VEGETATION CLASSIFICATION PROJECT
SAHTU SETTLEMENT AREA
SUMMARY OF THE 1998 FIELD SEASON

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ABSTRACT

Production of a detailed classification of all vegetation types in the Sahtu Settlement Area has been a priority project of the DRWED Sahtu Region and Forest Management. Knowledge of the types and distribution of different habitats that occur within the Sahtu is essential for land, forestry, and wildlife management. LANDSAT TM images were identified as the most suitable for this project and 17 full and 4 partial images have been selected to cover the area. An initial 7 images have been purchased. During the 1998 summer field season, all 7 images were prepared for ground truthing, four complete images were ground truthed, and more that 75% of two additional images were ground truthed.

TABLE OF CONTENTS

Introduction:

Production of a detailed classification of all vegetation types in the Sahtu Settlement Area has been a priority project of the DRWED Sahtu Region and Forest Management (Fort Smith). Knowledge of the types and distribution of different habitats that occur within the Sahtu is essential for land, forestry, and wildlife management.

Vegetation classification has been done with aerial photography, satellite imagery, or both. Aerial photography is commonly used in forest management because of its high resolution (i.e., detail). However, it would take at least 10,000 aerial photos to cover the Sahtu and the huge cost to acquire those is prohibitive. Satellite images are simply another form of aerial photograph taken by satellites that orbit 700 km above the Earth. Colours on satellite images result from differential light reflection from objects on the ground - the reflection from a spruce tree is different from that from a grass meadow; therefore, they appear as different colours on the satellite image. With appropriate software and field work, a computer can be used to classify vegetation based on these different reflectance values.

One of the most commonly used satellites for taking images is the LANDSAT Thematic Mapper (TM). Early in the project's development we identified LANDSAT TM images as the most suitable for the project due to their long history (available since 1972), commercial availability, resolution (30 m by 30-m pixel size), and widespread use across Canada and the rest of the world. Each LANDSAT image covers an area of approximately 180-km by 180 km (i.e., 32,000 km^2).

In Canada, *Radarsat International* is the sole supplier for LANDSAT TM images. L. Leverington (GIS Specialist, Sahtu Renewable Resources Board) visited their Canadian office in Burnaby, BC in December 1996 to look for a complete set of images for the Sahtu that met the following specifications: taken between 08 June and 07 August (i.e., while vegetation in 'full leaf'), no more than 5% total cloud cover, and taken between 1992 and 1996. A set of 17 full and 4 partial images that met these criteria was selected.

The first 5 of those images on CD-ROM were purchased by the SRRB in March 1997 and two more images were purchased by RWED in February 1998.

The process we are using involves the following:

- *preparation of the image* –
  - geo-reference using 1: 250,000 scale NTS base maps
  - select appropriate 3 wavelength bands to highlight differences in vegetation types
  - enhance each selected band to maximize colour differences

  print image at 1: 100,000 for selection of ground-truthing sites
- *selection of ground – truthing sites* – approximately 150 sites are selected for each image based on homogenous patches of colour.
- *ground-truthing* - identifying the type of vegetation that exists at the sites from helicopter or fixed-wing aircraft.
- *supervised classification of the image* - taking ground truthing information to assign vegetation classes to groups of pixels with similar reflectance values.

A critical component of classifying vegetation from the LANDSAT TM images is first to determine how many classes (categories) of vegetation are needed. In early May 1997, a workshop on vegetation classification using LANDSAT TM imagery was hosted by Forest Management in Fort Smith and was attended by GIS and remote sensing specialists with the Gwich'in and Sahtu co-management boards, the Centre for Remote Sensing (DRWED, Yellowknife), Alberta Lands and Forest, and Wood Buffalo National Park. At this workshop the participants drafted *NWT Vegetation Classification Guidelines for TM LANDSAT Imagery*, which included identifying a list of common vegetation cover classes and a protocol for ground-truthing the satellite images.

The satellite image classification software that will be used for this project is *ER MAPPER 5.5*.

In May-August 1997, a Ph.D. graduate student (University of Alberta) was hired by the SRRB with funds provided by a contract with Forest Management (Fort Smith) to assist with setting up the Vegetation Classification Project. Between June and August 1997 training sites on two images were selected and flown in helicopter and fixed-wing aircraft. Unfortunately, since methods differed from protocol identified at the image classification workshop in Fort Smith, the results were not suitable for the project's requirements.

