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Project Report
Willmore Wilderness Park Inventory and Map Analysis

Submitted to:
Foothills Model Forest
Alberta Environment

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Executive Summary

A vegetation inventory of the Willmore Wilderness Park is needed from which a fire management plan could be developed by Alberta Environment. The only completed inventory for Willmore is an Alberta Phase 1 completed some 50 years ago. The Phase 1 inventory is not digital, and it may not adequately represent the structure, composition and distribution of the present land cover. There has been no recent history of fire disturbance, and growing conditions were considered poor due to rugged topography. A need existed to assess the extent the extent to which the Phase 1 inventory could represent current land cover. The Phase 1 inventory was digitized under contract to Alberta Resource Data Division. A sample of 8 townships within the Willmore Wilderness Park was selected for an Alberta Vegetation Inventory (AVI) that was subsequently compared to the digitized Phase 1 inventory. This comparison was undertaken from both non-spatial and spatial perspectives that included compilation of frequency distributions of land cover and generation of Kappa statistics. If the AVI map is assumed to represent the current distribution of land cover in Willmore, then the vegetation has changed significantly with respect to species distribution, crown closure, stand height and non-forest cover. These differences were attributed to scale, photo interpretation judgments, and successional processes. The significance of this work for generation of a fire management plan lies in assessing the differences between the Phase 1 and AVI inventories for the selected townships from a forest fuels perspective. Given the lack of industrial activity in Willmore, it is the differences in forest fuels that will govern whether a new inventory of Willmore will be necessary.

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1.0 Background and Introduction

Located on the Alberta/British Columbia border northwest of Hinton and south of Grande Cache, the Willmore Wilderness Park is 460,059 hectares (4,601 km^2) in size. It contains 63 whole and part townships (equal to 49.3 full townships). Based on a previously completed Willmore Ecological Land Classification, approximately 60% of the park is dominated by forest.

The landscape is characterized by foothills in the eastern portion of the park and mountainous terrain in the remainder of the park. Lodgepole pine (*Pinus contorta* Dougl. Ex Loud. var. *latifolia* Engelm.) forests dominate the northwest trending ridges in the foothills. In the Hoff, Berland and Persimmon ranges, trembling aspen (*Populus tremuloides* Michx.) intermixed with open grasslands occur on some of the southwest facing slopes. White spruce (*Picea glauca* (Moench) Voss) can be found on north aspects and sites with higher moisture levels. Deciduous trees (*Populus spp.*) and understory species diversity are higher in the foothills portion of the park.

The sub-alpine forests are dominated by lodgepole pine on south, east and west-facing slopes. Engelmann spruce (*Picea engelmannii* Parry ex Engelm.), white spruce and sub-alpine fir (*Abies lasiocarpa* (Hook.) Nutt.) occurs on north aspects and at higher elevations in the upper sub-alpine zone.

The responsibility for developing a management plan for Willmore Wilderness lies with the Land and Forest Service (LFS) Foothills District staff. A need has been identified to produce a vegetation inventory for use in the preparation of a fire management plan. This plan includes a detailed wildfire threat analysis for the area. Fire management will involve fighting lightning and person-caused fires and using prescribed fire and fuel management strategies to attain landscape management objectives.

A committee consisting of Rick Blackwood (formally with Foothills Model Forest), Cordy Tymstra (LFS), Dave Morgan (LFS), Lowell Lyseng (LFS), Doug Langner (Resource Data Division) and Ron Hall was struck to develop a methodology for conducting an inventory of Willmore. During the planning of this project, Alberto Parry, Marilyn Rayner and Ken Dutchak of Resource Data Division also participated in some of the meetings. Lowell Lyseng, a senior interpreter with LFS, recommended use of the 1:50,000 Phase 1 inventory. It is at least 40 - 50 years old, however, and not in digital format. Issues arose as to whether an inventory of that vintage would still be representative of the composition and distribution of vegetation existing today for the purposes of developing the fire management plan. Earlier cost analyses conducted by Alberta Environment suggested that although a complete Alberta Vegetation Inventory (AVI) at 1:20,000 would be preferable, it was cost prohibitive. The Phase 1 inventory is characterized by broader class intervals and less spatial detail than the AVI because it was derived from 1:40,000 to 1:50,000 aerial photographs. The premise of this study was to evaluate the assumption that within a stable natural region, 40 - 50 year old inventory data derived from lower resolution aerial photographs would still provide a reasonable expression of the current land

cover. There has been no reported history of recent fire activity in Willmore since at least the 1950's. Vegetation patterns therefore change as a function of successional dynamics and the level of detail in the vegetation classification schema. The Canadian Forest Service (CFS) suggested a sampling approach to undertake an AVI over selected townships that would be representative of the range of vegetation in Willmore. A comparative analysis between the Phase 1 inventory and AVI for the selected townships would follow using a subset of stand attributes.

A three-phase study was therefore created:

1) Digitize the 1:50,000 Phase 1 inventory under a contract to Alberta Environment that was managed by Doug Langner.
2) Undertake an AVI for 8 selected townships that should represent the range of cover types within Willmore. Foothills area staff selected the 8 townships that best represented management priorities and was representative of vegetation within Willmore (Figure 1). This area represented a 16 percent sample intensity based on the total area of Willmore. A map comparison exercise between the Phase 1 and AVI inventories for the 8 townships would follow. A set of rules would be used to reclassify the Alberta Vegtation Inventory into cover types of similar description to the Phase 1 inventory. A spatial and statistical analysis exercise would be undertaken to compare the two maps.
3) If the Phase 1 inventory did not adequately reflect the land cover type distribution depicted from the AVI, conduct a digital satellite remote sensing study to map the vegetative land cover in the Willmore.

This project is directed at the map comparison component of Phase 2. The CFS was tasked with undertaking the map comparison exercise and Nick Walsworth, a Natural Resources Canada graduate intern, was staffed to help with this project. Other staff within the CFS also assisted with portions of this project and included Mike Gartrell (GIS Analyst), Yonghe Wang (Landscape Analyst), Harinder Hans (GIS Programmer) and Deborah Klita (Remote Sensing Analyst).

2.0 Objective

To report on the degree to which the digital Phase 1 and reclassified AVI maps are similar. This objective was addressed by the following questions:
(i) How representative were the 8 selected townships of the vegetation distribution within Willmore? (ii) For each township and for the 8 townships as a whole, to what extent were the digital Phase 1 and reclassified AVI maps similar for crown closure, height, species composition and non-forest cover attributes?

3.0 Methods

3.1 Selection of map attributes

In addition to the requirement to develop a fire management plan for Willmore Wilderness Park, Weldwood needed to determine if there was any wildfire threat to their FMA

from the potential fuels in Willmore. Alberta Environment selected the attributes of interest that included species composition, crown closure, stand height and non-forested areas. These attributes are among those used by Alberta Environment, Forest Protection Division, in a set of rules to determine forest fuels and the relative susceptibility to crowning.

The AVI is a more detailed vegetation classification system than the Phase 1 inventory system. To facilitate comparative analysis, a data preprocessing and reclassification exercise was needed to reduce the attributes of species composition, crown closure, stand height and non-forest land to the same number of classes with descriptions that were as identical as possible (Figure 2). The reclassifications were undertaken in Arc/Info based on a program that was adapted for this project (Appendix 7.1). Based on consultation with representatives from Alberta Environment (ie., Cordy Tymstra, Lowell Lyseng, Don Harrison), rules were established to facilitate species comparisons (Table 1). In the Phase 1 inventory, species are listed in order of dominance in the stand, whereas in the AVI, species are listed to 10 percent intervals (Alberta Environmental Protection 1991). For forest fuel assessment purposes, pure stands were considered those where the leading species occupied at least 70 percent of the stand.

Table 1 Species classification.

Class	Rule
Deciduous	[1] Aw+Pb >= 70%
Conifer-Pine	[2] P + Pl >= 70%
Conifer – Spruce (Spruce and Fir)	[3] Sw + Sb +Se + Fa >=70%
Mixedwood	[4] 40% ≤ Aw+Pb ≤ 60%
Mixed conifer	[5] (40% ≤ P+Pl ≤ 60%) AND (40% ≤ Spruce, fir ≤ 60%)
NFL – vegetated	[6] PP + BL + BR + TM (Phase 1) = HF + HG + SC + SO (AVI)
NFL – non-vegetated	[7] NMR + NWL + NWR (Phase 1) = NMC + NMR + NMS + NWF + NWL + NWR (AVI)

[1] Composite deciduous comprising predominately trembling aspen and balsam poplar
[2] Lodgepole pine and undifferentiated pine occupying at least 70% of the stand
[3] Composite spruce: white spruce, black spruce, Engelmann spruce, subalpine fir
[4] Mixedwood with 40% - 60% composite deciduous
[5] Mixed conifer with 40% - 60% pine, no deciduous content
[6] Non-productive forest land, vegetated:
- Phase 1 consists of potentially productive, burned land, brush or old burn and treed muskeg
- AVI consists of herbaceous forbs, herbaceous grass, closed shrub, open shrub

[7] Non-productive forest land, non-vegetated:
- Phase 1 consists of barren rock, lakes and rivers
- AVI consists of cutbank, barren rock, sand, flooded, lakes and rivers

Phase 3 inventory rules were adopted to assign species composition percentages to Phase

1 species labels when two or more species occurred in a stand (Alberta Forestry, Lands and Wildlife 1988). In Phase 3, an occurrence of two species is assumed to exist with 65% for the leading species and 35% for the second species. To provide a translation to AVI, a 70/30 or 60/40 percent composition is possible for leading and secondary species, respectively. A conservative approach to the leading species was recommended and accepted by Alberta Environment whereby Phase 1 stands with two species were assumed to occupy the stand with a 60/40 percent composition. This approach would have been adopted for three species stands if any occurred in the Phase 1 inventory. In Phase 3, three species labels are assumed to represent 46, 30 and 27 percent for the leading, secondary and tertiary species, respectively (Alberta Forestry, Lands and Wildlife 1988). A conservative approach would result in a 40, 30 and 30 percent composition for the leading, secondary and tertiary species, respectively.

Following the definitions for crown closure and stand height between Phase 1 and AVI, a translation table was created to reclassify stands based on class values that would be as similar as possible (Tables 2, 3). Three classes were created for crown closure and stand height and the spatial coverages were created in Arc/Info based on the reclass AML program (Appendix 7.1).

Table 2. Crown closure translation.

Phase1	AVI	Closure	Numeric
A	A	0-30%	1
B	B,C	31-70%	2
C,D	D	71-100%	3

Table 3. Stand height translation.

Phase1	AVI	Numeric
A	≤ 9m	1
B	10-18m	2
C	> 18m	3

The definitions of non-forested land were more problematic since they were composed of several land cover descriptions that did not always have direct equivalents. Non-forested lands were separated into two classes that were considered either vegetated and non-vegetated. Several classes were aggregated into either of the vegetated or non-vegetated categories (Table 1).

3.2 Representation of selected townships

The study area was based on the selection of 8 townships scattered throughout the Willmore Wilderness Park that were assumed to be representative of the distribution of vegetation within the Willmore. Small scale maps of the entire Willmore Park were created and boxes that highlight the selected townships were outlined to provide a visual perspective of the vegetation with respect to species composition, crown closure and stand height. A qualitative assessment was preferred to a quantitative analysis because some of the non-productive forest had not been classed. Aberrant polygons within the selected townships were fixed with the aid of paper maps, so that subsequent analysis was not compromised.

3.3 Non-spatial and spatial analysis methods

The study employed a combination of non-spatial and spatial analysis approaches to describe the distribution of vegetation as represented on the Phase 1 and reclassified AVI maps. Comparisons between maps were made on individual township areas. Since the AVI was undertaken on a township basis, for comparative map analysis purposes the Phase1 was similarly stratified on a township basis. Three methods were devised for determining the relative differences between the Phase 1 and AVI maps.

Non-spatial analysis: The non-spatial data approach entailed tabulating the frequency distribution (area) by class for each of the two maps. The area values were normalized to facilitate interpretation and in landscape metric terms, this was represented by the landscape suitability index (LSI) described in the patch analysis section. The two maps were hypothesized to be similar if there were minimal or no differences between the two maps. The analysis consisted of area tabulations using the table summary feature in ArcView (8 townships x 3 features x 2 inventories). Stacked bar charts were created to compare the Phase 1 inventory with the AVI, which provided an aggregate impression of class distribution and trends.

Patch analysis: This was an extension of the non-spatial analysis whereby class complexity was analyzed with 3 landscape metrics: patch mean area, frequency (counts) and LSI. A patch is a landscape fragmentation term defined as a spatially contiguous and homogeneously classed area. Patches were constructed from the vector data and dissolving polygon boundaries based upon each of the 3 classed themes of species, height and crown closure. LSI is the percentage of the landscape comprised of a corresponding patch type. It is computed as total class area divided by landscape area multiplied by 100 (McGarigal and Marks 1995):

$$LSI = \frac{\sum_{j=1}^{n} a_{ij}}{A}(100)$$

LSI approaches 0 when the patch type (a_{ij}) occurs infrequently in the landscape, and approaches 100 when the entire landscape is comprised of a single patch. Stacked bar charts were created to compare the Phase 1 and AVI attributes by each of the landscape metrics for the overall 8 townships. When comparing the number of unique polygons these measures provided an understanding of class spatial structure and distribution for each of the attributes.

Spatial analysis: The spatial data approach entailed the creation of contingency (confusion) matrices based on a map overlay between the two maps. Several statistics can be calculated from a confusion matrix that include average accuracy, overall percent accuracy, and the Kappa index (Storey and Congalton 1986; Congalton and Green 1999):

$$Average\ accuracy = \frac{\sum_{i=1}^{\#\ classes} class\ accuracy}{\#\ classes}$$

$$Overall\ accuracy = \frac{\sum_{i=1}^{k=\#\ classes} n_{ii}}{n}$$

$$Kappa = \hat{K} = \frac{P_o - P_c}{1 - P_c}$$

Where:

$$P_o = \sum_{i=1}^{k} P_{ii}\ , actual\ agreement \quad and \quad P_c = \sum_{i=1}^{k} P_{i+}\ P_{+j}\ , chance\ agreement$$

Note: chance agreement is the proportion of samples correctly classified by column and row.

Kappa requires that classes have a 1:1 correspondence to be able to establish a proportions matrix and an expected proportions matrix, which quantifies the correlation due to chance. The normalized difference between the two matrices is a measure of positive correspondence. An overview of the data processing methods is described in a methods flowchart (Figure 2) that was supported by the following procedures:

a) Definition of the key attributes of interest (i.e., species, crown closure, stand height, etc.) for which the analysis would be undertaken.
b) Analysis was undertaken for each of the 8 townships independently and also collectively (9 sets of analyses).
c) The Phase 1 inventory and AVI map comparisons were undertaken by first converting the vector coverages to 10m raster coverages. An Arc/Info Confusion AML was written to compute the map overlay statistics (Appendix 7.2).
d) Two sampling scenarios were implemented, which included a random sampling vs. 100% sample. The initial analysis was undertaken based on a 100% sample generated from a map overlay between the Phase 1 and AVI maps of the attributes of interest. Due to the potential effects of large variable size classes on the calculation of the Kappa index, testing was undertaken with a random sample of pixels. For example, taking a random sample with the same number of samples for each of the 4 classes for crown closure would ensure all crown closure classes were being sampled with the same intensity.

Sampling for determination of a proportions matrix can consist of a regular grid (10m) or a random sample based upon class area proportions. A regular grid provides an estimate of area

coverage accuracy while random area normalized sampling would be indicative of class accuracy between two maps. For the area normalized random sampling, 2000 sample pixels were used for each gridded map class and a small test was conducted on the 8 individual townships to determine if more definite trends could be derived from random sampling. Given an expected township size of 10km x 10km and 4 classes per attribute for crown closure and height, 8000 sample points would be extracted per township resulting in a nominal 0.8% sample intensity. For species the random sample numbers were maintained but in a couple of instances the deciduous class was very small and was therefore under sampled.

4.0 Results

4.1 Representation of the 8 selected townships

The location of the 8 selected townships were outlined within an overview map of the Willmore in each of the Phase 1 species, crown closure and height map compositions and visually assessed for representation (Figures 3a-c). The selected townships appear to represent the pine, mixed conifer and non-productive types with an under representation of composite spruce (Figure 3a). Deciduous and mixed-wood areas were more predominant in Township 56, Ranges 8 and 9 and were not represented in the 8 selected townships. Both crown closure (Figure 3b) and stand height (Figure 3c) were represented by a null class and 3 numerical classes (Tables 2 and 3) that were well-represented in the 8 selected townships. The selected townships were considered a reasonable representation of Willmore with the exception of the deciduous and mixed-wood stand types.

4.2 Non-spatial analysis

The differences between the Phase 1 and AVI inventories can be explained, in part, by successional trends that have occurred during the time between the two inventories (Figure 4a-h). To visualize these trends, the patterns for species, crown closure and height must be assessed for each township because the structure and composition of vegetation varies by township. The implicit assumption is that changes were minimal if the frequency distributions for Phase 1 and AVI were similar. A brief assessment of each township was conducted followed by an attempt to summarize the overall trends exhibited in the 8 townships.

Township 52, Range 4: The greatest change in this township is the reduction in mixed conifer and a consequent increase in spruce and pine (Figure 4a). Composite spruce is dominant and occupies approximately 40% of the township. Forest stands ranged mostly from 31% to 100% crown closure and up to 18 m in height. Stands that were classified in Phase 1 as highest in crown closure were also the smallest in height. Stands became more open, comprising the 0 to 30%, and 31 to 70% crown closures. Stand heights were mostly in the less than 9 m and 9 to 18 m height classes. A successional trend may have occurred from young, short, dense stands to taller, more open stands.

Township 53, Range 6: This township was predominately classified as non-productive land in Phase 1 (Figure 4b). Mixed conifer was dominate in Phase 1 but likely succeeded to spruce and some pine. This observation is supported by the increase in proportion of township area represented by stands that were up to 70% crown closure and 18 m in height.

Township 53, Range 9: This township was predominately pine and mixed conifer that appeared to change to predominately pine and composite spruce (Figure 4c). The distribution of crown closure was similar between Phase 1 and AVI but stand height moved from predominately less than 9 m to mostly 9 to 18 m, supporting the observation of growth and successional development.

Township 53, Range 11: The most notable change in species is the large reduction in mixed conifer to spruce and pine (Figure 4d). This was accompanied by a reduction in crown closure and an increase in stand height. Most forest stands are spruce and pine that range up to 70% in crown closure with stand heights that ranged from 9 to 18 m.

Township 54, Range 4: There were no changes in the proportion of the township classified as mixed conifer or pine (Figure 4e). Stand structures changed, however, from Phase 1 to the AVI. There was an increase in the 0 - 30% and 31 - 70% crown closures, and an increase in the proportion of 18 - 24m tall stands. Thus, stands were taller and more open in the AVI than in the Phase 1 inventory.

Township 54, Range 8: This township also exhibited a large decrease in mixed conifer with a large increase in composite spruce that occupied approximately 45% of the township as mapped from the AVI (Figure 4f). The proportion of the township with 71 - 100% crown closure decreased, with subsequent increases in the 0 - 30% and 31 - 70% crown closure classes. This supports, in part, the successional trend exhibited with the decrease in the < 9 m stands and increase in the 9 - 18 m and 18 - 24 m classes. Stands were generally taller and more open in the AVI in comparison to the Phase 1 inventory.

Township 55, Range 7: Mixed conifer and non-productive, vegetated land decreased and the proportion of pine and composite spruce increased from Phase 1 to AVI (Figure 4g). The pine and spruce occupied more than 75% of the township on the AVI. These stands occupied the full range of crown closures with close to 70% of the township in the 0 - 30% and 31 - 70% classes on the AVI. The dominant height was 9 - 18 m (55% of the township) followed by the 18 - 24 m (25% of the township) class.

Township 56, Range 11: This township was largely classified as mixed conifer and non-productive land in Phase 1 but was predominately composite spruce and pine in the AVI (Figure 4h). These stands were predominately open in crown closure and less than 9 m in height in Phase 1. In the AVI inventory, there was a marked increase in stands to the 31 - 70% crown closure and 9 - 18 m height classes.

A pattern across the aggregated 8 townships (Figure 4i) was an increase in forest cover type discrimination and evidence in successional trends when stand types in the Phase 1 and AVI inventories were compared. Mixed conifer identified in Phase 1 was significantly reduced in the AVI with increases in spruce and pine dominant stands. The smaller scale of photos used in the Phase 1 inventory likely influenced the degree to which species could be discriminated. Mixed conifers were perhaps better separated to pine or composite spruce categories on the AVI due to the larger photo scales and improved photo quality that could be acquired today relative to air photo technology available during the Phase 1 inventory. Forest stands could also have been better defined. Several of the selected townships exhibited successional trends due to changes in both crown closure and stand height between the two inventories. The trends exhibited in the non-spatial analysis suggest the vegetation patterns are not equivalent between the Phase 1 and AVI inventories, and this may be attributed to aerial photo scale differences, interpretation, and successional processes.

4.3 Patch analysis

The influence of scale on patch (polygon) size and number of patches was clearly evident in the mean patch size and number of patches stacked bar charts for species, crown closure and height (Figures 5a, b). Large mean patch sizes corresponded with a small number of patches for Phase 1 and conversely, small mean patch sizes for AVI corresponded with a large number of patches (Figure 5a, b). These results highlight the importance of considering the influence of scale and class definition in the generation of metrics to compare vegetation from two inventory systems at two different times.

Mixed conifer and non-productive forest land were most frequently classified in the Phase 1 inventory, but spruce and pine were the dominant land cover classes in the AVI (Figure 5c). These results were consistent with the interpreted trends from individual townships in the non-spatial analysis. Two trends were most obvious from comparing LSI values for crown closure and stand height from Phase 1 and AVI data (Figure 5c):

a) Forest stands classified on both the Phase 1 and AVI inventories were predominately 31 - 70% crown closure and 9 - 18 m in height; and
b) The magnitude of changes in stand structure were larger for the AVI than they were for Phase 1. This result was attributed, in part, to the influence of Phase 1 photo scale on discernability of stand structure.

