An Analysis of Low Altitude Infrared Aerial Photography as a Tool for Monitoring Human Impact Site Changes at Gates of the Arctic National Park and Preserve.

Project Report

By

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I. Introduction

The Gates of the Arctic National Park and Preserve (GAAR), which was established in 1980, is a remote 'Wilderness Park' with approximately 2,000-4,000 visitors each year. Within the some 8.5 million acres of land that the Park and Preserve encompasses, there are no officially established trails, campsites or road access. Visitation is concentrated in the main river drainages and signs of visitor use are most evident along rivers and close to lakes within these drainages. The drainages, most heavily visited, serve as the easiest mode of travel through GAAR because tussocks and wet areas make hiking difficult. The lakes near these river drainages serve as float plane drop off points for visitors. Exact records of human visitation to GAAR are not available because GAAR has no official visitor registration/permit system or recent studies of human use patterns. Main human use areas, that are most in need of long term monitoring, have been selected for this study through GAAR's internal ranger reports, an established Human Impact Site (HIS) inventory system, unofficial talks with visitors and Park rangers, as well as, personal visitation of the Park. The main areas with high concentration of human use include the Noatak River Valley, the North Fork of the Koyukuk River Valley, the Kobuk River Valley including Walker Lake and the Itkillik River Valley. Although visitor use may seem low compared to other areas of this size, the vegetation within the Park is easily impacted and extensive studies are needed to monitor impact and prevent further damage to vegetation.

The GAAR, Resource Management Division is in need of an efficient, reliable system of measurement to interpret changes at Human Impact Sites (HISs) within GAAR boundaries. HISs, for our purposes, will be defined as areas within GAAR where vegetation has been disturbed and soil compacted and/or exposed by use of the area by humans. Human impact is generally characterized by cut trees, fire-rings, litter, developed human trails, tent pad sites, exposed soil and damaged vegetation. In previous years at GAAR, permanent vegetation sampling plots were used to monitor an increase or decrease of human impact in an area. Permanent plot markers were not used because of problems with ground heaving and the avoidance of disruption of the Park patron's 'Wilderness Experience'. Plots were referenced by trees, photographs and maps of the plot sites. In 1989, a summary and evaluation of the data collected for analysis of Human Impact Sites by means of the permanent vegetation plots was written. The methods employed throughout various permanent vegetation plot studies proved to be inadequate for the objectives of the general study which in short were to "provide GAAR with descriptions of current vegetation, ... document the continuum from the undisturbed to disturbed vegetation in a given microhabitat" and "to document impacted locations, amounts of trash, species indicative of impact, exotic species, mineral soil exposed, the effect of impact of loss of soil cover and the change in species over time" (Green 1982). The problems with the methodology used were manifold and include: 1.) too few plots sampled for each vegetation type (approximately 5-6 $1m^2$ plots per transect with approximately 1-3 transects per site), 2.) absence of careful photo documentation and mapping necessary with methods used, 3.) lack of human use documentation at each site needed to study vegetation succession, 4.) inconsistent interpretation of data from year to year and 5.) movements of original plot measurements.

In light of all the difficulties with permanent vegetation plots used in the past by the Park, GAAR's Resource Management Division staff members were looking for an alternative system of HIS evaluation. In the summers of 1989 and 1990, GAAR took a series of low-altitude infrared aerial photographs of HISs in the Park. This was done to determine if this method of data gathering would be more effective in reading HIS changes than the permanent vegetation plots that GAAR was using at the time. The infrared aerial photographs in general were easily interpreted and clearly showed the main features of the impact sites. In order to use this tool for long-term monitoring, further analysis was needed to detail the capabilities of this technique.

There are several advantages to monitoring by remote sensing over intensive ground vegetation analysis. Once a remote sensing monitoring system is established the time and monetary costs of aerial photography would be minimal in comparison to ground vegetation analysis. Additionally, aerial photography is more easily repeatable, easily interpreted and has the possibilities for integration with a Geographical Information System (GIS) which can be used for complicated integration and analysis of data. Low altitude infrared aerial photography is an option for HIS evaluation and this summer as a Biological Technician for GAAR I explored the utility of this technique as a management tool for assessing vegetation change at HISs.