Objective:

Our goal this summer was to prepare and ground (air) truth 2, or possibly 3, of the seven LANDSAT TM satellite images in the Sahtu that had been purchased.

Results:

Due to hard work by all members of the Vegetation Classification Project team, we exceeded the objective we had set for the project at the beginning of the field season.

Between May 26th and July 31st all 7 satellite images were prepared for ground-truthing. Please refer to the attached map and *Satellite Image Information* for details on satellite images for the Sahtu. Training in field procedures for ground-truthing from the air occurred from June 11th through June 13th. Between June 11th and August 21st four complete images (Tulita, Wrigley/Drum Lake, Sheep/Keele, Canol), 88% of the Colville image, and 76% of the Fort Good Hope image were ground-truthed. The Grandview image has been prepared; however, no ground-truthing has yet been done on this image. The Hottah Lake and Keller Lake images were prepared and ground-truthed by Bruno Croft (DRWED Forest Management, Fort Smith).

Procedures:

Two staff were hired by DRWED to directly focus on the project - Katherine Thiesenhausen (Vegetation Classification Project Supervisor, DRWED, Forest Management, Fort Smith) and Arianna Zimmer (Vegetation Classification Assistant, DRWED, Sahtu Region). However, project work also included three staff from Forest Management (DRWED, Fort Smith), five staff from DRWED, Sahtu Region (Wildlife Management and Forest Management), and a student hired by the Sahtu Renewable Resources Board (SRRB). It was deemed essential that permanent, full time staff from DRWED, Sahtu Region be trained on the ground-truthing methods. Their involvement resulted in more work being accomplished.

Each of the satellite images requires at least five days in the office to prepare for field work. See *Vegetation Classification Office Work* (attached) for details. Following procedures established at a Fort Smith Vegetation Classification Workshop in May, 1997, a minimum of 150 'training sites' are chosen per image. Of those, the majority will be used to do the supervised classification of the image on computer, but a set of ca. 30 will be 'held back' for use in image classification accuracy assessment. In cases where an image included large water bodies (e.g., the Hottah Lake image that includes a large section of Great Bear Lake) - less than 150 sites were chosen.

A small, homogeneous patch of colour on the image is considered a training site. In the air, the vegetation and other relevant information (e.g., slope, aspect, etc.) at each training site is recorded on a standard data form (see attached example) and 2 to 6 representative photographs (400 ASA, print film) of the site are taken and later attached to the relevant data form.

The key to this year's project success was teamwork and interdepartmental cooperation (See attached *Flights Overview* for details):

- Forest Management (DRWED, Fort Smith) provided guidance, training, personnel, and funding. Bruno Croft, Rita Antoniak, and Ron Antoine put in long days flying to train and assist us with the truthing of 5 images.
- Forest Management (DRWED, Sahtu Region) contributed helicopter time (94.3 hours), fuel and fuel caching, personnel, and funding. Forest Technician (DRWED, Sahtu Region), Wayne McCowan, assisted with ground- truthing on several images.
- Parks and Tourism Division (DRWED, Sahtu Region) purchased the Canol image and provided the funding to ground-truth the mountainous and remote image.
- Wildlife Management (DRWED, Sahtu Region) staff supplied overall project supervision, staff time, and funding.
- The SRRB provided funding to hire summer student Nancey Whiteman for six weeks, who identified and recorded vegetation data in the field, helped prepare the images prior to field work, and organized data and photographs after ground-truthing flights. Lana Leverington (GIS Specialist, SRRB) helped modify the data forms to enable classification of vegetation in the Mackenzie Mountains, assisted with ground-truthing, and provided overall support and guidance for the project.

Over 30 hours were flown in small fixed wing aircraft and approximately 127 hours in helicopters to ground-truth images. The method of using two staff per flight, one in the front of the aircraft navigating and taking photos, and the other in the back recording vegetation and site information on the data forms was a quick and reliable way to obtain quality data at each training site.

The team also devised procedures to effectively organize the large amount of data and photographs gathered during field work. Of special note is the procedure of designing pre-set flight paths that saved both valuable time and fuel during ground-truthing flights.

Lana Leverington and Arianna Zimmer developed this method, upon which pilots provided compliments as they found it was an improvement over methods used in 1997.