4.4 Spatial analysis

Spatial depictions by township along with their respective confusion matrices and accuracy values have been summarized in Figures 6a to 6h. The color maps for each township clearly depict the broader generalizations in the Phase 1 inventory maps compared with the AVI maps. The average accuracy, overall accuracy, and kappa values were poor for all townships. Kappa values ranged from 10% to 43% for species, 13% to 48% for crown closure and from 3% to 39% for stand height (Figure 6). The poor correspondence between species, crown closure and stand height support the results from the non-spatial analysis that vegetation patterns are not the

same between the Phase 1 and AVI inventories.

Due to the possible influence of variable size land cover units on Kappa accuracies, an AVI area-normalized random sample was generated and the spatial analysis was repeated. The results show little percentage change in the cross tabulation due to sampling. Overall, Kappa values were comparable with 100% sampling with values that ranged from 12% to 34% for species, 14% to 43% for crown closure and 7% to 48% for stand height (Table 4). For this study, differences were sufficiently similar that the concern and treatment for random sampling was unnecessary because the general conclusion of poor correspondence does not change.

Table 4. Kappa values for each of the 8 selected townships produced using random sampling.

Township	Average accuracy (%)	Overall accuracy (%)	Kappa (%)
		Species	
52-4	33.3	47.1	33.7
53-6	21.3	28.7	11.6
53-9	29.1	34.1	20.9
53-11	32.9	45.9	32.4
54-4	33.4	39.3	27.0
54-8	26.7	26.9	14.7
55-7	20.8	43.7	19.9
56-11	25.6	28.0	14.6
		Crown Closure	
52-4	39.1	39.3	19.0
53-6	37.7	49.8	26.7
53-9	57.6	57.6	43.5
53-11	44.9	45.1	26.7
54-4	39.9	39.7	19.6
54-8	40.8	41.4	21.6
55-7	43.2	43.4	24.5
56-11	35.7	35.6	14.3
		Stand height	
52-4	35.1	34.5	13.1
53-6	36.2	36.5	15.2
53-9	61.0	61.0	48.0
53-11	45.8	46.3	28.1
54-4	45.3	45.7	27.3
54-8	38.0	37.8	17.1
55-7	35.5	35.8	14.2
56-11	30.1	30.3	6.8

The relative accuracies of species composition, crown closure and stand height were similar when a spatial aggregate of all 8 sample townships were considered (Table 5). Overall accuracies ranged from 50% to 53% with Kappa values that ranged from 0.29 to 0.34 for the stand attributes. These results suggest the differences in stand types between the Phase 1 and AVI were consistent overall. An assessment of the user's and producer's accuracy, however, illustrated large differences in one class for species composition and stand height. Composite spruce on AVI was classified into multiple categories on Phase 1. This result may be attributed to visibility and stand size during the Phase 1 inventory that was now sufficiently dominant to be identified during the photo interpretation for the AVI. The tallest stands on AVI (> 18 m) were distributed throughout all classes on Phase 1 but were most associated with the 10 to 18 m class (Table 5). The height differences were perhaps the strongest evidence of the growth trend that stands grew between the two inventories.

The non-forest land class was the most similar between the Phase 1 and AVI with an overall accuracy of 74% but the Kappa value was only 0.54 (Table 5). The lower Kappa value was attributed to the low producer's and user's accuracies as a result of the frequent reduction in area of the non-forest vegetated class observed from Phase 1 to AVI (Figure 4). The overall results from viewing these aggregate statistics were consistent with trends observed in the individual townships, and supports the notion that photo scale, interpretation differences and successional trends largely explain the differences between the two inventories.

Table 5. Summary of confusion matrices for height, crown closure, species and non-forested land.

Height : Pixel confusion matrix all townships

			Phase1				
			<9	10-18	>18		
Value	Code	0	1	2	3	Sum	Producers %
AVI 0	0	1913141	58193	59969	4838	2036141	93.96
<9m	1	808975	324404	165667	9961	1309007	24.78
9-18	2	666455	1252459	1483925	119703	3522542	42.13
>18	3	75045	92400	463602	53581	684628	7.83
Sum		3463616	1727457	2173163	188082	7552318	
Users %		55.2	18.8	68.3	28.5		

Average accuracy =	42.2%
Overall accuracy=	50.0%
Kappa=	28.6%

Crown closure: Pixel confusion matrix all townships

			Phase1				
			A	B	C,D		
Label	Code	0	1	2	3	Sum	Producers %
AVI 0	0	2234521	94735	66800	28989	2425045	92.1
A	1	735111	415794	502527	168778	1822210	22.8
B,C	2	475729	652207	1061502	498589	2688027	39.5
D	3	27821	89561	206579	292806	616767	47.5
Sum		3473182	1252298	1837408	989161	7552049	
Users %		64.3	33.2	57.8	29.6		

Average accuracy=	50.5%
Overall accuracy=	53.0%
Kappa=	34.3%

Species: Pixel confusion matrix for all townships.

			Phase1							
Label	Code	1	2	3	4	5	6	7	Sum	Producers %
AVI 0	0	0								
Deciduous	1	0	2542	381	0	6987	2875	1118	13903	0.0
Conifer Pine	2	0	1067671	8044	0	780486	176767	40397	2073365	51.5
Spruce Comp.	3	0	297645	103628	0	1487540	544210	426428	2859450	3.6
Mixedwood	4	0	6754	439	0	8616	1074	7	16890	0.0
Mixed Conifer	5	0	48200	1679	0	76978	31577	5224	163658	47.0
NFL veg	6	0	29642	13043	0	95094	281940	478690	898408	31.4
NFL non veg	7	0	20092	357	0	32875	34094	1439207	1526625	94.3
Sum		0	1472546	127570	0	2488576	1072536	2391071	7552300	
Users %			72.5	81.2	0.0	3.1	26.3	60.2		

Average Accuracy=	19.4%
Overall Accuracy=	53.0%
Kappa =	28.8%

NFL: Pixel confusion matrix all townships.

			Phase1				
			NFL Veg.	Non-Veg			
Label	Code	0	6	7	Sum	Producers %	
AVI 0	0	3897590	756502.513	473173.84	5127266	76.0	
NFL Veg.	6	137778.4	281940.085	478689.729	898408.3	31.4	
NFL Non-Veg.	7	53324.3	34093.7773	1439207.4	1526625	94.3	
Sum		4088692	1072536.38	2391070.97	7552300		
Users %		95.3	26.3	60.2			

Average Accuracy=	67.2%
Overall Accuracy=	74.4%
Kappa =	53.6%

5.0 Summary and Conclusions

A sample of 8 townships within the Willmore Wilderness Park were selected from which an AVI was undertaken and compared to an earlier Phase 1 inventory for species composition, crown closure, stand height and non-forest cover. Differences between the two inventories over the 8 townships was determined by a combination of non-spatial and spatial methods. The non-spatial analysis for each township, entailed a compilation of stacked bar charts to compare frequency distributions for the selected attributes. In addition, using the vector GIS data, landscape metrics were computed to compare how patch size, patch number, and landscape suitability index differed between the Phase 1 and AVI. The spatial analysis entailed a map overlay from which confusion matrices were generated for each of species composition, crown closure and stand height. The percent accuracy and Kappa values provided a measure of the spatial correspondence between the two inventories.

If the AVI map is considered to represent the correct distribution of forested land cover in Willmore today, then from a spatial distribution perspective, the vegetation has changed significantly with respect to species distribution, crown closure, height and to some extent, non-forest cover. For the sample townships, the accuracies of the stand attributes were similar suggesting that no one attribute was significantly different than the other. Patterns in the user's and producer's accuracies supported the growth trend between the two inventories, and the shift from non-forest land vegetated to largely composite spruce and pine. These changes were attributed to photo scale, photo interpretation, photo quality, and succession. Average patch (polygon) sizes were much larger in Phase 1 and the polygon descriptors were broader than the AVI. Water, such as rivers, was more precisely defined in the AVI and was often missing on Phase 1. Subalpine fir in Phase 1 may have been classified as non-productive vegetated land instead of a stand type (L. Lyseng, personal communications). When species differences were considered, there were changes in crown closure and stand height that could be attributed, in part, to successional processes. Many of the areas appear to indicate taller stands that would suggest increased biomass than was recorded during the Phase 1 inventory. There appears to be very few areas of appreciable deciduous stands over the Willmore as a whole, and these were not represented in the selected townships. Their structure and composition would be of interest from a forest fuel perspective, especially if the deciduous stands contained appreciable amounts of conifer understory.

The significance of this work for generation of a fire management plan lies in assessing the differences between the Phase 1 and AVI inventories from a forest fuels perspective. Cordy Tymstra from Alberta Environment has developed a reclassification program to transform the inventory to FBP types and that exercise will ultimately govern whether a reinventory of the Willmore is necessary. Based on the information derived from the AVI, and from a stand composition and structure perspective, species composition, stand heights, and proportions of non-forest land cover have changed. Thus, the Phase 1 inventory does not represent the current land cover of Willmore Wilderness Park.

6.0 References

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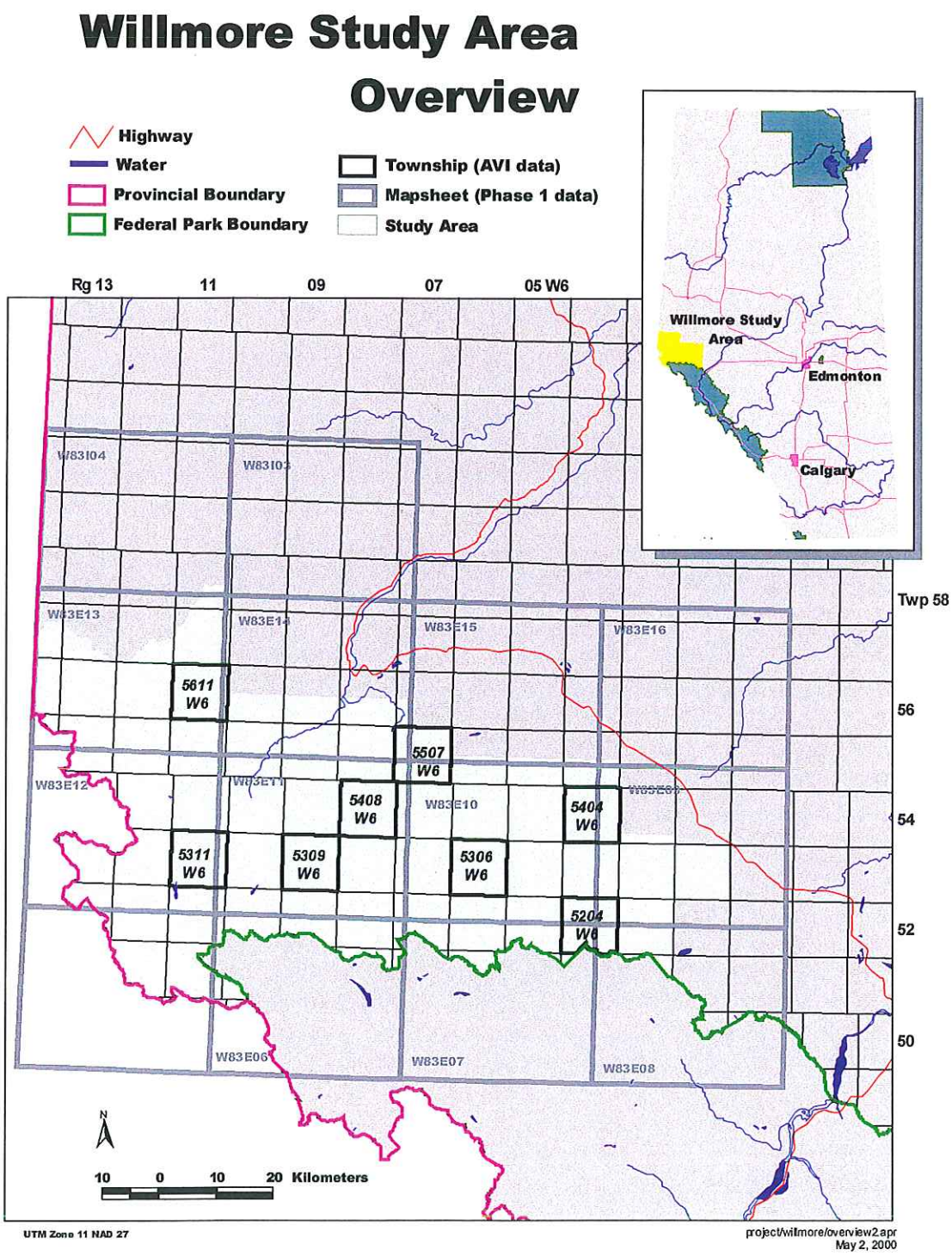
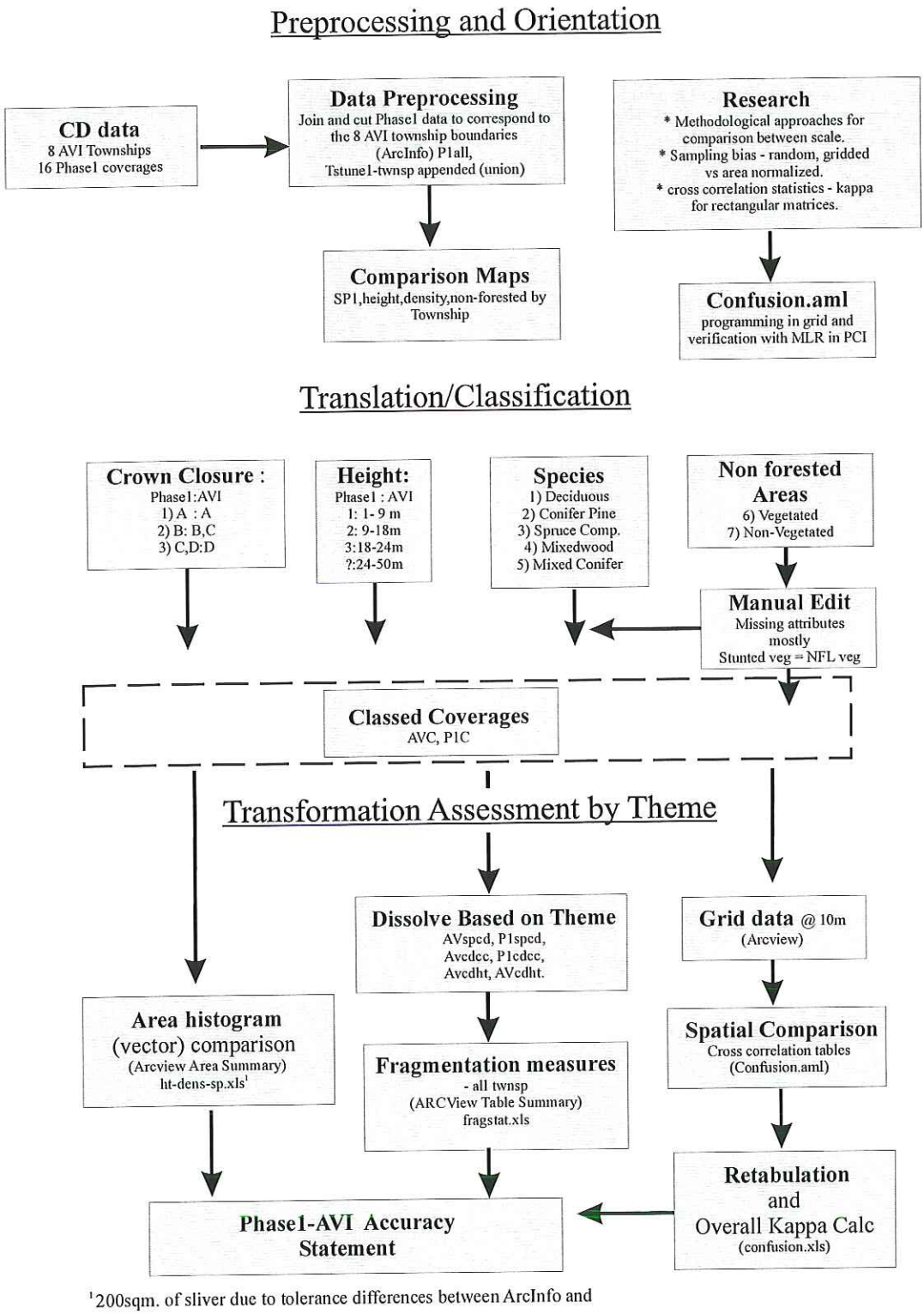


Figure 1. Willmore study area overview.

Willmore : Relaxed AVI Translation Process



[1]200sqm. of sliver due to tolerance differences between ArcInfo and

Figure 2. Methods flowchart: Digital Phase1 - Willmore AVI Comparison.

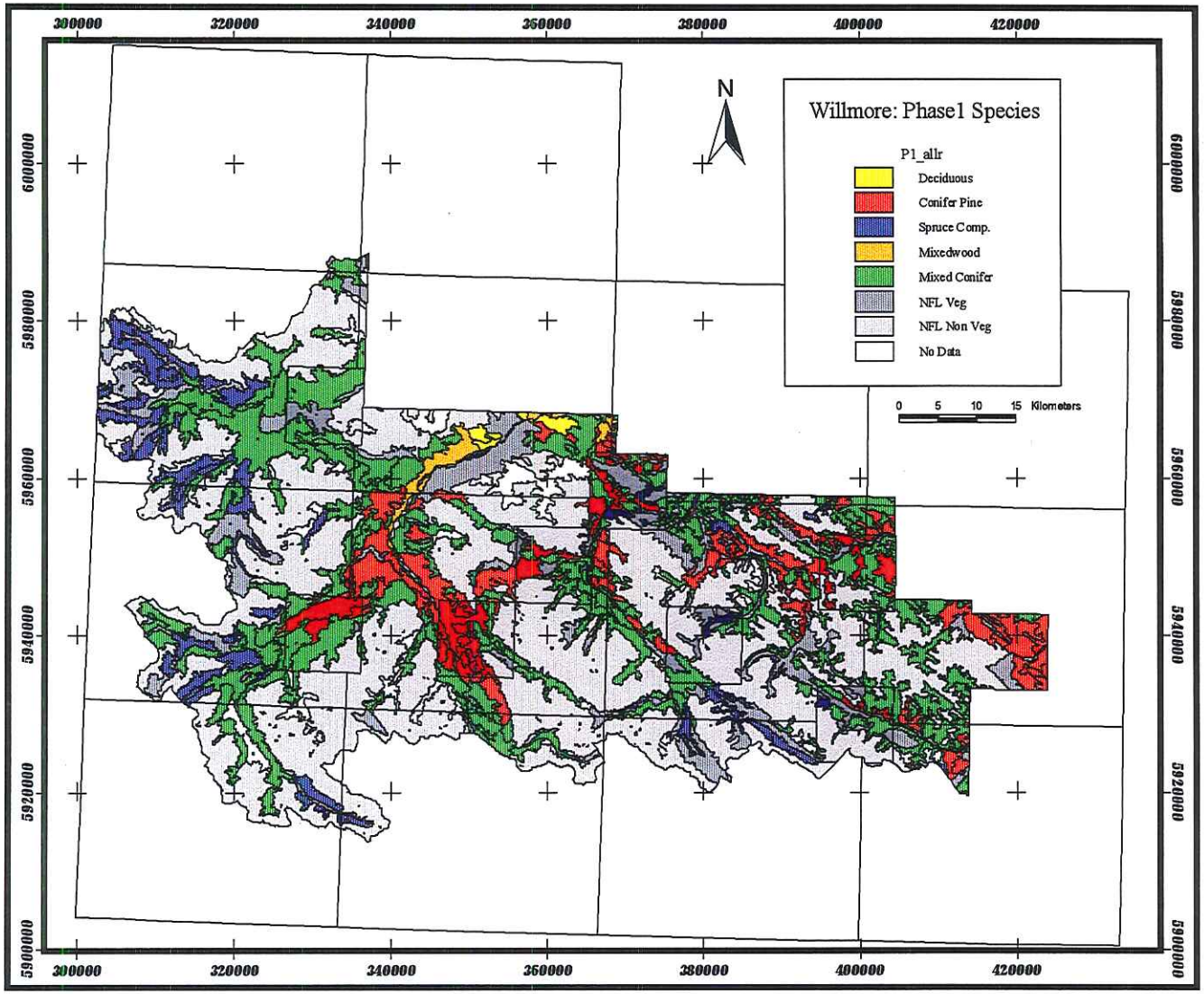


Figure 3a. Phase1 Species distribution - location of 8 townships.

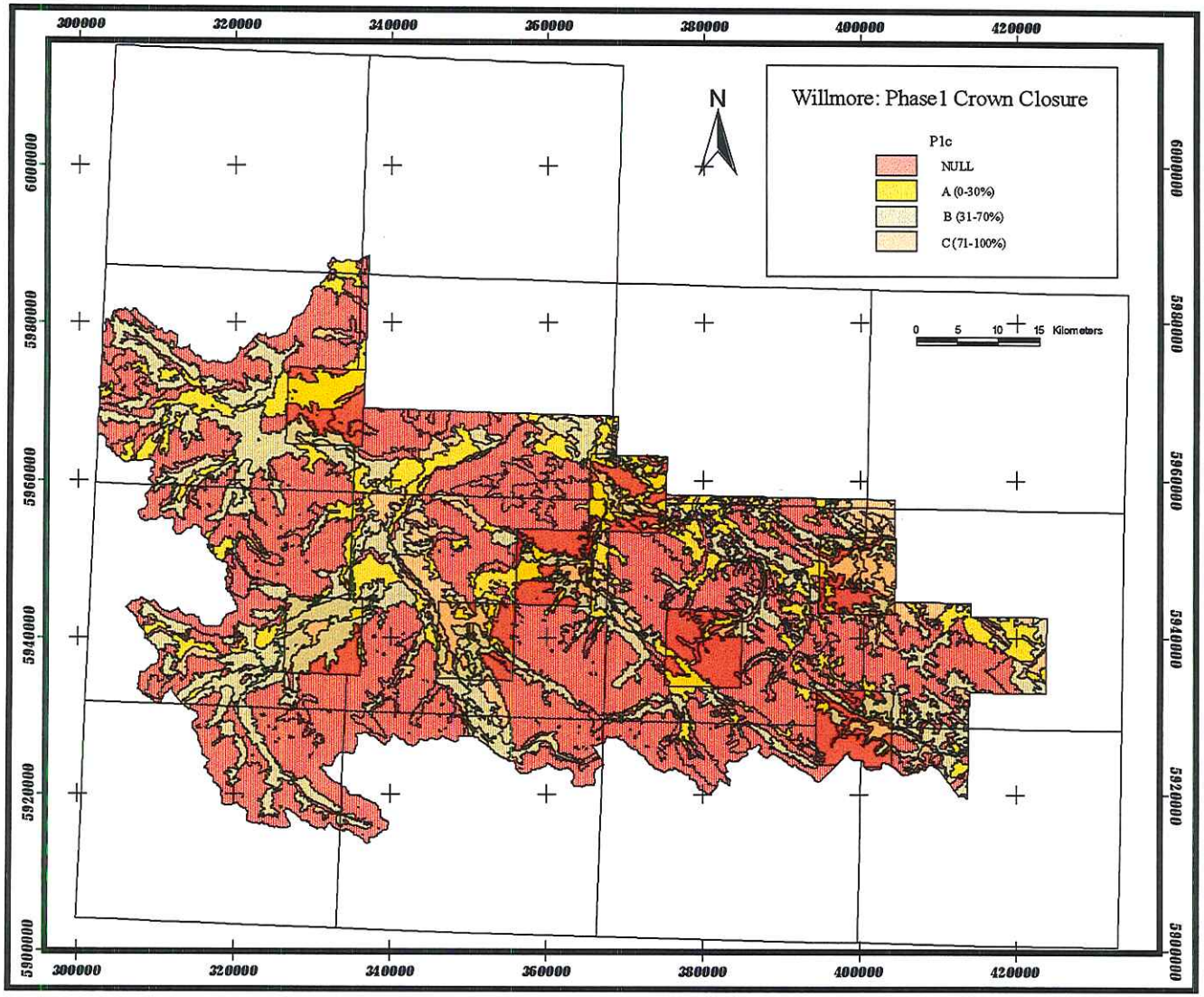


Figure 3b. Phase1 Crown closure ditribution - location of 8 test townships.

