

RESULTS

Land Cover and Accuracy for Each Landsat Scene

All 14 scenes were successfully classified. The following section displays the results of the land cover classification, the homogenous filtering, and the accuracy assessment for each individual scene. Each scene was classified differently and covers a different geographic area, therefore it is important to report the results of all 14 scenes. Classified scenes 1434 (Figure 11), 1534 (Figure 14), 1634 (Figure 17), 1734 (Figure 20), and 1834 (Figure 22) are shown in color to display the land cover types. These scenes ending in “34” (i.e., Landsat row 34) generally display the largest land area of the rows in Virginia. The rest of the scenes are in black and white, showing land cover patterns.

The number of pixels, acres, hectares, and percentage of each land cover type are presented for each scene. The percent of the original area (i.e., at the every-pixel level) that remain following use of the 3x3 and 5x5 homogeneity filters is also reported. The results of both homogeneity filters are displayed below each classified scene (Figures 11-24). Within the images of the filter results, gray or colored areas show homogeneous pixels (i.e., all cells within either the 3x3 or 5x5 matrix are the same land cover). White areas are heterogeneous cells (i.e., all cells within either the 3x3 or 5x5 matrix are not the same land cover). The heterogeneous cells (white areas) were not evaluated during the corresponding accuracy assessment. The percent of the cells considered homogeneous is listed for each cover type, for both 3x3 and 5x5 assessments.

The purpose of using the 3x3 and 5x5 homogeneity filters was to account for the spatial inaccuracies and extreme variability of the reference land cover data. As a result of these filters, only cells with all the same values in each matrix (i.e., homogeneous)

were kept for evaluation. Only reference points that fell on a homogeneous cell were counted in the accuracy assessment for that respective level. Of course, all pixels and reference points were used in the every-pixel level assessment. The 3x3 and, to a greater extent, the 5x5 filter reduced both the assessable area and the number of available reference points in each scene. The percent of the area remaining in each category is presented.

From the videography flights and SAA photographs, 1773 reference points were obtained across the Commonwealth (Table 5). Due to overlap between scenes, some reference points can be used on more than one image. Eighty-two of the points were from the SAA photos, while the other 1691 were from the videography. The highest percentage of reference points (42.9%) occurs in the deciduous forest category. Herbaceous land cover is the second most abundant with 23.1% of the reference points. The other categories each account for less than 10% of the points. The lowest proportion of points is in coastal wetlands (1.4%), followed by open water (3.8%). Disturbed land was observed within 4.7% of the points. Shrub/scrub accounted for 6.8%. Each of the other forest types (coniferous and mixed) was represented by 8.6% of the points. Overall, slightly over 60% of the accuracy assessment data were of forested points.

The distribution of random reference sites within the SAA photographs was also dominated by deciduous forest and herbaceous land cover (Table 6). Thirty-three of the 82 points were non-random over-sampled points. Over-sampled points were those points deliberately chosen to add representation of land cover types not included in the random sampling. Unfortunately, the land with the SAA photos is dominated by a few cover

Table 5. Number of interpreted reference points in each land cover class. Reference points obtained through the SAA photographs are in parentheses.

Land Cover Class	Number of Reference Points	Proportion of Points
Deciduous Forest	759 (32)	0.428
Coniferous Forest	149 (9)	0.084
Mixed Forest	146 (4)	0.083
Shrub/Scrub	123 (11)	0.069
Herbaceous	416 (19)	0.235
Open Water	70 (1)	0.039
Disturbed	85 (6)	0.048
Wetlands	25	0.014
Total	1773 (82)	1.00

Table 6. Distribution of random and over-sampled reference points interpreted from SAA photographs across land cover categories.

Land Cover Class	Random Points	Over-Sampled Points	Total
Deciduous Forest	31	1	32
Coniferous Forest	1	8	9
Mixed Forest	1	3	4
Shrub/Scrub	3	8	11
Herbaceous	10	9	19
Open Water		1	1
Disturbed Wetlands	3	3	6
Total	49	33	82

types (mostly deciduous forest and herbaceous). These over-sampled points assured some reference information for each land cover category.

