PIMS
Photographic Inventory Monitoring System

A Monitoring Protocol for Measuring Trail Treadway Impact in the Mount Mansfield Arctic-Alpine Zone

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Abstract

The purpose of this study was to design, create, and evaluate a monitoring protocol for the University of Vermont Mount Mansfield Natural Area. There is a lack of quantifiable data related to the impacts of increasing visitor use on the fragile and rare alpine environment within the Natural Area. The Photographic Inventory Monitoring System (PIMS), is designed to provide that data over the long term in the form of quantifiable trend analysis. PIMS is designed to be easy to execute requiring little to no ecological knowledge, require little field time to collect data, and provide for a wide range of data.

Key Phrases:
Alpine
Ecological Monitoring
Endangered, Threatened, and Rare Species
Photomonitoring
Quadropod
Species of Special Concern
Treadway Impact Monitoring

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"*Ecological Monitoring is not in-depth ecological research; and, while the two are related, they should not be confused with each other.*" (Henry and McCanny, 1994, p. 2)

Chapter One - Introduction

The Photographic Inventory Monitoring System (PIMS) is designed to provide a quantitative database about the trail treadway and the associated ecosystems located along the Long Trail in the University of Vermont (UVM) Natural Area Mount Mansfield. This Natural Area has been in university ownership since the late 1800's; it is a registered National Natural Landmark, a Vermont Fragile Area, and a registered Core Area in the Champlain Adirondack Biosphere Reserve under UNESCO.

The focus area of this study is within the alpine zones encompassing a section of the Long Trail located between the Nose and the Chin on Mount Mansfield. Due to the harsh growing environment and the natural history of the alpine zones, several Species of Special Concern (both state rare and federally endangered) exist in the study area. For example, *Prenanthes boottii* (Boott's Rattlesnake-root) grows on Mount Mansfield and is listed as endangered in Vermont and a candidate for federal protection. The increasing visitor usage along the ridgeline has created a strong concern for the health of the ecosystems and the continued existence of those remaining rare species.

Currently ridgeline use on Mount Mansfield has been the center of much debate among the Natural Area's associated managing parties. Permeating this debate is the need for a database that will reflect the impact of visitor use on the floral communities of the alpine zone. PIMS targets this need with an ecological monitoring design that is easy to repeat, execute, and that provides a viable data set for ecological trend analysis.

Maintenance of this protocol by the UVM Natural Areas will provide an efficient monitoring program to aid in future management decisions. With a quantifiable database, issues such as visitor use impacts will be more discernible. The proposed monitoring protocol will offer the opportunity to explore the management and protection of rare and fragile environments by providing a wide range of data. The database will serve to: provide photographic vouchers of species protected from collection, provide ecological benchmarks for further testing, track changes over time in the specific alpine ecosystem, provide a map for reconstruction if the system is subject to any catastrophic event, aid in predicting future changes, aid in the development of restoration goals, provide a time indicator for key phenological and weather related changes, and serve as an "early warning system" for the ecological integrity of the communities.

Finally, the resulting monitoring protocol may serve as a model program for other fragile natural areas under stress from elevated levels of visitor usage.

1.1 Background, Justification, Statement of the Research Problem

In 1859 the alpine zone of Mount Mansfield officially became limited to "scientific use" when it was deeded by William Henry Harrison Bingham for $1,000. It is the same deed that the Natural Areas Resolutions of 1974 are designed to address. In turn it is these resolutions that guide the management strategy adopted for that area.

The property, still in University of Vermont ownership, includes approximately 2.5 miles of the Long Trail. The Long Trail is a border to border trail across the spine of the Green Mountains from Massachusetts to Canada. The trail and the unique nature of the alpine setting make the area attractive to a large number of people. Accessibility to the alpine zone is facilitated by an auto road and visitor facilities.

Shortly after the development of several tourist and communication structures within the alpine zone the area began to receive recognition as a unique, fragile, and historically significant ecosystem. In 1968 over 3,800 acres of State Forest was designated as a Natural Area. In 1969 the Summit Caretaker (formerly Ranger Naturalist) program was initiated as an effort to minimize the impact of visitation in the alpine zone through public education about the fragility of the environment. Five years later the University declared the area a UVM Natural Area under the management of the Environmental Program. Other designations to follow were: in 1977 UVM's Natural Area was designated a Vermont Fragile Area; in 1980 the Park Service designated the combined lands of the state, UVM, and the Mansfield Company a National natural Landmark; in 1989 UNESCO identified Mount Mansfield as a core area in the Champlain Adirondack Biosphere Reserve.

The designations have created an awareness within the research, educational, and recreational communities about the unique character of the alpine zone. In 1991 the Vermont Monitoring Cooperative began to establish monitoring sites on Mount Mansfield. Research is currently ongoing and extensive. Also in 1991 an Alpine Areas Assessment was made to critique the current management strategy of the ridgeline and to make recommendations. In 1994 an interpretive center was opened in the Summit Station.

There is much evidence to support the claim that there are more and more people utilizing the backcountry for recreation, research, therapy, and a host of other reasons. Ever since the early 1950's the steady increase in backcountry use has led to resource managers rethinking the focus of their management issues. Essentially land managers had to shift from a "facility-maintenance" to "people management" mentality. The most pressing management issue is no longer maintaining campsites, roads, and parks but is management of the population who use these resources (Decker et al., 1991, p. 318). Ketchledge argues that operational programs had to be expanded into the backcountry as well. The maintenance of the resource that attracts the visitation has taken priority over the maintenance of the facilities used (Ketchledge and Regan, 1993).

Currently the situation on Mount Mansfield indicates that the number of visitors to the alpine zone is the foremost management concern. A *Burlington Free Press* article titled "Mansfield Takes it on the Chin" states that on Sunday, September 3, 1995 close to 1,300 people made the hike across the alpine zone (Bazilchuck, 1995). Due to the topography of the area and the limited size of the summit zone a visitor could expect to meet upwards of two to three hundred people during their visit.

Mount Mansfield is an area where management of people is the most effective means of managing the resource. The Mansfield Natural Area consists of approximately 400 acres of rare alpine zone. This area hosts the largest extent of alpine zone in the state of Vermont and, therefore, is of value for its natural heritage. There are several state rare and a couple federally endangered species that grace the ridgeline. According to the resolutions adopted by UVM in respect to the Natural Areas it is the task of UVM to manage the parcel so that it is maintained in a natural and pristine state to the extent possible. This requires intensive people management.

The task is made more challenging in that the Mount Mansfield ridge sees approximately 40,000 visitors per year. According to an article written by Paradis "five times as many people visit the summit of Mount Mansfield as tour Vermont's State Capitol" (Paradis, 1995). Other concerns are the continued expansion of a ski area on the eastern side of the mountain, a road hosting upwards of 10,000 automobiles each summer, and the proliferation of radio and TV towers in the alpine zone.

To further emphasize the complex situation on Mount Mansfield Paradis again states, "Incredibly, these activities are to be accommodated in an area that possesses the greatest concentration of rare, threatened, an endangered species and natural communities in Vermont" (Paradis, 1995). This fact coupled with the situation where there is very little quantifiable data on visitor impact in the alpine zone results in management decisions being made on opinion and common sense. For the most part the expert opinions that are used to guide management decisions in the Mount Mansfield Natural Area are sufficient. However, when the various interests, or 'stake-holders', in the alpine zone have differing agendas to meet, there is conflict. When this occurs there is a need to resolve the conflict with quantifiable data. PIMS will provide that data.

The monitoring protocol designed for this project will provide for the data needed to resolve the discussions among the associated managing parties over the long term. The challenge that this protocol will meet is to monitor, in a quantifiable manner, the impact of human use on the plant communities associated with the trail treadway. In the long term the data will answer the question: is human use of favored locations reaching or exceeding the capacity of those sites to withstand excessive levels of impact?

It is unclear what impact is occurring and to what extent. It is also unclear whom is responsible for what impact. This protocol is designed to tackle that issue in a quantifiable manner.

1.2 Study Hypothesis

1. It is hypothesized that photo-monitoring can provide accurate and quantifiable data on trail treadway growth/regression and associated floral community trends.

2. It is hypothesized that photo-monitoring meets the largest set of data needs while still remaining relatively easy to maintain and execute.

3. It is hypothesized that photo-monitoring is the lowest-impact methodology for collecting anthropogenic disturbance data on trails in the alpine zone.

1.3 Study Objectives

The objectives designed to guide this research are:

1. To develop and establish a long-term monitoring program for the trail system in the alpine zone within UVM's Mount Mansfield Natural Area.

2. To critique and refine the monitoring protocol with emphasis on ease of repetition, data processing, data management, and data relevance.

1.4 Operational Definitions

1. Alpine.
Used to describe regions above treeline (Fernald, Merritt Lyndon., *Gray's Manual of Botany Vol. II,* Theodore R. Dudley, Ph.D., General Editor, Dioscorides Press, Portland Oregon, 1991). The combination of northern latitude plus high altitude on the mountainside results in a distinct treeline, beyond which trees are replaced by prostrate shrubs, wildflowers, and lichens. Above treeline, the habitat is called *alpine tundra,* and it is open and windswept habitat where wildflowers abound, along with lichens and mosses (Kricher, John C., *A Field Guide to Ecology of Eastern Forests North America,* Houghton Mifflin Company, Boston and New York, 1988.)

2. Endangered.
A species that normally occurs in the State and whose continued existence as a viable component of the State's wild fauna or flora is in jeopardy, or a species determined to be an endangered species under the Federal Endangered Species Act (*V.S.A. Title 10, Chapter 123, Sections 5401 (6) and 5402 (b).*)

3. Threatened.
A species whose numbers are significantly declining because of loss of habitat or human disturbance and unless protected will become an endangered species, or a species determined to be a threatened species under the Federal Endangered Species Act (*V.S.A. Title 10, Chapter 123, Section 5401 (7) and 5402 (c).*)

4. Species of Special Concern.

Breeding populations which are thought to occur in very low numbers relative to other taxa in Vermont, and which appear to be vulnerable here, and/or whose status in the State is undetermined and in need of study. These species may be found in a restricted geographic area or occur sparsely over a wider area; they may even be found in good numbers in other portions of their range *(Vermont Endangered Species Committee working definition.)*

5. Rare.
Floral populations which are thought to have twenty or fewer occurrences and are defined by the Nature Conservancy Ranking Standard as either S1 or S2*(Vermont Endangered Species Committee working definition.)*

6. Treadway.
Generally defined as the area of visible trampling impact characterized by exposed soils and/or bedrock and complete lack of vegetation.

7. Photo-monitoring.
The systematic use of photography to provide site data indicating trends.

8. Quadropod.
The quadropod is a four legged camera mounting device (like a tripod) used for photo-monitoring efforts.

Chapter Two - Project Chronology

The PIMS design originated from work done for Acadia National Park's Little Moose Island. The island ecology is often referred to as a "summit in the sea" as it has several individual species and communities representative of a summit or alpine zone. The natural stress regime is quite similar to that of the Mount Mansfield ridgeline. The anthropocentric stressors also closely mimic those of Mount Mansfield in that trampling and treadway establishment are the most pressing concerns. A literature review and a site visit was made in the summer of 1994. Through discussions with the Park staff and the literature reviews I began to develop the photographic inventory monitoring protocol. A formal proposal based on this monitoring technique was submitted to the Park in the fall of 1994.

Unfortunately the Park was unable to fund the research. Also extensive networking with local land protection and stewardship organizations resulted in little financial interest. The collection of a viable data set needed to meet requirements for standard statistical analysis demands 3-4 years of research. This time requirement is not practical for an undergraduate thesis.

In discussions with Rick Paradis, University of Vermont (UVM) Natural Areas manager, it was determined that the research design would serve well in the alpine zone of Mount Mansfield. The thesis project, it was decided, should consist of only the research and design of a monitoring protocol and be applied to Mount Mansfield. Statistical analysis would be an option in future but not specifically part of the thesis project, thereby keeping the scope of the project more focused.

Interest in applying the photo-monitoring protocol to the Mount Mansfield Natural Area extends beyond the University community. On June 16, 1995 Sandy Wilmot, the Monitoring Coordinator of the Vermont Monitoring Cooperative (VMC), approved of the project and offered to create the archiving system for the resulting data using VMC resources. The VMC requires an application process before a research or monitoring project can be supported. Issues such as objectives, sampling frame, measurements, spatial context, time budgets, specific locations, availability of data, and data compatibility are addressed. (The VMC application and workplan are included in the Appendix.) The application process also outlines any research restrictions to which the project must adhere before approval is made. For example it was necessary to clear the project with the manager of the UVM Natural Areas. It was also necessary to contact Laurie Eaton of the US Fish and Wildlife Service concerning working around the federally endangered (candidate) *Diapensialaponnica* , and Chris Fichtell at the Vermont Agency of Natural Resources Heritage Program concerning working around the state rare and threatened species.

Further support came from the Green Mountain Club (GMC) who expressed interest in the resulting database and possible future application in the Camel's Hump alpine zone.

The location, the fragile nature of the area, and the contemporary nature of the project all lent to the success of the funding search. The involvement of the VMC, GMC, and the UVM Natural Areas proved invaluable in convincing funding sources of the viability of the project. My familiarity with the area and with the management of alpine zones also facilitated funding success.

Credit must also be given to administrative help from the UVM Natural Areas and the GMC. I was able to conduct assisted searches of the SPIN database to locate funding sources by approaching the Office of Sponsored Programs as a representative of the Natural Areas. Bob Lincoln, the grant coordinator for the GMC, also assisted me in defining possible funding sources. The largest supporter of PIMS resulted from his recommendation of the Sweet Water Trust. A graduate student, Kristian Omland, also gave me the addresses of several funding sources that he tapped into for his research work. The end result was the submission of proposals to six different funding sources in the fall of 1994. Three were independent sources and three were within the University.

The majority of the funding resulted from support outside UVM. The total budget of \$2,395 was met by a \$2,160 grant from the Sweet Water Trust, a \$100 grant from the Central Vermont Audubon Society, \$110.00 grant from the Environmental Program Merck Fund, with the remaining funding coming from personal savings.

With funding in place research began in the summer of 1995. I was able to live and work on-sight through a special arrangement with the GMC. I served as a Summit Caretaker on the busy weekend days and was able to do field work on the other days while lodging in the Stone Hut located just off the Mount Mansfield site. The remaining days I was in Burlington where I maintained an apartment to conduct my literature reviews as well as design and construct the monitoring tools.

During the summer of 1995 transect sites were established according to parameters outlined in the literature and the recommendations of Rick Paradis, William Howland, the Executive Director of the Green Mountain Audubon Nature Center, and Lars Botzojorns, the Director of Field Programs with the GMC. The remainder of the summer was spent hand-drilling and anchoring the transect locator pins. As the sites were established they were documented with site descriptions and photographs that now serve as locating tools for conducting the monitoring protocol. Species curves were also made to establish the optimal quadrat frame size for the monitoring tool.

I experimented with a tripod to serve as the camera orientation structure during the summer. The tripod did not meet all the needs of the monitoring protocol and was returned. I then purchased materials to build the four legged quadropod that now serves as the camera orientation structure. This work was all done in Burlington utilizing personal tools and my own design. A photo chronology is included in the Appendix.

Articles on the research were printed in *The UVM Record, The Shelburne News, Natural Area Notes,The Vermont Monitoring Cooperative Newsletter*, and *Prenanthes*. These news articles disseminated information about the project to the general public and are included in the Appendix.

In September of 1995 the first photographs were taken using the quadropod and the established transects. In the following winter the monitoring protocol manual was created and is included in a separate Appendix.

Chapter Three - Review of the Literature

3.1 The Natural History of the Alpine Zone

The state of Vermont hosts several small alpine communities. The two largest communities are on the summits of Mount Mansfield and Camel's Hump. Another alpine community, on Mount Abraham, is so small and impacted that the integrity of the site is under question. The alpine zones on Mount Mansfield and Camel's Hump have been under study for many years resulting in research that suggests a need to explore the issues of human visitation as a stressor on the alpine ecosystem.

In 1993 the *Bulletin of the Torrey Botanical Club* published a report by Peter Zika on the historical floral species loss in the alpine zone of Camel's Hump (Zika, 1993). In this report Zika compared the first botanical records of 1829 with current records associated with the Camel's Hump alpine zone. His research suggests that two species were extirpated between 1840 and 1874 and another two were lost by the end of 1876. To account for this decline Zika recognizes two central threats to the species: the effects of air pollution and the effects of recreational use. Zika notes that the limited size of the alpine zones coupled with the increase in human visitation is the central reason for the loss of floral species.

In conclusion Zika states, "Preventing further reduction of biological diversity is desirable in this important Natural Area" (Zika, 1993, p. 74). The number of endemic alpine species is limited and the extirpation of four species on the summit of Camel's Hump comprises 19% of the rare native alpine species. This is a large percentage to lose for a system that is dependent on community structure for survival.

To understand the issues associated with trampling and heavy visitor usage in the alpine zone a clear understanding of the natural history is important. Most important to the development of the PIMS system is the natural and anthropocentric stressors that determine the characteristics of the ecosystem.

The alpine zones in the state of Vermont are comprised of remnant arctic tundra species. These species grew extensively throughout the area when the local climate was regulated by the Wisconsin Ice Sheets over 10,000 years ago. As the ice sheets receded and the temperature became more temperate, the tundra species were displaced by more opportunistic species. The only locations where they were able to compete was on exposed ridges and summits of mountain ranges where they still exist today as alpine communities. A distinction between the species on the summit of Mount Mansfield and those found further north in the tundra of Canada is that the species of the alpine zones in Vermont have been genetically isolated ever since the retreat of the ice sheets. Therefore many botanists make a distinction between the arctic-tundra of the north and the arctic-alpine of the Vermont Green Mountain summits.

Several factors enable the alpine species to compete with other flora. The factors are the physiological and mechanical stresses associated with the alpine zone. These include:

- Very cold and dry winters
- Abrasion and wind scour
- High winds
- Intense solar radiation
- Rime ice damage
- Freeze/thaw shearing action of ice in the soil substrate
- Wet soil substrate
- Erosion and trampling impact
- Windthrow

(Slack and Bell, 1995)

The combination of all these factors create the alpine environment and largely determine the structural design of PIMS.

During the summer season the plant communities store energy for the coming winter, flower, and grow to the best of their ability. These efforts must happen in a short three to four month growing season. All the while these efforts are hampered by the natural conditions. The summer brings intense solar radiation, high levels of precipitation, and severe temperature fluctuations. Intense days are often followed by much cooler evenings. Other stressors are intensely high precipitation due to cloud interception, rapid runoff due to the thin soil substrate, and the associated physical nature of the sites (i.e. steepness). In the fall the plants gear up for the winter and shunt energy from the leaves and stems. In result the plants become brittle and less resistant to the winter rime ice and scour caused by windborne ice crystals.

Essentially the plants must go through their entire growth, flowering, and storage phases during a very short and intense growing season when trampling impact is at its greatest. The plants have adapted to the natural stressors in many ways yet the anthropogenic stress of trampling is too recent a phenomena for the plant communities to have adapted.

Reproduction by alpine plants is also characteristic of the harsh growing environment. The plants perform more asexual reproduction than their relatives in the valleys. Rather than supplying a lot of energy to seeds the plants reproduce several different ways. They often spread underground forming dense tufts of grasses and sedges, reproduce viviparously, and produce berries. The establishment of seedlings is very infrequent because of the frost/heave shearing action of winter and the relatively ineffective dispersal influences in the alpine zone. According to Slack and Bell (1995) a dispersal of three feet is a long way for a seed to travel . This presents a clear problem for communities bisected by a treadway often 2 to 3 meters in width.

Communities are very dependent on each other for survival. If parts of mat communities are disturbed the remaining community becomes vulnerable to impact. The extent of impact within these mat communities is far reaching. For example, a hole in the mat left by intense trampling may open the mat to windthrow. The hole may then be enlarged allowing wind scour to impact the root structure. Eventually the area open to the elements will increase. For this reason the PIMS system is designed to monitor both the treadway itself as well as the mat communities bordering it.

"With the increasing traffic of recreationists crossing the alpine tundra over the last several decades, trails have degraded down to bedrock, exposing the peaty substrate of trailsides to natural erosion. In effect, the vegetation mat retreats away from the axis of the traffic. On several of the highest alpine peaks the once-continuous alpine vegetation is now dissected into separate discontinuous parcels hydrologically isolated from each other." (Decker, 1991, p. 321)

PIMS is designed to discover what effects such an isolation will have on the associated plant communities.

3.2 Defining the Stressor

In 1991 the Canadian State of the Environment Reporting Organization (SOER) convened a group of ecologists at Dalhousie University to develop and comment on a conceptual framework for a National Ecological-Monitoring Program (Stacier et al. 1991). Throughout a series of workshops the participants explored several issues related to the task of a national monitoring program. There are several tasks that the ecologists undertook that offer insight to the creation of a protocol for the Mount Mansfield Natural Area.

The ecologists gathered in a series of workshops to discuss the art of ecological monitoring and indicator development. Within these parameters the ecologists set out to meet five major objectives. Most pertinent to PIMS is the second objective. It reads: "(2) identify regional stressors considered to be actually or potentially important in the ecozone(s) within each region." (Stacier st al., 1991, p. 8)

The range of stressors indicated for each region varied widely and was inclusive of such concerns as: long-range transported air pollutants (LRTAP), long-range transported aquatic pollutants (LRTaqP), stratospheric ozone, climate change, human population growth, hunting, fishing, trapping, forestry, sewage disposal, mineral industries, oil and gas industries, hydroelectric, highways, tourism, wildfire, flooding, permafrost, isostasy, habitat changes, harassment of wildlife, trace toxics, acid rain, and oceanic toxics. An important aspect of this list is the realization of tourism as a stressor.

All of the stressors were in turn given a number from 0-2 indicating their significance in each particular region. Zero indicates a stressor of little to no importance whereas a two indicates a stressor of significant influence. In the High Arctic areas of the northern region the influence of tourism was ranked as a (2) stressor alongside the issues of mining exploration, oil and gas exploration, and transportation. The ranking of tourism as a significant stressor signals that the impacts of tourism effect the health of the ecosystem and needs further study akin to that being done on Mount Mansfield.

This thought is echoed in the Executive Summary of the report. It states: "A major deficiency identified for existing regional or national monitoring programs was the general lack of data on biological responses to important environmental stressors." (Stacier st al., 1991) The protocol developed for Mount Mansfield should (due to its standardized data, archiving system, availability, and focus) provide such data that could be utilized in a regional or national monitoring program.

3.3 The Axiological Test - Defining the Research Parameters

Data collection tools can be created that are easy to use and provide a range of information. However if the information provided does not match the values that are associated with the area monitored, the information becomes superfluous. An extreme example of this would be monitoring the impact of foot travel on a natural area that has been, and will be, closed to the public forever. In this case the monitoring of foot travel and the values (i.e. there shall be no visitation to this natural area) do not mesh. In this instance the values are the real, or actual, conditions of the site. To best design the monitoring protocol for Mount Mansfield an axiological test was undertaken to determine the broad parameters within which the monitoring design must fit.

Ian Worley, the Interim Director of the University of Vermont Environmental Program, botanist, and ethics professor states: "Once those values are expressed then the botanist, and the soils person, and the hydrologist, and the climatologist, and the weatherologist, and whomever else you need can then tell you: 'As I understand those values and you would like to monitor transgressions on them, here are the elements from my field of knowledge and here is the way I would do it'" (Worley ,1995). In order for the scientist/researcher to offer recommendations for monitoring parameters the axiological process must be explored.

Another benefit of the axiological process is focus. Again Worley states: "If the list of values is too broad you will not be able to come up with a thing to monitor." Essentially if the list of values is too broad then the collection protocol will be far too cumbersome to be effective over the long term. The following is a list of values that remain consistent with the focus, extent, and nature of this monitoring project and the University of Vermont Mount Mansfield Natural Area.

Specific to the UVM Natural Areas:

- The University has the responsibility of leadership in the preservation of the important natural areas on University-owned lands.
- This area contains unique biological communities and physical environments vital to scientific research.
- Uses of this area shall be compatible with the preservation of its natural character.
- The preservation of its natural character and use shall be ensured by regulation of impacts.
- The Natural Areas are to be preserved to the greatest extent possible in their natural state, and for educational and scientific purposes insofar as such uses are compatible with the preservation of their character. (Natural Area Resolutions, 1974)

Specific to the monitoring protocol:

- There shall be monitoring of visitation to the trail system in the alpine zone on Mount Mansfield, Vermont.
- There shall be monitoring of the impacts associated with executing this study.
- The monitoring shall be specific to the trail treadway and the associated floral communities.
- The monitoring protocol shall consist of photographic data collection only.
- The monitoring protocol shall be easy to maintain and execute.

This listing of values enables the researcher to design a monitoring protocol that is both focused and compatible with the goals and objectives of the site. Once this test is completed the researcher is able to examine more closely the specific needs of the botanist, geologist and manager and integrate their needs into a protocol that remains true to the values of both the Natural Area and the monitoring protocol.

3.4 Defining the Art of Ecological Monitoring

In 1994 David Henry and Stephen McCanny spurred discussion about monitoring in the prairie and northern national parks of Canada with publication of a report entitled *An Integrated Core Monitoring Program for Prairie and Northern National Parks*. This report addresses the question - What is monitoring? The authors draw on reports concerned with the monitoring of natural and fragile areas. From the synthesis of these reports come several concepts that need definition before a monitoring program, such as PIMS, can be designed. These concepts are Ecological Integrity, Maintenance of Ecological Integrity, and Ecological Monitoring. PIMS is designed to collect data that would reflect any transgressions on ecological integrity through the art of monitoring. Therefore a clear understanding of the previous concepts is important to establishing proper goals for PIMS.

The Canadian Heritage policy designed to address monitoring issues in Canada defines Ecological Integrity as: a condition where the structure and function of an ecosystem are unimpaired by stresses induced by human activity and are likely to persist (Canada, 1994). The same document defines Maintenance of Ecological Integrity as: managing ecosystems in such a way that ecological processes are maintained and genetic species and ecosystem diversity are assured in the future.

These definitions serve to guide ecological maintenance policy of the Canadian Parks. However, as Henry and McCanny note, the policy does not offer a definition for the action of Ecological Monitoring. The question raised is how do we define the act according to the definitions offered in Ecological Integrity and Maintenance?

To answer this question Henry and McCanny offer the following definition: "Ecological Monitoring is any repeatable ecological measurement used for assessing changes in the structure or function of an ecosystem with the purpose of influencing management decisions" (Henry and McCanny, 1994). This definition has guided the study objectives of this project. PIMS is designed to be repeatable and specific to the structure of the alpine zone.

The reading of vital signs is an early warning system for the integrity of the ecosystem. Such a warning system is the aim of the monitoring protocol designed for Mount Mansfield. The premise is that ecosystems under stress will indicate symptoms consistent with that stress. On Mount Mansfield the stressor is the high level of foot travel on and near the floral communities.

The Henry paper defines three issues concerned with the act of ecological monitoring. The protocol for Mount Mansfield addresses each of these concerns.

i. Standardization of commonly used methods.
ii. Monitoring of low impact areas.
iii. Focus on vital signs of ecosystem health.

In summary, the definitions offered by Henry and McCanny clarify the notions of ecological integrity and monitoring. The maintenance of ecological integrity is monitored via the ecosystems vital signs.

A good monitoring protocol will not become overly ambiguous or cumbersome, will possess a good early warning system, will focus on ecological indicators in sync with the values of the area monitored, is scientifically sound, assembles long term databases, is user accessible, and is standardized for compatibility (Henry and McCanny, 1994). This extended definition of a good monitoring protocol is met by the design of PIMS.

The PIMS design is based upon the standardization of a commonly used technique. PIMS uses quadrat sampling and a protocol to guide that sampling over the long term. As long as PIMS is utilized for the repetition of data collection the data will be standard over the long term. The parameters monitored are common to parameters indicated by other research in similar environments (Cole, 1993; Doucette and Kimball, 1989; Ketchledge, 1985; Leonardet al., 1984, 1985).

The dual monitoring of high and low impact areas provides experimental controls. William Howland of the Green Mountain Audubon Nature Center indicates that his inventory work in the alpine area of Mount Mansfield should serve this need (Howland, 1995). The sampling parameters used in his project are similar to those used for PIMS. Therefore future comparisons can be made between the two databases.

The use of photographs as data collection will offer a researcher the information needed to examine the vital signs characteristic of alpine ecosystem health through quantitative analysis. Such signs as species density, species cover, species changeover, treadway growth/regression, and treadway condition are consistent with similar research on trampling impact (Doucette and Kimball, 1989; Ketchledge, 1985; Leonard et al., 1984, 1985; Marion, 1991).

3.5 Study Area and Sample Location Criteria

PIMS is designed to provide data on the trail treadway between the Nose and the Chin on the Mount Mansfield ridgeline. This area is within the Mount Mansfield Natural Area and is selected in response to the monitoring needs described in the Justification section of this report. The area between the Nose and the Chin is currently seeing the heaviest visitation of the alpine area on Mount Mansfield. It is the impact resulting from this visitation that is the focus of the monitoring protocol. Selection of the alpine area in a non-random manner limits the database versatilty causing the results of any analysis to be only extrapolateable to the Mount Mansfield ridgeline.

Transects have become standard for trail impact evaluation (Cole, 1978,1993; Doucette and Kimball, 1989). Randomly establishing transects results in an unbiased database. The elimination of bias allows for a database to be viable for prediction in similar environments.

However there are several factors within the alpine zone of Mount Mansfield that limit such random establishment.

The physical character of the Mount Mansfield ridgeline does not allow for a standard sampling methodology to be conducted on the entire study site. For example there are areas that are devoid of any vegetation or are perched on precarious rocky slopes that will not allow for the monitoring methodology to be effectively employed. As well there are areas that have been specifically identified as areas to be monitored. Trail junctions, dog trails, staging areas, and viewing spurs have been identified as areas of particular interest.

The result is the area to be monitored with PIMS and the transects within that area have been selected with bias. Any results from the database are only extrapolated to that specific location.

3.6 Trail Treadway Monitoring

3.6.1 Data Type

In depth literature reviews and information assimilation has been undertaken by Manning (1977), in the areas of recreational impact on riparian soils, for the American Water Resource Association. The Manning study provides a comprehensive literature review covering the nature of impacts due to recreational trampling. With a firm understanding of the environmental impact patterns, proper techniques can be employed to monitor those patterns. The results of the Manning review clearly outline several cycles of impact. This study is designed to address management issues throughout a two part discussion of the types of soil impacts.

Part one identifies a seven step soil impact cycle as well as four major types of recreational impact. For example Manning states that the effects on soil of trampling fit into a seven step model of environmental degradation consisting of:

- Scuffing away of leaf litter
- Loss of organic matter
- Reduction in soil macro porosity
- Reduction in air and water permeability
- Reduction in water infiltration rate
- Increase in water runoff
- Increase in soil erosion

Impacts on vegetation resources, it was noted, come in four principle modes. They are: trampling effects, removal of small stems in the shrub and sapling layer, soil compaction, and mutilation.

Part two addresses the spatial and temporal concerns of recreational environmental impact. Both soil and vegetation impacts fit into yet two more categories of definition including temporal considerations (i.e. rate of soil compaction, ground cover response and succession, and resource response to varying degrees of recreational impact) and spatial (i.e. specific location of heaviest impact, and progressive expansion of impact) (Manning, 1877).

To fully quantify these impacts Manning defines three types of recreational impact measurement techniques: before and after, control and treatment plots, and comparative sampling from previously impacted and non-impacted sites. These measurement techniques are affected by two problems associated with this type of research. They are: the recreational use and ecological characteristics vary greatly according to site location, and the time frame in which impact occurs is usually extensive and therefore not easily associated directly with the impact that caused them.

The Manning study offers both a comprehensive overview of research done prior to 1979 and the findings associated with them. Much of this research is still accurate today.

The seven step model of soil impact could serve as part of a framework for the assessment of trail conditions on Mount Mansfield. The inclusive nature of this review also introduces many of the associated issues of trampling impact and so offers a more balanced understanding of the research needs.

The Manning study defines the array of parameters that should be taken into consideration when designing a monitoring protocol that will indicate the impact of trampling effect. An element of time must be involved as well as a technique that is versatile enough to capture a wide array of impact parameters. PIMS is able to meet all three of the recreational impact measurement techniques. It is a perpetual design and so results in data before and after impact. William Howland's Mountain Biogeography Project serves as control plots while PIMS plots serve as treatment plots. Finally there is the opportunity to compare data from previously impacted sites (areas now closed to use) to areas still under impact stress.

3.6.2 Transect

Many of the monitoring and assessment reports in the mid to late seventies as well as even more current research employ variations on the trail transect method (Chambers 1983; Cole 1978, 1993; Coleman, 1977; Rinehart, 1978). Currently research is indicating a move toward photo-monitoring to assess and quantify trail impacts and associated vegetation integrity (Brewer and Berrier, 1984; Leonard et al., 1984, 1985; Magill 1989; Ratliff 1973; Rinehart 1978; Sutter 1993; Wells 1971). Leonard (1977) fully describes the trail transect method in a report in 1977 that covers the methods of setting up, choosing sites for, and assessing information from the transect.

The report is broken down into six sections including ground control, site selection, establishing trail transects, measurement procedures, trail borders, and trail profile. The report also goes on to identify three categories of data termed trail width, rate of soil loss, and percent vegetation cover. These categories can be run through the basic application of statistical techniques for evaluation of the acquired data (Leonard, 1977).

Leonard states throughout the report that the data acquired from such a technique can be used for determining the best physical condition for trail construction as well as new trail design. The mechanics of this method, however, may no longer be desirable in light of more accurate and easily applied photo-monitoring techniques. PIMS makes use of trail transects in association with photo-monitoring to collect data on trail width and vegetation cover. However PIMS information on soil loss will be qualitative versus quantitative.

3.6.3 Impact Assessment Methods

Harsh growing conditions in the alpine environment are the result of thin soils, acidic soils, short growing seasons, rapid water runoff, high solar radiation and a host of other measures (Slack and Bell, 1995). Similar sites to Mount Mansfield have been studied for trampling impacts and associated recovery rates. Two such studies were undertaken on Hurricane Island, Maine by Leonard, Conkling, and McMahon in 1984 and 1985. The first study focused on the recovery rate of a bryophyte community. The second study concentrated on the effects of controlled trampling on several different representative ecosystems found on the island.

The 1984 study used an artificially denuded site to attain baseline recovery data for managers to use in future resource planning. Researchers felt the site was representative of the coastal islands in the Northeast in respect to vegetation, climate, geology, and history. These islands are often referred to as "Summits in the Sea" because they closely mimic the alpine zone in species mixture, community type, and physical stress.

The methods used for the bryophyte study were centered around the use of photo-monitoring and a quadrat. The artificial denudation of the bryophyte community was a planned occurrence and so a baseline data set was acquired prior to the removal of the community. This data was then used in comparison with the photographic monitoring data to detect trends in recovery rates. The photo-monitoring technique established four varying length transects and placed quadropod photo points about 1m apart along the transects. This resulted in nine monitored plots. The plots were photographed once a year for four years (1980-1983). The photographs included a quadrat frame within the photo frame. Using the photographs, trends in the percent cover were then defined according to community.

The results of the study indicated a strong correlation between area coverage of mor plus litter and moss. The bryophyte community was 50% recovered after four years with full recovery expected in three more years. These rates are considerably high. The study also pointed to factors that may have influenced recovery rates such as moisture, nutrient supply, regeneration ability, precipitation rates, fog intensity, sea salt, and depth of soil.

The overview of recovery rates and associated impacts would be almost identical to those found on Mount Mansfield due to the similar environmental stressors. The findings concerning litter/mor and recovery rates also point out possible restoration considerations. Possible factors affecting recovery rate point to specific monitoring parameters for creating a more versatile data set. Such parameters are already being monitored on Mount Mansfield by various researchers in conjunction with the VMC. The result is a very inclusive data set for establishing trends in the integrity of the trail treadway and the associated community. The second study conducted by Leonard et al. in 1985 on Hurricane Island was more intensive and controlled. The purpose of this study was to examine the relationship of ecosystem health to a controlled rate of trampling impact. Treadway formation and recovery rates of the associated species were monitored. Monitoring was conducted using the same quadropod technique as mentioned above. It was found that, in general, the climate conditions of Hurricane Island promoted rapid recovery. The study was initially proposed as a reaction to the virtual lack of information on the trampling effects of visitor use on Maine coastal islands.

The methods used were very controlled for this type of research. Fifteen trails were established in areas free from any impact and represented diverse plant/ecosystem associations. Plots were established along these trails and were monitored using a quadropod photo-monitoring stand. This method of photo-monitoring effectively reduces much of the variance associated with other photo techniques in that relocation of the quadropod is accurate within an acceptable degree of error. The trails were trampled according to a strict agenda and photos were taken two weeks after each trampling. The photos were then analyzed by comparing percent vegetation cover (Leonard et al., 1985).

It was found that the two trails most representing the ecosystems found on Mount Mansfield recovered only 15% and 18% in year one respectively and 36% and 31% after year two. These recovery rates are the slowest of all the representative trail sites. In fact two species, black crowberry (*Empetrum nigrum*) and bayberry (*Myrica pensyvanica*), were grouped in the slowest of the group recovery rates.

This fact indicates a specific monitoring concern for ecosystems that consist of those species. On Mount Mansfield specifically, the rate of impact is far outpacing the recovery rate of the species sustaining that impact. The conclusions of the report indicate that any trails should be routed away from these species in favor of more hardy species. On Mount Mansfield PIMS will monitor areas where such action has been taken and areas where it was not practical to re-route the trail.

3.6.4 Analysis of Trail Treadway Trends

One study evaluated the efficacy of scree walls for the passive protection of alpine habitat (Doucette and Kimball, 1989). The concept of passive restoration is, for this research, the effective removal of visitor impact without direct contact. Again, the ecosystems of Mount Mansfield exhibit many of the same morphological characteristics due to their growing conditions.

The Doucette study was conducted on the Franconia ridgeline in New Hampshire. The history of that ridgeline exhibited similar impacts that Mount Mansfield is currently displaying.

The study made use of trail transects about 6-14m in length located perpendicular to the trail treadway at about every 25m. The transects were then broken up into three distinct sections according to proximity to the trail and relative disturbance. Differences were quantified according to the line intercept method using data collected in 1975 compared to the 1989 data. As well a series of 50 oblique photographs, previously established and monitored, (every 10-12m) was monitored in 1989 and were assessed visually for qualitative comparison. Finally a hiker questionnaire was employed to better define trail use and hiker profiles. Interviews were conducted on a time available basis (Doucette, 1989).

The results indicate that impacts next to the screed trails have significantly decreased. However, some species were better equipped to recover in the impacted sites and there was a slight change in species composition. The Doucette study clearly indicates the effectiveness of scree walls at reducing impacts, but raises concerns about the change in species composition during recovery. This will be a monitoring parameter to consider when designing the PIMS transect lengths and locations.

3.6.5 Recovery Rate Assessments

A more direct relative to the Mount Mansfield alpine zone, the Adirondack alpine areas of New York state, was studied for recovery rates by Ketchledge in 1985. The research by Ketchledge was designed to address the problem of protecting rare alpine environments. As is the case on Mount Mansfield, the alpine ecosystem in New York is highly specialized due to the harsh growing conditions. Competition with trampling impacts overwhelms the system leading to quick and extensive deterioration in ecosystem integrity. This study explored the possibilities of aiding the recovery of the communities after the trampling effects have been removed.

The findings of the study point to many issues that relate directly to the impacts on Mount Mansfield. The alpine ecosystem studied was found to be highly sensitive to foot travel. In the summer the area is predominantly wet and subject to crushing and compaction, in the late summer the area is dry and the soils are susceptible to scuffing and wind, and in the winter the ice crystallization in the humus layer makes the peat open to shearing and crushing. It was also found that trails through an alpine zone are highly impacted by water damage and the action of gullying. These findings indicate parameters that should be monitored to properly assess the impact of trampling on the trail treadway and the associated ecosystem. As mentioned earlier the VMC has a database of such parameters that could be used in conjunction with the PIMS database to define these types of relationships on Mount Mansfield.

Ketchledge explored assisted recovery in the alpine ecosystem. He used non-native grasses to enhance the stability of the soil substrate and fertilizer to suplement the nutrient needs of those non-native species. The recovery rate of the system with the applied grasses was rated at about four years and possibly longer for those untreated sites. This indicates a relative time frame for proper assessment of trends in the ecosystems associated with the trail corridor indicating a conceptual time frame before analysis can be successfully done with PIMS data. Lastly it was made clear in the final conclusions that the recovery of these systems would only occur with the removal of the initial impact altogether (Ketchledge, 1985). This indicates that PIMS will be in demand as long as there are human visitors to the ridgeline.

3.6.6 Analysis Parameters

In 1993 David Cole published a report on trampling effects on mountain vegetation in Washington, Colorado, New Hampshire, and North Carolina. This study was designed to examine the response of vegetation to controlled amounts of foot traffic. To examine the response Cole utilized changes in species cover, height, richness, and composition as indicators.

The experiment was conducted in a highly controlled manner in sixteen different vegetational zones. The results were then compared on a variety of different levels to establish a pattern of vegetation durability as associated with community type and level of impact. The intent of the project is to provide managers with information on the relationship between amount of use and amount of impact (Cole, 1993). The methods utilized were developed around recommendations for standardized methodologies offered by Cole and Bayfield (1993).

Of the sixteen vegetation types studied three were considered to be alpine communities. One of these alpine communities was from the northeast. The community is defined as a Terrestrial Herbaceous Community - Meadow and Grassland - Above Timberline Community. The community is also defined as containing*Carex bigelowii* as the dominant species (Cole, 1993).

Four replicate trampling sets were established in each vegetation zone. Each set consisted of five lanes 0.5m wide and 1.5m long. These lanes were each trampled by individuals wearing lug sole boots and weighing approximately 70 kg at 25-700 passes per lane. The measurements were taken within 30cm by 50cm subplots. The parameters measured were: vascular plant, lichen, and moss cover to the nearest 10%, bare ground cover to the nearest 10%, and mean vegetation height (Cole, 1993).

The subplot size of 30cm x 50cm indicated a usable plot size for monitoring on Mount Mansfield. This information coupled with the recommendations of Howland (1995) was used to establish a quadrat frame size suitable for monitoring alpine vegetation on Mount Mansfield. Further refinement of this quadrat frame size was conducted by creating six species curves. The species curves and the resulting quadrat frame dimensions for PIMS can be found in the results section of this report.

Cole's experiment mimics the current situation on Mount Mansfield. There are, however, two major differences. The Mount Mansfield monitoring protocol will not be able to control for visitor use but will have accurate data on the numbers of visitors to compare with the collected data. Secondly the data collected in the Mount Mansfield project will not be quantified in the field, rather it will be conducted in the laboratory free from any extraneous variables such as weather or bugs that may influence the data collection.

The strength of the Cole (1993) research project is the quantifiable nature of the data analysis stage. The experiment utilizes seven parameters for assessment. Of these seven six are directly applicable to the data collected through the Mount Mansfield monitoring protocol. The parameters used to describe the vegetation response to the treatments are bare ground, relative vegetation cover, species richness, species composition, durability indices, and individual species response (Ibid.).

Bare ground is defined as the proportion of the measurement that is not covered by live vegetation. It should not be, Cole warns, confused with exposed mineral soil. The bare ground definition closely resembles the definition for Treadway in the Operational Definitions section of this report. Relative vegetation cover is based on the sum of the coverages of all species rather than a single estimate of vegetation cover. For example relative vegetation cover is calculated as:

$$RVC = \frac{\text{Surviving cover on sampled subplots}}{\text{Initial cover on trampled subplots}} \times CF \times 110\%$$

Where

$$CF = \frac{\text{Initial cover on control plots}}{\text{Surviving cover on control plots}}$$

Species richness is defined as the number of species counted in the subplots. Means are expressed with the richness counts. Species composition is what species are sampled in the respective subplots. Floristic similarity is utilized to compare the composition before and after the treatments (Mueller-Dombois and Ellenberg, 1974).

Durability indices are established by the researchers for this experiment. The indice is essentially a calculation of a vegetation's ability to withstand impact (resistance) and its ability to recover after the impact treatment (resilience). This indice is called the tolerance durability. Further discussions of this indice can be found in Cole's report.

The final parameter measured is individual species response. These responses are calculated according to the tolerance durability and the vegetation cover and are only described in relative terms.

