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Classification of Space Images for Forest State Identification Within the Siberia Region: Part 1

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Abstract

This paper describes the initial stages of a multi-phase collaborative effort underway between IIASA's Forestry Project and the Center of AeroSpace Research of the Earth (CASRE). The main goal of this effort is to develop a procedure for the retrieval of forest inventory information across Siberia, Russia. Due to the great size of the area, satellite data may play an important role. We are currently investigating the application of a multi-sensor approach, whereby a combination of high and low resolution sensors is used to achieve results.

Initial efforts have focused on the classification of high-resolution Landsat images with the aid of GIS ground-truth data. In addition, a brief analysis was made of SPOT Vegetation data over the study site. The interaction between the detailed GIS data, the high-resolution Landsat data, and the coarse resolution SPOT Vegetation data was explored. It appears difficult at present to merge these various datasets in a meaningful way. It will be necessary to incorporate other sensors, possibly those of a moderate resolution in order to tackle the problem. One additional area of investigation begun here was the possible identification of different types of disturbances, in particular, damage from pests. At this stage, it appears that the interpretation of a classified Landsat image after thresholding allows for the identification of forests affected by the Siberian moth.

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Classification of Space Images for Forest State Identification Within the Siberian Region: Part 1

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1 Introduction

A multi-phase collaborative effort has begun between IIASA's Forestry Project and the Center of AeroSpace Research of the Earth (CASRE). The main goal of this effort is to develop a procedure for the retrieval of forest inventory information across Siberia, Russia. IIASA has acquired a substantial volume of ground truth data in digital format within Siberia, along with various satellite images/formats and local knowledge. CASRE has performed multiple classifications of satellite imagery within boreal forest types and has developed a number of procedures for classification. The combined effort of these two groups could produce meaningful results.

IIASA has focused on acquiring and analyzing forest information in Siberia for several years, the main focus being the analysis of Russia's carbon and greenhouse gas balance. Due to the great size of this area, and the significant decrease in both the quantity and quality of forest inventory and monitoring in Russia during the last decade, satellite information may play an important role. However, issues arise such as satellite resolution, processing time, costs, and achievable results. We are investigating the application of a multi-sensor approach, whereby high-resolution datasets are used as training sites for low-resolution datasets spanning a larger area. In addition, we aim to look for ways to merge radar and optical data in an effort to maximize the usefulness of the results.

The initial step described here is the processing and classification of high-resolution optical data (Landsat-7) that overlapped several ground truth sites. A brief comparison was made of the resolution of SPOT Vegetation data with that of ground truth data. Following this report, modifications will be made to the classification methodology by adding more ground truth sites and Landsat scenes. The next steps will involve merging these results with radar data and medium to coarse resolution optical data to broaden the research territory.

2 Background

The territory investigated in this study lies within the subzone of the southern taiga, within Krasnoyarsk Kray and Irkutsk Oblast, and is dominated by heterogeneous coniferous forests. These forests, while playing an important role in the ecology of the region, are intensively exploited for timber, particularly near railways and rivers, on which it is possible to transport wood. This region is one of the major areas of forest harvest in Siberia. The main harvesting of forests is conducted in the south.

The region is dominated by typical taiga forest with a high percentage of forest cover — 72.1% in Krasnoyarsk Kray and 80.4% in Irkutsk Oblast (FFMR, 1999). Pine is the dominant species in the central and northern areas of the region — 9.6 million hectares (ha) in Krasnoyarsk Kray and 15.0 million ha in Irkutsk Oblast. In addition, significant areas (largely in the north) are covered by larch — 6.2 million ha in Krasnoyarsk Kray and 17.4 million ha in Irkutsk Oblast. Mixed coniferous forest dominates in mountain areas, with areas covered by spruce (5.8 million ha), Russian cedar (8.0 million ha) and fir (5.7 million ha) in Krasnoyarsk Kray and 3.2, 7.0, and 1.6 million ha in Irkutsk Oblast, respectively.

The large size of the territory, insufficient infrastructure, inaccessibility of many areas, and the severe climatic conditions considerably complicate its study by traditional methods. In the past, significant areas of forest were inventoried by very rough methods and much of the inventory data is now obsolete, e.g., 23% of the forest fund of Irkutsk Oblast was inventoried between 1948 and 1953, and these materials cannot be used for any management purposes (Vaschuk, 2001). Given these conditions, the use of satellite imagery is of great value in estimating forest vegetation of the region, and defining forest structure, age, growing stock, health, fire risk assessment, etc. With the help of these tools, it is also possible to monitor harvesting and regeneration and to estimate a transportation infrastructure of the region.

In Russia, satellite images of forest ecosystems have been available since the 1970s (Malysheva *et al*., 2000), with the first applications of satellite data in forest inventory occurring at the end of the decade (Sukhikh and Sinitsyn, 1979). Taking into account the great territories to be inventoried, the application of remote sensing data is strongly recommended for future national Russian forest inventories and monitoring (Banko, 1998; Shvidenko and Nilsson, 1997; Isaev and Sukhikh, 1998). Especially important is the integration of data from different sensors, because the variety of remote sensing data will increase in the near future and this approach allows for multi-resource and multi-phase forest inventory designs.

The systematic inventory of the region’s forests began only in the last 50 years of the 20th century. In this time a great amount of information was gathered, but the significant size of the territory and its inaccessibility have made data collection difficult, prompting the widespread use of aerial survey methods. Today, this approach is insufficient, because within this territory significant blocks of forest are maintained with different intensity. This work should be carried out using satellite images complimented by ground research data.

Three important fields of applications of remotely sensed data are of major interest: (1) forest inventory as a basis for sufficient forest management, (2) forest monitoring, e.g., forest fire monitoring, forest pathological monitoring, etc., and (3) estimating the biospheric role of forests, in particular, the assessment of major greenhouse gasses. System solutions of these tasks are only possible through the relevant combination of a multi-sensor remote sensing concept and a detailed description of landscapes in a Geographical Information Systems (GIS) form, e.g., an Integrated Land Information System (ILIS) combined with ecological modeling.

The Global Observation of Forest Cover (GOFC) group has proposed the following program of coarse resolution [250–1000 meters (m)] land cover mapping on a five-year cycle, combined with periodic mapping and monitoring of forested areas at fine resolution (~25 m) (see *Figure 1*). We are planning to test, in part, this model in an effort to improve the inventory of Siberian forests.

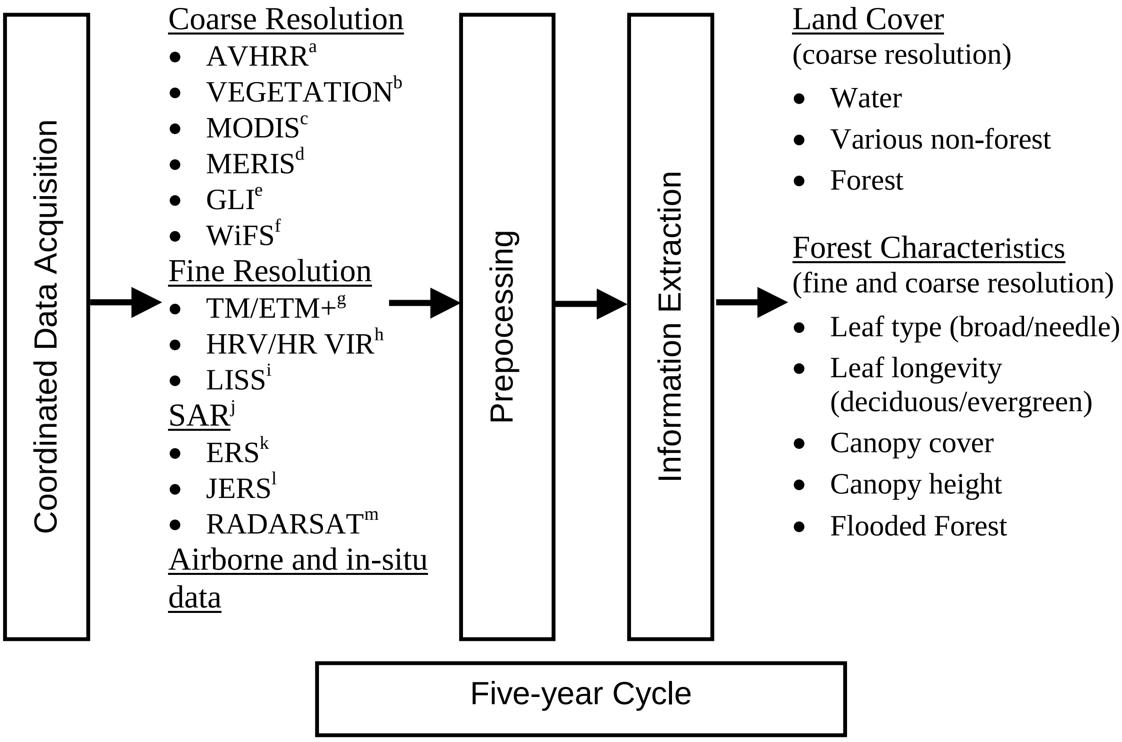
3 Research Territory

The research territory is located within the taiga forests of southern and central Siberia (*Figure 2*), contained within the coordinates 88 and 112 E and 50 and 62 N, covering an area of almost 1 million km^2. Lake Baikal is situated in the southeast of the territory. The cities of Irkutsk and Krasnoyarsk are the two main centers of urbanization. The Yenisey and Angara rivers flow through the area towards the Arctic Ocean.

A number of test areas, limited by boundaries of forest enterprises, were selected based on regularities of the zonal distribution of forest vegetation, major land forms (mountains and plains), and the specific major forest formations of the region (*Figure 3*). Inside each test area a number of test sites have been used for detailed consideration. In *Figure 3*, shaded areas (red) contain ground truth test areas stored in a GIS. At this stage of the research, only the Bolshe Murtinsky and Chunski areas were studied. Within these two test areas a total of nine test sites exist, containing spatial forest inventory information complete with attributes.

3.1 Specific Study Area Description

The specific territory considered in this report (Bolshe Murtinsky and Chunski test areas) lies within the southern taiga of Siberia within the limits of Krasnoyarsk Kray (*Figure 4*). Its northern limit passes along the Angara River, in the south it borders with the forest-steppe belt and in the east and west its limits coincide with the administrative borders of Krasnoyarsk Kray. The area can be divided into east and west, split by the Yenisey River. To the west of the river lies the gently sloping West-Siberian Plain. The height of the district falls within the limits of 135–295 m above sea level. The river valleys of the Ob and Yenisey rivers interrupt the surface of the plain. The eastern part of the research territory falls within the southwestern region of the Siberian plateau. The relief is more varied here, with such features as the Angara depression dividing the Yenisey Ridge into northern and southern parts, the Chuno-Birjusa plateau, etc. The general climate of this region can be characterized as continental.



[a] Advanced Very High Resolution Radiometer, a multi-spectral imaging system with a 1.2 km resolution.
[b] SPOT Vegetation, a 1 km product monitoring land parameters on a global, daily basis.
[c] Moderate Resolution Imaging Spectroradiometer viewing entire earth surface every two days at 0.25–1.1 km.
[d] An imaging spectrometer that measures the solar radiation reflected by the earth, at a ground spatial resolution of 300 m, in 15 spectral bands. Allows global coverage of the earth in three days.
[e] GLobal Imager is an optical sensor which observes solar light reflected from the earth's surface.
[f] The Wide Field Sensor collects images with a spatial resolution of about 200 m in both a red and near-infrared spectral band.
[g] Landsat Thematic Mapper and the Enhanced Thematic Mapper. The ETM+ instrument is an eight-band multi-spectral scanning radiometer with a resolution of 15–60 m.
[h] Haute Resolution Visible (on SPOT); and Haute Resolution Visible-InfraRouge (SPOT-4).
[i] Linear Imaging Self-scanned Sensor.
[j] Synthetic Aperture Radar.
[k] European Radar Satellite launched by the European Space Agency in July 1991. The main payload instrument includes a SAR at C-band.
[l] Japanese Environmental Radar Satellite launched by Japan in February 1992. It includes an L-band SAR.
[m] This carries a C-band SAR.

Figure 1: Proposed five-year cycle of data acquisition and analysis (GOFC, 2001).

Figure 2: Research territory located in south-central Siberia.

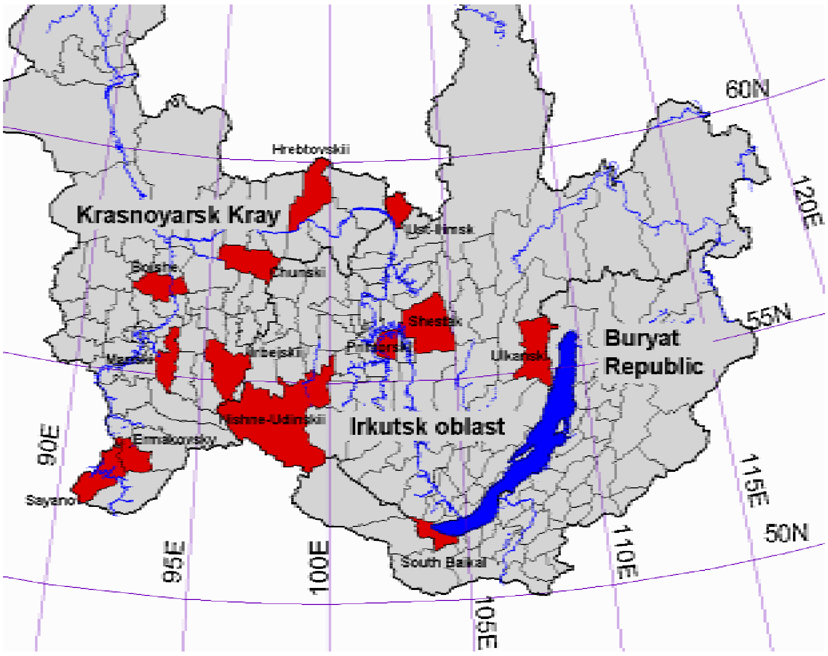
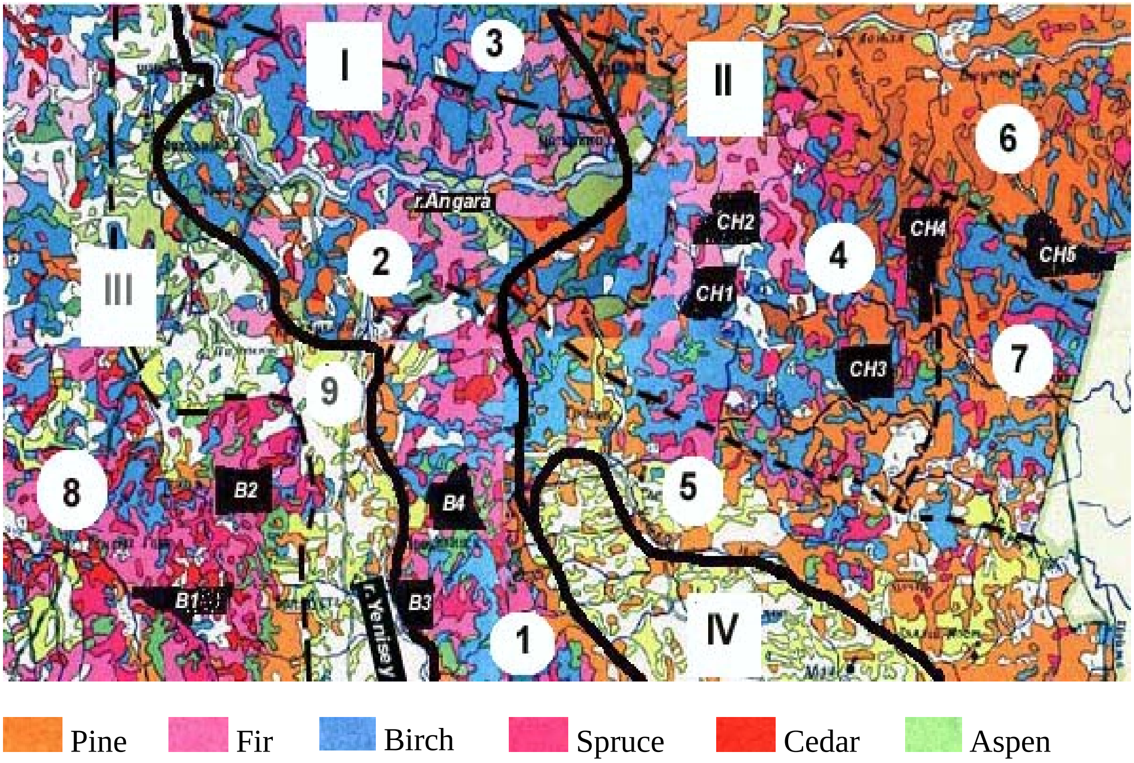


Figure 3: Research territory showing IIASA test areas (shaded red), containing test sites with GIS forest inventory — the current focus is on the Bolshe Murtinsky and Chunski areas.



Notes: I = Yenisey Ridge Province: (1) Fir forests of South Yenisey Ridge; (2) Mixed coniferous forests of Angara depression; (3) Mixed coniferous forests of North Yenisey Ridge.
II = Angara Province: (4) Taseevsky region of deciduous forests and pine forests; (5) Birjusinsky region of pine and mixed coniferous forests; (6) Mursky region of pine forests; (7) Chuno-Kovinsky region of pine and spruce forests.
III = Ketsko-Chulimskay Subprovince (of mixed coniferous and deciduous forests of West-Siberian province of flat forests): (8) Region of mixed coniferous forests; (9) Region of mainly deciduous forests with pine and larch.
IV = Kanskay Natural Region.
B1–B4: GIS ground truth test sites in the Bolshe Murtinsky test area.
CH1–CH5: GIS ground truth test sites in the Chunski test area.

Figure 4: Forest regions within the research area from the Atlas of forest vegetation (DGC, 1973; Elizarieva, 1965; Popov, 1982) and the 9 test sites (B1–B4 and CH1–CH5).

3.2 Forest Regions

In a subzone of the southern taiga of central Siberia within the limits of the examined area, the following forest regions are described by Popov (1982): the region of fir forests of South-Yenisey Ridge, the district of mixed coniferous forests of the Angara depression, the Taseevsky region of mixed coniferous and pine forests, the Mursky region of pine forests and the Birjusinsky region of pine and mixed coniferous forests.

3.2.1 Yenisey Ridge Province

In the region of forests of South-Yenisey Ridge (Lapshina *et al*., 1971), the forest vegetation is represented by mixed coniferous taiga with fir dominating. Fir forests have optimum conditions for growth on the main watershed. On the western slope, in connection with a reduction in humidity, pine forests dominate. The current vegetative cover of the Ridge consists of forest communities at different stages of growth. Mature spruce and fir forests generate a specific altitudinal belt on the Ridge. A significant part of the territory, especially on the western slope, is occupied by secondary forests representing various stages of post-disturbance succession in coniferous, birch, and aspen forests. Burned forests also occur in this territory. In the southeast region there are significant harvest blocks (up to 1,000 ha), consisting mainly of pine at different stages of regeneration. The age of stands varies from 70 to 200 years. Significant areas of overmature forests are typical for this forest region. The stands are characterized by relatively good productivity, with the growing stock volume ranging from 180 to 320 m^3 per ha.