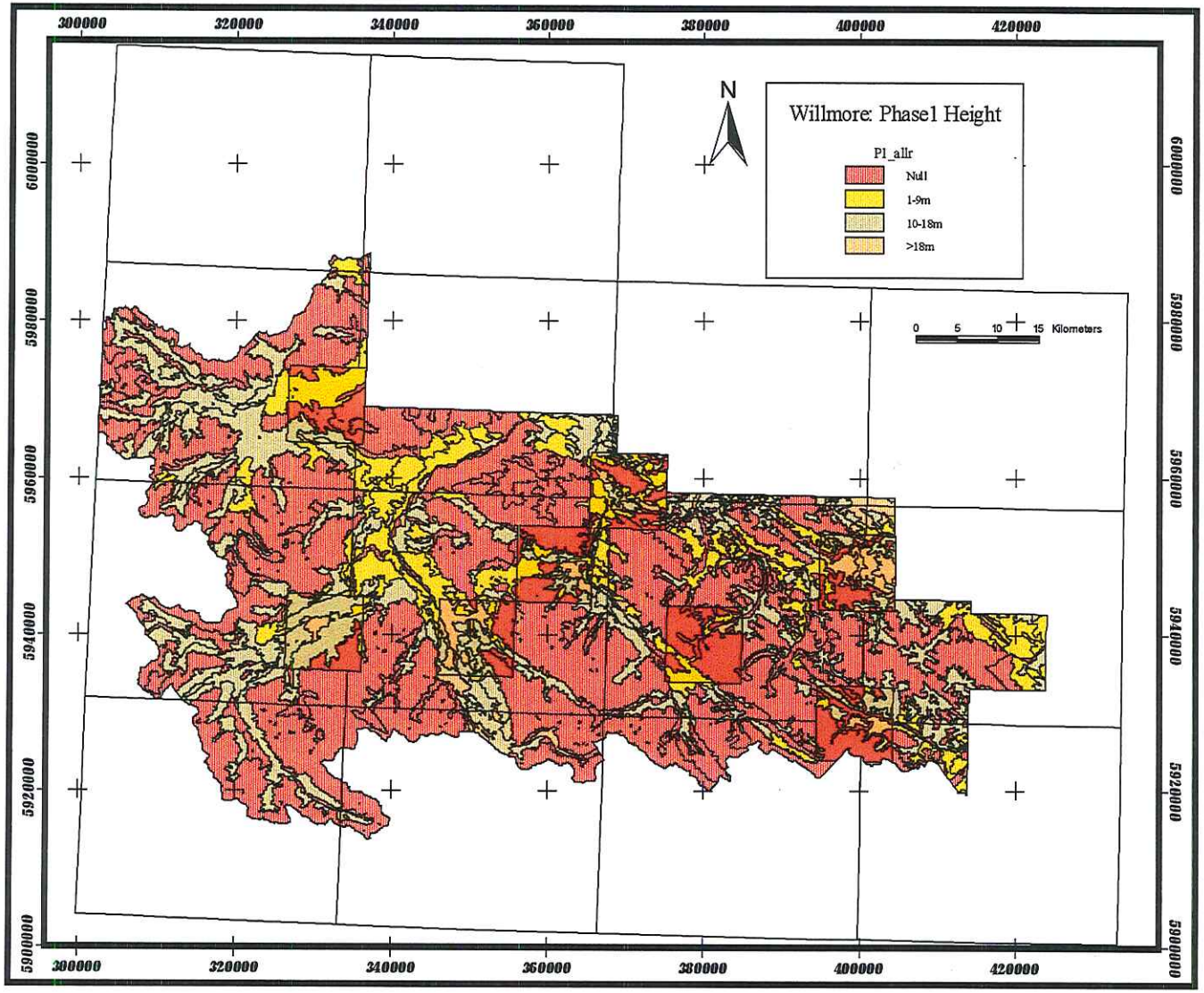


Figure 3c. Phase1 Stand height distribution - location of 8 test townships.

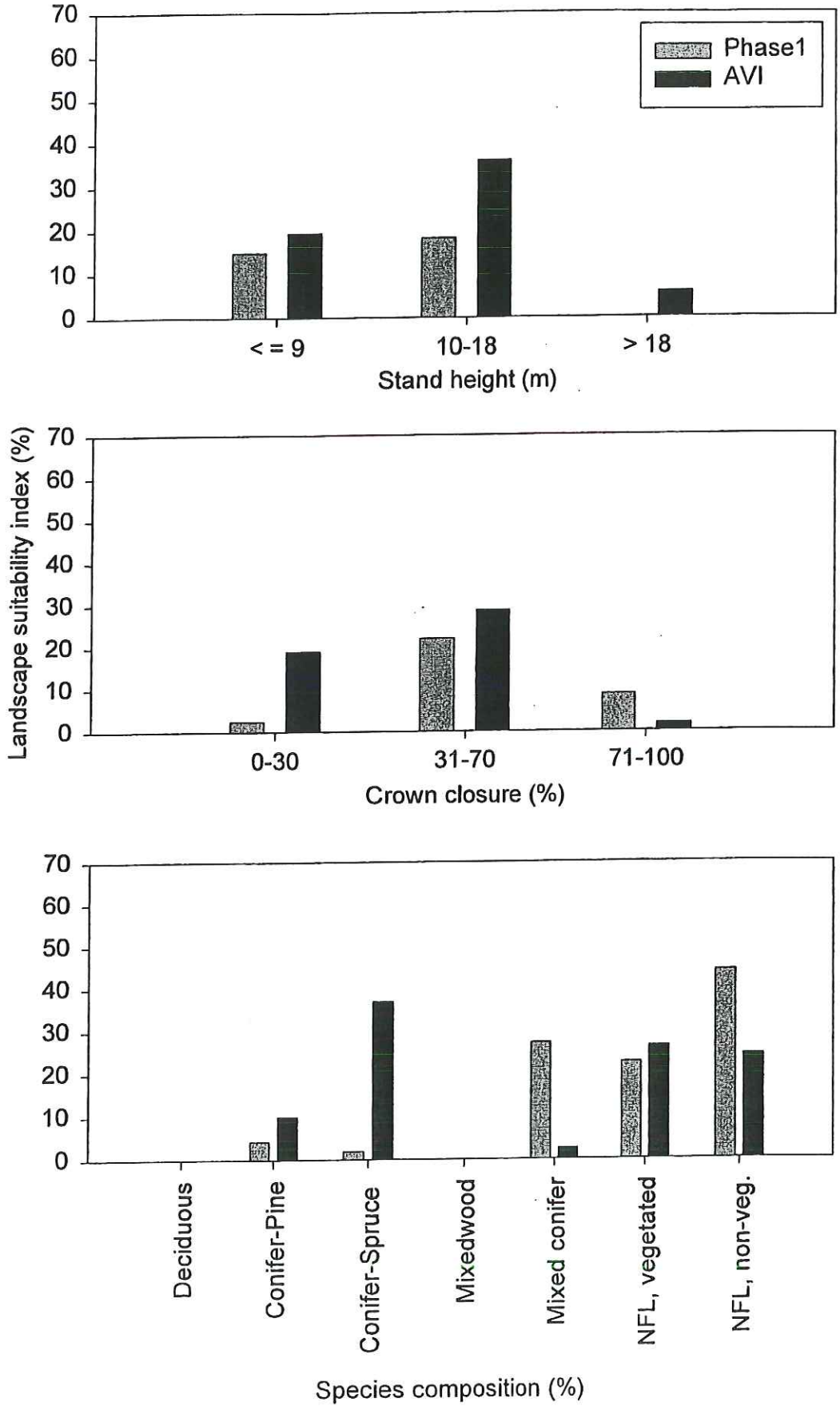


Figure 4a. Non-spatial analysis. Percentage area coverage comparison for Township 52, Range 4 for species composition, crown closure, and stand height.

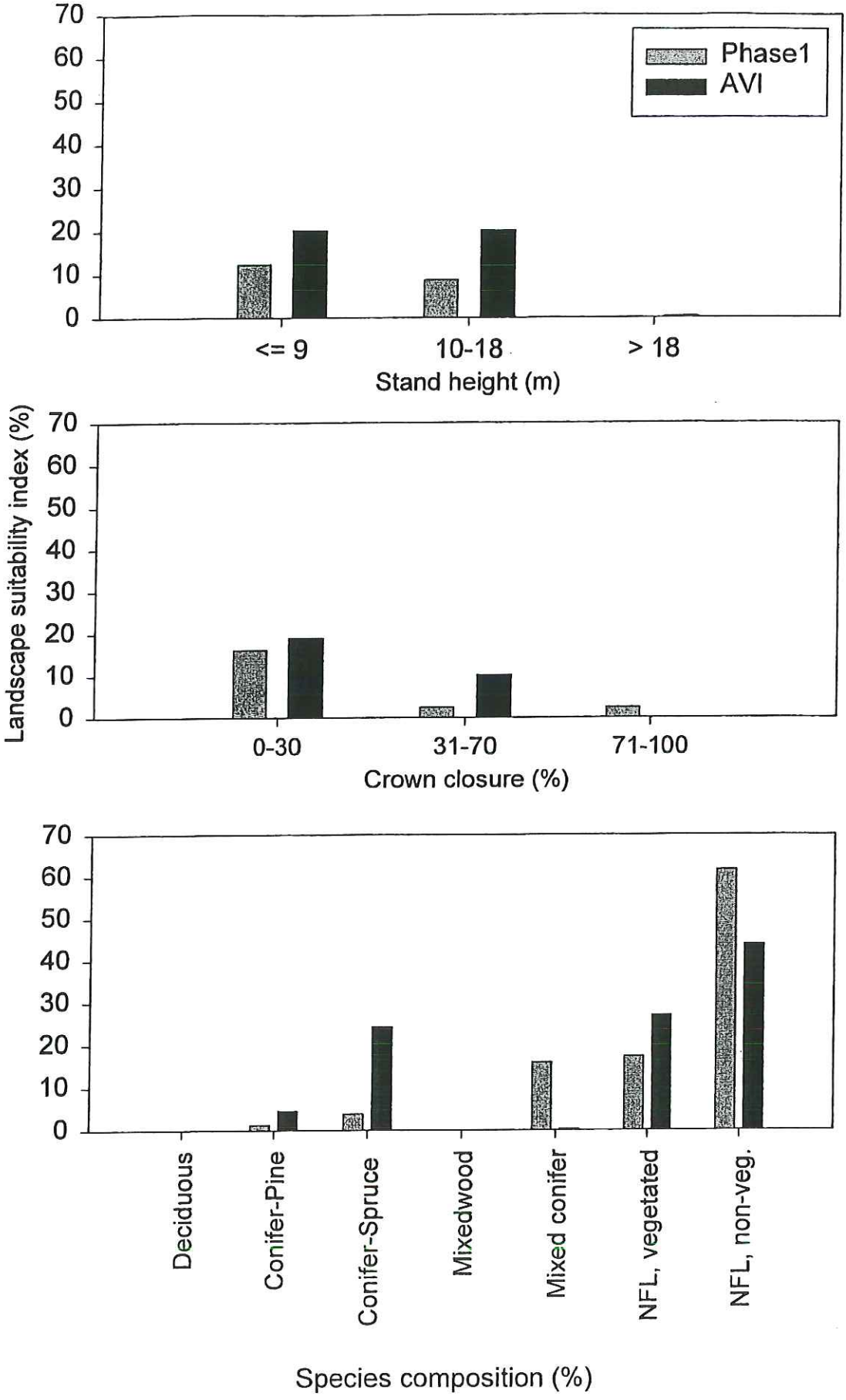


Figure 4b. Non-spatial analysis. Percentage area coverage comparison for Township 53, Range 6 for species composition, crown closure, and stand height

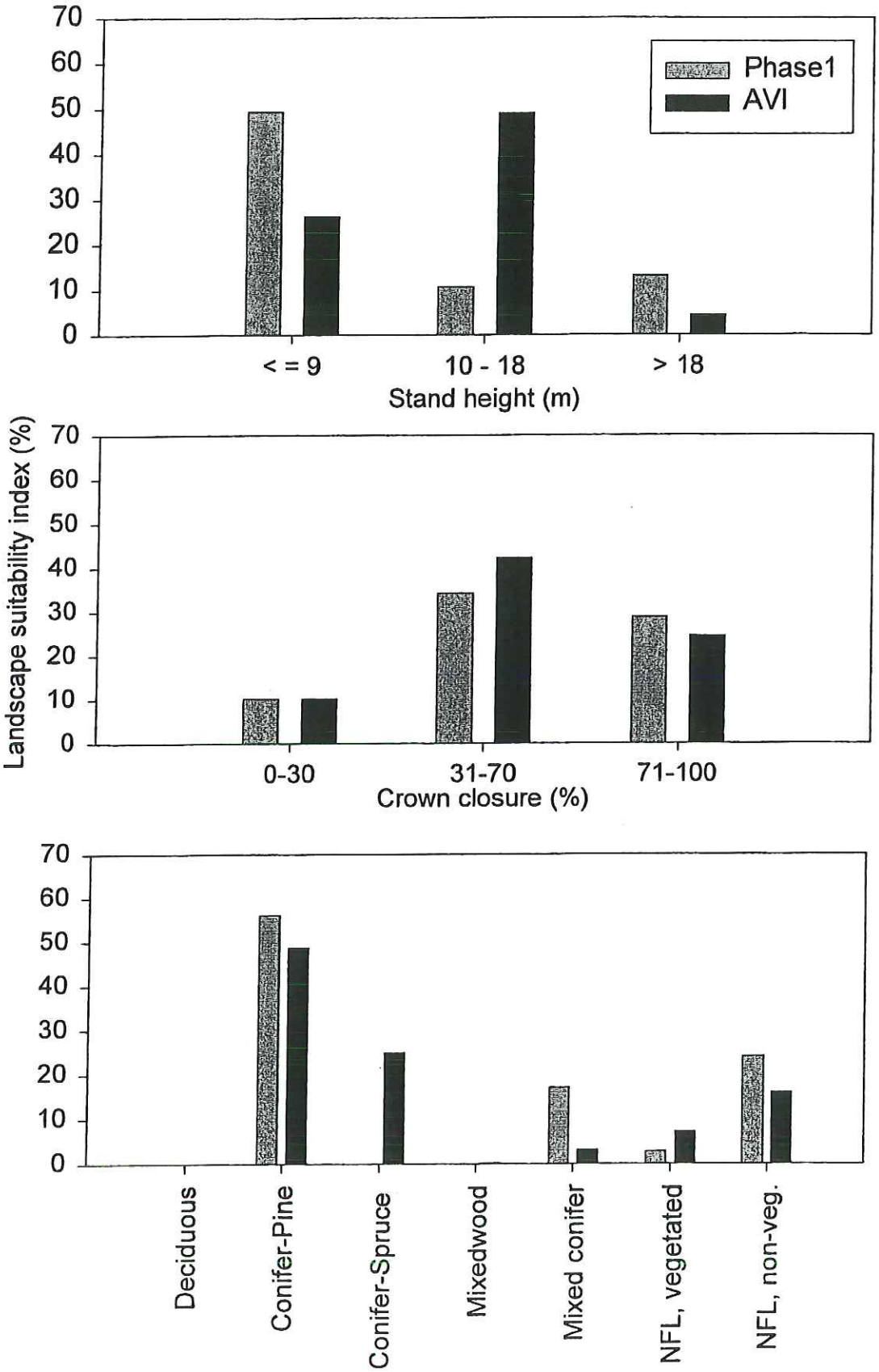


Figure 4c. Non-spatial analysis. Percentage area coverage comparison for Township 53, Range 9 for species composition, crown closure and stand height

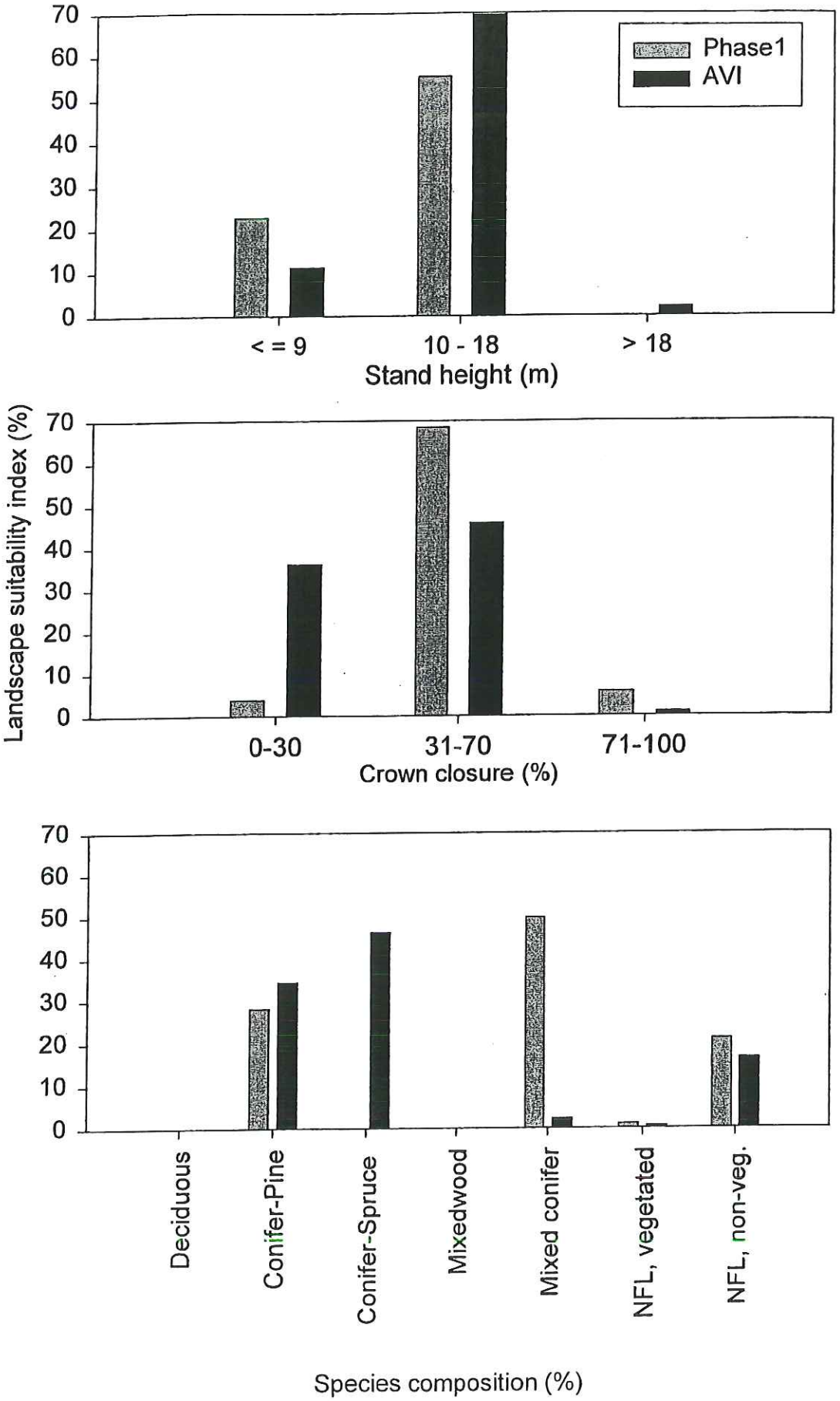
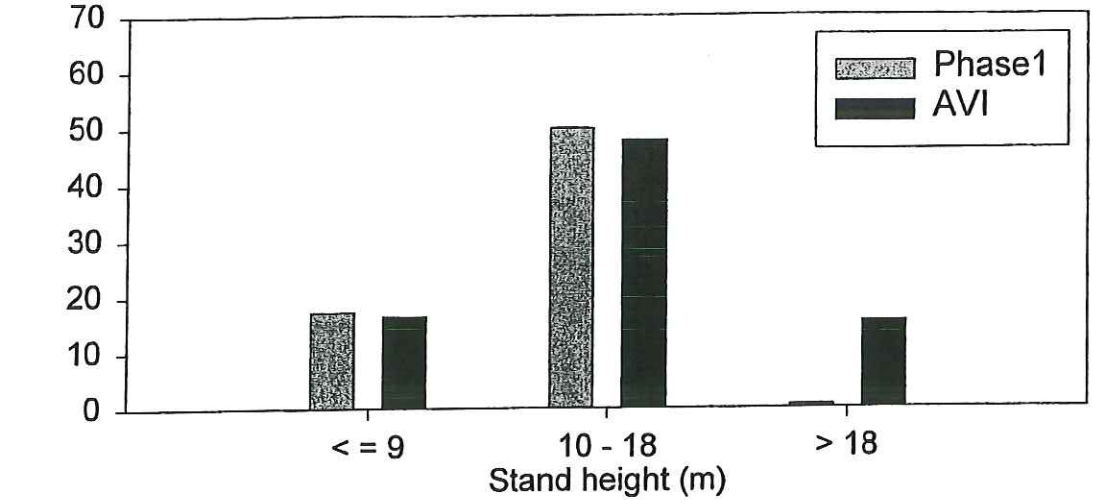
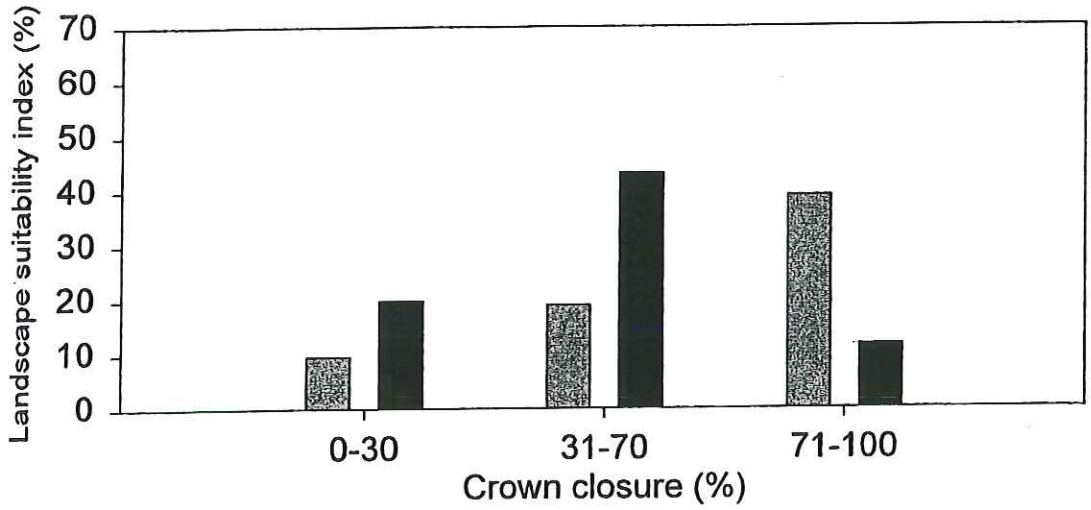


Figure 4d. Non-spatial analysis. Percentage area coverage comparison for Township 53, Range 11 for species composition, crown closure, and stand height.