The data is analyzed statistically using ANOVA techniques. Nonparametric tests are utilized based on rank rather than individual values to accommodate the heterogeneity of the variances.

The findings that resulted from this controlled trampling study indicate several important facts about trampling effects on various vegetation types. The best predictor of impact was whether or not the vegetation was erect. The most resistant plants were caespitose (tuft-forming) and mat-forming graminoids (grasses, sedges, and rushes). The best predictor of resilience was whether or not the vegetation was dominated by chamaephytes (above ground bud regenerating plants). The chamaephytes were substantially less resistant than the hemicryptophytes (growing points at the soil surface) and cryptophytes (growing points at or below the soil surface) (Cole, 1993).

The findings indicate the alpine vegetation is the most resistant and resilient of the vegetation types studied. However in the case of Mount Mansfield the extenuating circumstances indicate that visitation has exceeded the resistance and resilience of even the hardy alpine species. For example the highest number of passes studied in the Cole research was 700. On Mount Mansfield 700 passes occurs on one average weekend day. Whereas Cole indicates that the more hardy species (those of the alpine environment) can accommodate 25-30 times more trampling with little to no more damage, the situation on Mount Mansfield asks can they handle 57 times the amount of impact (figures based on estimates of 40,000 visitors per year). The amount of passes Mount Mansfield receives has clearly exceeded the resistance and resilience levels of the hardy alpine species. It is now a question of what the effect of such elevated trampling will have on the community makeup.

Further findings in Cole's report offer aid in focusing the data analysis in respect to individual species response and florisitc similarity over time. For example Cole states: "in Carex, all of the trampled lanes remained significantly different from their original composition. In fact, composition became more dissimilar over the year of recovery. This was the result of pronounced recovery of Carex bigelowii, while few of the subordinate species recovered as quickly" (Cole, 1993, p. 32). Clearly there is a strong management message presented here particularly in reference to the Mount Mansfield Natural Area. If the trampling is effectively causing a changeover in species composition it will be important to assess what species are disappearing and which are taking over the sites.

3.6.7 Guiding Management Decisions

A research experiment currently in progress is addressing similar issues by utilizing the system responses from Cole's report. This research is being conducted by Chris Monz of the National Outdoor Leadership School (NOLS) as a part of the Leave No Trace Program. The intent of this study is very similar to that of Cole's 1993 study in that it is an attempt at defining the capacity of a vegetation type to withstand trampling (system tolerance) utilizing monitored plots and trend analysis (Monz, 1994).

However, the vegetation communities studied are more similar to that of those found on Mount Mansfield. As well the trampling data makes an important distinction between impact of trampling on wet versus dry tundra. Such a distinction is important to the management decisions that may need to be made concerning carrying capacity and time of year as associated with the Mount Mansfield site. For example the findings of these experiments indicate that 500 passes would result in nearly 100% dieback in moist tundra versus nearly 90% in dry tundra (Monz, 1994). Another important finding indicates that though alpine areas exhibit the most resistance to foot travel, they have the lowest resilience. Once their tolerance level is exceeded the grow back is quite slow due to the general characteristics of alpine morphology and weather.

Data on vegetation tolerance will aid land managers in making decisions concerning carrying capacities, trail route locations, and types of use. These are all issues of growing concern in the Mount Mansfield Natural Area. Such principles are echoed in research from all over the globe. Carles Castell notes in a short report titled *Ecological Monitoring Programs In Four Natural Reserves of Barcelona County (Spain)* that "The results obtained in detection monitoring will indicate the processes that need to be evaluated thoroughly to try to understand their causes, dynamics, and effects, and to help to decide management policy" (Castell, 1994, p. 4). PIMS is designed to provide detection monitoring as well as provide a database that can be used to quantify any trends that are detected.

3.7 Methodology Design

3.7.1 A Model Project

Sutter (1993) monitored the effectiveness of using a boardwalk over a four year period (1987-1990) to protect a federally listed species Heller's blazing-star (*Liatrishelleri (Porter)* Porter) over four years (1987-1990). Trampling impacts natural communities by reducing species richness and percent cover and results in soil compaction, soil moisture problems, and erosion. The location for the Sutter study was an exposed rocky ridge in North Carolina that has similar ecological growing stresses as the ecosystem of the Mount Mansfield ridgeline.

It was undertaken to determine the impact of hikers leaving the boardwalk and crossing over the surrounding vegetation. The study used twenty-one belt transects at random and preferentially (with bias) located spots along an 81m boardwalk. Along these transects continuous photographic plots were located at specified locations. From these photo-monitored plots information on presence/absence of trampling, severity of trampling, and percent vegetation cover was measured. To make these measurements the slides were projected onto a large planimeter where the previous parameters were counted (Sutter, 1993).

This research outlines an effective photo-monitoring technique for monitoring visitor impact and trail treadway establishment and regression. Percent vegetation cover is indicated as a data set that is created through the use of photo-monitoring.

3.7.2 Photo-monitoring Methods

As indicated previously, photography has become an integral part in the perpetual assessment of monitored plots. Monitored plots can range in type from linear transects to randomly established circular plots. The techniques for using photography for such measurements as percent cover rebound/dieback, species composition, species richness, and species diversity have evolved according to the individual research needs for a project.

In 1984 Les Brewer and Debbie Berrier undertook a study to compile techniques used for the photographic monitoring of change at small scale locations. The study focused on the monitoring of micro sites. This type of monitoring consists of small scale ground-based monitoring versus large scale aerial surveying.

The study is a compilation and assessment of the latest design and implementation techniques for photo-monitoring through 1984. Study methods consisted of resource gathering (archival, research, and interviewing). The results indicate reasons for using photo-monitoring, the role of the monitoring technique, and a separation of the varying techniques into specific design categories with associated reviews.

Photo-monitoring is useful for determining what, where, why, and how fast changes are occurring in the physical, biological, and aesthetic resources being monitored. Beyond these reasons for using photo-monitoring the technique also offers other advantages. Photographs resulting from monitoring are a pictorial display of resource impact/change rather than standard written form. For some this type of display is easier to "read" and assess. Secondly the photos can be conveniently assessed in the laboratory rather than out in the field thereby reducing the extraneous variables of the researcher and the environment. Thirdly the photos are easily and accurately reproduced offering a precise comparative model for assessment. Lastly the photos reduce the level of subjectivity by the personnel utilizing the photographic data.

The role of the photographic monitoring system is not seen by Brewer and Berrier as replacing traditional quadrat monitoring rather it should be available for suplementation of that data. Howland's Mountain Biogeography Project on Mount Mansfield serves as an excellent compliment to PIMS. Photographic data can act as verification (photographic vouchers) for other acquired data (i.e. rare species location and existence). The technique can also reduce field costs of data gathering by reducing the number of researchers needed to make the assessments and the time required to do so. Lastly the technique can be employed where others may not work (i.e. fragile low-lying alpine areas such as Mount Mansfield).

There are six categories of techniques described in the Brewer and Berrier study: Photo point, Campsite Panoramas, Trail Mosaic, Quadrat, Perspective Grid, and Stereo Trail Transect. The Stereo Trail Transect method has a different analysis proceedure from that of PIMS and is not described here.

Photo point photography is utilized for the accurate repetition of photographic location creating a qualitative comparative data set for change over time. The methodology entails the location of the camera on the same point for each and every shoot. This methodology is usually used for oblique photographs of an area of interest (i.e. a campsite or trailhead). Campsite Panoramas are essentially the same yet utilize a far greater number of photographs to create a panorama of the site.

The Trail Mosaic technique is a more subjective approach to reaching the same ends. This technique employs multiple images taken around a site to establish a visual record of change. This technique does not employ the use of a fixed point from which subsequent photographs are taken.

The Quadrat method is the same in principle as Photo point photography yet it offers a more precise framework for assessing the change in the photographed area. The photographs using the quadrat methodology are oriented vertically to the ground with each image capturing a graduated quadrat frame attached to the legs of the camera stand. This technique employs a methodology that allows for the cameras to be very accurately located over a fixed point for subsequent samplings. The PIMS design is based on this technique.

The last technique is the most technical and accurate. The Perspective Grid utilizes an accurate grid display photographed prior to the field samplings for the assessment of the photographic data. The grid works as an overlay when the slides are projected for analysis.

In conclusion the study found that the use of photography for monitoring micro site changes over time is an effective technique. Photography often has the versatility to acquire the needed data where other forms of data gathering will not meet the specified needs or be too cumbersome for simple repetition.

It is important to determine the type of data needed (the axiological test), the site conditions (morphological characteristics), and any other restrictions (such as money and time) before choosing the category of photographic techniques to be used.

3.7.3 Photo-monitoring Format Issues

A more recent study of the use of repeat photography and color slides as a monitoring tool was published in 1989. Arthur Magill of the Pacific Southwest Forest and Range Experiment Station, part of the US Department of Agriculture, examined the current methodologies associated with color slide analysis as a monitoring device. His report titled *Monitoring Environmental Change with Color Slides* is specific to human impact on outdoor recreational sites. It is his opinion that the use of color slides with established camera points is an inexpensive way of monitoring for environmental change (Magill, 1989).

The report focuses on the sensitivity of the viewer (analyst) in detecting changes in oblique photos. For this reason the Magill report is recommended reading for the analyst prior to working with the oblique photos of the Mount Mansfield database. However, the analysis procedures for the vertical format pictures should be conducted using standard quadrat assessment techniques outlined in several ecological textbooks and papers (Brower et al., 1990; Chambers and Brown 1983; Cole 1983, 1993; Goldsmith, 1991; Howland, 1995; Leonard et al., 1984, 1985).

The use of photography works well where there is limited resources in respect to time, skilled labor, and finances (Berrier 1984; Leonard et al., 1984; Magill, 1989). For example Magill states: "Using ecological surveys to monitor environmental change is costly, and may not be necessary where there is little or no change" (Magill, 1989, p. ii). The situation on Mount Mansfield is such that there is change yet at a rate not compatible with conducting yearly ecological surveys. For example the Summit Caretaker program, the intense interpretive presence, the morphological characteristics of the plants, and the seasonal use results in change but at a very slow rate. Significant changes may only be detectable with five to ten years of accumulated data as evidenced by the recovery rates of the Hurricane Island study plots (Leonard et al., 1984 and 1985).

Echoing previous monitoring recommendations, the use of color slide photography is considered an early warning system that would activate an ecological survey if adverse trends are detected (Magill, 1989). At that point a sound monitoring program would ensure that the survey takes place by not using up limited funds just to detect the trend. In this sense the technique is quite useful. On the other hand, Magill notes, "it is unlikely that the resource managers, responsible for monitoring the environment to detect potentially detrimental changes, possess the necessary visual sensitivity to make the photographic assessments without additional training" (Magill, 1989, p.1). He is referring to the assessment of oblique photographs. Much of the report is devoted to this training and is recommended prior to analysis of the slides. The report indicates methods by which oblique photographs can be more accurately assessed for trends.

The next question he addresses is the use of color slides versus black and white film. There are several arguments for the use of either black and white or color, however in the long run there are more benefits associated with using color slides (Berrier, 1984; Magill, 1989; Paradis, 1995; Wang, 1995; Worley, 1995). Citing previous research Magill notes that using black and white photography made differentiating low or prostrate vegetation (much like that found in the alpine environment) hard to differentiate from vegetative litter. As well the vegetation common to the Mount Mansfield site would be hard to differentiate unless there was an associated color difference. Secondly, Magill notes, dead vegetation would be hard to differentiate from live vegetation with black and white photography. Lastly color photography offers a greater ability to identify the morphological changes occurring in a species than black and white.

The use of color slides is also more mechanically feasible. For example a color slide can be scanned into a computer image just as well as a print. Secondly a color slide can be turned into a print more accurately than a print to a slide. Thirdly a color slide can be scanned or converted to a black and white image far more readily than the reverse.

The final consideration is given to slide versus print format. A color slide would be hard to analyze on its own. However, using a projector a slide can be magnified with much more ease than can a print. The use of a projector would allow for a slide to be projected onto a large planimeter for more accurate measurement. Magill remarks in his analysis of slide viewing; "Viewing the slide with magnification or increasing the size by projection permits one to identify objects barely discernible to the unaided eye" (Magill 1989, p. 2). Assuming the resources are available one could project slides side by side to qualitatively analyze change/time. In short the slide format is overall more versatile than prints.

In conclusion Magill notes the importance of camera relocation in the use of repeat photography as a monitoring tool. PIMS relocation methodology is designed to be accurate and easy. The design is mostly original due to the unique nature of the study site.

3.7.4 Detection Versus Evaluation Monitoring

Another benefit of using photography for monitoring is its versatility in covering both detection and evaluation monitoring. These two types of monitoring are defined by Castell (1994) as the two broad lines of research that must be incorporated in any long-term monitoring protocol.

He defines detection monitoring as detecting changes and trends occurring in the species populations being studied. The quadropod monitoring technique is specific to this type of monitoring. The collected data is over a specified time frame and so indicates change/time which in turn is translated into trends.

Secondly Castell defines evaluation monitoring as examining the effects resulting from human interaction with the environment, providing for a base of understanding for minimizing those effects, and providing a base of understanding to adjust the current management models. The use of photographic indicators of change/time (trends), the control plots set up by Howland, the usage statistics being maintained by the Green Mountain Club, and data archived at the VMC will provide for clear indications of the effect of human-environment interactions. In essence the monitoring protocol utilizing photographs rounds out an existing set of data enabling an evaluation of human-environment interactions.

3.7.5 Blending State of the Art Technology with Photo-monitoring

Use of a digital camera for data gathering has several advantages over the use of regular emulsion photography. The digital information can be processed and directly downloaded into a storage database eliminating the scanning and processing steps involved with slide data. The use of a digital data collection tool would effectively eliminate the photo purchase and processing steps involved with emulsion photography thereby making the monitoring protocol that much more financially viable. Finally there are several different digital image processing software packages available that could be used for both ease of data retrieval and assessment.

Processing possibilities include the use of Geographic Information System (GIS) software as a relational database for both storage and retrieval of data as well as for data assessment (Smith, 1995). The software ArcInfo would create an efficient means of retrieving data (images) according to any number of parameters. A researcher could select images according to location, time of day of sampling, camera aperture, etc. Using ArcDraw a researcher could then qualitatively establish trail edges and incorporate them into the image.

This would result in polygon coverages that could be assessed for area and percent cover. From this data one could assess trail treadway growth and regression.

The digital cameras available today within the PIMS research budget would not provide the resolution necessary to identify plant species (Wang, 1995). There are digital cameras that would provide the necessary resolution but would be far beyond the financial means of this research (Cavrak, 1995). Both Cynthia Rubin (1995) and Cavrak recommended the use of a video camera to capture the data. The video camera would increase the resolution of the images to a great degree but would also then require a fair amount of computer lab time in capturing the desired images off the video tape. This is a process not compatible with a monitoring protocol that is meant to be as simple as possible.

Worley recommends digital photography. This type of data would be the most compatible with the rapidly developing assessment software packages and technology of today. The storage of digital data then becomes an issue. According to Wang (1995) every type of storage system for digital images would become obsolete within five years and, therefore, require continual updating and maintenance. The objective, as he sees it, is to define a storage system that will be compatible with future technology yet remain stable for an extended period of time. His experience points to emulsion photography (slide images) as the most efficient means of data storage because: "the slide technology will be around for at least another twenty years and scanner technology is only going to get better" (Wang 1995). Wang has been working on a project with the Vermont Monitoring Cooperative to monitor tree canopy growth and regression. To conduct this research he has utilized digital imaging as a data format and found it to be more troublesome than regular color slide photography. He has since moved to color slides and spreadsheets or ASCII for data storage (Wilmot and Scherbatskoy, 1994).

The application of the latest in technology to the monitoring protocol is questionable. However, every person I discussed it with seems very enthusiastic about the possibilities depending on the level of data needs. The final recommendation of both Steve Cavrak and Dean Wang was to try different devices and experiment with the accumulated data sets to see what matched best with the needs and restrictions of the monitoring protocol.

3.7.6 Archiving and Storage of Data

In the search to find what would be compatible, the concepts of digital cameras, video cameras, remote sensing, Geographic Information Systems (GIS) technology, and other more technical tools were explored.

The amount of data associated with computer images would immediately become a storage issue. The amount of digital data derived from a computer imaging tool would be tremendous. UVM has the capabilities of storing, in a convenient fashion, such data but only with the experience of a knowledgeable computer specialist. The conclusion is that regular emulsion photography (color slides) is the easiest format for storage, retrieval, and analysis.

The next question is where to store all this data? Fortunately for many studies in the state of Vermont there exists the Vermont Monitoring Cooperative (VMC). The VMC is designed to facilitate information exchange and cooperation among the scientific community working on ecosystem health issues. In 1993 the Department of Forests, Parks and Recreation designated land between Browns River, Stevensville Brook, and Ranch Brook in Vermont for use by the VMC for monitoring and research activities (Wilmot and Scherbatskoy, 1994). The PIMS system is designed for land in the ownership of the UVM, outside the official VMC area, but the VMC has agreed to integrate the data into its storage and archiving system.

On June 16, 1995 Sandy Wilmot, the monitoring coordinator for the VMC, approved the PIMS project. The system fits well with the objectives of the VMC, does not interfere with the objectives of other VMC projects, and is compatible with the archiving ability of the cooperative. The PIMS system will be the initiation of a new anthropogenic category for monitoring within the VMC titled "Humans". The VMC hopes to expand on this category further by integrating similar research being conducted.

The data stored by the VMC will be in the form of color slides. The specifics of the archiving system is to be developed by the VMC which will also serve as the clearinghouse for the accumulated data.

Chapter Four - Findings

4.1 Study Area

The area studied is within the alpine zone located between the Nose and the Chin on the UVM Natural Area Mount Mansfield. This area was selected as it sustains a high level of trampling impact. The area has also been selected because of its relative easy access via the Mansfield Company auto-road. Lastly the area is of a reasonable size to monitor in one day.

4.2 Sample locations

Samples will be taken along transects bisecting the trail treadway. These locations were selected according to areas of special concern and available exposed bedrock for anchoring transect locator pins.

Transect 1 - A heavily used visitor staging area. Visitors not well enough equipped or not desiring to go all the way to the summit often arrive at this site as the terminus of their hike. The area offers open views and areas to sit and relax. For that reason it sees a high number of visitors spreading out or straying from the trail treadway. The transect crosses the treadway in a sedge meadow and offers a good example of a community that is fragmented by the denudation of the trail treadway.

Transect 2 - An example of a heavily eroded section of the treadway. Where the transect crosses the treadway erosion has created a gully upwards of 12 inches deep. This evidences the gullying effect of trampling impact. It is also located within a convienient distance from transect 1 making monitoring of both sites quick and easy.

Transect 3 - An example of an area that is under little to no trampling stress. This area is strung off to the visitors due to previous impact. The site is not located on the trail treadway. This site is a representation of an area that is revegetating from past impact.

Transect 4 - An example of a heavily used trail junction. This site receives traffic arriving from the gondola, the Subway Trail, and the Long Trail. It also offers good views and areas to rest therefore visitors are prone to stray from the trail treadway.

Transect 5 and 6 - Examples of wet bog communities. Both of these sites bisect the treadway in a trail junction/staging area where the environment is saturated for most of the hiking season. Existing at this site are puncheons that are used to traverse the wet area. Because of the proliferation of dogs on the summit and their affinity for the cooling effect of getting wet, the bog is showing signs of dog trails paralleling the puncheons. As well the area is showing the increasing denuded area in the bog mat that is used by dogs to lay down in and cool off. Both the dog trails and the cooling area are selected as sites to be monitored.

Transect 7 - An example of an area that is bordered on one side by a restricted use area. Where the transect bisects the trail treadway the northwestern side is strung off as a research site and, therefore, should see a reduction in the amount of impact sustained by the plants. The opposite side of the site represents a standard makeup of community types.

Transect 8 - This site is selected because of its proximity to the inventory sites established by Howland for his Mountain Biogeography project. The site lies just off a large meadow in which Howland has done extensive inventory work.

Transect 9 - This final transect is selected because of its proximity to the summit. The site is a heavily eroded and gullyed section of the treadway located just prior to the summit. The area is representative of the largest staging area of the ridgeline - the summit.

4.3 Samples

The samples gathered with PIMS are in the form of color slides shot on Fugi Provia 200 ASA slide film. Provia film is designed to be scanned and should facilitate any computer assisted analysis of the database. The slides will be vertical shots of the vegetation with a graduated quadrat frame included in the photo frame. Oblique photos will also be taken at each site offering a qualitative element to the database.

The quadrat frame size has been established at 30cm x 100cm with a 5cm grid pattern. This design is used to provide a reference for counting the vegetation and quantifying the change in species density, frequency, and cover. The grid pattern has been established by creating six species curves to determine the optimal sampling size. The quadrat frame was designed in conjunction with the design of the quadropod and the limitations of the camera. The quadrat frame is designed to allow for random sampling of any size area in multiples of 5cm to allow for unbiased sampling within the individual data sets. Species curves and inventories are included in the Appendix.

4.4 Sampling Frequency

PIMS is designed to indicate trends. The recommended sampling frequency is once per year (perpetually) within the summer season to include July or August. To sample outside those months will create a data set that is affected by the morphological characteristics of the plants.

4.4 Quadropod

The quadropod consists of the camera mounting box, the quadrat frame support legs, the oblique orientation platform and post, and the oblique compass arm. When assembled, these pieces are used to orient the camera for an accurate repetition of the photos that were taken when the monitoring was last done. The quadropod is collapsible to facilitate traveling between the transect sites along the trail.

The quadropod is constructed of MDO plywood. This material was chosen because it has a high number of laminates in respect to its thickness. This results in a strong and relatively lightweight material for constructing the quadropod. MDO is also resistant to warping over time which could affect the camera orientation.

Compasses are used as an orientation tool for the quadropod and the oblique orientation platform. An azimuth is indicated for each quadrat site to which the quadropod is oriented. The compass for the oblique photos is affixed to the compass arm which effectively removes the compass from the magnetic effects of the clinometer and camera quick release mounts.

The oblique orientation platform also has a clinometer affixed to the platform. This device is used to vertically orient the platform either up or down the trail treadway. The vertical orientation data is given in the form of (+) up, or (-) down, degrees and is matched to the scale on the side of the clinometer ensuring the camera is oriented vertically the same at each monitoring.

The quadropod is leveled front to back and side to side with a set of levels oriented perpendicular to each other and affixed to the camera mounting box. When both levels are set correctly the quadropod will be level in all directions ensuring that the camera focal point is in the same place as when the monitoring last occurred.

The camera is attached to the quadropod on one of four quick release mounts depending on which photo series is being shot. Three quick release mounts are located on the camera mounting box and one is located on the oblique orientation platform. The quick release mounts are used to allow the shooting of five different (three vertical and two oblique) photographs while only orienting the quadropod once. This effectively reduces any impact that may occur when orienting the quadropod.

The quadrat frame support legs are designed to hold the quadrat frame at a specific distance from the camera lens. The result is the shooting of the grid pattern of the quadrat frame over the vegetation. The distance remains the same for each shoot and so remains consistent for quantifying the photographs. The quadrat frame support legs each have two adjustable legs attached to them. The legs are adjusted so the quadropod is at a specified height at each transect site and properly leveled out.

4.6 Quadrat Frame

The quadrat frame is constructed of 1/2" PVC piping with nylon stringing for the grid pattern. The PVC piping is chosen because it is strong and flexible. The size of the quadrat frame is 100cm x 30cm with a 5cm square grid pattern.

4.7 Transect Locators

The transect sites are permanently identified with locator pins. These pins are 1/2" stainless steel bolts driven into the bedrock with lead expansion bolts and capped with epoxy. The bolts are placed between 1m and 10m off the trail treadway to remain hidden from view. The pins are relocated using site descriptions and site photographs.

4.8 Transect Lines

The transect lines are 1/4" braided nylon rope with loops at either end. The loops are stretched taut over the pins according to an east/west orientation. Along the transect lines are aluminum ferrules crimped to the line. The ferrules each represent a quadrat site for monitoring.

4.9 Camera

The camera is a Cannon EOS Elan EF with a 28-80mm f/3.5-5.6 Ultrasonic Lens. The camera has the quick release mount adapter permanently affixed to the bottom to assure accurate positioning in the release mounts for the photo shoots. The camera functions allow for bracketing of the photos, remote triggering, and manual aperture setting. The bracketing creates a series of photographs that are over, under, and correctly exposed so as to ensure at least one picture with good contrast. The remote trigger eliminates shaking of the quadropod when shooting the pictures. The aperture can be set manually so as to create the greatest depth of field for each photograph.

4.10 Data Processing

The data processing requirements consist of maintaining the photo series schedule outlined on the transect data sheets and making note if there is any alteration to it. The film, when taken, is sent to the developers. When it is returned the slides are arranged into archiving sheets per the instructions in the protocol manual and sent to the VMC for permanent storage. The data is accessed at the VMC according to their archival and retrieval process.

4.11 Data Sheets

There is one data sheet annually for PIMS. One side consists of the site data that must be recorded at each transect site. The other side consists of the photo series schedule and must be used if there is any change to the schedule.

Chapter Five - Conclusions

1. Ease of transect relocation.

The transects are relocated using a series of six photographs as well as a site description. Even with this amount of information relocating the locator pins will be difficult. The pins stand at most 1" off the bedrock and are situated such that they are not readily evident from the trail treadway in an effort to maintain the natural character of the ridgeline. However, once one pin is located the second will be very easy to locate by using an azimuth from the first pin to the second. Over time the pins may become covered by vegetation or worked free of the bedrock due to the severe freeze/thaw that the ridgeline receives.

2. Ease of quadropod assembly.

The quadropod can be assembled in under ten minutes with little to no experience required. It is necessary, however, that the person conducting the monitoring read the entire protocol manual and understand the procedures prior to going to the site. No tools are necessary for assembly. It can not be assembled incorrectly due to the physical design of the structure.

3. Ease of camera orientation.

Camera orientation is the most time consuming and important feature of PIMS. Camera orientation is inclusive of quadropod orientation. The first quadrat can take anywhere from fifteen to twenty minutes to orient the quadropod. Once it becomes more famillar the process can be accomplished in under five minutes. The fragility of the extendible legs makes orientation more time consuming because special attention must be given to the legs as the quadropod is leveled and adjusted according to the correct azimuth.

4. Camera performance.

The camera can be intimidating in that it has many features. However, the same features enable the data set quality to be more than sufficient. The remote triggering allows the person doing the monitoring to trigger the camera while standing away from the quadropod. The person conducting the monitoring can avoid casting a shadow on the focal point.

5. Ease of data management.

Data management is simple with this design. The process is laid out step by step in the protocol manual for data processing. Long term management is to be the responsibility of the VMC. The association of the VMC with PIMS ensures a secure future for the archiving of the data and accessibility to it.

6. Overall complexity of data gathering.

The overall complexity of data gathering is extensive for the first transect. However, the design is such that each quadrat site is monitored using the very same methods. By the end of the day the process should become quite famillar and the complexity of the system as a whole is minimal.

7. Time requirement for sampling.

The execution of PIMS takes a full day from early morning to early evening. As well, an evening should be spent with the manual and the equipment prior to the day of monitoring to establish a familiarity with the equipment and procedures. In respect to the amount and quality of the data gathered PIMS is very efficient. In one day data is gathered on twenty-two quadrat sites (198 images) and sixteen oblique images are taken along nine different transects.

8. Available technical support.

The protocol manual has been designed to give all the information needed to execute PIMS. However, the study site is remote and no external help will be available.

9. Viability of database for various management needs.

The literature indicates that the data set will provide for a series of analysis procedures that should indicate various management strategies. There should be kept in mind the distinction between ecological research and monitoring as they are truly separate tasks. It is important to remember that this project consists of the design and implementation of a monitoring protocol. The suggestions for data analysis and procedures that follow are offered as a means of illuminating one of many routes that a researcher can take in utilizing the database.

Calculations of relative cover are a convenient way to compare changes in vegetation (Cole 1993). The resulting data can be displayed via projection onto a large screen for quantification. The quadrat frame is included in each vertical shot and can be used to aid in counting the vegetation according to three primary types of target data. They are density, cover, and frequency. The photographs can also be used to assess comparative percent cover change, species abundance, bare ground cover, and individual species response. The characteristics of the alpine communities, low-lying and interdependent, may limit the ability of the researcher to accurately assess richness and density of species from photographs.

Some restricting variables in trend analysis are eliminated in the PIMS data set. For example the commonness and rarity of certain species will not affect the analysis as the monitored plots are hypothetically representing entire populations. Auto correlation will also fail to be a factor because this stage is primarily interested in change/time and not necessarily what is causing that change.

The resulting data on density, cover, frequency, and diversity can then be analyzed according to the three features of time series data. They are trend, cycles, and noise. Standard errors of means (SEMs) can be applied to the new data sets to determine the validity of the trends, cycles, and noise (Goldsmith 1991).

Assuming the resulting data is found to be within the SEMs tables and/or graphs can be developed to illustrate these features. These can then be subjectively analyzed to determine which plots show the strongest trend toward rebound (increased cover, density, and frequency). To achieve this analysis the researcher will assume the plots are all subject to equal impact variables above and beyond those of hiker trampling impacts.

Statistical analysis can be achieved in the following ways:

- Frequency distributionscan be created resulting in a visual map of individual quadrat change where x=time and y=frequency, density, or cover.

- Having calculated the sampling distribution of the mean one could then calculate single sample confidence intervals for each of the individual plots. This would result in being (x)% confident that quadrat (y) will show between (n) and (t) change in density, cover, or frequency according to some determined time frame.

- Plots could also be tested for hypothesis and statistically significant changes according to the Z-Table and the associated Alpha level (most likely .05).

- Plots could be compared for durability by conducting two sample confidence and hypothesis testing steps resulting in ($u_1 - u_2 = 0$) or an alternative hypothesis. An example may read: "The rock treadway corridor grew/regressed at a statistically slower rate than in the bog areas". Compare the results of the two sample hypothesis test to the Z/T-Table and one could accept or fail to reject the null hypothesis.

Chapter Six - Recommendations for further research

- Arrange transects according to trail structures (i.e. scree walls, stringing, brushing, stumble stones). From the resulting database one could do the statistical analysis of which structure functioned best over time.
- The quadropod could be rebuilt with lighter materials. Perhaps an aluminum material would provide for the strength needed yet still remain lightweight.
- The compass orientation method could be replaced with a protractor reading taken off the transect line itself. This would eliminate the need to correct for declination each year.
- The transect locator pins could be located with a GPS device eliminating the time required to find the pins at each site.
- The adjustable legs of the quadropod could be made stronger or the attachment redesigned to increase the strength.
- Will the *Diapensialaponica* (or other less resilient species) be lost to the *Carex bigelowii* (or other highly resistant species) due to slower recovery rates?
- PIMS can be effectively employed on other sites with similar morphological characteristics as Mount Mansfield.

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Appendix

PIMS Recipients

- Sandy Wilmot, Monitoring Coordinator, Vermont Monitoring Cooperative
- Lars Botzojorns, Director of Field Programs, Green Mountain Club
- Rick Paradis, Natural Areas Manager , University of Vermont
- William Howland, Executive Director, Green Mountain Audubon Nature Center
- Ken Kimball, Research Director, Appalachian Mountain Club
- Linda Gregory, Acadia National Park Staff Botanist
- Kathy Regan, Director of Science and Stewardship, Adirondack Nature Conservancy/Adirondack Land Trust

Appendix

Approximate Budget

Film:	$72.00
Developing:	$48.00
Gas:	$5.00
Lunch:	$5.00
Slide Sheets:	$5.00
Postage:	$5.00

TOTAL: $140.00 - per year plus any administrative and maintenance overhead

Appendix

Vermont Monitoring Cooperative Application and Work Plan

VERMONT MONITORING COOPERATIVE APPLICATION FOR 1995

FOR MONITORING AND/OR RESEARCH ON MOUNT MANSFIELD

Applicant's Name: Mark Haberle
Applicant's Adress: 37 Russell St.
Burlington, VT 05401
802-658-4905
mhaberle@moose.uvm.edu
Organization/Affiliation: University of Vermont Environmental Program Natural Areas
ProjectTitle: **Designing a Monitoring Protocol to Measure Trail Treadway Impact in the Arctic-Alpine Zone, Mount Mansfield**

1. Describe your project, including: purpose, details on study area size, number of samples and parameters to be taken, any changes made to the site, study area markings, structures or equipment to be installed. (This application may be accompanied by a more detailed project description of up to two pages in length.) We would likle to include information on your activity in our annual VMC Monitoring Work Plan. See the attached example for format and content required.

The objectives designed to guide this research are:

1. To establish a long-term (perpetual) monitoring program for the trail system hosted by the arctic-alpine zone under the ownership of the University of Vermont (UVM).

2. To critique and refine the monitoring protocol with emphasis on ease of repetition, data processing, data management, and data relevance.

The project is to be located in the arctic-alpine zone hosting the Long Trail within the UVM Natural Area Mount Mansfield site. Site will consist of approximately 10-15 transects of 3 meters in length bisecting the trail treadway. Transects will be located with bias to areas of particular concern between the "Nose" and the "Adam's Apple" along the summit ridgeline (approximately 1.4-1.6 miles.) Every effort will be made to reduce researcher impact to a minimal degree.

Ttransects will be photographed in a vertical format of 3-6 pictures per transect depending on transect size and location. Oblique photographs both north and south along the treadway will be taken for qualitative assesments.

Sampling proceedure will be as follows:

1. Transects will be established with one-half inch stainless steel bolts driven into the bedrock on either side of the treadway approximately 1.5 meters from the center of the treadway. These will serve as locators for subsequent sampling. Bolts will protrude from the surface approximately one-quarter inch and have a one-quarter inch head. Bolts will not be readily evident from the trail and should not in any way affect the aesthetic value inherent in the arctic-alpine zone.
2. A tape with pre-measured photo points will be streched taught between the transect pins.
3. A graduated quadrat will be placed along the transect tape according to pre-measured quadrat points.
4. A tripod will be erected over the photo points and quadrat on the tape. The tripod will consist of a camera and a camera orientation platform.

5. The camera orientation platform will utilize two levels to orient the camera level, a compass to orient the camera's direction, and a plumb bob to orient the camera over the photo point. The height of the camera will be established using the plumb bob string as an indicator.
6. Three photographs will be taken at each photo point (one at correct F-Stop, one at one stop aove, and one at one stop below). At each central photopoint oblique photos will be shot both north and south for qualitative assesments.
7. A transect summary sheet will be maintained to indicate all relevant data (ie. weather, temperature, aperature, F-stop, general comments, date, transect location, time.)

Please refer to attached proposal for further information

2. What types of activities by other VMC cooperators would be incompatible on the area you are using?

Any disturbance to transect area locations would distort the accumulated data set. Such disturbances may include collections of species, manipulation of communities, or development of any type. Interestingly enough the database is designed to indicate change/time within the Long Trail corridor due to human influence. Therefore any changes to the environment due to human interference would be relevant to the data set. This would include any researcher activities as well. However, to maintain a dataset specific to treadway response to foot travel any environmental manipulations by other researchers on or around a transect location should be brough to the attention of the UVM Natural Areas.

3. What is the anticipated duration of the project?

The protocol research and design phase will be conducted during the months of June, July, and August 1995. Protocol write up will be finished by December 1995. Transect sampling will occur continually throughout the research and design phase. Thereafter sampling will occur in perpetuity according to the protocol recommendation.

4. Has the specific study area location been identified, and if so, please indicate location on attached map. If location is not known at this time, what criterea are you looking for in locating a plot?

As indicated on the attached map the project location will be within the arctic-alpine zone hosting the Long Trail within the UVM Natural Area Mount Mansfield site. Individual transect locations are not yet determined. The criterea for transect location are areas of special concern (ie. dog trails, bog areas, trail junctions, viewing spurs, and visitor staging areas.) Effort will be made to avoid areas where researcher/sampling activity will have heavy impact on a fragile community. As well areas where the photographic data collection technique is not viable (ie. cliff areas) will be avoided. Final transect locations will be indicated with a written site description, GPS points, and a photographic guide.

5. List the ways in which this project fits the goals and objectives of the VMC.

The resulting database will provide for a greater understanding of the conditions, trends, and relationships in the physical and biological communities of the arctic-alpine zone of Mount Mansfield by providing a database of change/time.

The resulting database will utilize impact parameters of current ongoing studies and will be a usefull supplement to ongiong survey studies being conducted within the arctic-alpine zone. In this way the project is efficiently coordinated with other research activities administered to by the VMC.

The project will increase the range of monitoring of the VMC by offering a Human componant as well as serving to represent a very rare and fragile ecosystem, the arctic-alpine zone.

6. Is your project going to be available to other VMC cooperators, and if so, when and in what form?

The resulting database will be archived at the VMC and the UVM Environmental Program Natural Areas. Both organizations serve as a location for the dissemination of such information and so will be readily available to any and all interested researchers and public.

Data will be in the form of color emulsion photographs in slide format. The archiving methodology is to be designed by the VMC and will be consistant at both archiving sites.

Data will begin to be accumulated during the month of August and perpetually thereafter according to the monitoring protocol.

____

Applicants signature

____

Date

Terms of approval (if any):

Project Approval:

____

VMC Official Signature

____

Date

Location Approval:

____

VMC Official Signature

____

Date

Appendix

VERMONT MONITORING COOPERATIVE WORK PLAN FOR 1995

Mansfield
Humans

Trail Treadway Impacts in the Arctic-Alpine Zone

OBJECTIVES: To establish a long term monitoring program for the trail system in the arctic-alpine zone along the summit of Mount Mansfield; to critique and refine the monitoring protocol with emphasis on ease of repetition, data processing, data management, and data relevance.

Using photography as a monitoring tool, areas of high impact along recreational trails will be sampled for vegetative cover, treadway growth/regression, and visual indicators of current condition. Feasibility of utilizing the photographic data for assessments of species richness, abundance, and density will be assessed during this study.

Start Date
June 1 1995

Site Characteristics
Approximately 2 mile section of arctic-alpine zone hosting the Long Trail between the "Nose" and the "Adam's Apple" on Mount Mansfield

Sampling Frame
10-15 3 meter transects bisecting trail treadway
3-6 sequential vertical photographs per transect
2 oblique north and south photographs per transect

Measurements
Denuded site area
Vegetative cover area
Species frequency, richness, diversity

Spatial Context
Mansfield arctic-alpine zone only

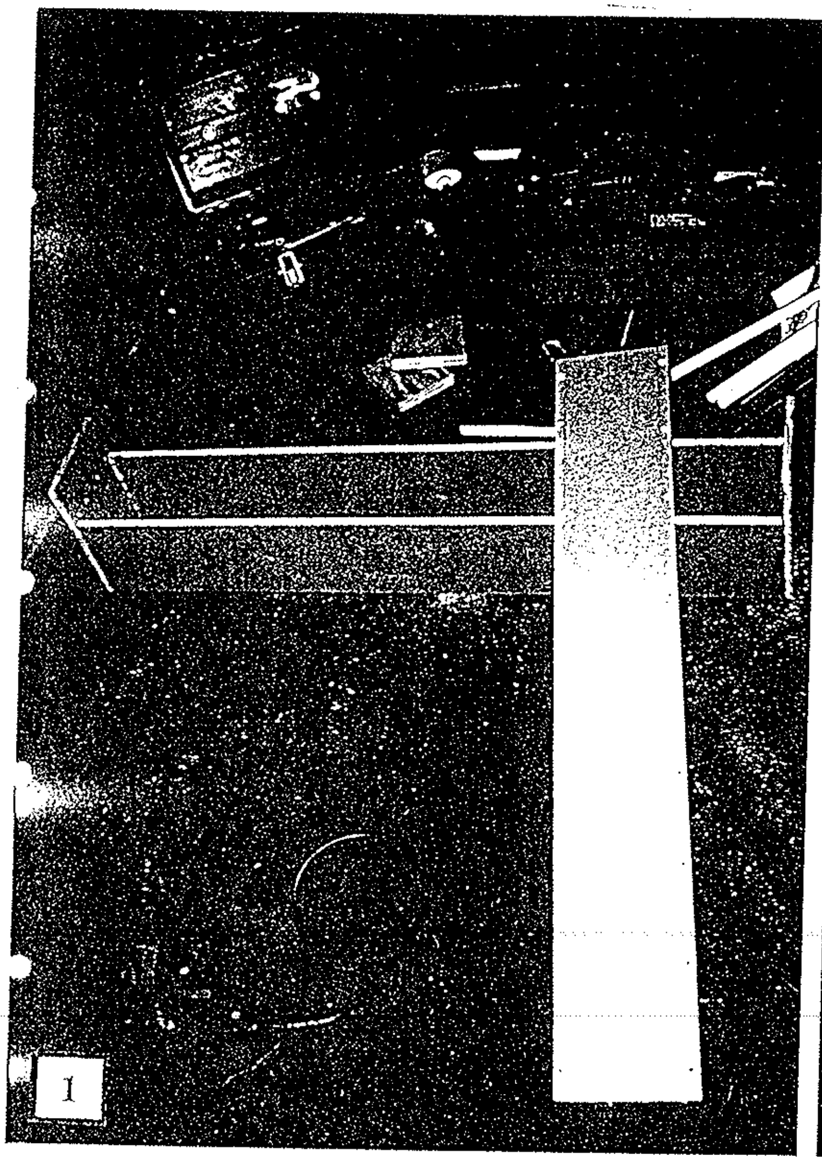
QA/QC
Data collection protocol guide

Contact: Mark Haberle
37 Russell St.
Burlington, VT 05401
802-658-4905 Phone/Fax
mhaberle@moose.uvm.edu

Sampling protocol assessed by: Mark Haberle, UVM
Data accessed at: VMC and Environmental Program Natural Areas, UVM
Data format: Color slides, Slide summary sheets

Appendix
Photographic Chronology of PIMS Development

1) Design and construction of the camera mounting box.
2) Design and construction of the quadrat frame support legs.
3) Materials used in PIMS design and construction.
4) Determining camera focal length and focal area.
5) Determining camera focal length and focal area.
6) Recording transect pin locations with photographs.
7) Drilling transect pin locator sites.
8) Conducting species inventory for species curves.
9) Materials used for transect pin locators.



