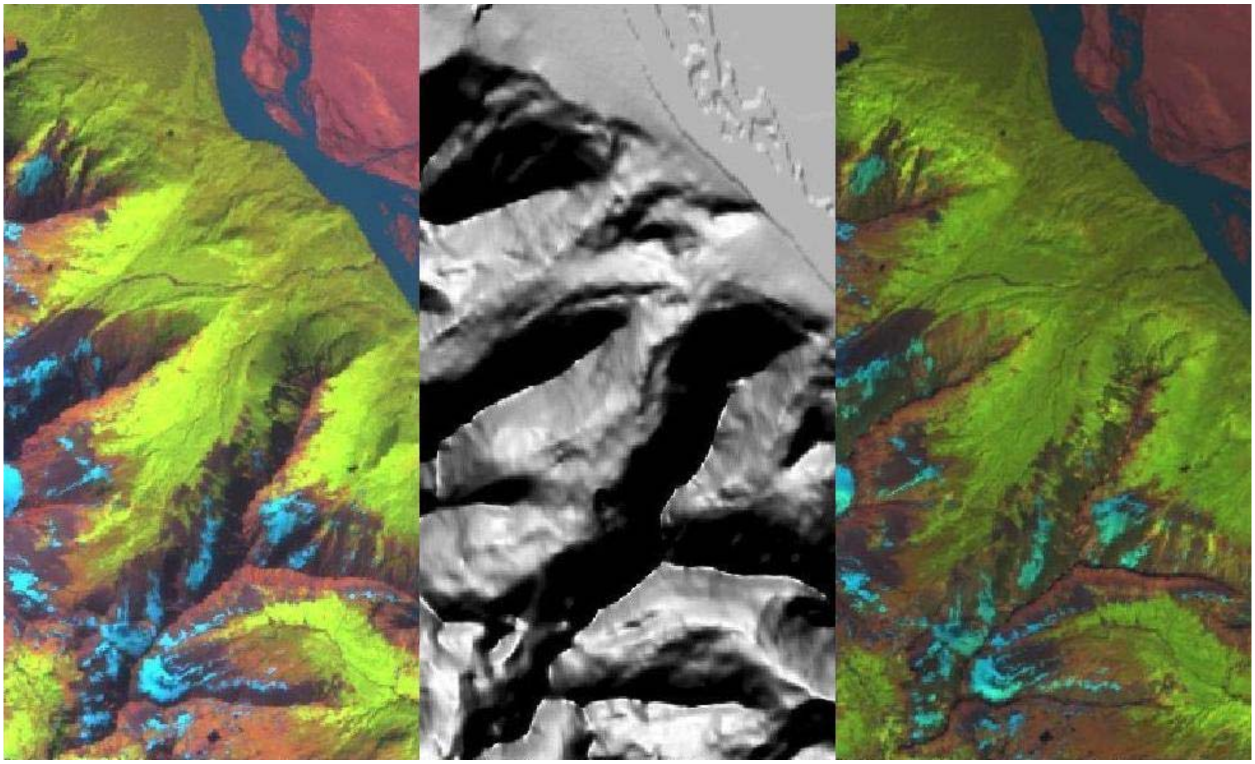

Figure 5: Illumination Adjustment - Raw Image / Shaded Relief / Corrected Image

Ecotype section boundaries developed for the WRST Project Area by Swanson (2001) were provided by the AKRO and made available to **GRS** in digital format for use in this project. These ecotype section boundaries represented 16 different major ecotype sections throughout the WRST Project Area. After consulting AKRO and ABR vegetation experts to determine the most appropriate use of these ecotype section areas, two of the geographically distinct areas of land cover characteristics were split into smaller subsections, resulting in 18 ecotype subsections (see Figure 6). Refinement primarily concerned the development of a separate section to represent the different vegetation characteristics thought to exist in the Bremner River area within the Northern Chugach Mountains section. These 17 ecotype sections were used for the initial stratification of the image data set that would be used in subsequent training data development efforts. The second refinement was made later in the project during classification efforts when it became necessary to break out the riverine portions of the Bering-Malaspina Forelands section from the rest of the section.

Candidate Image Classification Training Sites

The principal objective of this task was to develop a set of candidate training areas that would maximize field data collection efforts during the time periods allotted for aerial survey of field sites. This would be accomplished by eliminating the collection of data from invalid or heterogeneous spectral sites, redundant sites, and sub-minimum size sites while at the same time developing a training data set representative of the large area being mapped, both in terms of the diversity of land cover types present and the geographic distribution of those types. Areas suitable for aerial survey would be identified prior to field data collection efforts to maximize efforts during the limited time available for field data collection.

Image Stratification

The creation of a pool of potential/candidate training sites relies on stratification of the project area. The project area is stratified into many different classes, where each class represents a grouping of spectrally similar pixels; through stratification, areas of spectral homogeneity that represent different land cover characteristics are identified.

The goal of image stratification is to group the project area spectral data into a large number of different classes, each representative of a somewhat unique set of land cover features that need to be sampled and represented in the final data set. Stratification yields two significant results. One result is that the diversity of the sample area is represented in the stratified image. A second result is that the frequency or relative magnitude of each class is estimated by the number of pixels that are assigned to each individual class. After stratification the potential diversity of the area and the relative significance, in terms of size, of each class may be determined. This information enables the development of training data representative of all the diverse land cover data present in the area, while not under sampling some classes and over sampling others.

During stratification, much of the same data is processed that will also be processed during the subsequent classification efforts. The image data is the foundation of this effort and ecotype section area data is used to differentiate different portions of the project area within each image. Ecotype sections are introduced to form an initial level of stratification, while the ISODATA classification within the ecotype region is a second level of stratification that assures that many strata representative of the diversity of land cover types throughout the project area will be developed. A large number of classes are developed during the ISODATA classification processing within each area of interest (ecotype section). Between 30-50 training classes per ISODATA classification are typically developed, and sometimes as many as 60-75 training classes are developed in each image/ecosection data set. If initial classification efforts result in too few or too many classes, the ISODATA classification statistical parameters are reset and the imagery is reclassified to develop the desired number of ISODATA classes. Too few classes will yield sample areas with too much variability, whereas too many classes may result in a very heterogeneous data set with areas too small to realistically identify and sample in the field.

Development of unsupervised classification data was completed for each of the nine images using ZI Imaging's Image Analyst software in a Bentley Systems' MicroStation environment. **GRS** used an ISODATA clustering algorithm based on a minimum Jeffries-Matusita (J-M) distance of 1.4 and an initial random seeding of 20 classes to generate unsupervised classes within the ecotype sections present within each image. For each image, illumination corrected spectral bands 1, 2, 3, 4, 5, and 7 were processed. The application of ecotype section masks limited the spectral variability found within any particular region and enhanced the identification of separable classes throughout the classified ecosections. Clustering parameters used in unsupervised classifications ensured high homogeneity of resulting classes. Careful review of the J-M distance reports generated for each scene confirmed sufficient separability of the unsupervised classes.