Can low altitude infrared aerial photography effectively measure changes in HISs in a remote interior Alaskan wilderness area? Will a low altitude infrared aerial photography monitoring program be more accurate than a ground based monitoring system for such a wilderness area? Can a low altitude infrared aerial photography monitoring program be more time and cost effective than a ground based monitoring system for such a wilderness area? The purpose of my project is to develop a useable, accurate, effective human impact change monitoring program for GAAR. This project once complete will be used as reference and instructional material for future GAAR Resource Management employees for the continuation of a monitoring program with analysis of results for use in making future policy decisions concerning human use of the Park.

II. Methodology

Several HISs were chosen for this study from each of the following areas: the Noatak River Valley, the North Fork of the Koyukuk River Valley, Walker Lake, and the Itkillik River Valley (Appendix A). HISs were chosen from the most heavily impacted areas of GAAR. The sites chosen are representative of most major vegetation classifications found in GAAR. This was done to ensure representative data throughout the Park that would serve as a future guide for interpretation of changes in all GAAR HISs.

Two 35mm SLR cameras were used to take aerial photographs of the HISs. This choice of equipment was made because of cost, size, and accuracy. Several film choices were selected for experimentation. Based on current photogrammetry literature, color infrared (CIR) film in combination with a yellow filter has the highest contrast and is quite effective in identifying vegetation, soil, and stresses on vegetation and soil. Regular color film is less costly and does not need uniform brightness like CIR film does but does not have such high contrast and sensitivity. CIR and color film were chosen as film types used. Kodak Ektachrome infrared film (IE 135-36) which is best purchased in bulk from a film supplier for freshness, can be purchased from Rainier Photographic Supply in Seattle, WA (1-800-255-3456), Lindahls in Denver CO (303-534-3948), or Castleton Labs in Anchorage, AK (907-274-3017). Color infrared film when purchased in bulk comes in groups of 20 rolls, each roll having 36 exposures. Color film can be purchased through most retail camera outfits. The color film chosen was Kodak Vericolor 400 Professional Color Negative Film (5VPH 135-36, Process C-41). This particular color film was recommended to me by the Kodak aerial photography expert as a good choice for low altitude aerial photographs. Advantages and disadvantages of each film type will be noted in this study's analytical phase so that GAAR will be able to make effective decisions when selecting film for future aerial photographs.

One to several stereopair were taken of each HIS with each of the two film types of film. CIR photographs were taken with the FG Nikon with MD-14 and Tiffin 52mm #12 Yellow using a 70mm lens. Photographs were taken out of the left hand window of GAAR's Piper Supercub. CIR stereopairs were attained by setting the motor drive (MD-14) on low having an exposure cycle of 2 frames per second. The plane was flown at a height above ground of 400 feet and a speed of 70 mph giving the photographs a scale of 1in./145ft. (1/1741 unitless ratio). Color photographs were taken with the Canon T-70 with Command Back using a 135mm lens. These photographs were also taken out of the left hand window of GAAR's Piper Supercub. Color stereopairs were attained by continuous pressure on the shutter button for an exposure cycle of 1.5 frames per second. The plane was flown at a height above ground of 825 feet and a speed of 60 mph giving the photographs a scale of 1in./155ft. (1/1863). Once exposed the CIR film was frozen and sent in a padded mailer immediately to Rocky Mtn Film Lab., 145 Madison St. Denver Co. 80206 (303-399-644) for special E-4 processing. Once the processed slides were received a careful selection of the best stereopairs was made and the selected slides were sent back to Rocky Mtn Film Lab for direct print 8 X 10 enlargements. Please note that once purchased the CIR film should be frozen to slow down aging of the film. It is necessary to pull out the film four hours in advance of exposure to ensure thawing. Another option since flying weather is very unpredictable, is to put several rolls of CIR film in the refrigerator if you plan on using the film within a week or two. If CIR film is taken out in the field for a flying mission but not exposed, it is necessary to refrigerate or freeze immediately upon return. Color film was kept fresh by refrigeration. Color film was sent to Fast Photo in Fairbanks for development. Approximately, nine rolls of CIR film and nine rolls of color film were used this summer to document seven HISs.

By chance, GAAR was able to enlist the cooperation of the Bureau of Land Management high altitude aerial photography experts to take several vertical, high altitude, black and white, 70mm stereo photographs of HISs at Itkillik Lake, Oolah Lake and Island Lake. This was very fortunate because it will allow a comparison of the oblique low altitude aerial photographs with the vertical high altitude aerial photographs. Advantages and disadvantages of both types of photographs will be assessed in my analysis and a recommendation will be given to GAAR as to the best method to use in the future.