The region of mixed coniferous forests of the Angarian depression is located between Yenisey, Angara, and Tasseeva rivers. The territory is a hilly landscape of southern taiga. Mixed coniferous forests of watersheds and slopes prevail here. The forests dominated by fir and spruce, occupy about 38% of the area. Birch and aspen forests, representing the first restoration stages of coniferous stands, occupy about the same area. Cedar comprises less than 8%, pine 15% and approximately 1% of the area is occupied by larch.

3.2.2 Anagara Province

The Taseevsky region of mixed coniferous and pine forests is located at the merging of the Birjusa and Chuna rivers and includes a significant part of the territory between the Angara and Taseeva rivers. The territory is a hilly plain, which has undergone strong erosion in connection with the existence of large rivers with deep valleys. The pine forests cover approximately a quarter of the area. The mixed coniferous forests are typical for flat watersheds in the south of region, on rather high altitudes of landscapes between the Taseeva and Angara rivers. The climate of this part of the district strengthens the position of fir in its mutual relation with other forest vegetation species, especially with cedar. Therefore, the fir forests dominate everywhere at the latter stages of growth of mixed coniferous taiga, both on drained and on flat watersheds.

Within the limits of Krasnoyarsk Kray, lies the extreme western part of the Mursky region of pine forests. The territory is a low plain with significant erosion. Here, pine forests occupy more than 60% and larch forests cover about 14% of the area. They are usually situated on slopes and in some places on flat watersheds. The spruce forests are situated at the bottom of slopes. Small areas are occupied by spruce in the south of the region, with fir and cedar forests practically nonexistent. Birch forests cover about 16% of the area on indigenous pine forest types and aspen forests occupy less than 1% of the area.

The Birjusinsky region of pine forests is represented by a rather narrow strip in the left part of the Taseeva and Birjusa rivers. Pine forests occupy about 45% of the forest area of the region. Smaller areas are occupied by pine near the bottom of slopes and on sandy podzol soils. The spruce forests, which share about 12% of the area, are found at lower elevations. A smaller area of spruce forests is on drained watersheds and slopes. The fir forests of flat watersheds and humidified slopes are widespread in the western part of the region. Aspen forests are also found, being an initial stage of regeneration of fir or pine forests in the bottom part of slopes and flat watersheds. Cedar forests of wet slopes are typical for small sites in areas of low relief. Larch forests cover an insignificant area, usually in places with frozen ground. Birch forests, found in various stages of regeneration, occupy less than a quarter of the forest area and are basically in the western half of the region.

3.2.3 Ketsko-Chulimskay Subprovince

In the west-Siberian lowland, the Ketsko-Chulimskay subprovince is described by a number of authors (DGC, 1973; Elizarieva, 1965; Jukov, 1969). The territory is located within the Chulimsko-Yenisey plateau with an elevation of 200–250 m above sea level. The forested area occupies 67%, while bogs cover about 30% of the land. The main dominant forest species of the area are distributed as follows: fir 28%, birch 20%, cedar 20%, spruce 3%, pine 28%, and aspen 1%. Fir and birch forests prevail in the south of the subprovince. To the north, cedar and pine forests cover a significant area along with fir forests.

3.2.4 Kanskay Natural Region

Pine, larch, and deciduous forests prevail and are bordered by forests of the southern Taiga of the Birjusinsky region of pine and spruce (in the north) and the fir forests of South Yenisey Ridge (in the northwest). In the north and northeast of the region, forests consist of pine, birch, and less frequently Siberian larch. Spruce and fir forests occur in the northwest edge of the district. It is worth noting that the percentage of area occupied by forests in this region compared to the Birjusinsky region and the South Yenisey Ridge is significantly less.

More information regarding the growing conditions of the region can be found in DGC (1973), Elizarieva (1965), Lapshina *et al*. (1971), Jukov (1969), Popov (1982), and Shivdenko and Nilsson (1997).

4 Methodology

In this study, we utilized two common software packages for image processing and GIS analysis, namely ERDAS Imagine 8.4 and ESRI ArcView 3.2.

4.1 Satellite and Reference Data

This study considers two test areas (Bolshe Murtinsky and Chunski) containing forest inventory polygons and attributes in GIS format, Landsat-7 scenes, and a complete SPOT Vegetation coverage for one season.

4.1.1 GIS Ground Truth Data

Forest Inventory and Planning (FIP) data is structured according to forest districts and administrative areas (kvartal). Each kvartal is divided into primary inventory units (SKNR) (in forested areas these are sometimes called stands). A SKNR is a relatively homogenous area in terms of tree species composition, age, height origin, site index, and relative stocking (see Appendix 1). Some SKNR boundaries have an ecological origin, (e.g., the edge of an area once burned by fire) and others follow kvartal boundaries. The SKNR boundaries are explicit but, when we look at the forest according to different attributes (e.g., age or species composition), they may become more or less obvious. It is important to recognize that SKNR boundaries are based on subjective, human interpretation, usually of aerial photos, and they are not always visible in small-scale satellite-based remotely sensed images, but can often be recognized on large-scale images. As a rule, the FIP is interpreted from 1:10 000 or 1:20 000 scale aerial photos. The research territory is contained within several administrative units of the Russian Federation, which complicates research as the ground data was collected by different groups and consequently are not always easily compared.

A total of nine ground truth test sites in GIS format located within two test areas were used in this study. Their spatial and attribute data was updated to 1998. The number of primary inventory units within each of the test sites generally exceeds several hundred polygons. Within the Bolshe Murtinsky test area there are four such test sites, each with a contiguous coverage of ground truth information. The B3 test site was used as the main test site for the analysis presented in this paper (see *Figure 4*).

4.1.2 Landsat-7

Landsat-7 ETM+: 4 images in 7 spectral bands (excluding panchromatic band) (1: .45–.52 micrometers (µ); 2: .53–.61 µ; 3: .63–.69 µ; 4: .78–.90 µ; 5: 1.55–1.75 µ; 6: 10.40–12.50 µ; 7: 2.09–2.35 µ). The images were captured in the summers of 1999 and 2000 and each image spans 180 x 180 km, overlapping the test areas of Bolshe Murtinsky and Chunski. The quality of images is good with cloud cover not exceeding 2%.

4.1.3 SPOT Vegetation

SPOT Vegetation: 18 images (product S10), for the period 1 April–30 September 1999. The images cover an area of 2500 x 1600 km and include the entire research territory. Each image has a resolution of 1 x 1 km and four spectral bands, which integrate the spectral reflectance of terrestrial covers in four spectral channels for 10-day periods. The SPOT Vegetation images include the following four channels and wavelengths; 1: .43–.47 µ; 2: .61–.68 µ; 3: .78–.89 µ; 4: 1.58–1.75 µ. The quality of the images is good, but they have a very low resolution. SPOT Vegetation images will only be considered briefly in this report, as the emphasis is initially on the high-resolution Landsat data.

4.1.4 Geometric Correction

ERDAS Imagine software allows importing this format with automatic georeferencing. The accuracy of the georeferencing changes from several meters up to several hundreds of meters. Therefore, further georeferencing is usually required for test sites, using vector data from a GIS. The intersections of roads, boundaries of harvest areas, and small rivers were used to perform more accurate georeferencing. This was necessary as the GIS ground truth data had to be overlayed on the images for supervised classification.

4.1.5 Radiometric Correction

At this stage of the research, no radiometric corrections were applied. This will be reviewed for future work but would be dependent on the acquisition of an accurate Digital Elevation Model (DEM).

4.2 Signature Analysis

As a first step, the analysis of spectral brightness was performed for the classification of the Landsat-7 images with the purpose to construct maps of forest distribution. This study utilized supervised training and classification. The result of the training process was a set of signatures for the selected classes. At this stage, we considered the parametric signatures, which describe pixels by their statistical parameters. We analyzed the statistics and histograms of the signatures to determine their uniqueness. Contingency matrices were created to test the pixels in a set of training samples to determine what percentage of pixels was classified as expected.

The efficiency of different band combinations was analyzed using signature separability with the Jeffries-Matusita Distance algorithm. Signature separability is a statistical measure of the distance between two signatures. Separability can be calculated for any combination of bands used in the classification, enabling the user to omit bands that are not useful in the results of the classification (ERDAS, 1997).

4.3 Classification

Previous research by the authors (Lyalko *et al.*, 1996, 1999; Sakhatsky *et al.*, 1999) and others (Andersen, 1998; Ardo and Pilesjo, 1995; Banko, 1998; Nordahl, 1996; Reutor and Akgoz, 1995), demonstrated that the classification method, Maximum Likelihood, contains the best parameters concerning the accuracy of the allocation of forest classes, and was consequently applied at this stage of the work.

The Maximum Likelihood decision rule is based on the probability that a pixel belongs to a particular class. The basic equation assumes that these probabilities are equal for all classes, and that the input bands have normal distributions (ERDAS, 1997). There is the possibility to take into account different probabilities for all classes through the introduction of a weight factor. This variation of the Maximum Likelihood algorithm is known as the Bayessian classifier (Smith *et al.*, 1995). Initially however, we do not specify a weight factor and assume that for all classes it equals 1.0 in the base equation.

4.4 Verification

At the completion of the classification, both thresholding and an accuracy assessment were performed to test the accuracy of the classification. Thresholding is the process of identifying pixels in a classified image that are the most likely to be classified incorrectly (ERDAS, 1997). Using chi-square parameters the various classes from the classification were evaluated. Accuracy assessment is a general term for comparing the classification to geographical data that are assumed to be true, in order to determine the accuracy of the classification process (ERDAS, 1997). A polygon-based (not pixel-based) accuracy assessment was performed with polygons not used in the training samples.

We considered the traditional approach of accuracy assessment based on random pixels (ERDAS, 1997). However, the design of the forest inventory data does not allow for this method. The description of an SKNR generally concerns a large area and it is often not homogeneous, especially for mixed forests. If the forest composition of an SKNR, for example, is fir 50%, spruce 30%, and birch 20%, it does not mean that in every pixel of the SKNR the percentage of vegetation species are the same. Sometimes the forest species occupy isolated areas within the SKNR. This is easily visible on the satellite images. In this case, the random pixel method can show either spruce or birch and it could be correct. Similar results would occur using a window of 3 x 3 or 5 x 5 pixels. Therefore, we must analyze all pixels, covering the area of an SKNR to compare the ground truth data (composition of forest) and results of the classification.

We propose the following assessment method using an expert assessment scale, which ranges from 0 to 12 marks. Twelve marks infers excellent coincidence, 10–11 is very good, 8–9 good, 6–7 satisfactory, 4–5 poor, and below 4 very poor. The marks for every site are determined as follows: the expert analyzes the pixels of a classification within the entire SKNR and then attempts to complete the forest inventory description using only the results of the classification, attempting to determine the composition of the forest, sparse (Rs <0.5) or stocked (Rs >= 0.5),[1] young or mature/old (Schmullius *et al.*, 2001). Then, the ground truth data and expert description are compared. If the description is the same, the mark is 12 (excellent). If there are any species divergences, the expert must summarize the absolute difference between the composition of species. This sum is divided by two and the result is used to reduce the mark. If there is a mistake in age, the mark is reduced by one. If there is an error concerning sparse or stocked stands, the mark must also be reduced by one unit.

For example, the expert evaluation is: birch 80%, aspen 20% (8B 2A), stocked, and mature/old; the inventory description is: birch 10 (10B), age 50, and stocking 70. So the mark is 11 (very good). Another example, the expert evaluation is: fir 4, spruce 2, cedar 1, birch 3 (4F 2S 1C 3B), sparse, and mature/old; the inventory description: fir 8,

[1] Rs is Relative stocking.

spruce 2 (8F 2S); stocking 60, and age 160. The mark must be 7 (satisfactory) and such divergences are the subject for discussion.

5 Results and Discussion

5.1 Satellite and Reference Data

Initially, a review was made of the ground truth data in order to prepare for signature creation. An example of this is *Figure 5*, a map created of species composition for the B3 test site. This figure provides one view of the resolution of the ground data.

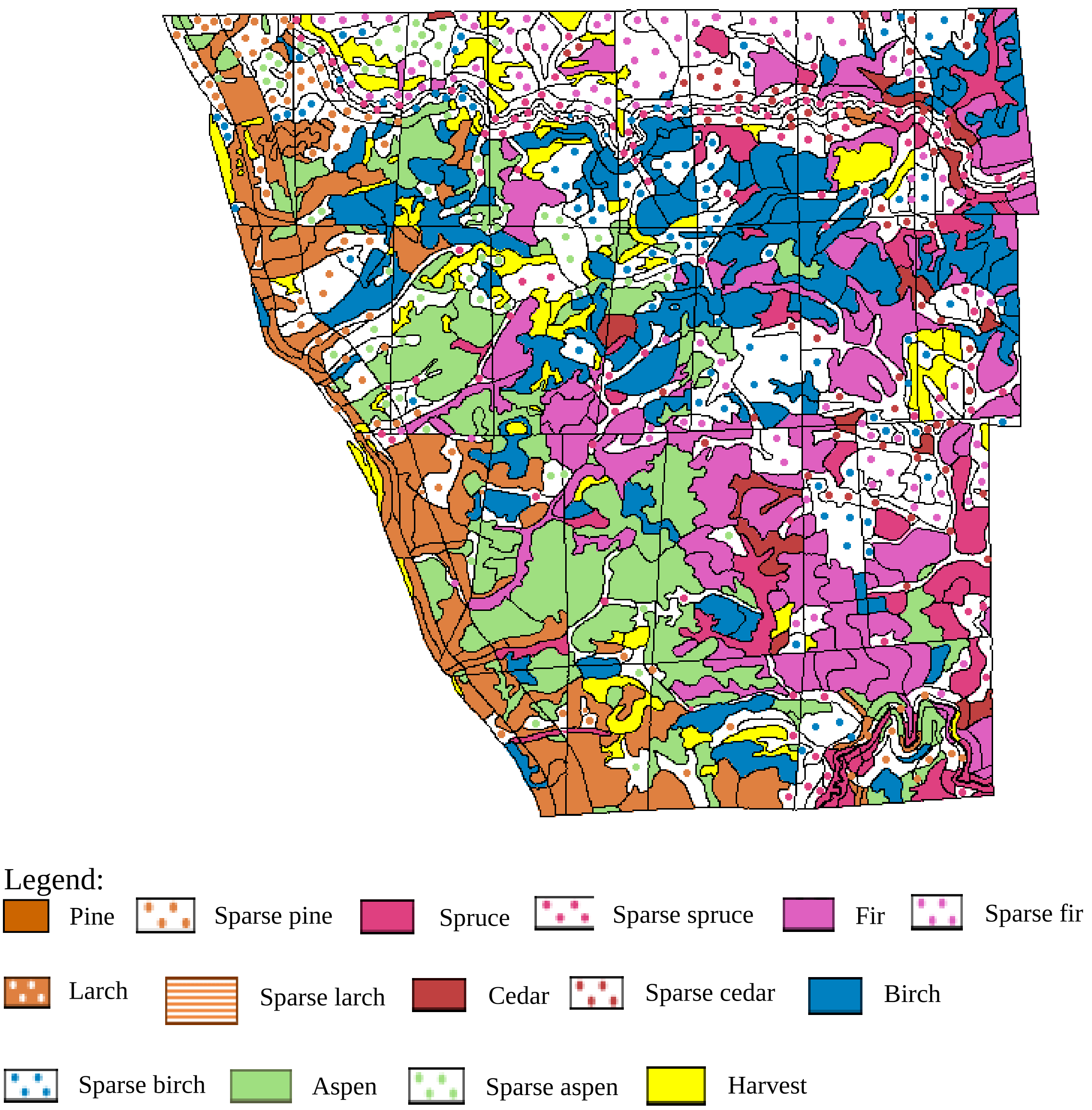


Figure 5: Species classification image constructed from the forest inventory data of test site B3 within the Bolshe Murtinsky test area.

In order to use the ground truth data for signature creation, the satellite images had to be geometrically corrected (*Figure 6*). As can be seen from the figure, the fit was reasonable for this stage of the analysis.

Figure 6: Overlapping of the vector data of test site B3 within the Bolshe Murtinsky test area, with a Landsat-7 image (22 June 2000) (near infrared band).

5.2 Signature Analysis

Pixels from the image within a significant quantity of primary inventory units of a test site were analyzed. As a result, the mean and other statistical parameters of the distribution of spectral reflectance for different forest species for each channel of a multiband image were received. At this stage, a total of 258 sites were created for processing. From the analysis of test site B3 (*Figure 6*) a total of 62 signatures describing relatively homogeneous vegetative species and communities, which are typical for this area, were created (another 10 sites were identified for non-vegetative areas). Spectral characteristics for separate forest vegetation species and different landscapes were analyzed using approximately four or five test sites for every class.

The following classes of vegetation species and communities were analyzed (Appendix 2). The statistical parameters of the signatures of every class are shown in Appendix 3.

The analysis of signature separability showed that an increase in the number of bands increases the separability. Therefore, it is reasonable to use all bands (except Panchromatic). According to the Jeffries-Matusita Distance the most effective combinations in decreasing order are presented in *Table 1*.

Table 1: Jeffries-Matusita Distances and band combinations.

	Number of Bands	Best Combination	Average Jeffries-Matusita Distance
1	7	1,2,3,4,5,6(1),6(2)	1287
2	6	1,2,3,4,5,6(2)	1279
3	5	2,3,4,6(2),7	1266
4	4	3,4,5,6(2)	1255
5	3	3,4,6(2)	1224
6	2	4,6(2)	1181

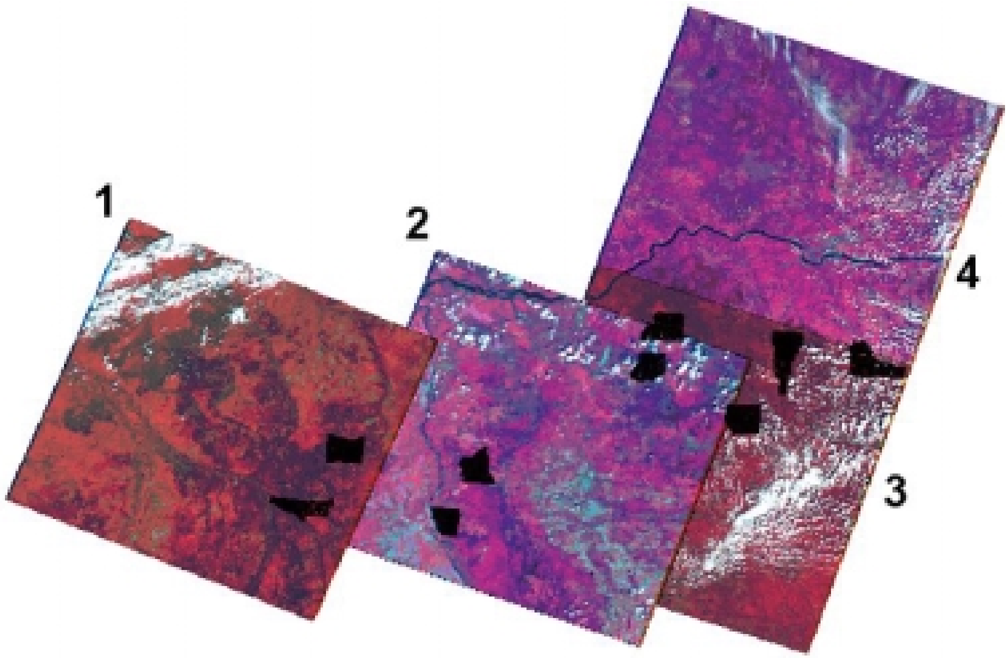
5.3 Classification

The analysis of signatures of the previously allocated classes was performed for an initial accuracy assessment of the classification. The contingency matrix of signatures was used, based on the method of Maximum Likelihood, as a basis for accuracy discussion (Banko, 1998; ERDAS 1999) (Appendix 4). The contingency matrix shows the cross tabulation of the classified land cover and the actual land cover within the sample sites. The main diagonal of the matrix lists the percentages of the correctly classified pixels.