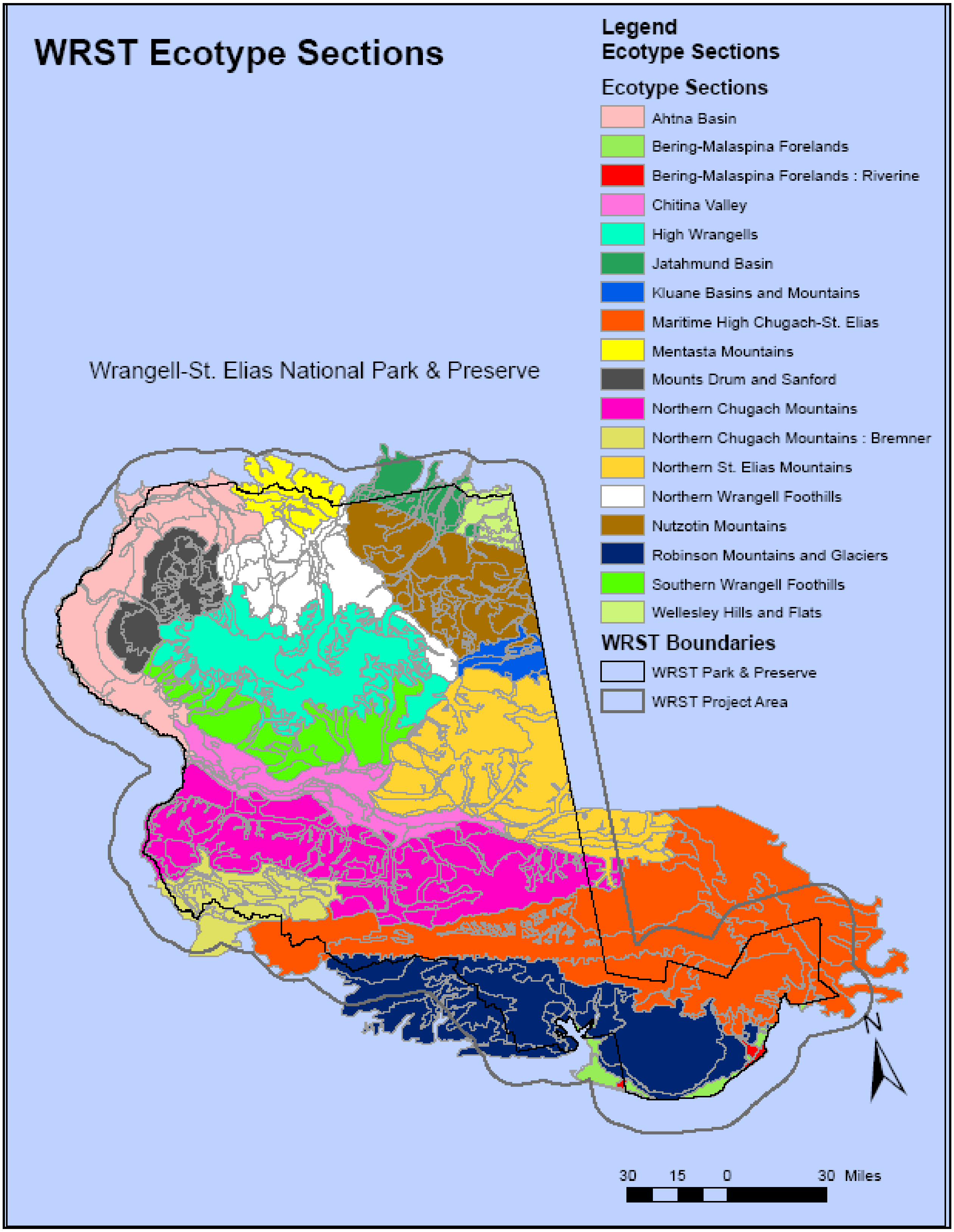

Figure 6: WRST Ecotype Section Areas

These ISODATA training data sets were then applied to the satellite imagery using both a supervised maximum-likelihood classifier as well as a minimum distance classifier. This resulted in two class maps for each area of interest (ecosection) within a scene. During initial aerial survey efforts during the summer of 2004 based on ecotype section stratification, **GRS** found that such a specific level of stratification as the ecosection was not necessary, as there was significant overlap of similar strata between different ecosections. Stratification for subsequent aerial survey efforts was based on ISODATA training classes developed using a more simplistic stratification that attempted to segregate potential types by the level and type of vegetation present at any particular location. This was accomplished by developing a Normalized Difference Vegetation Index mask (the ration of (B4 – B3)/(B4 + B3)) for each image and training on the areas with values less than or equal to 124 separately from those areas with NDVI greater than 124. Stratification (training) based on the NDVI grid was an attempt to basically segregate the images into areas with vegetation as opposed to areas lacking vegetation. This level of stratification generated more classes per image (approximately 250), but fewer classes overall (due to less redundancy of similar classes in different ecosections).

Candidate Site Selection

The end result of the stratification process is a set of ISODATA class raster maps that contain pixels that have been stratified into the many different spectrally homogeneous classes. Two sets of maps existed for each area of interest that was stratified, one based on a maximum-likelihood classifier and the other based on a minimum-distance classifier. These data sets were then processed and pertinent database information was developed to guide the selection of potential candidate training site areas. Each corresponding set of maximum-likelihood and minimum distance class maps was overlaid to determine areas where the same class value occurred in the same pixel location in both maps. These are the areas estimated to be most spectrally homogeneous and consistent in spectral reflectance, as they had the same value using different classifiers. Pixels lacking the same value in both class maps were set to a NULL value. The grid processing yielded a new grid data set of ISODATA classes, each having a unique identifier, iso_class number, and pixel frequency. Only areas at least 20 pixels in size were retained in this data set. These data were loaded into a table (candidate_trsites) for subsequent processing. A total of 1,072,624 unique areas were identified. A small selection of data from the candidate_trsites table is shown in Table 4. Pixel frequency values may be used to filter areas too small to sample, as well as describe the distribution of the project area, or ecosection area, by ISODATA class. The distribution of pixels by ISODATA class was generated by simply summing the pixel frequency by ISODATA value. Pixel frequency by ISODATA class for ecosection

Table 4: Candidate_trsites Table Data

Id#	iso_class	#pixels
...		
896151	2019	48
896152	2020	50
896153	2012	29
896154	**2020**	**78**
896155	**2016**	**446**
896156	2010	20
896157	2009	30
896158	2019	56
896159	2019	34
896160	**2010**	**410**
896161	2012	31
896162	**2020**	**405**
896163	2010	31
896164	2019	37
896165	**2020**	**86**
896166	2020	29
896168	2019	44
896169	2020	53
896170	2009	22
896171	**2020**	**83**
896172	**2017**	**67**
896173	2020	23
896174	2012	31
896175	2017	26
896176	2014	24
896177	2020	38
896178	2012	22
896179	2014	28
896180	2019	23
...		

2, the Bering-Malaspina Forelands is shown in Table 5. This information was useful in the identification of the relative abundance of the different classes and the identification of both common and scarce ISODATA classes. Frequently occurring ISODATA classes are readily distinguished from scarce ISODATA classes. Scarce ISODATA classes were identified and targeted for sampling.