Aerial photographs and ground vegetation study of each HIS followed closely in terms of time, to minimize plant growth change and additional human impact of the sites which would cause inconsistent comparisons of ground and air data. Since spectral variation between vegetation species is greatest in spring and fall, aerial photographs were taken of each HIS in June and September. Due to overcast skies throughout most of the month of August's available flying time, it was difficult to take the 2nd set of CIR photos of all HISs. When weather finally permitted (sunny skies), I was able to take the photographs but not until the first part of September. At this time the leaves on most of the vegetation were senescent which may present a problem in interpretation of the CIR photographs. Since the summer season is so short in the arctic I would suggest taking the CIR photographs for HISs, in the future, during the end of June or throughout July. This time table would most likely give the photographer the most available sunny days in which to take the CIR photographs. Plane availability is also another factor that must be taken into account when planning over-flights of HISs. This availability changes field season to field season and day to day. My suggestion, to the photographer planning his/her schedule, is to be flexible! The best way to plan is to be available for a stretch of 5-10 days where one would be in Bettles Ranger Station ready to fly, but would have other work to do if the flying was not possible. If this is not possible, it is feasible, as was proven this field season, to get the flying done with several days in between other backcountry assignments.

For comparison with aerial photos, a vegetation sampling study was conducted. Vegetation sampling began with a reconnaissance of the area. This included a general inspection of the site where an initial species presence list was made. Identification of species was taken from Hulten's Flora of Alaska and Neighboring Territories, Viereck and Little's Alaska Trees and Shrubs and Vitt, Marsh, and Bovey's Mosses, Lichens and Ferns of Northwest North America. Changes from impacted to non-impacted areas were observed with a visual delineation of a core impact area. A core impact area is defined by pronounced changes in vegetation cover, vegetation composition, vegetation height/disturbance, topography, and organic litter. At this time a general site description was made giving site location in latitude and longitude, map quadrat and HIS area. Next a condition class was given to the area from a choice of 5 classes seen in Appendix B. Bearing and distance of each trail from the center stake or other permanent feature were recorded for mapping. A vegetation classification was made for each area using Vierek, Dyrness, and Batten's The 1986 Revision of the Alaska Vegetation Classification. If the area was forested a clinometer reading of a prominent healthy tree was taken and a calculation of the height of the tree was made. Descriptive information was noted for future relocation of tree. The formula used was (apex measurement + base measurement)/100 X distance from tree to the person taking measurement. This formula is only appropriate when the base measurement is zero or negative which was the case with all base measurements taken on the selected HISs. This will later help as a reference guide when measurements are taken from aerial photographs. All reconnaissance information was recorded on a data sheet to be looked at further (See Appendix C).

After a thorough reconnaissance of the area a measurement of the core impact area with auxiliaries was made. The procedures used to measure these area were the Azimuth Method or Geometric Method. The decision of which measurement technique to use was determined by the shape of the core area and auxiliaries. If the core area and auxiliaries was reasonably shaped like a square, rectangle, circle or other geometric form the Geometric Method was used. This measurement technique consisted of visualizing the impacted area as a geometric form and measuring it accordingly. This may mean the trimming off and adding on of certain parts of the impacted area with the measurement. With this technique a rather gross estimation of the impacted area is attained. When an HIS was very oddly shaped and a Geometric Method would have a large margin of error the Azimuth Method was used. When using the Azimuth Method a center point of the core impact or auxiliary area is established. The center point was established visually and marked with a painted tent stake. Eight linear transects were laid out radiating from the center point. These linear transects were laid out every 45° starting at 0° N. Each linear transect was measured. The linear transect measurements were added up and averaged. The averaged linear transect measurement was then used as the averaged radius (r_A) in the mathematical formula for the area of a circle, πr_A^2. This Azimuth Method is much more time consuming than the Geometric Method, but will give a more accurate measurement. All measurements were recorded for future comparison (Appendix D)

