

Ecological Studies 150

J. Belnap O. L. Lange (Eds.)

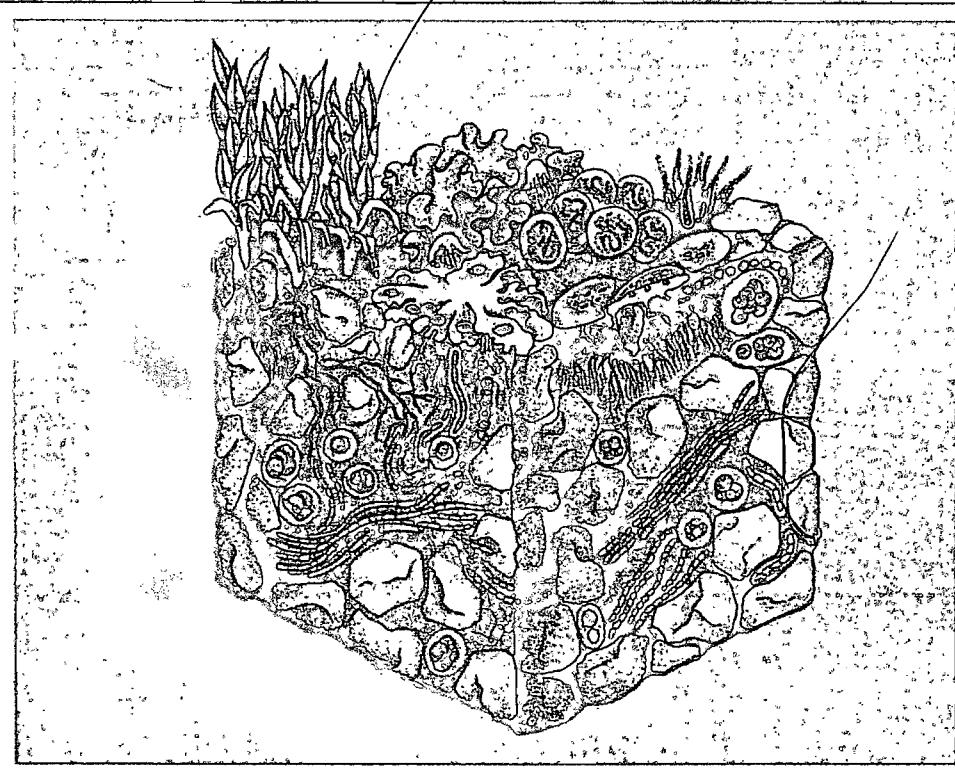
California Energy Commission
DOCKETED
11-AFC-02