Teamwork was most evident when often short notice was given on aircraft availability. Since most of the ground-truthing was done by taking advantage of unused minimum hours on the contract helicopter dedicated to Forest Management (DRWED, Sahtu Region) - it was important to have the office preparation work done for an image well ahead of time. There were several occasions when the project team had to pull together on short notice to ensure readiness for a flight.

Next Steps:

The success of the summer field work has created a large amount of computer classification of the 6 images ground-truthed this summer. This work will be done by Lana Leverington (GIS Specialist, SRRB) during the fall, winter, and spring of 1998-1999. Without assistance it is highly unlikely that a supervised classification for all six of these images can be achieved by the start of the 1999 field season; therefore, such assistance will need to be obtained.

Eighteen satellite images cover the Sahtu. Two images have been truthed by Forest Management (DRWED, Fort Smith) ,who will also most likely do the supervised classification. Six full and one partial image still need to be puchased, prepared, and ground-truthed. Two additional images already purchased need to be prepared and ground-truthed. The three remaining images prepared this summer (Colville, Fort Good Hope, Grandview) need to have ground-truthing completed (88%, 76%, and 0% truthed, respectivly). See *LANDSAT TM Image Coverage in the Sahtu* (attached) for details.

We anticipate that field work for ground-truthing all LANDSAT images that cover the Sahtu Settlement Area should be completed by the end of the 1999 field season. If the same methods and spirit of cooperation and teamwork that were employed in 1998 are used next year, we should see another productive and successful field season in 1999.

FIELD PERSONNEL:

Katherine Thiesenhausen, Vegetation Classification Supervisor,RWED

Arianna Zimmer, Vegetation Classification Assistant, RWED

Nancy Whiteman, Wildlife Management Trainee, SRRB & RWED

Richard Popko, Wildlife Technician, RWED

Alasdair Veitch, Supervisor, Wildlife Management, RWED

Lana Leverington, GIS Specialist, SRRB

Wayne McCowan, Forest Technician, RWED

Bruno Croft, Forest Planning Officer, RWED, Fort Smith

Rita Antoniak, Forest Management Technician, RWED, Fort Smith

Ron Antoine, Forest Management Technician, RWED, Fort Smith

SRRB = Sahtu Reneable Resources Board
RWED = Resources, W ildlife and Economic Development, Govt. NWT
All RWED staff based in Norman Wells unless otherwise noted.