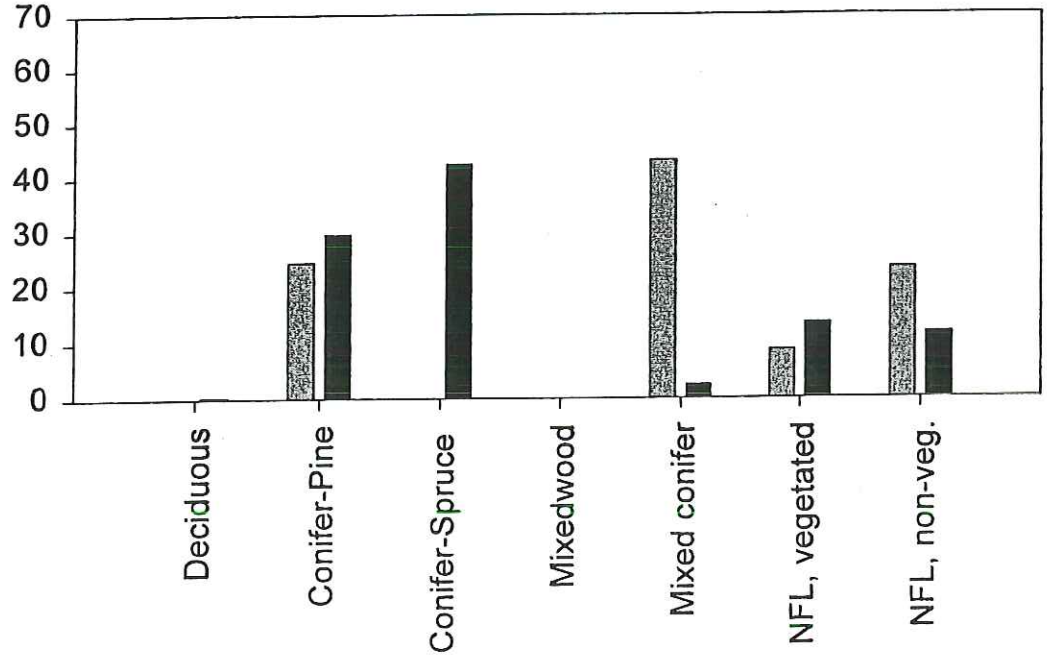


Figure 4e. Non-spatial analysis. Percentage area coverage comparison for Township 54, Range 4 for species composition, crown closure and stand height.

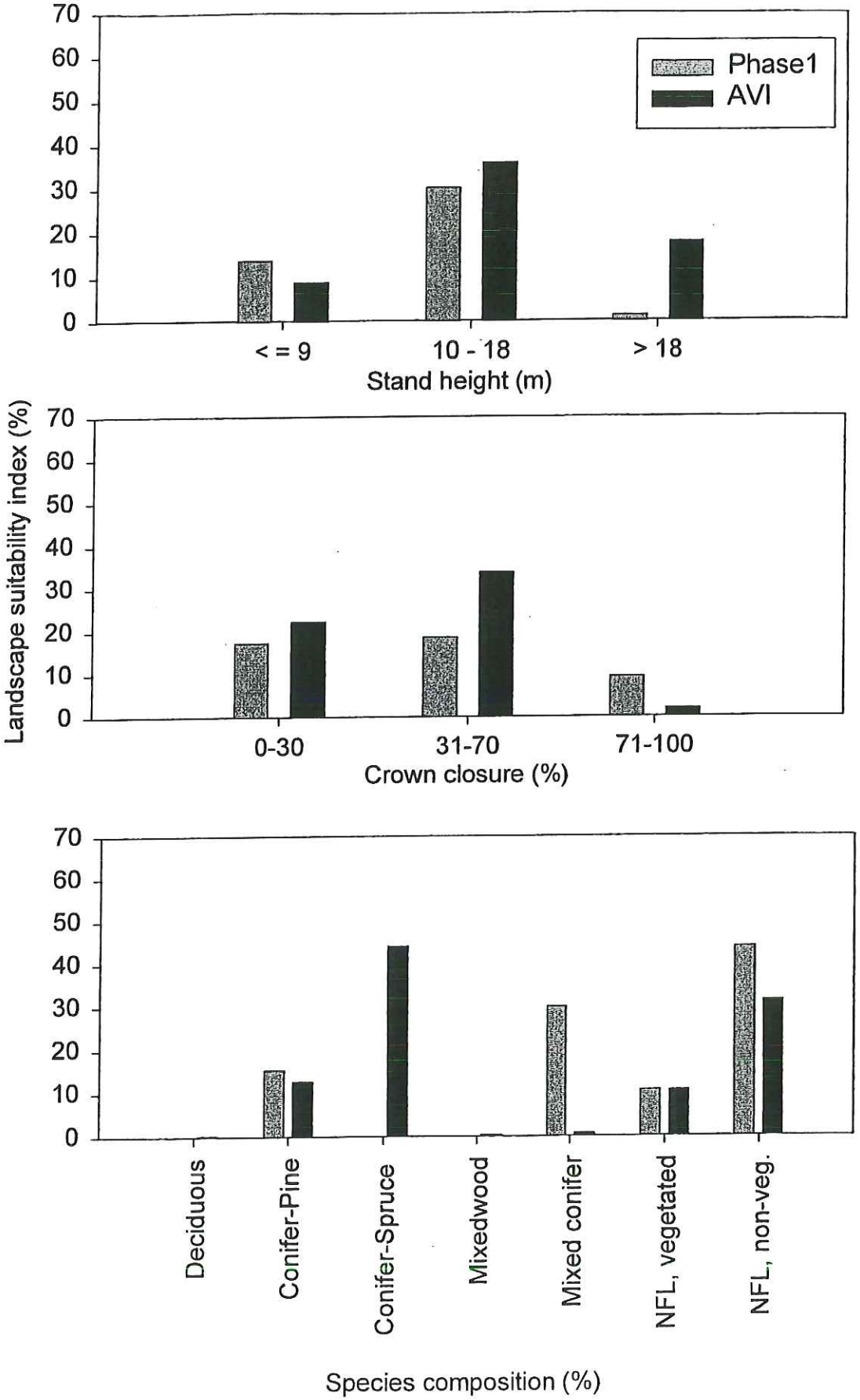


Figure 4f. Non-spatial analysis. Percentage area coverage comparison for Township 54, Range 8 for stand height, crown closure, and species composition.

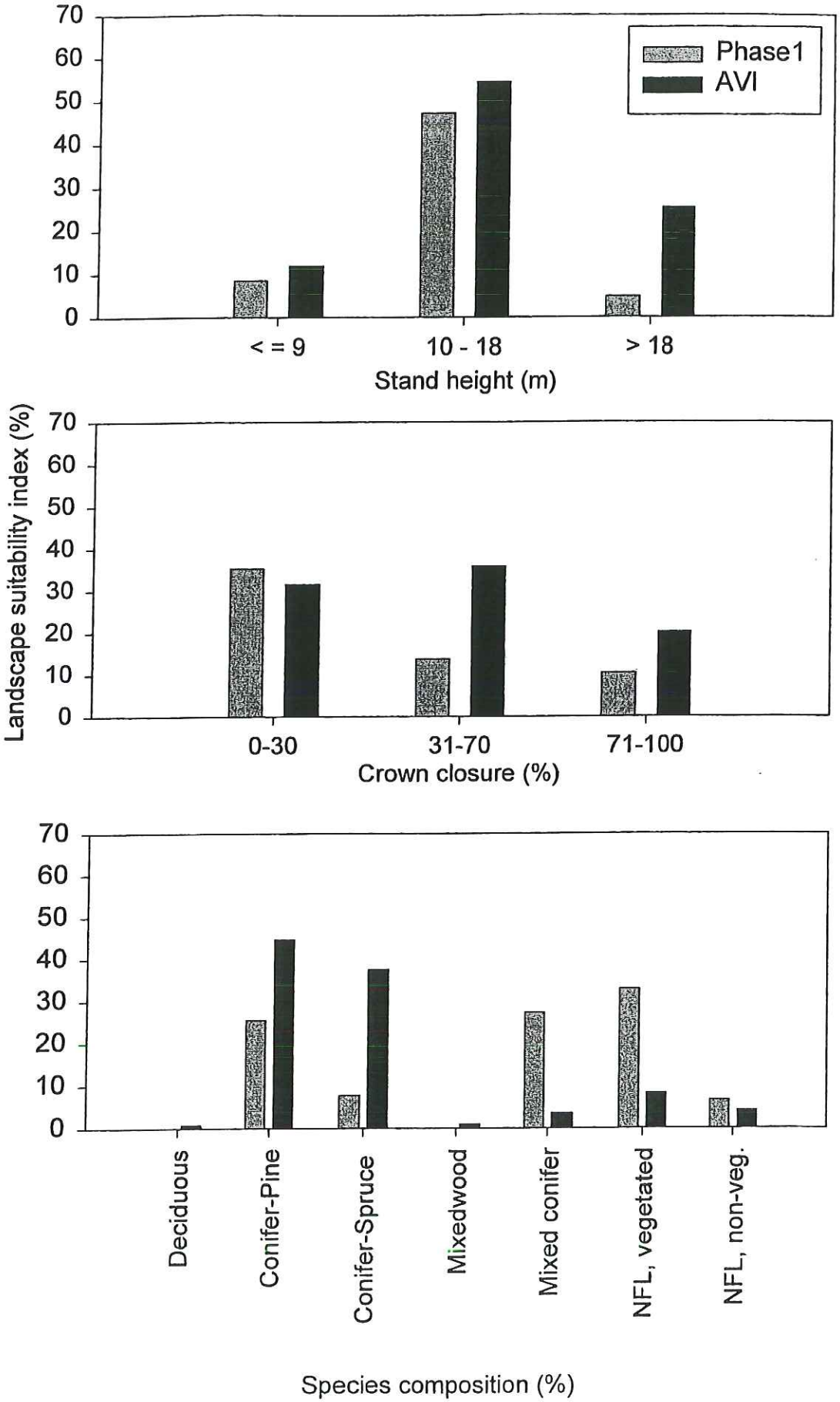
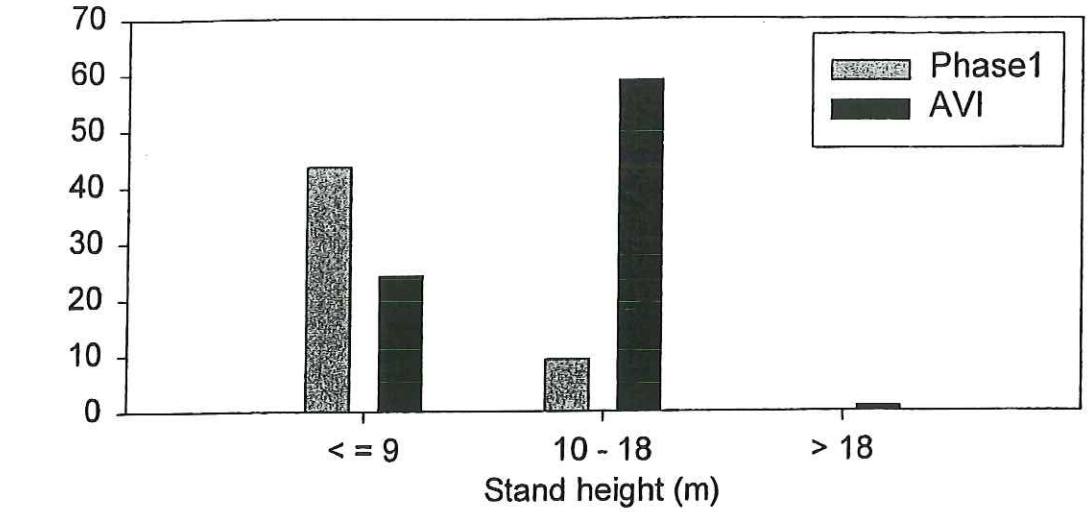
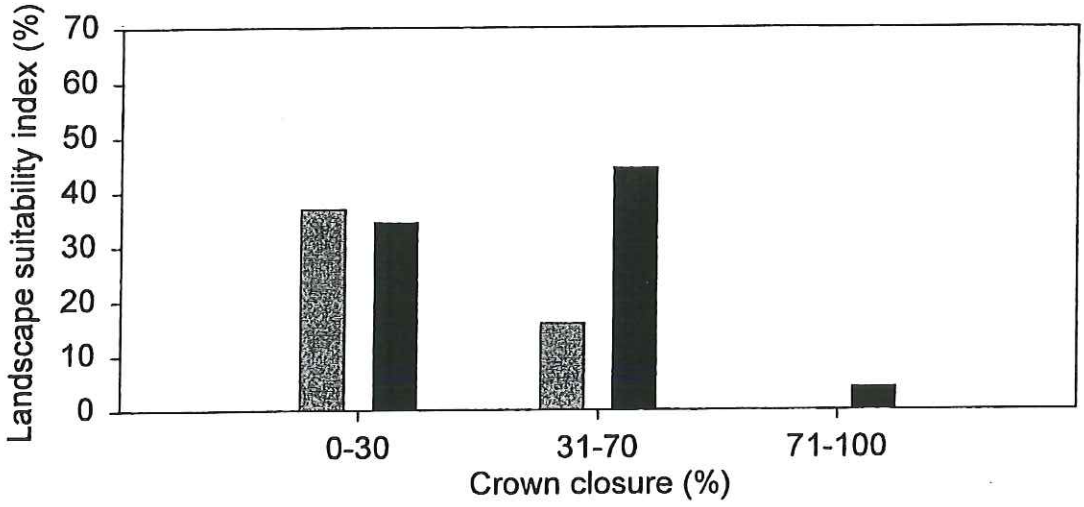


Figure 4g. Non-spatial analysis. Percentage area coverage comparison for Township 55, Range 7 for species composition, crown closure and stand height.





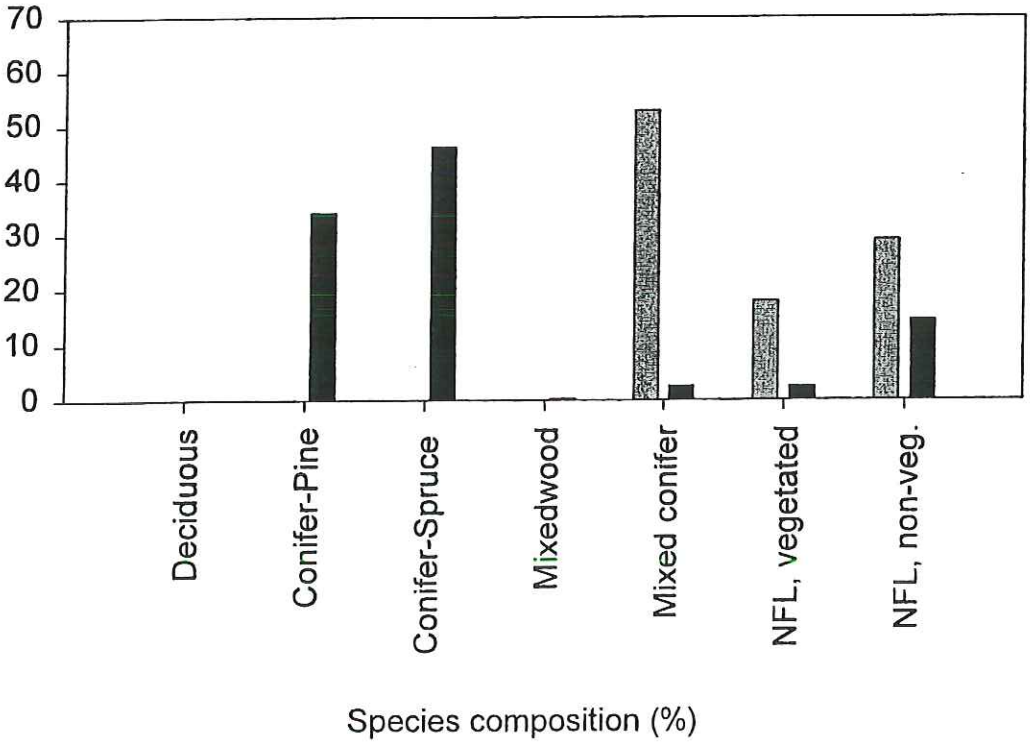
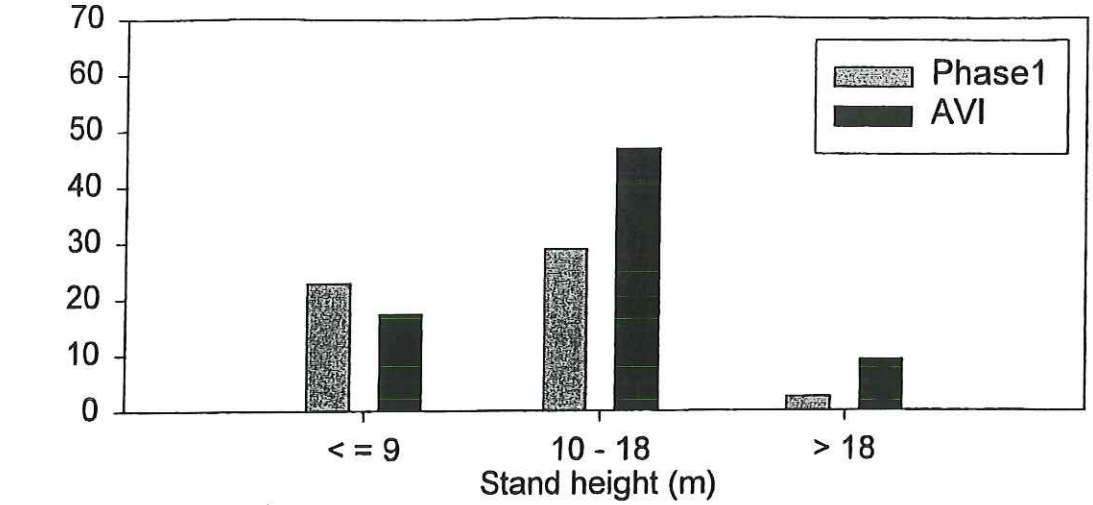
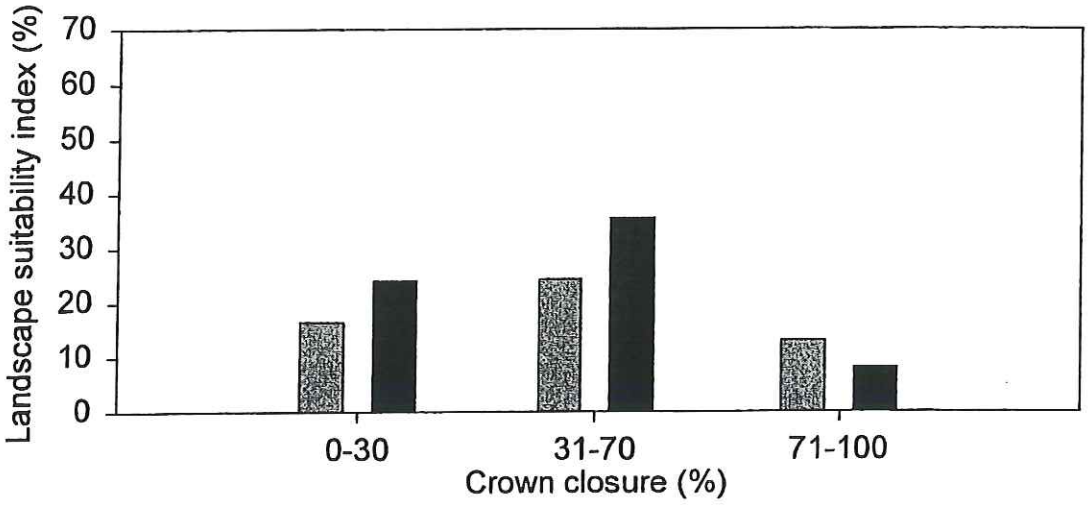


Figure 4h. Non-spatial analysis. Percentage area coverage comparison for Township 56, Range 11 for species composition, crown closure and stand height.