TN # 69966
MAR. 20 2013

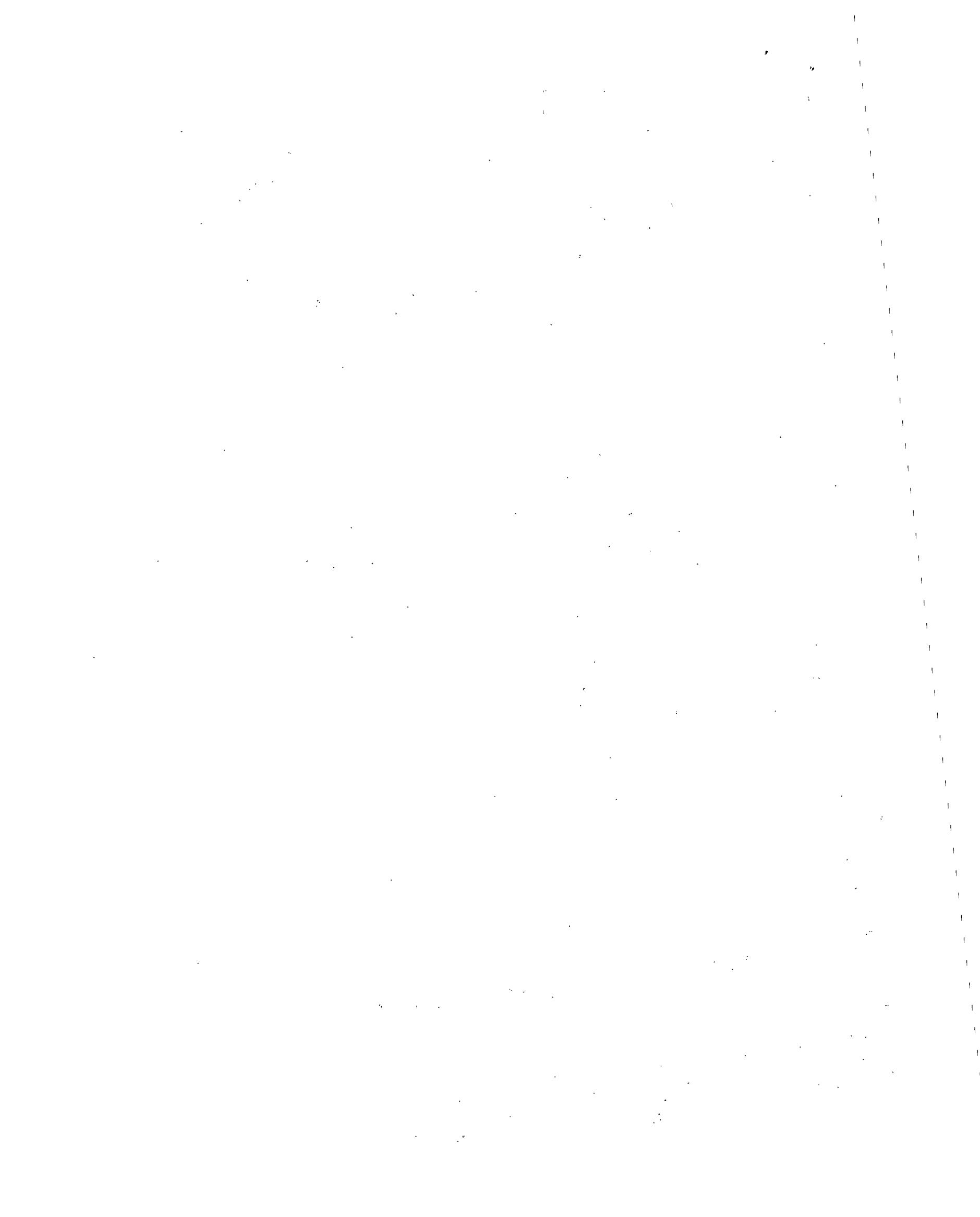
Biological Soil Crusts: Structure, Function, and Management