Table 5: Pixel Frequency by ISODATA Class

Iso Class	Frequency	Pct(%)	Cumul. Pct(%)
3101	24670	3.76%	3.76%
3102	20921	3.19%	6.95%
3103	23144	3.53%	10.48%
3104	31231	4.76%	15.25%
3105	42020	6.41%	21.65%
3106	42551	6.49%	28.14%
3107	33692	5.14%	33.28%
3108	25732	3.92%	37.20%
3109	29360	4.48%	41.68%
3110	36586	5.58%	47.26%
3111	11890	1.81%	49.07%
3112	8853	1.35%	50.42%
3113	7089	1.08%	51.51%
3114	22467	3.43%	54.93%
3115	6603	1.01%	55.94%
3116	25757	3.93%	59.87%
3117	23601	3.60%	63.47%
3118	24494	3.74%	67.20%
3119	33112	5.05%	72.25%
3120	23467	3.58%	75.83%
3121	9343	1.42%	77.26%
3122	21133	3.22%	80.48%
3123	19006	2.90%	83.38%
3124	22422	3.42%	86.80%
3125	17221	2.63%	89.42%
3126	9957	1.52%	90.94%
3127	16077	2.45%	93.39%
3128	18053	2.75%	96.15%
3129	4615	0.70%	96.85%
3130	10274	1.57%	98.42%
3131	10386	1.58%	100.00%
Total	655727		100.00%

The next step in the sample area selection process was to filter out the areas thought to be too small to sample. The minimum size (number of pixels) sample site will obviously be related to the resolution of the imagery being processed. The most important aspects of this minimum size limit are that the sample site is large enough to use as a supervised image classification training site, the site can be easily located in the field by the field crew, and the site can be distinguished from the surrounding land cover types. There is no point in selecting a sample site that is too small to use as part of the supervised classification training set, or that cannot be found or identified in the field when performing an aerial survey from a helicopter. For this project, a minimum size training site area of 60 pixels, or approximately 13.0 acres was selected. Areas meeting this minimum size were readily identified by performing a simple query of the ISODATA class database based on the size attribute of each contiguous area. This query had the following construct:

```
   select id, iso_class from candidate_trsites where
pix_count >= 60
```

Several records that met these criteria are shown as **bold** type in Table 4. Identification of areas larger in size than this minimum size reduced the number of ISODATA class areas from over one million areas to 245,665 potential sample areas that were all at least 60 pixels in size. This reduced set of candidate areas was checked to determine that it was still representative of all the ISODATA classes present in the stratified ISODATA data and to assure that all ISODATA classes were represented in the candidate_trsite table. The database check that was performed to determine that all ISODATA classes were represented in the candidate sample data set was performed using a database query of the following construct:

```
select iso_class, count(*) from candidate_trsites
  group by iso_class
  order by iso_class
```

and then checking that the results agreed with the number of training classes in the training data sets.

This check did not identify any missing ISODATA classes. All ISODATA classes had at least one sample area that met the minimum size limit. A total of **3,165** ISODATA classes were identified in the different stratifications that were performed.

The next step was to determine if any ISODATA classes were extremely rare (few in number) or small (size less than 60 pixels), such that sampling these areas might be difficult. It was important to identify and include scarce or small classes in the candidate database so there would be sufficient coverage of the many land cover types present in the project area. Scarce and small classes were identified using the following queries:

```
select iso_class, count(*) from candidate_trsites where px_cnt >= 60
  group by iso_class order by iso_class
```

```
select iso_class, count(*) from candidate_trsite where px_cnt >= 60
   group by iso_class having count(*) < 5  order by iso_class
```

The first query identified **2,831** classes indicating that 334 classes only occurred in areas of size smaller than 60 pixels. These 334 candidate sites are considered **small** sites. The second query identified an additional 270 iso_classes that did not occur in more than 5 locations in groups of at least 60 pixels. These were considered **scarce** iso_classes - those having less than 5 candidate sample sites of the minimum 60 pixel size throughout the entire project area. Additional candidate areas were then generated for these ISODATA classes by decreasing the minimum size limit from 60 pixels to 45 pixels, or approximately 10.0 acres. 94 additional sample areas representing small or scarce ISODATA classes were added to the candidate sample site database. By continuing to drop the minimum size requirement to lower thresholds (45, 30, and 20 pixels) candidate sites were identified as small or rare and flagged in the database, to identify their presence in subsequent database query operations. A total of 307 candidate sites were identified as small sites using this approach. Small sites were flagged by setting a database table column value to reflect the scarcity of the class using an SQL statement like the following statement:

```
update candidate_trsites set visit_status=45 where px_cnt >= 45 and px_cnt < 60
  and visit_status is NULL
  and iso_class not in ( select iso_class from candidate_trsites where visit_status > 0 group by
iso_class having count(*) >= 5 )
```

Scarce or rare candidate sites were identified by selecting those iso_classes that had a very low (<5) number of occurrences in the data set. A total of 297 sites were identified as rare sites using the following SQL statement:

```
update candidate_trsites set visit_status=visit_status + 100
  where iso_class not in ( select iso_class from candidate_trsites group by iso_class having
count(*) >= 5 )
```

Information regarding scarcity and size of iso_class sites was very useful in prioritizing sample sites when actually selecting the specific training data sample sites that would comprise the sampling plan during the field data collection sampling efforts. Small and rare sites were represented with labels of different colors when plotted on the field maps to assist in their identification during planning efforts.

The next step in this process was to move from the grid world into the vector world, in order to integrate and manipulate the candidate sample unit data in a graphic context. To accomplish this conversion process, two steps were necessary. First, the ISODATA class map was reclassed to form a candidate area grid map - all pixels in areas that were not candidate sample units were reset to a value of 0 (NODATA), while all other pixel values remained the same. The resulting grid map represented only those areas that had been determined to be candidate training data collection sites. A portion of the resulting grid is shown in the left side of Figure 7. This candidate area grid was then vectorized to form a vector database representing the candidate sample areas. Other data, such as ISODATA class labels, were developed to enhance the training site information. These area boundaries and corresponding labels, including areas symbolized as rare or small (see blue labels in Figure 8) could then be overlaid on the imagery, as shown in the right side of Figure 7. The resulting database represented the initial set of candidate training sites that would be used to plan field data collection efforts.