The analysis of the contingency matrix results provides the following assessment of classification reliability: overall, separation of coniferous and deciduous forests was performed well; the vegetation on meadows and harvest blocks of varying ages can easily be identified as well as water surface and sandy formations along the Yenisey river. However, the distinction of aspen, birch, and mixed coniferous forests proved difficult. The birch or aspen forests frequently classify to mixed birch-aspen forests.

There are two possibilities to reduce the number of classes, which according to the confusion matrix have a low reliability of being distinguished correctly: (1) merge signatures, or (2) use similar colours for display. The first possibility is to merge the signatures of similar classes. In this case, the new signatures of the united classes will contain different mean and standard deviations from the individual classes. In many cases, the standard deviation will increase and the new class will intersect with other classes more easily, thereby decreasing, not increasing accuracy. The second option is to use the same colour in the display of the classified image for similar classes. Based on our experience, this second option maintains the integrity of the classes until more test sites can be added later. Therefore, initial classes were merged using a color attribute editor. See Appendix 5 for the new classes that were formed taking into account the contingency matrix of signatures (see Appendix 4).

Figure 7 demonstrates the overlaying of the nine ground truth areas used in this study, with the four full scenes of Landsat-7 data that were classified, based on the spectral classes developed for this study.



Notes: (1) Bolshe Murtinsky-1 (20 June 2000).
(2) Bolshe Murtinsky-2 (22 June 2000).
(3) Chunsky-2 (31 July 1999).
(4) Chunsky-1 (31 July 1999).

Figure 7: Position of Landsat-7 full scenes with overlap of ground truth test sites.

The signatures created on the basis of the Bolshe Murtinsky test site B3 were used for full scene classification of all four Landsat-7 scenes. A few signature classes were added to the specific classified area, for example, settlements, which are not within the Bolshe Murtinsky test site B3. A fragment of the classification is demonstrated in *Figure 8*.

Obviously, the most reliable results for the full scenes were within the vicinity of the test sites used in signature creation. The detailed analysis of the full scene classification results and the use of these results for SPOT Vegetation image processing is the task of future investigation.

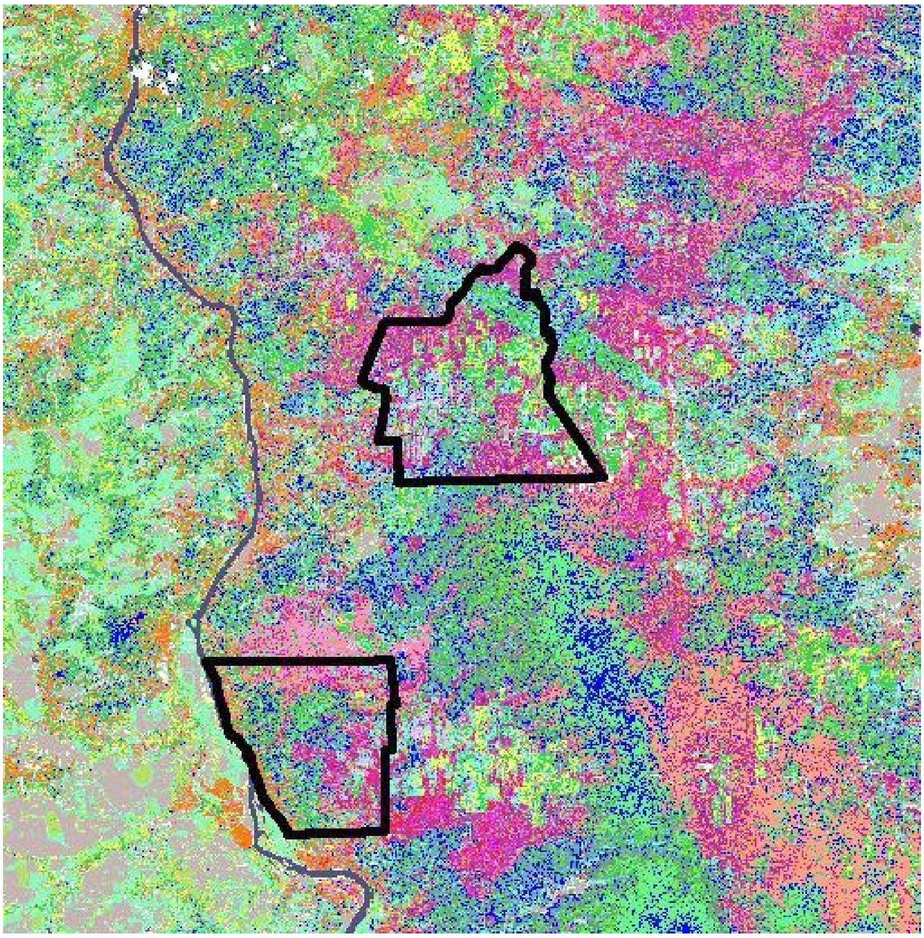


Figure 8: A fragment of the classified Landsat-7 scene showing overlap of B3 (lower) and B4 (upper) test sites (for the legend, see Appendix 7).

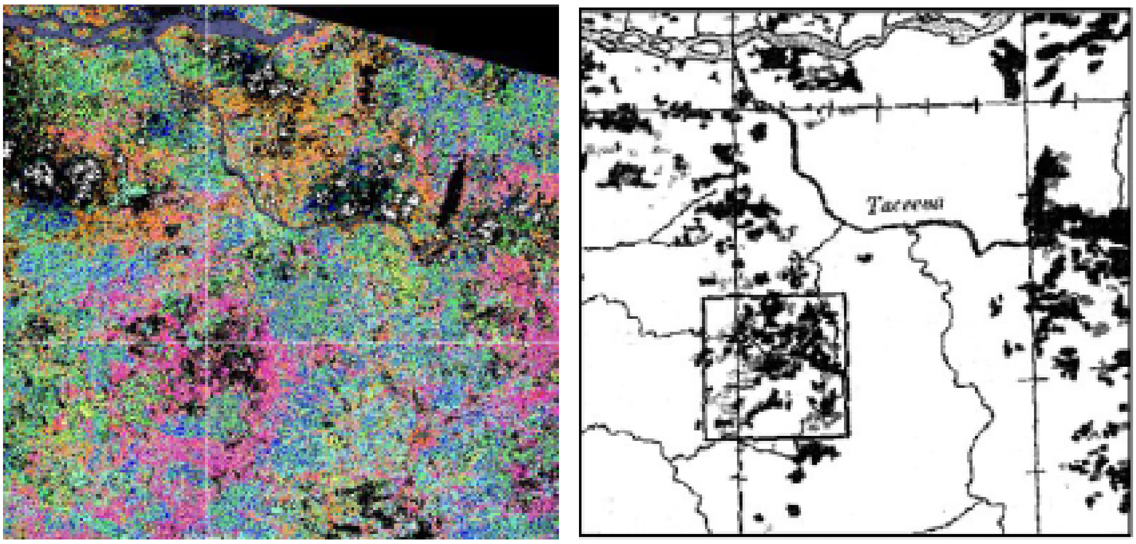
5.4 Verification

The results of the expert evaluation of the classification within test site B3 of the Bolshe Murtinsky test area are given in Appendix 6. The expert mark is usually within the interval 8–10 (acceptable). The distribution of marks is as follows: 12 = 11.5%; 11 = 10.8%; 10 = 20.4%; 9 = 19.1%; 8 = 12.1%; 7 = 10.2%; 6 = 5.7%; 5 = 1.3%; and 8–9% are less than 5 but in this case we think that the ground truth data are disputable. Of course, this method of assessment can be improved but in general these marks reflect the results. The results confirm the reliable allocation of coniferous and deciduous forests, with sparse and young forests distinguished clearly. The harvest blocks of different ages are also allocated rather well. Typically, the classification has difficulty properly identifying mixed forests.

In some cases, pixels of spruce and deciduous forests are classified as pine. Forest species on the slopes of river valleys are not classified successfully, indicating that radiometric orthocorrection is necessary. Our experience shows that marks less than 4 are usually connected with disturbances not updated in the database. Some errors are connected with the difference in time of forest inventory data production and Landsat-7 image acquisition and, in some cases, the ground truth data description is disputable. We are planning to make a more detailed description of the ground truth data and discrepancies in the next phase of the work.

5.4.1 Thresholding

The most interesting results from thresholding were obtained for the full scene (Bolshe Murtinsky-2). At this stage, it appears that the interpretation of the classified image after thresholding allowed for the identification of forests affected by *Dendrolimus superans sibiricus*. *Figure 9* demonstrates that some sites with thresholding of the classified full scene (Landsat-7 Bolshe Murtinsky-2, 22 June 2000) match with the affected forests according of the forest health map (1:15 000 scale) obtained from aerial surveys carried out by the East-Siberian Forest Enterprise for *Dendrolimus superans sibiricus* (between 1993–1996) (Kharouk *et al*., 2001), however this will be looked at in more detail in future research.



(A) Fragment of Landsat-7 classification after thresholding.

(B) Forests affected by *Dendrolimus superans sibiricus* (air survey data) Source: Kharouk *et al*. (2001).

Figure 9: Comparison of classification image after thresholding with aerial survey data.

5.5 SPOT Vegetation

At this stage in the project, effort has focused on developing a classification system using the high-resolution Landsat-7 data. However, an overlay was performed of the GIS ground truth data on the SPOT Vegetation Product (*Figure 10*). It is obvious from the figure that one pixel from the SPOT Vegetation image overlaps multiple primary inventory units and is consequently not suitable for the detailed analysis of spectral reflectance of forest vegetation species and would require special sub-pixel processing. Therefore, the first step in the process was to analyze the spectral reflectance of vegetation species using Landsat-7 images with the purpose to create integrated signatures of certain classes of vegetation or vegetative communities of the landscape. The next phase of this work will look at making the step from high-resolution data to coarse resolution data such as SPOT Vegetation.

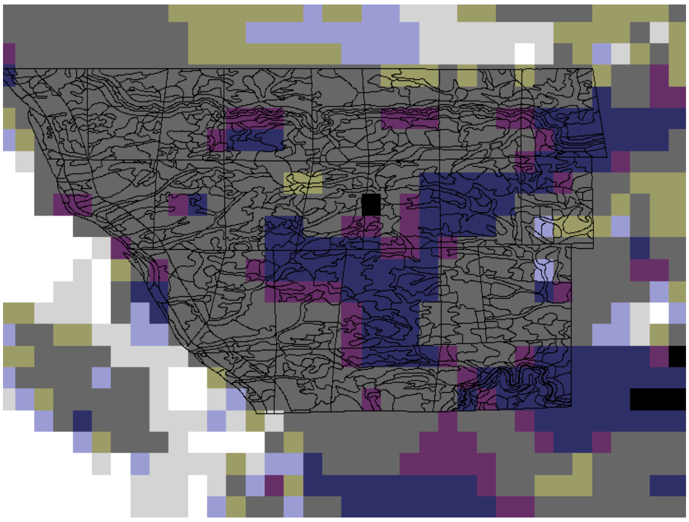


Figure 10: Overlapping of the vector data from the B3 test site within the Bolshe Murtinsky test area on the SPOT Vegetation coverage (1 km x 1 km resolution).

5.5.1 Image Transformation with NDVI[2]

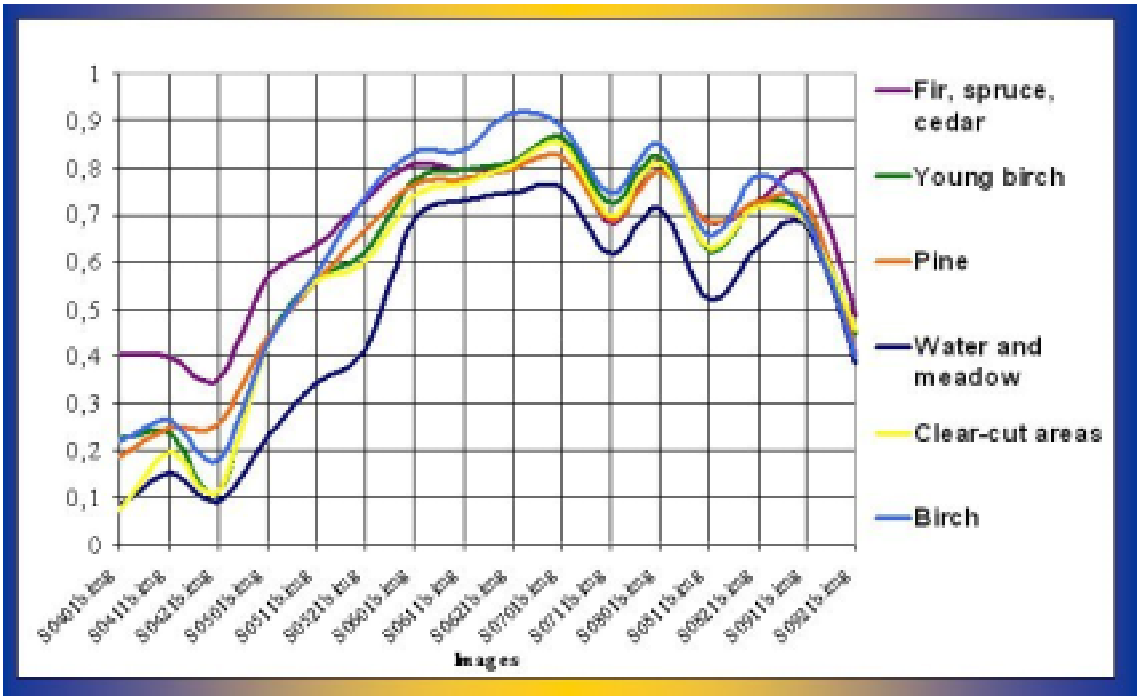
Some preliminary results were obtained from the investigation into the possibilities for classification of SPOT Vegetation images. The classified Landsat-7 images and GIS forest inventory data allow us to identify specific pixels of SPOT Vegetation that are somewhat homogeneous, for the investigation of spectral reflectance of different landscape and vegetation species.

The following landscapes within the Bolshe Murtinsky test site B3 were taken into consideration: (1) mixed coniferous forest (fir, spruce, cedar), (2) pine forest, (3) birch forest, (4) young birch on harvest sites, (5) clear-cut areas, and (6) water of the Yenisey river including the meadow bank.

For the identification of vegetation using multi-band space images, the NDVI is often used, calculated on the basis of the spectral reflectance of the near infrared (NIR) and red (R) bands of the images.

Changes in NDVI from April to September 1999 were investigated using spectral values of the homogeneous pixels corresponding to the noted landscapes for different SPOT Vegetation images. The results are shown in the *Figure 11*.

[2] Normalized Difference Vegetation Index.



April – May – June – July – August – September

Figure 11: Fluctuations of NDVI for different landscapes based on SPOT Vegetation images for the April to September 1999 growing season (Bolshe Murtinsky B3 test site).

Maximum changes of NDVI occur in birch forests (0.2–0.9), with minimum changes occurring in mixed coniferous forests (0.4–0.85). The mixed pixels (water-meadow) have the lowest values, but also change like other classes due to the inclusion of vegetation species along the riverbanks. For all landscapes, the minimum values of NDVI occur in April and the maximum values occur in June–July as would be expected. This and other avenues of analysis will be explored in future work.

6 Conclusion

The first phase of a multi-phase project to develop a classification procedure for Siberian forests has begun. The initial results presented include the classification of Landsat-7 images with the aid of a digital forest inventory in GIS format. The initial results are positive, with a total of 62 separate vegetation classes and 10 non-vegetation classes identified. Typical findings from the verification indicate that non-vegetation areas are classified well. Additionally, homogeneous forest types were classified successfully but, typically, difficulties arose separating mixed wood forest types. In the next phase, additional test sites will be added and various avenues will be explored to improve the classification and verification. These include a more in-depth analysis of the ground truth data anomalies, possible addition of a detailed DEM for geometric and radiometric correction and the use of other sensors to improve the signature creation.

A brief analysis was made of SPOT Vegetation data over the study site, using aggregate vegetation classes taken from the initial Landsat-7 classification and GIS ground truth data. The interaction between the detailed GIS data, the high-resolution Landsat data, and the coarse resolution SPOT Vegetation data will continue to be explored. However, it will be necessary to incorporate other satellite products in an effort to develop a procedure for the retrieval of forest inventory information across Siberian Russia. One additional area of investigation would be the possible identification of different types of disturbances, in particular, damage caused by pests.

References

Andersen, G.L. (1998). Classification and Estimation of Forests and Vegetation Variables in Optical High Resolution Satellites: A Review of Methodologies. Interim Report IR-98-085. International Institute for Applied Systems Analysis, Laxenburg, Austria.

Ardo, J. and P. Pilesjo (1995). Classifying Forest Damages in the Czech Republic using Neural Networks, Bi-temporal Landsat Thematic Mapper Data and Topographic Data. In: *Proceedings of the Workshop on Pollution Monitoring and GIS,* 15–18 May 1995, Brandys nad Labem, Czech Republic, pp. 115–120.

Banko, G. (1998). A Review of Assessing the Accuracy of Classification of Remotely Sensed Data and of Methods Including Remote Sensing Data in Forest Inventory. Interim Report IR-98-081. International Institute for Applied Systems Analysis, Laxenburg, Austria.

DGC (1973). *Atlas of USSR Forests*. Department of Geodesy and Cartography (DGC), Council of Ministers of the USSR, Moscow, Russia, pp. 154–157 (in Russian).

Elizarieva, M.F. (1965). To the Question of Zone Section of Left Bank of Yenisey River within the Taiga Zone (Krasnoyarsky Region). In: *Krasnoyarsk Region. Geography Data*. Krasnoyarsk University, Krasnoyarsk, Russia, pp. 77–91 (in Russian).

ERDAS (1997). *ERDAS Field Guide*. Fourth Edition, ERDAS Inc., Atlanta, Georgia, USA.

ERDAS (1999). *ERDAS Field Guide*. Fifth Edition, Revised and Expanded. ERDAS Inc., Atlanta, Georgia, USA.

FFMR (1999). Forest Fund of Russia (data of the State Forest Account, 1 January 1998). Federal Forest Service of Russia (FFMR), Moscow, Russia, 650 pp. (in Russian).

GOFC (2001). Global Observation of Forest Cover (GOFC). Information downloaded and available on the Internet: http://www.gofc.org.

Isaev, A.S. and V.I. Sukhikh (eds.) (1998). Aerospace Methods and Geoinformation Systems in Forestry and Forest Management. Center for Ecology and Productivity of Forests, Moscow, Russia, 215 pp. (in Russian).

Jukov, A.B. (ed.) (1969). *Forests of USSR*. Science, Moscow, Russia, pp. 157–248 (in Russian).