1st Edition 2001, Revised 2nd Printing 2003

Paperback



Springer

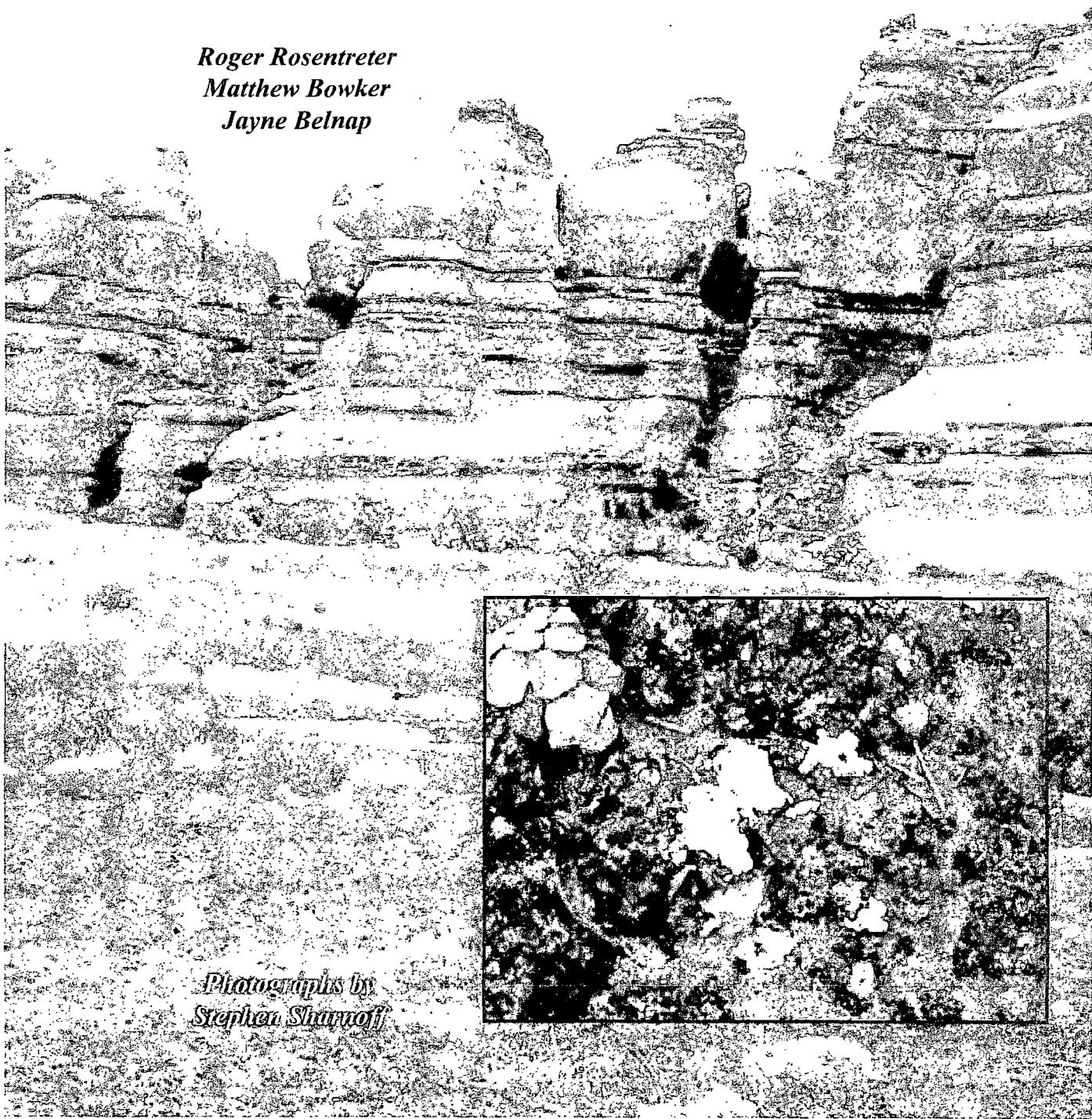


Michael Garabetian
916-719-7296

A Field Guide to Biological Soil Crusts of Western U.S. Drylands

Common Lichens and Bryophytes

Roger Rosentreter
Matthew Bowker
Jayne Belnap



Photographs by
Stephen Shuroff

Table of Contents

Acknowledgements	4
How to use this guide	4
Introduction	4
Crust composition	4
Cyanobacteria.....	5
Successional series	5
Ecological function	6
Soils.....	7
Lichen morphology	7
Monitoring	8
Crust morphology.....	9
Monitoring BSCs using level of darkness.....	10
Moss Key	11
Moss structure	13
Liverwort Key	25
Liverwort structure.....	25
Lichen Keys	29
Major Division Key.....	29
A: On-Moss	30
B: Yellow	31
C: Black.....	31
D: Crustose	32
E: Fruticose	33
F: Foliose.....	34
G: Squamulose	35
Lichen structure.....	39
Lichen chemistry: spot tests	39
Appendix: Authorities	92
Glossary.....	94
Additional resources.....	98
Websites.....	98
Books and articles	99
Index.....	101

Michael Garabedian

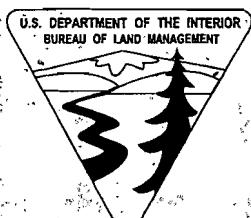
BIOLOGICAL SOIL CRUSTS: ECOLOGY AND MANAGEMENT



Technical Reference 1730-2
2001

U.S. Department of the Interior

Bureau of Land Management



U.S. Geological Survey



TABLE OF CONTENTS

1.	Introduction to Biological Soil Crusts	1
1.1	Biological Soil Crust Components	3
1.2	Microstructure	5
1.3	Morphological Groups	6
1.4	Differentiating Types of Biological Soil Crusts in the Field	6
1.5	What Biological Soil Crusts Are Not: Physical Soil Crusts	7
2.	Distribution and Factors Influencing Species Composition	11
2.1	Distribution	11
2.2	Factors Influencing Distribution	14
2.2.1	Elevation	14
2.2.2	Soils and Topography	17
2.2.3	Disturbance	19
2.2.4	Timing of Precipitation	21
2.2.5	Vascular Plant Community Structure	22
2.2.6	Ecological Gradients	22
2.2.7	Microhabitats	23
2.3	Unique Crustal Communities in North America	23
2.3.1	Gypsum	23
2.3.2	Glades (Lithic and Shallow Soil Sites)	24
2.3.3	Thermal Springs	24
2.3.4	Playas	25
2.3.5	Alpine Sod	25
2.3.6	Arctic Tundra	25
2.4	Example: Biological Soil Crusts in Sagebrush Communities.....	26
3.	Ecological Roles	29
3.1	Species Composition and Biomass	29
3.2	Carbon Fixation	29
3.3	Nitrogen Fixation	31
3.4	Albedo	32
3.5	Effects on Vascular Plants	33
3.5.1	Seed Germination	33
3.5.2	Plant Establishment and Cover	33
3.5.3	Nutrient Levels in Vascular Plants	34
3.6	Water Relations	35
3.7	Soil Stabilization	40