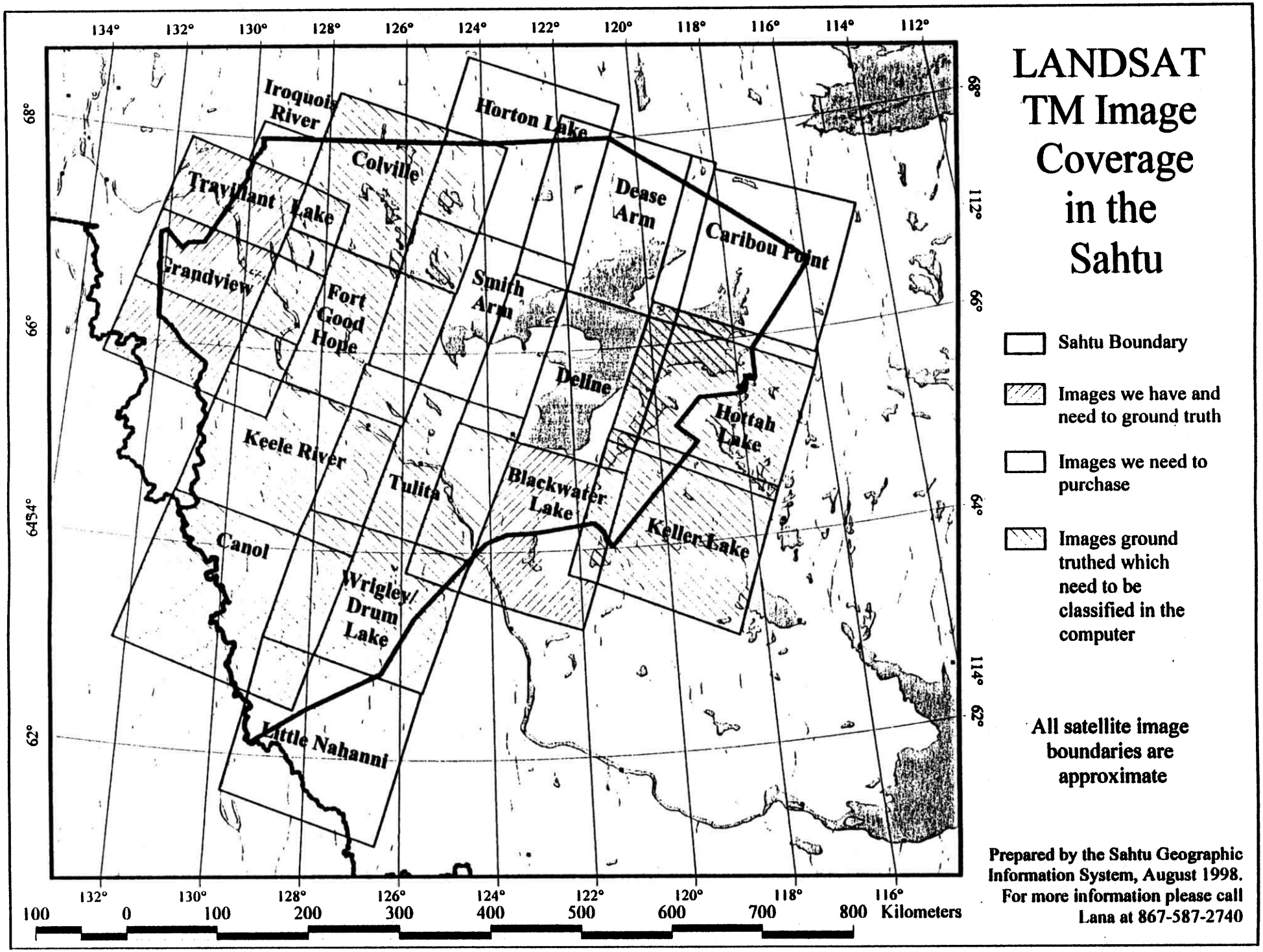
PILOTS:

Fixed wing - Mark Stewart, Ursus Aviation, Tulita

- Jim Robillard, North-Wright Airways Ltd.,Norman Wells

Helicopter - Jim Broadbent, Great Slave Helicopters, Norman Wells

- Len Marten, Great Slave Helicopters, Norman Wells
- Mark Hutcheson, Canadian Helicopters, Norman Wells
- Tim Simmons, Canadian Helicopters, Norman Wells


LANDSAT TM Image Coverage in the Sahtu
Sahtu Boundary
Images we have and need to ground truth
Images we need to purchase
Images ground truthed which need to be classified in the computer
All satellite image boundaries are approximate
Prepared by the Sahtu Geographic Information System, August 1998.
For more information please call Lana at 867-587-2740
Iroquois River
Horton Lake
Colville
Travillant Lake
Dease Arm
Caribou Point
Grandview
Fort Good Hope
Smith Arm
Deline
Hottah Lake
Keele River
Tulita
Blackwater Lake
Keller Lake
Canol
Wrigley/ Drum Lake
Little Nahanni
134° 132° 130° 128° 126° 124° 122° 120° 118° 116° 114° 112°
68° 66° 64°34° 62°
100 0 100 200 300 400 500 600 700 800 Kilometers

LANDSAT TM SATELLITE IMAGE INFORMATION - SAHTU

SATELLITE IMAGE	SITE RANGE	# SITES PICKED	# SITES DROPPED	# SITES ADDED	# SITES FLOWN	# SITES TO BE FLOWN
TULITA	1-150	150	17	38	153	0
WRIGLEY (DRUM LAKE)	573-737	164	3	0	161	0
SHEEP (KEELE)	279-285 413-571	166	14	4	156	0
CANOL	900-1051	152	34	32	150	0
COLVILLE	286-412 P2-P37	165	10	10	132	23
FORT GOOD HOPE	151-278	128*	32	24	114	6 (36*)
GRANDVIEW	738-899	162			0	162
HOTTAH LAKE	1-135	135			50	0**
KELLER LAKE	1-185	185			100	0**