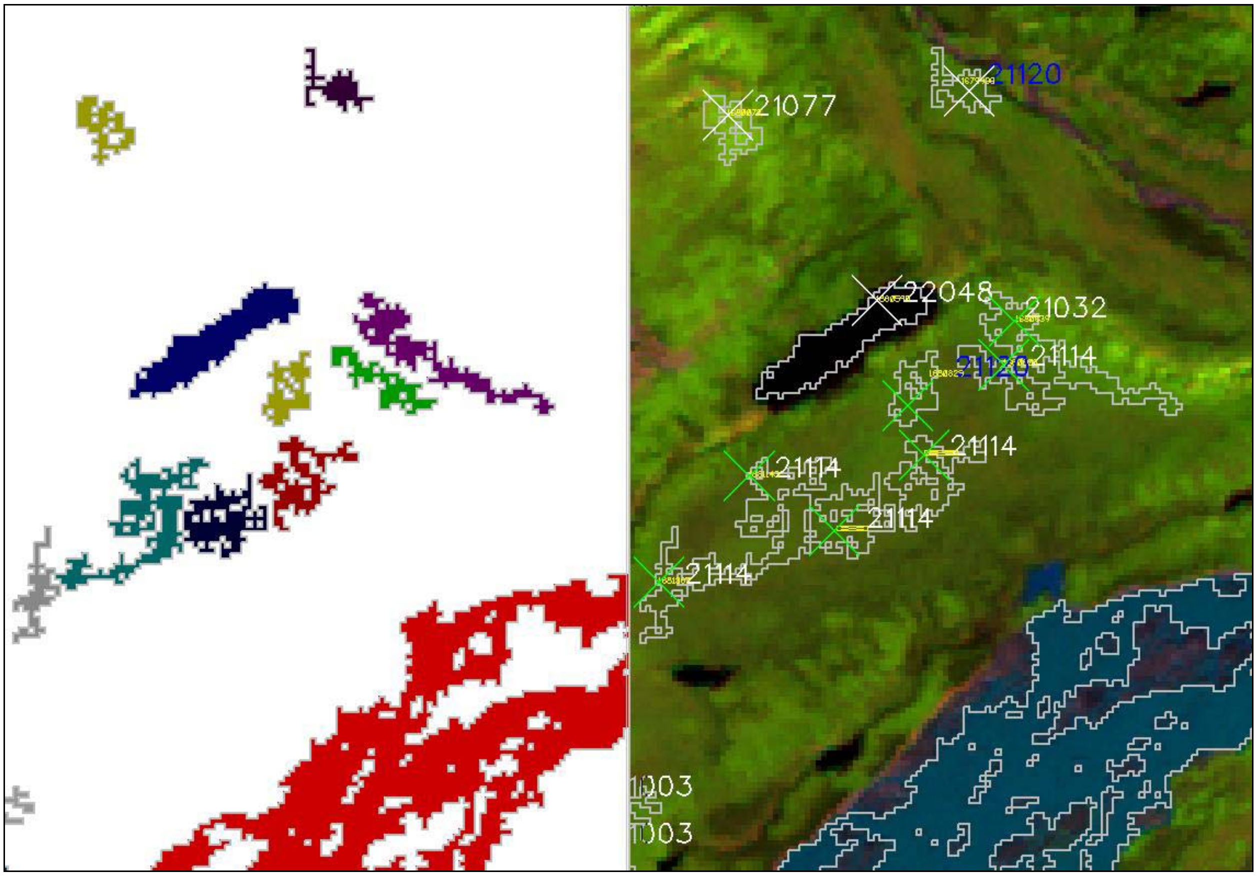

Figure 7: Candidate Training Sites

Candidate Site Field Maps and Data

A series of 1:47,500 scale (20” X 15”) color maps were developed to facilitate training area location and navigation in the field. Maps showed candidate training area polygons, iso_class numbers, and 400’ elevation contour lines, over a 5, 4, 2 RGB composite built from the LandSAT imagery. A total of 132 field maps were generated and uniquely labeled using a row-column code with origin on the upper left corner of the project area grid. Two copies of each map were produced, one for the aerial survey crew and the other for the ground survey crew.

All maps were laminated for protection and to enable flight planning and notations directly on the map with permanent color pens. A portion of one of these field maps (I2) is shown in Figure 8.

Efforts were made to determine potential training site locations that covered the spectrum of significant land cover types within the project area before starting field data collection efforts. All unsupervised areas meeting homogeneity and size requirements were kept as part of the pool of candidate training sites, in order to enable changes to the sampling plan while in the field due to time and fuel limitations. Additional training site characteristics were also generated; site specific estimates of slope, aspect, and elevation themes were developed for each candidate site using grid overlay processes. X,Y coordinate values representing each training site were also loaded into the database table. These training area coordinates were used for navigation and positional confirmation using GPS receivers in the field. Location of training areas in this manner allowed for careful flight planning and more efficient and safer access to field plots. The pool of candidate sites was completed and mapped.

