continued existence of well-developed microphytic crusts have been found. (N. E. West) In a study by D.N. Cole, results showed that after one year of recovery from trampling, cryptogam cover increases significantly, after three years, vertical distances are similar to pre-trampling levels, and after five years, cryptogam cover returns to pre-trampling levels.

Years since trampling	Crytogam cover (%)	Vertical distance mm	Coefficient of variation (%)
0	3 a	511 a	1.3 ab
1	20 b	499 b	1.0 a
3	71 c	491 c	1.9 b
5	85 d	490 c	1.9 b
Pre-trampling	89 d	492 c	2.7 c

*Any two values in the same column followed by the same letter are not significantly different +Table taken from D.N. Cole

Conclusion

Microphytes are important components in the dynamics of desert ecology. They help to stabilize the soil, reduce water loss, fix nitrogen, and provide safe havens for seed germination. Because of this, it is in our best interest to maximize and retain the amount of cryptogamic soil we have in our desert regions. However, if applied in moderation, the damage done to the soil by machanical forces such as grazing and hiking seem to be reversible. So, although it may be in our best interest to 'tread softly' while among the microphytes, we most likely will not be destroying the soil for generations to come.

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2) www.gorp.com Arches National Park; 'Cryptobiotic Soil'
3) www.gorp.com Arches National Park; 'Plant Ecology'
4) www.4corners.net Belnap, Jane; 'Cryptobiotic Soil: Holding the Place in Place'