*need to pick 30-40 more sites after adding 1998 fires

**less than 150 training sites flown due to amount of water included in these images

VEGETATION CLASSIFICATION OFFICE WORK BEFORE FLYING:	TIME
- in ER Mapper, Georeference satellite image	0.5 day
- add firehistory to satellite image	
- print 2 copies of satellite image (2x13sheets)	1 day
- choose & number about 150 sites on 1 copy	2 days
- cut & label all sheets of both copies	1 hour
- copy sites onto second set	2.5 hours
- in ER Mapper, zoom to each individual site and enter the latitude & longitude into an Excel file	1 day
- in ER Mapper "paste" the sites (lats./longs.) onto the image from the Excel file	1.5 hours
- print overview (2 copies) of satellite image with sites marked on them	0.5 hours
- write the major features & NTS map #'s on both copies (for navigating) and the sheet divisions on the overviews	0.5 days
- laminate and cut both copies & both overviews	2 hours

Just before flying:

- choose flight path & sort sites by lats./longs.	
- print out/photocopy 3 copies of flight path	
- fax GPS lats./longs to aircraft company for them to enter into their GPS unit	2 hours
- photocopy sufficient data sheets	
-find and fold the laminated satellite image sheets for the flight	

subtotal = 5days+2.5hrs

SATELLITE IMAGERY DATA SHEET

GENERAL INFORMATION:

Transect No.: _____
Site No.: P38
Coordinates: 66 47 38 N 124 45 29 E
Image Map Sheet: COLVILLE 96
Colour of site on satellite image: dk green

Observer: R-1
Date: AUG - 19 - 98
Source: ☑ Fixed Wing ☐ Helicopter ☐ Ground ☐ Air photos
Ht: ____ Scale: ____

TOPOGRAPHIC AND SITE DESCRIPTION:

Location: ☐ Ridge top ☐ Upper slope ☐ Mid slope ☐ Lower slope ☐ Upland bench ☐ Alluvial flat ☐ Other: _____

Slope: ☑ 0-30% ☐ 31-40 ☐ 41-50% ☐ 51% and +

Aspect: ☐ North ☐ South ☐ East ☐ West

Site photos:

Roll-frame	Look direction	Time
64 A		10:32

VEGETATED AREAS (> 10 % VEGETATION):

Forests: >10% c.c. tree species

☐ Coniferous (≥ 75 %)
- ☐ Pine ____ %
- ☑ Sb 40% %
- ☐ Sw ____ %
- ☐ Other ____ %

sct tamarack ≤ 10%

☐ Deciduous (≥ 75 %) Species: _____

☐ Mixed wood (No species ≥ 75 %) Species: _____

Another very wet site

☑ Mature ☐ Young

☐ Closed (>40 % c.c.)

☑ Open (10-40 % c.c.) ≤ 15%

☐ Stunted

Ground cover: ☐ HUMMOCK % %
- ☐ Lichen 10%
- ☐ Lichen/Shrub 30% = 40%
- ☐ Lichen/Moss
- ☐ Moss
- ☐ Moss/Shrub
- ☐ Sphagnum
- ☑ Water 30%
- ☐ Burn
- ☐ Burn/Lichen
- ☐ Burn/Moss
- ☐ Sand
- ☐ Till/Gravel
- ☐ Rock
- ☐ Other: _____

graminoids 30%

Shrubs: ≥25% tree < 10%

☐ Tall ≥ 1.5 m in height

☐ Low < 1.5 m in height

☐ Closed (> 40 % c.c.)

☐ Open (25-40 % c.c.)

Ground cover: ☐ HUMMOCK % %
- ☐ Lichen
- ☐ Lichen/Shrub
- ☐ Lichen/Moss
- ☐ Moss
- ☐ Moss/Shrub
- ☐ Sphagnum
- ☐ Water
- ☐ Burn
- ☐ Burn/Lichen
- ☐ Burn/Moss
- ☐ Sand
- ☐ Till/Gravel
- ☐ Rock
- ☐ Other: _____

Herbaceous: tree < 10% shrubs < 25%

☐ ≥ 50 % herbs (fireweed, dogwood, lupine, lily, vetch, ...)

