Lichen Biomonitoring Program and Baseline

USDA Forest Service Region 1
Western Montana Wilderness Areas

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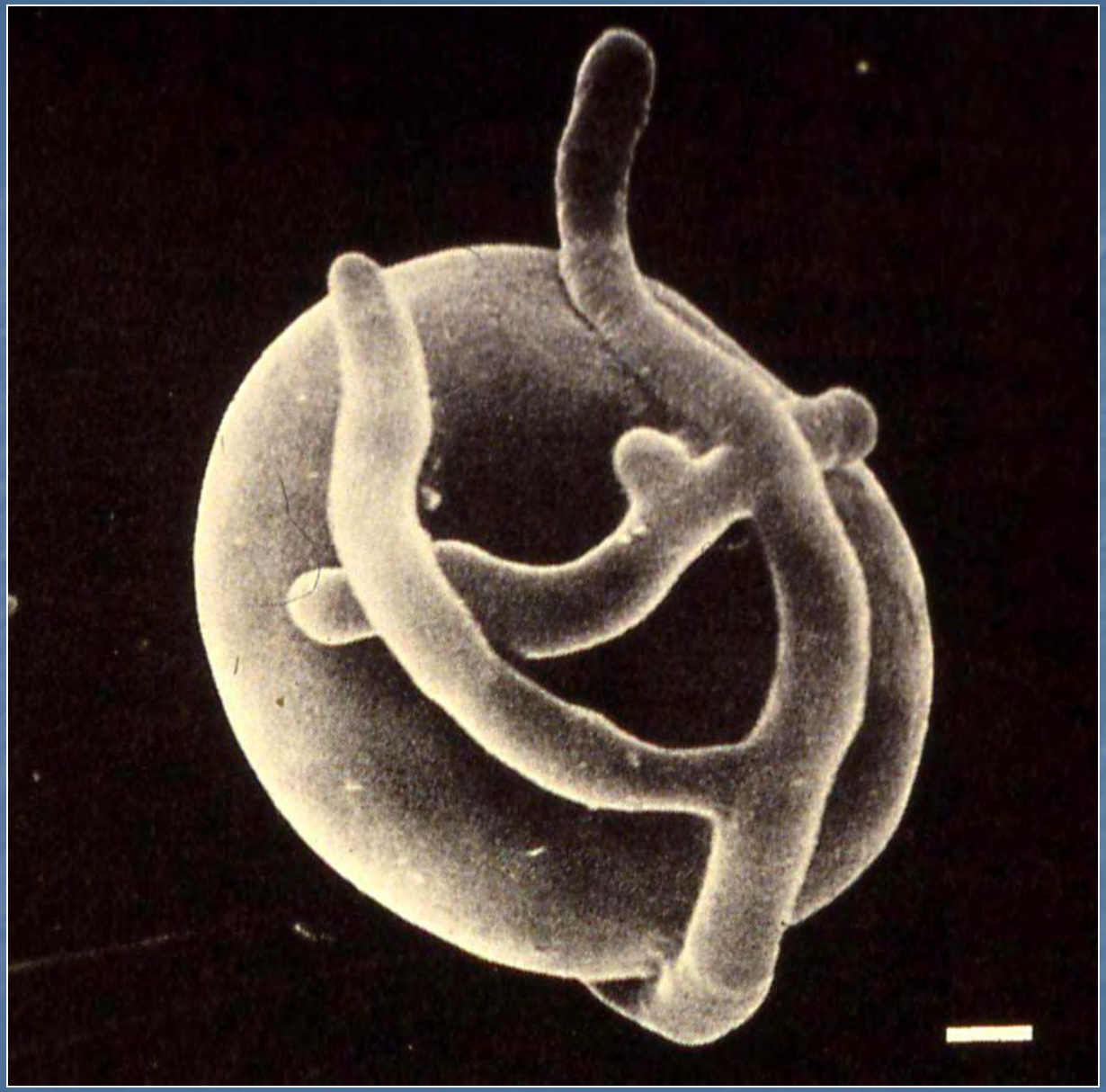
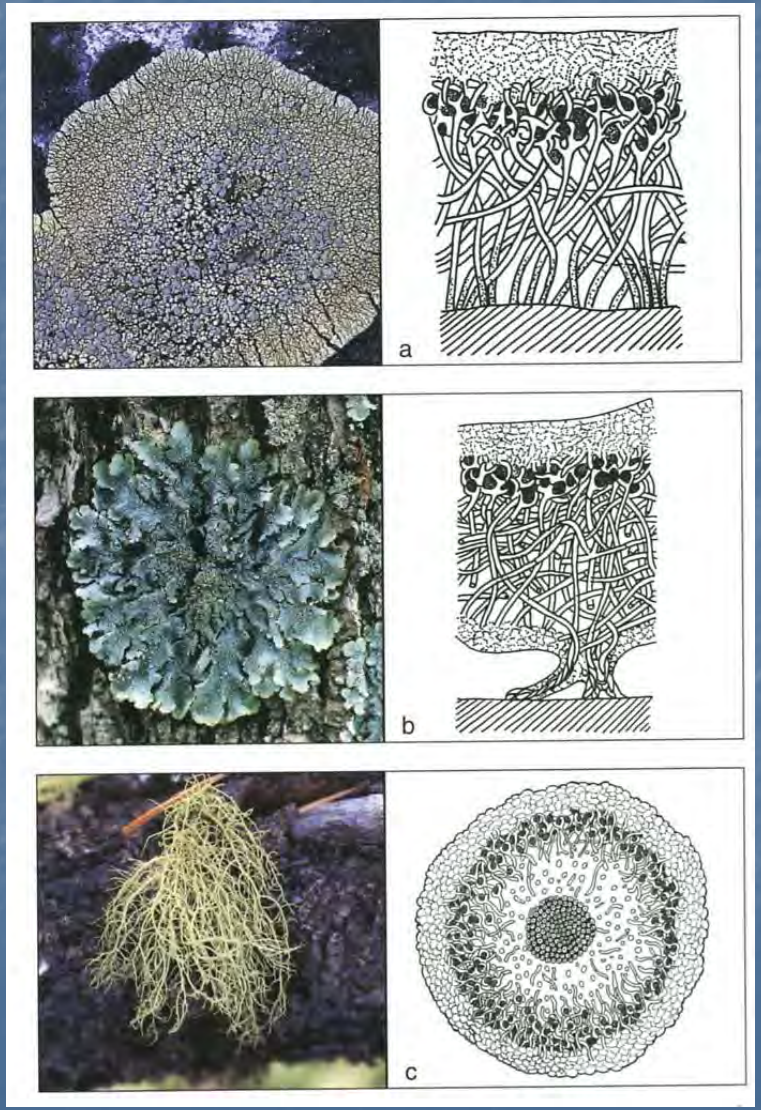
A Brief Lichen Primer