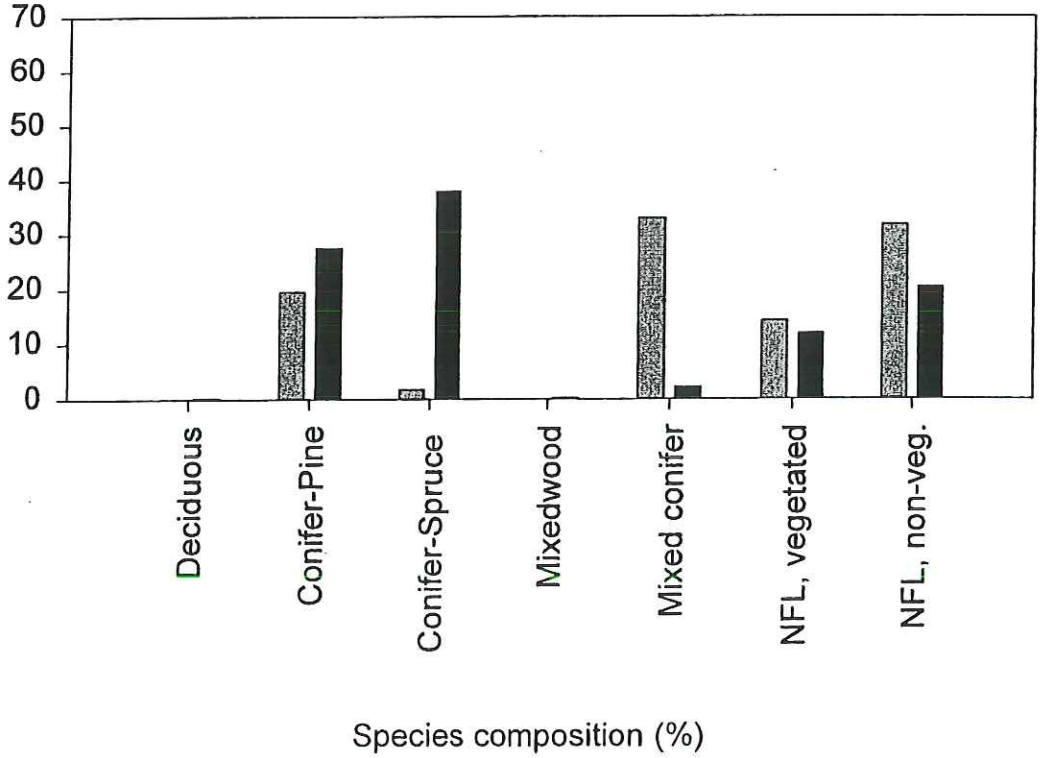


Figure 4i. Non-spatial analysis. Percentage area coverage comparison for all 8 townships for species composition, crown closure and stand height.

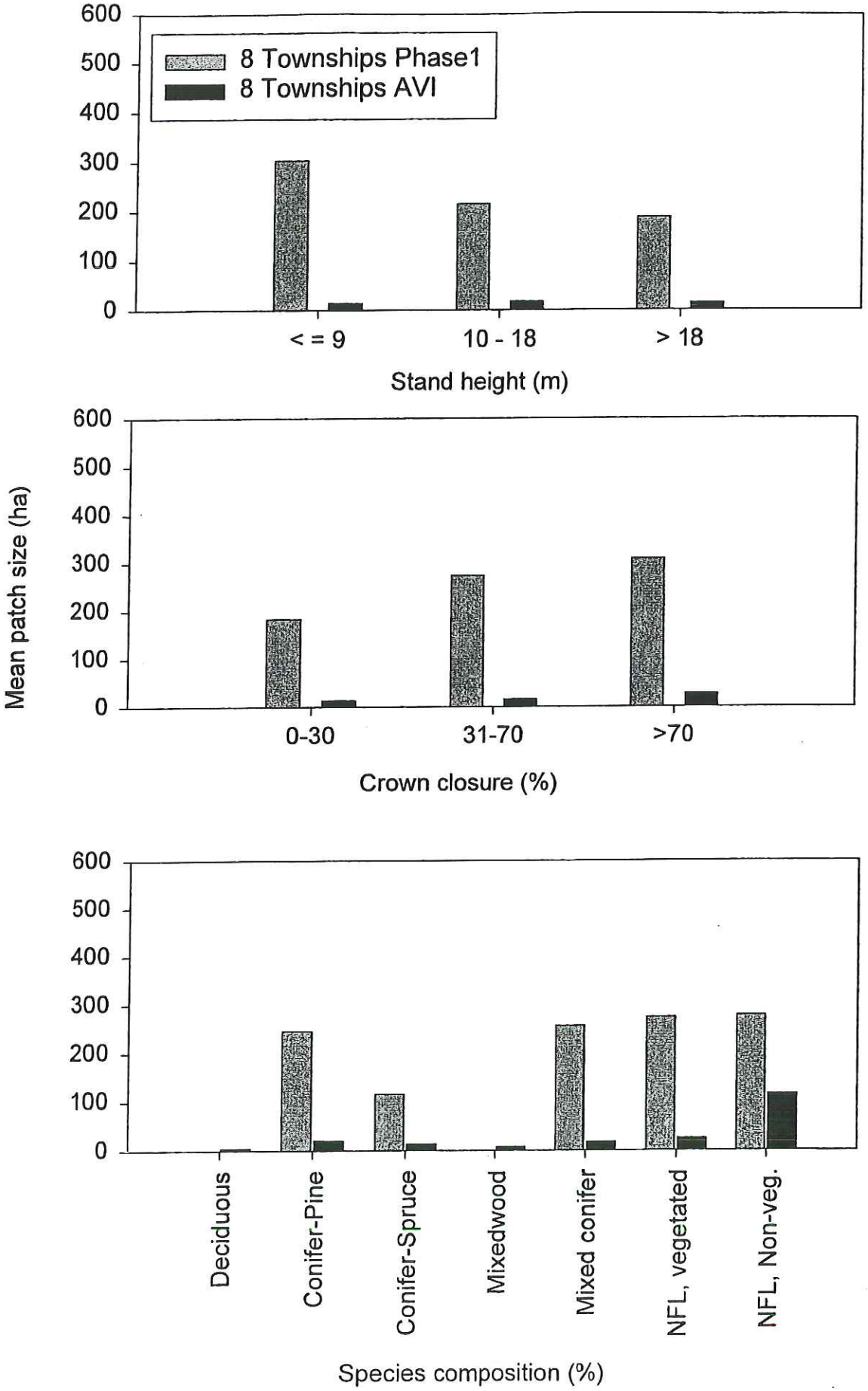


Figure 5a. Non-spatial analysis: Mean patch size for all 8 townships.

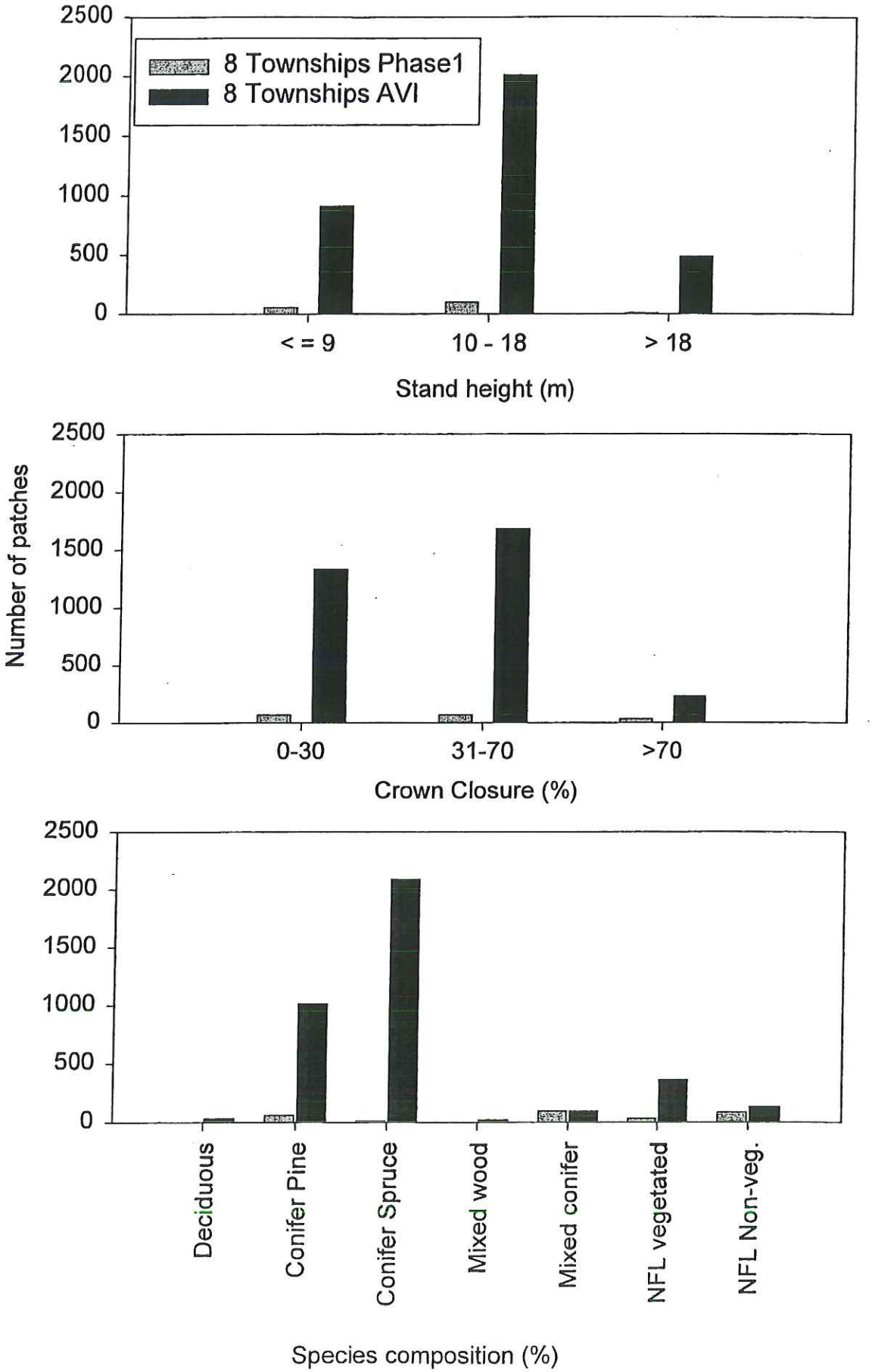


Figure 5b. Non-spatial analysis: Number of patches for all 8 townships.

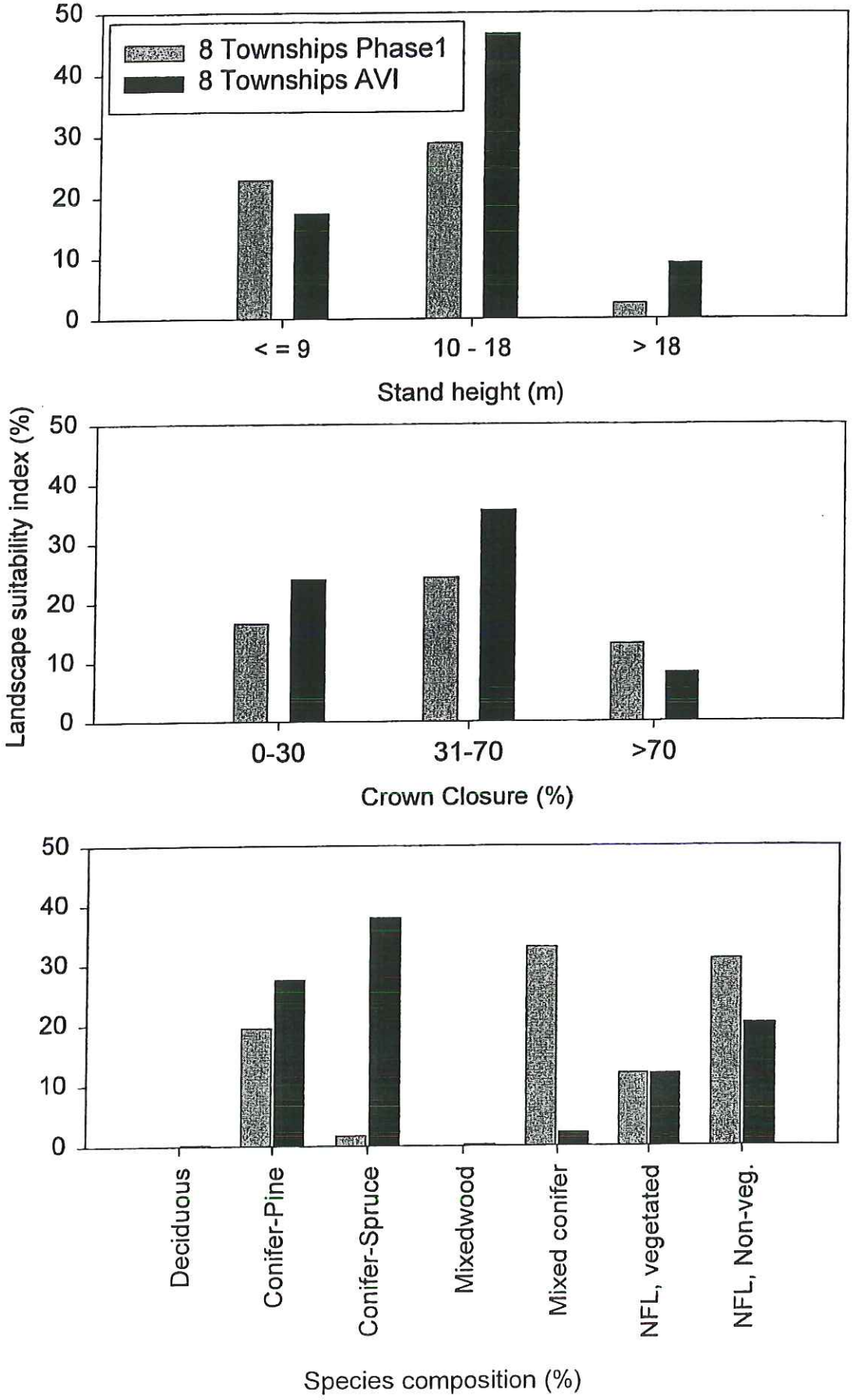
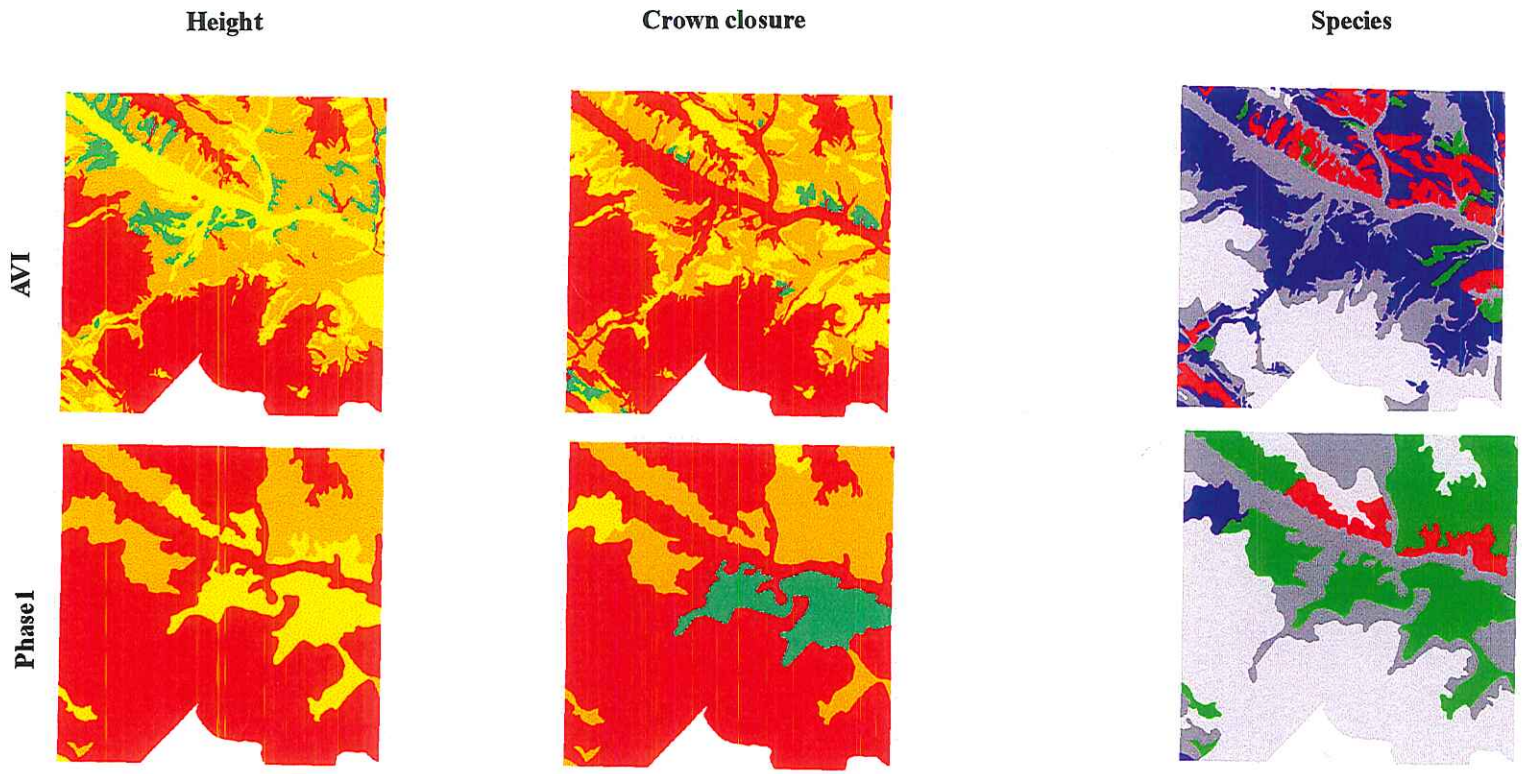


Figure 5c. Non-spatial analysis: Landscape suitability index for all 8 townships.



Height: Twp 52 Range 04 — Phase1

AVI		0	1	2	3	CELLS
	0	97.00%	1.09%	1.91%	0%	351606
<9.1m	1	82.76%	9.79%	7.45%	0%	177901
9.1-18.3	2	33.65%	32.86%	33.49%	0%	329945
18.3-24.4	3	17.22%	13.68%	69.11%	0%	52933
CELLS		608426	136925	167034	0	912385

AVERAGE ACCURACY = 35.07%
OVERALL ACCURACY = 51.40%
KAPPA = 24.95%

Crown Closure: Twp 52, R4 — Phase1

AVI		0	A	B	C,D	CELLS
	0	94.93%	0.28%	3.33%	1.47%	461070
A	1	56.43%	6.17%	22.98%	14.43%	173524
B,C	2	25.62%	4.19%	51.99%	18.21%	261768
D	3	35.89%	0%	60.84%	3.27%	16023
CELLS		608426	22943	201034	79982	912385

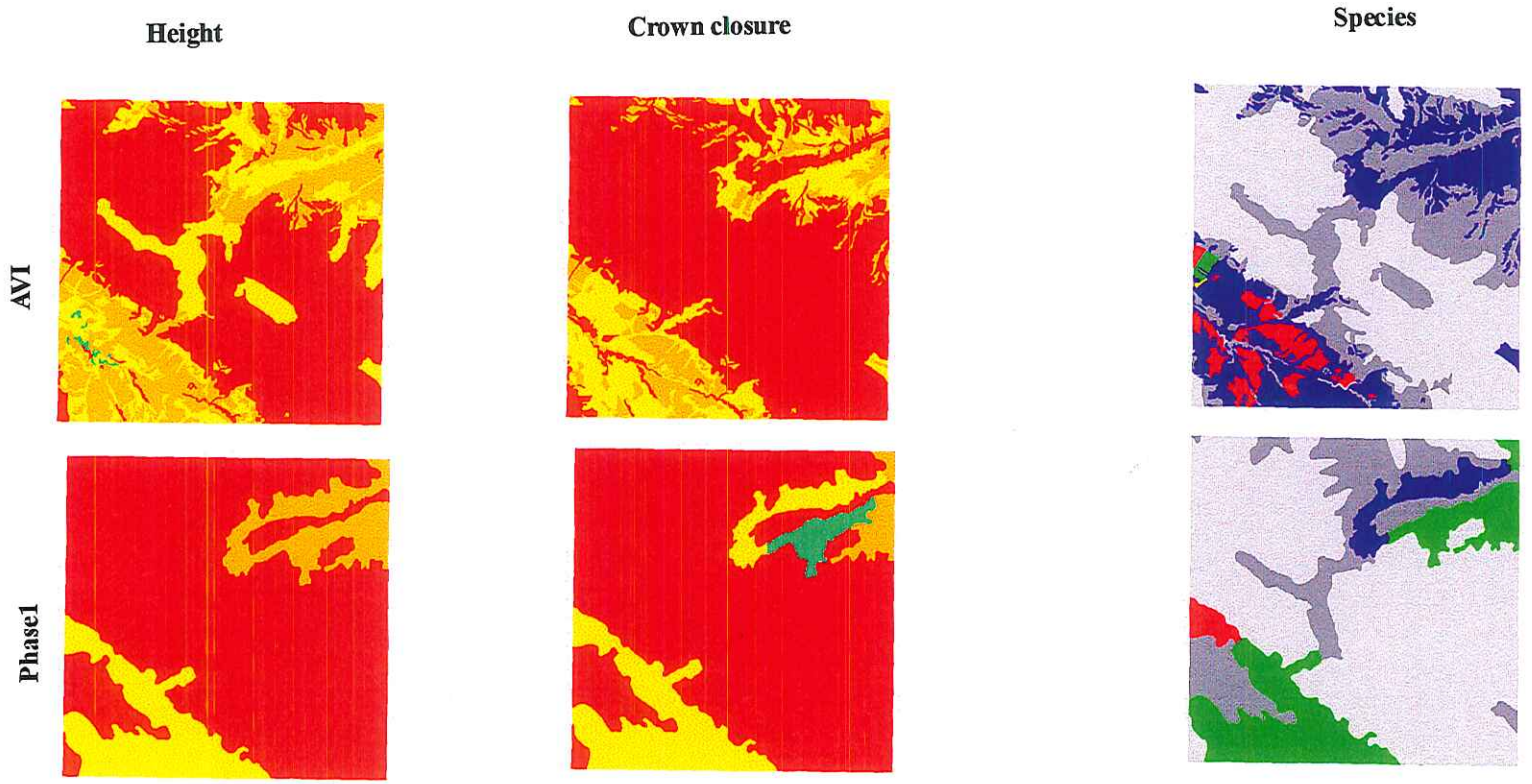
AVERAGE ACCURACY = 39.09%
OVERALL ACCURACY = 64.12%
KAPPA = 39.54%

Species: Twp52, Range4 — Phase1

AVI		1	2	3	4	5	6	7	CELLS
Deciduous	1	0%	0%	0%	0%	0%	0%	0%	0
Conifer Pine	2	0%	30.12%	0%	0%	31.35%	27.51%	11.02%	90995
Spruce Comp.	3	0%	1.62%	4.92%	0%	55.22%	23.59%	14.65%	337533
Mixedwood	4	0%	0%	0%	0%	0%	0%	0%	0
Mixed Conifer	5	0%	11.01%	0%	0%	60.12%	18.79%	10.08%	22790
NFL veg	6	0%	1.49%	0.35%	0%	7.51%	39.53%	51.11%	240087
NFL non veg	7	0%	0%	0%	0%	0.41%	1.06%	98.54%	220980
CELLS		0	38983	17442	0	247535	206196	402229	912385

AVERAGE ACCURACY = 33.32%
OVERALL ACCURACY = 40.59%
KAPPA = 27.17%

Figure 6a. Spatial analysis: Township maps and confusion matrices for species, crown closure and stand height for Township 52-4-W6.