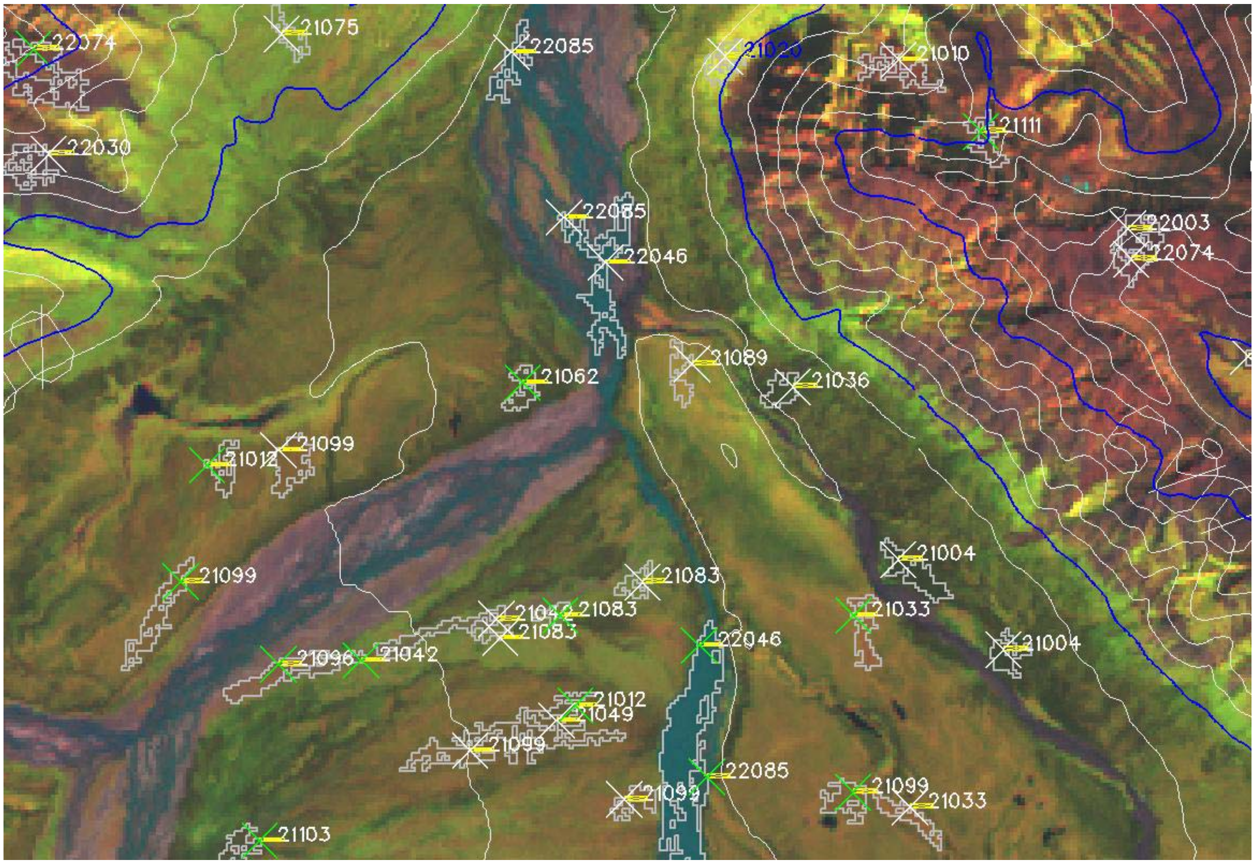

Figure 8: Field Map with Candidate Training Sites

Field Sampling Restrictions

Aerial sampling from a helicopter was used to maximize the number and diversity of sampled aerial training sites. This approach would yield the land cover components as viewed from above ("bird's-eye view") and enabled rapid (and safer) on-demand access to target training areas. However, constraints to sampling efforts existed due to fuel supply and availability, aircraft range, crew-ferrying time, no-flight zones, and weather conditions. Only two areas were designated as "no-fly" areas; these areas were the McCarthy Creek watershed just to the east of McCarthy and the Chitisone River/Chitisone Pass vicinity. All other portions of the park were deemed accessible, with the only limitation being to avoid collecting aerial data close to private inholdings/homesites or wildlife. High priority was given to identifying and targeting training sites in areas of image overlap, as these sites could be used for training in all overlapping scenes. Large groups of candidate training site areas incorporating as many ecosections and ISODATA classes as possible were identified for sampling.

Aware of these constraints, and at the request of the AKRO, efforts were made to maximize field data collection efficiency by reducing travel time between training collection sites and the number of collection sites required to develop comprehensive supervised classification training data sets. Thus, potential training sites were organized as groups of sites, as much as possible, to minimize distance traveled between sample areas, while at the same time facilitate access by both ground and helicopter crews and adequately sample the geographic diversity of the Wrangell-St. Elias Project Area. Sample areas that fulfilled the sampling constraints, as well as the apparent project training data needs were identified. These proposed sample areas are shown in Figure 9.

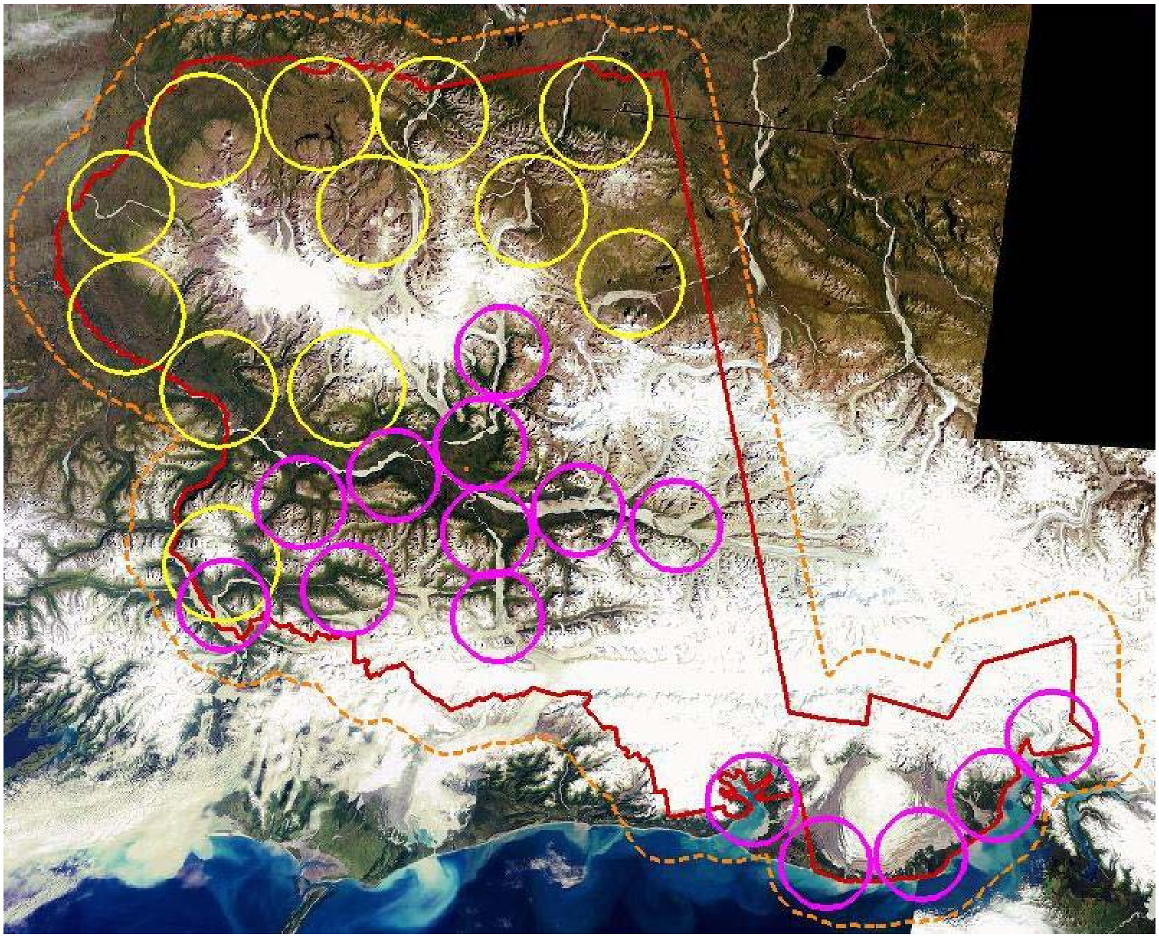

Figure 9: Sampling Areas-of-Interest in WRST

The magenta circles represent initial areas of interest identified for the 2004 field season and the yellow circles represent areas of interest for the 2005 field season. As is evident by the placement of the circles of interest, low priority was placed on sampling areas dominated by snow, ice, and glaciers.

Field Training Site Data Collection

Field data or “ground truth” information is one of the critical components of a land cover mapping effort like this project. The field data provide the land cover or “bird’s-eye view” descriptions that will both guide the classification efforts as well as describe the resulting land cover features in the final classification map. Accurate and detailed field data are essential for the successful completion of such an effort. Any misinformation collected during this stage and later applied during classification efforts will be embedded in the final map. Care was taken during initial aerial survey sessions to use methods that would result in as consistent-as-possible vegetation cover estimates, recognizing the significance of the relative abundance of different types (genus) of plants but attempting to identify individual species whenever possible. Particular care was taken to properly identify differences between white and black spruce trees. As this was an aerial survey and not a ground survey, notes were taken whenever the botanist believed his/her species call might be suspect.

Field Data Collection Goals

Image classification training data sets must encompass the complete range of significant land cover characteristics present in the project area. To this end, **GRS** worked with AKRO staff and ABR botanical and ecological experts to identify a matrix of the land cover characteristics and conditions thought to exist in the project area. This matrix represented the variety of land cover characteristics, including species/cover components and vegetation density classes. The land cover class matrix was composed of a combination of the target (known) land cover classification system, as well as other recognized (potential) land cover types that might also be found within the project area. This land cover type matrix formed the basis of the land cover classification system that would be applied during the mapping project. This matrix also formed the basis for field data collection efforts, as classes that would ultimately be recognized and mapped would require training site locations associated with the many different land cover attribute descriptions (“ground truth”).