- Lichens are symbiotic systems consisting of a fungus (usually an ascomycete) and an alga and/or a cyanobacterium. They have a worldwide distribution, occurring in virtually all natural habitats; however, they are usually less abundant in and around urban areas. They are commonly found growing on a variety of natural substrates including various types of rocks, bark, decomposing wood, and soil; they are also known to occur on a variety of man-made substrates.



Common Lichen Growth Forms

- Crustose lichens have an upper cortex but lack a lower cortex. They are tightly adherent to their substrate.
- Foliose lichens have both an upper and lower cortex and are variously adherent to their substrate.
- Fruticose lichens have a single point of attachment and are extensively branched.

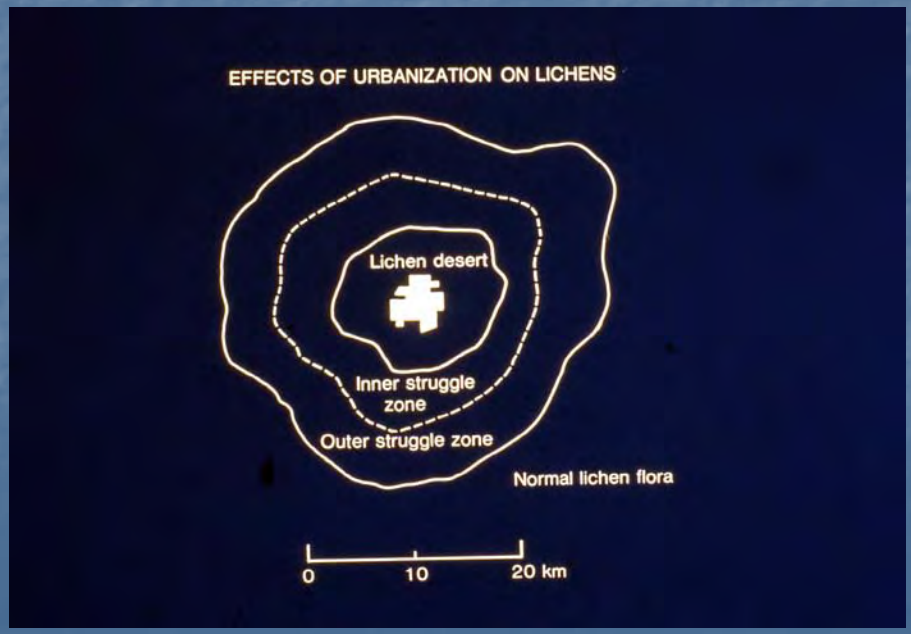


Natural Lichen Substrates

Man-made Lichen Substrates

Lichens as Biomonitors of Air Quality

- In the late 19th century lichen sensitivity to air pollution was first suggested.
- Point sources of pollution typically distribute lichens based on levels of sensitivity.
- Compounding urban factors include:
  - Altered natural substrates
  - Altered water dynamics



Lichens – As Early Indicator Species

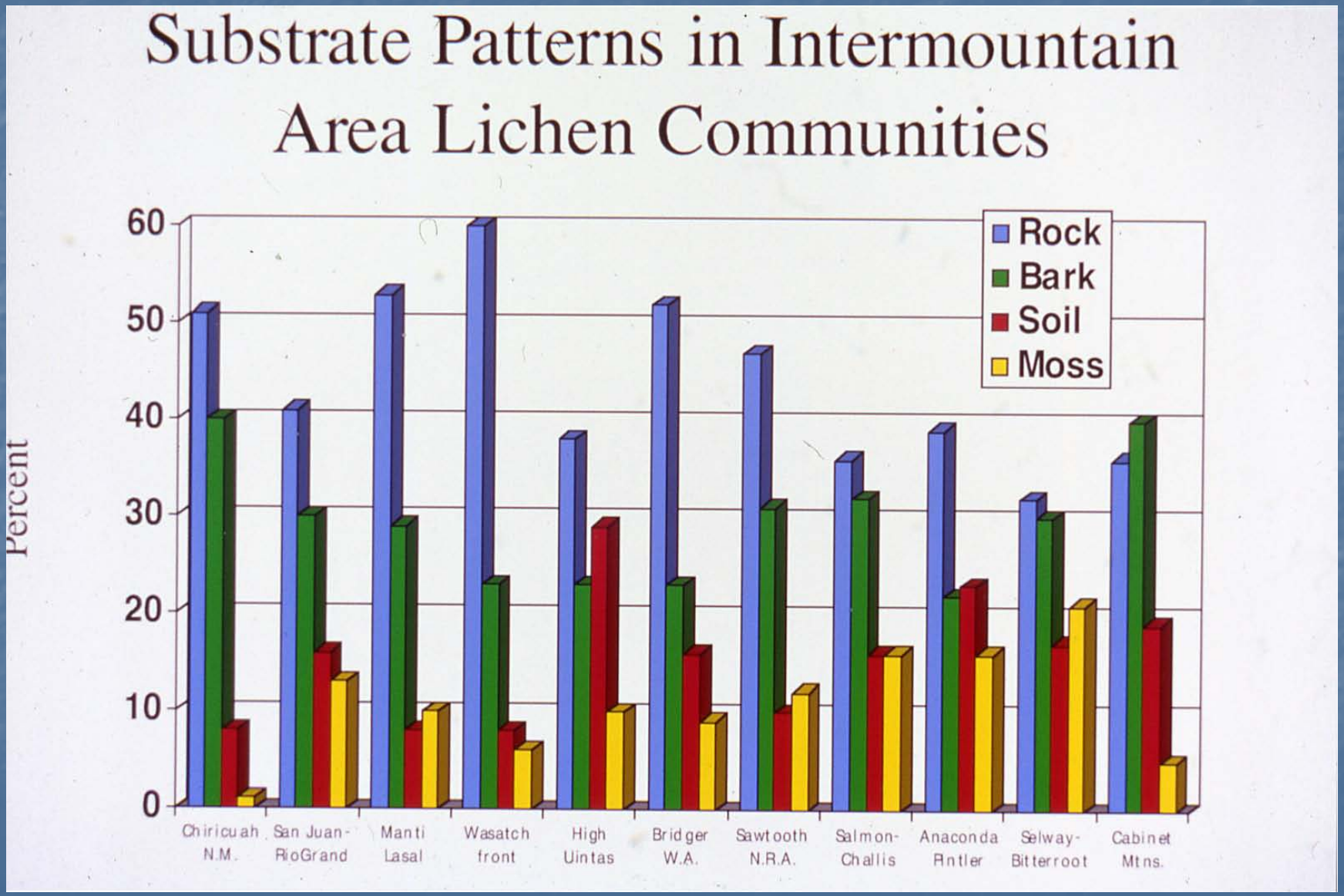
Air Quality Biomonitoring Techniques Using Lichens