Height: Twp 53, Range 6

AVI \ Phase1	0	1	2	3	CELLS
0	97.83%	1.18%	0.98%	0%	561787
<9.1m 1	80.23%	13.17%	6.60%	0%	191628
9.1-18.3 2	22.03%	44.34%	33.63%	0%	191761
18.3-24.4 3	100%	0%	0%	0%	2715
CELLS	748313	116910	82668	0	947891

AVERAGE ACCURACY = 36.16%
OVERALL ACCURACY = 67.45%
KAPPA = 33.51%

Crown Closure: Twp 53, R6

AVI \ Phase1	0	A 1	B 2	C,D 3	CELLS
0	96.82%	2.43%	0.33%	0.42%	670935
A 1	42.55%	42.29%	4.91%	10.25%	180250
B,C 2	22.77%	62.66%	12.36%	2.21%	96706
D 3	0%	0%	0%	0%	0
CELLS	748313	153137	22999	23442	947891

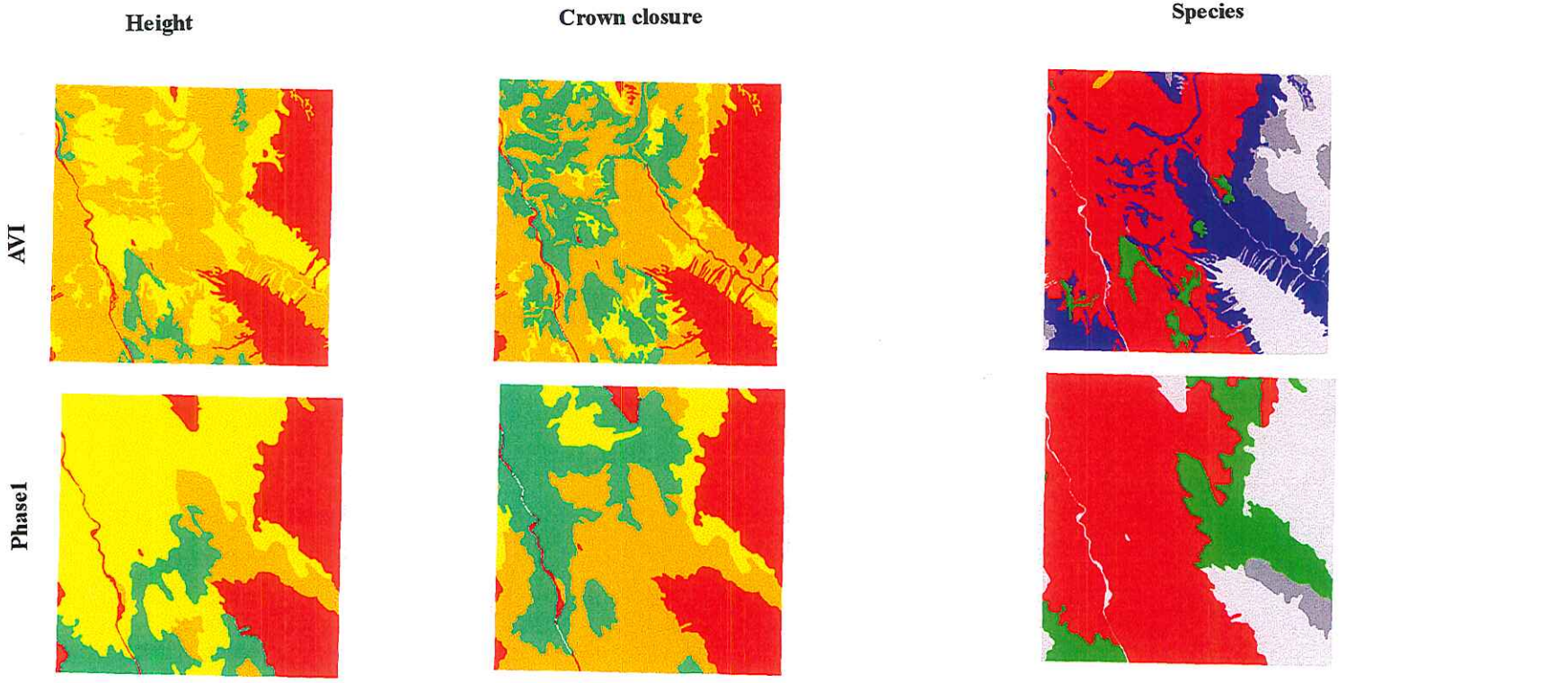
AVERAGE ACCURACY = 37.87%
OVERALL ACCURACY = 77.84%
KAPPA = 45.68%

Species: Twp53, Range 6

AVI \ Phase1	1	2	3	4	5	6	7	CELLS
Deciduous 1	0%	36.19%	0%	0%	0%	63.81%	0%	373
Conifer Pine 2	0%	3.47%	0%	0%	78.28%	16.56%	1.68%	42865
Spruce Comp. 3	0%	2.65%	12.23%	0%	45.58%	25.87%	13.48%	230398
Mixedwood 4	0%	0%	0%	0%	0%	0%	0%	0
Mixed Conifer 5	0%	99.52%	0%	0%	0%	0%	0.48%	3319
NFL veg 6	0%	0.19%	3.15%	0%	4.29%	35.24%	57.12%	255907
NFL non veg 7	0%	0%	0%	0%	0.43%	1.75%	97.82%	415029
CELLS	0	11994	36246	0	151339	164392	583920	947891

AVERAGE ACCURACY = 21.25%
OVERALL ACCURACY = 55.47%
KAPPA = 33.84%

Figure 6b. Spatial analysis: Township maps and confusion matrices for species, crown closure and stand height for Township 53-6-W6.



Height: Twp 53, Range 9

AVI \ Phase1	0	1	2	3	CELLS
0	96.75%	0.69%	1.16%	1.41%	193474
<9.1m 1	16.28%	68.94%	12.60%	2.18%	249029
9.1-18.3 2	5.74%	61.32%	13.65%	19.30%	464463
18.3-24.4 3	0.04%	24.28%	10.44%	65.24%	41206
CELLS	254377	467792	101298	124705	948172

AVERAGE ACCURACY = 61.14%
OVERALL ACCURACY = 47.37%
KAPPA = 30.53%

Crown Closure: Twp 53, R 09

AVI \ Phase1	0	A 1	B 2	C,D 3	CELLS
0	93.41%	1.77%	4.73%	0.10%	218586
A 1	24.67%	12.45%	49.54%	13.35%	96951
B,C 2	6.50%	17.70%	53.36%	22.45%	400398
D 3	0.11%	4.23%	22.68%	72.98%	232237
CELLS	254377	96601	324672	272522	948172

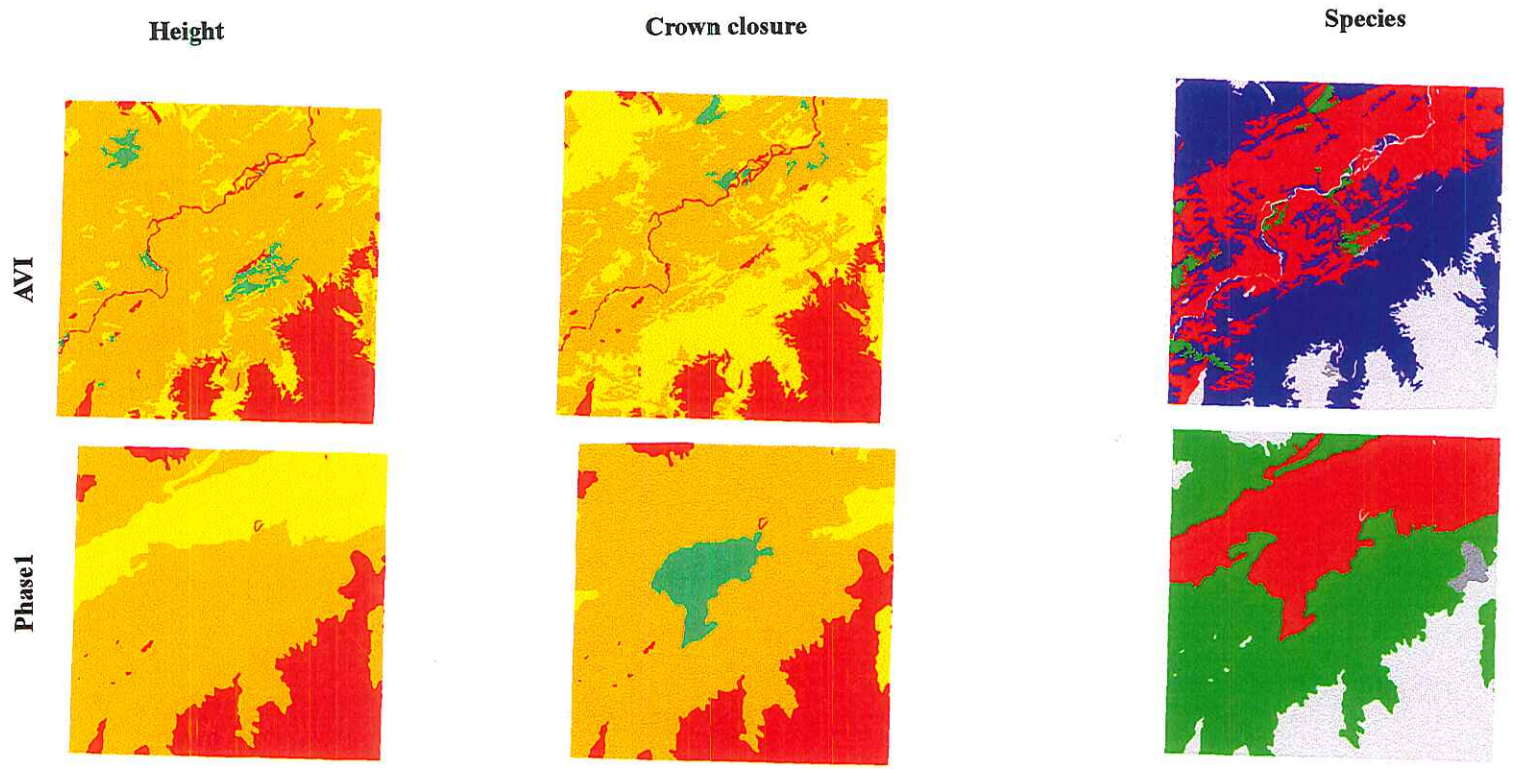
AVERAGE ACCURACY = 58.05%
OVERALL ACCURACY = 63.21%
KAPPA = 48.39%

Species: Twp 53, Range 9

AVI \ Phase1	1	2	3	4	5	6	7	CELLS
Deciduous 1	0%	0%	0%	0%	0%	0%	0%	0
Conifer Pine 2	0%	93.09%	0%	0%	6.17%	0%	0.75%	461490
Spruce Comp. 3	0%	29.16%	0%	0%	51.05%	8.67%	11.12%	236235
Mixedwood 4	0%	100%	0%	0%	0%	0%	0%	2283
Mixed Conifer 5	0%	90.24%	0%	0%	9.76%	0%	0%	29577
NFL veg 6	0%	3.10%	0%	0%	13.53%	4.18%	79.19%	67599
NFL non veg 7	0%	1.46%	0%	0%	0.64%	1.95%	95.95%	150988
CELLS	0	531742	0	0	162056	26263	228111	948172

AVERAGE ACCURACY = 29.00%
OVERALL ACCURACY = 61.19%
KAPPA = 43.04%

Figure 6c. Spatial analysis: Township maps and confusion matrices for species, crown closure and stand height for Township 53-9-W6.



Height: Twp 53, Range11 — Phase1

AVI		0	1	2	3	CELLS
0	0	91.53%	2.43%	6.04%	0%	159414
<9.1m	1	41.88%	23.81%	34.32%	0%	106331
9.1-18.3	2	2.65%	28.11%	69.24%	0%	663582
18.3-24.4	3	0.22%	0.63%	99.15%	0%	18963
CELLS		208097	215845	524348	0	948290

AVERAGE ACCURACY = 46.14%
OVERALL ACCURACY = 66.51%
KAPPA = 39.17%

Crown Closure: Twp 53, R 11 — Phase1

AVI		0	A	B	C,D	CELLS
0	0	91.46%	0.62%	6.85%	1.08%	161225
A	1	12.27%	5.90%	80.33%	1.51%	343104
B,C	2	4.26%	3.45%	81.30%	10.99%	435253
D	3	0%	0%	99.89%	0.12%	8708
CELLS		208097	36227	649204	54762	948290

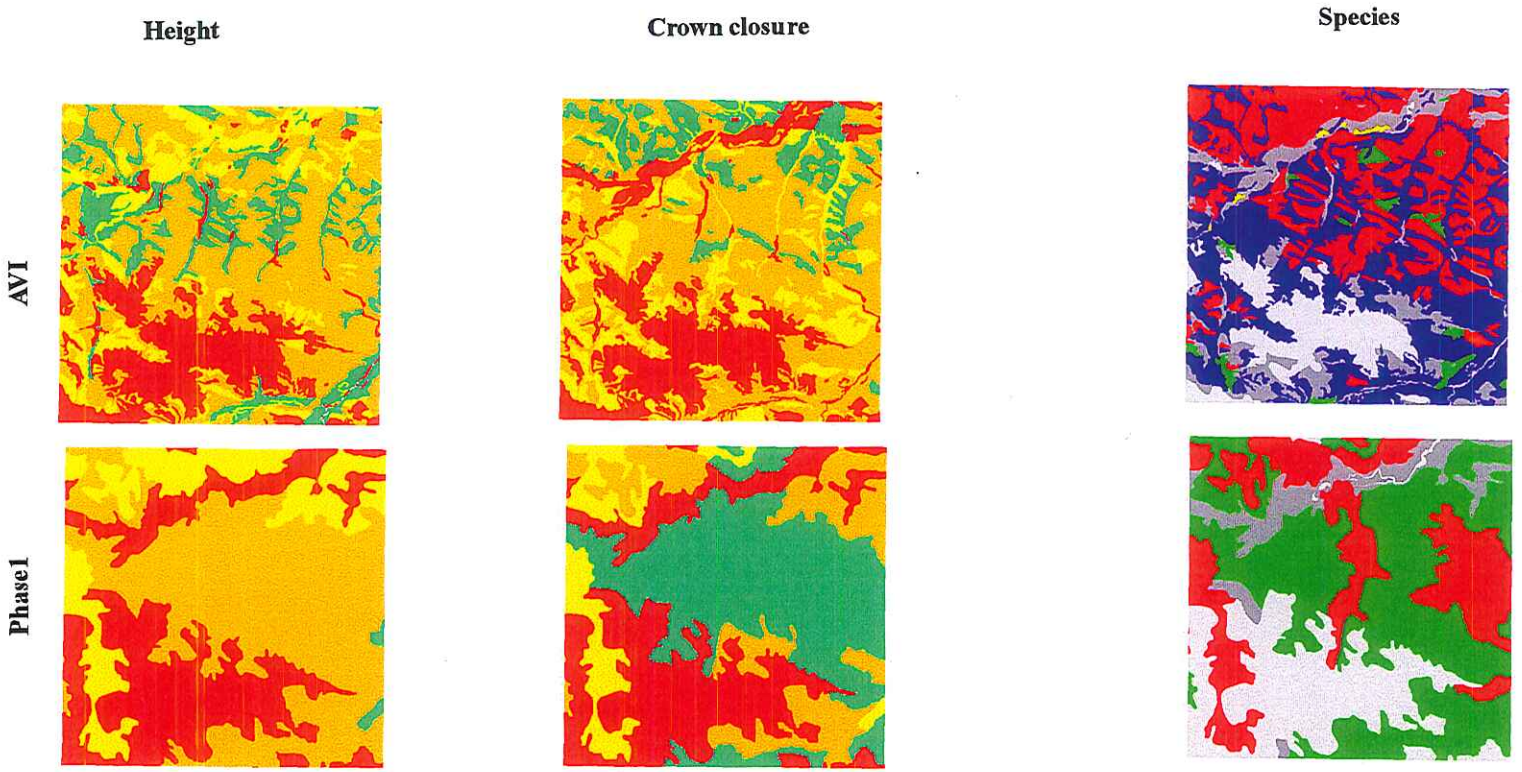
AVERAGE ACCURACY = 44.69%
OVERALL ACCURACY = 55.00%
KAPPA = 29.03%

Species Twp 53, Range 11 — Phase1

AVI		1	2	3	4	5	6	7	CELLS
Deciduous	1	0%	0%	0%	0%	0%	0%	0%	0
Conifer Pine	2	0%	66.35%	0%	0%	33.64%	0%	0.01%	326803
Spruce Comp.	3	0%	9.00%	0%	0%	77.19%	2.10%	11.72%	438883
Mixedwood	4	0%	0%	0%	0%	0%	0%	0%	0
Mixed Conifer	5	0%	26.71%	0%	0%	73.29%	0%	0%	21375
NFL veg	6	0%	10.82%	0%	0%	40.66%	0%	48.52%	4946
NFL non veg	7	0%	3.25%	0%	0%	3.94%	0.04%	92.77%	156283
CELLS		0	267656	0	0	472539	9265	198830	948290

AVERAGE ACCURACY = 33.20%
OVERALL ACCURACY = 39.81%
KAPPA = 29.76%

Figure 6d. Spatial analysis: Township maps and confusion matrices for species, crown closure and stand height for Township 53-11-W6.



Height: Twp 54 Range 4

AVI \ Phase1	0	1	2	3	CELLS
0	84.01%	6.31%	9.24%	0.44%	191357
<9.1m 1	55.89%	23.76%	20.35%	0%	155521
9.1-18.3 2	9.82%	22.20%	67.77%	0.22%	451797
18.3-24.4 3	8.39%	9.33%	79.73%	2.55%	146721
CELLS	304359	162979	472502	5556	945396

AVERAGE ACCURACY = 44.52%
OVERALL ACCURACY = 53.70%
KAPPA = 30.55%

Crown Closure: Twp 54, R 4

AVI \ Phase1	0	A	B	C,D	CELLS
0	83.88%	5.74%	4.60%	5.78%	238080
A 1	30.90%	14.10%	15.33%	39.67%	187802
B,C 2	9.68%	10.46%	21.84%	58.02%	408930
D 3	6.38%	7.15%	46.23%	40.25%	110584
CELLS	304359	90840	180182	370015	945396

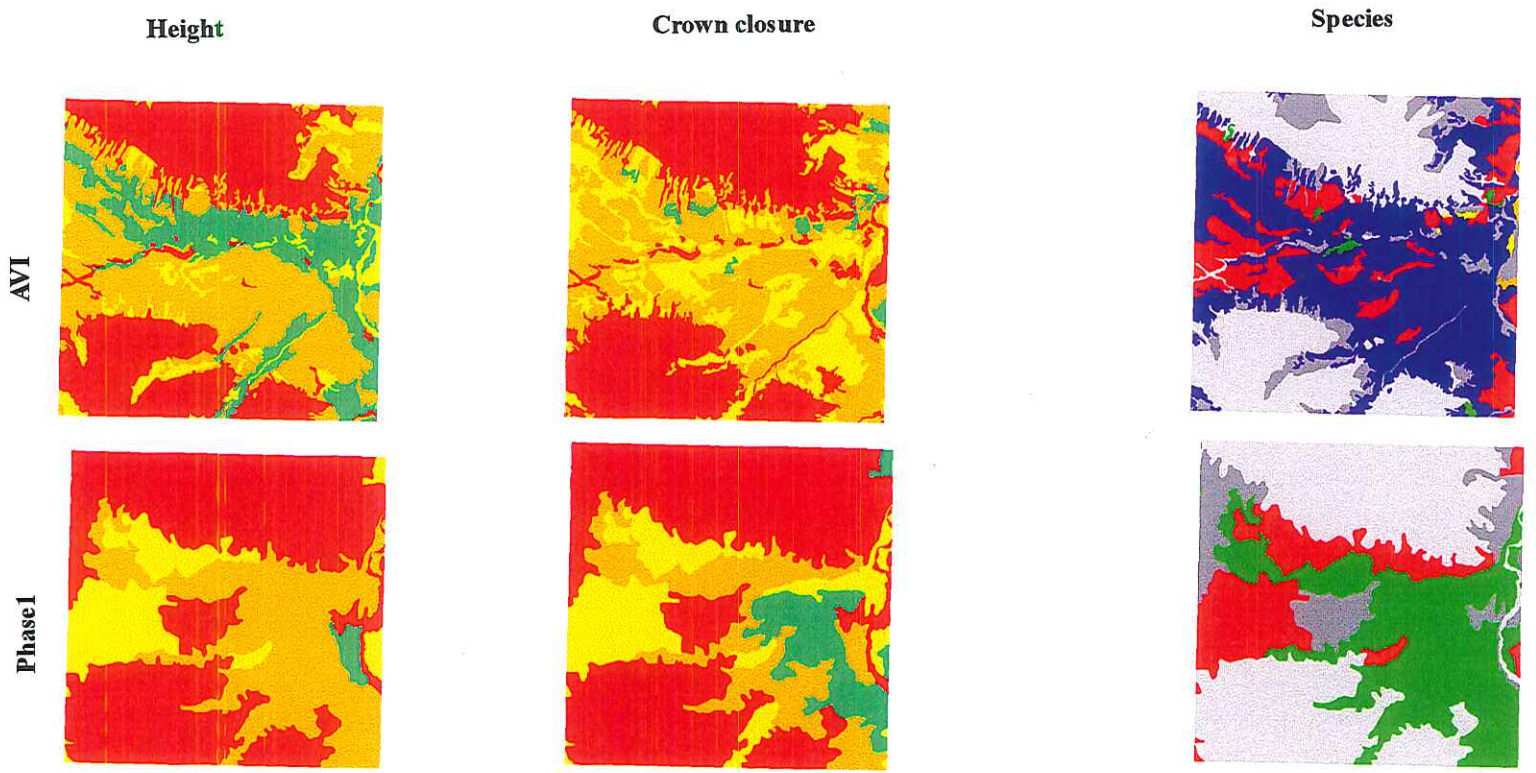
AVERAGE ACCURACY = 40.02%
OVERALL ACCURACY = 38.08%
KAPPA = 19.75%

Species: Twp 54, Range 04

AVI \ Phase1	1	2	3	4	5	6	7	CELLS
Deciduous 1	0%	3.81%	0%	0%	6.38%	68.92%	20.89%	2336
Conifer Pine 2	0%	44.62%	0%	0%	47.82%	5.14%	2.42%	280581
Spruce Comp. 3	0%	21.42%	0%	0%	58.88%	5.58%	14.12%	401847
Mixedwood 4	0%	0%	0%	0%	0%	0%	0%	0
Mixed Conifer 5	0%	24.89%	0%	0%	65.38%	1.24%	8.50%	22551
NFL veg 6	0%	9.29%	0%	0%	13.43%	32.10%	45.17%	127716
NFL non veg 7	0%	3.31%	0%	0%	5.17%	2.03%	89.49%	110364
CELLS	0	232484	0	0	408553	81955	222403	945395

AVERAGE ACCURACY = 33.09%
OVERALL ACCURACY = 29.59%
KAPPA = 19.76%

Figure 6e. Spatial analysis: Township maps and confusion matrices for species, crown closure and stand height for Township 54-4-W6.



