

PIMS

Photographic Inventory Monitoring System

Excerpts from this Thesis and Procedural Manual

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

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March 1996**

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

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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.

1.3 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.

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 convenient 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 gullied 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 Fuji 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.

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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)
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Oblique (T1-OBS)	Azimuth: 160°	Inclination: (-15)
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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 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

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.

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°

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 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: 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)
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Oblique (T5-OBS)	Azimuth: 120°	Inclination: (-25)
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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°

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 bedrock 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)
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Oblique (T7-OBS)	Azimuth: 120°	Inclination: (-25)
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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: 1,031 cm

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)

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 channelling 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 Line Specifications

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