- Floristic Surveys*
- Documentation of Sensitive Indicator Species*
- Evaluation of Substrate and Growth Form Distribution Patterns*
- Analysis of lichen tissues for potential pollutant elements*
- Ecological Surveys
- Transplant studies
- Measurement of Various Physiological Parameters
  - Photosynthetic activity
  - Cellular Respiration
  - Protein Synthesis
  - Nitrogen fixation
  - Membrane permeability

Intermountain Lichen Air Quality Biomonitoring Program

- Over the last 30 years we have established more than 500 air quality biomonitoring reference sites in the Intermountain western United States – this represents one of the largest regional air quality biomonitoring programs in the world.
- Reference sites have been established in 8 Intermountain Area states – Montana, Idaho, Wyoming, Nevada, Utah, Colorado, Arizona, and New Mexico.
- More than 35,000 herbarium specimens have been collected and deposited in the Herbarium of Nonvascular Cryptogams at Brigham Young University.
- More than 1100 tissue samples have been analyzed for more than 20 potential pollutant elements.
- Excess material from all elemental analysis tissue samples is archived in the Herbarium of Non-vascular Cryptogams at Brigham Young University.
- Most reference site baselines have been re-evaluated at least once.

Intermountain Area Lichen Biomonitoring Baselines – A Comparative View



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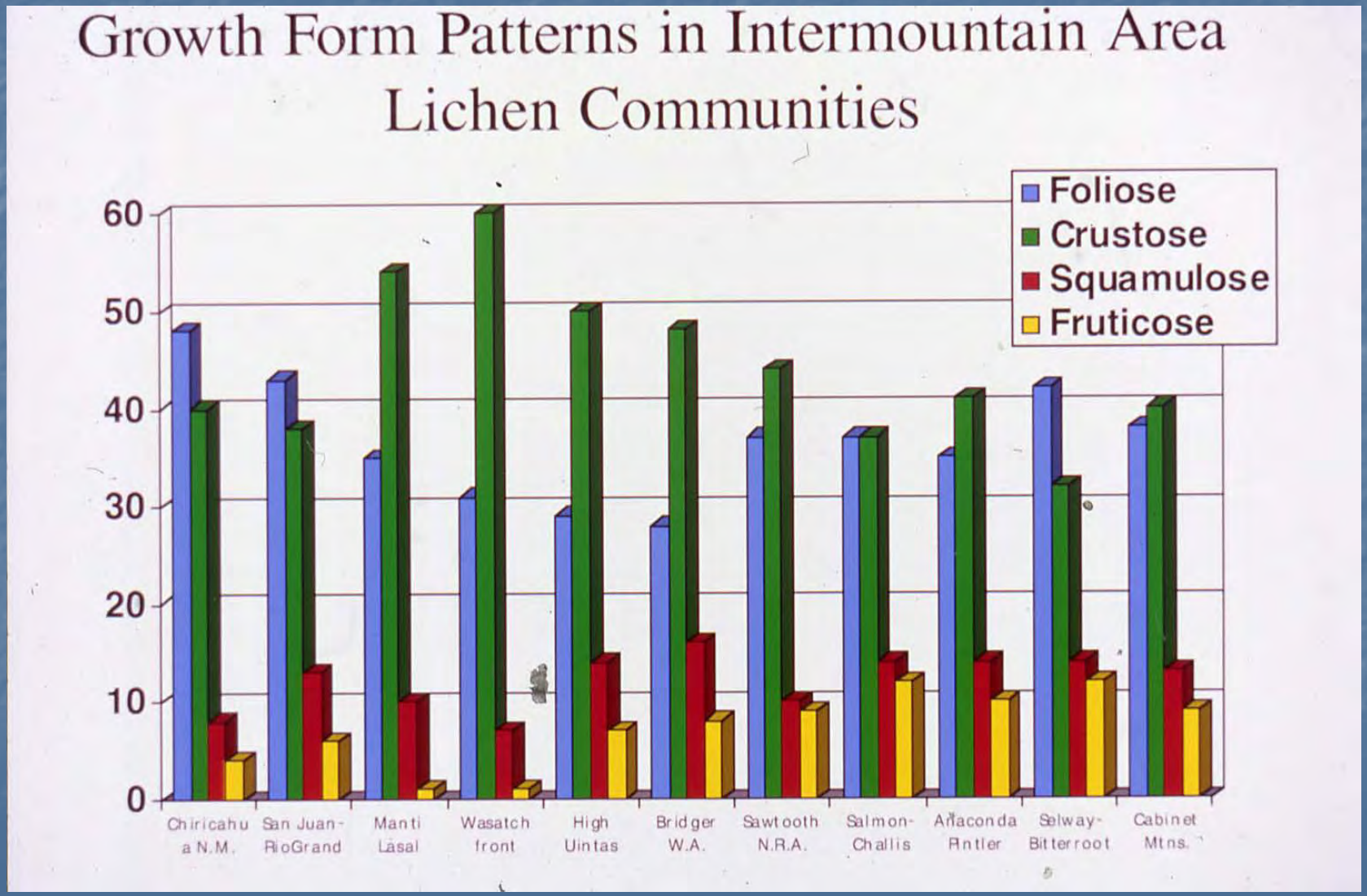