☐ ≥ 50 % grasses, sedges, or other graminoids

☐ ≥ 50 % sphagnum moss

☐ ≥ 50 % lichen (not on bedrock)

Ground cover (if applicable): ☐ HUMMOCK % %
- ☐ Lichen
- ☐ Lichen/Shrub
- ☐ Lichen/Moss
- ☐ Moss
- ☐ Moss/Shrub
- ☐ Sphagnum
- ☐ Water
- ☐ Burn
- ☐ Burn/Lichen
- ☐ Burn/Moss
- ☐ Sand
- ☐ Till/Gravel
- ☐ Rock
- ☐ Other: _____

UNVEGETATED AREAS: < 10% vegetation

Little or no vegetation: ☐ Recent burn to mineral soil ☐ Barren (rock, mudflats, developed areas, ...) ☐ Ice or snow

Water and wet-

☐ Wetlands

☐ < 25 % vegetation
- ☐ Water > 2m (deep)
- ☐ Water ≤ 2m (shallow)
- ☐ Water clear
- ☐ Water cloudy, milky, opaque

☐ ≥ 25 % vegetation ☐ Floating or emergent vegetation

Flights Overview

IMAGE	SHEET#	DATE FLOWN	WHO WAS IN PLANE/HELICOPTER	
Tulita	1,2A,2B	Thurs.June 11 8am-noon	Bruno,Rita, Katherine,Wayne	Jim Robillard, pilot,North-Wright Cesna 206 EXCELLENT PILOT FOR VEG.CLASS.
"	3,6A,6B	Thurs.June 11 3pm-7pm	B, R, W	"
"	5A,5B	Fri. June 12 8am-noon	B, R, K	"
"	7A,7B,8	Fri. June 12 2pm-6pm	B, R, Arianna	"
" & 2 fires for smoke patrol	4A,4B	Wed, June 17 8:30am-12:15pm	K, A, W	Jim Broadbent pilot,Great Slave Helicopters., A-Star
Fort Good Hope	4B,5B,6B,	Sat.June 13 8:30am-11am	B, R, K	Jim R.,pilot, N-W,Cesna 206
"	7,8A,8B	Sat.June 13 11:45am-6pm?	B, R, W	"
"	1,2A,2B, 3,4A,5A,6A	Sun.June 14 8am-?	B, R	"

IMAGE	SHEET#	DATE FLOWN	WHO WAS IN PLANE/HELICOPTER	
Colville	4B,5B,6B, 7,8A,8B	Mon.June 15 6am-?	B, R	Jim R.,pilot,N-W, Cesna 206 on floats
"	1,2A,2B 4A,5A,6A	Wed.Aug. 4 11am-9:30pm	B, Ron, Nancy	"
"	1,2A,3,5A 5B,6B,8A,8B	Wed.Aug. 19 8:30am-9:30pm	Richard, N	Mark Stewart,pilot Ursus Aviation, Maule Lunar Rocket on floats
Sheep	5B,7	Fri. June 5 4pm-4:30pm	Richard	Tim Simmons, pilot,Canadian Helicopters,A-Star
"	6A,5A, 2B,1,4A	Thurs. June 25 1:30pm-5pm	K, A, W	Len Marten,pilot, G.S.Heli.,A-Star EXCELLENT PILOT FOR VEG.CLASS.
"	6B,8A,8B	Tues. June 30 9:30am-12:15pm	K, W, Lana	"
"	5B,6A	Thurs.July 16 9am-1pm	A, W	Jim B., pilot G.S.Heli.,A-Star
"	6A,3,5A	Thurs. July 30 9am-11am	K, A, N	"
"	5A,5B,6B	Mon. Aug. 17 11:30am-2:30pm	K, Richard	Mark Hutcheson, pilot, Can.Heli.,208B EXCELLENT PILOT FOR VEG.CLASS.

IMAGE	SHEET#	DATE FLOWN	WHO WAS IN PLANE/HELICOPTER	
Sheep	1,2A,2B,3	Fri. Aug. 21 10:30am-4pm	K, Richard	Tim S., pilot Can.Heli.,208B
Sheep Wrigley	4A,4B,5B,7 1,4A	Sat. July 18 9am-8:30pm	A, Richard	Jim B., pilot G.S.Heli.,A-Star
Sheep Wrigley	6B,8A,8B 1,2A,2B	Thurs. July 9 9:20am-5:20pm	K, A	"
Wrigley	2A,2B,4A, 4B,5A,5B,7A	Sun. July 19 9am-7:30pm	A, Richard	"
Wrigley	2A,2B,3A, 5A,5B,6A,6B	Mon.July 20 10am-7pm	A, Alasdair	"
Wrigley	3A,5B,6A, 8A,8B	Wed.July 22 "full day"	A, Alasdair	"
Canol	2A,4A, 4B,5B	Fri.Aug. 14 10:30am-8:30pm	K, Alasdair	Mark H.,pilot, Can.Heli.,206B
"	2A,4B,5A, 5B,7,8A,8B	Sat. Aug. 15 9am-8:30pm	K, Alasdair	"
"	2A,3,5A, 5B,6A	Sun. Aug. 16 9:30am-5pm	K, Alasdair	"