Area of sampling was established next. A plot size was determined depending on the HISs size and diversity of the vegetation community. A transect marker line was established from the center stake outward, if possible so that it would extend through impacted, transitional, and non-impacted area. In areas where this was not possible because of size of the HIS, separate plots were established, one plot being primarily impacted and transitional and a second comprised of primarily non-impacted and transitional area. The transect marker line endpoints were marked for second visit accuracy. Off of the transect marker line, parallel transects were laid at regular intervals. Four transect lines were established at each site. Descriptions of locations of transect marker lines and quadrats were noted on forms (Appendix E) with bearings and lengths. Quadrats were placed along the transect lines regularly. Five 20cm x 50cm herb quadrats and five 2m x 5m or 2m x 2m shrub quadrats were placed along each of the transect lines. This made for a total of 20 herb quadrats and 20 shrub quadrats per HIS. Herb quadrats were nested within the shrub quadrats. If shrubs on the site were dwarf in size, the 2m x 2m shrub quadrat was used. If shrubs on the site were larger than dwarf in size, the 2m x 5m shrub quadrat was used. Locations of quadrats on transects were noted for second visit relocation. Size and number of transects and quadrats were originally selected according to vegetation diversity of this general arctic region, and time available for sampling. It is the hope of the author that increasing the number of transects and quadrats as well as decreasing the size of the herb quadrat and adding a shrub quadrat will help to avoid past vegetation sampling mistakes.

Quadrats were sampled first with a species presence list and next by percent cover using Daubenmire's cover scale (Daubenmire, 1959, 1968; Dieter Mueller-Dombois and Heinz Ellenberg, 1974, p. 63) (Appendix F). Vitality was estimated using the following symbols by Braun Blanquet (Dieter Mueller-Dombois and Heinz Ellenberg, 1974, p. 65):

^ very feeble and never fruiting (e.g., 2^)
* feeble (e.g., 1*)
  no index; normal
! exceptionally vigorous (e.g. 3!)

If the HIS had trees on it, seedlings, saplings and trees within the plot area were recorded. Species and number were recorded for seedlings and saplings while species and DBH were recorded for adult trees. Along with vegetation other conditions were noted in each herb quadrat for complete analysis. These conditions included percent cover of litter and mulch, bare soil, rock fragments, water scat, bone, and other. Vegetation sampling sample forms can be seen at the end of this paper in Appendix G.

Photo documentation was done at each site for reference and on the ground photo comparison with aerial photos. General reference photos were taken for easy second visit orientation. Center stake, transect marker line and transect lines were photographed. Site boundaries and distinction between impacted and non-impacted areas were documented. All photos were referenced with roll and frame number as well as description of content (Appendix H).

Vegetation sampling on each HIS was by far the most important and hence, time consuming activity of my study. One complimentary part of this study added to the vegetation sampling, was soil sampling. Soil samples of both impacted and non-impacted areas of each HIS were taken to be paired with vegetation sampling. Information taken from the soil samples included description, classification and measurement (thickness of litter horizon, fermentation layer and humus layer) of organic mat; description, texturization and color classification (using Munzel color charts) of mineral soil; and volume, weight, and bulk density of mineral soil clods (Appendix I). Bulk density measurements were done back at the Bettles field station where clods taken in the field were weighed, encased in wax and dunked in water to find volume. Bulk density measurement is useful for its ability to show changes in soil compaction. Soil compaction is often viewed as a sign of impact.

A rough map of each site was made at the time of visitation. Maps will be formalized this fall and winter so that they are drawn to scale using a grid, measurements taken in the field and aerial photos. The site will be referenced to a smaller scale map of 1:63,360. Transects, the transect marker line, quadrats, vegetation, delineation between impacted and non-impacted area and any other significant features will be included on this map.

All sites were visited and photographed twice to gain information about each site at two different times during the season and at two different stages of impact and plant growth.

III. Analysis

All analysis of vegetation sampling, soil sampling and photographs will be made during the fall and winter of 1992-1993 after all photographs have been developed. The data collected this field season and the subsequent analysis is part of my master's thesis work at the University of Wisconsin - Madison, Institute of Environmental Studies - Land Resources Program. Once completed my thesis will serve as an instructional manual for Gates of the Arctic National Park and Preserve as it pursues an aerial photography monitoring program for HISs throughout the Park.

The analytical phase of this project will include the comparison of data retrieved from site vegetation sampling with information gathered from infrared aerial photographs. Initially vegetation information will be analyzed separately from photographs through multi-variate analysis techniques. Then the comparison will ensue and the degree of photographic detail will be analyzed. Ground vegetation plots will be matched with the same points on photographs and compared using a stereoscope or through computer digitization of photographs. A classification accuracy assessment will be made using a contingency table (error matrix). This assessment will statistically test the interpretation accuracy of the infrared and color aerial photographs. Comparisons of film choice and altitude choice will be made. Accuracy of interpretation of seasonal and impact changes between first and second site visits will be assessed with information derived from contingency tables. All contingency tables will be standardized and similar factors compared. Best level of altitude and best choice of film for vegetation and stress interpretation will be assessed. This accuracy assessment will aid future interpretation of photographs. Advantages and disadvantages of the various film choices including the black and white, high altitude 70mm photographs will be documented so that GAAR will be able to use this information when choosing a film for future documentation.