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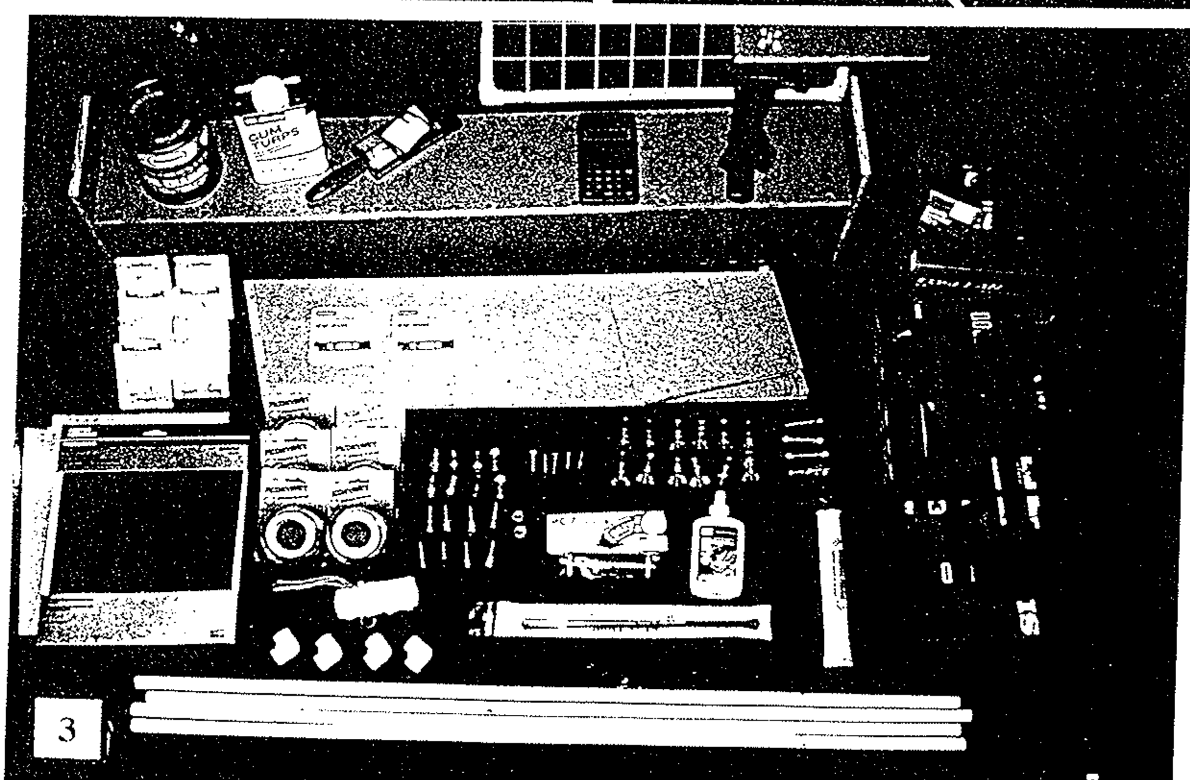

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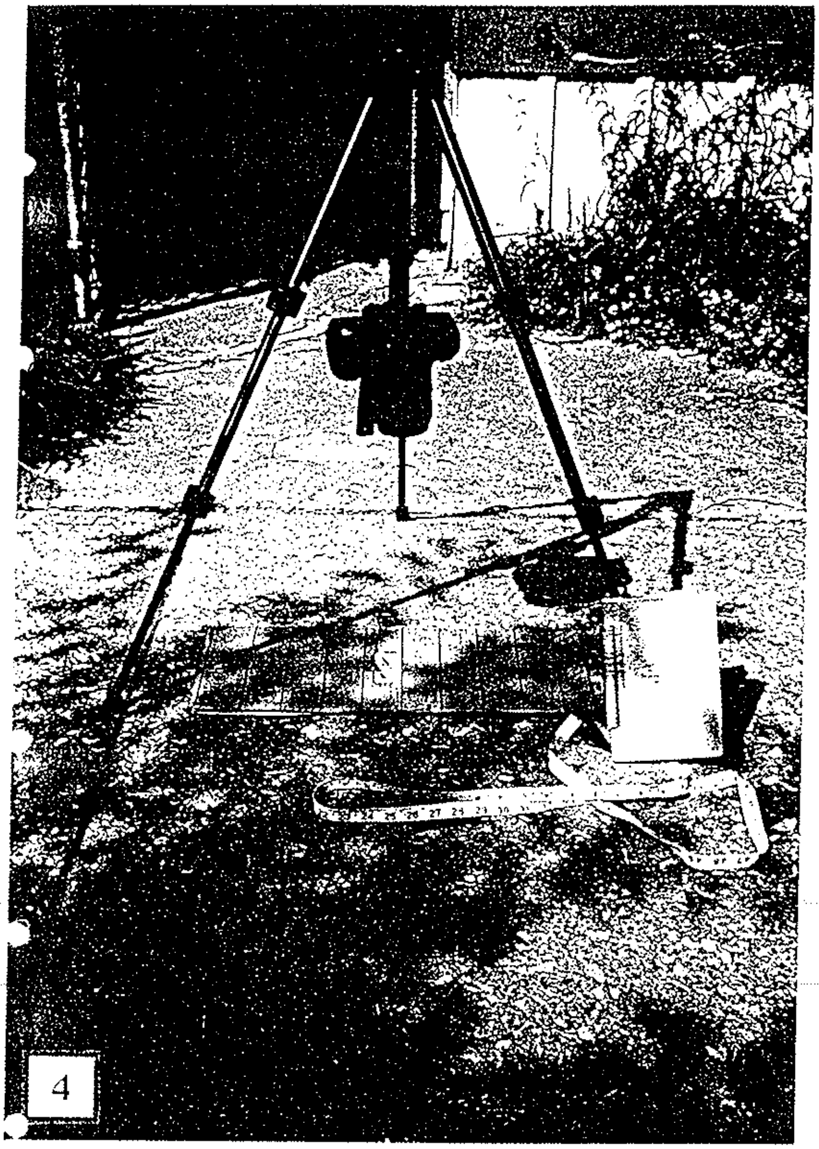

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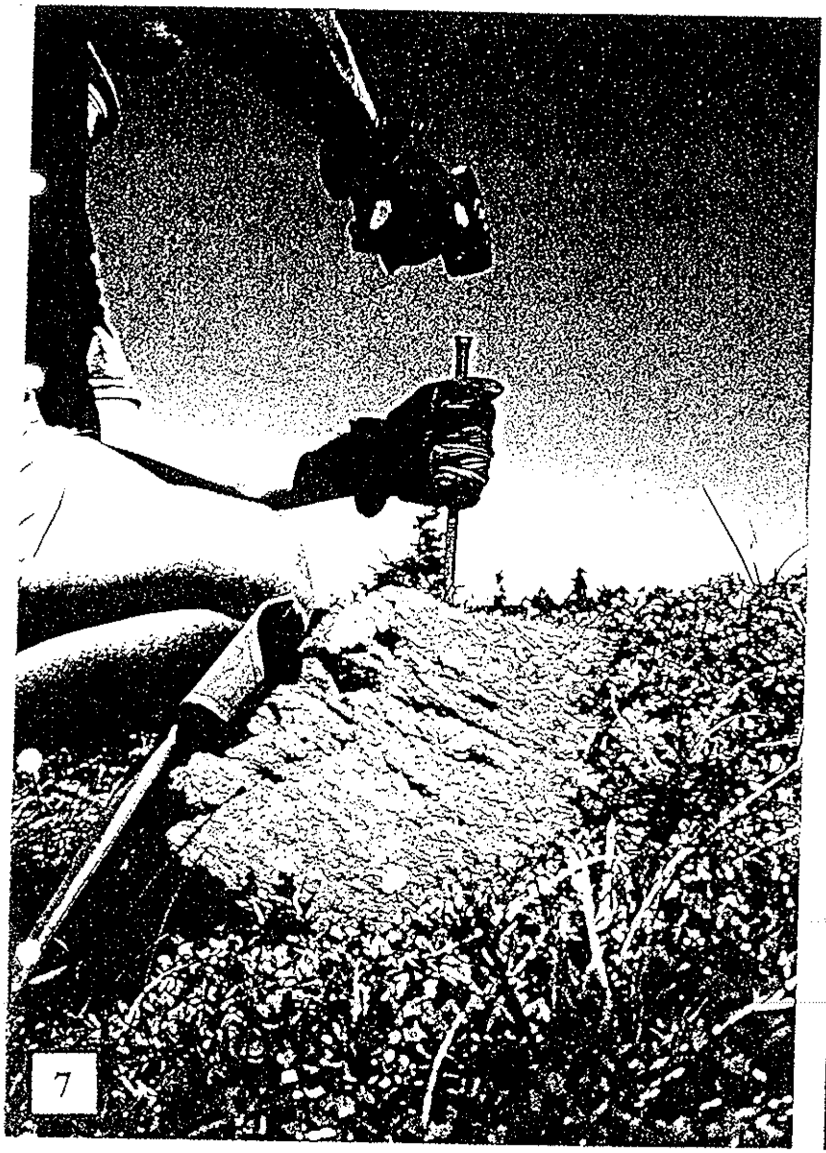

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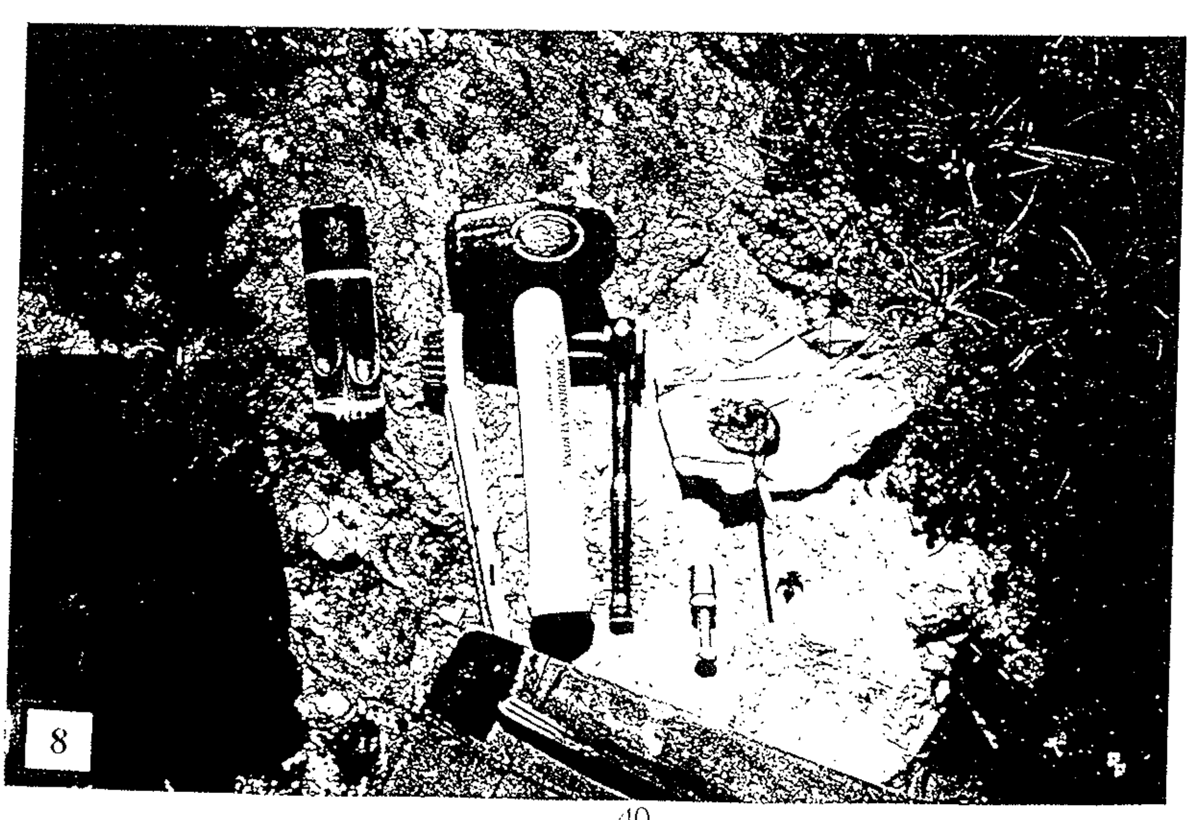

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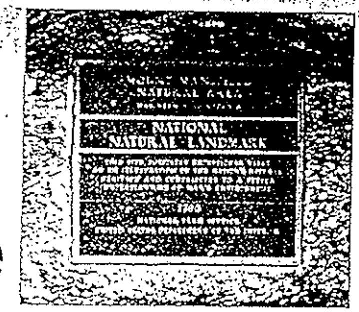
Appendix
News Articles about PIMS

Susan J. Harlow, "UVM Student Stays on Top of Trail Dsamage",*The University of Vermont Record*, October 6 to 19, 1995, Vol. 14, No. 4, p. 12.

UVM student stays on top of trail damage



Mark Haberle visits with, from left, Rick Paradis of the Environmental Studies Program and Dave Kieschtel, a graduate student. Haberle was working as a summit caretaker that day. On other days, he might be working on his senior thesis project to measure the impact of trail usage. UVM owns the 500-acre summit strip of land from the Forehead to the Chin.

By Susan J. Harlow

On top of Mount Mansfield, everything has a tenuous hold except humans. Protected by Goretex and polypropylene, we find our way to once-remote spots like the top of Vermont's highest mountain. But everything else up here at 4,600 feet — soil, plants, wildlife — hunkers down when the wind blows hard.

So when a hiker on the summit ridge treads across a patch of sedge, Mark Haberle, 26, cringes. To Haberle, a summit caretaker and a UVM student researching a method to measure trail impact, stepping off the path is akin to kicking a Ming vase. Damage to the vegetation from just one footstep can take years, if ever, to repair. Already, several species have been lost forever. Hairy arnica, northern birch, black sedge and a half-dozen others have already vanished from the mountaintop.

UVM owns the 500-acre strip of land that caps Mansfield from the Forehead to the Chin. The university bought it in 1859 in one of the country's first-known efforts to protect land as a natural area. Part of the university's Natural Areas System, the ribbon of fragile alpine terrain is the premiere natural area in Vermont, home to such rare species as the Boott's rattlesnake root and diapensia.

On a busy weekend, 1,000 people a day may tramp along the ridgeline. But the continuing debate about human effect on the summit has a weakness: no real quantitative data. Haberle's senior thesis, designing a way to monitor changes along the trail using photographs, would provide that.

His work should yield the start of the first long-term database using photographs to document impact on a trail. It can be used to track the impact of trail usage over time and give researchers valuable

When a hiker on the summit ridge treads across a patch of sedge, Mark Haberle, 26, cringes. To Haberle, a summit caretaker and a UVM student researching a method to measure trail impact, stepping off the path is akin to kicking a Ming vase. Damage to the vegetation from just one footstep can take years, if ever, to repair.

information on alpine vegetation, such as changes in plant species or verification of a species' existence. For example, it might answer whether the Labrador tea is flowering later, or whether the small, white diapensia is thriving or failing. It could help answer management questions, such as whether the Summit Caretaker Program is successfully keeping hikers to the trail, or whether restrictions must be placed on the trail's use.

The photographs will be archived by the Vermont Monitoring Cooperative. The Green Mountain Club helped secure funding from the Sweet Water Trust in Boston for the project.

Haberle is locating about 10 transects (imaginary lines bisecting the trail) along a two-mile stretch of the Long Trail on the ridge, using a global positioning device. To make it easier to count vegetation, he'll position a one-half-meter-square quadrat, or cross-hatched square, along each transect. He'll photograph the quadrats by section; those photographs will be the beginning of one of the most complete databases on an arctic/alpine zone available anywhere.

The key is to take the photographs today, and 10, 25 or 50 years from now, of the same spots, from the same location and angle. Haberle's job is to design a protocol for doing that and to prepare a baseline inventory.

Next, he'll produce a manual detailing the procedure, one that can followed even by amateurs.

But there are plenty of problems to iron out. First, Haberle and the researchers don't want to add to the summit usage problem. Where can someone set up the camera so it doesn't crush a bog bilberry? "Somehow we'll have to set up the tripod off the trail, and that's going to impact the vegetation each and every time," he said.

Second, Haberle isn't even sure photography can do the job of documenting changes in vegetation. Alpine plants are tiny, interwoven ground-huggers. From a photograph, will a researcher be able to count individual plants and pinpoint changes in species?

Throughout the summer, when Haberle wasn't researching the project, he was working the same stretch of trail as a summit caretaker. The program was begun in the 1960s to educate the hikers about trail use. Along with other caretakers here and on Mount Abraham and Camel's Hump, Haberle greeted hikers, answered questions and politely asked them to stay on the trail. Nine out of 10 were happy to comply, he said. It was the other 10 percent he needed to reach

Appendix
News Articles about PIMS

"UVM Student Visiting the Mountain Tops to Prove Impact of Humans on Vegetation", *The Shelburne News*, August 21, 1995, p. 23.

Shelburne News August 21, 1995 Page 23

UVM student visiting the mountain tops to prove impact of humans on vegetation

While more hikers are finding their way to the top of Vermont's highest mountains, damage to alpine vegetation from just one of their footsteps can take years, if ever, to repair.

But the debate over human impact has one weakness, no real quantitative data. To remedy that, University of Vermont student Clark Haberle is developing a method using photographs to monitor changes on the trail along Mt. Mansfield's summit ridge.

Haberle's work should yield the start of the first long-term data base documenting human impact on a trail tread way. It can be used to track the impact of usage on the trail far into the future and provide researchers with invaluable information on alpine vegetation.

For example, data collected through Haberle's method might answer whether the Labrador tea is flowering later, or whether the small, white Diapensia is thriving or failing. It could help answer management questions, such as whether the Summit Caretaker program is succeeding in its goal to educate hikers to stay on the trail, or whether restrictions should be placed on trail's use.

The key is to be able to take photographs of the same spots from the same locations and angles time after time, whether tomorrow or 50 years from now. Haberle's job is to design a protocol for doing that and prepare a baseline inventory. Next, he'll produce a manual detailing the procedure, one that can be handed to anyone to go out and take the photographs.

The photographs will be archived by the Vermont Monitoring Cooperative. The Green Mountain Club helped secure funding from the Sweet Water Trust in Boston for the project.

The days Haberle isn't researching the project, he's working the same stretch of trail as a Summit Caretaker. UVM bought the 500-acre strip of land that caps Mansfield's summit from the Forehead to the Chin in 1859 in one of the country's first known efforts to protect land as a natural area.

Appendix
News Articles about PIMS

Mark Haberle, "How Can We Measure Impact - Researching a Monitoring Protocol", *Prenanthes*, Spring, 1995. Vol. 1, No. 1. pp. 13-14.

How Can We Measure Impact?

Researching a Monitoring Protocol

~ by Mark Haberle

Recent discussions concerning the management of Mount Mansfield's ridgeline have highlighted the need for a comprehensive database to assess the impacts of visitation on the Long Trail corridor and associated natural communities. In meeting this need, a monitoring protocol must be developed that will provide accurate and quantifiable data on trail treadway growth and regression as well as associated floral response.

Current research indicates photographic monitoring can meet these protocol requirements. In order to test this methodology, a research project is being designed with two goals in mind. The first goal is the establishment of a photographic monitoring program for the Long Trail corridor and other visitor staging areas along the ridge. The second goal is the subsequent refining of the monitoring program with emphasis on ease of application and data management.

Completion of these two goals will offer the University of Vermont Natural Areas Program a workable monitoring protocol for the collection of data to aid in future management decisions as well as ecological assessments.

Photomonitoring will be conducted along approximately two miles of the Long Trail located on the ridge of Mount Mansfield in the arctic-alpine zone. A very brief overview of the protocol designed for this project is as follows: 1) transects will be established along the trail with bias towards areas of special concern (such as dog trails, bogs, or staging areas); 2) these transects will be broken down into three separate photographic points that will overlap (for 3-D stereographic viewing capability) and cover an area approximately three to four feet on either side of the treadway; 3) pictures will be taken using a quadropod with a graduated quadrat affixed to the legs to serve as real-world coordinates for comparison of images indicating change/time; 4) images will be utilized to provide quantifiable data for analysis of such parameters as treadway growth, regression, and floral community response according to cover, density, and frequency.

As a program designed to meet the needs of both the ecologist and the manager, it is essential that input comes from both. Information on sampling methods, assessment methods, database structure, and any other needs is welcome. ♦

- For further information please contact: Mark Haberle, 37 Russell St., Burlington, Vermont 05401, (802) 658-4905 Phone/Fax, <mhaberle@moose.uvm.edu> E-Mail.

Appendix
News Articles about PIMS

Mark Haberle, "How Can We Measure Impact - A Monitoring Methodology Design for Arctic-Alpine Communities", *Prenanthes*, Winter 1996, Vol. 1, No. 2. p. 5.

How Can We Measure Impact?

A Monitoring Methodology Design for Arctic-Alpine Communities

Management of the heavily visited Mt. Mansfield arctic-alpine zone in north-central Vermont is a difficult task at best. It is a challenge to find a balance between visitation and the ecological integrity of plant communities surrounding the trail treadway. This challenge begs the question: "What is the relationship between visitation and change in the makeup (density, frequency, and cover) of plant communities near the trail?"

In the summer of 1995 the Photographic Inventory Monitoring System (PIMS) was developed by Mark Haberle under the auspices of the University of Vermont (UVM) Natural Areas Program to provide quantitative data on the visitor-use/ plant-resilience relationship (see *Prenanthes*, Spring 1995, p. 13). PIMS is designed to provide data for as long as the UVM Natural Areas Program remains in effect. The system is also designed to be easy to repeat, requiring little or no experience in botany or ecology.

A key to the success of PIMS is the ability to compare photographs over time to ascertain changes in plant communities. Therefore, ease of repeatability and accurate relocation of the camera is important. To meet these needs an adjustable quadropod was developed which can be easily and accurately repositioned to photograph permanent quadrants in subsequent years. The system does not compromise a visitor's backcountry experience, as it avoids placement of permanent pin locators within the trail treadway. Responsibility for monitoring and monitoring equipment will rest with UVM's Natural Areas Program. The slides will be archived by the Vermont Monitoring Cooperative.

PIMS is an effective, low cost, efficient, and reliable method of monitoring visitor impacts on the integrity of the arctic-alpine communities. For further information on the system and its development, contact Mark Haberle at 37 Russell St., Burlington, Vermont, 05401, (802) 658-4905, e-mail: mhaberle@moose.uvm.edu or the University of Vermont Natural Areas Manager Rick Paradis at (802) 656-4055.

Mark Haberle *is completing his degree in environmental studies at the University of Vermont and has worked as a summit caretaker for GMC.*

Appendix
News Articles about PIMS

Rick Paradis ed., "Monitoring Visitor Impact on Mount Mansfield", *Natural Areas Notes*, Autumn 1995, p. 3.

MONITORING VISITOR IMPACT ON MOUNT MANSFIELD

The management of the heavily visited ridgeline of the Mount Mansfield Natural Area is a difficult task at best. Central to this effort is finding a balance between visitation and protecting the ecological integrity of the arctic-alpine natural communities associated with the Long Trail along the ridgeline. This challenge begs the question: "What is the relationship between visitation and change in the makeup (density, frequency, and cover) of the plant communities associated with the trail treadway?"

In the summer of 1995, the Photographic Inventory Monitoring System (PIMS) was developed to provide quantitative data on this relationship. Conceived by senior Environmental Studies student Mark Haberle, PIMS is designed to provide comparable data of site conditions over the long term. The system is also designed to be easy to replicate by field technicians requiring little to no experience or training.

This summer's research and development resulted in the creation of a monitoring protocol that makes use of color slides as the data format. The data collection tools and responsibility will be housed within the University of Vermont Natural Areas. The color slides will be archived by the Vermont Monitoring Cooperative.

Central to the success of PIMS is the ability to compare the color slide images over time to measure for changes in the plant communities and trail treadway. Therefore, ease of replicability and accurate relocation of the camera is important. To meet these needs an adjustable quadropod has been designed and constructed. Used in conjunction with a protocol manual, the quadropod is relocated for subsequent shoots easily and accurately. The system also avoids compromising a visitor's backcountry experience by avoiding placement of pin locators or other permanent objects within the trail treadway.

PIMS is an effective, low cost, efficient, and reliable method of collecting data that will help monitor visitor impacts on the integrity of the arctic-alpine communities along the ridgeline of Mount Mansfield. Over time, managers will benefit considerably from the information gathered by these monitoring efforts as they fine tune field activities and programs to protect this fragile and important alpine ecosystem.

For further information on PIMS and other monitoring activities on Mount Mansfield, contact Mark Haberle, 37 Russell Street, Burlington, Vermont 05401, (802) 656-4055, <mhaberle@moose.uvm.edu>.

Appendix
News Articles about PIMS

Sandy Wilmot ed., "VMC Photographic Archiving System in Development", *Vermont Monitoring Cooperative Newsletter*, June-July 1995, Vol. 1, Issue 1.

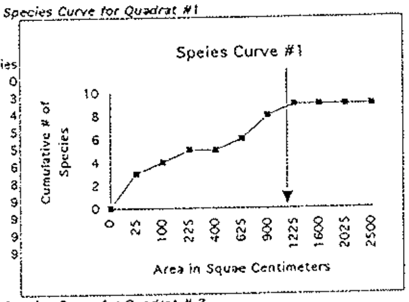
VMC Photographic Archiving System in Development

This summer the VMC will be developing a system for archiving photos and slides, including a process for documentation and easy retrieval. The immediate need was to accommodate slides being taken on the summit of Mount Mansfield to document current status of trail treadways for comparison over time. Other uses could include photography of landscapes, plots, methodologies, cooperators, and species records. Help develop the system, or make use of it in the future for storing and documenting your studies.

Appendix
Species Curves

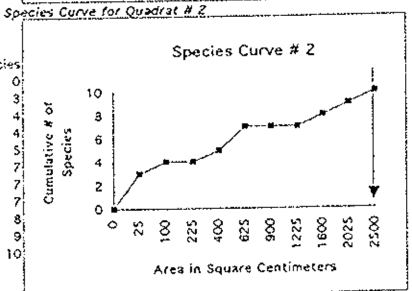
Species Curve for Quadrat #1

Area Square cm	Cum # O Species
0	0
25	3
100	4
225	5
400	5
625	6
900	8
1225	9
1600	9
2025	9
2500	9



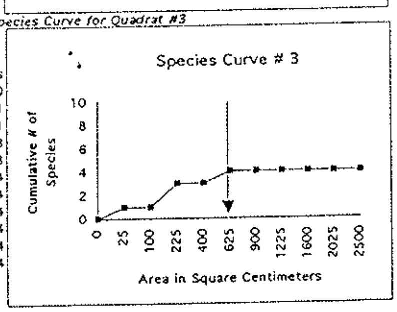
Species Curve for Quadrat # 2

Area Square cm	Cum # O Species
0	0
25	3
100	4
225	4
400	5
625	7
900	7
1225	7
1600	8
2025	9
2500	10



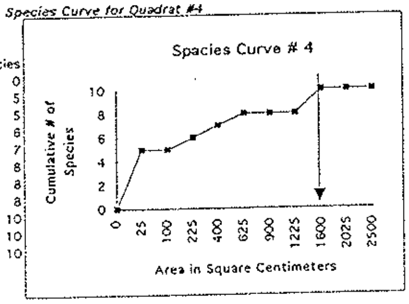
Species Curve for Quadrat #3

Area Square cm	Cum # O Species
0	0
25	1
100	1
225	3
400	3
625	4
900	4
1225	4
1600	4
2025	4
2500	4



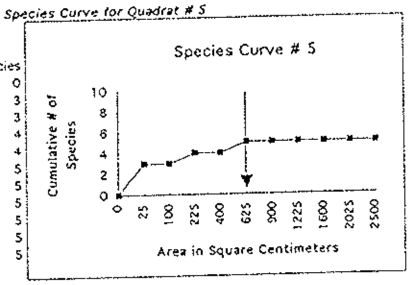
Species Curve for Quadrat #4

Area Square cm	Cum # O Species
0	0
25	5
100	5
225	6
400	7
625	8
900	8
1225	8
1600	10
2025	10
2500	10



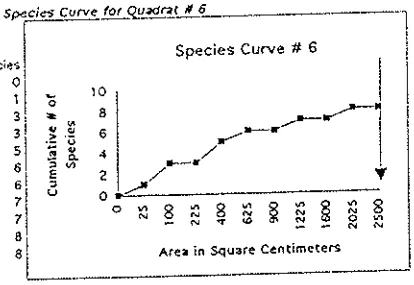
Species Curve for Quadrat # 5

Area Square cm	Cum # O Species
0	0
25	3
100	3
225	4
400	4
625	5
900	5
1225	5
1600	5
2025	5
2500	5



Species Curve for Quadrat # 6

Area Square cm	Cum # O Species
0	0
25	1
100	3
225	3
400	5
625	6
900	6
1225	7
1600	7
2025	8
2500	8

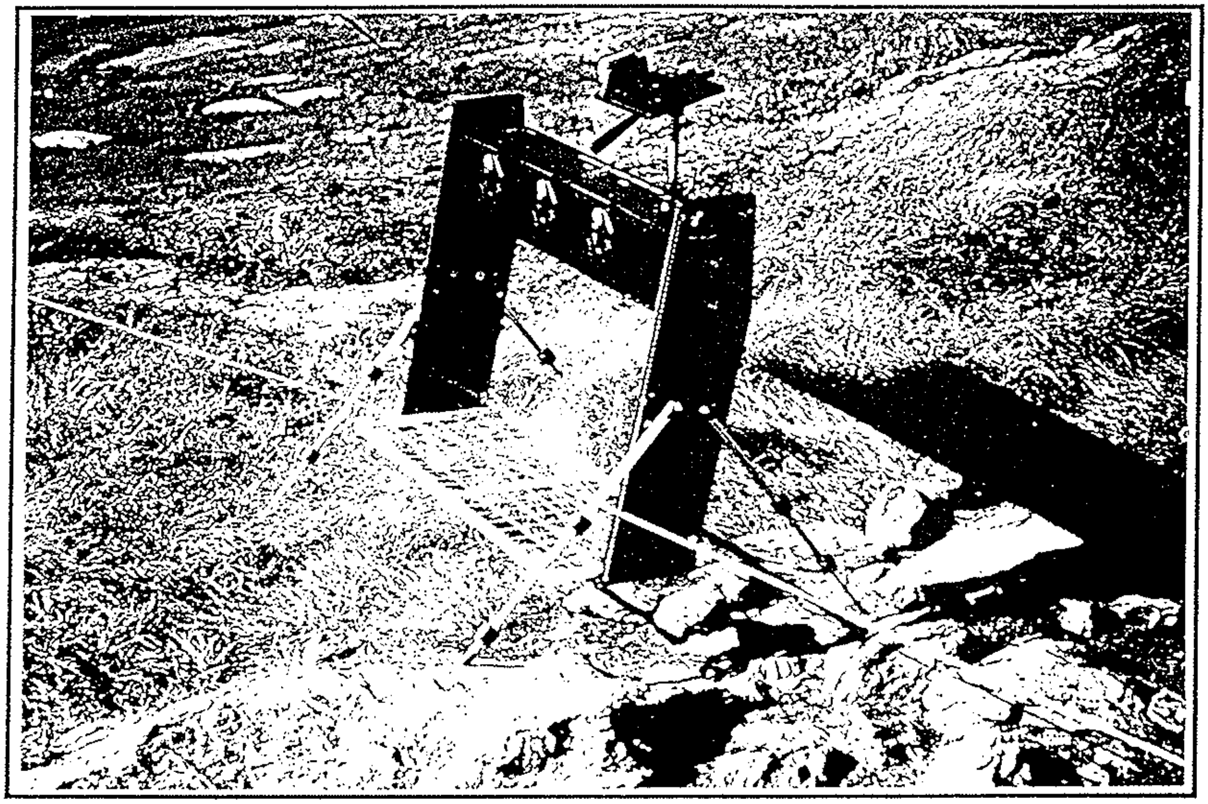


Appendix
Species Inventories

Species Curve Inventories

Sample Size	5x5cm	10x10cm	15x15cm	20x20cm	25x25cm	30x30cm	35x35cm	40x40cm	45x45cm	50x50cm
Sample #1	*Carex bigelowii* *Vaccinium uliginosum* *Polytrichum sp.*	*Vaccinium ites-idea*	*Cetraria laevigata*	>no new species<	*Deschampsia flexuosa*	*Cladonia sp.* *Arenaria groenlendica*	*Bryophagus sp.*	>no new species<	>no new species<	>no new species<
Total Species	3	4	5	5	6	8	9	9	9	9
Sample #2	*Vaccinium angustifolium* *Cetraria laevigata* *Ledum groenlendicum*	*Cladonia sp.*	>no new species<	*Vaccinium ites-idea*	*Vaccinium lichen sp.* *Vaccinium uliginosum*	>no new species<	>no new species<	*Empetrum nigrum*	*Albies balsemea*	*Vaccinium sp.*
Total Species	3	4	4	5	7	7	7	8	9	10
Sample #3	*Polytrichum sp.*	>no new species<	*Vaccinium uliginosum* *Carex bigelowii*	>no new species<	*Polytrichum sp. #2*	>no new species<	>no new species<	>no new species<	>no new species<	>no new species<
Total Species	1	1	3	3	4	4	4	4	4	4
Sample #4	*Ryzocarpum geographicum* *Leconora sp.* *Ryzocarpum blodotrum* *Ryzocarpum sp. grey #1* *Ryzocarpum sp. black #1*	>no new species<	*Umbilicaria sp.*	*Parmelia sp.*	*brown/black fruit dots #1*	>no new species<	>no new species<	*fuzzy brown #1* *Stereocaulon sp.*	>no new species<	>no new species<
Total Species	5	5	6	7	8	8	8	10	10	10
Sample #5	*Vaccinium ites-idea* *Vaccinium uliginosum* *Carex bigelowii*	>no new species<	*Cetraria nevallis*	>no new species<	*Cetraria laevigata*	>no new species<	>no new species<	>no new species<	>no new species<	>no new species<
Total Species	3	3	4	4	5	5	5	5	5	5
Sample #6	*Arenaria groenlendica*	*Carex bigelowii* *Vaccinium uliginosum*	><	*Polytrichum strictum* *Ryzocarpum geographicum*	*Cetraria laevigata*	>no new species<	*Carex bigelowii*	>no new species<	*Cladonia amaurocraea*	>no new species<
Total Species	1	3	3	5	6	6	7	7	8	8

PIMS
Photographic Inventory Monitoring System



Mark Haberle
March 1996

A Senior Thesis
Submitted in Partial Fulfillment of a Bachelor of Science Degree
Environmental Program - University of Vermont

Introduction

The University of Vermont owns and manages 400+ acres on the top of Mount Mansfield as a Natural Area. For many reasons the integrity of the mountain top's alpine ecosystem is at risk. A major stressor that has put the integrity of the alpine communities at risk is human visitation and trampling.

This monitoring protocol is designed to allow the assessment of the effect of human trampling on the plant communities associated with the trail treadway on Mount Mansfield. The Photographic Inventory Monitoring System (PIMS) is designed to provide long term data that will indicate trends occurring in the alpine communities bordering the treadway.

To recognize trends it is necessary to analyze data collected at specified time intervals. The execution of this monitoring protocol is one step in providing that type of monitoring information. PIMS is designed as a data collection tool that is accurate, quantifiable, easy to use, and has little impact in the alpine zone.

The monitoring outlined in this manual has several key features. First, the orientation and location of the quadropod (the camera mounting platform) is the most time consuming and crucial element of the protocol. Second, all the data collected is recorded on color slide film. Third, the data is collected along transects that bisect the trail treadway.

In practice, emphasis must be placed on orientation. In order to re-capture a picture of the same quadrat frame within an acceptable level of error the quadropod must be oriented precisely each time. PIMS provides for permanent plot locations yet it does not result in a visual or physical obstruction to the visitor looking to have a natural backcountry experience.

It is important to remember several things. The alpine zone is a rare and fragile area. It is up to you to minimize your impact by taking the extra effort to tread only on the rocks while carrying out this protocol. (PIMS is a data collection process. Though the data collected facilitates the analysis proceedures you will not be required to do any analysis.)

The execution of this system takes place in one of the most unique, fragile, and beautiful environments on this planet. Look around, enjoy the view, and educate the passers by on what you are doing and why. The healthy future of such an ecosystem is dependent on the collective actions of individuals. Feel empowered to make your concern known.

How to Use this Protocol Manual

The manual should be read in its entirety before going out in the field. If there is something missing or confusing it is best to resolve the issue before ascending Mount Mansfield.

Chapter One - Overview: Introduces some of the equipment associated with the system and the terms used in the data collection methodology. Read Chapter One and get familiar with the concepts and terms. Once on the ridge you should not need to refer to this chapter again except for reminders.

Chapter Two - Procedural Instructions: Consists of descriptions of tasks that will have to be done in the field with the equipment. The descriptions include such things as putting the quadropod together, stretching the transect lines, orienting the quadropod, and orienting the oblique platform. In this chapter you will learn exactly what needs to be done at each transect.

Chapter Three - Site Data: Incorporates all the individual transect site data. This data includes the quadropod azimuth, ferrule height, oblique inclination, etc. This chapter contains information needed to properly orient the quadropod and record the data at each site.

PIMS is designed to become easier with practice. You may find that by the last transect you only need to refer to Chapter Three for the orientation information. The appendices are also very useful in the field. Before heading out you should take the time to read the manual in its entirety and be comfortable with all the chapters and appendices. The PIMS system can be accurate and efficient only if used with a fair amount of patience and attention to detail.

Before going out into the field you will need to:

- Read and understand the steps outlined in this manual.
- Inventory all equipment parts and pieces.
- Practice assembling and orienting the quadropod.
- Xerox extra data sheets onto weatherproof paper. The original data sheet can be found in the appendices.
- Purchase six (6) rolls of Fugichrome Provia 100 ASA 36 exposure color slide film.
- Plan on spending a FULL day in the alpine zone. Prepare yourself for all conditions.

Table of Contents

Chapter One - Overview

1.1 Operational Definitions

The following is a list of operational definitions frequently used in this manual:

Aperture Priority: (Av)	Aperture priority is a functional setting of the camera. It allows the aperture of the camera to be set manually. Using Av one can create the greatest depth of field from near to far within each picture.
Auto Bracketing: (AEB)	Auto bracketing is another functional setting of the camera. It allows the camera to shoot three shots with the push of one button. The pictures are shot at three different exposures to create either more or less contrast in the pictures. The picture with proper exposure called for by the camera light meter is essentially "bracketed" by the other two pictures.
Azimuth:	An azimuth is a direction between 1 and 360 degrees. When orienting the quadropod and oblique platform an azimuth will be given that indicates the direction those devices are to be pointed. A compass is used to establish the proper azimuth.
Ferrule:	A ferrule is a small aluminum bead. They are crimped onto the transect lines at various distances and are used to indicate the quadrat frame locations.
Inclinometer:	The inclinometer can be used to determine the angle of a plane relative to horizontal. For this system a plane is the oblique orientation platform. The inclinometer is used to orient the camera vertically for the oblique shots.
Oblique:	Oblique is an angle neither vertical nor horizontal. In this manual a reference to an oblique refers to the photos taken from the Oblique Orientation Platform up and down the treadway.
Oblique Orientation Platform:	This platform is a tool used to orient the camera during the oblique shots. In this case it is a platform with an inclinometer and compass that stands on an articulated post.
Photo Frame:	The photo frame is a reference to the entire field of a picture. Simply, it is the full 35mm photo format itself.
Photo-monitoring:	Photo-monitoring is the use of photography for the purpose of data collection over time. In this case the data is in the form of color slides. The purpose is to define trends that may indicate changes in ecological integrity.
Quadrat Frame:	The quadrat frame is a grid pattern within a larger frame and is used to aid in the counting of vegetation. For this system the quadrat frame is constructed of 1/2" PVC pipe, in the shape of a 50 x 100cm rectangle, with string lines that section the frame into 5cm squares.

Quadrat Frame Site: A quadrat frame site is a location where a quadrat frame is placed to be photographed. In this case it is where the quadropod will be set up along each transect line. Most locations have two quadrat frame sites per transect but some have three quadrat frame sites.

Quadropod: The quadropod is the camera platform and orientation tool. It is a device with four adjustable legs and three quick release mounts. It also has an oblique platform for shooting other than vertical photos.

Quick Release Mount: A quick release mount is designed to release and attach a camera with the flick of a lever. On the quadropod there are four mounts: three on the quadropod itself (1-3) and one on the oblique platform (4).

Transect Locator Pin: These pins are used to properly locate the transect site and line. In this case the pins are 1/4" stainless steel bolts that stand approximately 1/4 - 1/2" off the bedrock. They are the anchor points for the transect line and are located along the treadway in the alpine zone (Image 1.1).

Transect Site: A transect site is a location along the treadway where a series of quadrat frame shoots will be taken. There are nine transect sites located between the Summit Station and the Chin within the Mount Mansfield Natural Area.

Transect Line: The transect line is used to determine the exact location and height of one corner of the quadropod. In this case it is a 4 mm rope with aluminum ferrules crimped at specified distances. There are nine lines that individually correspond to the nine transect sites.

Treadway: The treadway is the trail itself. In this manual it refers to the obvious area of denudation due to trampling by the hiking public. These areas are generally free of any vegetative growth and organic matter.

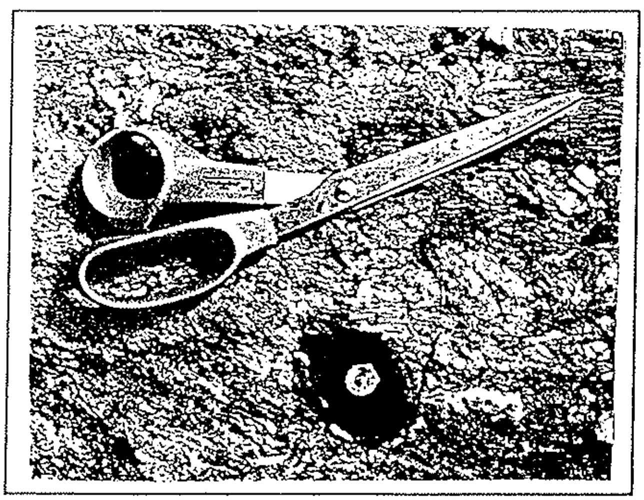


Image 1.1 Stainless Steel Transect Locator Pin. Shows 1/4" bolts in lead expansion anchors with an epoxy cap.

1.2 Equipment

1.2.1 Quadropod

The quadropod is the key feature of this monitoring protocol. It is rugged yet can be damaged. If damage does occur, the specifics of the design can be found in Appendix B.

The quadropod consists of the quick release mounting box, two quadrat frame support legs, and an oblique orientation platform (Image 1.2). Assembling the quadropod from these three pieces is designed to be quick and easy. In designing the quadropod consideration was given to the nature of the monitoring site and the need to have transportable instruments. In this respect PIMS can be entirely collapsed for ease of transport (Image 1.3). The construction directions are listed in Chapter Two of this manual.

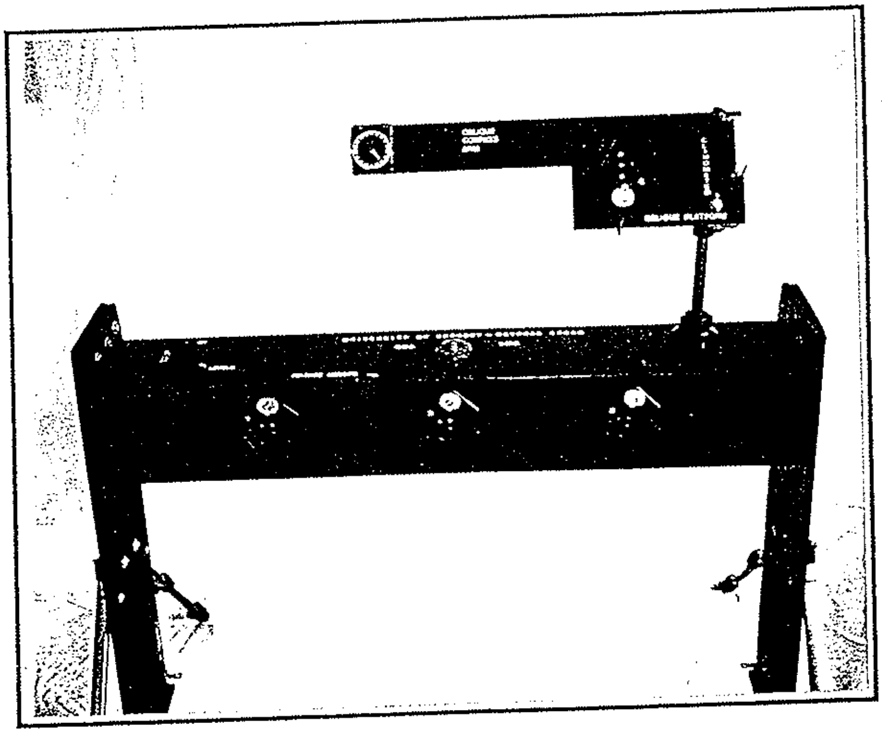


Image 1.2 Photographic Inventory Monitoring System - PIMS. (Camera not shown.)

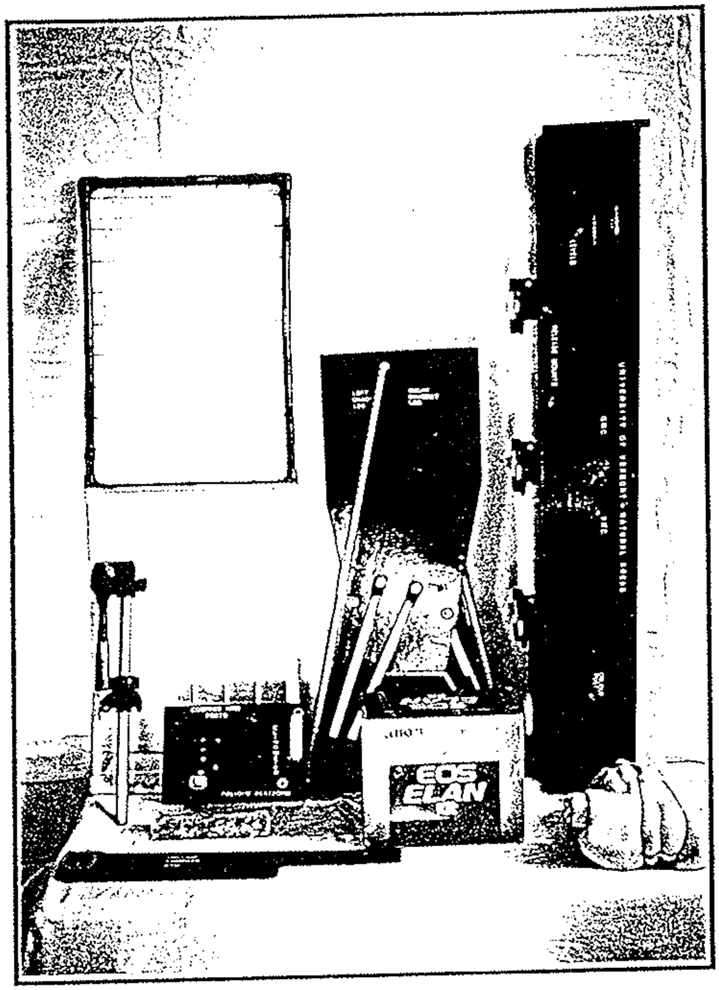


Image 1.3 Dissasembled PIMS ready for packing to the monitoring sites.