The range of possible land cover types must be adequately sampled within the subject imagery to develop suitable classification training sets that will yield accurate and reliable image classification pixel maps. The basic matrix/listing of land cover types used to guide field data collection efforts is listed in Table 6. At each field data collection site information would be developed that would describe the cover characteristics of the site. This information amounted to a “bird’s-eye view” from above of the land cover components that summed to a total of 100 percent cover. A field form was developed by AKRO, **GRS**, and ABR staff to record this information. A copy of one of these field forms is shown in Appendix A. The cover characteristics recorded at each site amount to a “bird’s-eye view” of the site, such that the site would be described by species specific (if possible) land cover/vegetation characteristics that would sum to 100% cover. Additional cover (understory or overtopped) would also be noted as part of the information. In additional any specific characteristics regarding moisture regime and environment would also be recorded. Lastly, a land cover type would be assigned based on the botanist’s interpretation of the cover composition of the site relative to the land cover classification rules being used in this project.

The vegetation/land cover classification system used for WRST was a modification of the Alaska vegetation classification developed by Viereck (Viereck et al 1992), and was designed by ABR vegetation experts in conjunction with AKRO. The system defined cover classes in terms of vegetation communities named after dominant species existing in principal layers.

The vegetation/land cover classification system evolved during the project as land cover data were processed and evaluated. The complete final set of cover types associated with this mapping project is included in the Results Section of this report in Table 24. A snippet of the C code used in **GRS** software to estimate the cover type class is listed in Appendix B. Schematic descriptions of project cover and density classes can be reviewed in the diagram in Appendices C and D.

Field Data Collection Operations

The collection of field data was a joint effort by personnel from AKRO, **GRS**, and ABR. All field data efforts were coordinated by AKRO personnel and guided by the project data collection needs, as identified by **GRS**, ABR, and AKRO. **GRS** was responsible for the development of daily aerial field survey data collection plans that included the selection of potential candidate field training sites and the information necessary to locate these locations. ABR was responsible for the ecological ground-sampling data collection efforts and the characterization (ecological description) of the different land cover types present in the WRST Project Area. This included the development of detailed land cover descriptions for the field training sites visited during aerial surveys. The AKRO was responsible for planning and coordinating all field data collection logistics over the three-year field data collection effort.

Field data collection efforts were planned to occur during July of 2004 and 2005. Data collection efforts were initiated on July 2, 2004 from Yakutat, AK, located near the southeastern extreme of the Park. A total of 5 days of field data collection surveys were undertaken from this coastal location. Field data collection efforts then shifted to the interior of WRST at May Creek located approximately 3 miles to the southeast of McCarthy, AK. For 8 days from July 16th through July 23rd, aerial survey data was collected south of the Wrangell Mountains. These 13 days comprised the 2004 field data collection effort. Starting on July 9th, 2005 field data collection efforts shifted to the northern side of the Wrangell Mountains where they were based out of Chisana, AK. Four days of field data collection efforts were undertaken from this location before crews relocated in Gakona, AK where field data collection efforts focused on the northwesterly portions of WRST for five days from July 13th through the 17th. Efforts then shifted back to the southern side of the Wrangell Mountains where field data collection efforts were initiated out of Kenney Lakes, AK. A total of 23.5 days of field data collection efforts were completed during 2004-2005. Upon an initial evaluation of the 2004-2005 data collection efforts and consultation with ABR and **GRS**, the AKRO Project Manager decided to schedule one last field data collection effort during July of 2006. This effort was designed to fill in any gaps or data thought to be missing from the 2004-2005 field data collection efforts.

Table 6: **WRST Original Land Cover Types**
Sitka Spruce:Closed
Sitka Spruce:Open
Sitka Spruce:Wdlnd
Black Spruce Stunted:Wdlnd
Black Spruce:Closed
Black Spruce:Open
Black Spruce:Wdlnd
Spruce Mix:Closed
Spruce Mix:Open
Spruce Mix:Wdlnd
White Spruce:Closed
White Spruce:Open
White Spruce:Wdlnd
Mixed deciduous-conifer:Closed
Mixed deciduous-conifer:Open
Mixed deciduous-conifer:Wdlnd
Aspen:Closed
Aspen:Open
Aspen:Wdlnd
Balsam Poplar:Closed
Balsam Poplar:Open
Balsam Poplar:Wdlnd
Paper Birch:Closed
Paper Birch:Open
Paper Birch:Wdlnd
Mixed deciduous:Closed
Mixed deciduous:Open
Mixed deciduous:Wdlnd
Tall shrub:Closed:Alder
Tall shrub:Closed:Mix
Tall shrub:Closed:Willow
Tall shrub:Open:Alder
Tall shrub:Open:Mix
Tall shrub:Open:Willow
Low shrub:Closed:Mix
Low shrub:Closed:Willow
Low shrub:Open:Alder
Low shrub:Open:Mix
Low shrub:Open:Willow
Dwarf Shrub
Aquatic Forb
Carex
Forb
Graminoid
Lichen
Moss
Sparse Vegetation
Snow/Glacier
Barren
Water

An additional week of field data collection efforts were scheduled for July of 2006. These efforts lasted from July 7th through the 12th and were based out of Nabesna, AK in the northern portion of the WRST for the first 3 days before returning down to Kenney Lakes, AK in the more central portion of WRST for the final three days. On July 12th survey data was collected on the ground as we had exhausted the helicopter flight time during the first 5 days of our field efforts. Only one area designated for sampling was not able to be sampled during these efforts. The logistics and time requirements to get to Icy Bay in the southeastern portion of WRST made it impractical to sample this area during the project.

Table 7 summarizes project field data collection efforts and the number of aerial survey sites visited and described during these efforts. In total, aerial survey data were collected on **29 days** during the three different aerial data collection efforts. During those days, **104.3 hours** of flight time or approximately **3.6 hours/day** of actual time were logged surveying aerial sites. Much of the remaining helicopter time was spent transporting ground data collection crews to and from the field, moving equipment, and refueling the helicopter.

GRS staff maintained a WRST project database on a **GRS** laptop computer system that was used in the field to develop, revise, and administer aerial survey data collection efforts throughout the Wrangell-St. Elias National Park & Preserve. This system contained all WRST project data and imagery, as well as GIS and Image Processing software. **GRS** used this system to develop and revise daily aerial survey plans and schedules, query and review candidate training site locations to develop alternative plans, download and store GPS data and digital photography, and monitor data collection progress relative to project land cover sampling needs.