Color infrared aerial photographs taken in previous years will be interpreted. This data will be incorporated with the analysis of this field season's work.

Soil compaction differences will be looked at on impacted and non-impacted areas of each HIS. Changes in soil coloration on aerial photos will be analyzed and may help in determination of levels of impact on HISs. Variation in soil compaction are often displayed as color intensity variations on aerial photographs.

It is the hope of the author that visitation of each HIS at two different seasons, stages of impact and stages of plant growth will provide adequate documentation for future reference and interpretation of the sites documented this summer and the future.

The final product of my work this season on HISs will be a documentation of the procedures that I used to gather and interpret data. This documentation will be easy to follow so that future resource management people will be able to follow step-by-step the procedures used for future gathering and interpretation of data. An aerial photograph, interpretative, dichotomous key will be made to aid in interpretation of vegetation and impact on vegetation and soil. The documentation that is planned for this project will ensure that no information is lost throughout the years if staff changes are made and implementation of this monitoring project is not immediately made.

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APPENDIX A

HUMAN IMPACT SITES VISITED

Itkillik River Valley

#114 North End of Oolah Lake
Vegetation - Scrub/Tall Shrub
Herbaceous/Graminoid

#155 Southeast Itkillik Lake Site
Vegetation - Scrub/Low Shrub
Herbaceous/Graminoid

Noatak River Valley

#51 River End of Portage Trail to Matcherak Lake
Vegetation - Scrub/Dwarf Tree
Forb

#103 Portage Pond
Vegetation - Dwarf Shrub

North Fork of the Koyukuk River Valley

#21 Bombardment Creek - East Airstrip Cache Area
Vegetation - Forest/Needleleaf
Scrub/Tall Shrub

Walker Lake

#61 East of Outlet
Vegetation - Forest/Needleleaf

#59 Penninsula
Vegetation - Forest/Needleleaf
Scrub/Low Shrub

APPENDIX B

Condition Class Definitions

Class 1: Recreation site barely distinguishable; slight loss of vegetation cover and/or minimal disturbance of organic litter.

Class 2: Recreation site obvious; vegetation cover lost and/or organic litter pulverized in primary use areas.

Class 3: Vegetation cover lost and/or organic litter pulverized on much of the site, some bare soil exposed in primary use areas.

Class 4: Nearly complete or total loss of vegetation cover and organic litter, bare soil widespread.

Class 5: Soil erosion obvious, as indicated by exposed tree tree roots and rocks and/or gullying.
(Natural Resources Report NPS/NRVT/NRR-91/06,36)

APPENDIX C

HIS #________________ Surveyer ________________
Area ________________ Date ____________________

Reconnaissance

1. Reconnaissance Notes:

2. Class Number:

3. Bearing and Number of trails, taken from center stake.

    1. Compass reading:
       Description:

    2. Compass reading:
       Description:

    3. Compass reading:
       Description:

    4. Compass reading:
       Description:

    5. Compass reading:
       Description:

    6. Compass reading:
       Description:

    7. Compass reading:
       Description:

    8. Compass reading:
       Description:

    9. Compass reading:
       Description:

    10. Compass reading:
        Description:

APPENDIX D

Azimuth Method

HTS# __________ Area __________ Surveyed by __________
Date __________ Quad __________

Center Stake Location
Description: ______________________________
____
____

Bearings:
1. Description: ______________________________
Distance: __________ Compass heading: __________

2. Description: ______________________________
Distance: __________ Compass heading: __________

3. Description: ______________________________
Distance: __________ Compass heading: __________

Transect 1
Compass Heading: ______ Distance/Length: __________
Transect 2
Compass Heading: ______ Distance/Length: __________
Transect 3
Compass Heading: ______ Distance/Length: __________
Transect 4
Compass Heading: ______ Distance/Length: __________
Transect 5
Compass Heading: ______ Distance/Length: __________
Transect 6
Compass Heading: ______ Distance/Length: __________
Transect 7
Compass Heading: ______ Distance/Length: __________
Transect 8
Compass Heading: ______ Distance/Length: __________