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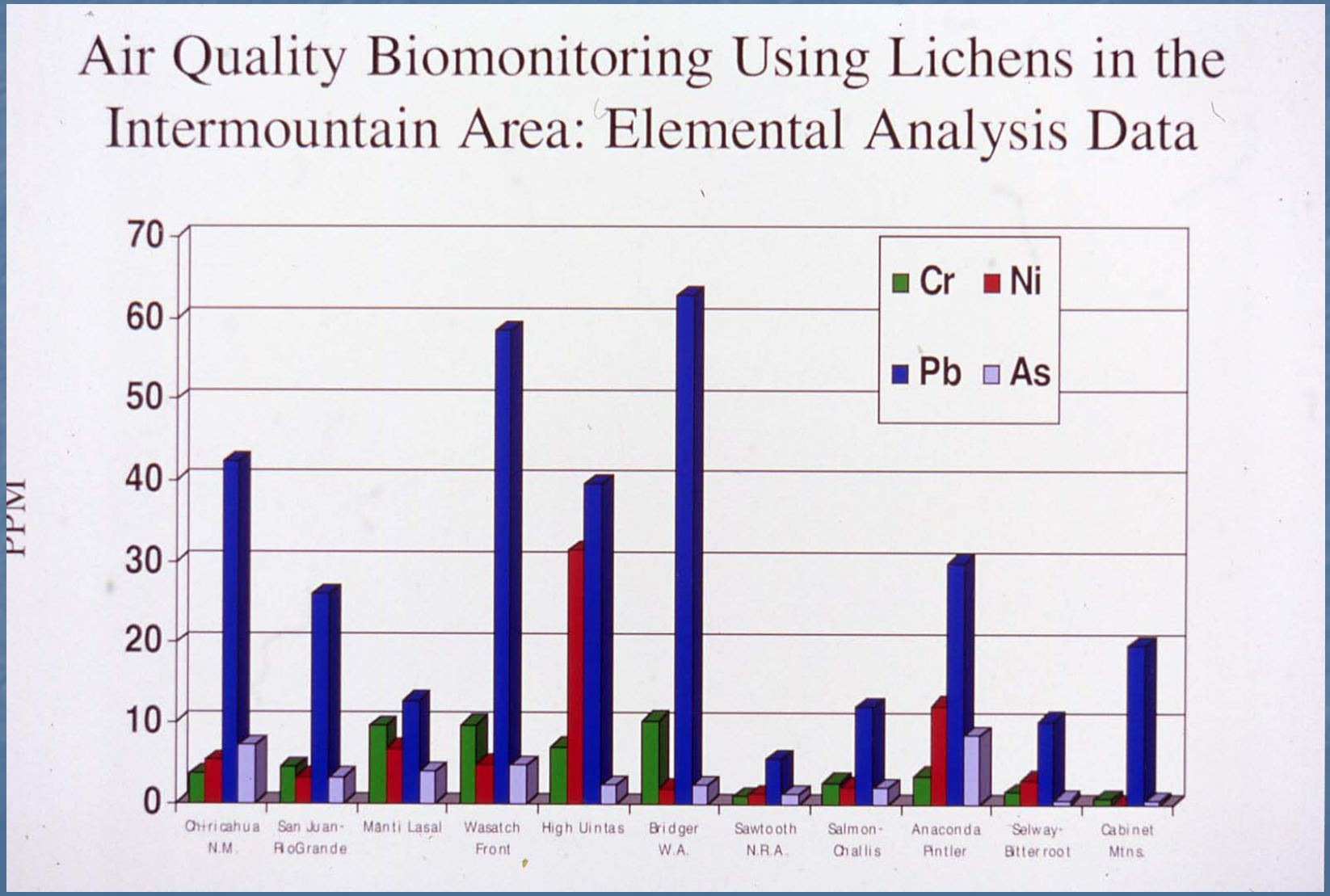