The results of the accuracy assessment of each scene for the full pixels, 3x3 homogeneous, and 5x5 homogeneous are shown in Tables 49 to 132. Each assessment consisted of an error matrix, user's and producer's accuracy for each class, overall accuracy, and the Kappa statistic. All of the statistics are derived from the error matrix. The error matrix shows the comparison of each reference point (across the top of the table) to the land cover pixel (listed down the side of the table) at the same geographic position. Overall accuracy is the number of correctly classified reference points divided by the total number of reference points then multiplied by 100 for a percentage expression. User's and producer's accuracy measured the correctness of each category with respect to errors of commission and omission. Accuracy of each class cannot be completely stated in one statistic, both accuracies are needed for a valid assessment. User's accuracy is obtained by dividing the number correctly classified by the total number of pixels, within the classified image, of that class assessed (far right hand column of error matrix). A low user's accuracy represents a high error of commission. Producer's accuracy is calculated by dividing the number of pixels correctly classified by the total number of reference points within that class (bottom row of error matrix). A low Producer's accuracy represents a high error of omission. The Kappa statistic describes the degree of superiority (expressed as a proportion), that the classification results have as compared to a random classification. The range of Kappa is from 0 to 1. The value 1.0 is the highest (i.e., 100% better than random), 0 means that the classification is not any

better than random. The results for each individual scene are presented below. Negative values indicate a systematic erroneous classification.

Scene 1434

This coastal scene contains the Saxis/Chincoteague and Chickahominy study sites. This abundance of training data allowed a relatively easy classification of the haze-corrected satellite imagery (Figure 11). Water was found on over 50% of the area (Table 7). The next most prevalent land cover categories were coniferous forest, herbaceous, and deciduous forest. Each of these covered greater than 10% of the area. This scene also had the greatest amount of coastal wetland (58,967 ha).

The homogeneous area of this scene did not decrease as much as it did on other scenes, following the homogeneous filters. Scene 1434 retained 73.3% (Table 8) and 59.4% (Table 9) of its land area, at the 3x3 and 5x5 homogeneous levels respectively. Mixed forest and shrub were reduced the most by the filtering procedure (i.e., these categories were the most heterogeneous). These types maintained only 0.9% and 10.7% of their original area, respectively, following the 5x5 procedure (Table 9). Two-hundred and thirty reference points were available for the accuracy assessment at the every-pixel level (Table 10). This number was reduced to 131 for the 3x3 level (Table 12) and 88 for the 5x5 level (Table 14). The overall accuracy increased from 62.2%, every-pixel (Table 11), to 79.4%, with the 3x3 filter (Table 13), and finally to 83.0%, with the 5x5 filter (Table 15). All of the individual classes increased in accuracy, both user's and producer's, except for shrub and disturbed, following the filters. Mixed forest user's, shrub producer's, and disturbed user's accuracy were not calculated at the 5x5 level due