VEGETATION CLASSIFICATION OFFICE WORK TO DO AFTER FLYING: TIME

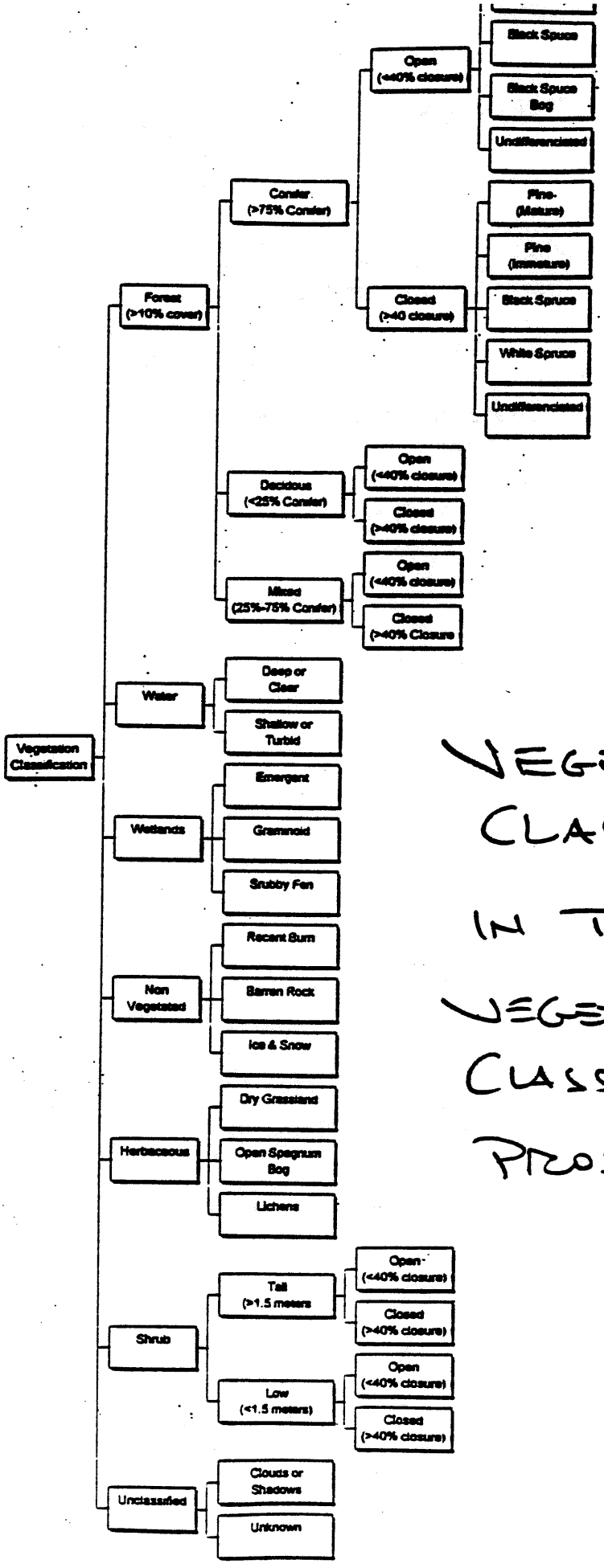
After flying:

- copy over any added sites and other info. written on each laminated copy to the other copy — 0.5 hours

- update the Excel file by marking down sites done — 0.5 hours

- attach photos to their data sheet & ensure data sheet completely filled out
- label negatives and envelopes — 2 hours

Total = 5 days + 5.5 hours



VEGETATION CLASSES USED IN THE SAATH VEGETATION CLASSIFICATION PROJECT.