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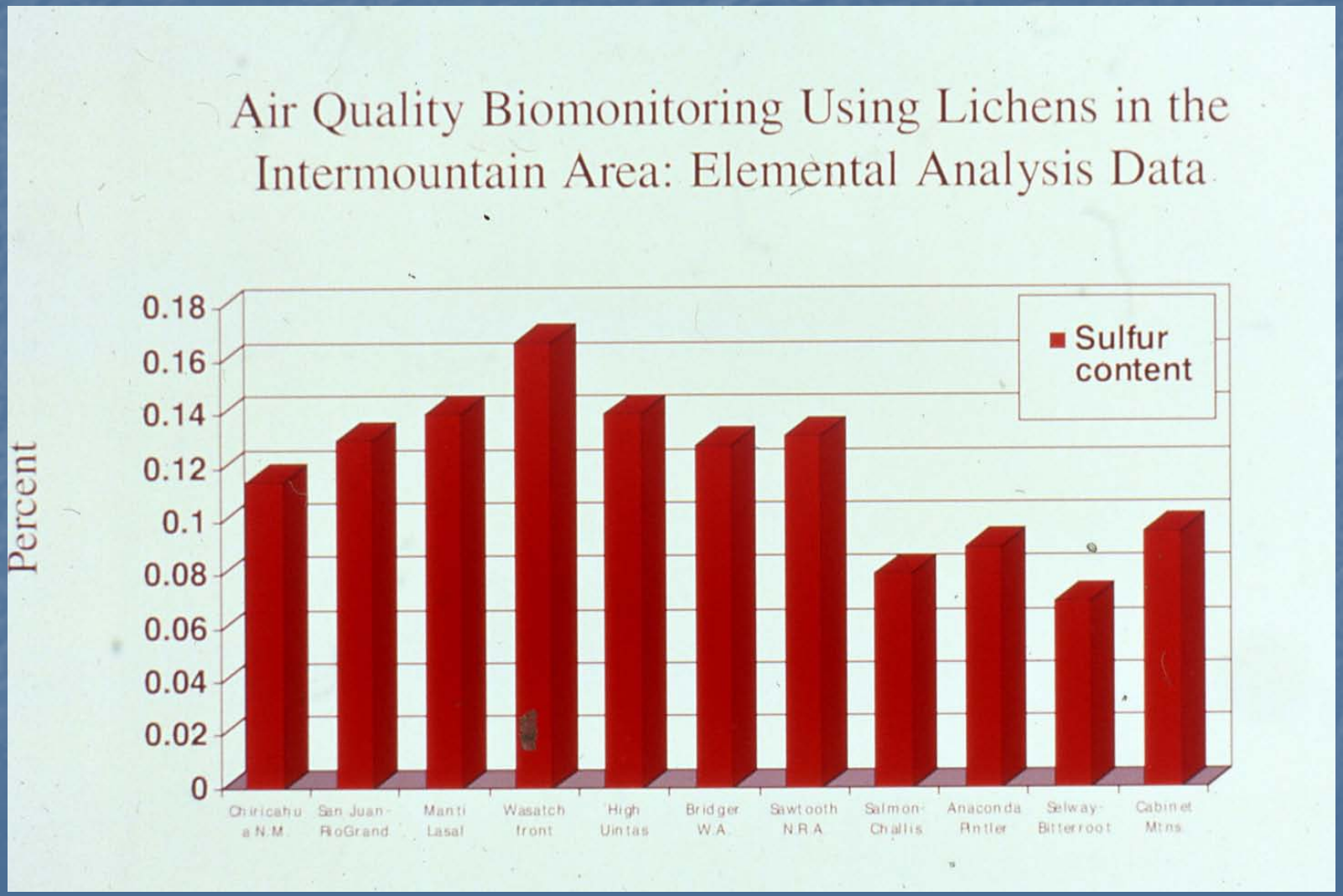
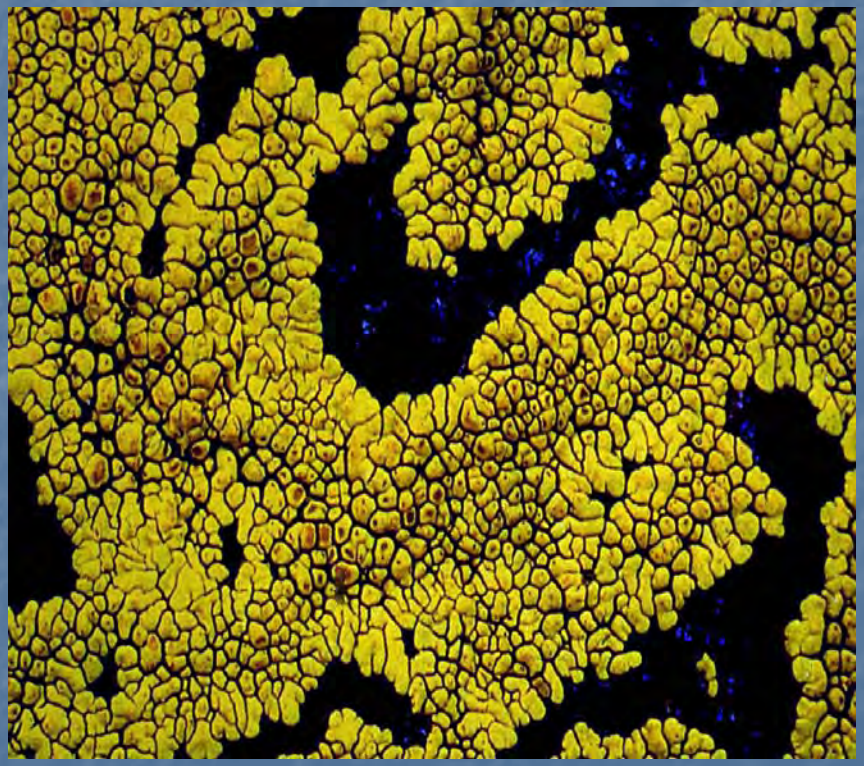