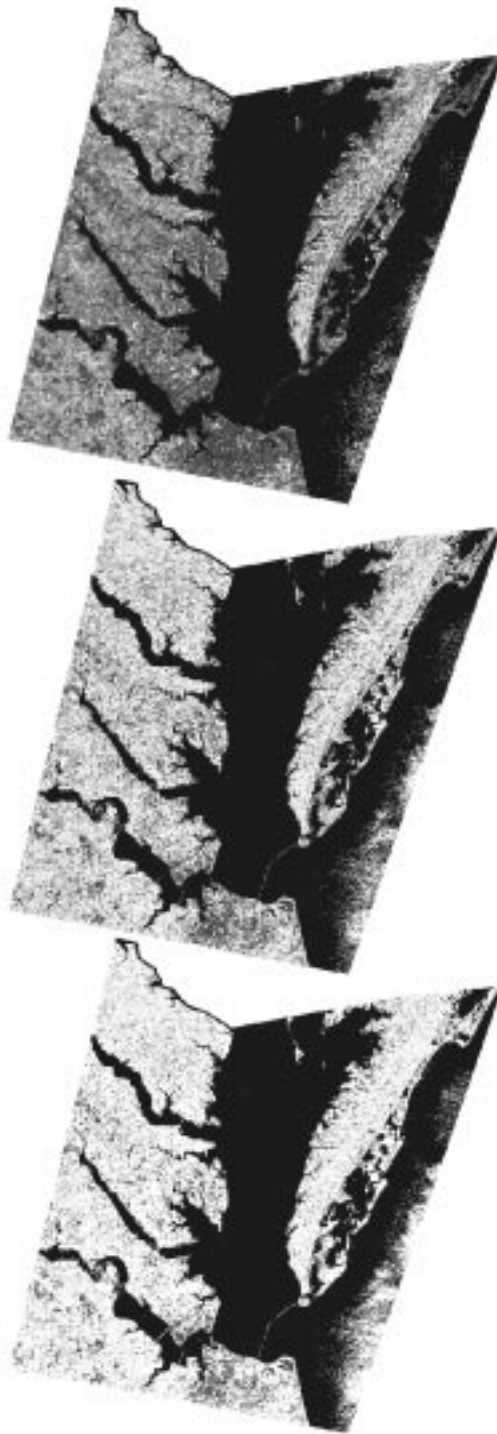


Figure 11. Classification output for scene 1434 full, 3x3 homogeneous, and 5x5 homogeneous.

Table 7. Total area and proportion of each land cover type for scene 1434 when analyzed at the every-pixel level.

	Pixels	Hectares	Acres	Proportion of Total Area
Deciduous Forest	1,905,515	171,496.0	423,767.0	0.106
Coniferous Forest	2,245,627	202,106.0	499,405.0	0.125
Mixed Forest	233,533	21,018.0	51,935.4	0.013
Shrub/Scrub	670,319	60,328.7	149,072.0	0.037
Herbaceous	2,118,741	190,687.0	471,187.0	0.118
Open Water	9,369,265	843,234.0	2,083,631.0	0.520
Disturbed	817,651	73,588.6	181,837.0	0.045
Coastal Wetland	655,186	58,966.7	145,707.0	0.036
Total	18,015,837	1,621,425.0	4,006,542.0	1.000

Table 8. Results of the 3x3 homogeneous filter on land cover types within scene 1434 in area, proportion of total area, and proportion remaining from the 1434 every-pixel level.

	Pixels	Hectares	Acres	Proportion of Total Area	Proportion of Every-Pixel
Deciduous Forest	969,215	87,229.4	215,543.7	0.073	0.509
Coniferous Forest	1,220,566	109,850.9	271,441.7	0.092	0.544
Mixed Forest	20,898	1,880.8	4,647.5	0.002	0.089
Shrub/Scrub	209,556	18,860.0	46,603.2	0.016	0.313
Herbaceous	1,251,942	112,674.8	278,419.4	0.095	0.591
Open Water	8,807,510	792,675.9	1,958,702.0	0.666	0.940
Disturbed	451,615	40,645.4	100,434.7	0.034	0.552
Coastal Wetland	290,165	26,114.9	64,529.8	0.022	0.443
Total	13,221,467	1,189,932.0	2,940,322.0	1.000	0.734

Table 9. Results of the 5x5 homogeneous filter on land cover types within scene 1434 in area, proportion of total area, and proportion remaining from 1434 every-pixel level.

	Pixels	Hectares	Acres	Proportion of Total Area	Proportion of Every-Pixel
Deciduous Forest	475,757	42,818.1	105,803.6	0.044	0.250
Coniferous Forest	667,512	60,076.1	148,448.0	0.062	0.297
Mixed Forest	2,137	192.3	475.2	0.000	0.009
Shrub/Scrub	71,756	6,458.0	15,957.8	0.007	0.107
Herbaceous	719,821	64,783.9	160,081.0	0.067	0.340
Open Water	8,360,918	752,482.6	1,859,385.0	0.780	0.892
Disturbed	275,892	24,830.3	61,355.6	0.026	0.337
Coastal Wetland	136,183	12,256.5	30,285.7	0.013	0.208
Total	10,709,976	963,897.8	2,381,792.0	1.000	0.594

Table 10. Error matrix for scene 1434 at the every-pixel level. Reference data (aerial videography points) are shown as column headings, while actual pixel values are displayed in the left column as row headings. The number of points classified correctly in each cover-type is in bold.