Height: Twp 54, Range 8

AVI		Phase1				
		0	A	B	C,D	CELLS
0	0	94.98%	2.66%	2.34%	0.02%	349969
<9.1m	1	80.30%	6.31%	12.86%	0.53%	84412
9.1-18.3	2	29.62%	27.68%	42.51%	0.19%	340374
18.3-24.4	3	8.53%	13.11%	72.26%	6.10%	170891
CELLS		515571	131228	287089	11558	945446

AVERAGE ACCURACY = 37.48%
OVERALL ACCURACY = 52.13%
KAPPA = 29.00%

Crown Closure: Twp 54, R8

AVI		Phase1				
		0	1	2	3	CELLS
0	0	92.84%	4.37%	2.48%	0.32%	396563
A	1	39.65%	21.19%	25.73%	13.43%	211448
B,C	2	18.74%	29.84%	33.89%	17.53%	319895
D	3	20.63%	39.95%	22.65%	16.76%	17540
CELLS		515571	164591	176609	88675	945446

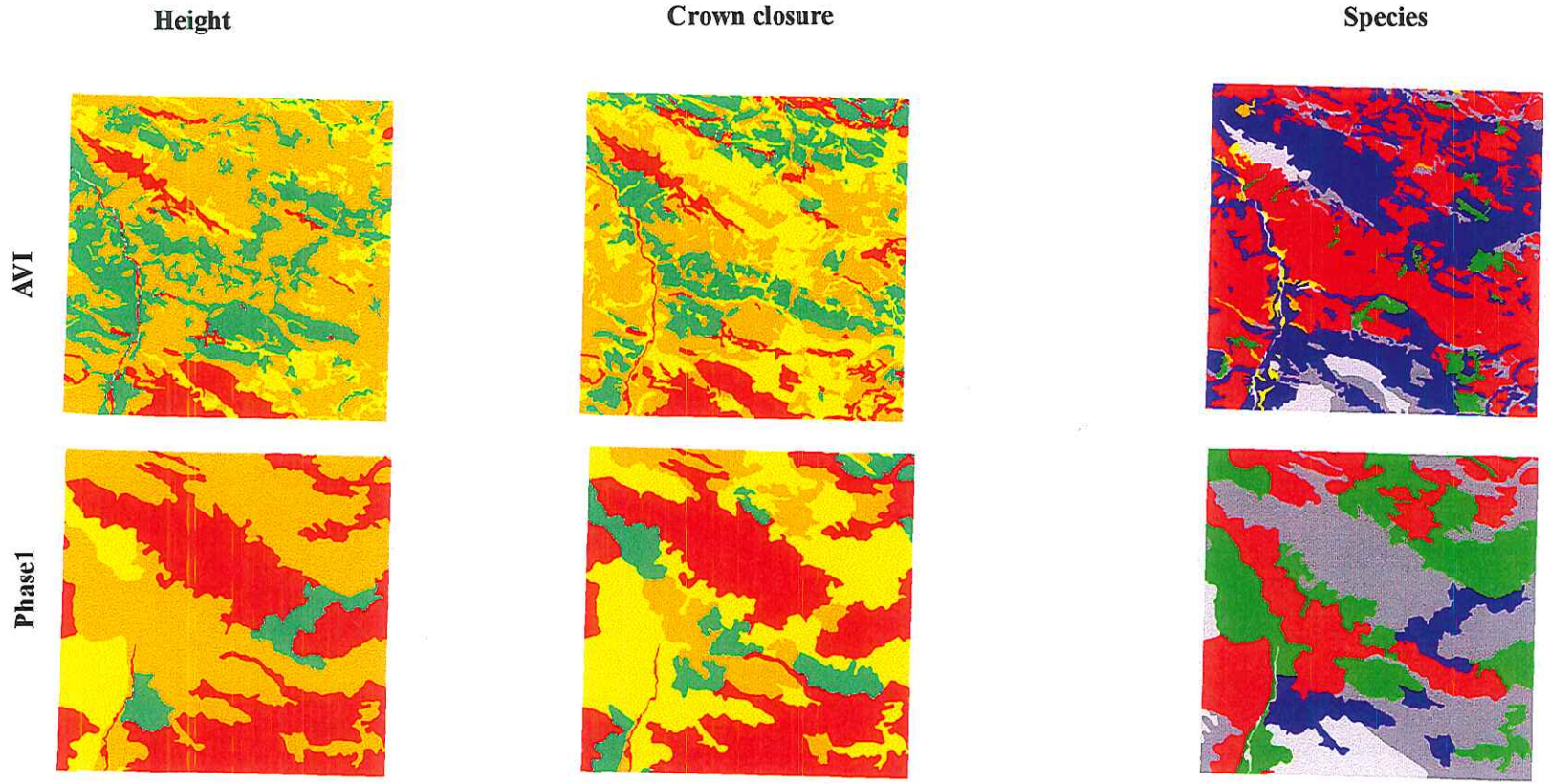
AVERAGE ACCURACY = 41.17%
OVERALL ACCURACY = 55.46%
KAPPA = 33.26%

Species: Twp 54 Range 08

AVI		Phase1							
		1	2	3	4	5	6	7	CELLS
Deciduous	1	0%	27.33%	0%	0%	48.42%	0%	24.25%	2243
Conifer Pine	2	0%	54.36%	0%	0%	24.18%	18.82%	2.63%	120433
Spruce Comp.	3	0%	15.72%	0%	0%	56.32%	14.14%	13.82%	417521
Mixedwood	4	0%	0%	0%	0%	73.86%	25.93%	0.21%	2387
Mixed Conifer	5	0%	12.37%	0%	0%	29.25%	57.60%	0.78%	6300
NFL veg	6	0%	5.87%	0%	0%	11.48%	7.93%	74.72%	100239
NFL non veg	7	0%	2.52%	0%	0%	1.19%	2.04%	94.25%	296323
CELLS		0	145869	0	0	284006	99941	415630	945446

AVERAGE ACCURACY = 26.54%
OVERALL ACCURACY = 37.50%
KAPPA = 24.64%

Figure 6f. Spatial analysis: Township maps and confusion matrices for species, crown closure and stand height for Township 54-8-W6.



Height: Twp 55, Range 7 — Phase1

AVI		0	1	2	3	CELLS
	0	86.10%	2.70%	9.68%	1.53%	77972
<9.1m	1	74.89%	0.55%	20.98%	3.58%	113920
9.1-18.3	2	36.13%	8.73%	49.67%	5.47%	519886
18.3-24.4	3	14.92%	13.85%	66.07%	5.17%	242735
CELLS		376508	81701	450038	46266	954513

AVERAGE ACCURACY = 35.37%
OVERALL ACCURACY = 35.47%
KAPPA = 6.26%

Crown Closure: Twp 55, R7 — Phase1

AVI		0	A	B	C,D	CELLS
	0	81.71%	12.73%	3.49%	2.06%	117944
A	1	56.38%	36.27%	5.94%	1.42%	301459
B,C	2	32.01%	49.61%	13.21%	5.17%	342449
D	3	5.24%	22.30%	33.21%	39.11%	192661
CELLS		386065	337210	131481	99757	954513

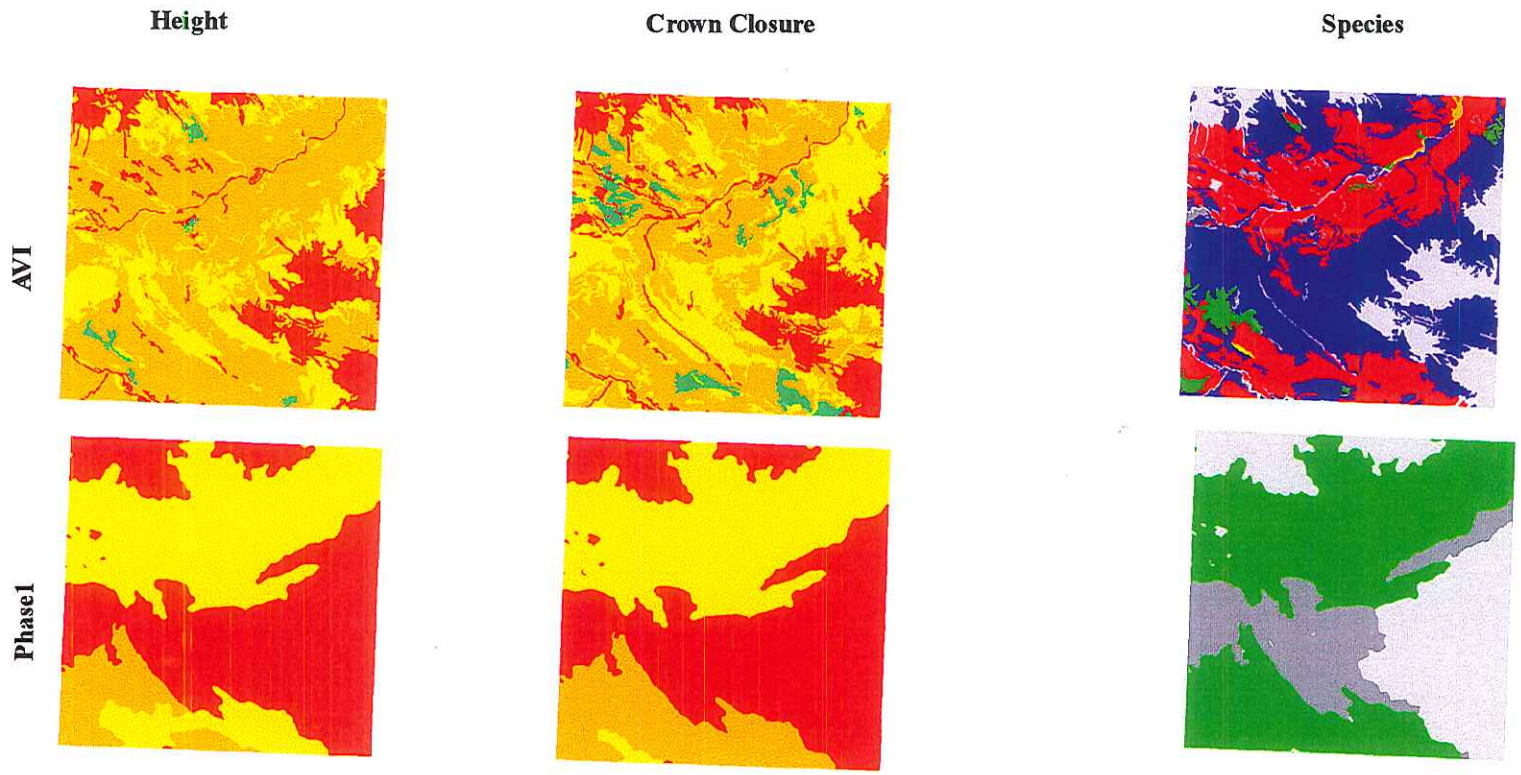
AVERAGE ACCURACY = 42.57%
OVERALL ACCURACY = 34.18%
KAPPA = 14.29%

Species: Twp 55, Range 07 — Phase1

AVI		1	2	3	4	5	6	7	CELLS
Deciduous	1	0%	21.31%	4.76%	0%	60.03%	12.83%	1.08%	8003
Conifer Pine	2	0%	47.29%	1.89%	0%	29.01%	20.36%	1.46%	426516
Spruce Comp.	3	0%	7.11%	16.40%	0%	29.89%	42.50%	4.10%	358740
Mixedwood	4	0%	47.68%	4.68%	0%	42.76%	4.85%	0.02%	9377
Mixed Conifer	5	0%	10.61%	4.95%	0%	28.62%	55.65%	0.17%	33932
NFL veg	6	0%	6.61%	5.28%	0%	9.99%	54.29%	23.84%	78367
NFL non veg	7	0%	4.24%	0.90%	0%	7.50%	29.60%	57.75%	39578
CELLS		0	243823	73880	0	260302	313907	62601	954513

AVERAGE ACCURACY = 29.19%
OVERALL ACCURACY = 35.17%
KAPPA = 20.68%

Figure 6g. Spatial analysis: Township maps and confusion matrices for species, crown closure and stand height for Township 55-7-W6.



Height: Twp 56, Range 11 — Phase1

AVI		0	1	2	3	CELLS
0	0	85.73%	12.63%	1.64%	0%	150557
<9.1m	1	79.44%	18.18%	2.38%	0%	230267
9.1-18.3	2	24.23%	62.03%	13.73%	0%	560729
18.3-24.4	3	0.90%	61.81%	37.30%	0%	8666
CELLS		447971	414065	88183	0	950219

AVERAGE ACCURACY = 29.41%
OVERALL ACCURACY = 26.09%
KAPPA = 3.38%

Crown Closure: Twp 56, R11 — Phase1

AVI		0	A	B	C,D	CELLS
0	0	81.76%	16.38%	1.86%	0%	160630
A	1	55.74%	35.39%	8.87%	0%	327669
B,C	2	31.46%	44.16%	24.38%	0%	422632
D	3	2.65%	55.64%	41.71%	0%	39288
CELLS		447971	350749	151499	0	950219

AVERAGE ACCURACY = 35.38%
OVERALL ACCURACY = 36.87%
KAPPA = 12.57%

Species: Twp 56, Range 11 — Phase1

AVI		1	2	3	4	5	6	7	CELLS
Deciduous	1	0%	0%	0%	0%	100%	0%	0%	948
Conifer Pine	2	0%	0%	0%	0%	90.50%	6.40%	3.10%	323679
Spruce Comp.	3	0%	0%	0%	0%	36.00%	32.26%	31.74%	438303
Mixedwood	4	0%	0%	0%	0%	100%	0%	0%	2843
Mixed Conifer	5	0%	0%	0%	0%	77.36%	18.91%	3.73%	23814
NFL veg	6	0%	0%	0%	0%	78.25%	10.72%	11.04%	23553
NFL non veg	7	0%	0%	0%	0%	7.93%	1.09%	90.99%	137078
CELLS		0	0	0	0	502248	170623	277347	950218

AVERAGE ACCURACY = 25.58%
OVERALL ACCURACY = 15.33%
KAPPA = 9.95%

Figure 6h. Spatial analysis: Township maps and confusion matrices for species, crown closure and stand height for Township 56-11-W6.

Appendix 7.1
Reclass AML

The stand height and crown closure data for the Phase 1 and AVI data underwent a simple reclassification performed by running the classify.aml program against the Phase 1 (p1hgt.rule and p1den.rule) and AVI (avhgt.rule and avden.rule) rule files.

The species reclassification was performed by running sp_classify.aml (attached) to compute the percent deciduous, coniferous-pine, and coniferous-spruce for each stand. In the case of AVI data, the percentages were explicit in the data, whereas in Phase 1, the percentages were based on the occurrence of primary, secondary, and tertiary species.

Final classes for species for both the AVI and Phase 1 data were assigned by subsequently running the classify.aml program in two stages: first against the preliminary rule file (species.rule1) which produces 27 classes, and then against the secondary rule file (species.rule2), further collapsing the classes to five: 1. Deciduous; 2. Coniferous-Pine; 3. Coniferous-Spruce; 4. Deciduous/Coniferous mixedwood; and 5. Mixed coniferous.

The main sp_classify.aml also calls a number of procedure AML's for processing Phase 1 and AVI species composition percentages (sp_bldspcls.aml, sp_calcper_avi.aml, sp_calcper_p1_1/2/3.aml, and sp_entspcls.aml).

Detailed Notes:

Reclassification was done as follows:

1. run sp_classify.aml against p1c and avc to assign:
   decper deciduous percentage
   conpper coniferous-pine percentage
   consper coniferous-spruce percentage
  * note that species Pp in phase 1 gets
    coded as Deciduous at this stage. Reassign
    DECPER to 0 (there is no deciduous in phase 1 anyway)

2. run classify AML and species.rule1 against p1c and avc to assign t1 item - too many classes result (has lots of garbage in it).

3. run classify AML and species.rule2 against p1r and avr to reclass t1 item to spc item (5 classes).

4. reselect NFL <> ""
   check for spc <> 0 and assign spc = 6
   reselect NatNon <> ""
   check for spc <> 0 and assign spc = 7

5. summary tables
   * note that a number of Phase 1 stands came out as class 0 (having no attributes at all). These were recoded as classes 6 and 7 by checking the Phase 1 maps.