Date(YYMMDD)	Frequency
40702	28
40703	24
40704	31
40705	32
40706	13
40716	28
40717	22
40718	18
40719	22
40720	29
40721	34
40722	24
40723	38
50709	16
50710	33
50711	28
50712	31
50713	7
50714	20
50715	17
50716	39
50717	30
50718	28
50719	20
60707	16
60708	31
60709	16
60710	31
60711	25
60712	8
Grand Total	**739**

Table 7: Aerial Sites by Date

Aerial Survey Logistics

The basis of the aerial data collection efforts was the daily flight plan. **GRS** generated a daily flight plan consisting of a list of specific aerial training sites. Each site was selected based on an evaluation of data needs relative to up-to-date data collection efforts and a site specific evaluation of potentially available sites in the particular portion of WRST to be sampled that day. Particular emphasis was placed on locating candidate sites that were situated in overlapping areas of cloud free imagery in multiple images. These sites were consistently mapped as homogeneous areas in multiple images, a further indication that these sites were spectrally homogeneous and would make good image training sites. Planning efforts of this manner were implemented to fulfill data collection needs as-best-as-possible. Each flight plan guided the aerial survey data collection efforts using the Bell or R44 helicopters. This plan, as a tabular report, was printed on the aerial sampling form and included the sampling area number (a regional number assigned to different areas of the project area), candidate training site *iso*_class number, positional coordinates (lat/longs), aspect, slope, and elevation of the sample site locations. This report was generated using the GIS by performing a formatted query of the candidate sites selected and sequenced for sampling for any particular day.

Field maps, imagery, and aerial photos were reviewed and sampling sequences were developed to minimize travel time. Field maps were annotated with additional information as a navigational aid to help locate the selected areas. A tentative sampling sequence was delineated on appropriate field maps indicating selected flight paths, and used as a flight plan for the aerial survey efforts. Coordinates were loaded into the Garmin Map 76S GPS units and used as a navigational tool to quickly and accurately locate the targeted candidate sites. Figure 10 shows a portion of one of these annotated field maps.

As the plans were implemented and sites were visited, **GRS** assigned a unique training site identification number (*trsite_id*) to each aerial survey site. This *trsite_id* was generating by concatenating the date with a sequential visit numbers for each location. For example, the *trsite_id* “071108” would designate the 8 th area visited on July 11th. If the same date was used in multiple years, the different years’ sets of *trsite_id* values were offset by 50 to retain sets of unique numbers. Actual field locations, based coordinate locations based on the GPS receivers, were collected to “mark” surveyed training area locations from the air. Digital pictures and video representative of the aerial sites was also collected.

GRS made efforts to adhere and exceed daily aerial survey schedules. However, fuel capacity, time limits, and other constraints did not always allow for complete sampling of the scheduled areas or sites. Opportunistic sampling was implemented whenever feasible in order to supplement scheduled sampling efforts, so long as such efforts were not excessive such that they would prevent the primary schedule from being implemented. Opportunistic sampling was implemented in two ways. The first way entailed locating alternative *iso_class* training areas printed on field maps that were spectrally equivalent to and nearby scheduled areas (i.e., same *iso_class* code) that could not be sampled. The second type of opportunistic sampling involved spotting and sampling apparently promising areas while en route to other locations. These areas were not necessarily plotted on the field maps and may not have had assigned *iso_class* codes. However, they were visually estimated to be large enough and appeared homogeneous enough to qualify as valid sampling sites. These sites also tended to be land cover types known to be ‘rare’ or missing in the land cover matrix, such as wet herbaceous or aquatic types.

The aerial survey crew consisted of the helicopter pilot, a **GRS** image processing specialist and a botanical specialist. The botanical specialist was either an ABR employee or the AKRO Project Manager. The **GRS** specialist’s responsibilities included navigating to and locating scheduled candidate training sites using coordinates listed in the daily flight plan printed on the sample schedule form and on the field maps. As the helicopter approached a target location, the **GRS** specialist used field maps to confirm arrival at the target site. Once arrival at a target sample site was visually confirmed and its extent described to the entire aerial survey crew, the pilot would begin to slowly circle the target site while the botanist proceeded with the ecological characterization of the land cover present within the training site. Meanwhile, the **GRS** specialist photographed and videotaped the site, recorded coordinate locations of the site using the GPS unit, and recorded pertinent comments. Once the ABR botanist and **GRS** specialist declared completion of their tasks, the **GRS** specialist provided navigational information and the pilot began flying to the next training site. If the botanist had questions regarding what he/she was viewing from the helicopter, the pilot would set down in the sample area, if possible, enabling the botanist to get out and actually see the vegetation and collect plant samples. This was not a common experience due to time and fuel limitations and happened at no more than 10% of the aerial survey sites.

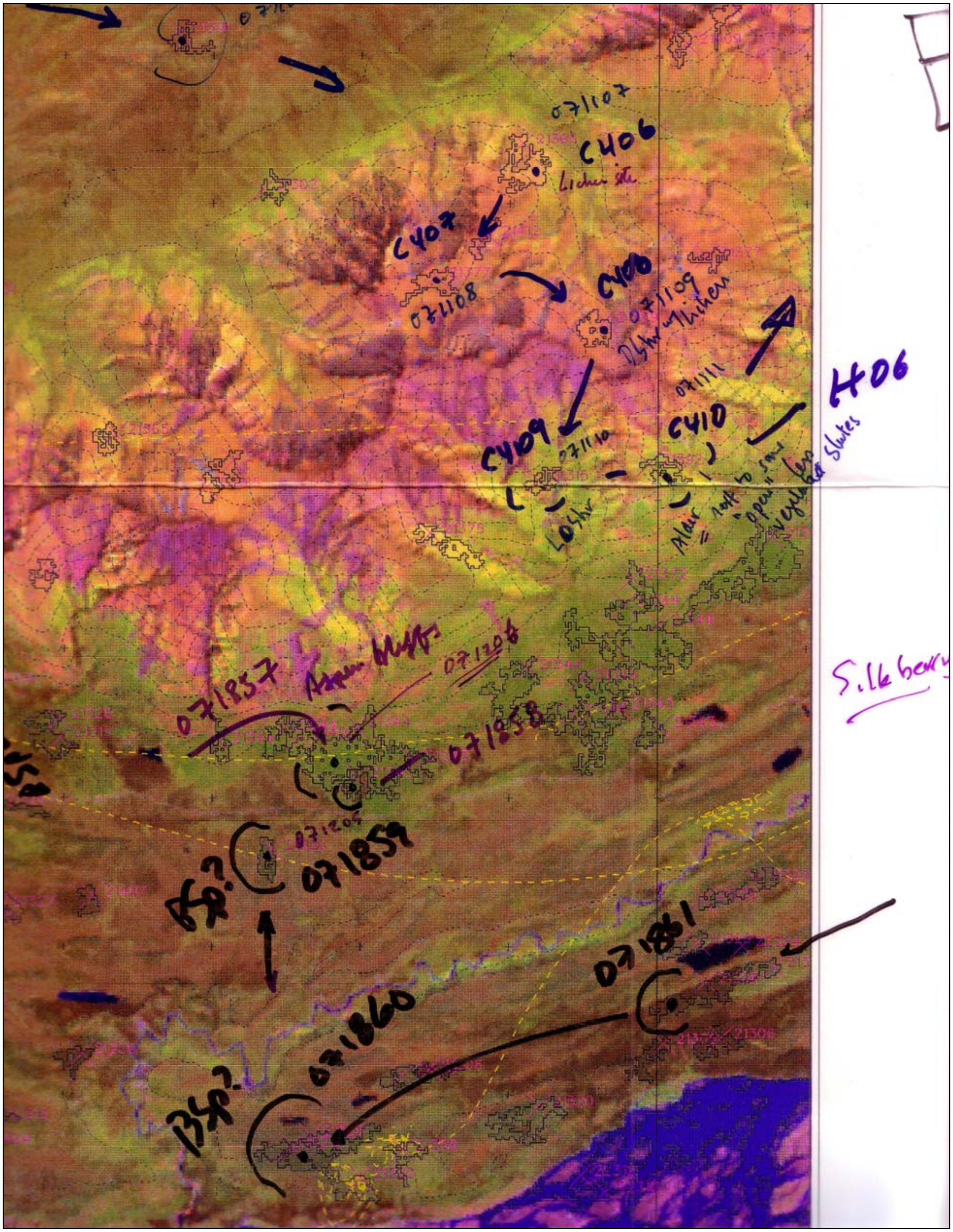

Figure 10: Annotated WRST Field Map (portion)