Kharouk, V.I., A.G. Kojukhovskay, I.A. Pestoonov, K.J. Ranson and G.M. Tsiboolsky (2001). NOAA/AVHRR Data for Dendrolimus Sibiricus Flare Monitoring. Earth Research from the Space, Moscow, Russia, No. 1, pp.80–86 (in Russian).

Lapshina, E.I., V.I. Gorbachev and A.A. Chramov (1971). Vegetation and Ground of Yenisey Ridge (Southern Part). In: *Vegetation of Right Bank of Yenisey River*, Science, Moscow, Russia, pp. 21–30 (in Russian).

Lyalko V.I., V.Yu. Djary, A.I. Sakhatsky, A.Ya. Khodorovsky, L.D. Wolfson, V. Ilieva, K.-H. Marek and S. Oppitz (1996). Estimation of Heavy Metal and Radionuclide Contamination of the Soils and Vegetation within the Chernobyl Danger Zone Using Remote Sensing Data. In: *Proceedings of the XYIIIth Congress of the International Society for Photogrametry and Remote Sensing*, Vienna, Austria, Vol. XXXI, Part B7, Commission YII, pp. 454–459.

Lyalko, V.I., A.I. Sakhatsky, A.Ja. Khodorovsky and A.T. Asimov (1999). Application of GIS Technology for Forest Ecology Researches on Multi-band Satellite Images (The Chernobyl Exclusion Zone as an Example). In: *Proceedings of GIS Forum-99*, GIS Association of Ukraine, Kiev, Ukraine, pp. 174–179.

Malysheva, N., A. Shvidenko, S. Nilsson, S. Petelina and A. Öskog (2000). An Overview of Remote Sensing in Russian Forestry. Interim Report IR-00-034. International Institute for Applied Systems Analysis, Laxenburg, Austria.

Nordahl, B. (1996). Comparison of Statistical Methods and Neural Networks in a Post Object Classification for Forestry Registration. In: *Proceedings of the XYIIIth Congress of the International Society for Photogrametry and Remote Sensing*, Vienna, Austria, Vol. XXXI, Part B7, Commission YII, pp. 542–546.

Popov, L.V. (1982). South Taiga Forests of Central Siberia. Irkutsk University, Irkutsk, Russia, p. 330 (in Russian).

Reutor, M. and E. Akgoz (1995). Forest Condition Assessment in the Fichtelgebirge and Erzgebirge using Remote Sensing and GIS Technology. In: Proceedings of the Workshop on Pollution Monitoring and GIS, 15–18 May 1995, Brandys nad Labem, Czech Republic, pp. 137–140.

Sakhatsky, A.I., V.I. Lyalko, A.Ya. Khodorovsky, A.T. Azimov, Z.M. Shportjuk, O.N. Sibirtseva and S.M. Bidna (1999). Application of Multi-band Space Images for Vegetation of Chernobyl Exclusion Zone Research. In: *Proceedings of Workshop New Methods in Aerospace Land Research*, Kiev, Ukraine, pp. 105–113 (in Russian).

Schmullius, C. (ed), J. Baker, H. Balzter, M. Davidson, L. Eriksson, D. Gaveau, M. Gluck, A. Holz, A. Luckman, U. Marschalk, I. McCallum, S. Nilsson, A. Öskog, S. Quegan, Y. Rauste, A. Roth, A. Shvidenko, K. Tansey, T. Le Toan, J. Vietmeier, W. Wagner, U. Wegmüller, A. Wiesmann and J.J. Yu. (2001). *SIBERIA Final Report*. Center for Earth Observation, Project Reports, European Commission Contract No. ENV4-CT97-0743-SIBERIA. Downloaded from and available on the Internet: http://pipeline.swan.ac.uk/siberia/.

Shvidenko, A. and S. Nilsson (1997). Are the Russian Forests Disappearing? *Unasylva* 188, Vol. 48, pp. 57–64.

Smith, C., N. Pyden and P. Cole (1995). *ERDAS Field Guide*. Third Edition, ERDAS Inc., Atlanta, Georgia, USA, 628 p.

Sukhikh, V.I. and S.G. Sinitsyn (eds.) (1979). Air-space Methods for Nature Preservation and Forestry. Forest Industry, Moscow, Russia, 228 pp. (in Russian).

Vaschuk, L.N. (2001). Forest Inventory in Irkutsk Oblast. Committee on Natural Resources of Irkutsk Oblast, Irkutsk, Russia, 106 pp. (in Russian).

Appendix 1: GIS Attribute Data

Item	Description
Unique*	Unique stand identifier (link to polygon file)
GIR	forest district
KV	kvartal
SKNR	stand
Area (ha)	area in ha
ZK	land category
	1101 — natural stand
	1102 — unclosed natural forest
	1103 — stands destroyed by mismanagement
	1104 — low productivity forest
	1108 — forest plantation
	1201 — unclosed forest plantation
	1400 — sparse forest
	1503 — burned forest
	1504 — dead stands
	1507 — stand marked for cutting
	1509 — clear-cut area
	2101 — arable land
	2109 — river
	2102 — agriculture, hay
	2103 — agriculture, pasture
	2110 — stream
	2116 — ox-bow lake
	2305 — soft-surface road
	2310 — cut line (for kvartal)
	2308 — lake
	2404 — log storage areas (landings)
	2507 — bogs
	2505 — exposed rock
	2512 — talus
	2540 — quarry or gravel pit

	2548 — electro transmission lines
STOCKING	relative stocking (percent)
TUR1H	growing stock volume (m^3/ha)**
AMZ	age of dominant species
pine_KF	pine composition (1–10)
pine_H	pine height (dm)
pine_D	pine diameter (cm)
spruce_KF	spruce composition (1–10)
spruce_H	spruce height (dm)
spruce_D	spruce diameter (cm)
fir_KF	fir composition (1–10)
fir_H	fir height (dm)
fir_D	fir diameter (cm)
larch_KF	larch composition (1–10)
larch_H	larch height (dm)
larch_D	larch diameter (cm)
cedar_KF	cedar composition (1–10)
cedar_H	cedar height (dm)
cedar_D	cedar diameter (cm)
birch_KF	birch composition (1–10)
birch_H	birch height (dm)
birch_D	birch diameter (cm)
aspen_KF	aspen composition (1–10)
aspen_H	aspen height (dm)
aspen_D	aspen diameter (cm)
salix_KF	salix composition (1–10) (not present in all areas)
salix_H	salix height (dm) (not present in all areas)
salix_D	salix diameter (cm) (not present in all areas)

Area (AREA_HA)

This is the vertical projection of the area of the SKNR as reported in the forest inventory. You may notice that the GIS files also contain an "AREA" item. This is the area as measured by the GIS in square meters. The GIS area is sensitive to shifting caused by georeferencing, therefore we advise that the forest inventory area (AREA_HA) be used for analysis purposes.

Land Category (ZK)

These are the basic categories of land for which the entire landscape is classified.

1101 — natural stand

A stand of growing trees resulting from natural regeneration following a forest disturbance. By definition, these stands have relative stocking greater or equal to 10 for young age groups and greater than or equal to 30 for all other age groups.

1102 — unclosed natural forest

Forests with relative stocking of 10 to 40 for young age groups and 10 to 30 for all other age groups *if this condition is a result of climatic conditions* (i.e., altitude or climate), otherwise they are classes as sparse forests (1400).

1104 — low productivity forest

According to "All-Russia Manual", these are mature and overmature exploitable forests of site index *Va* and *V*, and forests of higher productivity if growing stock is less than 40 m^3/ha in European Russia and less than 50 m^3/ha in Siberia. These criteria can be regionally adjusted.

1108 — forest plantation

A stand of growing trees, raised artificially, either by sowing (seeds) or (most commonly) planting. A forest plantation must have at least a relative stocking of 30 for young trees and 20 for mature (less than this it is an unclosed forest plantation). In some plantations, if they have been intensively managed, one may be able to see the trees in rows.

1201 — unclosed forest plantation

This is basically a younger stage of the forest plantation. If you imagine looking down from above on a young forest in which you can still see the forest floor then the canopy is considered "unclosed" (and relative stocking is less than 30 for young trees and 20 for all others). In terms of forest management, this means that there is still the possibility of competing vegetation (shrubs, grasses, etc.) to outgrow the planted trees and compete for sunlight and water resources.

1400 — sparse forest

The same relative stocking as in 1102, however, this state is the result of natural (e.g., fire) or human-induced disturbances.

1503 — burned forest

The full name of this category is burned and dead forest. This is a land category that describes areas that have experienced a "stand replacing" fire. This means that the "surviving" trees have a relative stocking of less than or equal to 10. If between 10 and 30% (relative stocking) survive the fire then it is classed as a sparse forest (category 1400).

1507 — stand marked for cutting

Stands planned to be cut during the year of forest inventory.

1509 — clear-cut areas

These are areas that are harvested under the clear-cut silvicultural system. They have a relative stocking of less than 10. This is a system of regenerating even-aged forest stands in which new seedlings become established in fully exposed micro-environments after most (some individual trees may remain standing) of the existing trees have been removed. Regeneration can originate naturally or artificially. Clear-cutting may be done in blocks, strips, or patches. Once regrowth occurs, the area could be classed into unclosed forest plantation (1201). Check the inventory update date of the test territory (this information is located on each test territory page) to verify before what date this harvest occurred.

Others:

2102 — agriculture, hay

2103 — agriculture, pasture

2110 — stream

2308 — lake

2507 — bogs

2505 — exposed rock

2512 — talus

2540 — quarry or gravel pit

Others — undefined:

1103

1504

2101

2109

2116

2305

2310

2404

2548

Relative Stocking (STOCKING)

Let us break relative stocking down into two parts: "relative" and "stocking". Stocking is an expression of the adequacy of tree cover on an area in terms of basal area. Basal area is the area of the cross section of a tree trunk near its base, usually 1.3 m above the ground (also called breast height). Basal area is a way to measure how much of a site is occupied by trees. The term basal area is used to describe the collective basal area of trees per hectare. Relative stocking is a comparison of the stocking of a particular stand to what the ideal stocking would be under perfect management conditions. The ideal conditions are a function of site quality and can vary according to the species composition and age of the stand. There are yield tables developed for Russia that would describe fully stocked stands.

Growing Stock Volume (TUR1H)

In general, growing stock volume (TUR1H) is the STEM volume for all living species in a stand. Specifically, however, only in young stands are all stems considered. In all other stands, trees must be greater or equal to 6 cm at "breast height" (1.3 m) to be included in the growing stock. The trees that are excluded from this measurement only represent about 1% of the volume — so it correct to say that this variable considers all trees. It is expressed in cubic meters per hectare.

NOTE: The Ust Ilimsk database has volume in $10m^3$/ha units!

Age of Dominant Species (AMZ)

This can be considered as the age of the stand expressed in years. Age *groups* are region-specific calculations that take into account forest site quality, dominant species and legislative requirements. In general, however, the age groups for the SIBERIA project area can be defined using simply the age of the dominant species. The following Table shows the age thresholds for the age groups in our project area.

Species	Young	Middle-aged	Immature	Mature	Overmature
Pine, spruce, fir and larch	1–40 years	41–80 years	81–100 years	101–140 years	>140 years
Cedar	1–80 years	81–160 years	161–200 years	201–240 years	>240 years
Aspen and birch	1–20 years	21–50 years	51–60 years	61–70 years	>70 years

Composition (KF)

Composition is the proportion of a species in a stand on a scale of 1 to 10 (e.g., PINE_KS = 1 means 10% of the growing stock of the trees in the main canopy layer of the stand are pine).

Height (H)

An estimate of the average tree height of the dominant species in the stand; expressed in meters.

Diameter (D)

An estimate of the average tree diameter of the dominant species in the stand based on a quadratic average. The diameter is measured at 1.3 m or "Breast height"; expressed in decimeters.

Appendix 2: Signature Classes

Table A2-1: Basic classes of vegetation species and vegetative communities for signature analysis.

No.	Short Name of Class	Description of Class
1	Water	Water surface
2	Meadow	Meadow
3	Sand	Sandy bare soil
4	Meadow, sand	Meadow on sandy soil
5	Road	Road
6	Road, forest	Road in forest
7	Hay	Agriculture, hay
8	Cut	Clear-cut areas
9	Cut (1510)	Clear-cut areas (1510)
10	Clouds	Clouds
11	pineold80	100% pine trees, mature/old, stocked
12	pineold50	100% pine trees, mature/old, sparse
13	7_9pine_dcon_l_old50	70–90% pine with mixed coniferous and deciduous trees, mature/old, sparse
14	7_9pine_l_old80	70–90% pine mixed with deciduous trees, mature/old, stocked
15	7_9pine_l_old50	70–90% pine mixed with deciduous trees, mature/old, sparse
16	7_9pine_l_young80	70–90% pine mixed with deciduous trees, young, stocked
17	4_6pine_l_old80	40–60% pine mixed with deciduous trees, mature/old, stocked
18	4_6pine_l_old50	40–60% pine mixed with deciduous trees, mature/old, sparse
19	spruceyoung50	100% spruce young, sparse
20	7_9sp_dcon_old80	70–90% spruce with mixed coniferous trees, mature/old, stocked
21	7_9sp_dcon_old50	70–90% spruce with mixed coniferous trees, mature/old, sparse
22	4_6sp_dcon_old80	40–60% spruce with mixed coniferous trees, mature/old, stocked
23	4_6sp_dcon_old50	40–60% spruce with mixed coniferous trees, mature/old, sparse
24	4_6sp_dcon_l_old80	40–60% spruce with mixed coniferous and deciduous trees, mature/old, stocked
25	4_6sp_dcon_l_old50	40–60% spruce with mixed coniferous and deciduous trees, mature/old, sparse
26	7_8fir_dcon_old80	70–80% fir with mixed coniferous trees, mature/old, stocked
27	7_8fir_dcon_old50	70–80% fir with mixed coniferous trees, mature/old, sparse
28	7_8fir_dcon_l_old80	70–80% fir with mixed coniferous and deciduous trees, mature/old, stocked
29	7_8fir_dcon_l_old50	70–80% fir with mixed coniferous and deciduous trees, mature/old, sparse
30	4_6fir_dcon_old80	40–60% fir with mixed coniferous trees, mature/old, stocked
31	4_6fir_dcon_old50	40–60% fir with mixed coniferous trees, mature/old, sparse
32	4_6fir_dcon_l_old80	40–60% fir with mixed coniferous and deciduous trees, mature/old, stocked
33	4_6fir_dcon_l_old50	40–60% fir with mixed coniferous and deciduous trees, mature/old, sparse
34	4_6fir_dcon_l_young50	40–60% fir with mixed coniferous and deciduous trees, young, sparse
35	5_6k_dcon_old80	50–60% cedar with mixed coniferous trees, mature/old, stocked
36	5_6k_dcon_old50	50–60% cedar with mixed coniferous trees, mature/old, sparse
37	5_6k_dcon_l_old50	50–60% cedar with mixed coniferous and deciduous trees, mature/old, sparse
38	3_4k_dcon_old80	30–40% cedar with mixed coniferous trees, mature/old, stocked
39	3_4k_dcon_old50	30–40% cedar with mixed coniferous trees, mature/old, sparse
40	3_4k_dcon_l_old80	50–60% cedar with mixed coniferous and deciduous trees, mature/old, stocked
41	3_4k_dcon_l_old50	30–40% cedar with mixed coniferous and deciduous trees, mature/old, sparse
42	birchold80	100% birch, mature/old, stocked
43	birchyoung50	100% birch, young, sparse
44	7_9b_l_old80	70–90% birch mixed with deciduous trees (aspen), mature/old, stocked
45	7_9b_l_old50	70–90% birch mixed with deciduous trees (aspen), mature/old, sparse
46	7_9b_l_pine_old80	70–90% birch mixed with deciduous trees (aspen) and pine trees, mature/old, stocked
47	7_9b_l_dcon_old80	70–90% birch mixed with deciduous trees (aspen) and mixed coniferous trees, mature/old, stocked
48	7_9b_dcon_old80	70–90% birch with mixed coniferous trees, mature/old, stocked
49	7_9b_dcon_old50	70–90% birch with mixed coniferous trees, mature/old, sparse
50	7_9b_dcon_young80	70–90% birch with mixed coniferous trees, young, stocked
51	7_9b_dcon_young50	70–90% birch with mixed coniferous trees, young, sparse

52	4_6b_l_old80	40–60% birch mixed with deciduous trees (aspen), mature/old, stocked
53	4_6b_l_old50	40–60% birch mixed with deciduous trees (aspen), mature/old, sparse
54	4_6b_l_young50	40–60% birch mixed with deciduous trees (aspen), young, sparse
55	4_6b_l_pine_old80	40–60% birch mixed with deciduous trees (aspen) and pine trees, mature/old, stocked
56	4_6b_l_pine_old50	40–60% birch mixed with deciduous trees (aspen) and pine trees, mature/old, sparse
57	4_6b_l_dcon_old80	40–60% birch mixed with deciduous trees (aspen) and mixed coniferous trees, mature/old, stocked
58	4_6b_l_dcon_young50	40–60% birch mixed with deciduous trees (aspen) and mixed coniferous trees, young, sparse
59	4_6b_dcon_old50	40–60% birch mixed with coniferous trees, mature/old, sparse
60	aspenold80	100% aspen, mature/old, stocked
61	aspenold50	100% aspen, mature/old, sparse
62	7_9a_l_old80_d	70–90% aspen mixed with deciduous trees (birch), mature/old, stocked (dark pixels on south slopes)
63	7_9a_l_old80	70–90% aspen mixed with deciduous trees (birch), mature/old, stocked (watershed)
64	7_9a_l_old50	70–90% aspen mixed with deciduous trees (birch), mature/old, sparse
65	7_9a_l_young80	70–90% aspen mixed with deciduous trees (birch), young, stocked
66	7_9a_l_pine_old80	70–90% aspen mixed with deciduous trees (birch) and pine trees, mature/old, stocked
67	7_9a_l_pine_old50	70–90% aspen mixed with deciduous trees (birch) and pine trees, mature/old, sparse
68	7_9a_l_dcon_old80	70–90% aspen mixed with deciduous trees (birch) and mixed coniferous trees, mature/old, stocked
69	7_9a_l_dcon_pine_old50	70–90% aspen mixed with deciduous trees (birch) and mixed coniferous trees and pine trees, mature/old, sparse
70	4_6a_l_pine_old80	70–90% aspen mixed with deciduous trees (birch) and pine trees, mature/old, stocked
71	4_6a_l_dcon_pine_old80	40–60% aspen mixed with deciduous trees (birch) and mixed coniferous trees and pine trees, mature/old, stocked
72	4_6a_l_dcon_pine_old50	40–60% aspen mixed with deciduous trees (birch) and mixed coniferous trees and pine trees, mature/old, sparse

Appendix 3: Statistical Parameters of Signatures

Table A3-1: Statistical characteristics of distribution of spectral brightnesses for the allocated basic classes of vegetation. (Bands: blue, green, red, and infrared).