1.2.2 Transect Line

Each transect site has a unique transect line. They are numbered according to transect site. The numbers can be found on the ferrules crimped onto the lines. The line is used to determine quadrat frame locations along a transect between the two fixed locator pins.

For a North-South trending treadway the transect lines have an East and a West end that correlate with the East and West locator pins. One end of the transect line is looped over the proper locator pin and the other end is stretched taut over the remaining pin. This results in a transect line that is oriented normal to the treadway.

Located at various distances along the line are aluminum ferrules. These ferrules are crimped onto the line as permanent markers for quadrat frame locations. For each transect these distances are different (Appendix C).

1.2.3 Camera

The camera used with this monitoring device is a Cannon Eos Elan body with a 28-80mm lens (Figure 1.1). The body has a quick release mount permanently attached to the bottom. The camera is far more versatile than this protocol needs, yet it has functions like auto-bracketing and aperture priority, that are convenient and accurate. Directions for setting these functions on the camera are outlined in Chapter Two of this manual. Other functions such as autowind and autofocus should all be preset.

Auto-bracketing - AEB

The camera can be set up to take a series of pictures that are each at different exposures. In this methodology the camera will be set up to shoot pictures at one f-stop below, one at the correct meter-selected f-stop, and one at one f-stop above. The correct exposure is "bracketed" by two others that are over and under exposed by one f-stop. The end result is a series of pictures that are more likely to include optimal exposures for analysis.

Aperture Priority - Av

The aperture priority function allows the operator to control the aperture and let the metering system set the exposure time. In the Av mode the aperture can be manually set. The camera essentially compensates for the restriction on the aperture size by adjusting the length of exposure time. The end result is the greatest depth of field, which is, for small f-stops, maximized.

The aperture is the size of the shutter when the film is exposed to the light. Larger apertures (smaller numbers) create a shorter depth of field. In turn the smaller apertures (larger numbers) create a longer depth of field from near to far. Smaller apertures may significantly extend the duration of the exposure, risking a blurry picture in, for example, windy conditions. **This manual recommends an aperture between f/5.6 and f/13.** Instructions for setting the aperture and autobracketing are outlined in Chapter Two.

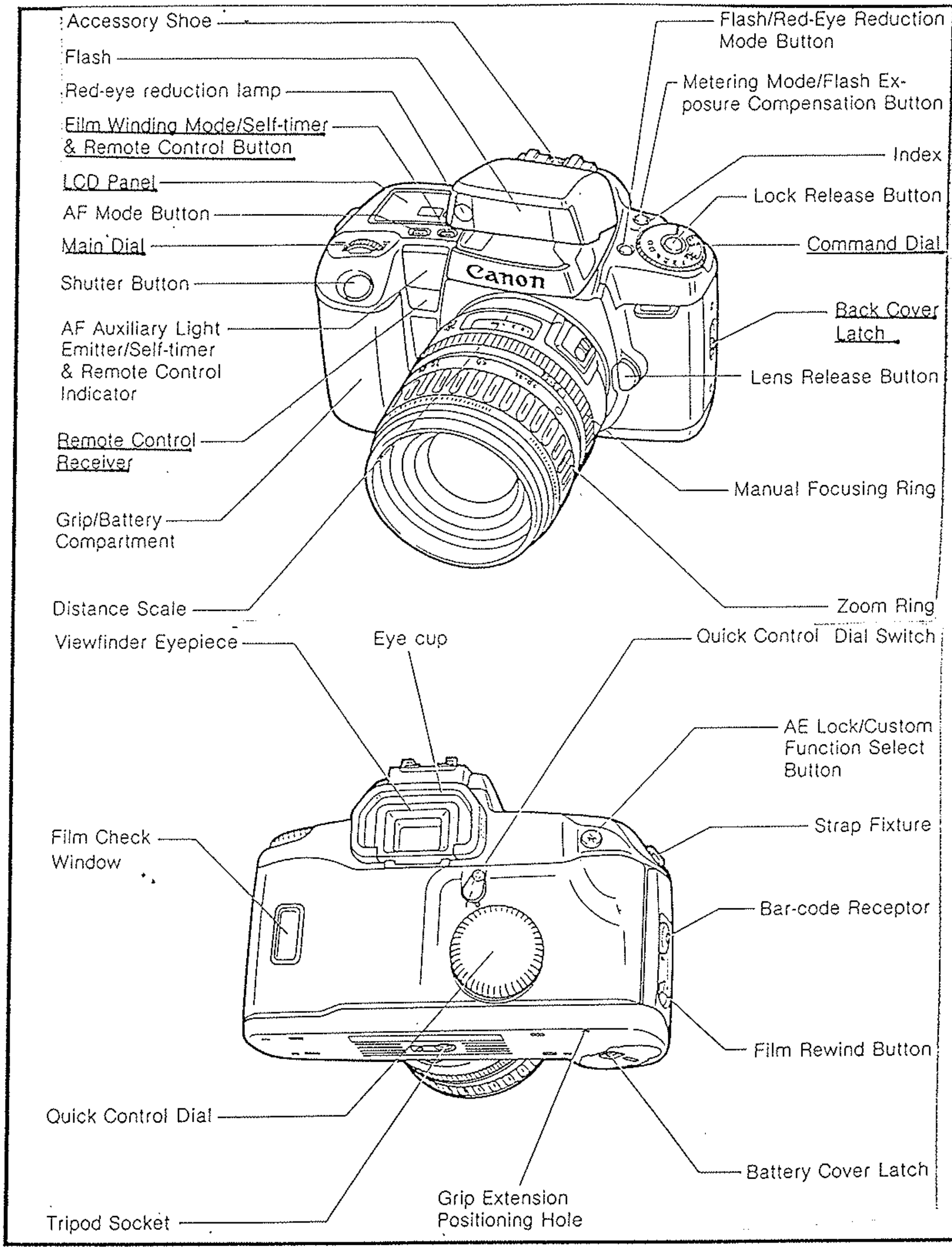


Figure 1.1 Cannon Eos Elan Camera Nomenclature per instruction manual PUB.C-IE-1611, Canon Inc. 1991 CY8-6121-002, Japan. Key labels are underlined.

1.2.4 Laser Remote

The quadropod is adjustable in several directions and so sacrifices some stability for versatility. To avoid shaking the quadropod when shooting the photos use the remote trigger.

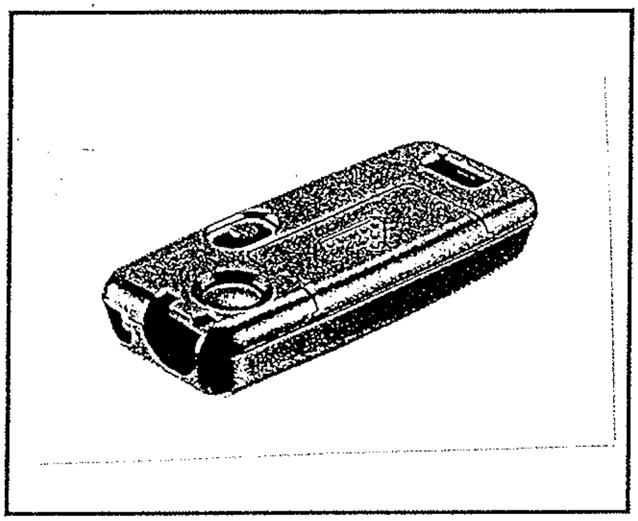


Image 1.4 Laser remote trigger.

1.2.5 Quick Release Mounts

The quick release mounts are located on the quadropod front and are numbered (1-3). There is also a release mount on the oblique orientation platform (4). On the underside of the camera is attached a disk that "clicks" into the mounts. The mounts release the camera with the flick of a lever.

The quick release system allows the use of one camera to cover a large area in detail. This system allows for detailed photos of 100 x 50 cm plots in three separate pictures while only orienting the quadropod once. This reduces the impact on the environment by eliminating the need to re-orient the quadropod for each photograph.

The release system also allows for oblique shots. Methodology for orientation of the oblique platform is included in Section 2.2.8.

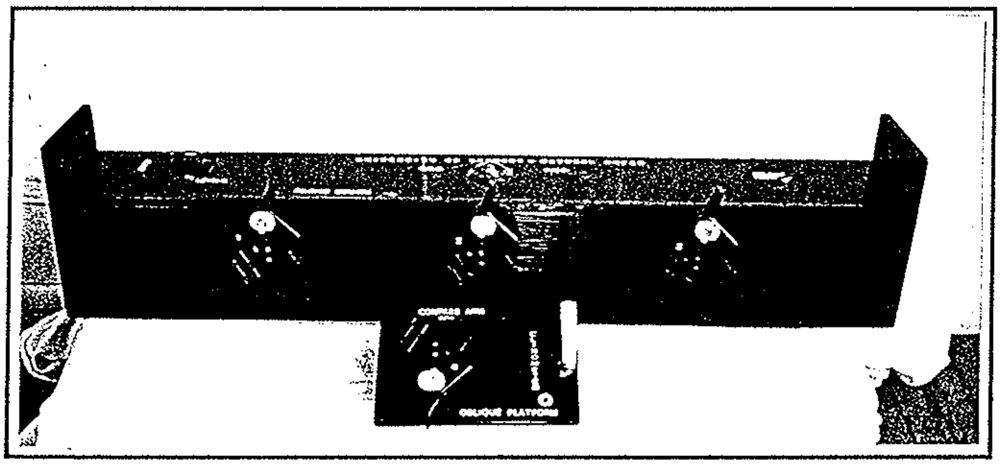


Image 1.5 Quadropod with quick release mounts.

1.2.6 Transect Summary Sheet

At each transect, information about the time, temperature, wind, estimated total cloud cover, weather, and photo schedule must be recorded. This data is recorded on a transect summary sheet (Figure 1.2). It is important to record all the data on the sheet legibly. Be careful not to lose the sheet in the wind or in transport. It is recommended that the data sheets be xeroxed onto "never-tear" waterproof paper. The data sheet should be double checked by another person to verify legibility and any notations. One sheet is used for all the transect sites and should accompany the film when archiving the photos at the Vermont Monitoring Cooperative.

	Roll #1		Roll #2		Roll#3		Roll #4		Roll #5		Roll #6	
	Photo Frame Contents	Corrected Series	Photo Frame Contents	Corrected Series	Photo Frame Contents	Corrected Series	Photo Frame Contents	Corrected Series	Photo Frame Contents	Corrected Series	Photo Frame Contents	Corrected Series
Photo #1	>Number Shot<		>Number Shot<		>Number Shot<		>Number Shot<		>Number Shot<		>Number Shot<	
2	T1-QE1		T2-QW3		T4-QE1		T5-QE3		T6-QW2		T8-QW1	
3	T1-QE1		T2-QW3		T4-QE1		T5-QE3		T6-QW2		T8-QW1	
4	T1-QE1		T2-QW3		T4-QE1		T5-QE3		T6-QW2		T8-QW1	
5	T1-QE2		T2-OBN		T4-QE2		T5-QM1		T6-QW3		T8-QW2	
6	T1-QE2		T2-OBS		T4-QE2		T5-QM1		T6-QW3		T8-QW2	
7	T1-QE2		T3-QE1		T4-QE2		T5-QM1		T6-QW3		T8-QW2	
8	T1-QE3		T3-QE1		T4-QE3		T5-QM2		T7-QE1		T8-QW3	
9	T1-QE3		T3-QE1		T4-QE3		T5-QM2		T7-QE1		T8-QW3	
10	T1-QE3		T3-QE2		T4-QE3		T5-QM2		T7-QE1		T8-QW3	
11	T1-QW1		T3-QE2		T4-OBN		T5-QM3		T7-QE2		T7-OBN	
12	T1-QW1		T3-QE2		T4-OBS		T5-QM3		T7-QE2		T7-OBS	
13	T1-QW1		T3-QE3		T4-QM1		T5-QM3		T7-QE2		T9-QE1	
14	T1-QW2		T3-QE3		T4-QM1		T5-QW1		T7-QE3		T9-QE1	
15	T1-QW2		T3-QE3		T4-QM1		T5-QW1		T7-QE3		T9-QE1	
16	T1-QW2		T3-QM1		T4-QM2		T5-QW1		T7-QE3		T9-QE2	
17	T1-QW3		T3-QM1		T4-QM2		T5-QW2		T7-QW1		T9-QE2	
18	T1-QW3		T3-QM1		T4-QM2		T5-QW2		T7-QW1		T9-QE2	
19	T1-QW3		T3-QM2		T4-QM3		T5-QW2		T7-QW1		T9-QE3	
20	T1-OBN		T3-QM2		T4-QM3		T5-QW3		T7-QW2		T9-QE3	
21	T1-OBS		T3-QM2		T4-QM3		T5-QW3		T7-QW2		T9-QE3	
22	T2-QE1		T3-QM3		T4-QW1		T5-QW3		T7-QW2		T9-QW1	
23	T2-QE1		T3-QM3		T4-QW1		T5-OBN		T7-QW3		T9-QW1	
24	T2-QE1		T3-QM3		T4-QW1		T5-OBS		T7-QW3		T9-QW1	
25	T2-QE2		T3-QW1		T4-QW2		T6-QE1		T7-QW3		T9-QW2	
26	T2-QE2		T3-QW1		T4-QW2		T6-QE1		T7-OBN		T9-QW2	
27	T2-QE2		T3-QW1		T4-QW2		T6-QE1		T7-OBS		T9-QW2	
28	T2-QE3		T3-QW2		T4-QW3		T6-QE2		T8-QE1		T9-QW3	
29	T2-QE3		T3-QW2		T4-QW3		T6-QE2		T8-QE1		T9-QW3	
30	T2-QE3		T3-QW2		T4-QW3		T6-QE2		T8-QE1		T9-QW3	
31	T2-QW1		T3-QW3		T5-QE1		T6-QE3		T8-QE2		T9-OBN	
32	T2-QW1		T3-QW3		T5-QE1		T6-QE3		T8-QE2		T9-OBS	
33	T2-QW1		T3-QW3		T5-QE1		T6-QE3		T8-QE2		>Spare Frame<	
34	T2-QW2		T3-OBN		T5-QE2		T6-QW1		T8-QE3		>Spare Frame<	
35	T2-QW2		T3-OBS		T5-QE2		T6-QW1		T8-QE3		>Spare Frame<	
36	T2-QW2		>Spare Frame<		T5-QE2		T6-QW1		T8-QE3		>Spare Frame<	

(Photo #) is the number of the picture frame indicated on the camera.
(Number Shot) is a picture to be taken of the number of the roll of film (i.e. 1-5).
(Spare Frame) is a frame that is not utilized in the photo series.

(T1-QE2) indicates a photo frame location where:
T-Transect
1-Transect Site Number
Q-Quadrat
E-East (quadrats are East, West, or Middle)
2-Release Mount #2 (mounts are #1, 2, and 3)

(T1-OBN) indicates an oblique photo frame location where:
T-Transect
1-transect Site Number
OB-Oblique
N-North (obliques are North or South)

(a)

	Transect #1	Transect #2	Transect #3	Transect #4	Transect #5	Transect #6	Transect #7	Transect #8	Transect #9
Time:									
Temperature:									
Wind:									
% Clouds:									
Weather:									
Site Notes:									

(b)

Figure 1.2 Sample Transect Site Data Sheet. Used to record site data at monitored locations on Mount Mansfield, Vermont. (a) Photo-frame sequence data sheet. (b)Site data sheet.

1.2.7 Quadrat Frame

The quadrat frame is a rectangle frame made of PVC piping. The specifications for the quadrat frame measurements are in Appendix A. **The quadrat frame is marked left and right. The left side of the quadrat frame is painted black and the right side remains white.** These colors should correspond with left and right support legs when setting the quadrat frame in place.

The quadrat frame is sectioned into five square centimeter increments. These increments will provide a frame of reference when the pictures are compared in the future. The grid pattern makes measuring vegetation an easier task. It is important that the quadrat frame be oriented properly per the instructions in Chapter Two.

Take the time to note the set screws used to align the quadrat frame with the photo frame (Image 1.7). These screws are used to ensure the proper location of the quadrat frame.

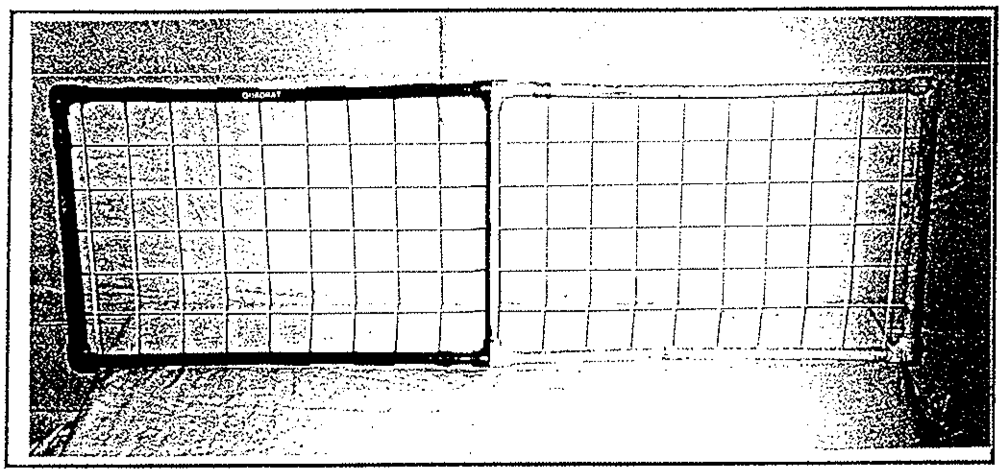


Image 1.6 Quadrat frame for vegetation measurement and counting. Photographed as part of the monitoring data.

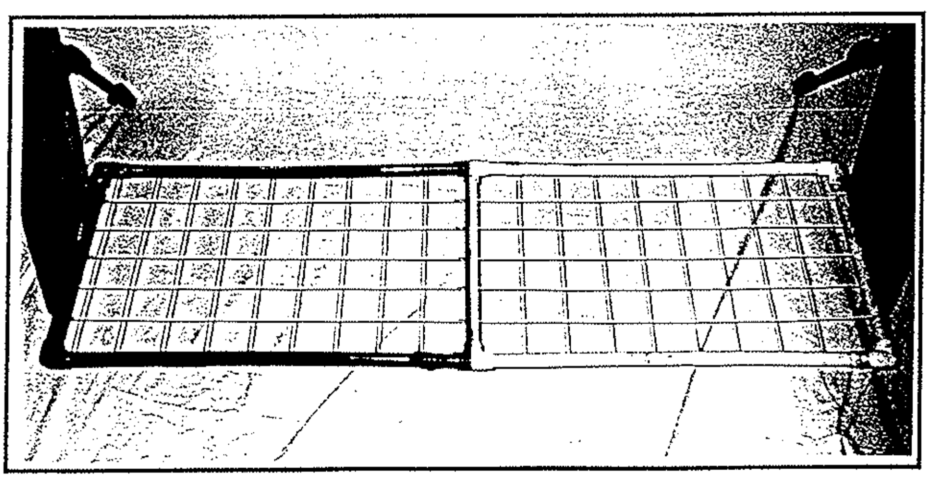


Image 1.7 Quadrat frame aligned with set screws on quadrat frame support legs.

1.2.8 Oblique Orientation Platform

The oblique orientation platform is a tool for taking pictures up and down the trail treadway. The platform is designed so that sequential shots will be accurate to within a reasonable error.

On the platform you will find a quick release mount (4) that is compatible with the camera. Also there is an inclinometer used to vertically orient the camera with reference to the angle measurement on the inclinometer's side. A camera that is oriented above 0 degrees has a positive angle measurement. A camera that is oriented below 0 degrees has a negative angle. Take note of this information when reviewing Chapter Three and orienting the camera.

Lastly, the oblique platform is laterally oriented with a compass. The compass sits on an arm that rests over the two posts on the platform (Image 1.8).

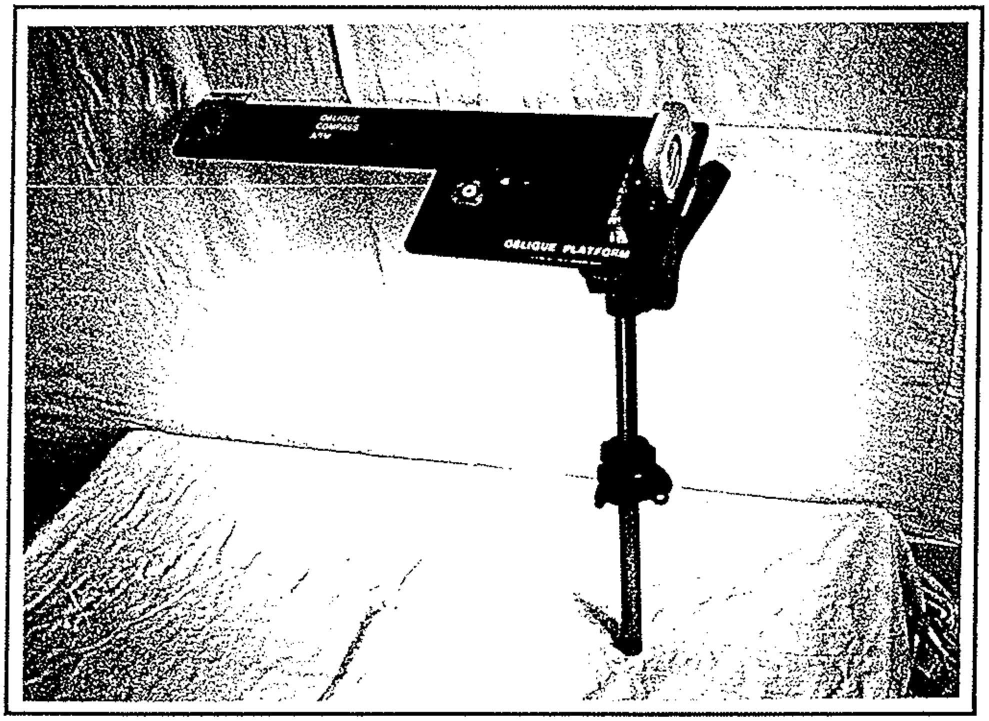


Image 1.7 Oblique orientation platform including inclinometer, quick release, and compass arm. (Compass arm shown as properly attached to platform.)

1.2.9 Ensolite Pad

The ensolite pad is used for two things. Assembling the quadropod should be conducted on the ensolite pad to protect the device from scrapes and other damage. Secondly, when adjusting the quadropod, some sites may require you to step on the vegetation. Your impact will be minimized if you distribute your weight by stepping on the ensolite pad thereby sparing the plant tissues from your boot tread.

Chapter Two - Procedural Instructions

2.1 Introduction

The use of the quadropod monitoring tool is designed to become easier as the methodology is performed. **For this reason it is very important that the monitor takes his/her time in conducting the first shoot.** By the end of the day the steps should become clear and easy to execute. Before proceeding further the monitor should take the time to review the **Terminology** and **Equipment** sections of this report. A good understanding of the equipment and terms used in this manual are essential to a rapid and accurate execution of this monitoring protocol.

The following tasks occur at every site and in the following order:

1. Locating the transect sites and transect locator pins.
2. Recording transect site data.
3. Assembling the quadropod.
4. Stretching the transect lines.
5. Locating and orienting the quadropod.
6. Setting the camera functions and shooting the quadrat frame photos.
7. Repeating steps (5) and (6) for the second and third quadrat frame locations.
8. Orienting the oblique platform.
9. Setting the camera functions and shooting the oblique photos.
10. Disassembling the quadropod and transect line.

The ten steps in this list will be repeated for the nine transect locations that are part of this monitoring protocol. The following discussion gives an overview of what is entailed in each of these tasks. Once the researcher has become familiar with these tasks he/she can then proceed to Chapter Three of this manual for the exact orientation measurements for each quadrat frame site.

It is important to proceed through this manual in an orderly fashion reading each subsection as it is presented. The tasks presented in each subsection will follow the same order in the field . Follow the steps outlined here at each site. The more methodical you are the more accurate the data will be.

2.2 Instructions

2.2.1 Locating the transect sites and transect locator pins.

A general description of each transect location is provided in Chapter Three. This description will make use of prominent features along the trail (such as Drift Rock) to aid in finding the transect locator pins. **Therefore it is very important that the monitor become familiar with the features along the trail that are used as a reference (refer to the ridgeline maps and mosaic in Appendix D).** To become familiar with the ridge the monitor should speak with the manager of the UVM Natural Areas and with any Green Mountain Club Summit Caretakers they encounter along the way.

Chapter Three also has a series of photos of each transect site. There are four pictures taken at the intersection between the treadway and the transect. Each picture is associated with a direction (i.e. north, south, east, or west).

There are also two pictures that look toward the pin locations from the same intersection. These two pictures are taken parallel to the transect line and include the pins with orange flagging. Lastly there is a third oblique shot of the entire transect site with transect line in place.

The monitor should use these picture series in conjunction with the general description of the site to locate the transect locator pins (Image 1.1). The pins are small, low to the ground, and placed so they are not readily evident to the casual visitor. To find each pin the monitor should use a systematic search rather than hunting in a random fashion. The orientation information for each site may also contain a listing of azimuths from prominent features to aid in pin location. If a pin is hard to find use these azimuths to find the general direction in which the pin should lie and walk slowly in that direction. A final piece of information is the transect azimuth. Once one pin is located the monitor only need take an azimuth from that pin to locate the second pin.

2.2.2 Recording transect site data.

Once the pins have been located the monitor should record transect site data. The data needed is indicated on the transect site summary sheet (Figure 1.2). There is one sheet for all the transect sites. Much of the data may seem redundant between each site but it is important to fill in each section thoroughly as weather conditions can change rapidly on the summit. **Do not try to fill in data "later". Do it right away.** It is important to do this before setting up the transect line as it is essential to keep the trail unobstructed as much as possible. Site data is important and neat writing is essential. Take your time.

2.2.3 Assembling the quadropod.

There are three pieces to the quadropod: the camera mounting box, the quadrat frame support legs, and the oblique orientation platform (Image 2.1). To erect the quadropod follow these five steps:

1. Lay out an ensolite pad on the ground and stand the camera mounting box on one end. Use the ensolite pad to minimize damage to the box.

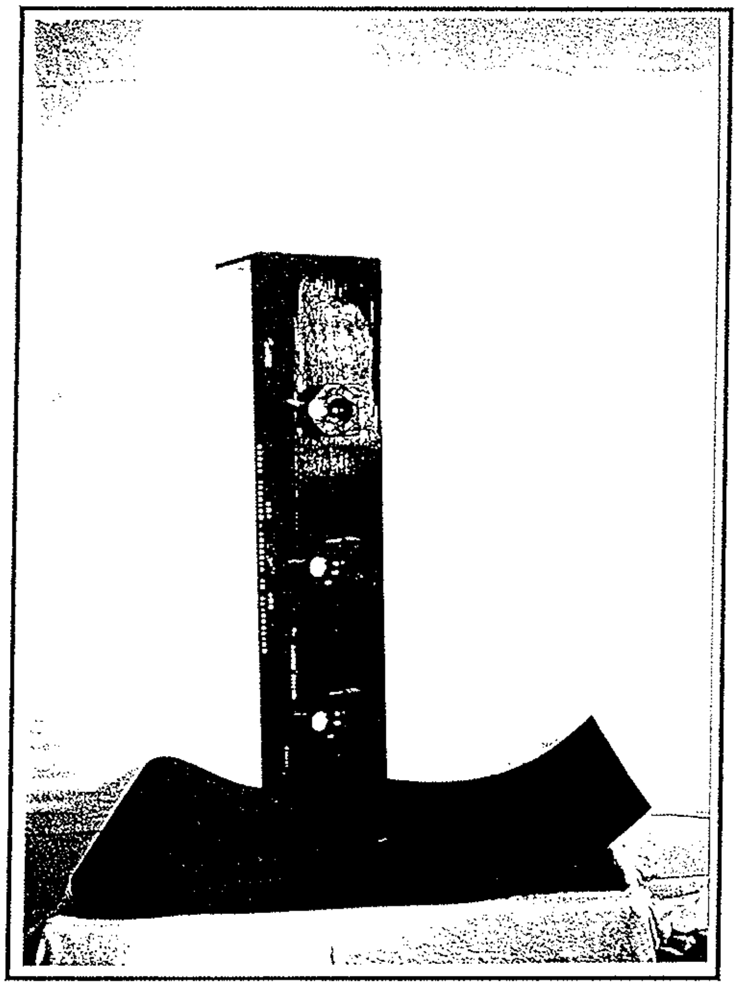


Image 2.1 Step one of quadropod construction.

2. Lay the proper leg (either left or right) on the end of the camera mounting box (Image 2.2). The legs and the box ends are labeled left or right. The adjustable legs should face out, or away from, the box.

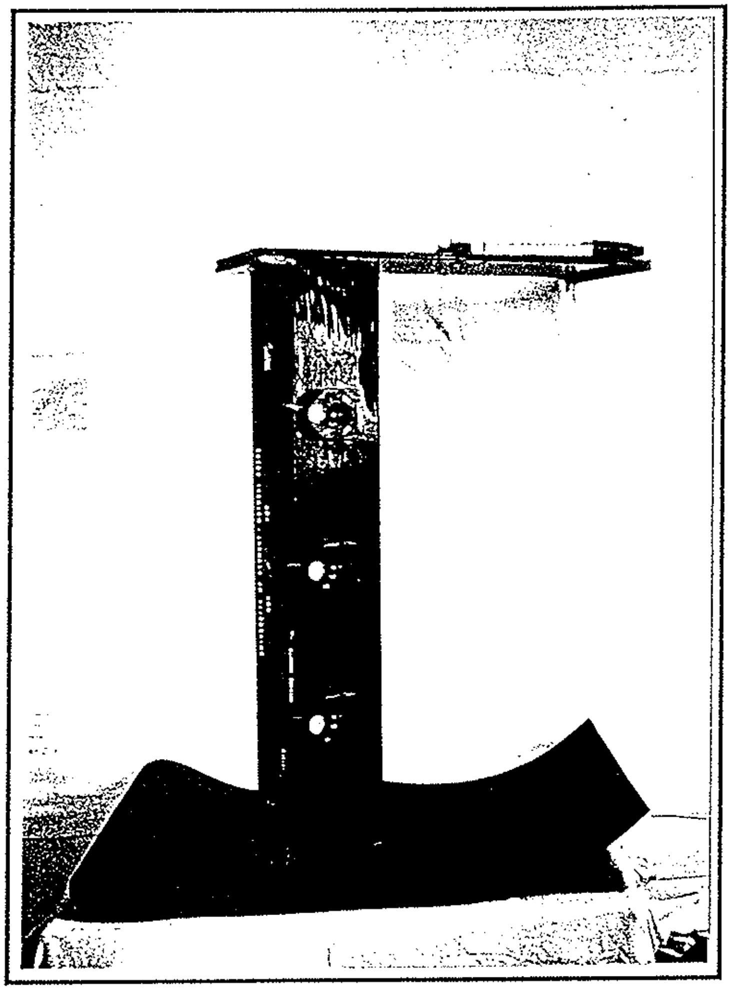


Image 2.2 Step two of quadropod construction.

3. Push the bolts through the holes and hand tighten the wing nuts (Image 2.3). A washer should go on either side of the bolt. **If the holes are not matching up you may be trying to put the wrong leg on the wrong side of the camera mounting box.**

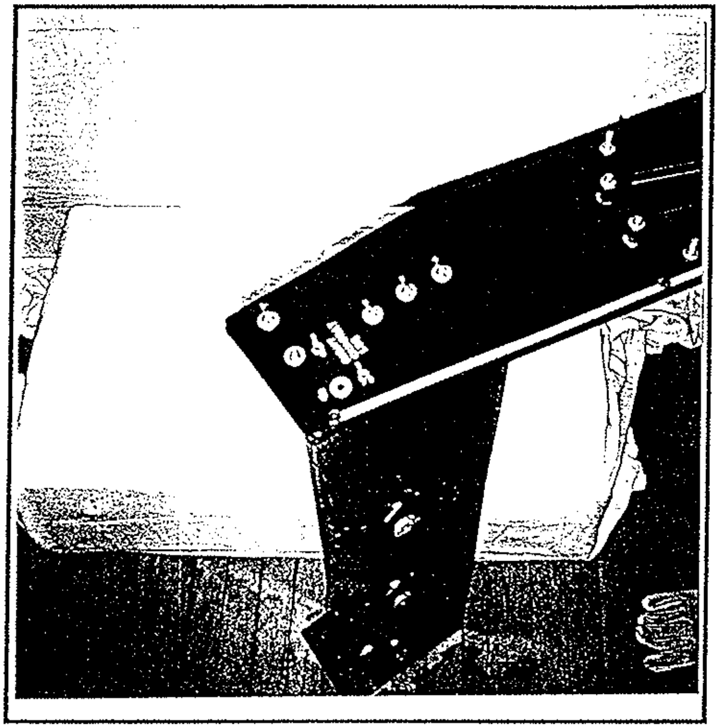


Image 2.3   Step three of quadropod construction.

4. Once both quadropod legs are in place you can extend the adjustable legs to allow the quadropod to stand on the ground without the quadrat frame support legs touching the ground (Image 2.4). Note: When the adjustable legs are extended they become unstable and vulnerable to damage. **Once the legs are extended take care of the box when lifting, shifting, and placing it on the ground.**

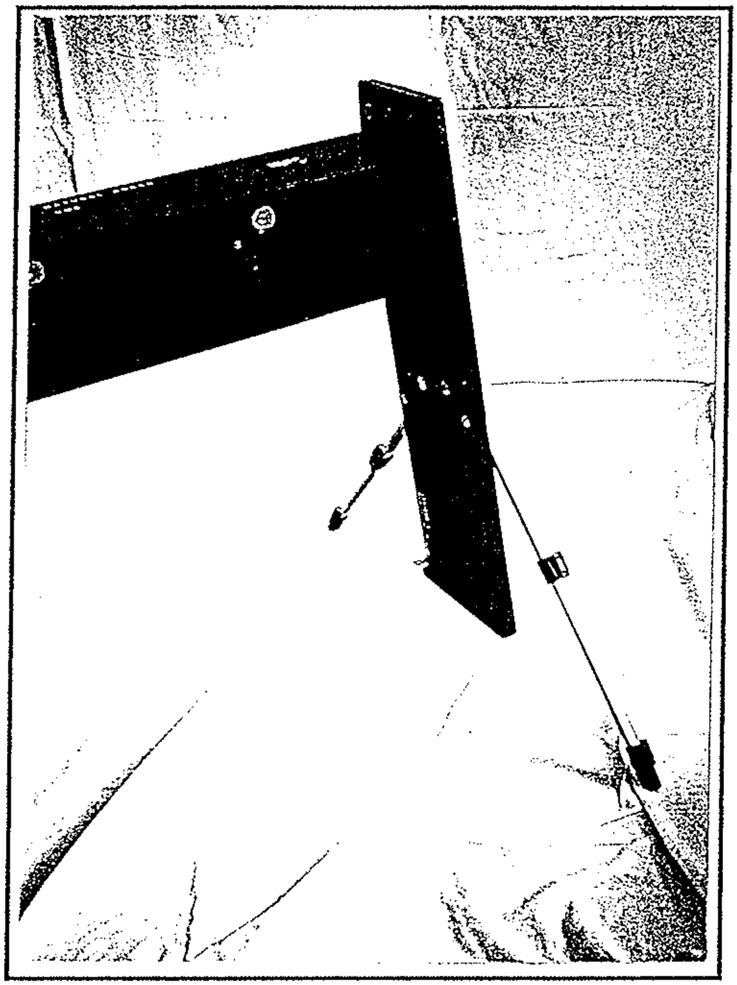


Image 2.4 Step four of quadropod construction.

5. Mount the oblique platform on the articulating post (Image 2.5). Insert the pole into the hole in the camera mounting box on the right side. The height of the post is pre-set and can not be adjusted.

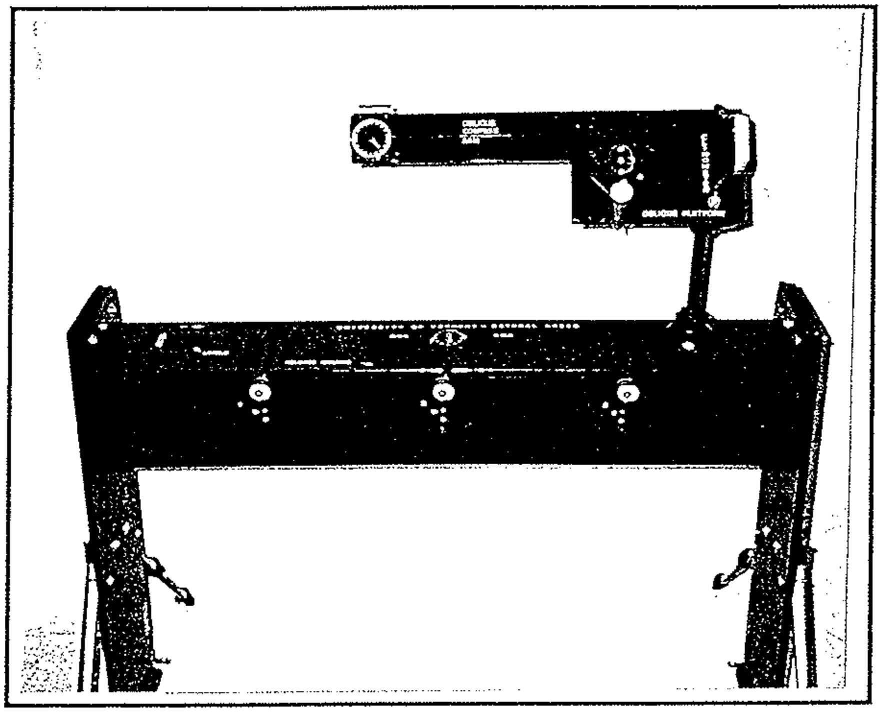


Image 2.5 Step five of quadropod construction.

2.2.4 Stretching the transect lines.

Once the transect site data has been recorded and the quadropod assembled, stretch the transect lines between the pins. Each transect has an individual transect line that matches the distance between the transect locator pins. It is important that the correct line is used at each site. The lines are looped at each end and are designed to be taut when looped over the transect locator pin ends. It may take a good pull to stretch the loops over the ends of the bolts. If a line is very loose or far too tight to stretch over the pin ends you may have the wrong line.

Each transect line also has an east and a west end. These ends correspond with the east and west bolts. Essentially the trail treadway runs north/south so the bolts are either on the east or west side of the treadway. The east loop has a ferrule crimped on it and the west does not (Image 1.3). Proper orientation of the line is crucial to the proper placement of the quadropod as associated with the ferrules. If a transect line is stretched backward the ferrules will not be in the same place as the last time the area was monitored.

Once the transect lines have been stretched it is important to warn all hikers of the obstruction. Lines should be flagged so visitors see them.

2.2.5 Locating and orienting the quadropod.

This is the most critical procedure of the entire PIMS system. It also takes the longest to execute correctly. It can not be over-emphasized that the monitor should take his/her time in executing this task.

The general design is based on three central steps. First locate one corner of the quadropod according to a ferrule location and height. Then orient the quadropod properly along a compass azimuth. Finally, level the quadropod.

Always orient the quadropod first at the eastern most quadrat frame location along a transect. Then proceed to the middle and lastly the westernmost location. The last orientation is always at the western most quadrat frame site. When orienting the quadropod follow these steps:

1. Locate the correct ferrule for the first quadrat frame location (eastern most ferrule).

There is only one ferrule per quadrat frame site. Each ferrule will match a certain height along the quadrat frame support legs according to a centimeter tape located along the front of the leg (Image 2.6).

2. Place the quadropod over the transect line aligning the proper leg with the ferrule.

At this point the quadrat frame should not be attached to the support legs. The orientation data will indicate which leg of the quadropod to match up with the ferrule (i.e. left or right).

Before placing the quadropod over the transect line extend the adjustable legs. Leave the thin leg section collapsed until it is needed for leveling. The legs should be fully swung into place so they are resting against their stops. This lends some stability to the structure.

The quadropod should be placed over the transect line at the correct azimuth so no adjustment will have to be done later. The azimuths for each quadrat frame site are also presented in Chapter Three. The compass glued to the center of the quadropod is used to orient according to the azimuth. To properly orient according to the azimuth rotate the quadropod until the north (red) end of the arrow is aligned with the number between 1 and 360 degrees as presented for each transect site in Chapter Three.

3. Adjust the legs of the quadropod so the ferrule matches the proper height.

Once the azimuth is correctly established and the leg is still aligned with the proper ferrule the next step is to adjust the quadropod to the correct height. Match the ferrule to the indicated height (Chapter Three) along the centimeter tape by adjusting the legs so the ferrule matches the indicated height (Image 2.6).

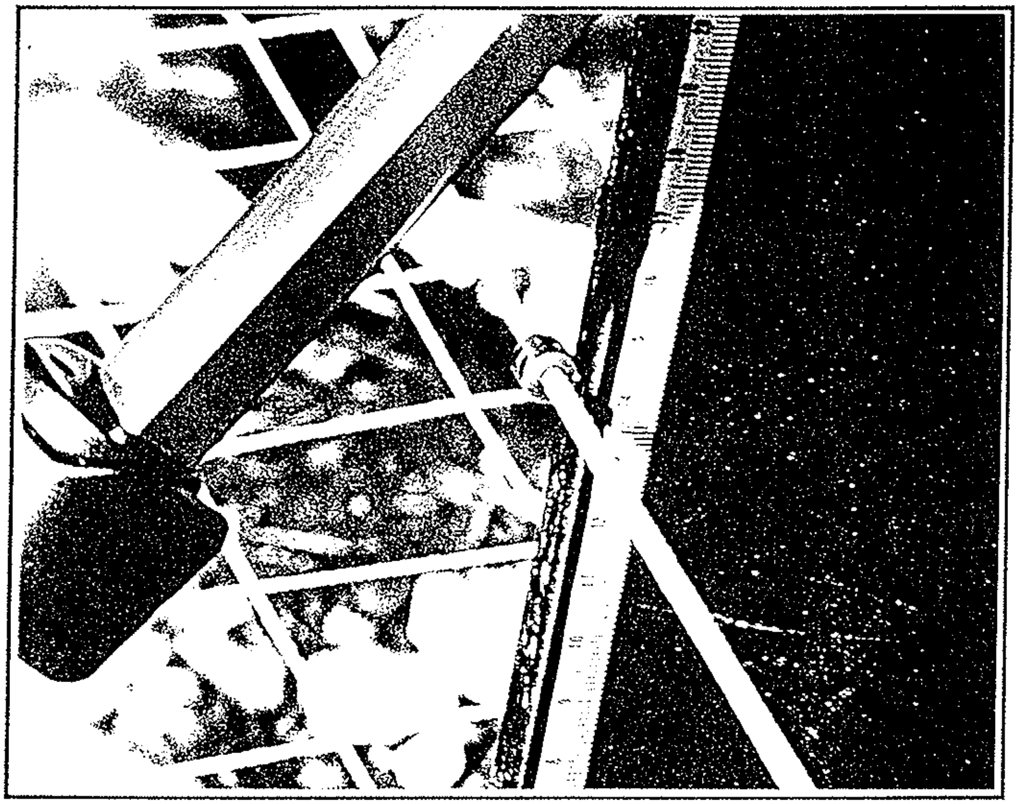


Image 2.6 Alluminum ferrule crimped on transect line. The ferrule is aligned at 14.5cm along the quadrat frame support leg.