Each day following completion of aerial survey site data, the data were processed and the number of sites that had been sampled were tallied in the database, thereby enabling tracking of the frequency of samples by iso_class and land cover type. This information was used to identify types still lacking samples, as opposed to common types with many samples. Subsequent data collection efforts were adjusted daily in an effort to completely cover/fill the land cover type matrix. In addition, remaining unsampled types were identified and reprioritized so that they could be sampled as opportunistic training sites, if the aerial survey crew found suitable sites of these known unsampled types.

Aerial Survey Results

An average sampling day consisted of approximately four hours for actual training area aerial surveying. A total of 739 training sites were described by the aerial survey crew. An average of 25 sites were surveyed from the air per sampling day. At the end of each sampling day, the **GRS** specialist imported coordinate values for sampled training sites into the project database and maps. Each sampled site field-recorded position was converted into a point feature attributed with its unique training site ID. This ID was later used to relate each point to its respective land cover description data. All recorded digital imagery was also saved to disk. These efforts resulted in plotted flight paths, where each aerial site was a waypoint on the flight path. Locations were reviewed relative to the candidate site locations and the imagery, and any inconsistencies relative to the candidate site locations were identified. If the candidate site was ‘missed’ during the sampling it was not recorded as a sampled iso_class.

As data collection efforts progressed, field data were reviewed on a daily basis to assess the variability and number of land cover classes visited to-date. These reviews enabled GRS personnel to reprioritize efforts and guide subsequent data collection efforts to include classes that appeared under-represented in the current sample set. A summary of the number of sites surveyed from the air by the original land cover types listed in Table 6 is shown in Table 8. These data collection sites and classes were distributed over the entire project extent visited, spanning all nine LandSAT images.

Cover data for surveyed sites were imported into the project database tables and made available for database query and report tools used in the subsequent resolution of class confusion, assessment of training class performance, and characterization of each site’s land cover attributes. SQL queries were performed to check for invalid data, such as sites for which the total “bird’s-eye view” cover did not equal 100 percent. SQL statements were also used to generate the modified Viereck land cover types, to check for incorrect or inconsistent field calls. Data inconsistencies were identified and corrected. Data were summarized using ***GRS_covmatrixsum*** to develop a calculated cover type (*calc_class*) using the modified Viereck rules and estimates of cover by individual specie, as well as groups of species, and were loaded into the relational database tables as attributes of each site. In addition, the predominant cover component and percent cover were also loaded into the database tables.

Supplemental Data Sources

In addition to the aerial survey data, additional data sources were also used during this project. The field data that was collected over a total of 29 days amounts to approximately 3 days per image or sampling about 600,000 acres per day. While efforts had been made to assure sufficient distribution of sampling throughout the range of types and images, 29 days were not enough time to develop the fully comprehensive sample necessary to map the entire WRST. Supplemental data would be necessary to increase the sample size for underrepresented images and types.

In addition, **GRS** found as the project progressed that more floristic components, such as *Dryas sp*, *Betula sp*, *Betula-Salix* mixes, and *Cassiope* could be spectrally distinguished and mapped, if such sites could be included in the training data sets. Additional data sources were used in an effort to supplement the existing aerial data set that had been developed. While none of these supplemental sites had been prequalified to see if they were spectrally homogeneous, they did have vegetation characteristics that were of interest to the project.

The additional sources included ABR ground survey site data, NPS FirePro (FP) plot data, Ducks Unlimited (DU) aerial survey data, and **GRS** photo-interpreted/occular estimates. ABR ground data was used to generate estimates for a few sites that were lacking from the vegetation land cover matrix, such as Low:Open:Silverberry. In addition, a few ABR sites were used to represent land cover types present in the matrix, but missing from a particular scene. The same rationale was used when adding FP site data to the training data set. The DU data set had been collected during the summer of 2005 for a mapping project performed for Tetlin National Wildlife Refuge. This data set was of value as it contained many black spruce and wet herbaceous sites out on the Tetlin flat north of WRST that were thought-to-be representative of similar areas in that northeasterly area of WRST that **GRS** had only been able to sample for one day. Lastly, **GRS** added some sites using photo-interpreted or ocular estimated techniques to represent areas that could be estimated with a high degree of reliability. Many of these sites were in areas that **GRS** had visited or observed during sampling efforts, but had not actively collected data at the site during the aerial survey. The types added in this manner were typically non-vegetated land cover types such as snow, barren, water, glacier, and so forth which had been relatively low priority sample types relative to vegetation types. Some areas, with vegetation, were represented by data from other sites where the two sites were thought to be comparable in composition.

Table 8: Sample by Type

WRST Original Land Cover Types	Sample Count
Sitka Spruce:Closed	4
Sitka Spruce:Open	5
Sitka Spruce:Wdlnd	2
Black Spruce Stunted:Wdlnd	1
Black Spruce:Closed	1
Black Spruce:Open	18
Black Spruce:Wdlnd	15
Spruce Mix:Closed	0
Spruce Mix:Open	10
Spruce Mix:Wdlnd	4
White Spruce:Closed	8
White Spruce:Open	59
White Spruce:Wdlnd	38
Mixed deciduous-conifer:Closed	11
Mixed deciduous-conifer:Open	42
Mixed deciduous-conifer:Wdlnd	13
Aspen:Closed	9
Aspen:Open	6
Aspen:Wdlnd	1
Balsam Poplar:Closed	7
Balsam Poplar:Open	17
Balsam Poplar:Wdlnd	6
Paper Birch:Closed	4
Paper Birch:Open	1
Paper Birch:Wdlnd	2
Mixed deciduous:Closed	5
Mixed deciduous:Open	14
Mixed deciduous:Wdlnd	9
Tall shrub:Closed:Alder	34
Tall shrub:Closed:Mix	12
Tall shrub:Closed:Willow	18
Tall shrub:Open:Alder	12
Tall shrub:Open:Mix	10
Tall shrub:Open:Willow	7
Low shrub:Closed:Mix	12
Low shrub:Closed:Willow	1
Low shrub:Open:Alder	1
Low shrub:Open:Mix	69
Low shrub:Open:Willow	26
Dwarf Shrub	70
Aquatic Forb	3
Carex	26
Forb	51
Graminoid	4
Lichen	7
Moss	5
Sparse Vegetation	21
Snow/Glacier	0
Barren	28
Water	9