No.	Short Name of Class	Bands							
		Blue		Green		Red		Reflective–infrared	
		Mean	SD[a]	Mean	SD[a]	Mean	SD[a]	Mean	SD[a]
1	Water	62.90	1.17	40.98	0.90	28.50	1.17	13.60	0.68
2	Meadow	69.64	1.69	59.26	1.82	44.95	3.35	92.69	11.85
3	Sand	86.54	3.21	74.67	4.42	80.01	7.06	63.46	4.01
4	Meadow, sand	79.83	2.04	63.98	1.86	62.89	3.78	58.11	3.07
5	Road	69.71	2.39	58.18	2.97	48.86	3.99	91.82	8.25
6	Road, forest	66.69	1.44	54.00	1.92	41.31	2.29	94.15	6.47
7	Hay	66.13	1.2	57.71	2.62	38.03	1.66	126.72	10.61
8	Cut	64.11	1.38	53.02	1.91	35.90	1.59	108.46	6.48
9	Cut (1510)	70.00	3.43	62.5	4.14	43.08	4.61	139.25	7.86
10	Clouds	71.34	2.98	59.11	3.94	55.76	7.01	75.53	6.17
11	pineold80	63.66	1.13	46.13	1.60	34.37	1.78	60.47	6.22
12	pineold50	63.11	1.18	47.13	1.71	33.67	1.19	71.14	5.77
13	7_9pine_dcon_l_old50	62.6	1.51	45.12	2.53	32.98	2.27	62.63	11.66
14	7_9pine_l_old80	62.86	1.23	45.88	1.39	32.89	1.22	70.71	6.51
15	7_9pine_l_old50	63.13	1.01	47.55	1.46	33.48	1.31	84.84	8.45
16	7_9pine_l_young80	62.12	1.04	45.5	1.04	32.35	1.08	75.45	10.04
17	4_6pine_l_old80	62.57	0.93	45.97	1.33	33.1	1.24	73.08	6.88
18	4_6pine_l_old50	62.76	1.34	47.12	2.08	33.4	1.8	78.13	10.41
19	spruceyoung50	61.9	1.12	44.9	1.07	30.7	1.08	82.45	7.64
20	7_9sp_dcon_old80	61.16	1.2	43.96	1.36	30.97	0.98	56.58	4.38
21	7_9sp_dcon_old50	61.42	1.31	44.48	1.75	31.14	1.52	62.99	6.42
22	4_6sp_dcon_old80	60.89	1.24	43.86	1.62	30.75	1.41	59.58	7.55
23	4_6sp_dcon_old50	60.81	0.99	43.19	1.72	30.47	1.27	56.83	9.35
24	4_6sp_dcon_l_old80	61.2	1.19	44.27	1.42	31.01	1.32	64.04	8.94
25	4_6sp_dcon_l_old50	62.04	1.37	45.86	2.50	32.32	1.96	64.53	7.95
26	7_8fir_dcon_old80	60.68	1.2	43.33	1.86	30.15	1.6	57.89	6.05
27	7_8fir_dcon_old50	61.29	1.49	45.12	2.78	31.67	2.22	63.21	8.1
28	7_8fir_dcon_l_old80	61.35	1.17	45.47	1.41	32.22	1.57	62.35	4.86
29	7_8fir_dcon_l_old50	62.9	1.4	49.84	2.67	34.83	2.04	73.69	2.04
30	4_6fir_dcon_old80	60.63	1.09	42.92	1.12	29.79	1.07	57.44	5.61
31	4_6fir_dcon_old50	61.54	1.37	45.25	2.6	31.72	2.15	63.17	5.77
32	4_6fir_dcon_l_old80	61.56	1.12	45.04	1.18	31.71	1.31	63.52	7.51
33	4_6fir_dcon_l_old50	61.72	1.12	46.45	1.84	32.14	1.44	67.61	5.87
34	4_6fir_dcon_l_young50	61.0	1.22	46.83	1.57	31.22	1.39	89.32	7.79
35	5_6k_dcon_old80	61.94	1.51	46.58	3.78	32.69	2.37	67.16	11.7
36	5_6k_dcon_old50	61.71	1.02	45.41	0.91	32.04	0.96	62.76	4.72
37	5_6k_dcon_l_old50	62.67	1.61	48.96	3.28	35.34	2.75	67.77	9.22
38	3_4k_dcon_old80	60.76	0.97	43.66	0.94	30.09	0.79	59.56	3.97
39	3_4k_dcon_old50	61.38	1.1	45.0	1.37	31.76	1.37	61.88	5.97
40	3_4k_dcon_l_old80	60.72	0.94	43.88	1.03	30.40	1.09	62.15	4.1
41	3_4k_dcon_l_old50	62.07	1.33	46.29	2.14	33.06	2.19	64.39	5.47
42	birchold80	62.17	1.17	46.26	1.39	31.91	1.29	92.66	7.74
43	birchyoung50	61.29	1.05	47.4	1.69	32.0	1.33	101.31	5.58
44	7_9b_l_old80	62.02	1.15	46.37	1.92	31.73	1.68	96.9	7.97
45	7_9b_l_old50	61.24	1.01	45.29	1.05	30.85	1.18	96.57	5.06
46	7_9b_l_pine_old80	62.29	1.42	46.21	1.41	32.66	1.37	81.92	8.33
47	7_9b_l_dcon_old80	61.19	1.0	44.81	0.96	30.67	0.96	85.92	5.48
48	7_9b_dcon_old80	61.46	0.89	45.59	1.0	31.23	1.11	88.43	8.69
49	7_9b_dcon_old50	62.00	1.08	48.0	1.78	33.30	1.54	84.47	6.99
50	7_9b_dcon_young80	61.3	1.03	45.44	1.02	31.27	1.08	80.2	7.87
51	7_9b_dcon_young50	61.95	1.09	48.4	1.84	32.59	1.18	101.3	7.90
52	4_6b_l_old80	61.43	0.98	45.52	1.22	31.22	1.08	97.52	6.58
53	4_6b_l_old50	61.68	0.85	45.85	1.19	31.47	0.99	97.98	5.86
54	4_6b_l_young50	63.29	1.10	50.35	2.67	33.46	1.58	122.62	9.79
55	4_6b_l_pine_old80	62.04	0.92	45.55	1.42	31.94	1.12	83.48	6.79

56	4_6b_l_pine_old50	62.26	1.38	46.25	1.61	32.34	1.15	83.94	7.61
57	4_6b_l_dcon_old80	60.98	1.03	44.67	0.95	30.38	0.89	85.09	5.24
58	4_6b_l_dcon_young50	61.57	1.06	47.73	1.32	32.01	1.12	103.01	4.17
59	4_6b_dcon_old50	61.6	1.18	45.9	1.02	31.81	1.11	79.22	8.79
60	aspenold80	62.14	1.43	46.72	2.18	31.9	1.83	97.73	7.8
61	aspenold50	63.95	1.68	51.41	4.01	35.92	3.03	94.62	10.1
62	7_9a_l_old80_d	62.48	1.09	47.14	1.81	32.66	1.4	87.77	6.94
63	7_9a_l_old80	61.70	1.20	46.14	1.56	31.41	1.31	97.78	6.33
64	7_9a_l_old50	61.91	1.19	46.53	1.81	31.81	1.33	104.57	8.53
65	7_9a_l_young80	61.39	1.2	45.46	1.56	31.42	1.47	103.73	5.57
66	7_9a_l_pine_old80	62.33	1.07	46.27	1.47	32.73	1.42	80.79	7.25
67	7_9a_l_pine_old50	62.68	0.92	46.68	1.32	32.04	1.38	86.85	6.97
68	7_9a_l_dcon_old80	62.58	1.43	47.81	.2.08	32.95	1.99	81.31	8.17
69	7_9a_l_dcon_pine_old50	61.88	9.86	46.0	1.32	31.53	1.12	82.88	11.24
70	4_6a_l_pine_old80	62.74	1.16	47.26	1.61	33.27	1.35	85.02	5.95
71	4_6a_l_dcon_pine_old80	61.75	1.0	45.84	1.41	31.84	1.04	81.17	7.15
72	4_6a_l_dcon_pine_old50	62.07	1.08	48.11	2.63	33.6	1.98	81.39	9.01

[a] Standard Deviation.

Table A3-2: Statistical characteristics of distribution of spectral brightnesses for the allocated basic classes of vegetation. [Bands: MIR(1), TIR(1), TIR(2), and MIR(2)].

No.	Short Name of Class	Bands							
		Mid infrared		Thermal–infrared (1)		Thermal–infrared (2)		Mid–infrared (2)	
		Mean	SD[a]	Mean	SD[a]	Mean	SD[a]	Mean	SD[a]
1	Water	11.42	0.80	115.34	1.74	121.35	3.04	10.19	1.03
2	Meadow	88.55	5.09	138.90	1.93	164.13	3.53	46.85	5.36
3	Sand	124.51	3.48	159.88	1.20	201.98	1.80	107.89	3.99
4	Meadow, sand	119.26	5.80	157.70	1.28	198.02	2.35	101.02	8.14
5	Road	88.39	9.63	132.61	0.88	152.14	1.15	53.57	7.90
6	Road, forest	81.77	9.44	130.77	0.73	149.0	1.16	45.31	6.41
7	Hay	86.08	5.5	133.15	0.96	153.39	1.59	39.08	2.85
8	Cut	84.73	6.81	132.57	0.98	152.5	1.61	40.17	3.29
9	Cut (1510)	96.0	6.22	129.67	0.57	146.83	0.76	45.42	3.5
10	Clouds	99.34	13.83	139.29	2.74	164.40	4.59	60.82	10.28
11	pineold80	51.48	6.04	131.42	1.43	150.3	2.51	27.81	3.28
12	pineold50	57.3	5.18	130.13	0.73	147.92	1.17	29.5	2.35
13	7_9pine_dcon_l_old50	52.17	9.63	129.58	1.36	146.98	2.41	27.88	4.48
14	7_9pine_l_old80	55.43	5.08	129.64	0.91	147.08	1.52	28.32	2.29
15	7_9pine_l_old50	65.20	6.13	129.71	1.04	147.38	1.75	31.84	2.85
16	7_9pine_l_young80	58.3	5.75	128.73	0.51	145.4	0.9	28.82	1.74
17	4_6pine_l_old80	57.58	5.17	129.24	0.98	146.39	1.79	29.2	2.34
18	4_6pine_l_old50	61.87	8.5	129.46	1.33	146.85	2.32	31.03	3.82
19	spruceyoung50	58.40	4.06	126.75	0.55	142.05	0.89	27.9	1.65
20	7_9sp_dcon_old80	49.58	4.38	130.48	0.5	149.28	0.67	26.69	2.15
21	7_9sp_dcon_old50	50.05	5.85	129.64	1.71	147.15	3.16	26.11	2.62
22	4_6sp_dcon_old80	47.42	5.63	129.39	1.19	146.72	1..99	25.21	2.65
23	4_6sp_dcon_old50	46.35	7.14	129.6	0.96	147.02	1.39	25.0	3.05
24	4_6sp_dcon_l_old80	51.08	6.88	129.98	0.87	147.65	1.68	26.48	2.76
25	4_6sp_dcon_l_old50	53.79	9.43	129.73	6.63	147.37	2.78	28.71	4.83
26	7_8fir_dcon_old80	45.5	6.67	129.29	1.25	146.52	2.19	24.5	3.45
27	7_8fir_dcon_old50	53.12	9.51	130.73	1.0	149.09	1.75	28.19	4.82
28	7_8fir_dcon_l_old80	52.79	4.75	130.27	0.98	147.96	1.58	28.13	2.74
29	7_8fir_dcon_l_old50	66.91	9.39	132.1	1.16	151.52	2.04	35.42	4.92
30	4_6fir_dcon_old80	44.03	4.41	129.14	1.17	146.33	1.99	23.5	1.94
31	4_6fir_dcon_old50	51.63	7.92	130.69	1.58	148.83	2.98	27.46	4.27
32	4_6fir_dcon_l_old80	51.73	4.56	129.12	1.08	146.2	1.81	27.11	2.01
33	4_6fir_dcon_l_old50	55.76	6.75	130.5	0.74	148.59	1.24	29.39	3.39
34	4_6fir_dcon_l_young50	61.85	6.26	130.17	10	148.12	1.57	29.35	2.85
35	5_6k_dcon_old80	57.54	13.49	130.79	1.72	149.12	2.99	30.61	6.79
36	5_6k_dcon_old50	53.15	4.21	129.12	0.85	146.24	1.34	28.17	1.97
37	5_6k_dcon_l_old50	64.33	12.92	132.82	2.47	152.67	4.46	35.1	7.3

38	3_4k_dcon_old80	46.92.	3.76	129.03	0.74	146.22	0.83	25.03	1.84
39	3_4k_dcon_old50	52.47	5.52	130.07	0.96	147.86	1.54	28.08	2.73
40	3_4k_dcon_l_old80	47.62	3.56	129.47	0.69	146.95	0.93	24.67	1.82
41	3_4k_dcon_l_old50	55.77	7.77	130.65	1.48	148.91	2.62	29.99	4.59
42	birchold80	65.03	4.78	127.25	0.73	143.0	1.1	30.37	1.94
43	birchyoung50	71.77	5.99	130.26	1.1	148.08	1.88	32.97	2.9
44	7_9b_l_old80	67.1	5.35	128.12	1.34	144.46	2.30	31.07	3.18
45	7_9b_l_old50	65.33	3.52	127.74	0.74	143.69	1.25	29.68	1.5
46	7_9b_l_pine_old80	61.44	5.13	127.8	1.49	144.34	2.58	29.0	2.12
47	7_9b_l_dcon_old80	60.49	3.03	128.01	0.95	144.25	1.65	28.22	1.53
48	7_9b_dcon_old80	62.64	4.34	128.31	0.91	144.58	1.56	29.14	1.56
49	7_9b_dcon_old50	65.23	7.0	131.3	0.65	150.43	1.41	32.03	3.23
50	7_9b_dcon_young80	59.78	4.32	128.85	0.79	145.76	1.26	28.68	1.58
51	7_9b_dcon_young50	71.99	7.29	130.28	1.35	148.21	2.28	33.57	3.25
52	4_6b_l_old80	65.79	3.91	126.98	0.78	142.09	0.97	29.87	2.09
53	4_6b_l_old50	65.51	4.70	126.94	0.78	142.41	1.22	30.3	2.22
54	4_6b_l_young50	79.57	6.45	127.29	0.58	142.57	0.75	36.11	3.38
55	4_6b_l_pine_old80	61.4	4.78	128.32	0.99	144.45	1.75	29.86	2.18
56	4_6b_l_pine_old50	62.43	5.82	128.82	2.24	145.93	3.15	30.45	2.62
57	4_6b_l_dcon_old80	59.73	3.09	127.22	0.56	143.20	1.14	28.2	1.18
58	4_6b_l_dcon_young50	69.14	3.83	128.81	0.64	145.86	0.73	31.38	1.93
59	4_6b_dcon_old50	60.69	3.8	128.48	1.43	145.32	2.59	29.79	1.78
60	aspenold80	67.81	5.49	128.49	0.98	145.0	1.66	31.11	3.13
61	aspenold50	77.05	11.24	130.90	2.14	149.4	3.71	38.31	6.20
62	7_9a_l_old80_d	65.62	5.34	129.0	0.76	145.73	1.26	30.94	2.61
63	7_9a_l_old80	68.18	4.04	127.96	0.81	144.13	1.33	31.18	2.3
64	7_9a_l_old50	70.15	5.6	127.35	1.04	142.0	1.61	31.95	2.92
65	7_9a_l_young80	67.69	3.63	126.62	0.50	142.0	0.85	30.12	1.75
66	7_9a_l_pine_old80	60.07	4 94	129.2	1.15	146.19	2.06	29.40	2.49
67	7_9a_l_pine_old50	64.62	5.1	128.6	0.9	145.32	1.16	31.03	2.68
68	7_9a_l_dcon_old80	64.76	6.56	128.7	0.78	148.5	1.25	32.04	3.75
69	7_9a_l_dcon_pine_old50	58.88	4.47	127.35	0.49	142.88	0.48	28.76	1.78
70	4_6a_l_pine_old80	63.98	4.1	129.23	0.69	146.43	0.97	30.9	1.99
71	4_6a_l_dcon_pine_old80	59.5	4.65	128.12	0.9	144.4	1.18	28.85	1.96
72	4_6a_l_dcon_pine_old50	65.67	2.03	130.46	1.92	148.26	3.12	33.28	4.96

[a] Standard Deviation.

Appendix 4: Contingency Matrix

Table A4-1: Contingency (confusion) matrix for evaluation of signatures of basic classes.

No.	Short Name of Class	1	2	3	4	5	6	7	8	9	10	11	12
1	Water	**100**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	Meadow	0.0	**97.90**	0.0	0.0	0.0	0.0	0.54	0.0	0.0	0.0	0.0	0.0
3	Sand	0.0	0.0	**100**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	Meadow, sand	0.0	0.0	0.0	**100**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	Road	0.0	0.0	0.0	0.0	**100**	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	Road, forest	0.0	0.0	0.0	0.0	0.0	**100**	0.0	0.0	0.0	0.0	0.0	0.84
7	Hay	0.0	0.70	0.0	0.0	0.0	0.0	**89.13**	3.73	0.0	0.0	0.0	0.0
8	Cut	0.0	0.0	0.0	0.0	0.0	0.0	7.07	**85.71**	00	0.0	0.0	0.0
9	Cut (1510)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**100**	0.0	0.0	0.0
10	Clouds	0.0	0.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**97.33**	0.0	0.0
11	pineold80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.63	**70.48**	3.34
12	pineold50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.96	**43.7**
13	7_9pine_dcon_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.42	0.84
14	7_9pine_l_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.08	13.45
15	7_9pine_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.54	1.24	0.0	0.0	0.88	1.68
16	7_9pine_l_young80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.20
17	4_6pine_l_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.54	7.56
18	4_6pine_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.62	0.0	0.0	0.22	0.0
19	spruceyoung50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	7_9sp_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.84
21	7_9sp_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.54	0.0
22	4_6sp_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	4_6sp_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	4_6sp_dcon_l_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.88	2.52
25	4_6sp_dcon_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.84
26	7_8fir_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	7_8fir_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.0
28	7_8fir_dcon_l_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.64	0.0
29	7_8fir_dcon_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.66	0.84
30	4_6fir_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.22	0.0
31	4_6fir_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.98	0.84
32	4_6fir_dcon_l_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0..44	1.68
33	4_6fir_dcon_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.20
34	4_6fir_dcon_l_young50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.62	0.0	0.0	0.0	0.84
35	5_6k_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.84
36	5_6k_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.20	0.84
37	5_6k_dcon_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.66	0.0
38	3_4k_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	3_4k_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.84
40	3_4k_dcon_l_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	2.52
41	3_4k_dcon_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.54	0.0
42	birchold80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	birchyoung50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.62	0.0	0.0	0.0	0.0
44	7_9b_l_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	7_9b_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	7_9b_l_pine_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.22	0.84
47	7_9b_l_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	7_9b_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	7_9b_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.54	1.86	0.0	0.0	1.32	0.0
50	7_9b_dcon_young80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	7_9b_dcon_young50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.11	0.0	0.0	0.0	0.0
52	4_6b_l_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
53	4_6b_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
54	4_6b_l_young50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55	4_6b_l_pine_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
56	4_6b_l_pine_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.62	0.0	0.0	0.0	0.0
57	4_6b_l_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

58	4_6b_l_dcon_young50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59	4_6b_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.36
60	aspenold80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
61	aspenold50	0.0	0.7	0.0	0.0	0.0	0.0	2.17	1.24	0.0	0.0	0.0	0.0
62	7_9a_l_old80_d	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	7_9a_l_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
64	7_9a_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65	7_9a_l_young80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66	7_9a_l_pine_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.84
67	7_9a_l_pine_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68	7_9a_l_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
69	7_9a_l_dcon_pine_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70	4_6a_l_pine_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.68
71	4_6a_l_dcon_pine_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
72	4_6a_l_dcon_pine_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.62	0.0	0.0	0.44	0.0
	Total (pixels)	***1614***	***143***	***84***	***47***	***28***	***13***	***184***	***161***	***24***	***38***	***454***	***119***

Table A4-1 continued.