The correct height of the rest of the quadropod is established by leveling it out using the two perpendicular levels glued to the top of the quadropod. The perpendicular orientation of the levels ensures that the quadropod will be level both front to back and side to side.

Leveling the quadropod is the hardest step to complete. It takes a lot of time (upwards of 15-20 minutes depending on the site) to get the quadropod properly leveled out. There is a lot of movment required to get at all the adjustable legs. Reduce your impact and stay on the rocks. To minimize your impact an ensolite pad should be placed down first so any trampling is buffered by the distribution of weight.

A four legged adjustable device is not an easy thing to level out. When one side is adjusted it effects the other side. First level the quadropod front to back and then side to side. The continual re-adjustment of the legs can put some strain on them. Make sure that as you adjust the legs on one side you do not put undue stress on a leg on the opposite side. It is sometimes necessary to lift the entire quadropod up several inches to make sure the legs are not straining against their stops. This will all become easier and more familiar as you work with the quadropod throughout the day.

4. Recheck the orientation information.

Once the quadropod is properly placed, leveled, and oriented the monitor should step back and re-check all the orientation data. Is the quadropod oriented correctly? Is it on the proper ferrule? Is the height correct? Was the right information from Chapter Three used to orient this quadrat frame site? The end result is a quadropod that is oriented to a specified compass azimuth, level, and in a specified location.

5. Lock the quadrat frame into place.

When the quadropod is correctly oriented lock the quadrat frame into place. It should be fitted onto the quadrat frame support legs from the bottom. The left side should be slipped into place under the L-bracket on the back edge of the support leg (Image 1.6). The right side should then be slipped into place under the right L-bracket. The last step is to pull the quadrat frame into proper orientation by sliding it toward the front of the quadropod until the set screws are in contact with the L brackets (Image 2.7).

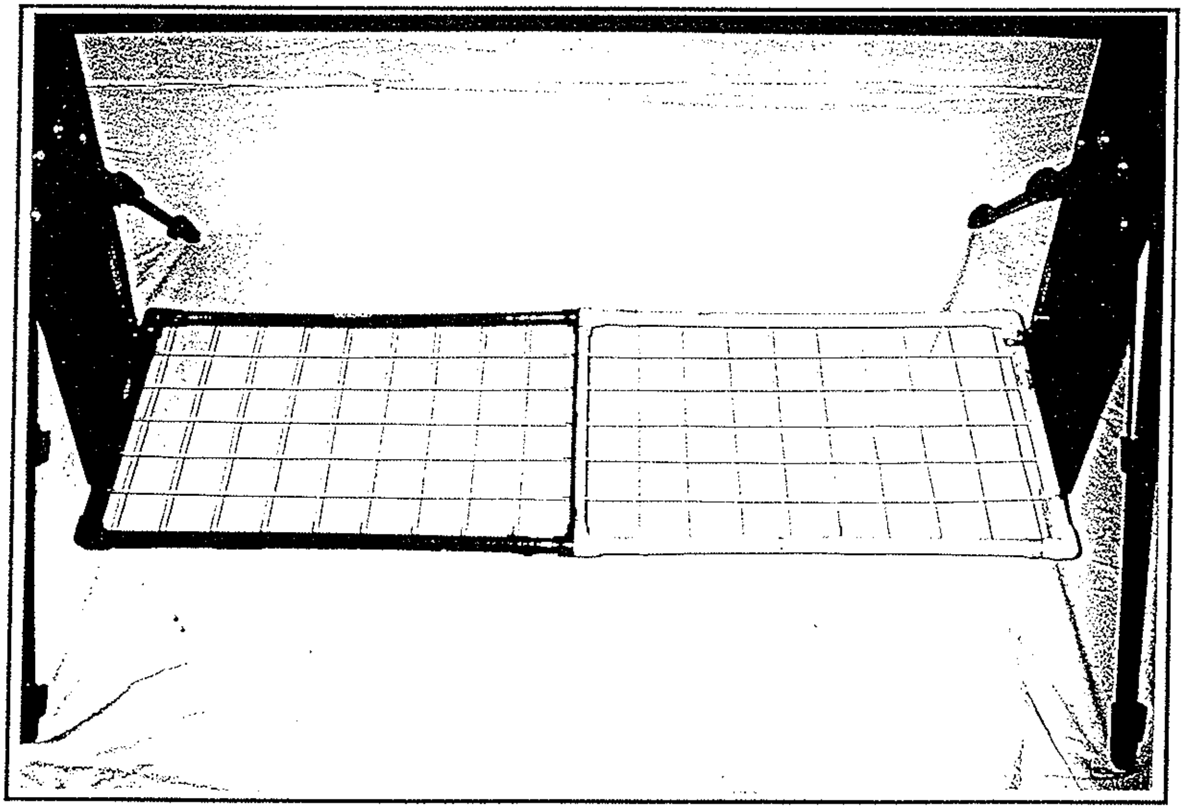


Image 2.7 Quadrat frame set properly on quadrat frame support legs. Stop screws are tight up against support leg L-brackets.

2.2.6 Setting the camera functions and shooting the quadrat frame photos.

Setting the camera functions should be a quick process and can be done prior to mounting the camera in the quick release mounts. First the camera must be set to auto bracketing (AEB). Turn the command dial to AEB (Figure 2.1a). "AEB" should appear in the LCD panel. Then turn the main dial to set the desired bracketing setting (Figure 2.1b). For all the vertical pictures the bracketing amount is 1 stop above and below correct exposure. This will be indicated on the LCD panel (Figure 2.2) as the main dial is turned.

Secondly the camera should be set for Aperture Priority (Av). To set the aperture turn the command dial to Av. (Figure 2.2). Then turn the command dial to the proper aperture setting. The camera will automatically adjust for the restrictions put on the aperture size with the exposure time.

The aperture should be between f/5.6 and f/13. Any aperture within those numbers should serve to provide a good depth of field. If the light is poor and the exposure length is long you risk a blurred photo. Feel free to adjust the aperture setting to larger numbers in an effort to create a faster exposure time in low light. Remember to record such changes as they occur on the transect summary sheet in the "Site Notes" section.

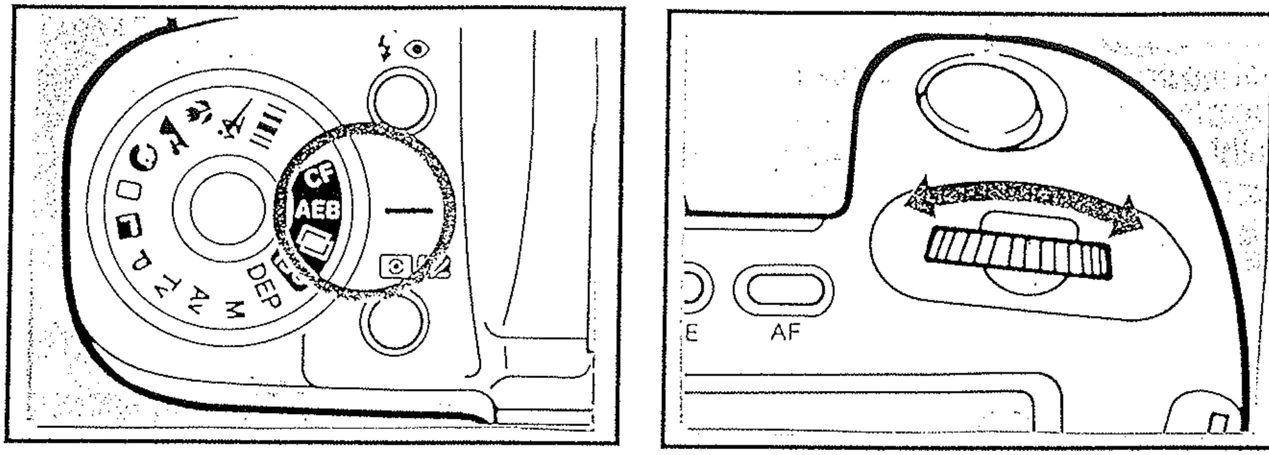
The camera should next be set for laser remote triggering. To do so the drive function (Figure 2.4) should be pressed until the self-timer remote icon appears in the LCD screen (Figure 2.2). At this point the camera is set and ready to shoot vertical shots.

Take all shots between 28 and 35 mm on the zoom ring. The proper setting is indicated by a white dash between the number 28 and the number 35 on the ring. Make sure the zoom ring is set correctly before triggering the camera.

The camera is then "clicked" into place in the quick release mount labelled (1). Sometimes it is necessary to give the camera a nudge to get it to fully settle into the quick release mount. Always check the photo frame by looking throught the viewfinder prior to triggering the camera. If this step is not done the camera will most likely not be oriented vertically. The mounts are designed to lock the camera in place while shooting, and to allow the release of the camera for the next shots. Lifting the quick release lever allows for removal of the camera. Once the camera is removed the lever should remain upright until the camera is put back in place for another quadrat frame site.

Once the camera is secured, the monitor should manually focus the image with the manual focus ring. Take care not to turn the zoom ring when focusing. After the camera is focused the camera eye-piece should be covered with the slip cover on the laser remote strap (Figure 2.5). The slip cover prevents sunlight from affecting the metering of the camera.

The last step is to point the laser remote at the camera and fire away. The camera will beep a few times and then fire three shots. Once the camera has been triggered with the laser remote the monitor should take care not to shade any part of the photo frame. It is sometimes necessary to quickly move out of the sunlight after the camera has been triggered. These steps are then repeated with the quick release mounts (2) and (3) on the camera mounting box.



(a) (b)

Figure 2.1 Auto bracketing (AEB) setting proceedure on Cannon EOS Elan body. Set AEB setting on Command Dial by matching the AEB setting with the indicated dash (a). Set the auto-bracketing amount by turning the Main Dial (b) until LCD panel indicates a one-stop bracketing amount (Figure 2.2).

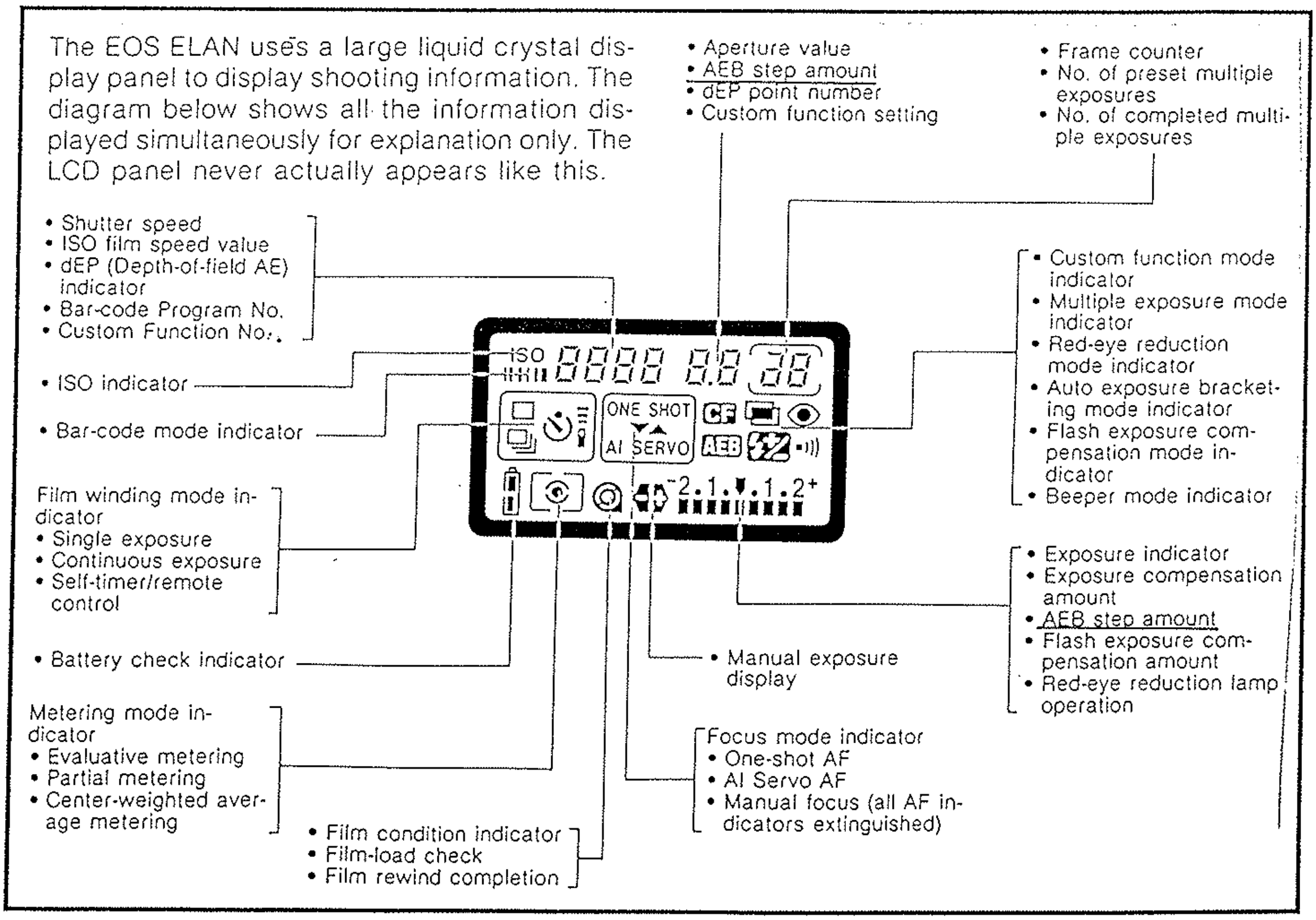


Figure 2.2 Cannon EOS Elan LCD panel display. Important functions are underlined.

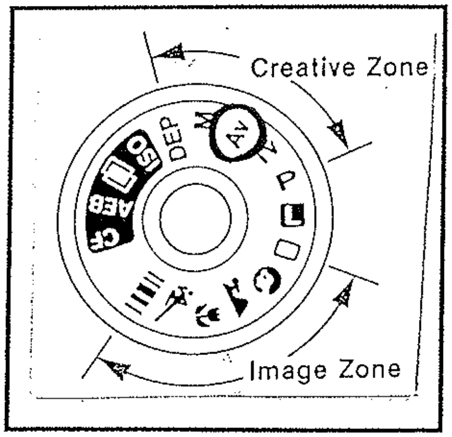


Figure 2.3 Cannon EOS Elan Command Dial. Aperature Priority (Av) is circled.

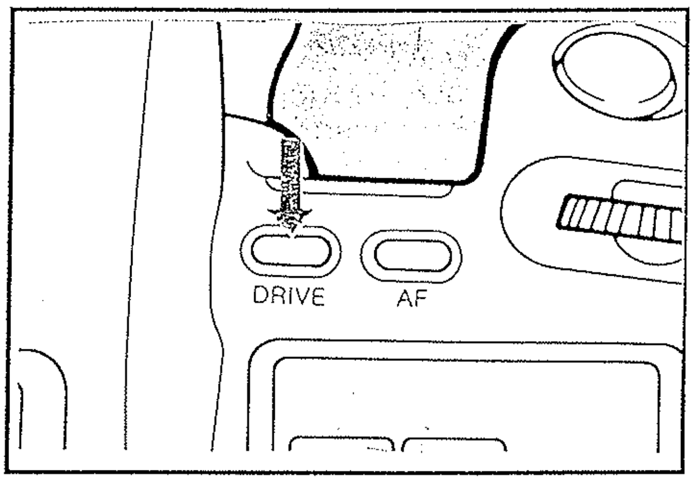
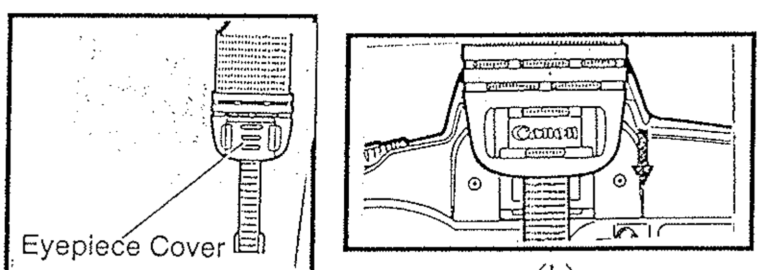


Figure 2.4 Drive button on Cannon EOS Elan body used for setting Laser Remote function. Laser remote setting is indicated on LCD panel (Figure 2.2).



(a) (b)

Figure 2.5 Capping the eyepiece on a Cannon EOS Elan body. Eyepiece cover is attached to laser remote strap (a). Eyepiece slides down onto viewfinder as indicated in (b).

2.2.7 Repeating steps (2.2.5) and (2.2.6) for the second quadrat frame location.

The previously mentioned steps (2.2.5 and 2.2.6) are then repeated for the remaining quadrat frame sites at that transect location.

2.2.8 Orienting the oblique platform.

The oblique platform is placed on the quadropod only for the two oblique shots. The platform is used at a specified quadrat frame site at each transect location (Chapter Three) for a photo both up and down the trail treadway.

To position the platform use the inclinometer to vertically position the platform according to the data given in Chapter Three. If there is a negative inclination figure given then the camera is essentially pointing slightly down. If the inclination figure is positive it means that the camera will be pointing slightly up. Each oblique shot has a specific inclination.

The platform is also oriented laterally by a compass azimuth much like that of the quadropod itself. In this case, however, the compass is set away from the metal of both the inclinometer and the quick release mount thereby avoiding any discrepancy in the reading. The compass and arm should be slipped over the posts on the oblique platform and then used to orient according to the specified compass azimuth (Image 1.7).

2.2.9 Setting the camera functions and shooting the oblique photos.

The camera functions for the oblique shots differ from those for the vertical shots only in that there is one picture per orientation. The pictures are not bracketed. When setting AEB turn the main dial until there is no bracketing indicated. This will result in only one shot per orientation. The Aperture Priority Av is the same as the vertical shots.

Once the camera is oriented it is then focused and triggered in the same manner as the vertical shots. Remember to cap the eyepiece before shooting (Figure 2.5).

2.2.10 Disassembling the quadropod and transect site.

After all the photos are taken the site needs to be disassembled. The first piece of equipment that should be taken down is the transect line. The trail treadway needs to be cleared of any obstruction so that hikers can get by easily. The quadropod may be disassembled or carried fully assembled to the next transect location if the next location is a short distance away and the trail treadway is easy to negotiate.

2.3 Film Management

Loading film in the camera is a task that you will have to undertake at least six times throughout the day. A full set of directions is located in the Appendix. The camera automatically takes up the film and primes the first shot when film is loaded. The first picture (indicated by picture number 1 in the LCD Frame Counter) is not exposed by the loading of the camera and can be utilized.

The first picture of every new roll should be of a number indicating the roll of film being shot. For example if you are in the middle of the day and have just finished the third roll of film the first shot of the new roll should be of the number four (4). Write the number of the roll of film on the film canister or on a piece of paper and take a picture of it. When the film is developed the first picture of each set will indicate which role, and therefore which transect site, and locations the pictures are from.

Take the photos in the specified order as explained in Chapter Three. It is crucially important to shoot the photos in the order they are presented so they are identifiable when sorting the slides after development. A full set of directions for preparing the developed slides prior to archiving them with the VMC is included in the Appendix. There are also a limited number of shots available. If mistakes are made and a location needs to be re-shot it should be clearly noted on the photo frame sequence data sheet and resolved when the photos return from the developer.

NOTE - the film used for PIMS is Fugi Provia. It is sold at most specialty camera stores. It should be purchased the day before as most camera stores will not be open when travelling to the site. The PIMS system calls for seven (7) rolls of 36 exposure 100 ASA color slide film. The protocol will only use six (6) rolls but it is a good idea to have a spare roll.

Chapter Three - Site Data

3.1 Introduction

The following chapter contains the core data for this protocol. In it you will find all the data needed to re-locate the transect sites and orient the quadropod. Once the rest of the protocol has become familiar this is the only chapter you may need to complete the data collection process.

The chapter is broken down into nine different subsections (3.2.1-3.2.9) each corresponding to the nine individual transect sites. Each subsection begins with a paragraph describing the location of the transect site. Following that is a list of orientation data to be used to locate the quadropod and the oblique orientation platform. Each subsection also has two pages of pictures to help in locating the transect site as mentioned in 2.2.1.

This chapter should be referred to for location of the individual transect sites and orientation of the quadropod and oblique platform. Again, once you are familiar with Chapter One and Chapter Two this chapter should provide all the information necessary to proceed from transect to transect.

Measuring Leg: The quadrat frame support leg that is matched to the indicated ferrule height.

Ferrule Height: The height along the quadrat frame support leg centimeter tape to which the ferrule is matched.

Azimuth: The direction the north arrow should indicate when the quadropod is correctly oriented.

3.2 Transect Site Data

Inclination: The degree of inclination indicated by the inclinometer when the oblique platform is correctly oriented.

3.2.1 Transect 1

Site Description:

A large rock cairn called Frenchman's Pile is located approximately .2 miles North on the Long Trail (LT) from the Summit Station. About 40 feet North along the LT from Frenchman's Pile is the first transect. At this transect the trail is lined on both sides by a scree wall (a low rock wall defining the edge of the trail treadway) and is about 1.5 meters in width.

East Pin Location: On a bedrock spur about 10-15 feet east of the treadway.
West Pin Location: On a bedrock spur approximately 15 feet west of the treadway.

Transect Azimuth: 340°
Transect Length from east to west loop: 1,058cm

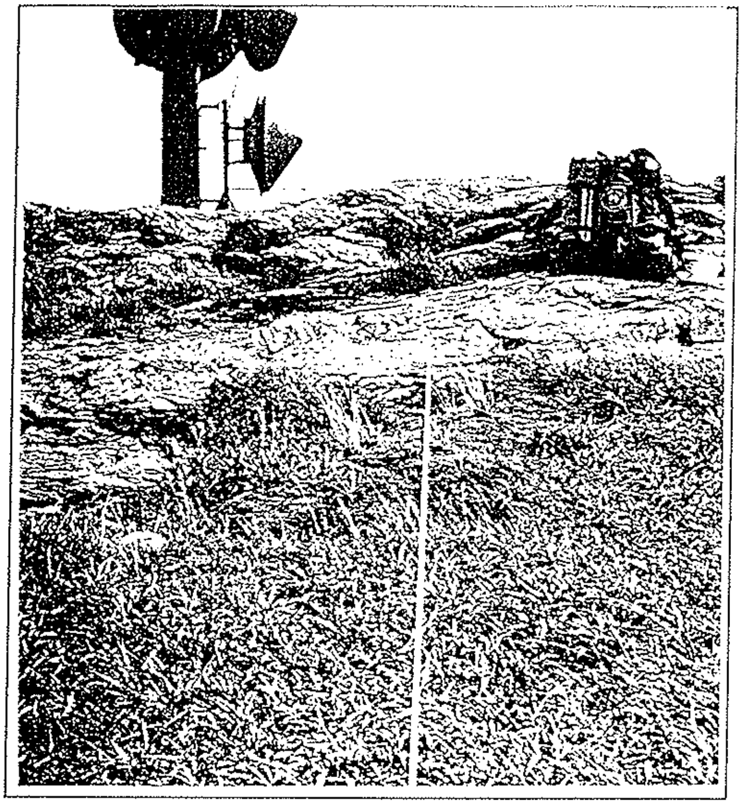
Azimuth from Frenchman's Pile to west pin: 110°
Azimuth from Frenchman's Pile to east pin: 150°

Orientation Information:

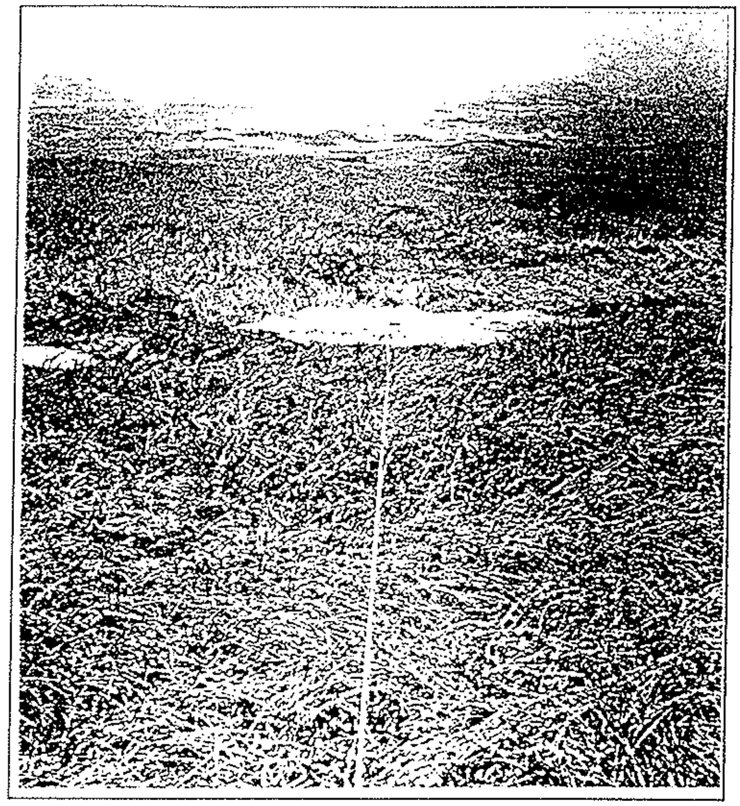
East Quadrat Frame (T1-QE)
Measuring Leg R
Ferrule Height 8.5
Azimuth 330°

West Quadrat Frame (T1-QW)
Measuring Leg R
Ferrule Height 20
Azimuth 330°
Oblique (T1-OBN) Azimuth: 340° Inclination: (-10)
Oblique (T1-OBS) Azimuth: 160° Inclination: (-15)

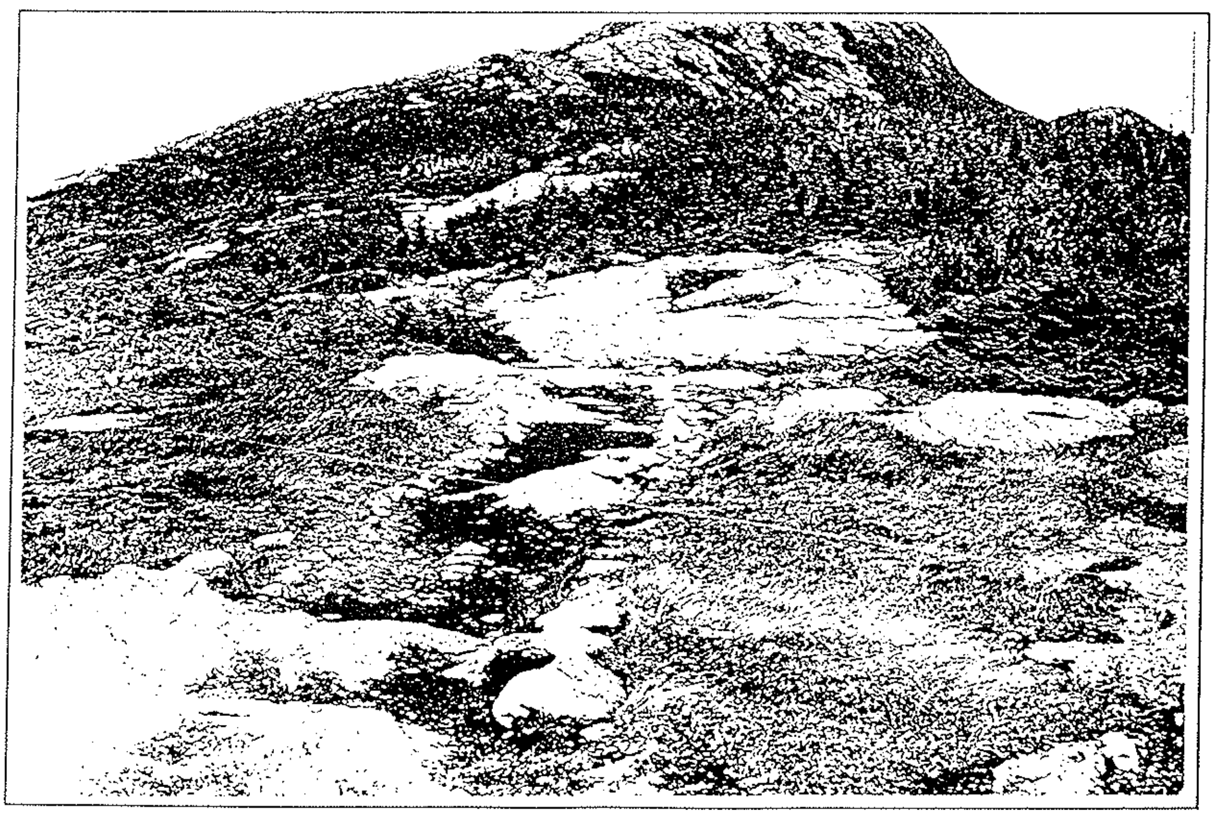
Transect Site #1



Transect Site #1 ~ East

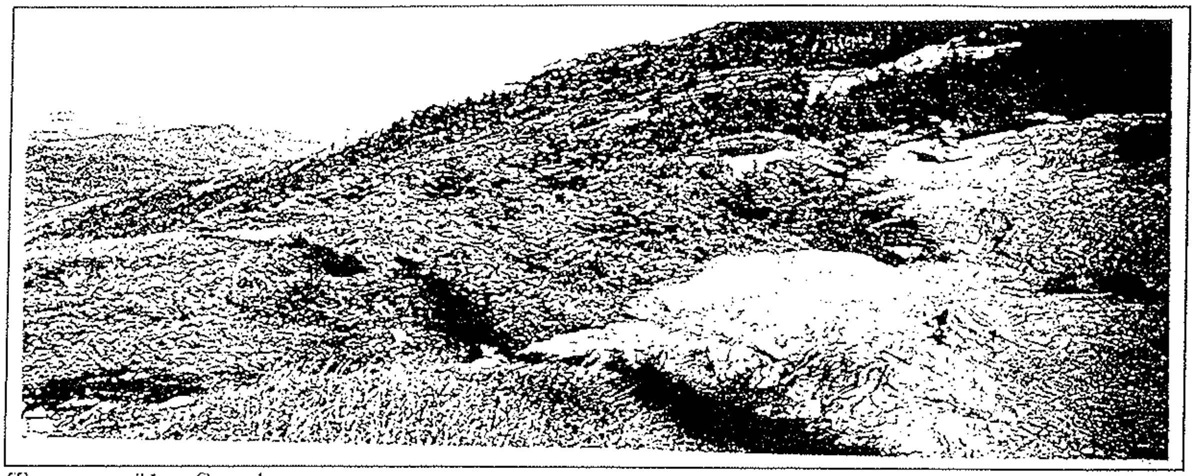


Transect Site #1 ~ West

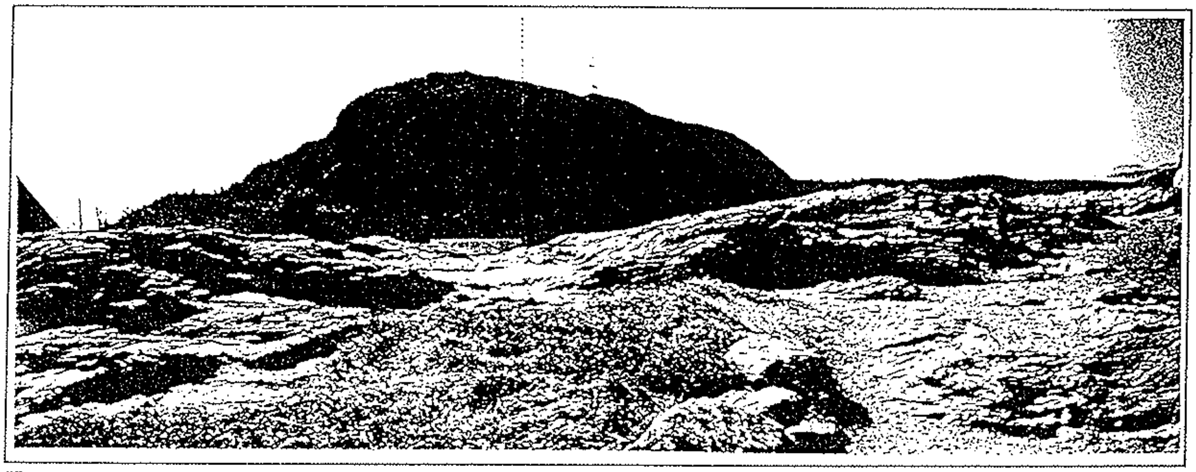


Transect Site #1

Transect #1 ~ North

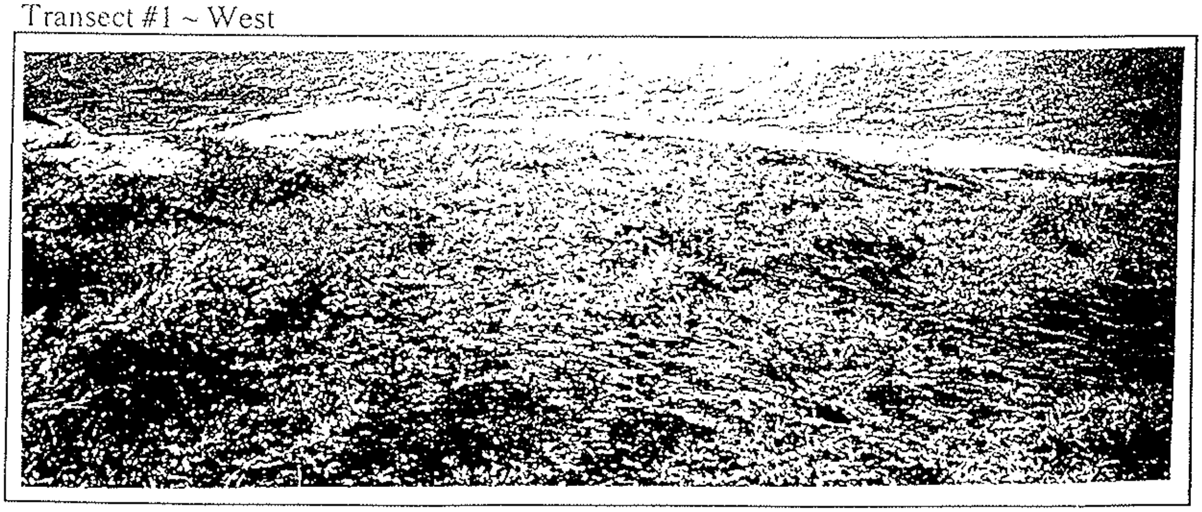


Transect #1 ~ South



Transect #1 ~ East

Transect #1 ~ West



3.2.2 Transect 2

Site Description:

Approximately 150-200 feet north on LT from transect 1 the treadway is about 1 meter in width and is characterized by a deep trench in the organic mat. The transect is located approximately 50 feet south of the first puncheon on the LT north of Frenchman's Pile. The transect is perpendicular to the treadway and shorter in length than transect 1.

East Pin Location: On a bedrock spur about ~~5~~ 10 feet east of the treadway.
West Pin Location: On an isolated block 5 feet west of the treadway in a Bearberry dominated mat.

Transect Azimuth: 280°
Transect Length from east to west loop: 559cm

Azimuth from first puncheon to west pin: 220°
Azimuth from first puncheon to east pin: 200°

Orientation Information:

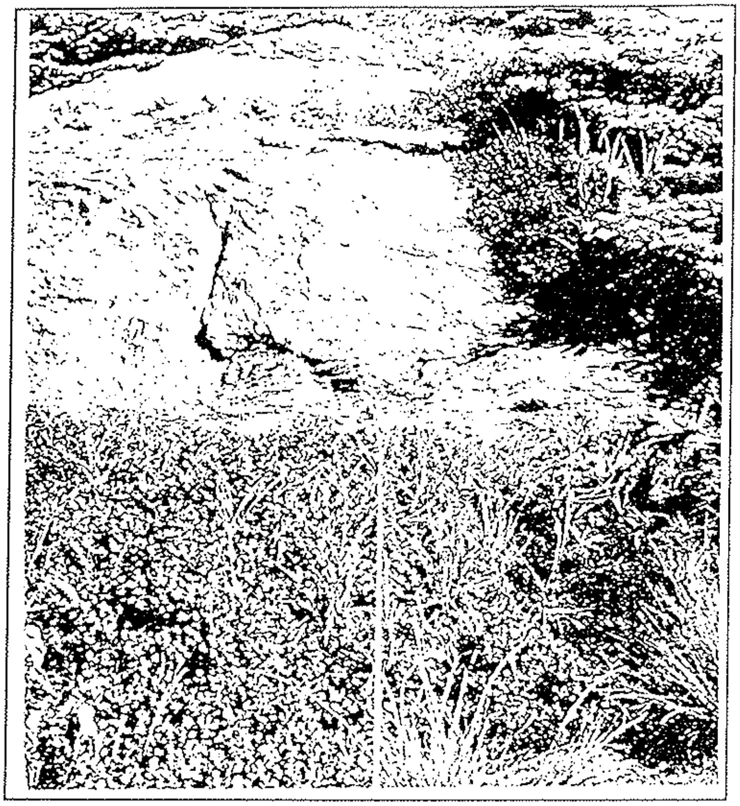
East Quadrat Frame (T2-QE)

Measuring Leg	L
Ferrule Height	7.5
Azimuth	345°

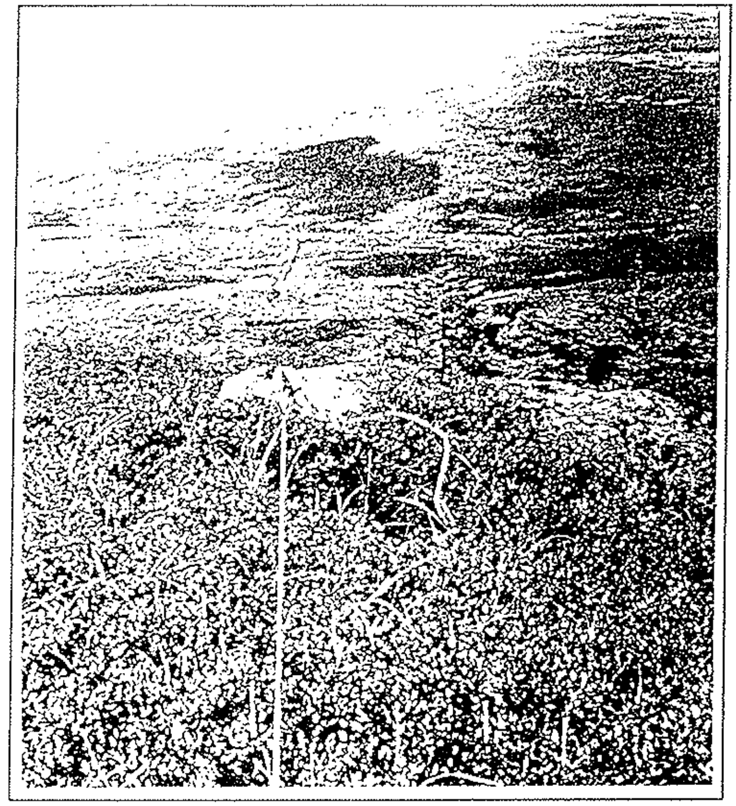
West Quadrat Frame (T2-QW)

Measuring Leg	R	
Ferrule Height	14.5	
Azimuth	345°	
Oblique (T2-OBN)	Azimuth: 340°	Inclination: (-15)
Oblique (T2-OBS)	Azimuth: 170°	Inclination: 15

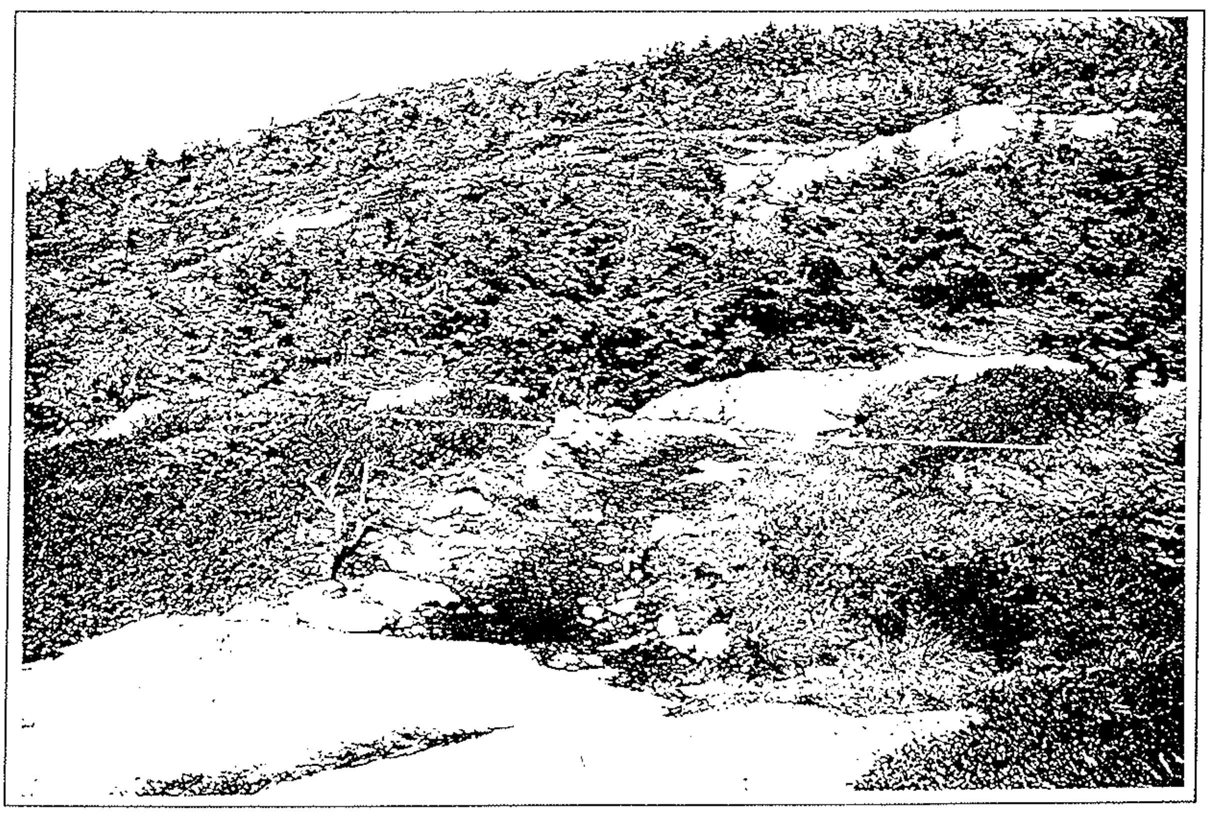
Transect Site #2



Transect Site #2 ~ East

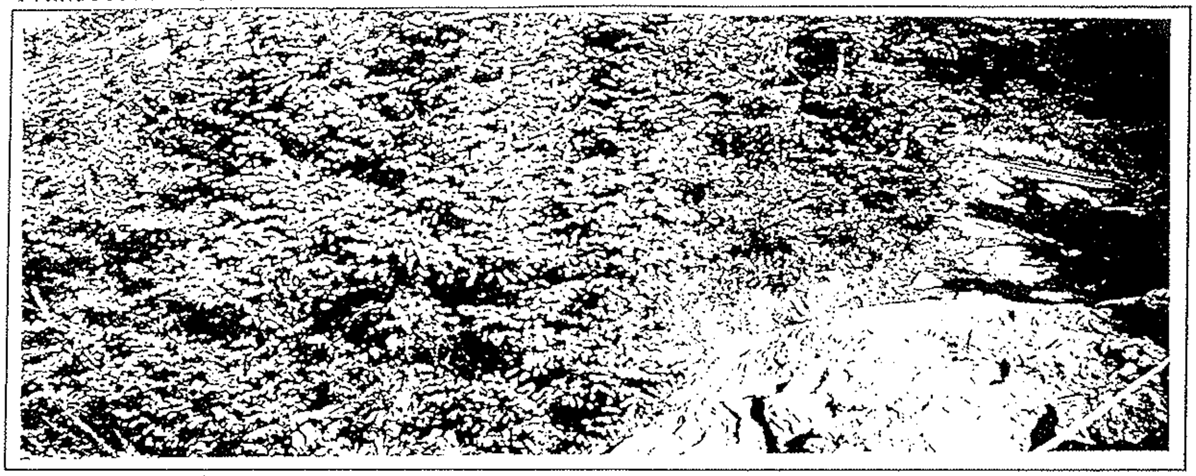


Transect Site #2 ~ West

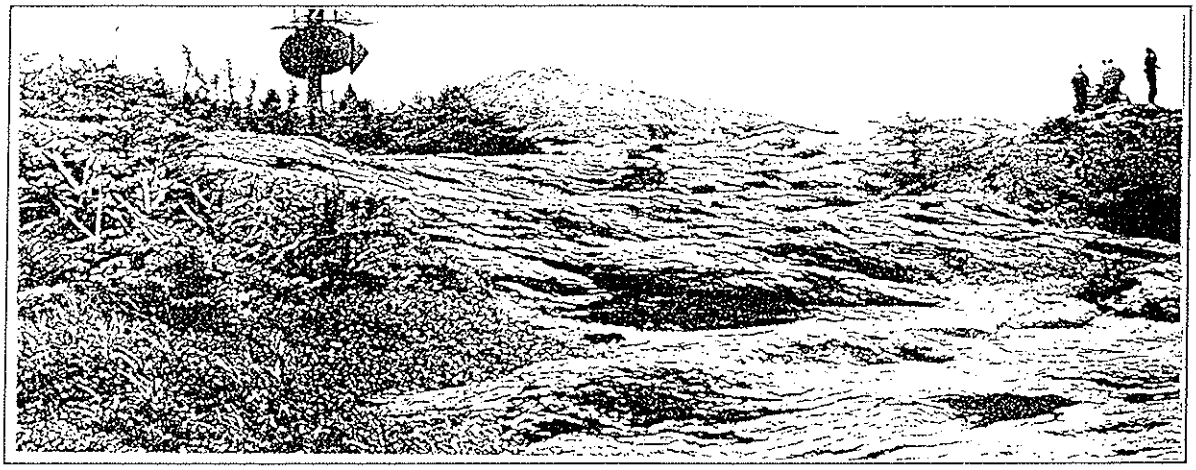


Transect Site #2

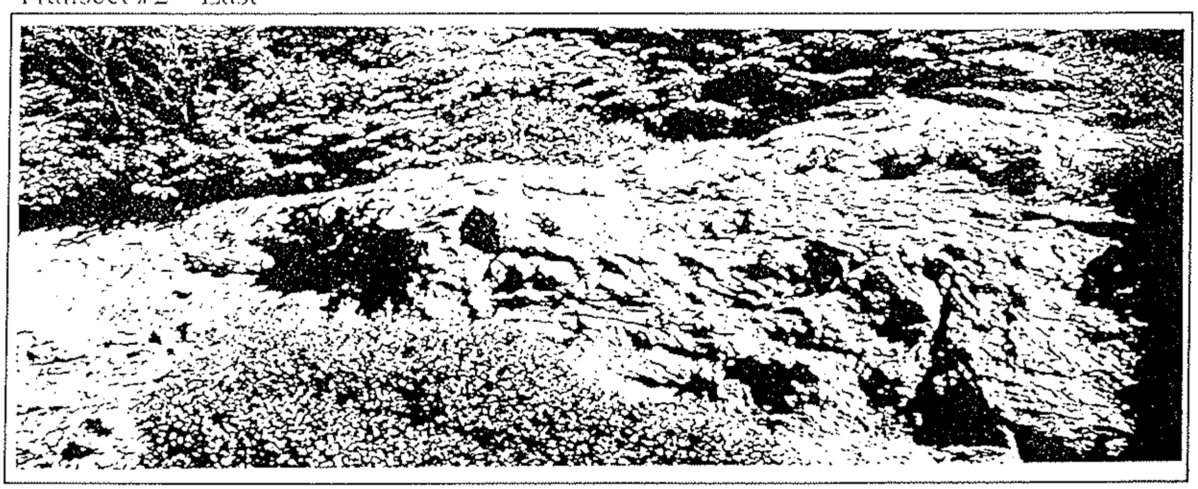
Transect #2 ~ North



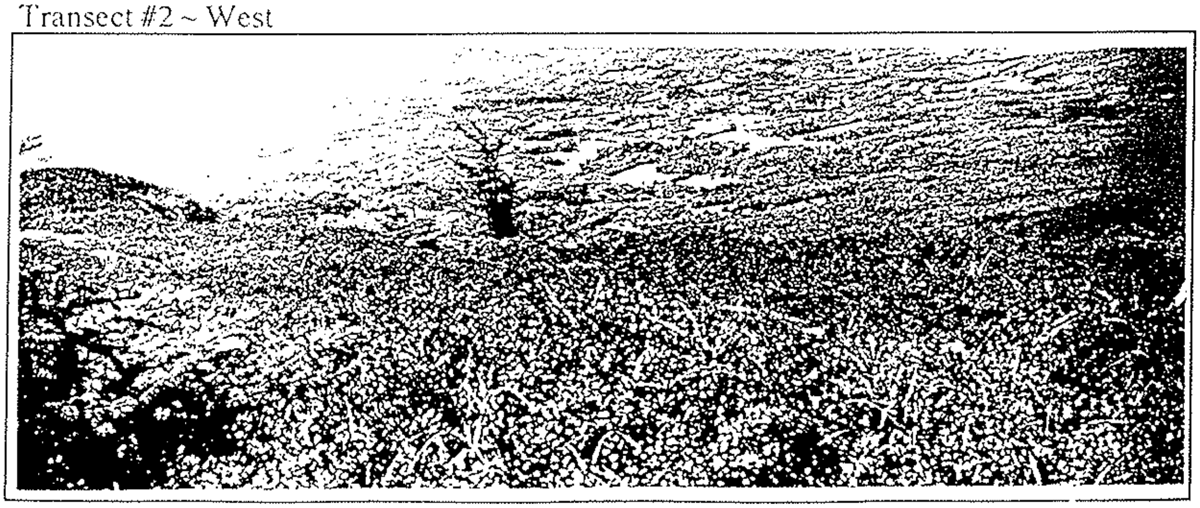
Transect #2 ~ South



Transect #2 ~ East



Transect #2 ~ West



3.2.3 Transect 3

Site Description:

Transect 3 is located at the northern junction of the Amherst trail and LT. This transect site lies just off the eastern edge of Drift Rock in a strung- off revegetation area. The transect is **not** on the Long Trail treadway.