6. same process was repeated for the P1_All coverage:
   ran sp_classify to calculate decper, consper, conpper
   ran classify using
   p1all_hgt.rule for height
   p1all_den.rule for density
   species.rule1 & 2 for species
   reclassed 6 for NFL <> "" or SP1 = "Pp"
   reclassed 7 for NatNon <> ""

```
/* CLASSIFY.AML
/* Creates a new field with a class for each combination of rules
/* specified in a datafile.  Was used to create 15, 30, and 40 clss
/* systems for conifer understory detection project.
/*
/* M. Gartrell, NoFC
/* Feb 11, 1997  first coding
/* Jan 10, 2000  modified MG: updated comments, quoted string values
/*
/* AML to classify a coverage based on rules from data file
/*
/* supports simple rules (=,<,>,<=,>=)
/* and compond expressions (AND,OR,XOR,...)
/*
/* the rules data file looks like this:
/* ; type 1 = char value      comment
/* ; type 2 = num value       comment
/* 2                          the number of fields
/* 2 density 1 EQ OR EQ       the number of rules, field name, type, operand and
compounders
/* A A                        the values for each rule, same values is ok to allow 2
values on next line
/* B C                        each value line must have the same number of values as
operands were specified above
/*
/* 3 height 2 GT AND LE       the next field info.  numeric operator is usually AND
/* 0 6
/* 6 24
/* 24 999
/*
/* The resulting classification system will be:
/* Class  Rules
/*     0  everything else
/*     1  density eq 'A' and height gt 0 and height le 6
/*     2  density eq 'B' or density eq 'C' and height gt 0 and height le 24
/*     3  density eq 'A' and height gt 6 and height le 24
/*     ...
/*     6  density eq 'B' or density eq 'C' and height gt 24 and height le 999
/*
/* Variables:
/*
/*         cover - the info file to be classified
/*       newitem - the new item added to cover
```

```
/*      rulefile - the datafile containing the classification rules
/*
/*             f - a counter for fields
/*      f%f%type - field data types
/*    f%f%nvalue - number of value sets for each field
/*      f%f%name - name of each field
/*       f%f%nop - number of operators for a field
/*             o - a counter for operators
/*      f%f%o%o% - each field operator (EQ, GT, LT, ...)
/*      f%f%c%o% - the concatenators (AND, OR, XOR, ...)
/*             v - a counter for the values
/*  f%f%v%v%o%o% - the values for each field, each operator
/*

&args cover newitem rulefile .debug

&s mes [show &messages]
&s ech [show &echo]

&if [null %.debug%] &then &do
   &s .debug .FALSE.
   &echo &off
   &mes &off
   &end
&else &do
   &s .debug .TRUE.
   &echo &on
   &mes &on
&end

&if [null %cover%] &then &do
   &type Please specify the name of an INFO file to be classified.
   &type CLASSIFY <info.file.name> <new.item> <rule.file> {debug-mode}
   &messages %mes%
   &echo %ech%
   &return
   &end
&else
   &if not [exists %cover% -info] &then &do
      &type Cannot find INFO file named %cover%.
      &type CLASSIFY <info.file.name> <new.item> <rule.file> {debug-mode}
      &messages %mes%
      &echo %ech%
      &return
      &end

&if [nul %newitem%] &then &do
   &type Please specify an item name for the class value.
   &type CLASSIFY <info.file.name> <new.item> <rule.file> {debug-mode}
   &messages %mes%
   &echo %ech%
   &return
&end

&if [nul %rulefile%] &then &do
   &type Please specify a filename for the rules.
   &type CLASSIFY <info.file.name> <new.item> <rule.file> {debug-mode}
   &messages %mes%
   &echo %ech%
   &return
   &end
&else
   &if not [exists %rulefile% -file] &then &do
      &type Cannot find RULE file named %rulefile%.
      &type CLASSIFY <info.file.name> <new.item> <rule.file> {debug-mode}
      &messages %mes%
```

```
      &echo %ech%
      &return
   &end

&s cover [translate %cover%]
&s newitem [translate %newitem%]
&watch %rulefile%.WAT

&if [iteminfo %cover% -INFO %newitem% -EXISTS] &then &do
   &type %newitem% already exists in %cover%.
   &s resp [query 'Overwrite (Y/N)']
     &if not %resp% &then &do
        &messages %mes%
        &echo %ech%
        &return
    &end
    dropitem %cover% %cover% %newitem%
&end

additem %cover% %cover% %newitem% 5 5 i

/* read in the rules
&type Reading rules...
&s rf [open %rulefile% stat -READ]
&if %stat% <> 0 &then &do
   &type Open %rulefile% failed error %stat%.
   &messages %mes%
   &s stat [close -ALL]
   &echo %ech%
   &return
&end

/* find how many fields...
&call getnextline
&if [type %word%] <> -1 &then &do
   &type First entry must be number of fields.  Read %word%.
   &goto ruleerror
&end
&s nfields %word%

&type _________________
&type %nfields% FIELDS.
&type -----------------\n
&do f = 1 &to %nfields%
   /* next non-comment line should contain the first field info (N, name, type, ...)
   &call getnextline
   &if [null %word%] &then &do
      &type Premature EOL while reading N for field %f%.
         &messages %mes%
         &echo %ech%
         &s stat [close -ALL]
         &return
   &end

   &s f%f%nvalue [unquote %word%]
   &if [type [value f%f%nvalue]] NE -1 &then &do
      &type Found [value f%f%nvalue] looking for field %f% N.
      &goto ruleerror
   &end

   /* field name
   &call getnextword
   &if [null %word%] &then &do
      &type Premature EOL while reading name for field %f%.
      &goto ruleerror
   &end
```

```
   &s f%f%name [translate %word%]

   &if not [iteminfo %cover% -INFO [value f%f%name] -EXISTS] &then &do
      &type No such item [value f%f%name] in INFO file %cover%.
      &goto ruleerror
   &end

   /* field type
   &call getnextword
   &if [null %word%] &then &do
      &type Premature EOL while reading type for field [value f%f%name].
      &goto ruleerror
   &end

   &s f%f%type [unquote %word%]
   &if [type [value f%f%type]] NE -1 or [value f%f%type] > 2 or [value f%f%type] < 1
&then &do
      &type Found [value f%f%type] looking for field type.
      &type Field type must be one of
      &type      1 - character
      &type      2 - numeric
      &goto ruleerror
   &end

   /* operators and concatenators
   &s o 1                  /* number of operators
   &call getnextword
   &if [null %word%] &then &do
      &type Premature EOL while reading operator %o% for field [value f%f%name].
      &goto ruleerror
   &end

   &s f%f%o%o% %word%      /* 1st operator

   &do &until [null %word%]
      &call getnextword
      &if not [null %word%] &then &do
        &s o %o% + 1        /* additional pairs of operator/concatenator
        &s f%f%c%o% %word%
        &call getnextword
        &if [null %word%] &then &do
            &type No operator to go with [value f%f%c%o%] concatenator for field
[value f%f%name].
            &goto ruleerror
         &end
         &s f%f%o%o% %word%
      &end
   &end

   &s f%f%nop %o%          /* number of operators for the field

   /* now the values.
   /* for each field, there will be nvalue values for each operator
   &do v = 1 &to [value f%f%nvalue]
      &call getnextline
      &s o 1
      &if [value f%f%type] = 1 &then
         &s f%f%v%v%o%o% %word%
      &else
         &s f%f%v%v%o%o% [unquote %word%]

      &do o = 2 &to [value f%f%nop]
         &call getnextword
         &if [value f%f%type] = 1 &then
            &s f%f%v%v%o%o% %word%
         &else
```

```
            &s f%f%v%v%o%o% [unquote %word%]
      &end
   &end

&end    /* now do all that again for the next field!

&s stat [close -ALL]

/* OK, we're ready to roll.
/* spit out the classification system for joey user...
/*
&type \n---------------------------------
&type Classifying %cover%, assigning item %newitem%
&s nclass 1
&do f = 1 &to %nfields%
   &s nclass [calc %nclass% * [value f%f%nvalue]]
&end
&type There will be %nclass% classes:

&do f = 1 &to %nfields%   /* one pointer for each field
   &s f%f%point 1
&end

&s af [open %rulefile%.aml stat -WRITE]
&if %stat% <> 0 &then &do
   &type Open %rulefile% failed error %stat%.
   &messages %mes%
   &s stat [close -ALL]
   &echo %ech%
   &return
&end

&s rec &DATA ARC INFO
&s stat [write %af% [quote %rec%]]
&s rec ARC
&s stat [write %af% [quote %rec%]]
&s rec SEL %cover%
&s stat [write %af% [quote %rec%]]

&do c = 1 &to %nclass%

   &s msg Class %c%:
   /* retrieve the value from each pointer...
   &do f = 1 &to %nfields%
      &if %f% > 1 &then &s msg %msg% AND
      &if [value f%f%type] = 1 &then &do /* string type needs quotes around values
        &s msg %msg% [value f%f%name] [value f%f%o1] [quote [value f%f%v[value
f%f%point]o1]]
        &do o = 2 &to [value f%f%nop]
          &s msg %msg% [value f%f%c%o%] [value f%f%name] [value f%f%o%o%] [quote
[value f%f%v[value f%f%point]o%o%]]
        &end
        &end /* if type
      &else &do
        &s msg %msg% [value f%f%name] [value f%f%o1] [value f%f%v[value f%f%point]o1]
        &do o = 2 &to [value f%f%nop]
          &s msg %msg% [value f%f%c%o%] [value f%f%name] [value f%f%o%o%] [value
f%f%v[value f%f%point]o%o%]
        &end
      &end /* else
   &end /* do

   &type %msg%
   &s p [search [quote %msg%] ':'] + 1
   &s rec RES [unquote [substr [quote %msg%] %p%]]
   &s stat [write %af% [quote %rec%]]
```

```
      &s rec CALC %newitem% = %c%
      &s stat [write %af% [quote %rec%]]
      &s rec ASEL
      &s stat [write %af% [quote %rec%]]

      /* push the pointers ahead one

      &s f1point %f1point% + 1
      &do f = 1 &to %nfields%
         &if [value f%f%point] > [value f%f%nvalue] &then &do
             &s f2 %f% + 1
             &s f%f%point 1
             &s f%f2%point [value f%f2%point] + 1
             &if %f2% > %nfields% and %c% < %nclass% &then &do
                /*over the top!
                &type Something is HORRIBLY wrong. :(
                &messages %mes%
                &echo %ech%
                &s stat [close -ALL]
                &return
             &end
         &end
      &end

&end  /* each class

&s rec QUIT STOP
&s stat [write %af% [quote %rec%]]
&s rec &END
&s stat [write %af% [quote %rec%]]

&s stat [close -ALL]
&type Classification routine %rulefile%.AML written.
&s q [query 'Proceed with classification (Y/N)']

&if %q% &then &r %rulefile%.aml

&messages %mes%
&echo %ech%

&return

&routine getnextline
   /* reads from the file until a non-comment line is found.
   &s comment .TRUE.
   &do &while %comment%

      &s rec [read %rf% stat]

      &if [type %rec%] = 1 &then
         &if [type [substr %rec% 1 1]] = 1 &then
            &if [substr %rec% 1 1] = ';' &then
               &s comment .TRUE.
            &else
               &s comment .FALSE.
         &else
            &s comment .FALSE.
      &else
         &s comment .FALSE.

      &if %stat% <> 0 &then &do
         &type Premature EOF %rulefile%.
         &messages %mes%
         &echo %ech%
         &s stat [close -ALL]
         &return
```

```
      &end
    &end
    &call getnextword
&return

&routine getnextword
  /* extract a %word% from %rec%, return null if no more words...
  /*
  &s fin .FALSE.
  &s c 1
  &do &until %fin%
     &s c %c% + 1
     &s p [search %rec% ' '] - 1
     &if %p% GE 0 &then &do
         &s word [substr %rec% 1 %p%]
         &s p2 =  %p% + 2
         &s rec [substr %rec% %p2%]
         &end
     &else &do
         &s word %rec%
         &s rec ''
     &end

     &s fin .TRUE.
     &if [type %word%] = 1 &then
        &if [substr %word% 1 1] = ';' &then
           &s fin .FALSE.

     &if %c% = 20 &then &stop

   &end
&return

&label ruleerror
   &type \nThe rule file should look like this...
   &type  ; type 1 = char value       comment
   &type  ; type 2 = num value        comment
   &type  2                           the number of fields
   &type  15 cls15 2 EQ               the number of rules, field name, type, operand
and compounders
   &type  1                           the values for each rule...
   &type  2
   &type  3
   &type  ...
   &type  5 height 2 GT AND LE        the next field info...
   &type  0 6
   &type  6 12
   &type  12 18
   &type  18 24
   &type  24 999
   &messages %mes%
   &echo %ech%
   &s stat [close -ALL]
   &return
```

Species.rule1

```
; type 1 = char value
; type 2 = num value
;
; we want these 5 classes:
;   1. Decid
;   2. Conifer-Pine
```

```
;   3. Conifer-Spruce
;   4. Mixedwood (Decid/Conif, Conif/Decid)
;   5. Mixed Conifer (C-P/C-S, C-S/C-P)
;
; this gives 27 classes
; D/P/S means decid, pine, spruce >= 7
; d/p/s means decid, pine, spruce <= 6
; blank means it doesn't occur at all
;
; 1 D/P/S
; 2 d/P/S  * many of these codes
; 3  /P/S    should not occurr (they don't make sense)
; 4 D/p/S
; 5 d/p/S  <-- 3. Conifer-Spruce
; 6  /p/S  <-- 3. Conifer-Spruce
; 7 D/ /S
; 8 d/ /S  <-- 3. Conifer-Spruce
; 9  / /S  <-- 3. Conifer-Spruce
;10 D/P/s
;11 d/P/s  <-- 2. Conifer-Pine
;12  /P/s  <-- 2. Conifer-Pine
;13 D/p/s  <-- 1. Deciduous
;14 d/p/s  <-- 4. Mixedwood
;15  /p/s  <-- 5. Mixed Conifer
;16 D/ /s  <-- 1. Deciduous
;17 d/ /s  <-- 4. Mixedwood
;18  / /s
;19 D/P/
;20 d/P/   <-- 2. Conifer-Pine
;21  /P/   <-- 2. Conifer-Pine
;22 D/p/   <-- 1. Deciduous
;23 d/p/   <-- 4. Mixedwood
;24  /p/
;25 D/ /   <-- 1. Decid
;26 d/ /
;27  / /
;
3
3 DECPER 2 GE AND LE
7 10
1 6
0 0
3 CONPPER 2 GE AND LE
7 10
1 6
0 0
3 CONSPER 2 GE AND LE
7 10
1 6
0 0
```

Species.rule2 AML

```
; type 1 = char value
; type 2 = num value
;
; we want these 5 classes:
;   1. Decid
;   2. Conifer-Pine
;   3. Conifer-Spruce
;   4. Mixedwood (Decid/Conif, Conif/Decid)
;   5. Mixed Conifer (C-P/C-S, C-S/C-P)
;
```

```
; from the 27 classes from rules1.willmore
; ok, now do the reclass...
; new description field  values
; 1 - deciduous  - c27 = 13, 16, 22, 25
; 2 - conif-pine - c27 = 11, 12, 20, 21
; 3 - conif-sprc - c27 =  5,  6,  8,  9
; 4 - mixedwood  - c27 = 14, 17, 23
; 5 - mixed-con  - c27 = 15
;
1
5 T1 2 EQ OR EQ OR EQ OR EQ
13 16 22 25
11 12 20 21
5 6 8 9
14 17 23 23
15 15 15 15
```

Phase 1 Crown closure rule (P1den.rule)

```
; type 1 = char value
; type 2 = num value
; CLASSIFY.AML Rule file for Phase1 density
;   0 --> 0
;   A --> 1
;   B --> 2
; C,D --> 3
;
1
3 p1den 1 EQ OR EQ
A A
B B
C D
```

Phase 1 Height rule (P1hgt.rule)

```
; type 1 = char value
; type 2 = num value
; CLASSIFY.AML Rule file for Phase1 height
;   0 --> 0
;   1 --> 1
;   2 --> 2
; 3,4 --> 3
;
1
3 p1hgt 2 GT AND LE
0 1
1 2
2 4
```

AVI Crown Closure rule (Avden.rule)

```
; type 1 = char value
; type 2 = num value
; CLASSIFY.AML Rule file for AVI density
;   0 --> 0
;   A --> 1
; B,C --> 2
```

```
;    D --> 3
;
1
3 avden 1 EQ OR EQ
A A
B C
D D
```

AVI Stand Height rule (Avhgt.rule)

```
; type 1 = char value
; type 2 = num value
; CLASSIFY.AML Rule file for AVI height
;      0 --> 0
;    1-9 --> 1
; 10-18 --> 2
;    >18 --> 3
;
1
3 avhgt 2 GT AND LE
0 9
9 18
18 99
```

Appendix 7.2
Confusion AML

```
&args grid1 grid2 cellSize classList:REST

/* Author: Harinder Hans
/*
/*         This procedure creates Confusion matrix and estimates Kappa
/*
/*
/* Input:
/*         grid1 and grid2:       Grids to be compared
/*        cellsize:         Cell size to compare grids
/*         classList:             List of calssification values
/*
/* Output:
/*         Number of cells for both grids
/*         Confusion matrix
/*        Kappa estimate
/*
/*
/*
/*
&if [NULL %grid1%] or [NULL %grid2%] or [NULL %cellsize%] or [NULL %classList%] &then
&do
    &type Usage: &r confusion <grid1> <grid2> <cell size> <list of class velues>
    &return
&end
/* &echo &on
/* &messages &off &all
&set grid1 [translate %grid1%]
&set grid2 [translate %grid2%]

&severity &error &routine anerror

setmask %grid1%
setcell %cellsize%
setwindow %grid1%
&set combineGr aTempGridDel


/* If temporary grid exists then delete it

&if [exists %combineGr% -GRID] &then
      kill %combineGr% all


/* Initilize

&do indGr1 &list [unquote %classList%]
      &if [type %indGr1%] ne -1 &then
      &do
          &type ERROR: %indGr1% is not a valid cell value in grid
          &return
      &end

      &do indGr2 &list [unquote %classList%]
            &set combCount%indGr1%_%indGr2% = 0
      &end
      &set diagTot := 0.0
      &set rowTot%indGr1% := 0.0
      &set columnTot%indGr1% := 0.0
      &set lastElement := %indGr1%
&end
```

```
/* Combine two grids

%combineGr% = combine( %grid1%, %grid2% )


&messages &off &all

/* Determine comfusion matrix

clearselect %combineGr%.vat info
reselect %combineGr%.vat info value ge 0
cursor class declare %combineGr%.vat info ro
cursor class open
&do &while %:class.aml$next%
      &s indGr1 = [value :class.%grid1%]
      &s indGr2 = [value :class.%grid2%]
      &set combCount%indGr1%_%indGr2% = [value :class.count]
      cursor class next
&end
cursor class close
cursor class remove


&messages &on

/* Calculate statistics

&do i &list [unquote %classList%]
      &do j &list [unquote %classList%]
            &set rowTot%i% := [calc [value rowTot%i%] + [value combCount%i%_%j%]]
            &set columnTot%i% := [calc [value columnTot%i%] + [value
combCount%j%_%i%]]
      &end
      &set diagTot := [calc %diagTot% + [value combCount%i%_%i%]]
&end
&set totTotal := 0.0
&do i &list [unquote %classList%]
      &if [value columnTot%i%] gt 0 &then
            &set columnDiagAccuracy%i% := [calc [value combCount%i%_%i%] * 100 / [value
columnTot%i%] ]
      &else
            &set columnDiagAccuracy%i% 0

      &if [value rowTot%i%] gt 0 &then
            &set rowDiagAccuracy%i% := [calc [value combCount%i%_%i%] * 100 / [value
rowTot%i%] ]
      &else
            &set rowDiagAccuracy%i% 0

      &set totTotal := [calc %totTotal% + [value  rowTot%i%]]
&end


&set overallAccuracy := [calc %diagTot% * 100 / %totTotal%]

&set marginalProduct := 0.0
&set diagMarginalSum := 0.0

&do i &list [unquote %classList%]
     &do j &list [unquote %classList%]
           &if [value  rowTot%i%] gt 0 &then
                &set  rowPerc%i%_%j% = [calc [value combCount%i%_%j%] * 100 / [value
rowTot%i%]]
           &else
```

```
                &set  rowPerc%i%_%j% = 0
     &end

     &set  rowMarginal%i% = [calc [value rowTot%i%]  / %totTotal% ]
     &set  columnMarginal%i% = [calc [value columnTot%i%]  / %totTotal% ]
     &set  diagMarginal%i% = [calc [value combCount%i%_%i%]  / %totTotal% ]

     &set  diagMarginalSum = [calc %diagMarginalSum% + [value diagMarginal%i%]]
     &set  marginalProduct = [calc %marginalProduct% + [calc [value rowMarginal%i%] *
[value columnMarginal%i%] ] ]
&end

&set count = 0
&set AverageAccu = 0
&do i &list [unquote %classList%]
     &set AverageAccu = [calc %AverageAccu% + [value rowPerc%i%_%i%]]
     &set count = [calc %count% + 1]
&end
&set AverageAccu = [calc %AverageAccu% / %count%]
&type
&type CELLS SIZE: %cellsize%
&type

&type [unquote [format '%1, -20%' 'CLASS']][unquote [format '%1, -20%'
%grid1%]][unquote [format '%1, -20%' %grid2%]]
&type [unquote [format '%1, -20%' 'VALUE']][unquote [format '%1, -20%'
'CELLS']][unquote [format '%1, -20%' 'CELLS']]
&do i &list [unquote %classList%]
    &type [unquote [format '%1,-20%' [value i]]][unquote [format '%1,-20%' [value
rowTot%i%]]][unquote [format '%1,-20%' [value columnTot%i%]]]
&end


&set firstItem = 1
&set columCount = 1
&set breakCount = 1

&do i &list [unquote %classList%]
     &if %columCount% eq %firstItem% &then
               &set classList%breakCount% = %i%' '
     &else
               &set classList%breakCount% = [unquote [value classList%breakCount%]]%i%'
'

     &set columCount = [calc %columCount% + 1]


     &if %columCount% gt 6 &then
     &do
           &set columCount = 1
           &set classList%breakCount% = [unquote [value classList%breakCount%]]
           &set breakCount = [calc %breakCount% + 1]
           &set classList%breakCount% = NULL
     &end
&end

&if [quote [value classList%breakCount%]] eq 'NULL' &then
     &set breakCount = [calc %breakCount% - 1]
&type breakCount = %breakCount%


&set veryFirstItem [unquote [before %classList% ' ']]

&type
&type
```

```
&type
&type
&type CONFUSION MATRIX:

&do k = 1 &to %breakCount%
     &set lineSeprater '                '
     &set bottomRow1 'CELLS       '
     &set bottomRow2 'ACCURACY     '
     &set topLine '            '
     &type
     &type
     &do i &list [unquote %classList%]
          &set confusionLine [format '%1,-12%' %i%]
          &do j &list  [unquote [value classList%k%]]

               &set confusionLine = [quote [unquote %confusionLine%]   [unquote
[format '%1,-6%' [value rowPerc%i%_%j%]][unquote '%']]]
               &if %i% eq %veryFirstItem% &then
               &do
                   &set topLine = [quote [unquote %topLine%]   [unquote [format '%1,-
7%' %j%]]]
                   &set lineSeprater [quote [unquote %lineSeprater%]----------]
                   &set percColAccu := [calc [value columnMarginal%j%] * 100]
                   &set bottomRow1 = [quote [unquote %bottomRow1%][unquote [format
'%1,-10%' [value columnTot%j%]]]]
                   &set bottomRow2 = [quote [unquote %bottomRow2%][unquote [format
'%1,-8%' [value percColAccu]][unquote '% ']]]
               &end
          &end

          &if %i% eq %veryFirstItem% &then
          &do
               &if %k% eq %breakCount% &then
                    &set topLine [quote [unquote %topLine%]     CELLS   ACCURACY]
               &else
                    &set topLine [quote [unquote %topLine%]]
          &end

          &set percRowAccu := [calc [value rowMarginal%i%] * 100]
          &if %k% eq %breakCount% &then
               &set confusionLine = [quote [unquote %confusionLine%]   [unquote
[format '%1,-7%' [value rowTot%i%]]]   [unquote [format '%1,-7%' [value
percRowAccu]]][unquote '%']]

          &if %i% eq %veryFirstItem% &then
          &do
               &type %topLine%
               &type %lineSeprater%
          &end

          &type %confusionLine%
          &if %i% eq %lastElement% &then
          &do
               &if %k% eq %breakCount% &then
                    &set bottomRow1 = [quote [unquote %bottomRow1%][unquote [format
'%1,-10%' [value totTotal]]]]
               &type %lineSeprater%
               &type %bottomRow1%
               &type %bottomRow2%
          &end
     &end
&end

&type
&type
&type AVERAGE ACCURACY = [unquote [format '%1,-8%' %AverageAccu%]]'%'
```

```
&type OVERALL ACCURACY = [unquote [format '%1,-8%' %overallAccuracy%]]'%'


&set kappa = [calc [calc %diagMarginalSum% - %marginalProduct%] * 100 / [calc 1 -
%marginalProduct%]]
&type KAPPA = [unquote [format '%1,-8%' %kappa%]]'%'
&type
&type
&return

&routine anerror
    &lv
&return &error An error has occurred
```