No.	Short Name of Class	13	14	15	16	17	18	19	20	21	22	23	24
1	Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	Meadow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	Sand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	Meadow, sand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	Road	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	Road, forest	0.0	0.0	0.0	0.0	0.0	0.77	0.0	0.0	0.0	0.0	0.0	0.0
7	Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	Cut	0.0	0.0	0.0	0.0	0.0	1.15	0.0	0.0	0.0	0.0	0.0	0.0
9	Cut (1510)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	Clouds	0.36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	pineold80	6.20	1.93	0.0	0.0	1.16	0.38	0.0	0.0	4.48	0.60	0.89	3.14
12	pineold50	5.84	14.29	1.45	0.0	8.49	0.17	0.0	0.0	0.60	0.30	0.0	1.05
13	7_9pine_dcon_l_old50	**29.2**	0.39	0.0	0.0	2.70	1.15	0.0	0.0	1.19	3.59	0.44	0.75
14	7_9pine_l_old80	2.55	**28.19**	9.18	0.0	11.20	7.66	0.0	0.0	1.49	0.40	0.44	2.84
15	7_9pine_l_old50	0.36	1.16	**22.22**	0.0	2.32	4.21	0.0	0.0	0.0	0.0	0.0	0.0
16	7_9pine_l_young80	3.28	3.47	6.76	**9.27**	6.13	0.0	0.0	0.0	0.0	1.10	1.33	1.20
17	4_6pine_l_old80	5.47	11.2	5.31	2.50	**21.62**	9.20	0.0	0.0	0.30	1.10	0.44	1.05
18	4_6pine_l_old50	0.36	0.39	2.42	0.0	0.39	**5.75**	0.0	0.0	0.30	0.0	0.0	0.0
19	spruceyoung50	0.36	0.0	0.0	0.0	1.16	0.0	**90**	0.0	0.30	0.40	0.0	0.0
20	7_9sp_dcon_old80	0.73	0.39	0.0	0.0	0.0	0.0	0.0	**85.07**	5.07	8.67	9.78	7.63
21	7_9sp_dcon_old50	0.0	0.39	0.0	0.0	0.0	0.0	0.0	0.0	**25.97**	1.20	0.0	2.84
22	4_6sp_dcon_old80	1.46	0.0	0.0	0.0	0.0	0.0	0.0	1.49	1.49	**4.78**	1.78	0.60
23	4_6sp_dcon_old50	4.01	0.77	0.0	0.0	0.0	0.0	0.0	0.0	1.79	6.87	**25.78**	4.79
24	4_6sp_dcon_l_old80	0.73	1.93	0.0	0.0	1.93	0.0	0.0	1.49	3.58	2.09	4.44	**15.42**
25	4_6sp_dcon_l_old50	0.36	0.39	0.48	0.0	0.0	1.15	0.0	0.0	0.90	1.39	0.0	0.0
26	7_8fir_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.49	3.88	2.49	2.22	0.45
27	7_8fir_dcon_old50	0.0	0.77	0.0	0.0	0.0	0.0	0.0	0.0	2.09	4.98	0.89	3.14
28	7_8fir_dcon_l_old80	2.19	1.16	0.0	0.0	1.54	0.0	0.0	0.0	0.60	3.09	3.56	2.84
29	7_8fir_dcon_l_old50	2.92	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.0	0.15
30	4_6fir_dcon_old80	3.28	0.0	0.0	0.0	0.0	1.15	0.0	1.49	12.84	12.15	5.78	8.38
31	4_6fir_dcon_old50	0.36	0.77	0.0	0.0	0.77	0.0	0.0	0.0	8.66	1.29	0.0	3.89
32	4_6fir_dcon_l_old80	6.20	0.77	0.0	0.0	0.77	3.45	0.0	0.0	1.19	5.58	2.22	1.35
33	4_6fir_dcon_l_old50	0.0	3.09	0.0	0.0	0.77	1.53	0.0	2.99	6.87	0.70	0.44	3.14
34	4_6fir_dcon_l_young50	0.0	0.39	2.42	0.0	0.39	1.53	0.0	0.0	0.0	3.88	0.0	0.30
35	5_6k_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.77	0.0	0.0	0.60	0.70	1.330	0.60
36	5_6k_dcon_old50	2.92	6.56	0.0	2.5	1.93	4.98	0.0	0.0	0.90	9.76	4.47	2.69
37	5_6k_dcon_l_old50	1.82	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.90	0.20	0.0	0.15
38	3_4k_dcon_old80	4.74	0.39	0.0	5.0	1.16	1.92	0.0	0.0	2.99	10.86	16.00	6.25
39	3_4k_dcon_old50	1.82	0.0	0.0	0.0	0.0	0.0	0.0	4.48	0.90	1.10	4.89	1.35
40	3_4k_dcon_l_old80	0.73	1.93	0.0	0.0	0.77	0.77	0.0	1.49	2.69	5.98	9.33	0.68
41	3_4k_dcon_l_old50	0.0	0.0	0.0	0.0	0.39	0.0	0.0	0.0	0.60	0.10	0.0	0.15
42	birchold80	0.0	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.0	0.0
43	birchyoung50	0.0	0.0	0.48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

44	7_9b_l_old80	0.0	0.0	0.48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	7_9b_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	7_9b_l_pine_old80	0.73	1.54	0.0	0.0	2.32	2.68	0.0	0.0	0.0	0.50	0.0	0.0
47	7_9b_l_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.30	0.44	0.60
48	7_9b_dcon_old80	0.36	0.39	0.97	5.0	0.39	1.92	0.0	0.0	0.0	0.20	0.0	0.0
49	7_9b_dcon_old50	0.36	0.77	7.25	1.0	1.16	7.66	0.0	0.0	1.79	0.60	0.0	1.20
50	7_9b_dcon_young80	0.36	1.93	0.48	10.0	3.09	0.38	0.0	0.0	0.30	1.0	1.78	7.93
51	7_9b_dcon_young50	0.0	0.0	7.25	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.0	0.0
52	4_6b_l_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
53	4_6b_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
54	4_6b_l_young50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55	4_6b_l_pine_old80	1.46	0.77	1.93	2.5	5.02	1.92	0.0	0.0	0.30	0.10	0.44	0.90
56	4_6b_l_pine_old50	1.09	1.54	1.45	0.0	2.32	0.77	0.0	0.0	0.0	0.60	0.0	0.15
57	4_6b_l_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.90	0.0	0.44	0.0
58	4_6b_l_dcon_young50	0.0	0.0	0.97	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59	4_6b_dcon_old50	0.73	0.39	0.97	0.0	1.54	1.92	5.0	0.0	0.60	0.10	0.44	3.14
60	aspenold80	0.0	0.0	0.97	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.0	0.0
61	aspenold50	1.09	0.0	1.93	0.0	0.39	3.07	0.0	0.0	0.0	0.0	0.0	0.0
62	7_9a_l_old80_d	0.36	0.0	0.97	2.5	1.54	1.53	0.0	0.0	0.0	0.0	0.0	0.15
63	7_9a_l_old80	0.0	0.0	0.48	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.0	0.0
64	7_9a_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65	7_9a_l_young80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66	7_9a_l_pine_old80	1.09	2.70	0.97	0.0	1.16	1.92	0.0	0.0	0.0	0.50	0.0	0.0
67	7_9a_l_pine_old50	0.36	0.77	5.80	0.0	0.39	2.30	5.0	0.0	0.30	0.0	0.0	0.0
68	7_9a_l_dcon_old80	0.36	1.54	1.45	0.0	3.09	7.28	0.0	0.0	0.90	0.40	0.0	0.30
69	7_9a_l_dcon_pine_old50	0.0	0.39	0.0	2.5	1.54	1.92	0.0	0.0	0.30	0.0	0.0	0.0
70	4_6a_l_pine_old80	0.0	3.09	9.66	0.0	4.63	4.60	0.0	0.0	0.30	0.0	0.0	0.30
71	4_6a_l_dcon_pine_old80	2.92	2.32	1.93	0.0	1.93	2.68	0.0	0.0	0.30	0ɔ30	0.0	0.0
72	4_6a_l_dcon_pine_old50	0.36	1.16	3.38	0.0	0.77	1.15	0.0	0.0	0.90	0.20	0.0	0.45
	Total (pixels)	***294***	***259***	***207***	***40***	***259***	***261***	***20***	***67***	***335***	***1004***	***225***	***668***

Table A4-1 continued.

No.	Short Name of Class	25	26	27	28	29	30	31	32	33	34	35	36
1	Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	Meadow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	Sand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	Meadow, sand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	Road	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	Road, forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	Cut	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.80	0.0	0.0
9	Cut (1510)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	Clouds	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	pineold80	2.51	0.34	0.67	2.52	0.96	0.0	0.91	0.67	1.16	0.0	0.43	0.48
12	pineold50	2.81	0.40	2.46	0.63	2.65	0.0	0.0	1.33	4.07	0.0	0.43	0.48
13	7_9pine_dcon_l_old50	3.11	1.42	0.45	2.52	0.48	0.47	2.73	4.66	0.29	0.0	1.74	0.96
14	7_9pine_l_old80	2.30	1.42	0.0	1.26	0.48	0.24	0.0	1.55	2.33	0.0	0.0	0.96
15	7_9pine_l_old50	0.0	0.0	0.22	0.63	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0
16	7_9pine_l_young80	2.0	0.11	0.0	1.89	0.0	0.24	0.0	1.72	0.0	0.0	0.43	5.29
17	4_6pine_l_old80	1.8	0.0	0.89	0.0	0.24	0.0	0.0	2.44	1.74	0.0	0.43	2.88
18	4_6pine_l_old50	0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.0	0.0	0.0	0.0
19	spruceyoung50	0.80	0.0	0.0	0.0	0.0	0.24	0.0	1.55	0.0	0.0	0.0	0.0
20	7_9sp_dcon_old80	5.01	4.59	9.15	8.18	0.96	1.89	4.55	3.77	4.07	0.0	4.35	0.0
21	7_9sp_dcon_old50	2.20	3.40	0.67	0.63	0.24	1.42	2.73	0.89	1.16	0.0	0.87	0.48
22	4_6sp_dcon_old80	1.20	2.21	0.45	0.0	0.0	1.42	3.64	0.44	0.29	0.0	0.43	0.0
23	4_6sp_dcon_old50	1.60	4.31	4.69	3.14	0.24	3.77	0.91	0.67	0.99	0.0	3.04	1.92
24	4_6sp_dcon_l_old80	2.10	2.04	4.24	0.63	0.0	1.89	1.82	1.33	2.91	0.7	1.74	0.48
25	4_6sp_dcon_l_old50	**4.11**	0.51	0.67	0.0	0.48	0.0	0.0	0.67	0.58	0.0	0.87	0.0
26	7_8fir_dcon_old80	2.0	**10.15**	1.56	0.0	0.0	4.72	0.0	1.11	0.0	0.0	0.0	0.0
27	7_8fir_dcon_old50	1.10	4.88	**12.28**	0.63	1..93	1.42	1.82	0.22	1.45	0.0	1.30	0.0
28	7_8fir_dcon_l_old80	4.21	0.74	3.79	**37.11**	3.86	0.71	0.91	7.32	4.65	0.0	8.70	9.62
29	7_8fir_dcon_l_old50	3,81	1.13	9.82	1.26	**51.08**	0.0	7.27	0.22	2.33	0.0	6.09	0.0

30	4_6fir_dcon_old80	6.51	28.19	13.84	0.63	0.0	**48.58**	8.18.	0.89	0.29	0.0	4.79	0.48
31	4_6fir_dcon_old50	2.10	2.95	5.13	2.52	6.99	1.65	**20.91**	0.67	4.94	0.0	3.48	0.0
32	4_6fir_dcon_l_old80	6.01	1.36	0.22	5.66	0.0	2.83	1.82	**20.18**	0.29	0.0	0.87	3.85
33	4_6fir_dcon_l_old50	4.81	1.19	2.90	2.52	4.34	0.24	5.45	1.33	**38.37**	0.0	5.65	2.40
34	4_6fir_dcon_l_young50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.22	0.0	**58.74**	0.0	0.0
35	5_6k_dcon_old80	1.4	1.25	2.90	1.26	6.99	1.89	0.91	0.0	3.20	0.0	**13.48**	0.0
36	5_6k_dcon_old50	10.62	3.57	2.01	3.14	0.72	0.47	4.55	16.41	6.69	0.0	16.09	**55.29**
37	5_6k_dcon_l_old50	3.01	0.11	1.12	1.89	5.30	0.47	4.55	0.0	0.0	0.0	0.0	0.48
38	3_4k_dcon_old80	3.51	15.20	3.35	5.03	0.24	12.50	14.55	6.65	2.33	0.0	5.65	4.33
39	3_4k_dcon_old50	3.41	0.85	1.34	6.29	1.20	0.0	0.91	3.55	3.20	0.0	6.09	6.73
40	3_4k_dcon_l_old80	2.10	6.98	6.603	5.66	0.72	9.67	9.09	4.43	6.69	0.0	7.73	0.0
41	3_4k_dcon_l_old50	1.40	0.45	4.02	1.89	3.37	0.24	0.0	0.0	1.16	0.0	0.0	0.0
42	birchold80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	birchyoung50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.24	0.0	0.0
44	7_9b_l_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	7_9b_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	7_9b_l_pine_old80	0.40	0.06	0.0	0.0	0.0	0.0	0.0	0.44	0.0	0.0	0.0	0.0
47	7_9b_l_dcon_old80	0.70	0.06	0.0	0.0	0.0	0.0	0.0	0.44	0.0	1.05	0.0	0.0
48	7_9b_dcon_old80	0.20	0.0	0.0	0.0	0.0	0.0	0.0	0.22	0.0	3.50	0.0	0.0
49	7_9b_dcon_old50	0.0	0.11	0.0	0.0	0.96	0.0	0.91	0.67	1.16	11.19	0.0	0.0
50	7_9b_dcon_young80	1.80	0.11	0.22	0.63	0.0	0.94	0.0	3.99	0.0	2.45	0.0	0.0
51	7_9b_dcon_young50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.10	0.0	0.0
52	4_6b_l_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
53	4_6b_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
54	4_6b_l_young50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55	4_6b_l_pine_old80	0.30	0.0	0.0	0.0	0.0	0.24	0.0	0.67	0.0	0.35	0.0	0.0
56	4_6b_l_pine_old50	0.20	0.0	0.22	0.0	0.0	0.0	0.0	0.0	0.0	3.15	0.0	0.0
57	4_6b_l_dcon_old80	0.10	0.0	0.0	0.0	0.0	0.47	0.0	1.77	0.0	0.0	0.0	0.0
58	4_6b_l_dcon_young50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.20	0.0	0.0
59	4_6b_dcon_old50	0.70	0.17	2.68	1.89	0.24	0.0	0.0	0.67	0.58	0.0	0.87	2.40
60	aspenold80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1ю58	0.0	0.0
61	aspenold50	0.20	0.23	0.22	0.0	0.96	0.0	0.0	0.0	0.58	0.0	2.61	0.0
62	7_9a_l_old80_d	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	7_9a_l_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
64	7_9a_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.35	0.0	0.0
65	7_9a_l_young80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66	7_9a_l_pine_old80	0.0	0.0	0.0	0.0	0.24	0.0	0.0	0.0	0.29	1.40	0.0	0.0
67	7_9a_l_pine_old50	0.10	0.0	0.0	0.0	0.0	0.0	0.0	0.22	0.0	0.0	0.0	0.0
68	7_9a_l_dcon_old80	3.41	0.0	0.67	0.0	0.0	0.0	0.0	0.44	0.58	0.0	0.0	0.48
69	7_9a_l_dcon_pine_old50	0.40	0.0	0.0	0.0	0.0	0.47	0.0	0.67	0.0	0.0	0.0	0.0
70	4_6a_l_pine_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.0	0.70	0.0	0.0
71	4_6a_l_dcon_pine_old80	1.30	0.11	0.22	0.0	0.0	0.94	0.0	3.77	0.0	0.0	0.0	0.0
72	4_6a_l_dcon_pine_old50	1.70	0.68	0.89	0.0	4.10	0.0	0.91	0.22	2.33	0.35	2.17	0.0
	Total (pixels)	***998***	***1763***	***448***	***159***	***415***	***426***	***110***	***451***	***344***	***286***	***230***	***208***

Table A4-1 continued.