East Pin Location: On 105° azimuth from the west pin.
West Pin Location: Under the overhang of the eastern side of Drift Rock.

Transect Azimuth: 285°
Transect Length from east to west loop: 464cm

Orientation Information:

East Quadrat Frame (T3-QE)

Measuring Leg	R
Ferrule Height	0
Azimuth	340°

Middle Quadrat Frame (T3-QM)

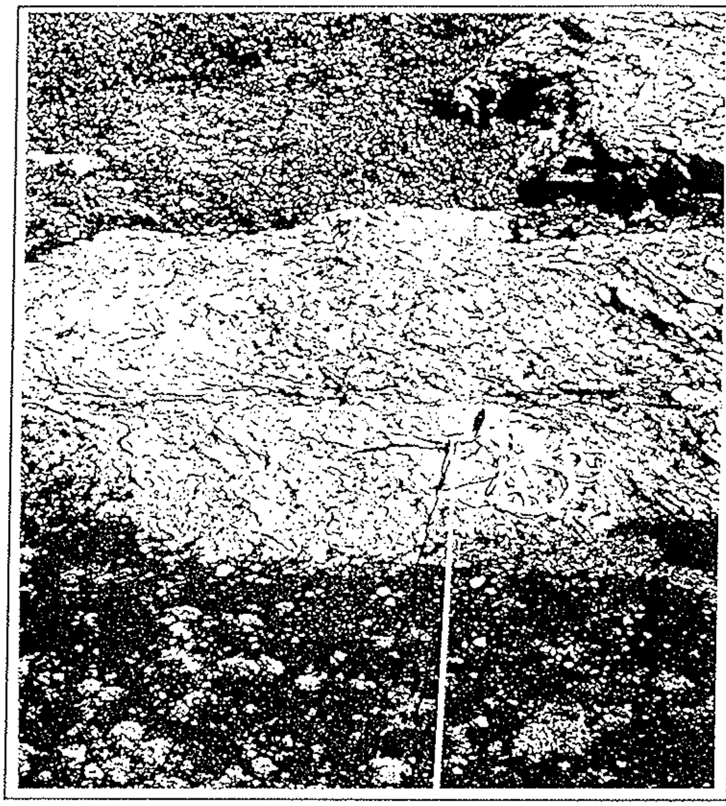
Measuring Leg	L
Ferrule Height	(-5)*
Azimuth	340°

West Quadrat Frame (T3-QW)

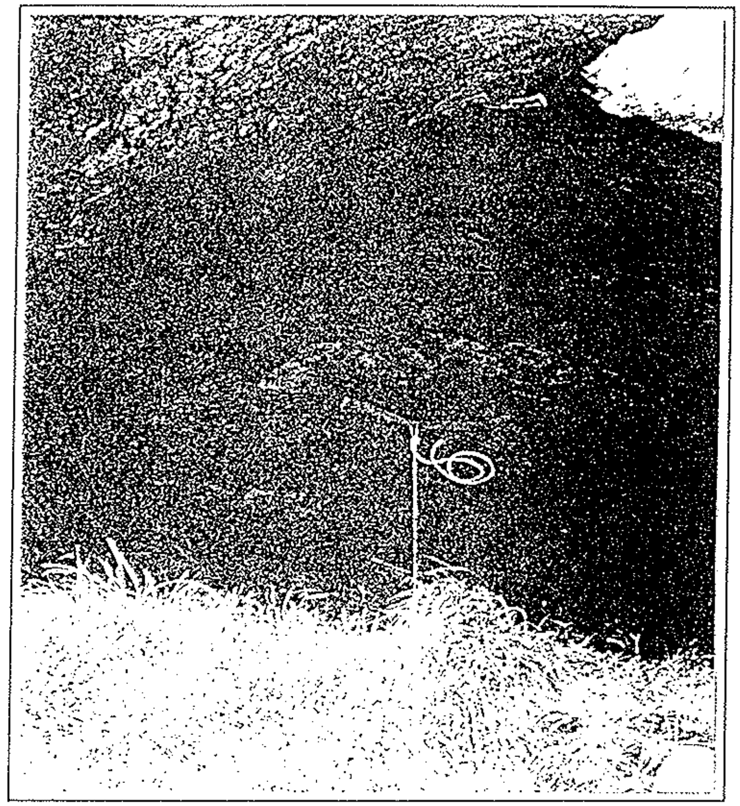
Measuring Leg	R	
Ferrule Height	5.5	
Azimuth	340°	
Oblique (T3-OBN)	Azimuth: 30°	Inclination: (-35)
Oblique (T3-OBS)	Azimuth: 160°	Inclination: (-20)

* The ferrule height for the Middle Quadrat Frame (T3-QM) is 5cm **below** the bottom of the quadrat support leg.

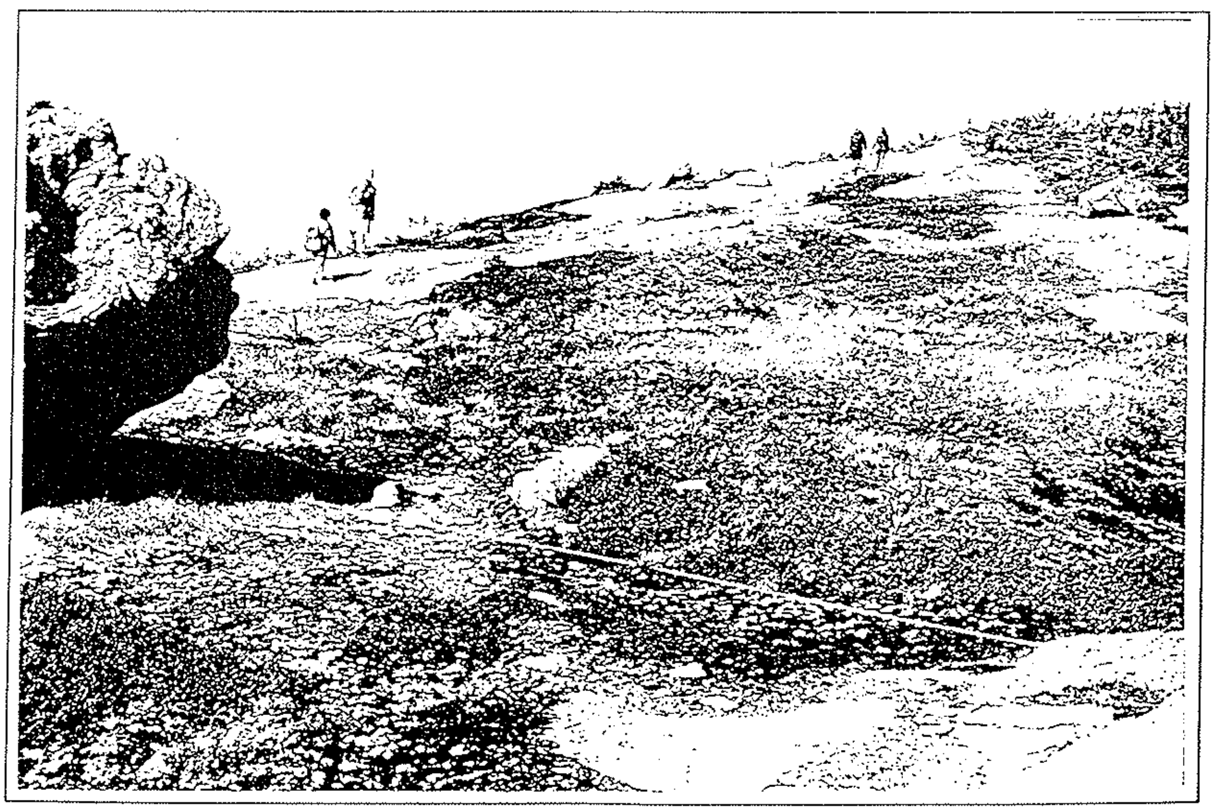
Transect Site #3



Transect Site #3 ~ East



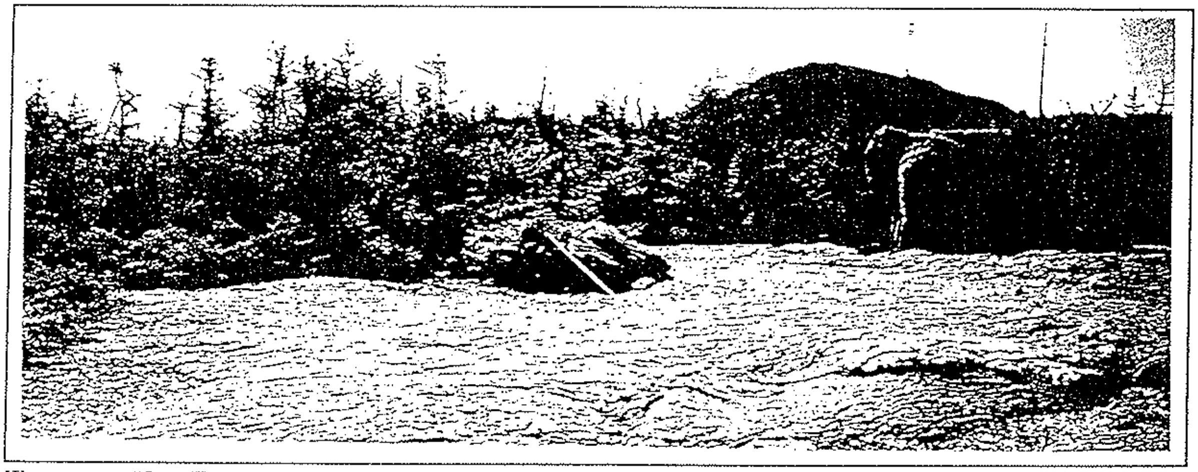
Transect Site #3 ~ West



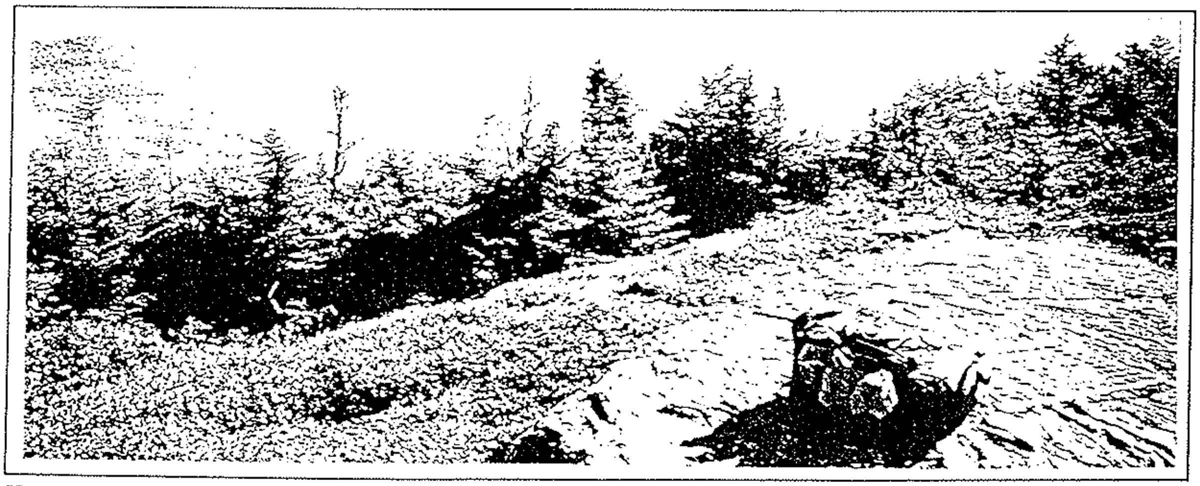
Transect Site #3

Transect #3 ~ North

Transect #3 ~ South



Transect #3 ~ East



Transect #3 ~ West

3.2.4 Transect 4

Site Description:

Transect 4 lies at the junction of the LT, Subway, and Cliff trails. More specifically, it lies across the area where the Subway trail intersects the LT. The transect bisects the last few feet of the Subway trail.

East Pin Location: A few feet prior to the Subway/LT junction. It is about two feet up on a rock block to the right of the treadway as you are headed north along the LT. It may be hidden under a fir branch
West Pin Location: To the left of the Subway trail as you approach the LT junction. It is located under a Black spruce next to a patch of screed-in moss and sedge.

The transect is perpendicular to the top of the Subway trail and diagonal to the LT.

Transect Azimuth: 340°
Transect Length from east to west loop: 733cm

Azimuth from the blaze at the top of the Subway trail to the west pin: 325°
Azimuth from the blaze at the top of the Subway trail to the east pin: 175°

Orientation Information:

East Quadrat Frame (T4-QE)

Measuring Leg	R		
Ferrule Height	33		
Azimuth	290°		
Oblique (T4-OBN)		Azimuth: 310°	Inclination: (-5)
Oblique (T4-OBS)		Azimuth: 180°	Inclination: (-10)

East Quadrat Frame (T4-QM)

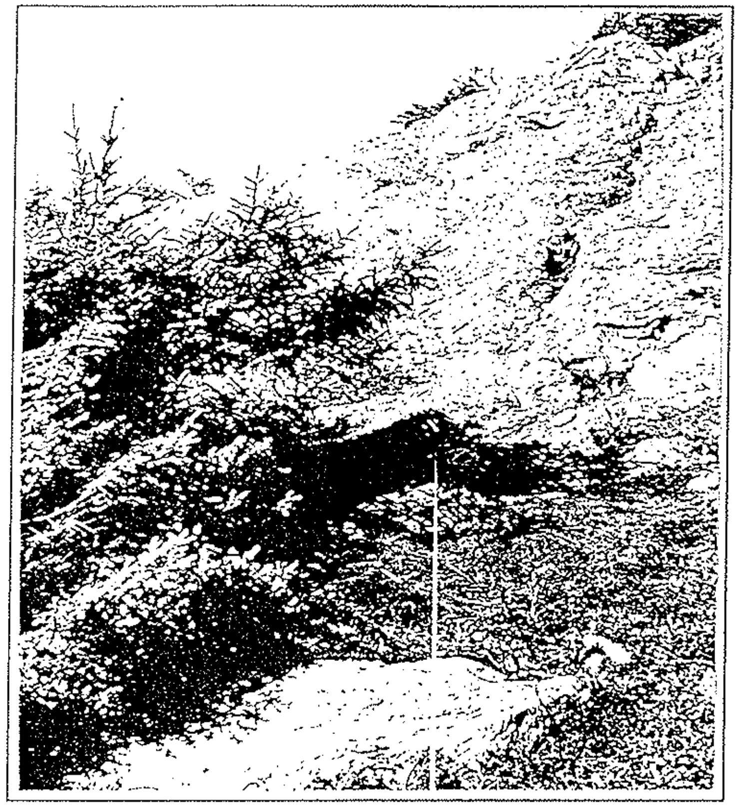
Measuring Leg	R
Ferrule Height	38.5
Azimuth	290°

West Quadrat Frame (T4-QW)

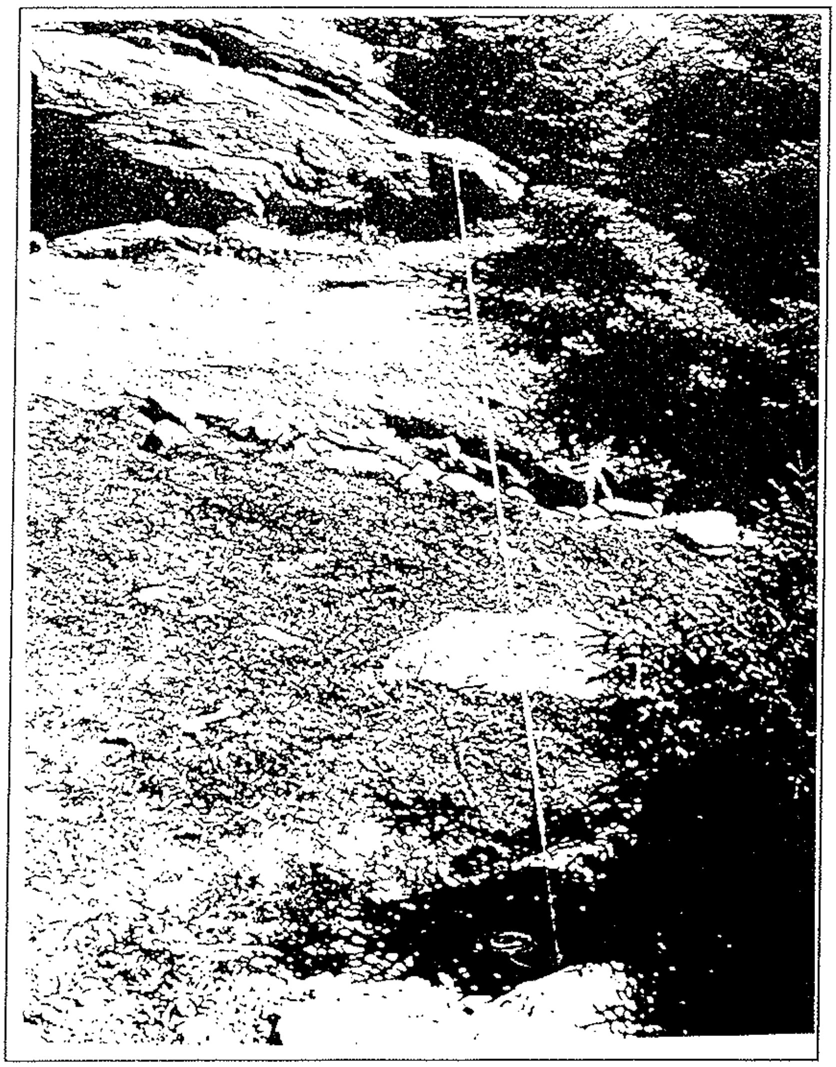
Measuring Leg	R
Ferrule Height	33.5
Azimuth	290°

Transect Site #4

Transect Site #4 ~ East

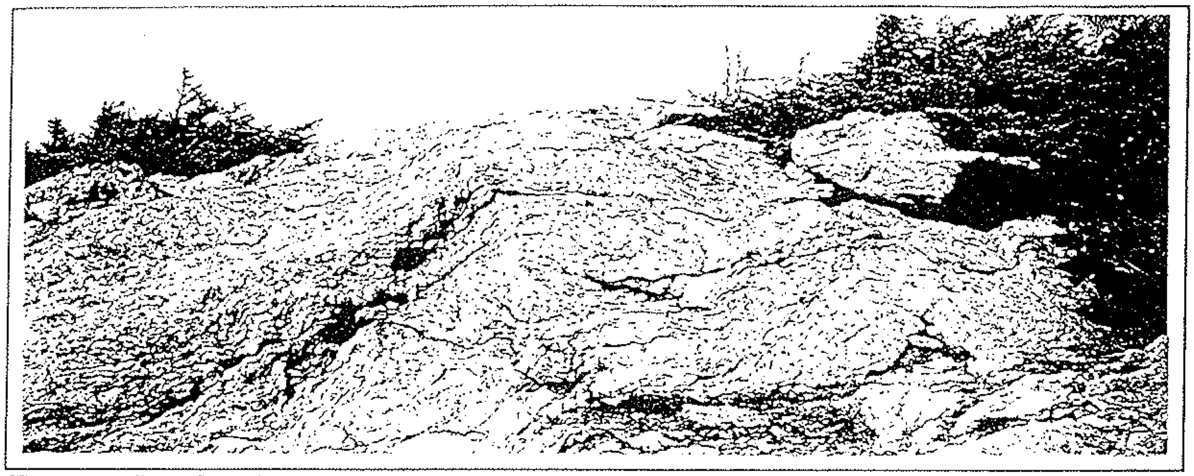


Transect Site #4 ~ West



Transect Site #4

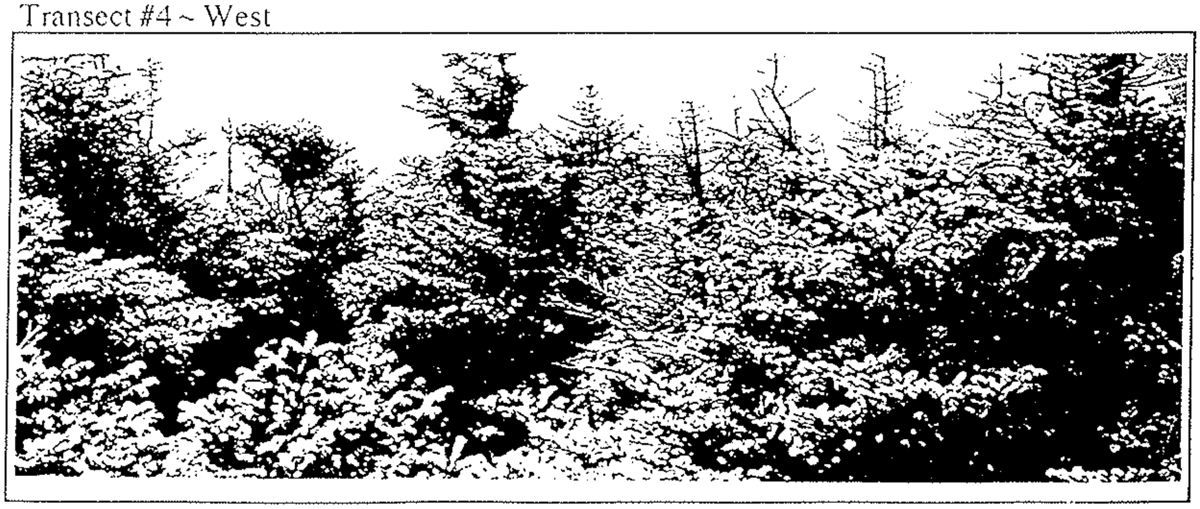
Transect #4 ~ North



Transect #4 ~ South

Transect #4 ~ East

Transect #4 ~ West



3.2.5 Transect 5

Site Description:

Both transect 5 and 6 are located across the marshy area at the Profanity, Sunset Ridge, and LT junction. Both transects cross the puncheon that lie along the LT.

East Pin Location: On a bedrock outcropping between the puncheons of the LT and the puncheons headed down Profanity Trail. It is about 15 feet from the LT treadway and is at the edge of the marshy area to the left of a bearberry mat.
West Pin Location: On the northern side ofthe marshy area along the base of the rock face. It is about 1 foot above the tops of the sedges and 15 feet from the treadway.

Transect Azimuth: 355°
Transect Length from east to west loop: 822cm

Azimuth from the Profanity/LT junction to the west pin: 200°
Azimuth from the Profanity/LT junction to the east pin: 335°

Orientation Information:

East Quadrat Frame (T5-QE)

Measuring Leg	R
Ferrule Height	8.5
Azimuth	305°

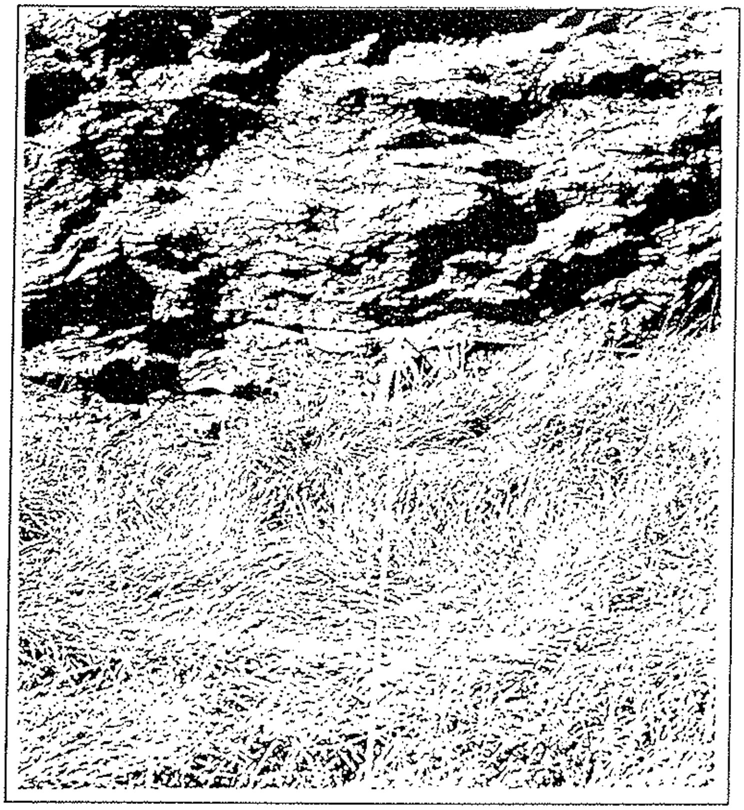
Middle Quadrat Frame (T5-QM)

Measuring Leg	R
Ferrule Height	8.5
Azimuth	300°

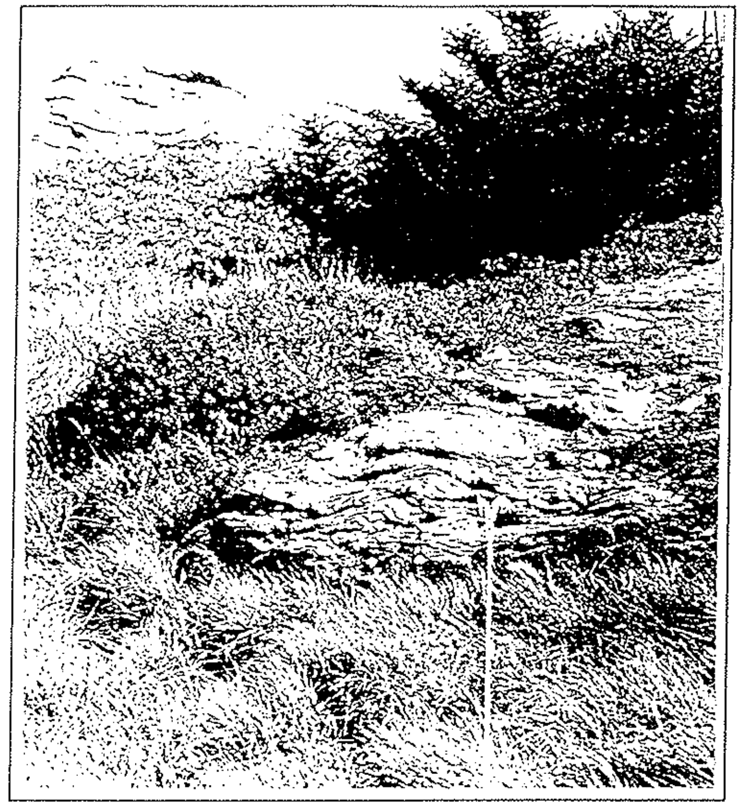
West Quadrat Frame (T5-QW)

Measuring Leg	R	
Ferrule Height	20	
Azimuth	300°	
Oblique (T5-OBN)	Azimuth: 300°	Inclination: (-15)
Oblique (T5-OBS)	Azimuth: 120°	Inclination: (-25)

Transect Site #5



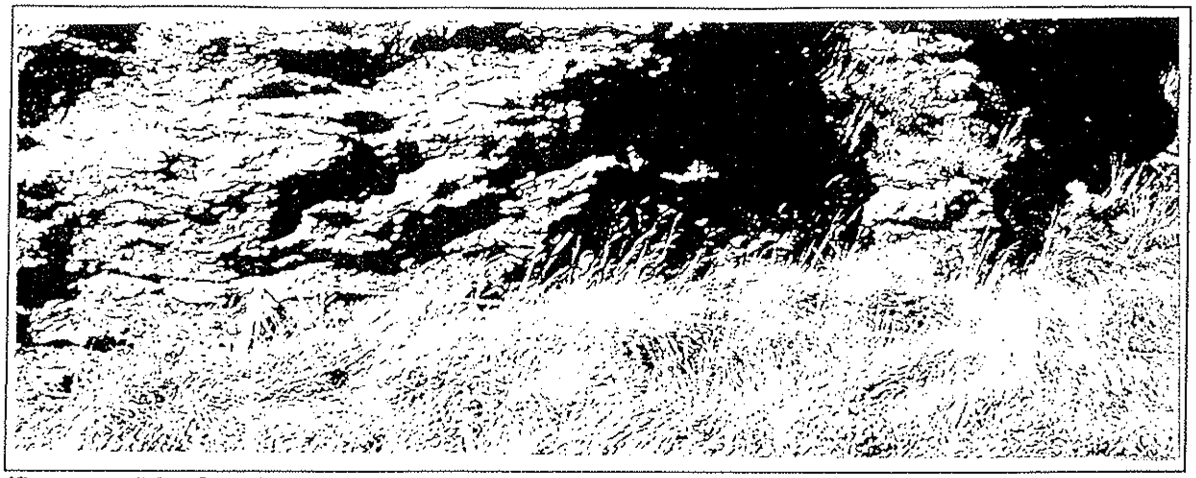
Transect Site #5 ~ East



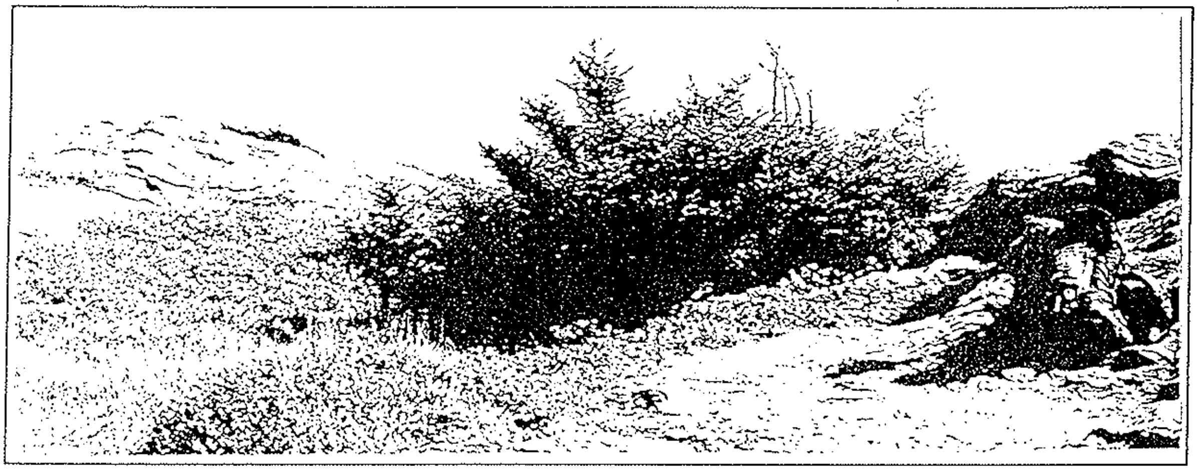
Transect Site #5 ~ West

Transect Site #5

Transect #5 ~ North

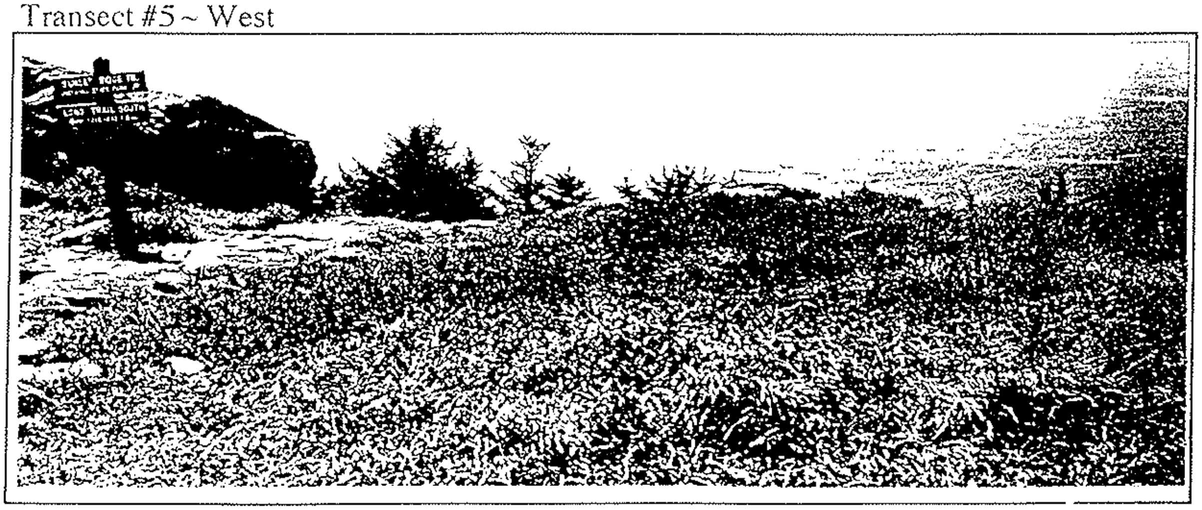


Transect #5 ~ South



Transect #5 ~ East

Transect #5 ~ West



3.2.6 Transect 6

Site Description:

Both transect 5 and 6 are located across the marshy area at Profanity Trail, Sunset Ridge, and LT junction. Both transects cross the puncheon that lie along the LT.

East Pin Location: On a bedrock outcropping between the LT north and Profanity Trail. It is located about 10 feet from the treadway to the left of a bearberry mat on a steep sloping rock spur.
West Pin Location: On the northern side of the marshy area along the base of the rock face. It is about 1 foot above the tops of the sedges and 15 feet from the treadway.

Transect Azimuth: 280°
Transect Length from east to west loop: 660cm

Azimuth from the Profanity/LT junction to the west pin: 60°
Azimuth from the Profanity/LT junction to the east pin: 335°

Orientation Information:

East Quadrat Frame (T6-QE)

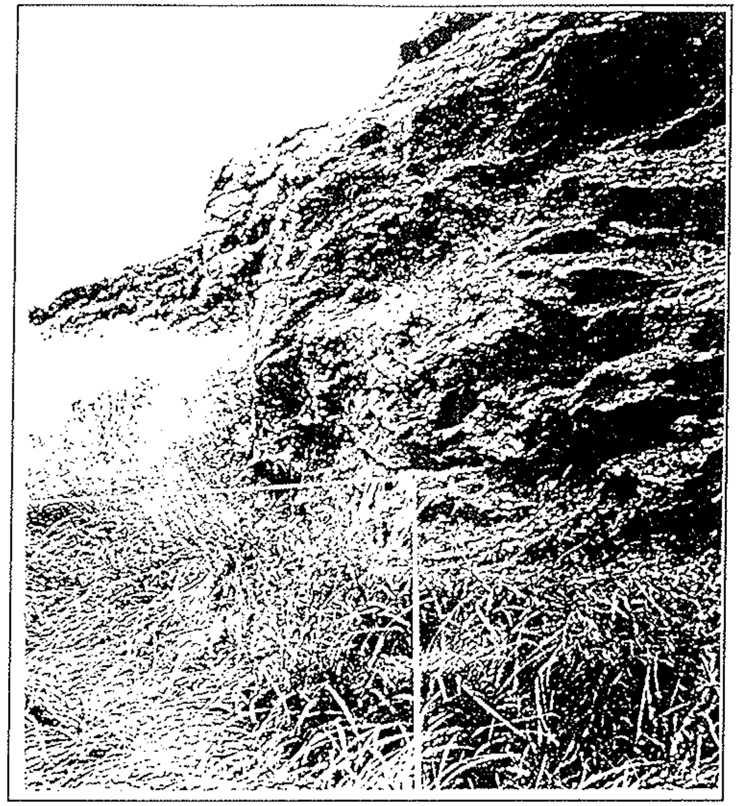
Measuring Leg	L
Ferrule Height	12
Azimuth	330°

West Quadrat Frame (T6-QW)

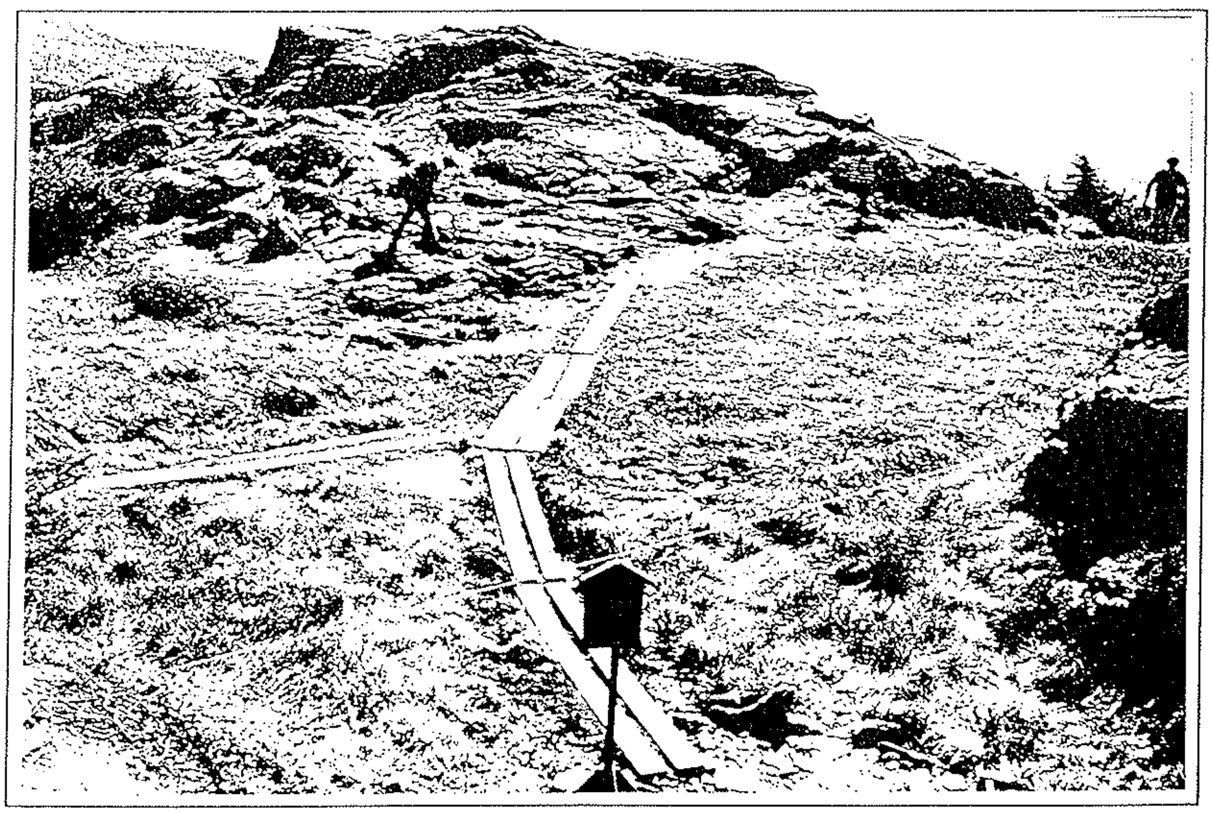
Measuring Leg	R
Ferrule Height	14
Azimuth	325°

Transect Site #6

Transect Site #6 ~ East



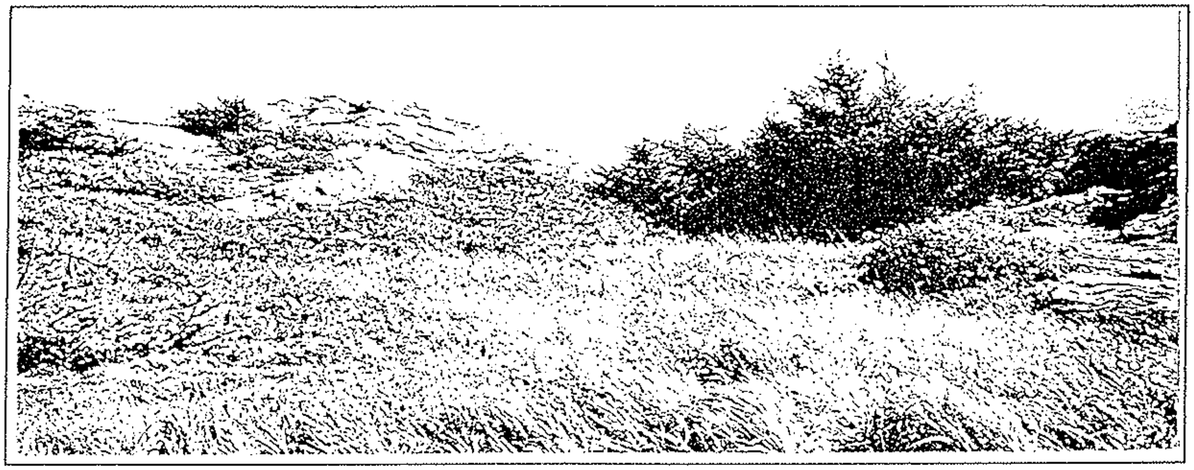
Transect Site #6 ~ West



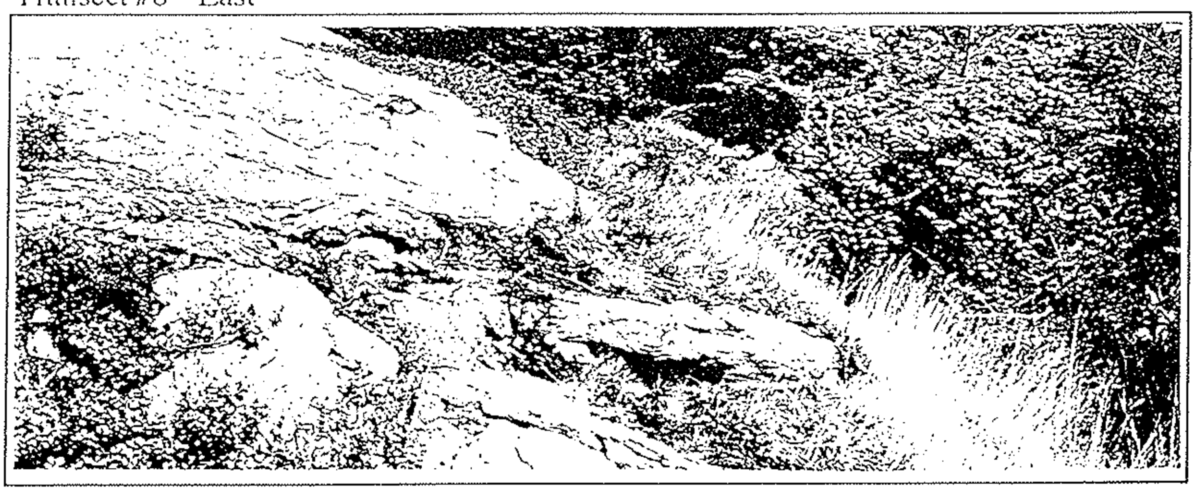
Transect Site #6

Transect #6 ~ North

Transect #6 ~ South



Transect #6 ~ East



Transect #6 ~ West

3.2.7 Transect 7

Site Description:

Transect 7 lies 15 feet north on the LT from the "West Chin Natural Area" sign. It is south on the LT from the Diapensia site by approximately 50 feet.