6.1.5	Line-point Intercept Methods	81
6.1.6	The Issues of Scale	81
6.1.7	Voucher Specimens	81
6.1.8	Statistical Considerations	82
6.2	Other Monitoring Methods	83
6.3	Impacts of Monitoring	83
7.	Internet Resources for Biological Soil Crusts.....	85
	Glossary	87
	References	89

List of Figures

Figure 1.1	Biological soil crusts of the Colorado Plateau	1
Figure 1.2	<i>Microcoleus vaginatus</i> , one of the predominant cyanobacteria comprising biological soil crusts	4
Figure 1.3	Physical soil crusts	10
Figure 2.1	Arid and semi-arid ecoregions of western North America	12
Figure 2.2	Biological soil crusts of the Great Basin and Sonoran deserts	13
Figure 2.3	Biological soil crust forms based on temperature characteristics of the environment	15
Figure 2.4	General ecological relationships for biological soil crusts	18
Figure 2.5	Soil stability relative to texture and moisture status	20
Figure 2.6	Gelatinous and other nitrogen-fixing lichens by relative soil temperature and calcareous influence	23
Figure 3.1	Disturbance plots on the Colorado Plateau showing the difference in soil surface color between undisturbed (dark) and disturbed (light) plots	32
Figure 3.2	Sandberg bluegrass (<i>Poa secunda</i>) growing in well-developed biological soil crusts in the northern Great Basin	33
Figure 3.3	Soil-water relationships with biological soil crusts	36
Figure 3.4	Biological soil crust and soil characteristics that influence infiltration	39
Figure 3.5	The sheath of <i>Microcoleus vaginatus</i> contains sticky polysaccharides that entrap soil particles and bind them together.....	40
Figure 4.1	Comparison of community structure in ecosystems that evolved with (midwestern prairie) and without (desert grassland) large herds of grazing mammals	41
Figure 4.2	Natural and altered fire cycles in sagebrush communities of the Great Basin	43
Figure 4.3	Successional sequence for biological soil crusts	46
Figure 4.4	Changes in the vascular plant community structure due to cheatgrass invasion	48

4.	Response to Natural Impacts and Human Actions	41
4.1	Evolutionary History of Natural Impacts	41
4.1.1	Grazing Characteristics	41
4.1.2	Fire	42
4.2	Disturbance Effects	44
4.2.1	Disturbance Severity, Size, Frequency, and Timing	44
4.2.2	Disturbance Effects on Species Composition	45
4.2.2.1	Air Pollution	45
4.2.2.2	Oil Spills, Insecticides, and Herbicides	47
4.2.2.3	Annual Plant Invasion	47
4.2.2.4	Fire	47
4.2.2.5	Mechanical Disturbance	49
4.2.2.6	Burial	50
4.2.3	Disturbance Effects on Nutrient Inputs and Retention	50
4.2.3.1	Carbon Fixation	50
4.2.3.2	Nitrogen Inputs	52
4.2.4	Disturbance and Vascular Plants	54
4.2.5	Disturbance and Surface Albedo	54
4.2.6	Disturbance and Soil Hydrology	55
4.2.7	Disturbance Relative to Wind and Water Erosion	55
4.2.7.1	Water Erosion	55
4.2.7.2	Wind Erosion	56
4.3	Factors Influencing Natural Recovery Rates	56
4.3.1	Sequence of Species Appearance	58
4.3.2	Soil Texture	58
4.3.3	Climate Regimes	61
4.3.4	Disturbance Type, Frequency, Severity, and Size	61
4.3.5	Condition of Adjoining Substrate	62
4.3.6	Vascular Plant Community Structure	62
4.3.7	Nitrogen and Carbon Fixation	63
4.3.8	Surface Albedo	63
5.	Management Techniques to Maintain or Improve Existing Biological Soil Crusts	65
5.1	Fire	65
5.1.1	Prescribed Fire	65
5.1.2	Post-fire Management	66
5.2	Livestock Grazing	67
5.3	Recreational Use Management	69
6.	Monitoring Biological Soil Crusts	71
6.1	Monitoring Methods	71
6.1.1	Sampling Design and Procedures	73
6.1.2	Using Morphological Groups for Monitoring	73
6.1.3	Quadrat Methods	74
6.1.4	Line-intercept Methods	75