Lichen Air Quality Biomonitoring Program – USDA Forest Service Western Montana Wilderness Areas An Overview

- Between 1992 and 2003 Lichen air quality biomonitoring baselines were established for 6 western Montana Wilderness Areas: Anaconda Pintler, Selway Bitterroot, Cabinet Mountains, Gates of the Mountains, Mission Mountains, and Bob Marshall.
- Baselines in the 3 original wilderness areas – Anaconda Pintler, Selway Bitterroot, and Cabinet Mountains were reviewed between 2000 and 2002.
- A total of 48 air quality biomonitoring reference sites have been established in and around all 6 wilderness areas.

Lichen Air Quality Biomonitoring Program – USDA Forest Service Western Montana Wilderness Areas Some General Patterns

- Lichen communities in all 6 wilderness areas are diverse and well developed.
- The data suggest that lichen communities in all 6 wilderness areas are generally healthy.



Lichen Air Quality Biomonitoring Program – USDA Forest Service Western Montana Wilderness Areas General Results and Observations

- All substrates (bark, lignum, rock, and soil) generally support diverse and abundant lichen communities.
- The average number of sensitive indicator species per reference site across all 6 wilderness areas is high - 18.2/reference site
- The more pollution sensitive growth forms (foliose and fruticose) are generally abundant across all reference sites.
- The only reference sites consistently showing air pollution-related damage are those located directly west of the old Anaconda Copper Smelter site – averaging 3.5 sensitive indicator species per reference site with the lichen community dominated by a greater number of pollution tolerant species.

Lichen Air Quality Biomonitoring Program – USDA Forest Service Western Montana Wilderness Areas
General Results and Observations: Pollutant Element Data

- Between 1992 and 2002, the Anaconda Pintler, Selway Bitterroot, and Cabinet Mountains wilderness areas showed a general decline in potential pollutant element concentrations across all reference sites. This was particularly notable at the sites immediately west of the Anaconda Copper Smelter site.
- Overall baseline pollutant element concentrations for the Gates of the Mountains, Mission Mountains, and Bob Marshall wilderness areas were within background levels. One exception to this general pattern was elevated sulfur levels in the 5 out of 7 samples from the Gates of the Mountains Wilderness Area.
- There were also a limited number of samples with slightly elevated levels of arsenic in each of the new wilderness areas.

Lichen Air Quality Biomonitoring Program – USDA Forest Service Western Montana Wilderness Areas Recommendations

- Consistent, periodic reviews of the biomonitoring program is essential.
- Generally, follow-up reviews every 5-7 years is ideal.
- More frequent reviews may be required if specific, local pollution sources develop or intensify.