East Pin Location: On an isolated block in the middle of an extensive Bearberry/Rush mat about 20 feet off the treadway. It is located on the terminus of a rock tumble that leads up a small rise to the Diapensia site.
West Pin Location: On a patch of isolated bedrock approximately 20 feet off the treadway. It is located on a patch of bedroack of about two square feet on the West Chin Natural Area in the middle of a Bearberry/Rush mat.

Transect Azimuth: 320°
Transect Length from east to west loop: 1,068cm

Azimuth from the summit to the west pin: 70° (or 250° from the pin to the summit)
Azimuth from the summit to the east pin: 60° (or 240° from the pin to the summit)

Orientation Information:

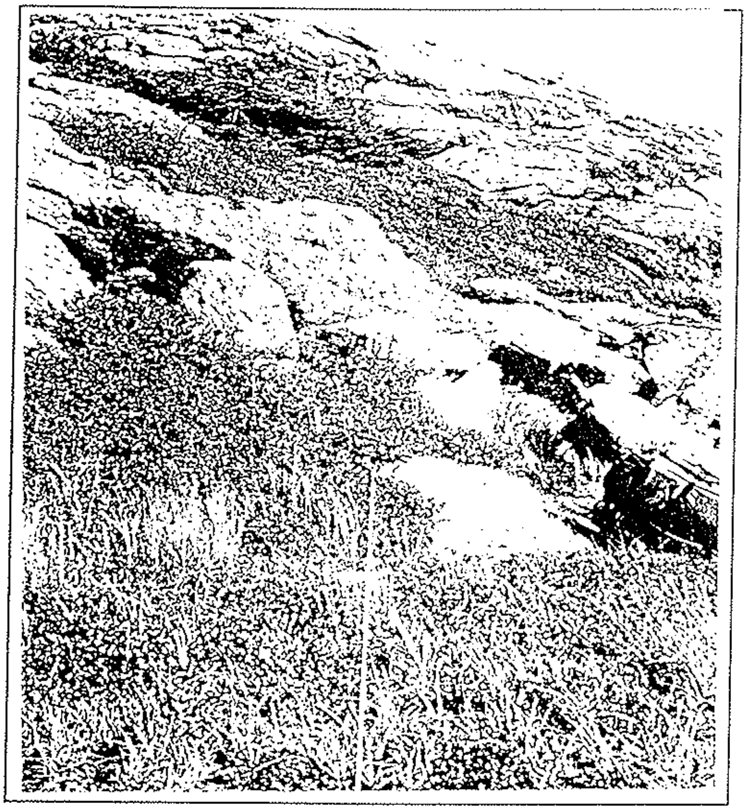
East Quadrat Frame (T7-QE)

Measuring Leg	R
Ferrule Height	6
Azimuth	300°

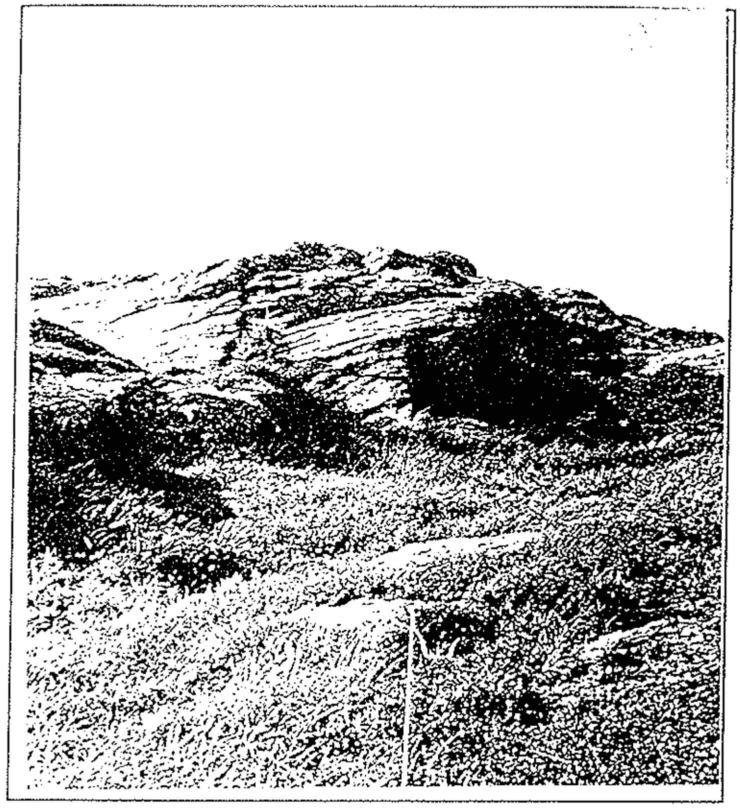
West Quadrat Frame (T7-QW)

Measuring Leg	R	
Ferrule Height	10	
Azimuth	290°	
Oblique (T7-OBN)	Azimuth: 290°	Inclination: (-10)
Oblique (T7-OBS)	Azimuth: 120°	Inclination: (-25)

Transect Site #7



Transect Site #7 ~ East

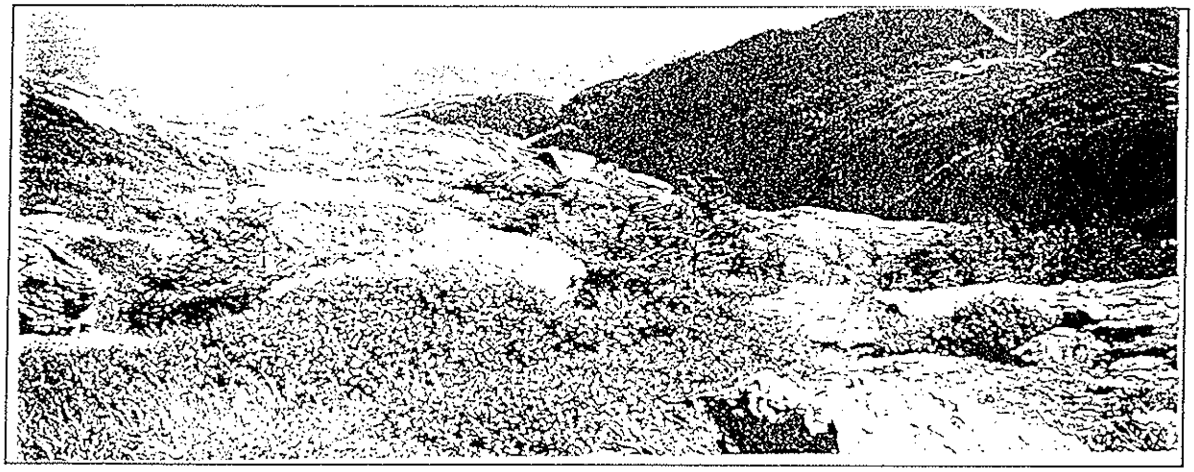


Transect Site #7 ~ West

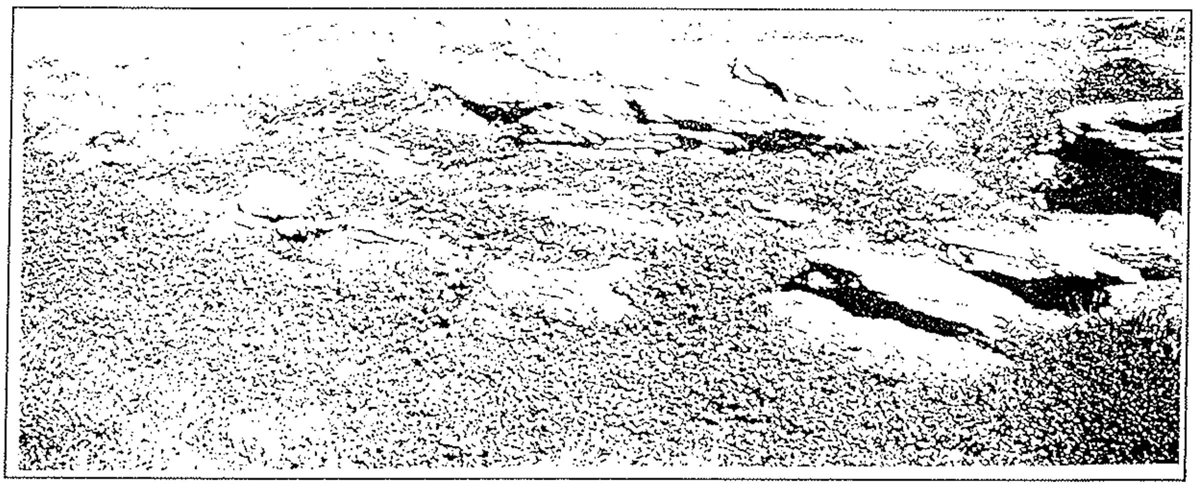
Transect Site #7

Transect #7 ~ North

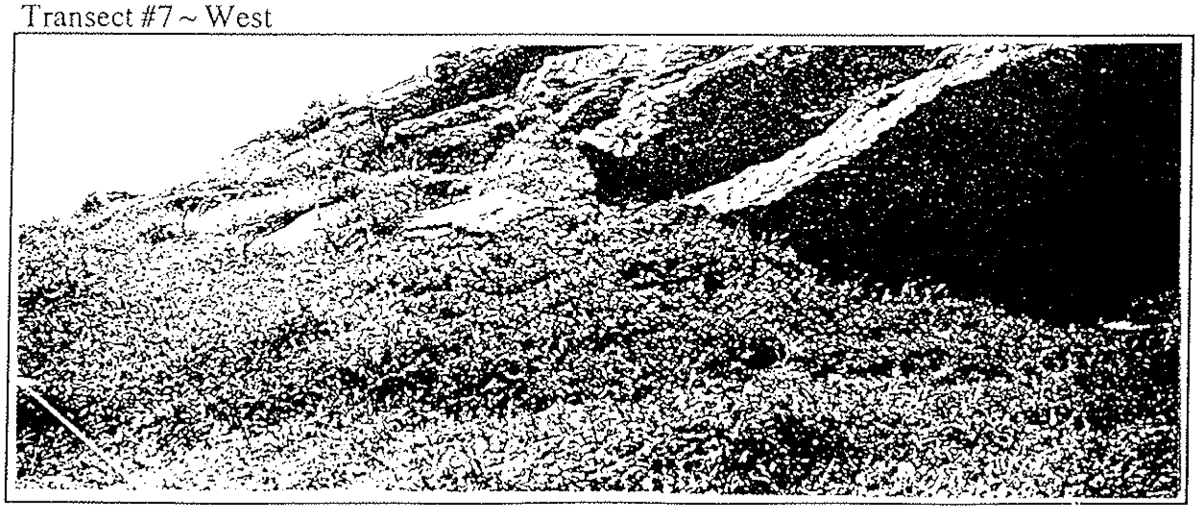
Transect #7 ~ South



Transect #7 ~ East



Transect #7 ~ West



3.2.8 Transect 8

Site Description:

Transect 8 bisects the LT treadway approximately one tenth of a mile south of the summit. It is located on the south side of the summit in a saddle between the Chin and the West Chin. The transect lies about 20 feet south along the LT from a drainage that runs out of the large sedge meadow to the east of the LT.

East Pin Location: On an bedrock point about 30 feet off the treadway up a series of rock steps. Follow a series of rock steps toward the center of the sedge meadow between the summit and the Diapensia site.
West Pin Location: On an isolated block about 5 feet from the treadway and 20 feet from the drainage that runs out of the sedge meadow in the saddle.

Transect Azimuth: 345°
Transect Length from east to west loop: 1,031cm

Azimuth from the summit to the west pin: 50° (or 230° from the pin to the summit)
Azimuth from the summit to the east pin: 60° (or 250° from the pin to the summit)

Orientation Information:

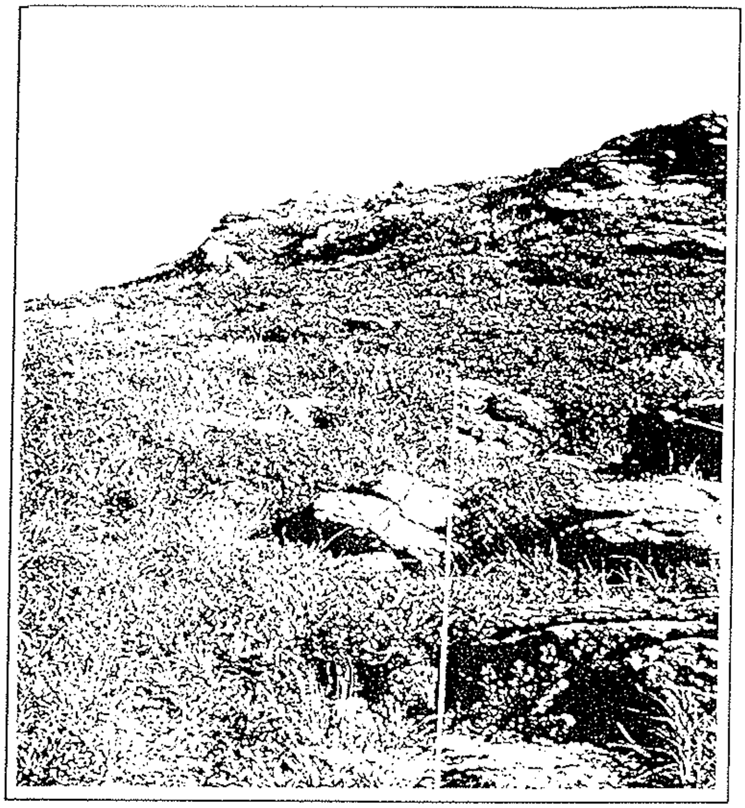
East Quadrat Frame (T8-QE)

Measuring Leg	R		
Ferrule Height	18.5		
Azimuth	280°		

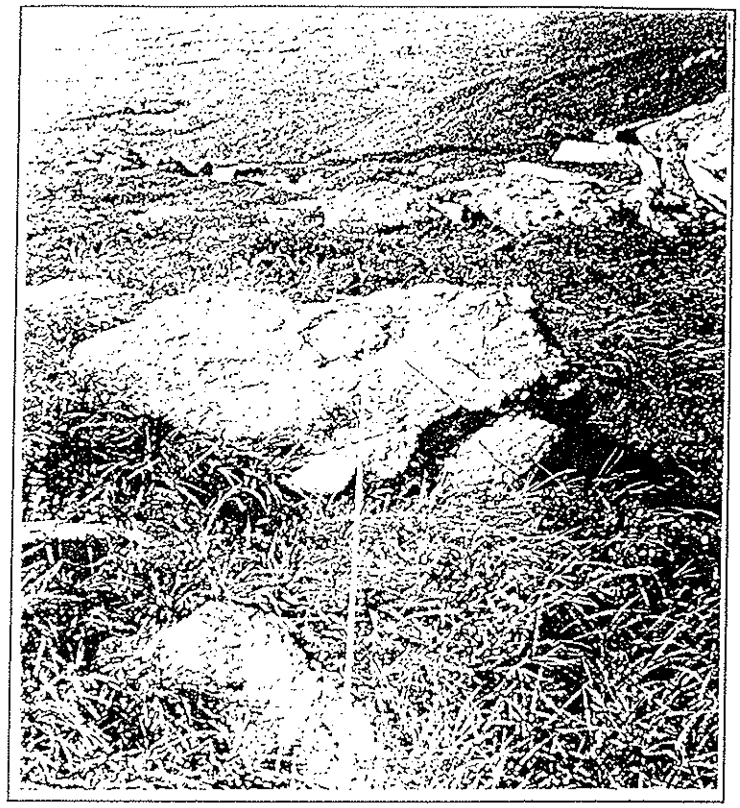
West Quadrat Frame (T8-QW)

Measuring Leg	R		
Ferrule Height	14.5		
Azimuth	280°		
Oblique (T8-OBN)		Azimuth: 305°	Inclination: (-5)
Oblique (T8-OBS)		Azimuth: 105°	Inclination: (-15)

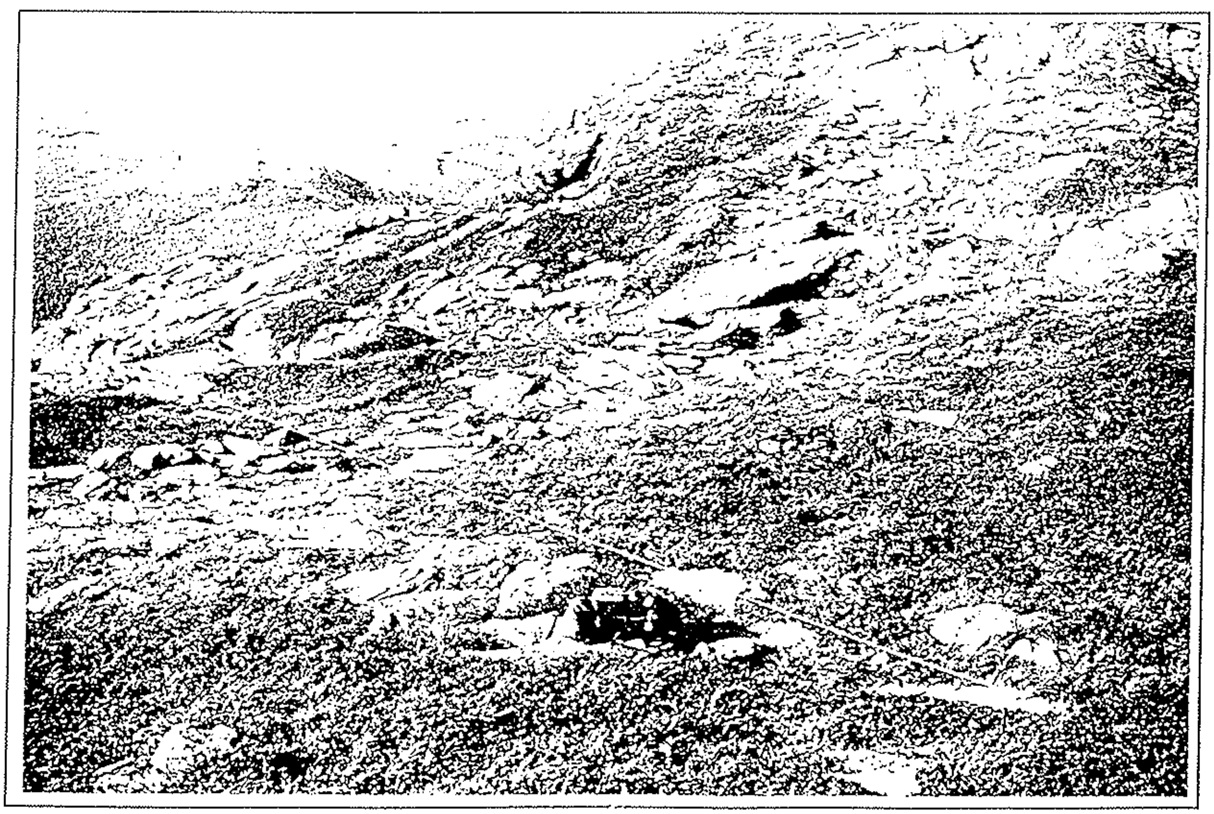
Transect Site #8



Transect Site #8 ~ East

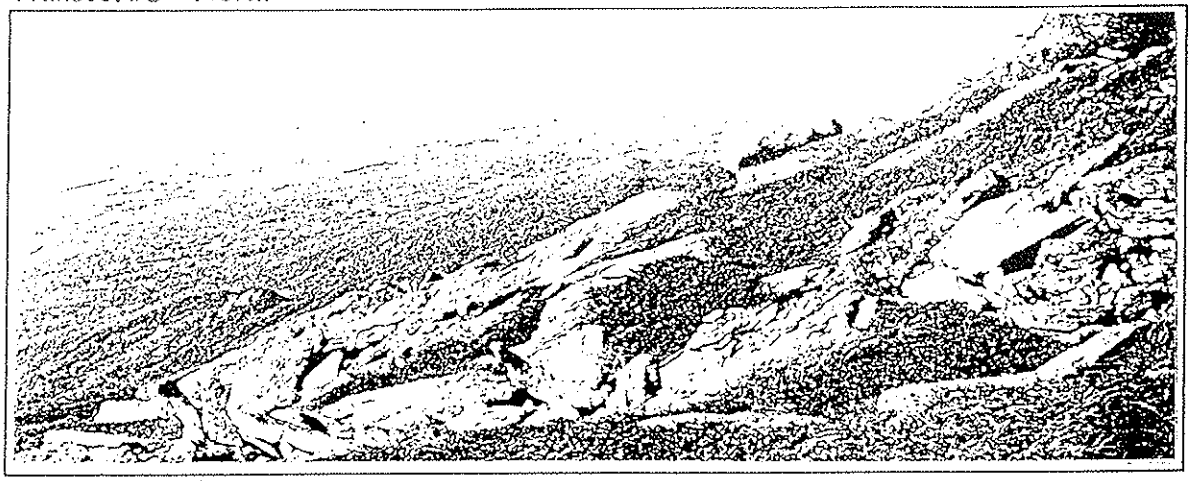


Transect Site #8 ~ West

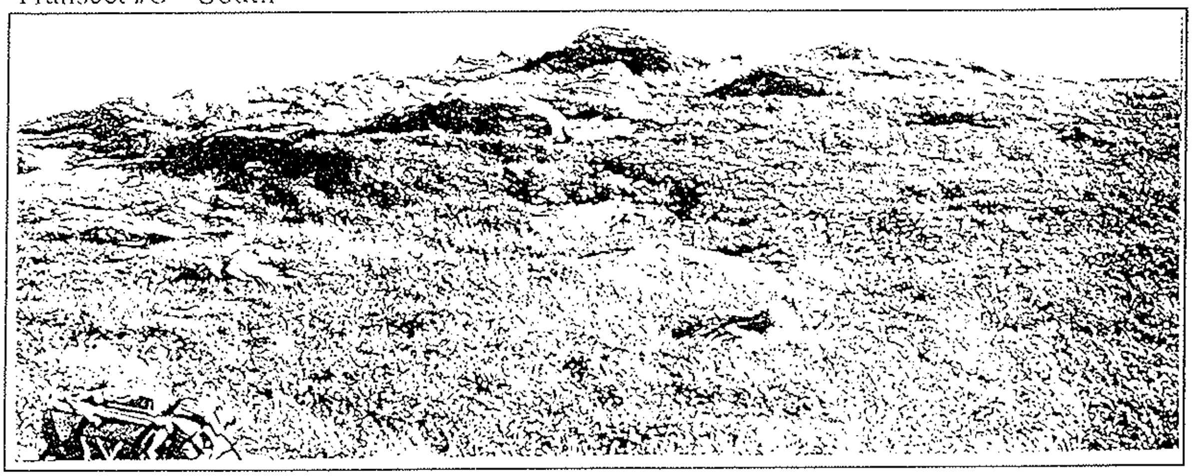


Transect Site #8

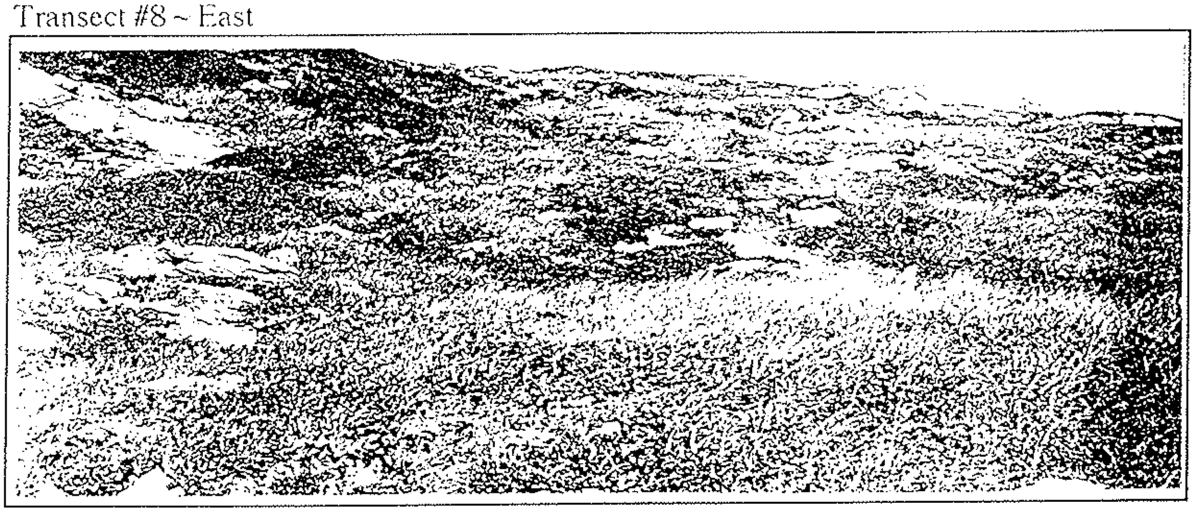
Transect #8 ~ North



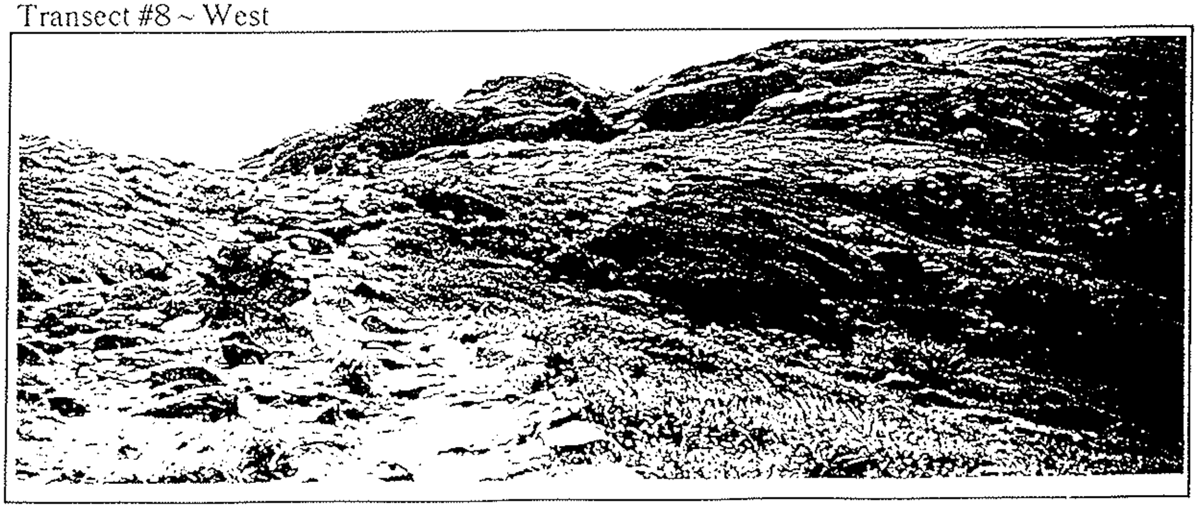
Transect #8 ~ South



Transect #8 ~ East



Transect #8 ~ West



3.2.9 Transect 9

Site Description:

Transect 9 lies about 100 feet south along the LT from the USGS survey marker located at the summit. The site is characterized by deep chanelling on the treadway's east side. The transect is located 5-10 feet north along the LT from the last cairn and the transect is perpendicular to the treadway.

East Pin Location: On a rock shelf about 10 feet off the treadway.
West Pin Location: On a bedrock depression approximately 10 feet off the treadway.

Transect Azimuth: 320°
Transect Length from east to west loop: 816cm

Azimuth from the summit to the west pin: 40° (or 220° from the pin to the summit)
Azimuth from the summit to the east pin: 65° (or 245° from the pin to the summit)

Orientation Information:

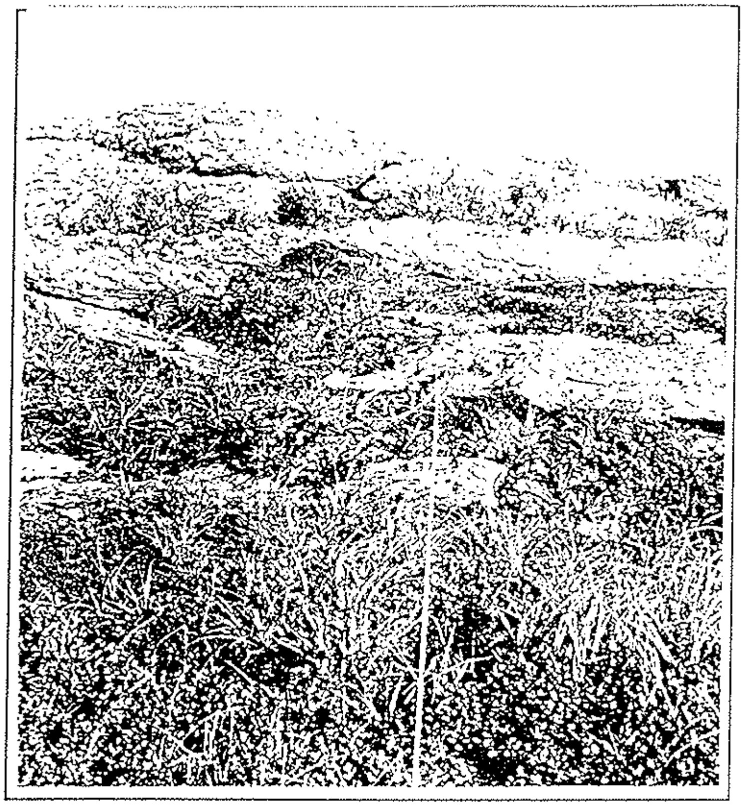
East Quadrat Frame (T9-QE)

Measuring Leg	L
Ferrule Height	20
Azimuth	305°

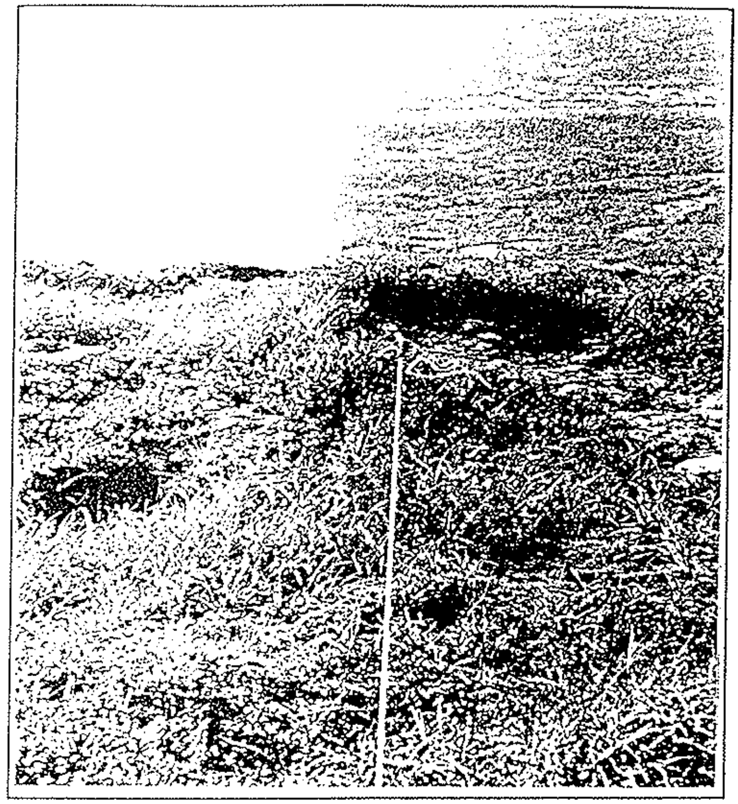
West Quadrat Frame (T9-QW)

Measuring Leg	R	
Ferrule Height	7	
Azimuth	305°	
Oblique 1 (T9-OBN)	Azimuth: 290°	Inclination: (-20)
Oblique 1 (T9-OBS)	Azimuth: 300°	Inclination: (-20)