No.	Short Name of Class	37	38	39	40	41	42	43	44	45	46	47	48
1	Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	Meadow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	Sand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	Meadow, sand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	Road	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	Road, forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	Cut	0.0	0.0	0.0	0.0	0.0	0.0	2.32	0.0	0.0	0.0	0.0	0.0
9	Cut (1510)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	Clouds	0.0	0.0	0.0	0.0	0.78	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	pineold80	1.69	0.0	1.79	0.0	3.91	0.0	0.0	0.0	0.0	2.33	0.0	0.0
12	pineold50	0.0	0.0	0.72	0.0	1.76	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	7_9pine_dcon_l_old50	5.08	0.0	1.79	0.0	1.37	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	7_9pine_l_old80	0.0	0.0	0.54	0.71	0.59	0.0	0.0	0.0	0.0	3.49	0.0	0.0
15	7_9pine_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.39	2.60	0.0	0.0	0.0	0.0

16	7_9pine_l_young80	0.0	0.0	0.89	0.0	0.78	0.0	0.77	0.65	0.0	1.16	2.99	0.86
17	4_6pine_l_old80	0.0	0.0	0.72	0.71	1.17	0.20	0.0	0.65	0.0	1.16	0.0	0.0
18	4_6pine_l_old50	0.0	0.0	0.36	0.0	0.0	0.0	0.0	0.65	0.0	1.16	0.0	0.0
19	spruceyoung50	0.0	0.0	0.0	0.0	0.0	4.64	0.0	0.65	2.28	2.33	4.48	2.57
20	7_9sp_dcon_old80	0.0	0.0	12.88	0.0	6.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	7_9sp_dcon_old50	0.85	0.0	0.54	0.71	0.59	0.0	0.0	0.0	0.0	0.0	0.0	0.29
22	4_6sp_dcon_old80	0.0	0.0	0.36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	4_6sp_dcon_old50	2.54	6.78	4.11	0.71	1.37	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	4_6sp_dcon_l_old80	0.0	3.39	4.29	1.42	3.71	0.0	0.0	0.0	0.0	0.0	1.0	0.0
25	4_6sp_dcon_l_old50	0.0	0.0	0.72	0.0	0.78	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	7_8fir_dcon_old80	0.0	0.0	0.72	1.42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	7_8fir_dcon_old50	0.0	0.0	3.04	0.71	1.76	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	7_8fir_dcon_l_old80	0.85	3.39	12.88	0.71	20.31	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	7_8fir_dcon_l_old50	5.08	0.0	0.0	0.0	1.56	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	4_6fir_dcon_old80	0.0	5.08	2.68	8.51	0.59	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	4_6fir_dcon_old50	5.08	0.0	1.61	1.42	7.81	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	4_6fir_dcon_l_old80	5.93	1.62	2.68	1.42	0.98	0.0	0.0	0.0	0.0	1.16	0.0	0.29
33	4_6fir_dcon_l_old50	1.69	0.0	2.86	2.84	9.57	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	4_6fir_dcon_l_young50	0.0	0.0	0.0	0.0	0.0	0.0	5.41	0.65	0.0	0.0	0.50	1.14
35	5_6k_dcon_old80	1.69	0.0	0.89	0.71	2.54	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	5_6k_dcon_old50	8.47	0.0	14.67	0.71	8.98	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	5_6k_dcon_l_old50	**57.63**	0.0	0.54	0.0	6.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	3_4k_dcon_old80	0.85	**67.8**	7.87	12.77	1.76	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	3_4k_dcon_old50	0.85	1.69	**11.09**	0.0	6.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	3_4k_dcon_l_old80	0.0	10.17	3.94	**62.41**	1.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	3_4k_dcon_l_old50	0.85	0.0	2.33	0.0	**4.88**	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	birchold80	0.0	0.0	0.0	0.0	0.0	**30.04**	0.0	5.84	0.57	10.47	2.99	4.86
43	birchyoung50	0.0	0.0	0.0	0.0	0.0	0.40	**59.85**	0.97	0.28	0.0	0.50	4.0
44	7_9b_l_old80	0.0	0.0	0.0	0.0	0.0	0.40	0.0	**9.42**	0.57	0.0	0.0	0.0
45	7_9b_l_old50	0.0	0.0	0.0	0.0	0.0	6.25	4.25	13.31	**51.28**	0.0	8.96	2.0
46	7_9b_l_pine_old80	0.0	0.0	0.0	0.0	0.0	3.02	0.0	0.65	0.0	**29.07**	0.50	1.14
47	7_9b_l_dcon_old80	0.0	0.0	0.18	0.0	0.0	3.42	0.0	0.32	1.71	0.0	**30.85**	6.57
48	7_9b_dcon_old80	0.0	0.0	0.0	0.0	0.0	4.03	4.25	6.17	2.28	1.16	2.99	**32.0**
49	7_9b_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.0	1.54	1.30	0.0	1.16	0.0	0.0
50	7_9b_dcon_young80	0.0	0.0	0.54	2.13	0.20	0.81	0.0	1.62	0.0	0.0	5.97	5.71
51	7_9b_dcon_young50	0.0	0.0	0.0	0.0	0.0	0.40	12.36	1.30	0.0	0.0	0.50	0.57
52	4_6b_l_old80	0.0	0.0	0.0	0.0	0.0	7.26	0.0	5.84	11.40	0.0	4.47	0.0
53	4_6b_l_old50	0.0	0.0	0.0	0.0	0.0	7.86	0.0	7.47	5.13	0.0	0.0	0.29
54	4_6b_l_young50	0.0	0.0	0.0	0.0	0.0	0.40	0.0	1.30	0.0	0.0	0.0	0.0
55	4_6b_l_pine_old80	0.0	0.0	0.0	0.0	0.0	2.42	0.39	0.97	0.0	3.49	3.98	5.71
56	4_6b_l_pine_old50	0.0	0.0	0.0	0.0	0.0	2.42	1.54	0.97	0.0	11.63	0.0	0.0
57	4_6b_l_dcon_old80	0.0	0.0	0.0	0.0	0.0	6.85	0.0	1.95	6.84	2.33	16.92	6.0
58	4_6b_l_dcon_young50	0.0	0.0	0.0	0.0	0.0	0.0	6.18	2.27	3.42	0.0	0.0	2.57
59	4_6b_dcon_old50	0.0	0.0	0.89	0.0	1.17	0.60	0.0	0.0	0.0	4.65	1.0	1.71
60	aspenold80	0.0	0.0	0.0	0.0	0.0	0.60	0.0	0.32	1.14	1.16	0.0	1.45
61	aspenold50	0.0	0.0	0.0	0.0	0.20	0.20	0.0	3.57	0.0	0.0	0.0	0.0
62	7_9a_l_old80_d	0.0	0.0	0.0	0.0	0.0	2.22	0.0	3.25	0.85	1.16	1.0	0.57
63	7_9a_l_old80	0.0	0.0	0.0	0.0	0.0	5.85	0.0	3.25	5.13	3.49	0.0	0.86
64	7_9a_l_old50	0.0	0.0	0.0	0.0	0.0	1.81	0.77	3.90	1.14	0.0	0.0	0.29
65	7_9a_l_young80	0.0	0.0	0.0	0.0	0.0	2.82	0.0	5.19	1.42	0.0	0.5	0.0
66	7_9a_l_pine_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.65	0.0	0.0	1.0	0.57
67	7_9a_l_pine_old50	0.0	0.0	0.0	0.0	0.0	0.40	0.0	3.25	0.85	2.33	1.99	2.86
68	7_9a_l_dcon_old80	0.0	0.0	0.72	0.0	0.39	0.20	0.0	1.95	0.0	1.16	0.0	0.0
69	7_9a_l_dcon_pine_old50	0.0	0.0	0.0	0.0	0.0	3.83	0.0	1.62	3.42	5.81	2.99	4.86
70	4_6a_l_pine_old80	0.0	0.0	0.0	0.0	0.20	0.0	0.0	1.30	0.0	0.0	0.50	0.86
71	4_6a_l_dcon_pine_old80	0.0	0.0	0.0	0.0	0.0	1.41	0.0	1.62	0.28	8.14	0.50	8.86
72	4_6a_l_dcon_pine_old50	0.85	0.0	0.18	0.0	0.20	0.20	0.0	2.60	0.0	0.0	1.0	0.57
	Total (pixels)	***118***	***59***	***559***	***141***	***512***	***496***	***259***	***308***	***351***	***86***	***201***	***350***

Table A4-1 continued.

No.	Short Name of Class	49	50	51	52	53	54	55	56	57	58	59	60
1	Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	Meadow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	Sand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	Meadow, sand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	Road	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	Road, forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	Cut	0.0	0.0	2.48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.78
9	Cut (1510)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.11
10	Clouds	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	pineold80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	pineold50	0.0	0.0	0.0	0.0	0.0	0.0	0.70	0.0	0.0	0.0	0.99	0.0
13	7_9pine_dcon_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.99	0.0
14	7_9pine_l_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.70	0.0	0.0	0.0	0.0	0.0
15	7_9pine_l_old50	0.0	0.0	0.62	0.0	0.0	0.0	0.70	0.93	0.0	0.0	0.0	1.68
16	7_9pine_l_young80	0.0	7.50	0.0	0.0	0.0	0.0	5.59	0.0	0.0	0.0	4.95	1.34
17	4_6pine_l_old80	0.0	1.67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.97	0.11
18	4_6pine_l_old50	0.0	0.83	0.0	0.0	0.0	0.0	0.70	1.79	0.0	0.0	0.0	0.11
19	spruceyoung50	0.0	0.83	0.0	3.33	1.14	0.0	2.10	0.0	6.67	0.0	6.93	0.22
20	7_9sp_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.99	0.0
21	7_9sp_dcon_old50	3.33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	4_6sp_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	4_6sp_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.79	0.0	0.0	0.99	0.0
24	4_6sp_dcon_l_old80	0.0	2.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.99	0.0
25	4_6sp_dcon_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	7_8fir_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	7_8fir_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.99	0.0
28	7_8fir_dcon_l_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	7_8fir_dcon_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	4_6fir_dcon_old80	0.0	0.83	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	4_6fir_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.95	0.0
32	4_6fir_dcon_l_old80	0.0	1.67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	4_6fir_dcon_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.96	0.0
34	4_6fir_dcon_l_young50	3.33	0.0	7.45	0.0	0.0	0.0	0.0	12.50	0.0	3.75	0.0	0.78
35	5_6k_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	5_6k_dcon_old50	0.0	4.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.98	0.0
37	5_6k_dcon_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	3_4k_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	3_4k_dcon_old50	0.0	0.83	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	3_4k_dcon_l_old80	0.0	2.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	3_4k_dcon_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.99	0.0
42	birchold80	0.0	1.67	3.11	1.11	6.82	1.54	0.0	8.93	2.22	0.0	5.94	3.92
43	birchyoung50	0.0	0.0	25.47	0.0	0.0	0.0	0.0	0.0	0.0	3.75	0.0	2.13
44	7_9b_l_old80	0.0	0.0	1.24	0.0	2.27	0.0	0.0	0.0	0.0	0.0	0.99	1.90
45	7_9b_l_old50	0.0	0.0	0.62	16.67	9.09	0.0	0.7	0.0	0.0	6.25	2.97	12.09
46	7_9b_l_pine_old80	0.0	1.67	0.62	0.0	0.0	0.0	2.10	5.36	0.0	0.0	0.99	0.78
47	7_9b_l_dcon_old80	0.0	7.50	0.62	0.0	0.0	0.0	9.09	3.57	1.11	0.0	2.97	2.91
48	7_9b_dcon_old80	0.0	5.83	4.35	0.0	0.0	0.0	2.10	0.0	2.22	0.0	7.92	6.61
49	7_9b_dcon_old50	**75.67**	0.0	0.62	0.0	0.0	0.0	0.0	7.14	0.0	0.0	0.0	0.0
50	7_9b_dcon_young80	0.0	**33.33**	0.0	0.0	0.0	0.0	8.39	5.36	0.0	0.0	5.94	0.34
51	7_9b_dcon_young50	0.0	0.83	**38.51**	0.0	1.14	0.0	2.10	1.79	0.0	2.50	0.0	2.13
52	4_6b_l_old80	0.0	0.0	0.0	**54.44**	10.23	3.08	0.0	1.79	6.67	0.0	0.0	3.25
53	4_6b_l_old50	0.0	0.0	0.0	8.89	**47.73**	1.54	0.70	0.0	4.44	0.0	1.98	2.13
54	4_6b_l_young50	0.0	0.0	0.0	6.67	0.0	**90.77**	0.0	0.0	0.0	0.0	0.0	0.34
55	4_6b_l_pine_old80	3.33	1.67	0.62	0.0	0.0	0.0	**31.47**	5.36	0.0	0.0	2.97	1.78
56	4_6b_l_pine_old50	0.0	0.83	0.0	0.0	0.0	0.0	0.7	**32.14**	0.0	0.0	0.99	0.78
57	4_6b_l_dcon_old80	0.0	0.83	0.0	2.22	2.27	0.0	1.40	0.0	**6.22**	0.0	4.95	2.13
58	4_6b_l_dcon_young50	0.0	0.0	3.11	0.0	2.27	0.0	2.80	0.0	0.0	**83.75**	0.0	8.06
59	4_6b_dcon_old50	0.0	0.83	0.0	0.0	0.0	0.0	0.7	0.0	2.22	0.0	**17.82**	0.11
60	aspenold80	0.0	0.0	1.24	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	**13.77**
61	aspenold50	3.33	0.0	0.62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.58
62	7_9a_l_old80_d	0.0	3.33	1.86	0.0	0.0	0.0	6.29	0.0	0.0	0.0	0.0	6.38

63	7_9a_l_old80	0.0	0.83	1.86	2.22	4.55	0.0	2.10	0.0	0.0	0.0	0.99	6.94
64	7_9a_l_old50	0.0	0.0	0.0	1.11	5.68	1.54	0.0	0.0	0.0	0.0	0.0	2.46
65	7_9a_l_young80	0.0	0.0	0.0	3.33	4.55	1.54	0.0	0.0	0.0	0.0	0.0	1.68
66	7_9a_l_pine_old80	6.67	2.50	0.0	0.0	0.0	0.0	1.40	3.57	0.0	0.0	0.0	0.57
67	7_9a_l_pine_old50	0.0	5.0	2.48	0.0	0.0	0.0	5.59	0.0	0.0	0.0	0.99	3.36
68	7_9a_l_dcon_old80	0.0	0.83	0.0	0.0	0.0	0.0	1.40	0.0	0.0	0.0	0.99	1.34
69	7_9a_l_dcon_pine_old50	0.0	1.67	0.0	0.0	2.27		2.10	0.0	0.0	0.0	4.95	1.34
70	4_6a_l_pine_old80	3.33	0.0	1.86	0.0	0.0	0.0	2.80	0.0	0.0	0.0	0.0	2.35
71	4_6a_l_dcon_pine_old80	0.0	6.67	0.62	0.0	0.0	0.0	4.20	0.0	2.22	0.0	2.97	0.34
72	4_6a_l_dcon_pine_old50	0.0	0.83	0.0	0.0	0.0	0.0	0.70	0.0	0.0	0.0	0.0	0.45
	Total (pixels)	***30***	***120***	***161***	***90***	***88***	***65***	***143***	***56***	***45***	***80***	***101***	***893***

Table A4-1 continued.

No.	Short Name of Class	61	62	63	64	65	66	67	68	69	70	71	72
1	Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	Meadow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	Sand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	Meadow, sand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	Road	0.39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	Road, forest	0.39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	Hay	0.39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	Cut	7.42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	Cut (1510)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	Clouds	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	pineold80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	pineold50	0.0	0.0	0.0	0.0	0.0	4.90	0.0	2.69	0.0	4.0	0.0	0.0
13	7_9pine_dcon_l_old50	0.78	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0
14	7_9pine_l_old80	0.39	0.70	0.0	0.0	0.0	5.59	0.0	0.0	0.0	3.75	0.56	0.0
15	7_9pine_l_old50	2.34	2.80	0.0	0.0	0.0	4.20	1.28	0.0	0.0	4.75	0.56	0.0
16	7_9pine_l_young80	0.39	9.09	1.73	0.0	0.0	2.80	11.54	1.61	0.0	4.50	6.18	6.52
17	4_6pine_l_old80	0.39	0.0	0.0	0.0	0.0	6.99	0.0	2.15	0.0	2.75	2.81	0.0
18	4_6pine_l_old50	1.56	0.0	0.35	0.0	0.0	0.0	0.0	0.54	0.0	1.00	0.56	0.0
19	spruceyoung50	0.0	0.0	0.35	0.39	3.85	2.80	3.85	1.61	11.76	0.0	5.06	0.0
20	7_9sp_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	7_9sp_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	4_6sp_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	4_6sp_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	4_6sp_dcon_l_old80	0.0	0.0	0.0	0.0	0.0	1.40	0.0	0.0	0.0	0.0	0.0	2.17
25	4_6sp_dcon_l_old50	0.0	0.0	0.35	0.0	0.0	0.0	0.0	1.08	0.0	0.25	0.56	0.0
26	7_8fir_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.56	0.0
27	7_8fir_dcon_old50	0.39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	7_8fir_dcon_l_old80	0.0	0.0	0.0	0.0	0.0	0.70	0.0	1.08	0.0	0.0	0.0	0.0
29	7_8fir_dcon_l_old50	0.78	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.04
30	4_6fir_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.56	0.0
31	4_6fir_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	4_6fir_dcon_l_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.61	0.0	0.0	1.12	0.0
33	4_6fir_dcon_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.54	0.0	0.0	0.0	8.70
34	4_6fir_dcon_l_young50	0.39	0.7	0.0	0.0	0.0	2.80	1.28	0.54	0.0	0.50	0..56	0.0
35	5_6k_dcon_old80	1.95	0.0	0.0	0.0	0.0	0.70	0.0	0.0	0.0	0.0	0.0	6.52
36	5_6k_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.70	0.0	2.69	0.0	0.0	0.0	2.17
37	5_6k_dcon_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	3_4k_dcon_old80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.17
39	3_4k_dcon_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.08	0.0	0.0	0.0	0.0
40	3_4k_dcon_l_old80	0.0	0.70	0.0	0.0	0.0	0.70	0.0	0.0	0.0	0.0	0.0	4.35
41	3_4k_dcon_l_old50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	birchold80	0.0	2.8	5.19	1.97	0.0	2.10	0.0	0.54	0.0	0.25	0.56	2.17
43	birchyoung50	0.78	0.7	0.35	0.39	0.0	0.0	0.0	0.0	0.0	0.25	0.0	0.0
44	7_9b_l_old80	0.0	0.0	1.73	2.76	0.0	0.0	1.28	0.0	0.0	0.50	0.56	2.17
45	7_9b_l_old50	0.0	3.50	19.03	8.66	0.0	1.40	1.28	0.54	0.0	0.0	3.93	0.0
46	7_9b_l_pine_old80	2.34	0.0	0.35	0.0	0.0	1.40	1.28	1.08	0.0	1.50	1.12	0.0
47	7_9b_l_dcon_old80	0.0	2.10	2.77	0.0	0.0	2.10	0.0	1.61	0.0	1.75	337	0.0
48	7_9b_dcon_old80	1.17	2.80	4.50	0.39	0.0	4.90	3.85	5.38	0.0	2.50	6.18	0.0

49	7_9b_dcon_old50	1.17	0.0	0.0	0.0	0.0	1.40	0.0	0.0	0.0	0.0	0.0	2.17
50	7_9b_dcon_young80	0.0	6.29	0.69	0.0	0.0	1.40	2.56	2.15	0.0	4.0	2.81	2.17
51	7_9b_dcon_young50	2.34	2.80	1.73	0.0	0.0	2.10	2.56	0.54	0.0	1.0	0.56	0.0
52	4_6b_l_old80	0.0	0.0	8.30	11.02	3.85	0.0	0.0	0.0	0.0	0.0	0.56	0.0
53	4_6b_l_old50	0.0	0.7	4.84	11.81	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
54	4_6b_l_young50	0.0	0.0	1.38	8.27	3.85	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55	4_6b_l_pine_old80	1.56	1.40	0.69	0.79	0.0	5.59	2.56	2.69	0.0	1.25	8.99	4.35
56	4_6b_l_pine_old50	1.17	3.50	0.69	0.0	0.0	3.50	2.56	0.54	0.0	1.75	1.12	0.0
57	4_6b_l_dcon_old80	0.39	0.0	2.77	0.79	0.0	0.70	1.28	1.08	0.0	0.0	4.49	0.0
58	4_6b_l_dcon_young50	1.95	0.0	4.5	4.72	0.0	0.0	1.28	0.0	0.0	0.25	0.56	2.17
59	4_6b_dcon_old50	0.78	0.0	1.38	0.39	0.0	2.10	1.28	3.76	0.0	2.50	4.49	0.0
60	aspenold80	2.34	1.40	2.08	3.15	0.0	0.70	0.0	0.0	0.0	0.5	1.12	2.17
61	aspenold50	**38.28**	2.10	0.0	0.0	0.0	2.10	1.28	3.76	0.0	0.5	0.0	0.0
62	7_9a_l_old80_d	3.52	**28.67**	3.81	1.18	0.0	0.7	2.56	1.08	0.0	6.75	1.69	2.17
63	7_9a_l_old80	1.17	2.10	**16.94**	8.27	0.0	1.40	1.28	1.08	0.0	0.75	1.12	2.17
64	7_9a_l_old50	0.39	0.0	4.84	**22.05**	0.0	0.0	1.28	0.54	0.0	0.0	0.0	0.0
65	7_9a_l_young80	0.0	0.0	2.77	9.06	**88.46**	0.0	0.0	0.0	5.88	0.0	0.0	0.0
66	7_9a_l_pine_old80	0.39	0.0	0.0	0.0	0.0	**9.09**	1.28	0.0	0.0	2.75	3.37	0.0
67	7_9a_l_pine_old50	5.47	6.29	2.77	1.57	0.0	0.0	**30.77**	4.84	0.0	5.25	4.49	2.17
68	7_9a_l_dcon_old80	7.81	2.80	1.04	1.18	0.0	0.0	5.13	**42.47**	0.0	3.50	2.81	4.35
69	7_9a_l_dcon_pine_old50	0.0	0.0	0.69	0.79	0.0	0.7	0.0	0.54	**82.35**	0.0	1.69	0.0
70	4_6a_l_pine_old80	3.52	12.59	0.0	0.0	0.0	16.78	8.97	5.38	0.0	**38.25**	4.49	2.17
71	4_6a_l_dcon_pine_old80	0.39	3.59	0.35	0.0	0.0	5.59	7.69	2.15	0.0	1.50	**20.22**	4.35
72	4_6a_l_dcon_pine_old50	5.08	0.0	1.04	0.39	0.0	0.0	0.0	1.08	0.0	0.75	0.56	**19.57**
	Total (pixels)	***256***	***143***	***289***	***254***	***26***	***143***	***78***	***186***	***17***	***400***	***178***	***46***

Appendix 5: Merged Classes

Table A5-1: Merging of classes of vegetation species and communities.