Average Radius = ______________________________
Total Core Impact Area: ______________________________

APPENDIX E

VEGETATION PLOT DESCRIPTION

HIS# __________ Area ______________ Surveyed by _____ Date _____

Plot # ________ Plot area ________________________

Transect Line Marker

Description: ____

Compass heading: ____________ Distance Length: ______________

Transect

1. From: ____________________
Distance/Length: _____________ Compass heading: ______________
2. From: ____________________
Distance/Length: _____________ Compass heading: ______________
3. From: ____________________
Distance/Length: _____________ Compass heading: ______________
4. From: ____________________
Distance/Length: _____________ Compass heading: ______________

Quadrats: 20cm x 50cm or meter square; herbs

1. Between ____m and ____m; ____side; center at _____
2. Between ____m and ____m; ____side; center at _____
3. Between ____m and ____m; ____side; center at _____
4. Between ____m and ____m; ____side; center at _____
5. Between ____m and ____m; ____side; center at _____

Quadrats: 2m x 5m; shrubs

1. Between ____m and ____m; ____side; center at _____
2. Between ____m and ____m; ____side; center at _____
3. Between ____m and ____m; ____side; center at _____
4. Between ____m and ____m; ____side; center at _____
5. Between ____m and ____m; ____side; center at _____

Comments:

APPENDIX F

The Daubenmire Cover Scale

Cover Class	*Range of Cover (%)*	*Class Midpoints (%)*
6	*95-100*	*97.5*
5	*75-95*	*85*
4	*50-75*	*62.5*
3	*25-50*	*37.5*
2	*5-25*	*15*
1	*0-5*	*2.5*

(Daubenmire, 1959, 1968; Dieter Mueller-Dombois and Heinz Ellenberg, 1974, p.63)

APPENDIX G

HIS # ________ Lat. ________ Surveyed by: ________ Slope: ________
Area ________ Long. ________ Date: ________ Aspect: ________
Transect & Plot # ____ Elev. ________ Quad: ________ Plot size: ________
Photo: ________

Quadrat Number

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Species cov																				
VASCULAR FLORA																				
MOSS																				
LICHEN																				
OTHER Litter & Mulch																				
Bare Soil																				
Rock frag																				
Water																				
Other																				

Cov % = 1=0-5% 2=5-25% 3=25-50% 4=50-75% 5=75-95% 6=95-100%.
Veg. Char = ^ very feeble and never fruiting, * feeble, no index: normal, ! exceptionally vigorous

Comments:

APPENDIX G (CONTINUED)

HIS # ____________ Lat. ____________ Surveyed by: ________ Slope: ________

Area ____________ Long. ____________ Date: ____________ Aspect: ________

Transect & Plot # ____ Elev. ____________ Quad: ____________ Plot size: ________

Photo: ____________

Quadrat Number

Species cov	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
SHRUBS																				
SEEDLINGS <3' tall																				
SAPLINGS >3'tall, <1cm DBH																				

Cov % = 1=0-5% 2=5-25% 3=25-50% 4=50-75% 5=75-95% 6=95-100%.

Veg. Char = ^ very feeble and never fruiting. feeble, no index: normal. ! exceptionally vigorous

Comments:

APPENDIX H

Human Impact
Site Photograph Description

HIS#_________ Area ______________
Photographer_____________________
Date ______________________________

Photographs:

Roll _____ Frame _____ Description:

Roll _____ Frame _____ Description:

Roll _____ Frame _____ Description:

Roll _____ Frame _____ Description:

Roll _____ Frame _____ Description:

Roll _____ Frame _____ Description:

Roll _____ Frame _____ Description:

Roll _____ Frame _____ Description:

APPENDIX I

Soil Survey

Soil Sample 1
Site Description:

Organic Mat
Description:

Classification:
Thickness:

Mineral Soil
Description:

Color classification:
Volume:
Weight:
Bulk Density:

Soil Sample 2
Site Description:

Organic Mat
Description:

Classification:
Thickness:

Mineral Soil
Description:

Color classification:
Volume:
Weight:
Bulk Density:

L = Litter horizon, consisting of "unaltered" or slightly altered dead remains of plants and animals.
F = Fermentation layer, consisting mainly of partly decomposed organic matter.
H = Humus layer, comprised of well-decomposed, amorphous organic matter.