Transect Site #9



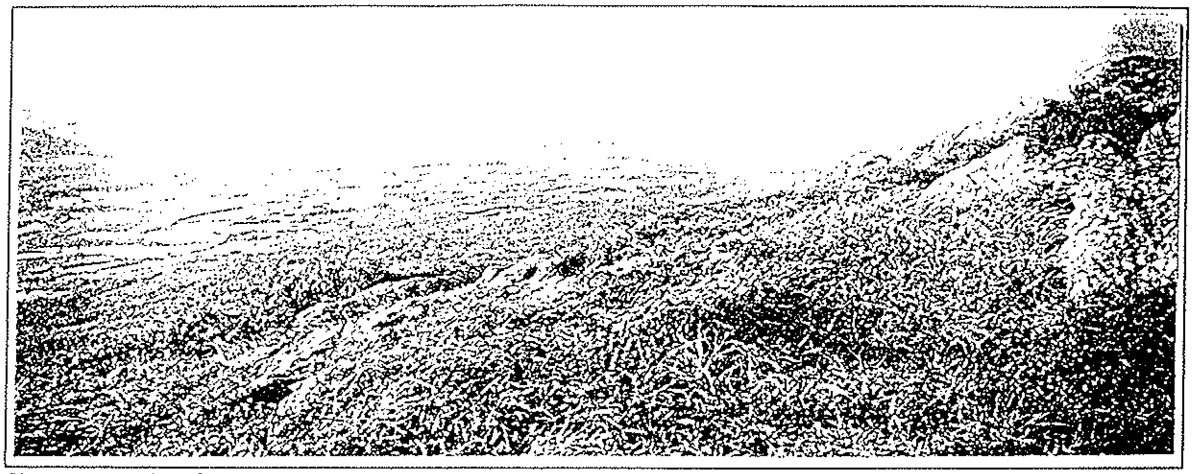
Transect Site #9 ~ East



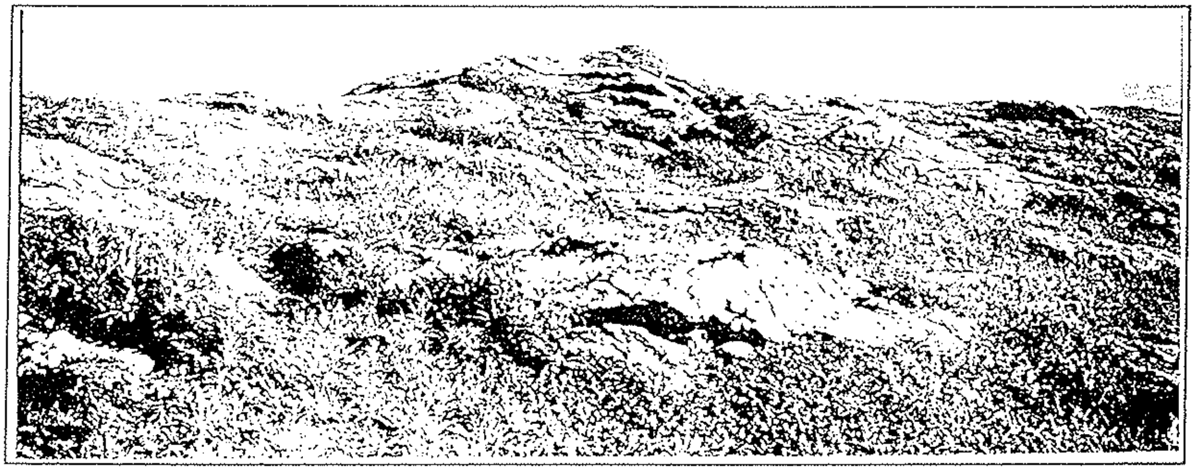
Transect Site #9 ~ West

Transect Site #9

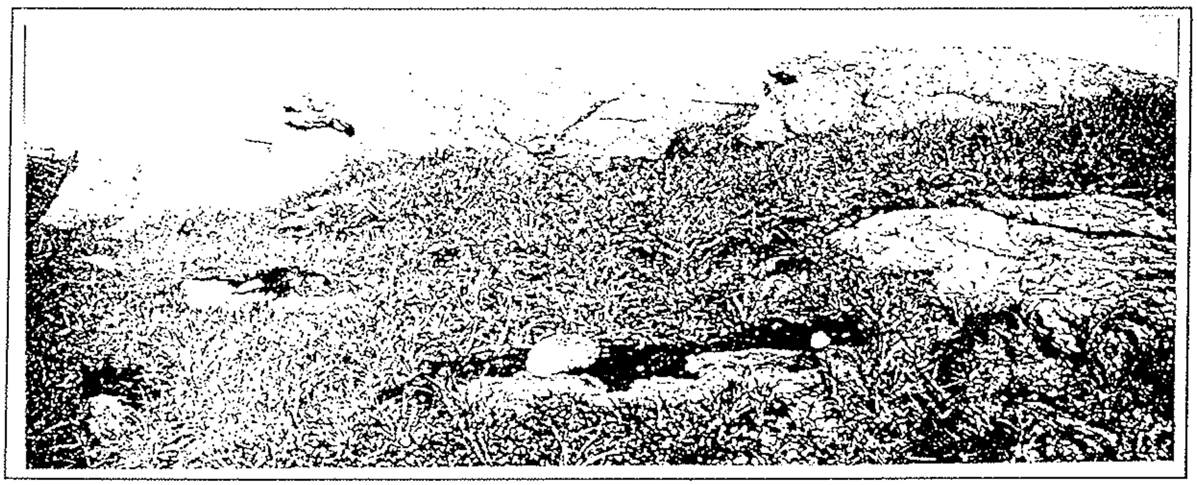
Transect #9 ~ North



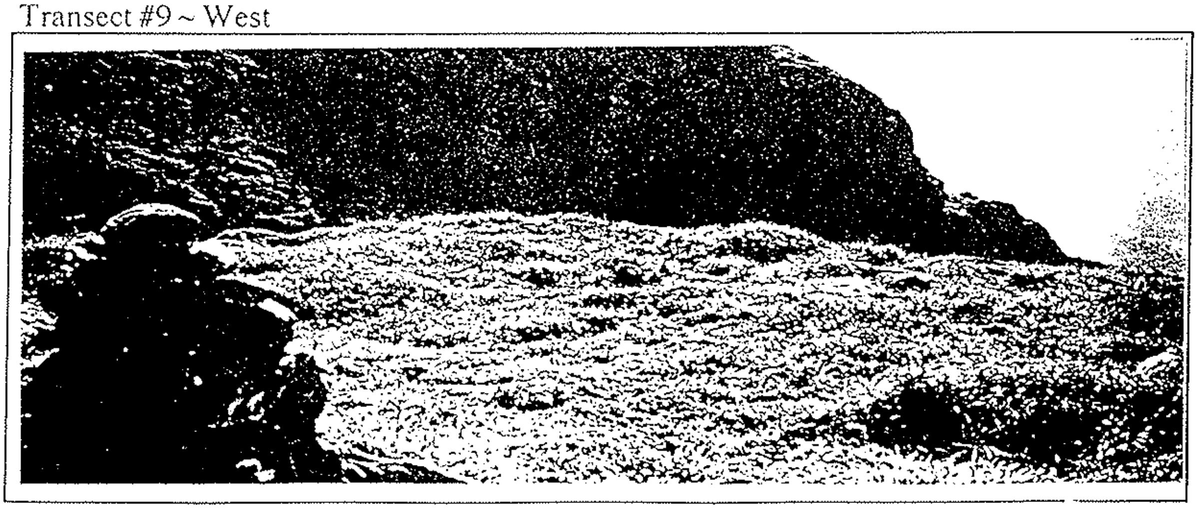
Transect #9 ~ South



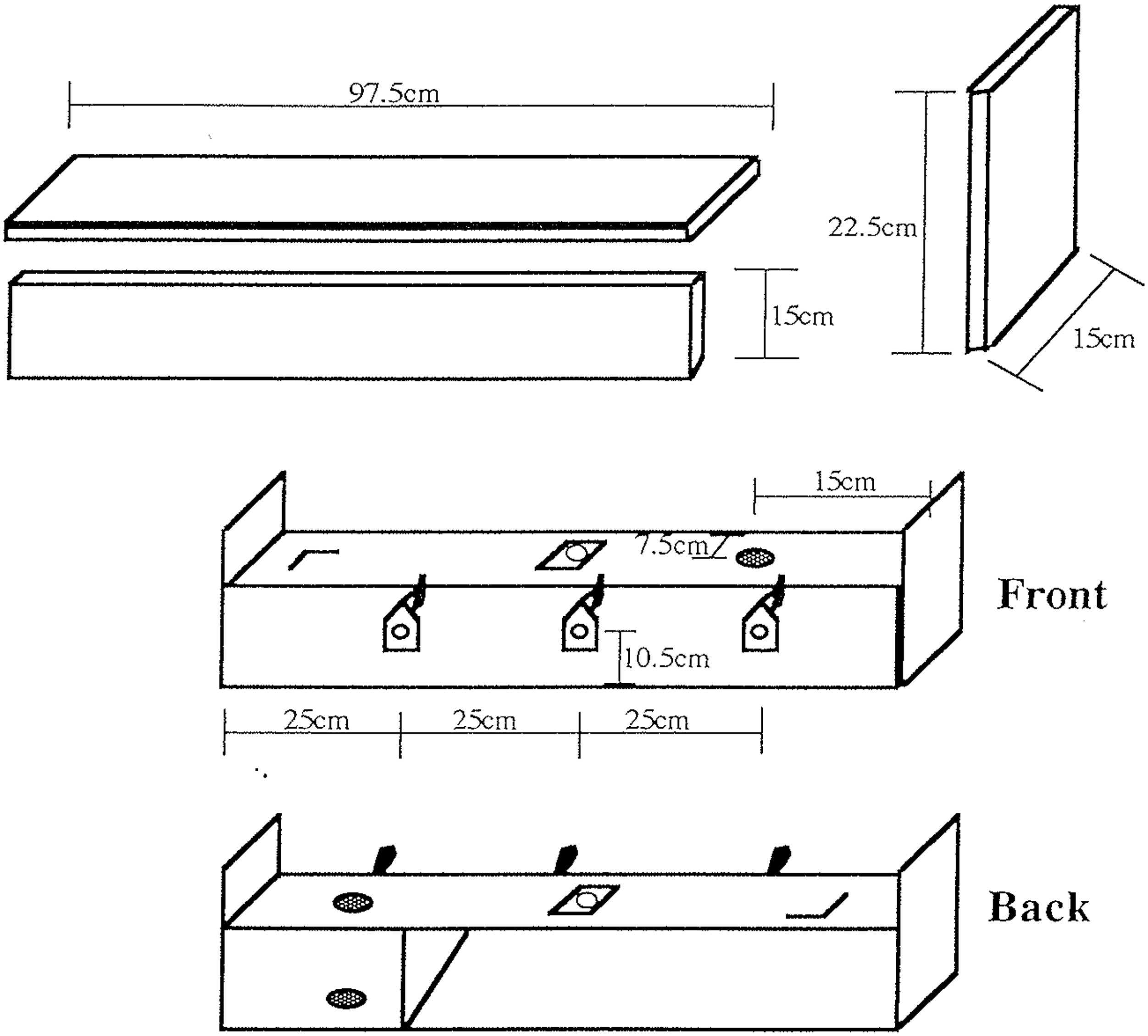
Transect #9 ~ East



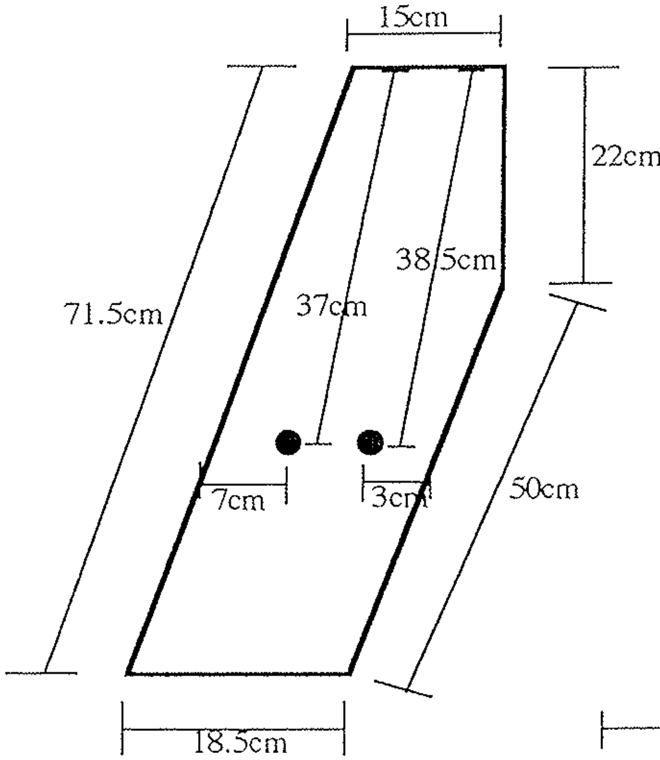
Transect #9 ~ West

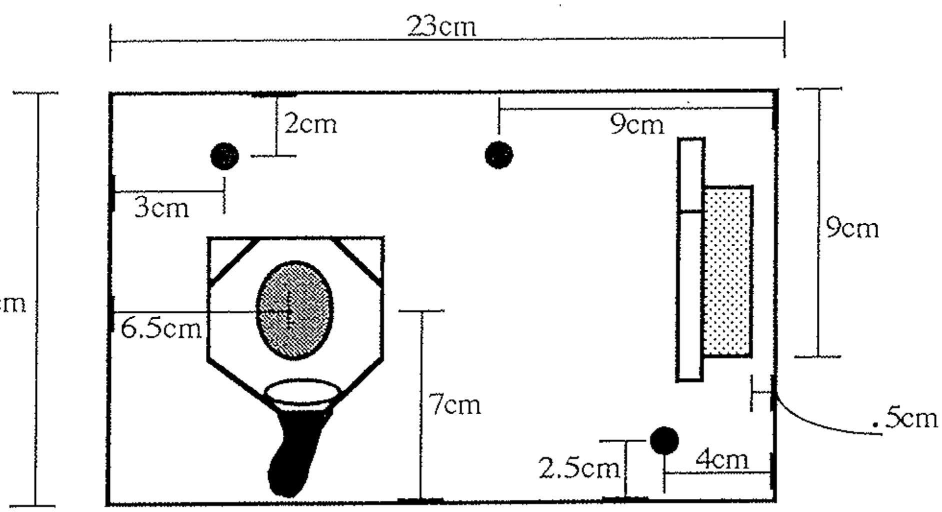


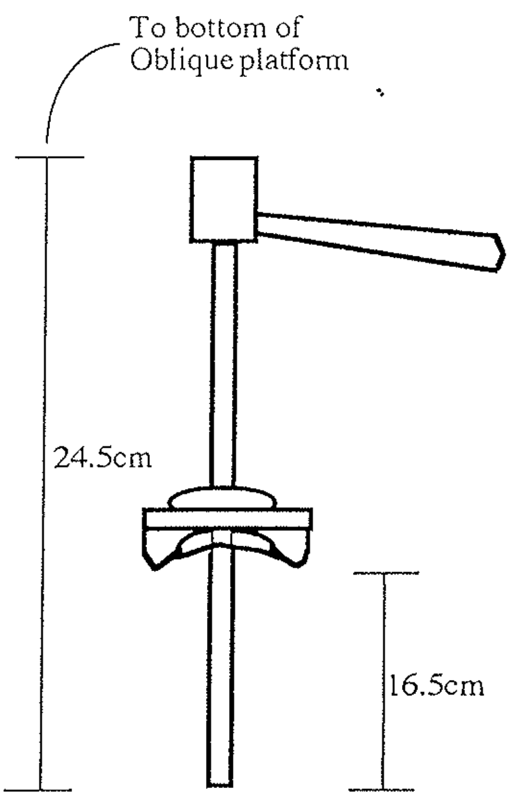
Quadropod Design Specifications
Quick Release Mounting Box



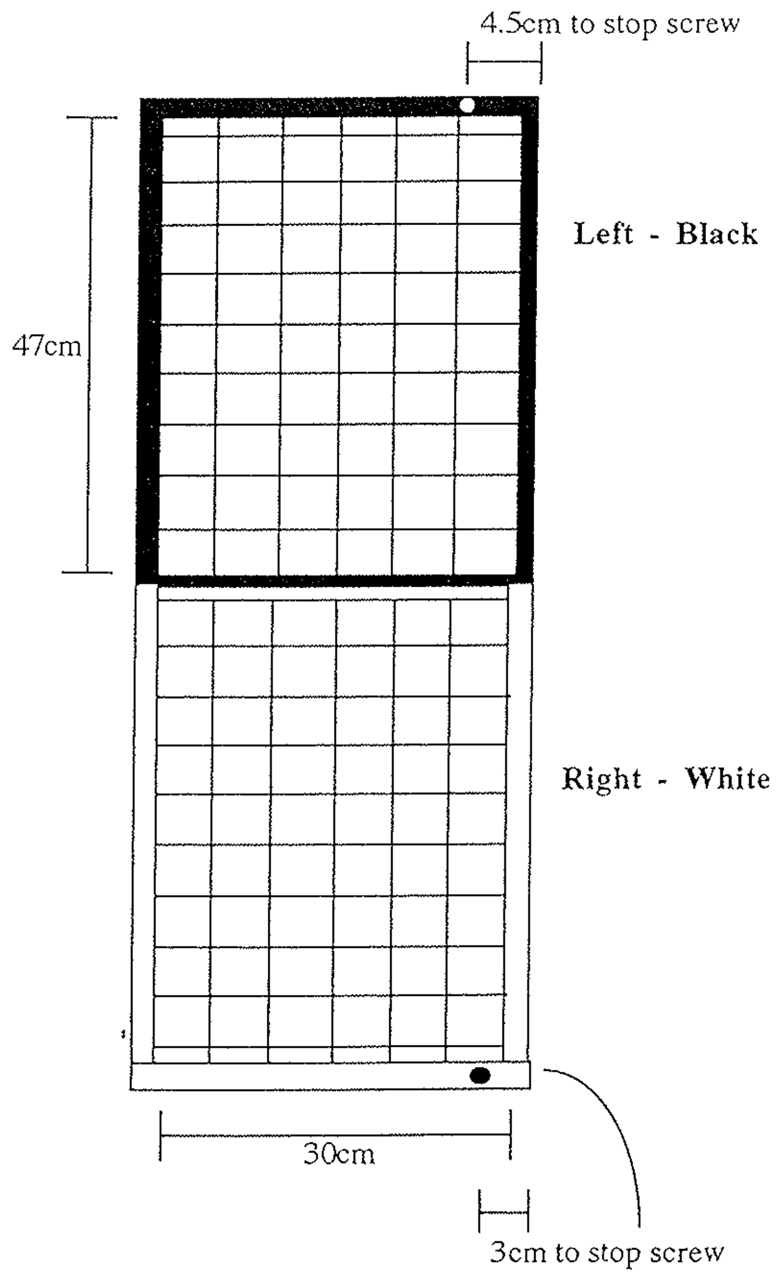
Quadropod Design Specifications
Quadrat Frame Support Legs, Oblique Orientation Platform and Oblique Orientation Platform Post

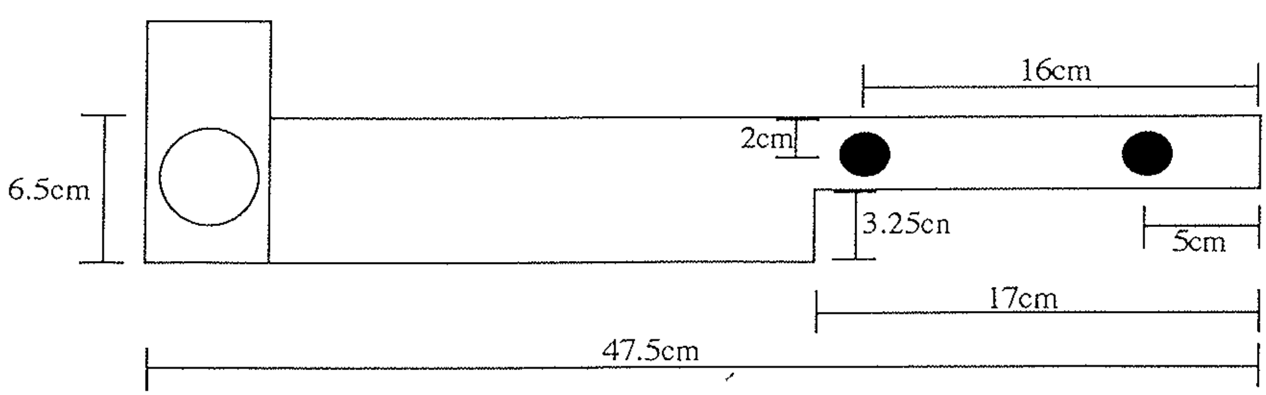






Quadropod Design Specifications
Quadrat Frame and Oblique Orientation Platform Compass Arm

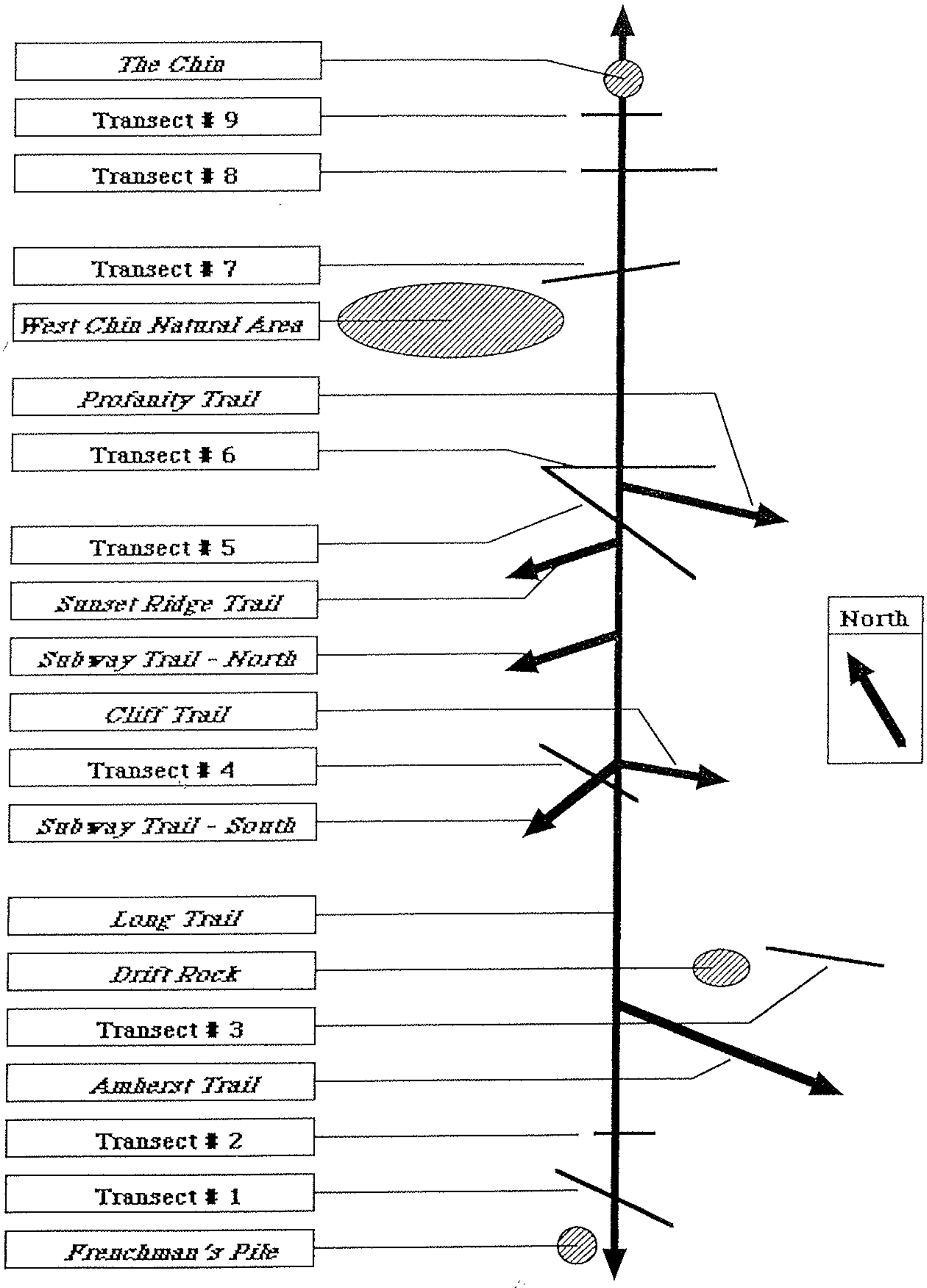




Transect Line Specifications

Transect #1		
From East Loop To:	Ferrule #1	315 cm
	Ferrule #2	549 cm
	West Loop	1,058 cm
Transect #2		
From East Loop To:	Ferrule #1	237 cm
	Ferrule #2	234 cm
	West Loop	559 cm
Transect #3		
From East Loop To:	Ferrule #1	50 cm
	Ferrule #2	262 cm
	Ferrule #3	300 cm
	West Loop	464 cm
Transect #4		
From East Loop To:	Ferrule #1	302 cm
	Ferrule #2	393 cm
	Ferrule #3	582 cm
	West Loop	733 cm
Transect #5		
From East Loop To:	Ferrule #1	136 cm
	Ferrule #2	239 cm
	Ferrule #3	373 cm
	West Loop	822 cm
Transect #6		
From East Loop To:	Ferrule #1	262 cm
	Ferrule #2	282 cm
	West Loop	660 cm
Transect #7		
From East Loop To:	Ferrule #1	368 cm
	Ferrule #2	522 cm
	West Loop	1,068 cm
Transect #8		
From East Loop To:	Ferrule #1	629 cm
	Ferrule #2	773 cm
	West Loop	1,031 cm
Transect #9		
From East Loop To:	Ferrule #1	350 cm
	Ferrule #2	411 cm
	West Loop	816 cm

Transect Site Location Map
Linear Rendition of Transect Site Locations



Transect Site Location Map
Mount Mansfield Area

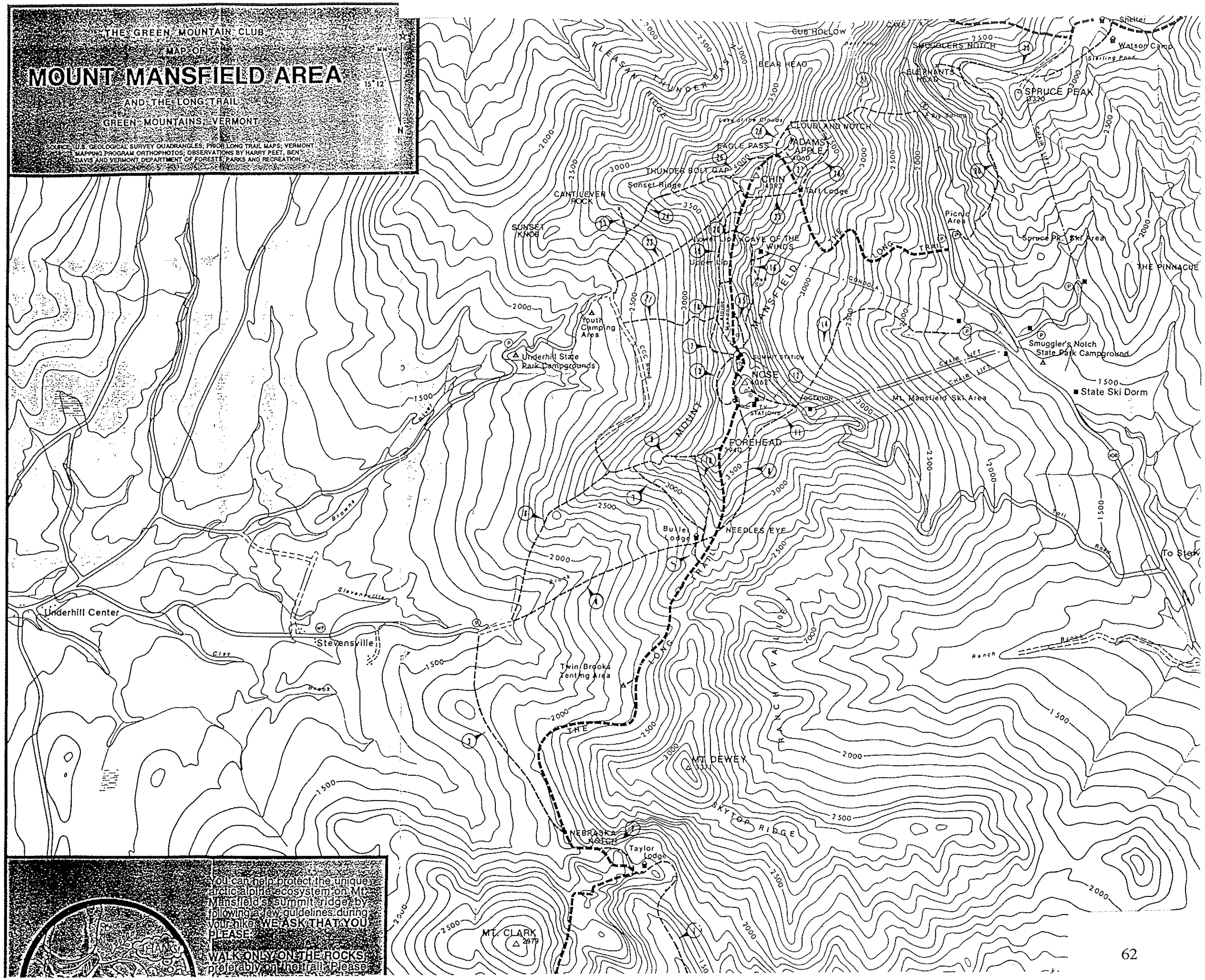
TRAILS

1	LAKE MANSFIELD	M
2	CLARA BOW	D
3	NEBRASKA NOTCH	E
4	BUTLER LODGE	M
5	WALLACE CUTOFF	E
6	FROST	M
7	ROCK GARDEN	M
8	FOREHEAD BYPASS	D
9	MAPLE RIDGE	M
10	WAMPAHOOFUS	DD
11	SOUTH LINK	M
12	TRIANGLE	DD
13	LAKE VIEW	M
14	HASELTON/NOSE DIVE	D
15	AMHERST	E
16	CLIFF	DD
17	CANYON	D
18	CANYON NORTH	D
19	CANYON NORTH EXTENSION	D
20	SUBWAY	DDD
21	HALFWAY HOUSE	DD
22	LAURA COWLES	D
23	CANTILEVER ROCK	E
24	SUNSET RIDGE	D
25	PROFANITY	DD
26	STORY	D
27	ADAM'S APPLE	E
28	HELL BROOK CUTOFF	M
29	HELL BROOK	DDD
30	ELEPHANT'S HEAD	DD

E EASY
M MODERATE
D DIFFICULT
DD VERY DIFFICULT
DDD EXTREMELY DIFFICULT

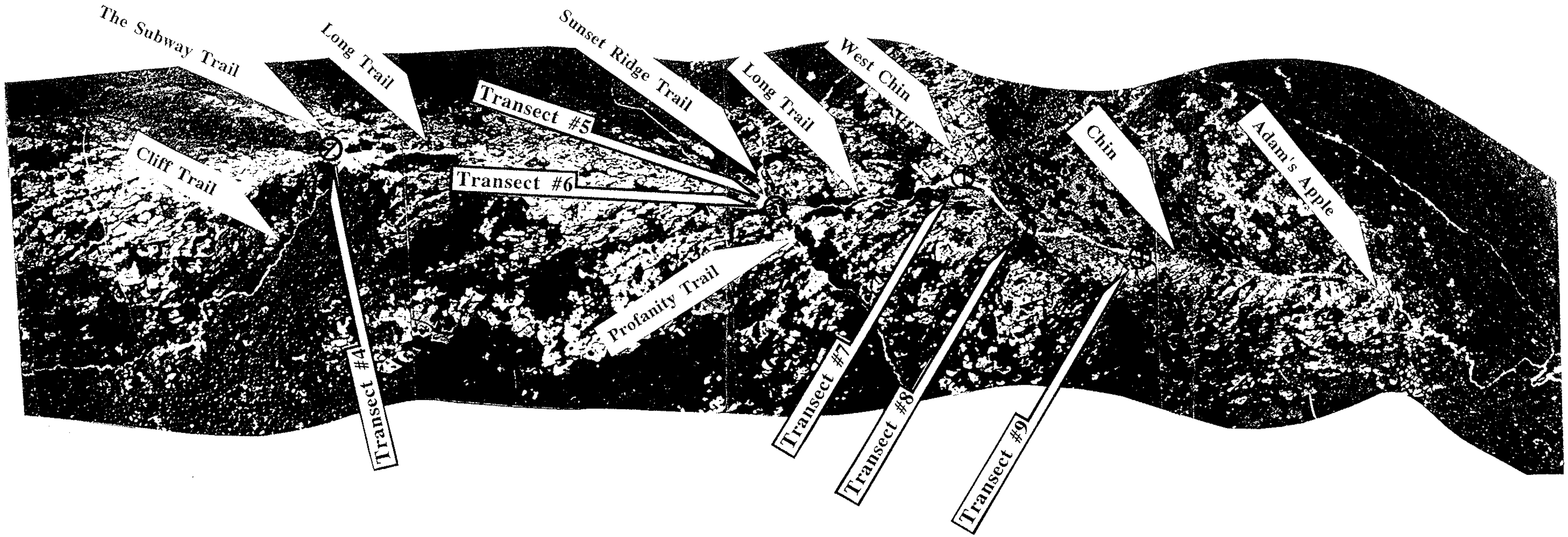
Trail numbers correspond to the 24th edition of the *Guidebook of the Long Trail.*

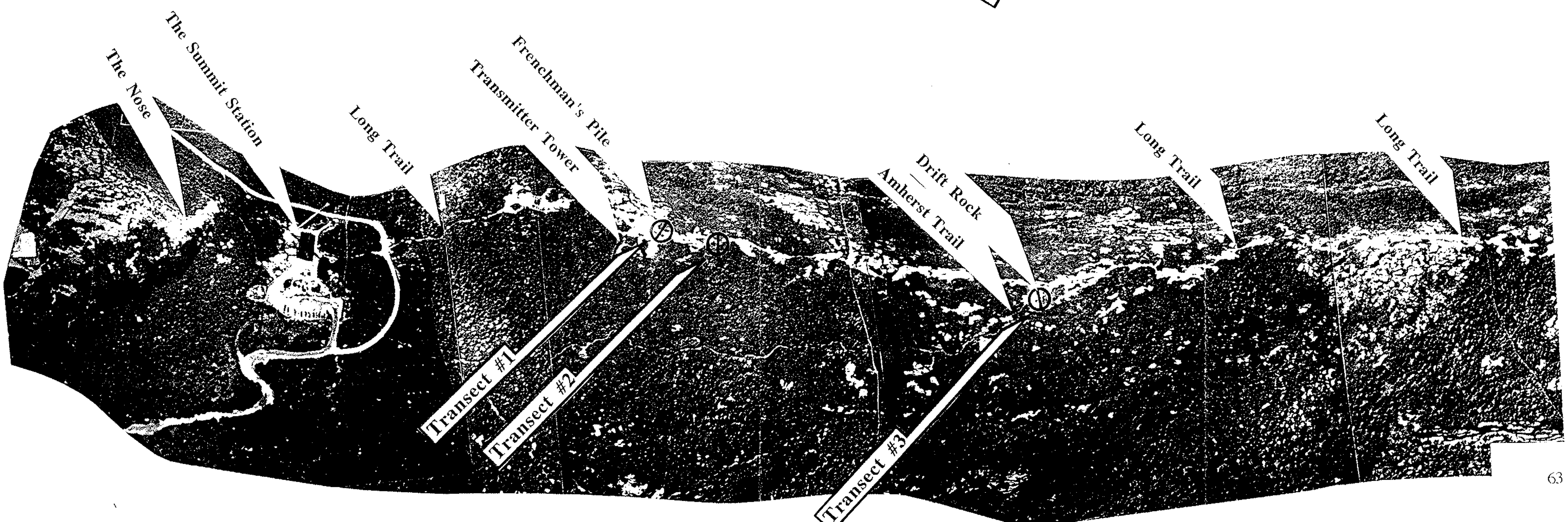
LONG TRAIL
SIDE TRAILS
ROADS
CHAIR LIFTS
STREAMS
LONG TRAIL SHELTERS
CAMPING AREA
OTHER BUILDINGS
SUMMITS
PARKING
WINTER PARKING
RADIO OR TV TOWERS



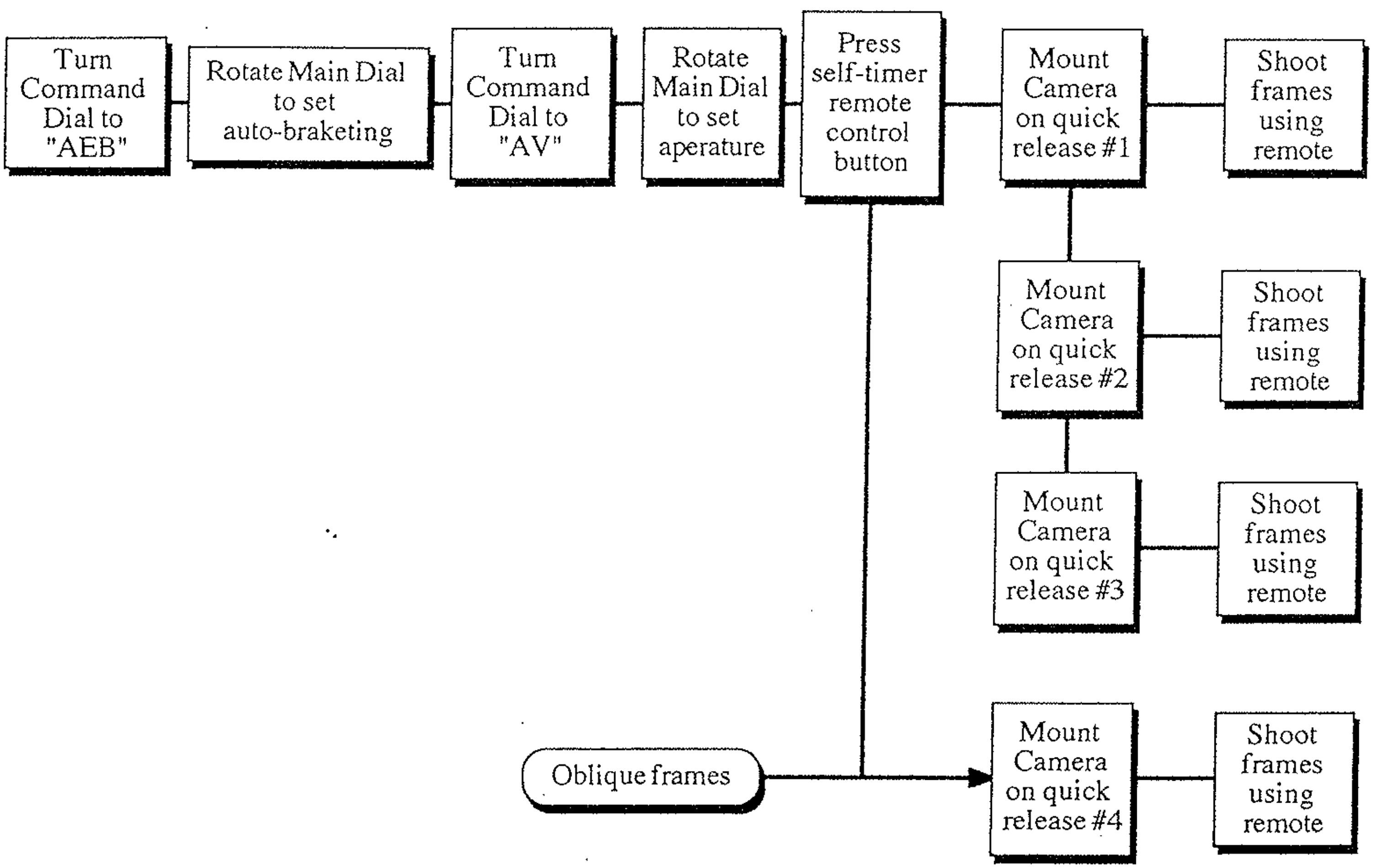
Transect Site Location Map

Arial photograph. Source: William Howland, Green Mountain Audubon Nature Center, Huntington Center, Vermont.

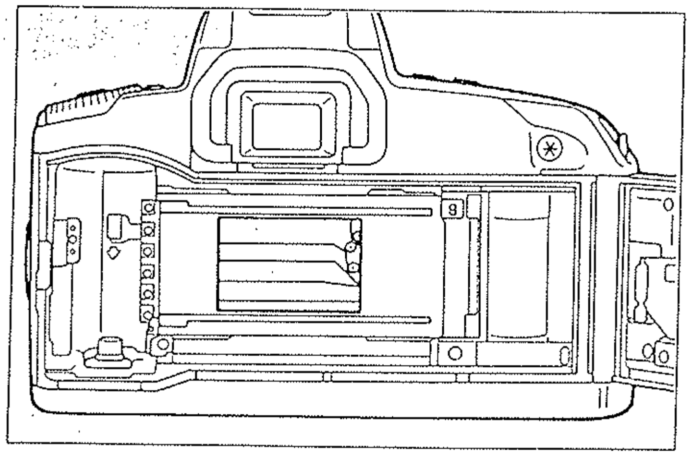


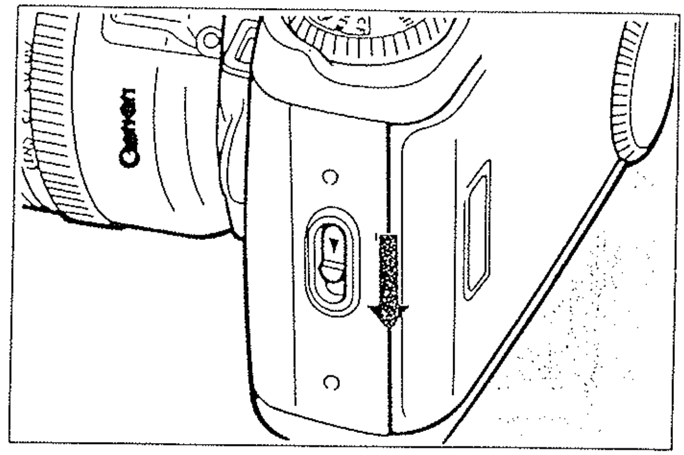


Camera Setting Task Flow Chart



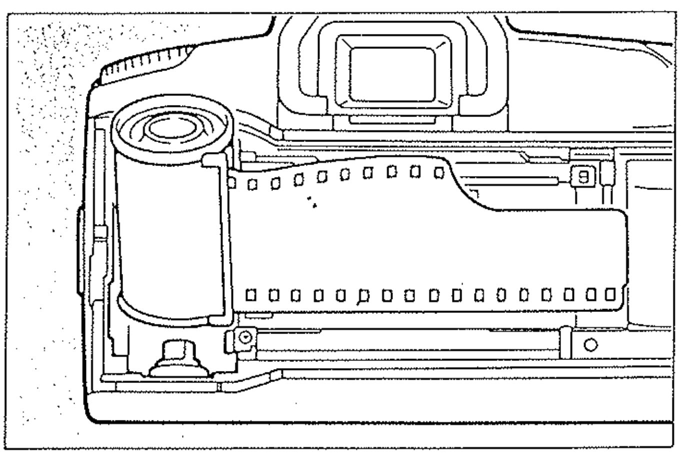
The shutter curtain operates with extremely high precision and can be easily damaged if touched. When loading or unloading film, be careful not to touch the shutter curtain accidentally with your finger or the tip of the film.



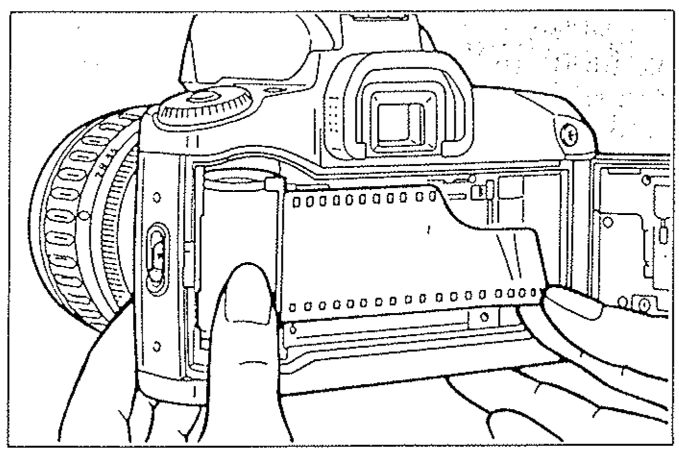


The film speed is set automatically according to the DX code on the film cartridge.

1) Open the back cover by sliding the back cover latch down.



2) With the film leader facing outward, insert the film cartridge so that the flat end enters the top of the film chamber.



3) While holding down the film cartridge, carefully pull the film tip across until it reaches the orange mark.
   * If you pull out too much film, wind the slack back into the cartridge.

Slide Preparation Prior to Archival

Deliver the film to the developers as soon as possible after the monitoring has been completed. Record the number of rolls submitted. After the film comes back from the developer check to make sure there are no developing problems that may adversely affect analysis of the slides. Immediately place the slides in archival slide pages. These are available at almost any camera store.

Each slide has an individual designation that refers to the transect site at which they were taken and where the camera was mounted for the picture. These designations follow the outline of the Photo Frame data sheet. The slides should be cross-checked with the Photo Frame data sheet to verify that each one is labeled properly. For example, the first slide should be a picture of the number one (1) indicating that it is the first roll of film shot. (When sorting the slides these numbered pictures can be discarded). The second slide will have the designation (T1-QE1). This designation means: T1 = Transect number 1 and QE1 = Quadrat East number 1. The third slide should have the designation (T1--QE2). This designation means: T1 = Transect number 1 and QE2 = Quadrat East number 2. The remainder of the slides should follow this pattern with the last slide having the designation (T9-OBS). This designation means: T9 = Transect number 9 and OBS = Oblique photo South.

Arrange the slides into the archiving sheets so that each transect is separated into individual sheets. Some transects require more than one archival sheet. There should be 12 sheets holding a maximum of twenty slides per sheet. The total number of slides is 205. Each slide pocket should be marked according to the proper slide designation. The sheets should be bound in a three ring binder and delivered to the Vermont Monitoring Cooperative for archiving.

Vermont Monitoring Cooperative
111 West St.
Essex junction, VT 05452-4695
802-879-6565

Equipment Specifications

Cannon EOS Elan EF 28-80mm F/3.5-5.6 Ultrasonic Still Camera EOS Elan Wide Strap and - Box #50339308 - Serial # 0H0806

Lithium Battery 2CR5

Cannon Remote RC-1, Cannon Inc., 1990 CY8-5689-009 PUYB. C-11-173P, Ohta-Ku, Tokyo 146 Japan.

Fujichrome PROVIA 100 Professional (Daylight Type) Process (CR-56 - E-6) RDP II

Silva Polaris Type 7 Compass. Siva Co., Box 1604 Binghamton, NY 13902

Suunto Optical Reading Clinometer - PM-5/360PC, SF-02920 Espoo, Finland

Stanley 3mm Line Levels

Slik U-5000 Tripod post and legs., Slik Coorporation, Tokyo, Japan. PAT.

Treadway Monitoring - Mount Manfield Natural Area

Site: This data is collected along the Mount Mansfield ridge line in north central Vermont, within the boundaries of the University of Vermont Mount Mansfield Natural Area. The individual transect sites are located along the Long Trail corridor hosted by the arctic-alpine zone between the "Nose" and the "Chin".

Field Collection

Name: ____________________

Date: ______|______|____

Office Check

Name ____________________

Date: ______|______|_____

	Transect #1	Transect #2	Transect #3	Transect #4	Transect #5	Transect #6	Transect #7	Transect #8	Transect #9
Time:									
Temperature:									
Wind:									
% Clouds:									
Weather:									
Site Notes:									

Photo-frame Sequence Chart

	Roll #1		Roll #2		Roll#3		Roll #4		Roll #5		Roll #6	
	Photo Frame Contents	Corrected Series	Photo Frame Contents	Corrected Series	Photo Frame Contents	Corrected Series	Photo Frame Contents	Corrected Series	Photo Frame Contents	Corrected Series	Photo Frame Contents	Corrected Series
Photo #1	>Number Shot<		>Number Shot<		>Number Shot<		>Number Shot<		>Number Shot<		>Number Sho<	
2	T1-QE1		T2-QW3		T4-QE1		T5-QE3		T6-QW2		T8-QW1	
3	T1-QE1		T2-QW3		T4-QE1		T5-QE3		T6-QW2		T8-QW1	
4	T1-QE1		T2-QW3		T4-QE1		T5-QE3		T6-QW2		T8-QW1	
5	T1-QE2		T2-OBN		T4-QE2		T5-QM1		T6-QW3		T8-QW2	
6	T1-QE2		T2-OBS		T4-QE2		T5-QM1		T6-QW3		T8-QW2	
7	T1-QE2		T3-QE1		T4-QE2		T5-QM1		T6-QW3		T8-QW2	
8	T1-QE3		T3-QE1		T4-QE3		T5-QM2		T7-QE1		T8-QW3	
9	T1-QE3		T3-QE1		T4-QE3		T5-QM2		T7-QE1		T8-QW3	
10	T1-QE3		T3-QE2		T4-QE3		T5-QM2		T7-QE1		T8-QW3	
11	T1-QW1		T3-QE2		T4-OBN		T5-QM3		T7-QE2		T7-OBN	
12	T1-QW1		T3-QE2		T4-OBS		T5-QM3		T7-QE2		T7-OBS	
13	T1-QW1		T3-QE3		T4-QM1		T5-QM3		T7-QE2		T9-QE1	
14	T1-QW2		T3-QE3		T4-QM1		T5-QW1		T7-QE3		T9-QE1	
15	T1-QW2		T3-QE3		T4-QM1		T5-QW1		T7-QE3		T9-QE1	
16	T1-QW2		T3-QM1		T4-QM2		T5-QW1		T7-QE3		T9-QE2	
17	T1-QW3		T3-QM1		T4-QM2		T5-QW2		T7-QW1		T9-QE2	
18	T1-QW3		T3-QM1		T4-QM2		T5-QW2		T7-QW1		T9-QE2	
19	T1-QW3		T3-QM2		T4-QM3		T5-QW2		T7-QW1		T9-QE3	
20	T1-OBN		T3-QM2		T4-QM3		T5-QW3		T7-QW2		T9-QE3	
21	T1-OBS		T3-QM2		T4-QM3		T5-QW3		T7-QW2		T9-QE3	
22	T2-QE1		T3-QM3		T4-QW1		T5-QW3		T7-QW2		T9-QW1	
23	T2-QE1		T3-QM3		T4-QW1		T5-OBN		T7-QW3		T9-QW1	
24	T2-QE1		T3-QM3		T4-QW1		T5-OBS		T7-QW3		T9-QW1	
25	T2-QE2		T3-QW1		T4-QW2		T6-QE1		T7-QW3		T9-QW2	
26	T2-QE2		T3-QW1		T4-QW2		T6-QE1		T7-OBN		T9-QW2	
27	T2-QE2		T3-QW1		T4-QW2		T6-QE1		T7-OBS		T9-QW2	
28	T2-QE3		T3-QW2		T4-QW3		T6-QE2		T8-QE1		T9-QW3	
29	T2-QE3		T3-QW2		T4-QW3		T6-QE2		T8-QE1		T9-QW3	
30	T2-QE3		T3-QW2		T4-QW3		T6-QE2		T8-QE1		T9-QW3	
31	T2-QW1		T3-QW3		T5-QE1		T6-QE3		T8-QE2		T9-OBN	
32	T2-QW1		T3-QW3		T5-QE1		T6-QE3		T8-QE2		T9-OBS	
33	T2-QW1		T3-QW3		T5-QE1		T6-QE3		T8-QE2		>Spare Frame<	
34	T2-QW2		T3-OBN		T5-QE2		T6-QW1		T8-QE3		>Spare Frame<	
35	T2-QW2		T3-OBS		T5-QE2		T6-QW1		T8-QE3		>Spare Frame<	
36	T2-QW2		>Spare Frame<		T5-QE2		T6-QW1		T8-QE3		>Spare Frame<	

(Photo #) is the number of the picture frame indicated on the camera.
(Number Shot) is a picture to be taken of the number of the roll of film (i.e. 1-6).
(Spare Frame) is a frame that is not utilized in the photo series.

(T1-QE2) indicates a photo frame location where:
T=Transect
1=Transect Site Number
Q=Quadrat
E=East (quadrats are East, West, or Middle)
2=Release Mount #2 (mounts are #1,2, and 3)

(T1-OBN) indicates an oblique photo frame location where:
T=Transect
1=Transect Site Number
OB=Oblique
N=North (obliques are North or South)