	Deciduous Forest	Coniferous Forest	Mixed Forest	Shrub/ Scrub	Herbaceous	Water Open	Disturbed	Coastal Wetland	Total
Deciduous Forest	35	3	8	2	6			3	57
Coniferous Forest	10	17	6		2	1	3	4	43
Mixed Forest	5				3	1	1		10
Shrub/Scrub	3	5	2	6	3			2	21
Herbaceous			1	1	29		2	2	35
Open Water						45			45
Disturbed			1				2	3	6
Coastal Wetland								9	9
Other						3		1	4
Total	53	25	18	9	43	50	8	24	230

Table 11. User's and producer's accuracy for each land cover class, along with overall accuracy and the Kappa statistic, for scene 1434 at the every-pixel level.

	User's	Producer's
Deciduous Forest	0.614	0.660
Coniferous Forest	0.395	0.680
Mixed Forest	0.000	0.000
Shrub/Scrub	0.286	0.667
Herbaceous	0.829	0.674
Open Water	1.000	0.900
Disturbed	0.333	0.250
Coastal Wetland	1.000	0.375
Overall Accuracy	0.622	
Kappa	0.602	

Table 12. Error matrix for scene 1434 at the 3x3 homogeneous level. Reference data (aerial videography points) are shown as column headings, while actual pixel values are displayed in the left column as row headings. The number of points classified correctly in each cover-type is in bold. The number of reference points for each category that falls on non-homogeneous pixels is shown in the last row.

	Deciduous Forest	Conifer Forest	Mixed Forest	Shrub/ Scrub	Herbaceous	Open Water	Disturbed	Coastal Wetland	Total
Deciduous Forest	20	1	2		2			1	26
Coniferous Forest	3	14	6			1	1	1	26
Mixed Forest									0
Shrub/Scrub	2	5	1	3					11
Herbaceous					21		1		22
Open Water						41			41
Disturbed									0
Coastal Wetland								5	5
Other									0
Total	25	20	9	3	23	42	2	7	131
Non-Homogeneous	28	5	9	6	20	8	6	17	99

Table 13. User's and producer's accuracy for each category, along with overall accuracy and Kappa statistic, for scene 1434 at the 3x3 homogeneous level.

	User's	Producer's
Deciduous Forest	0.769	0.800
Coniferous Forest	0.538	0.700
Mixed Forest		0.000
Shrub/Scrub	0.273	1.000
Herbaceous	0.955	0.913
Open Water	1.000	0.976
Disturbed		0.000
Coastal Wetland	1.000	0.714
Overall Accuracy	0.794	
Kappa	0.775	

Table 14. Error matrix for scene 1434 at the 5x5 homogeneous level. Reference data (aerial videography points) are shown as column headings, while actual pixel values are displayed in the left column as row headings. The number of points correctly classified in each cover-type is in bold. The number of reference points for each category that falls on non-homogeneous pixels is shown in the last row.

	Deciduous Forest	Coniferous Forest	Mixed Forest	Shrub/ Shrub	Herbaceous	Open Water	Disturbed	Coastal Wetland	Total
Deciduous Forest	7		1		1			1	10
Coniferous Forest		10	6						16
Mixed Forest									
Shrub/Scrub		4	1						5
Herbaceous					12		1		13
Open Water						40			40
Disturbed									0
Coastal Wetland								4	4
Other									0
Total	7	14	8	0	13	40	1	5	88
Non-Homogeneous	46	11	10	9	30	10	7	19	142

Table 15. User's and producer's accuracy for each land cover class, along with overall accuracy and Kappa statistic, for scene 1434 at the 5x5 homogeneous level.

	User's	Producer's
Deciduous Forest	0.700	1.000
Conifer Forest	0.625	0.714
Mixed Forest		0.000
Shrub/Scrub	0.000	
Herbaceous	0.923	0.923
Open Water	1.000	1.000
Disturbed		0.000
Coastal Wetland	1.000	0.800
Overall Accuracy	0.830	
Kappa	0.797	