No.	Numbers of Previous Classes of Vegetation (see *Table A2-1*)	Name of New Entire Class
1	11+14	Pine forest, mature/old, stocked
2	12+13+15	Pine forest, mature/old, sparse
3	16	70–90% pine mixed with deciduous trees, young, stocked
4	17	40–60% pine mixed with deciduous trees, mature/old, stocked
5	18	40–60% pine mixed with deciduous trees, mature/old, sparse
6	19	100% spruce young, sparse
7	20	70-90% spruce with mixed coniferous trees, mature/old, stocked
8	21	70-90% spruce with mixed coniferous trees, mature/old, sparse
9	22+30	Mixed, mixed coniferous trees, mature/old, stocked
10	23+31+39	Mixed, mixed coniferous trees, mature/old, sparse
11	24+32+40	Mixed, mixed coniferous and deciduous trees, mature/old, stocked
12	25+33+41	Mixed, mixed coniferous and deciduous trees, mature/old, sparse
13	26+28	Fir forests mainly with mixed coniferous trees, mature/old, stocked
14	27+29	Fir forests mainly with mixed coniferous trees, mature/old, sparse
15	34	40–60% fir with mixed coniferous and deciduous trees, young, sparse
16	35	50–60% cedar with mixed coniferous trees, mature/old, stocked
17	36+37	50–60% cedar mainly with mixed coniferous trees, mature/old, sparse
18	38	30–40% cedar with mixed coniferous trees, mature/old, stocked
19	42+44+46+47+48	Birch forest, mature/old, stocked
20	43	Birch forest, young, sparse
21	45	70–90% birch with deciduous trees (aspen), mature/old, sparse
22	49	70–90% birch with mixed coniferous trees, mature/old, sparse
23	50+51	70–90% birch with mixed coniferous trees, young, stocked/sparse
24	52+55+57	Mixed deciduous forests, mature/old, stocked
25	53+56+59+72	Mixed deciduous forests, mature/old, sparse
26	54+58	Mixed deciduous forests, young, sparse
27	60+62+63+66+68	Aspen forest, mature/old, stocked
28	61+64+63+69	Aspen forest, mature/old, sparse
29	65	70–90% aspen mixed with leaves trees (birch), young, stocked
30	70+71	Deciduous forest (mainly aspen) mixed with coniferous forest, mature/old, stocked

Appendix 6: Accuracy Assessment

Table A6-1: Expert accuracy assessment of classification.

No.	Kvartal	SKNR	Forest Inventory Data			Classification Data			Accuracy Mark (max = 12)
			Composition	Age	Stocking	Composition	Age	Stocking	
1	1	13	5P 4B 1A	90	50	5P4A1B	Mature/old	sparse	9
2	24	1	8P 2B	60	70	8P1F1A	Mature/old	stocked	10
3	24	28	8P 2B	210	70	8P1B1A	Mature/old	stocked	11
4	53	17	9A 1S	100	60	7A2B1P	Mature/old	stocked	9
5	54	17	6A 4B	80	60	6B4A	Mature/old	stocked	10
6	55	6	8F 1S 1C	180	70	6F2C2S	Mature/old	stocked	10
7	28	28	8B2A	90	50	10B	Mature/old	sparse	10
8	29	22	6F2S2C	220	60	2F3S5C	Mature/old	stocked	8
9	29	11	8B1S1F	150	60	10B	Mature/old	stocked	10
10	57	26	4S4F2C	240	60	5S2F3C	Mature/old	sparse	9
11	52	29	10P	130	80	9P1F	Mature/old	stocked	11
12	68	8	10P	90	80	10P	Mature/old	stocked	12
13	53	13	6F3S1C	180	60	6F1S2C1B	Mature/old	stocked	10
14	69	16	5P3B2A	180	60	5A3B2P	Mature/old	stocked	9
15	70	27	5P3B2A	210	60	5P4B1A	Mature/old	sparse	10
16	72	26	9B1P	110	60	10B	Mature/old	stocked	11
17	71	4	5F4S1C	220	60	7F2S1C	Mature/old	stocked	10
18	71	15	6B2A2P	190	40	8B1A1P	Young	sparse	9
19	70	5	7F2S1C	220	60	8B4F	Mature/old	stocked	11
20	56	8	8B1FS	70	50	6B4F	Young	sparse	9
21	55	22	5S3F2C	200	60	5F3S2C	Mature/old	stocked	10
22	55	14	6F2S2C	240	70	5F2S3C	Mature/old	stocked	11
23	55	3	5F2S3B	30	50	6F4B	Young	sparse	10
24	27	25	7B2A1S	110	70	7B2A1S	Mature/old	stocked	12
25	26	44	4F2S2B2A	150	60	4C3F2S1A.	Mature/old	sparse	7
26	52	4	7P2B1A	150	70	5B2A3P	Mature/old	stocked	8
27	25	19	10A	210	60	5A4B1P	Mature/old	stocked	7
28	25	18	5A1B2S1F1P	130	60	4A3B3P	Mature/old	stocked	8
29	26	24	8F1S1C	150	70	5F2S2C1B	Mature/old	stocked	9
30	6	3	4S3F3B	150	80	6F2S1C1B	Mature/old	sparse	6
31	6	7	4S4F2C	220	60	5F2S2C1B	Mature/old	sparse	9
32	5	4	7F1S1C1B	150	40	7F1S1C1A	Mature/old	sparse	10
33	4	12	6F2S2C	130	50	3C3F2S2A	Mature/old	sparse	9
34	4	10	8F1S1C	150	60	5F2S1C1A1B	Mature/old	sparse	8
35	26	3	7A3B	80	50	7B3A	Mature/old	sparse	8
36	4	33	4B3S2F1C	180	50	4F3C2S1B	Mature/old	sparse	[a]
37	4	35	10B	60	60	4A3B2C1F	Mature/old	stocked	[a]
38	1	3	9P1B	190	40	7P2B1A	Mature/old	Sparse	10
39	1	9	10P	190	50	10C	Mature/old	sparse	12
40	1	28	Hay			Hay			12
41	1	23	8P2B	210	60	8P2F	Mature/old	stocked	10
42	1	41	8P2B	230	70	8P1F1B	Mature/old	stocked	11
43	1	24	10P	210	40	4P1F4A1B	Mature/old	sparse	[a]
44	1	45	7A2B1P	110	60	7A3P	Mature/old	stocked	10
45	2	3	4F2S2C2B	150	40	6F1S2C1B	Mature/old	sparse	10
46	2	5	10A	150	30	7A1B1F1P	Mature/old	sparse	9
47	2	14	5F3S1C1B	150	50	5F2C1P2B	Mature/old	sparse	9
48	2	25	8P2B	15	90	5B3A2P	Young	stocked	6
49	2	37	7P3B1A	210	60	7P3B	Mature/old	sparse	10
50	2	43	7B3P	80	80	8B2A	Mature/old	stocked	9
51	2	29	8B2A	80	70	9B1A	Mature/old	stocked	11
52	2	12	3S2P2F2A1B	130	40	3F3P2C1S1B	Mature/old	stocked	9
53	2	22	6P3B1A	210	40	2F1C1S2P2A2B	Mature/old	stocked	6
54	24	14	9P1B	210	80	10P	Mature/old	sparse	10
55	24	48	6P3A1B	230	50	5A3B2P	Mature/old	sparse	8
56	24	57	10P	210	40	5P4A1B	Mature/old	sparse	7
57	3	3	4F2S2C2B	160	40	6F2C1S1B	Mature/old	sparse	10

58	3	8	6F2S2A	110	50	4F3S2C1B	Mature/old	sparse	9
59	3	16	4A2B2S2P	190	60	5A3B1P1F	Mature/old	stocked	9
60	3	28	7B3P	210	80	5B4A1P	Mature/old	stocked	8
61	3	42	10B	150	70	10B	Mature/old	stocked	12
62	3	30	3S2P3A2B	190	50	3F1S1C2P2A1B	Mature/old	Sparse	8
63	3	13	5F2S3A	150	30	4F2S2C1P1A	Mature/old	sparse	9
64	25	5	5P3B2A	150	60	4A4B2P	Mature/old	stocked	9
65	25	7	5S1F2B2A	130	30	4F2C1S2A1B	Mature/old	stocked	6
66	25	14	7A1S1F1P	130	40	4A2B1F1S2P	Mature/old	stocked	8
67	25	30	6F3S1C	150	60	5F3S1B1A	Mature/old	stocked	10
68	25	34	10A	120	70	5A4B1F	Mature/old	stocked	7
69	52	8	Hay			Hay			12
70	52	11	7P2B1A	150	70	4P4A2B	Young	stocked	8
71	52	18	9P1B	150	80	5A4P1B	Mature/old	stocked	[a]
72	52	14	5P2B3A	170	60	9B1A	Mature/old	stocked	[a]
73	52	35	5P3A2B	170	70	6P3A1B	Mature/old	stocked	11
74	52	33	8P2A	110	70	7P1F1C1A	Mature/old	stocked	10
75	4	2	4F2S2C2B	160	40	5F2C2S2A	Mature/old	sparse	10
76	4	7	5S2C3B	160	30	6F2S1C1B	Mature/old	sparse	[a]
77	4	31	10A	110	80	4B4A2F	Mature/old	stocked	[a]
78	4	44	6B4A	65	50	8B1A1S	Mature/old	sparse	9
79	4	22	5S2F1C2B	180	30	5C2S2A1B	Mature/old	sparse	6
80	26	6	7B3F	130	70	5B4A1F	Mature/old	stocked	7
81	26	15	6S2F1C1A	150	50	5F3C1S1B	Mature/old	stocked	5
82	26	31	8B2A	55	50	10A	Mature/old	sparse	8
83	26	43	7A3B	45	80	6A4B	Mature/old	stocked	11
84	53	2	8B1A1P	190	70	8B2A	Mature/old	stocked	11
85	53	6	6A2B1F1P	130	50	6A2B1F1P	Mature/old	sparse	12
86	53	12	10A	80	80	5B4A1P	Mature/old	stocked	6
87	53	21	6P3A1B	150	60	7P1F1B1A	Mature/old	stocked	10
88	68	6	10A	130	80	4A4B1P1F	Mature/old	stocked	[a]
89	68	11	9P2A	150	70	7P1F1B1A	Mature/old	stocked	10
90	68	27	10P	150	60	10P	Mature/old	stocked	12
91	5	2	5F2S1C2B	170	40	7F1S1C1A	Mature/old	sparse	9
92	5	14	7B3A	110	60	6B4A	Mature/old	stocked	10
93	5	21	6B4A	60	50	6B4A	Mature/old	sparse	12
94	5	32	7B3A	75	70	7B3A	Mature/old	sparse	11
95	27	6	7A3B	25	70	7A3B	Young	stocked	12
96	27	4	6B2A2Sl	25	40	7B3A	Young	sparse	10
97	27	12	7A3B	55	50	6B4A	Mature/old	sparse	9
98	27	17	5C3B1A1Sl	60	90	6B4A	Mature/old	sparse	[a]
99	27	18	6B3A1F	130	60	7B3A	Mature/old	stocked	11
100	27	33	7F2S1C	240	70	7F2S1C	Mature/old	stocked	12
101	54	4	5F2S1C1B1A	65	80	5F4C1S	Mature/old	stocked	8
102	54	8	6F2S2B	100	70	4F2C1S1P2B	Mature/old	stocked	9
103	54	10	6A3B1S	130	60	8B1A1S	Mature/old	sparse	6
104	54	19	8A2B	80	60	6A3B1P	Mature/old	stocked	10
105	68	2	5B3P2A	130	90	6B4A	Mature/old	stocked	9
106	69	11	Cut			5A4B1P	Mature/old	sparse	[a]
107	6	2	4F3S2C1B	150	50	4F3S2C1B	Mature/old	sparse	12
108	6	8	4C 3S2F1B	240	40	5F4S1B	Mature/old	stocked	6
109	6	13	4C3S3F	220	50	5S4F2C	Mature/old	stocked	8
110	6	20	8B2A	50	50	8B2A	Mature/old	stocked	11
111	6	28	6B2A2Sl	25	40	8B2A	Young	sparse	10
112	6	32	7B2A1S	90	60	8B2A	Mature/old	sparse	10
113	6	19	5S3F1C1B	180	50	4S3F3C	Mature/old	sparse	10
114	28	4	7B2A1S	90	60	7B2A1S	Mature/old	stocked	12
115	28	10	10A	130	80	6B4A	Mature/old	Sparse	5
116	28	13	7B3A	65	60	7B3A	Mature/old	Sparse	11
117	29	22	5F2S2C1A	220	60	4F2S3C1B	Mature/old	stocked	9
118	28	26	8B2A	80	50	8B2A	Mature/old	Sparse	12
119	55	24	8A2F	110	60	6A2B1F1P	Mature/old	Sparse	8
120	70	2	10A	130	70	4B4P1A1F	Mature/old	Sparse	[a]
121	70	12	7B3A	210	70	4B3A3P	Mature/old	Sparse	8
122	70	18	6S2P1F1B	130	40	3S3C2F2B	Mature/old	stocked	6

123	70	23	7P3B	190	70	5P3A2B	Mature/old	Sparse	7
124	7	1	4F3S2C1B	220	40	4F3S2C1B	Mature/old	Sparse	12
125	7	5	6B2A2F	25	50	7B2A1F	Mature/old	Sparse	11
126	7	18	5F1S1C3B	180	60	4F3C2S1B	Mature/old	stocked	9
127	7	32	10B	65	60	7B3A	Mature/old	stocked	9
128	7	34	Hay			Hay			12
129	7	30	4S2F2C2B	180	40	5C2F1S1P1A	Mature/old	Sparse	7
130	7	39	Hay			Hay			12
131	29	3	6S2F2C	90	60	3C3F1S3B	Mature/old	Sparse	7
132	29	4	5C3S2F	220	50	5C3F2S	Mature/old	Sparse	11
133	29	19	6F2S2C	220	60	5C4S1F	Mature/old	stocked	7
134	29	20	6C3S1F	30	50	4C4S2F	Mature/old	Sparse	10
135	56	4	5S3F2C	240	60	5F2S3C	Mature/old	stocked	9
136	56	17	4F2S2B2A	180	60	10A	Mature/old	Sparse	[a]
137	71	2	8F2S	220	70	5F4S1C	Mature/old	stocked	9
138	71	8	8F2S	150	50	4F4S2C	Mature/old	stocked	7
139	72	30	7S2F1B	130	60	5F3S1C1B	Mature/old	Sparse	7
140	72	7	7P1S1F1A	190	50	4F3S1C1P1A	Mature/old	Stocked	5
141	72	20	5S1C4B	150	60	4S3F2P1B	Mature/old	Stocked	7
142	8	1	10B	25	40	8B2A	Young	Sparse	10
143	8	12	4S2F4B	160	60	3S2F2C3B	Mature/old	Sparse	9
144	8	6	10B	40	60	7B1A	Mature/old	Sparse	9
145	8	22	10B	75	70	10B	Mature/old	Stocked	12
146	8	25	4S2F2C2B	180	50	6C2F1S1B	Mature/old	Sparse	8
147	8	32	5C3S2F	180	60	4C4F2S	Mature/old	Sparse	9
148	30	3	6S2F2C	220	70	4C3F2S	Mature/old	Sparse	7
149	30	80	7B2S1C			3B3A2F1C1S	Mature/old	Stocked	7
150	30	21	4C4S2B	160	50	4F2C1S3B	Mature/old	Sparse	7
151	30	31	Cut			Cut			12
152	30	15	8B1S1F	180	70	10A	Mature/old	Sparse	[a]
153	30	37	5F3S2C	240	60	4S4C2F	Mature/old	Stocked	9
154	57	2	9B1F	15	40	9B1F	Young	Sparse	12
155	57	8	4C4S2F	140	50	6S3F1C	Mature/old	Stocked	8
156	57	33	5F3S1C1A	180	60	5F3C2S	Mature/old	Stocked	10
157	57	38	6S3F1A	220	50	5F4S1C	Mature/old	Stocked	8
									Average = 8.41

[a] Ground truth data are disputable.

Appendix 7: Classified Legend

Table A7-1: Classified Landsat Image Legend.

No.		Name of New Entire Class
1		Water surface
2		Meadow
3		Sandy bare soil
4		Meadow on sandy soil
5		Road
6		Road in forest
7		Agriculture, hay
8		Clear-cut areas
9		Clear-cut areas (1510)
10		Clouds
11		Pine forest, mature/old, stocked
12		Pine forest, mature/old, sparse
13		70–90% pine mixed with deciduous trees, young, stocked
14		40–60% pine mixed with deciduous trees, mature/old, stocked
15		40–60% pine mixed with deciduous trees, mature/old, sparse
16		100% spruce young, sparse
17		70–90% spruce with mixed coniferous trees, mature/old, stocked
18		70–90% spruce with mixed coniferous trees, mature/old, sparse
19		Mixed, mixed coniferous trees, mature/old, stocked
20		Mixed, mixed coniferous trees, mature/old, sparse
21		Mixed, mixed coniferous and deciduous trees, mature/old, stocked
22		Mixed, mixed coniferous and deciduous trees, mature/old, sparse
23		Fir forests mainly with mixed coniferous trees, mature/old, stocked
24		Fir forests mainly with mixed coniferous trees, mature/old, sparse
25		40–60% fir with mixed coniferous and deciduous trees, young, sparse
26		50–60% cedar with mixed coniferous trees, mature/old, stocked
27		50–60% cedar mainly with mixed coniferous trees, mature/old, sparse
28		30–40% cedar with mixed coniferous trees, mature/old, stocked
29		Birch forest, mature/old, stocked
30		Birch forest, young, sparse
31		70–90% birch mixed with deciduous trees (aspen), mature/old, sparse
32		70–90% birch mixed with mixed coniferous trees, mature/old, sparse
33		70–90% birch mixed with mixed coniferous trees, young, stocked/sparse
34		Mixed deciduous forests, mature/old, stocked
35		Mixed deciduous forests, mature/old, sparse
36		Mixed deciduous forests, young, sparse
37		Aspen forest, mature/old, stocked
38		Aspen forest, mature/old, sparse
39		70–90% aspen mixed with deciduous trees (birch), young, stocked
40		Deciduous forest (mainly aspen) mixed with coniferous forest, mature/old, stocked