Satellite Comparison for Riparian Corridor Analysis

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National Science Foundation – 2004 Research Experience for Undergraduates, Oklahoma State University

Introduction

The Oklahoma Conservation Commission (OCC) has a finite amount of monies available to implement best management practices (BMP's) throughout Oklahoma watersheds. In an effort to more efficiently use the funds, the OCC is quantitatively targeting areas with the highest potential for water quality improvement. The study watershed is Turkey Creek which lies in Northwest Oklahoma within Alfalfa, Major, Garfield, and Kingfisher Counties. The primary agricultural land covers of the watershed are wheat and pasture.

Figure 1. Oklahoma with Turkey Creek watershed identified in black.

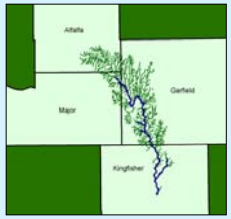


Figure 2. Turkey Creek perennial (—) and intermittent (—) streams.

The first step in watershed BMP targeting is to obtain land usages. This is typically accomplished using aerial photographs or satellite imagery. Two types of satellite images, SPOT 5 and Landsat 7, and aerial photographs were evaluated for this study. The Landsat satellites, which have 30 meter multispectral resolution, are a joint mission between the U. S. Geological Survey and the National Aeronautics and Space Administration. The SPOT (Satellite Pour l'Observation de La Terre) satellites, which have 10 meter multispectral resolution, are funded through Centre National D'Etudes Spatiales, the French space agency.

Objectives

Compare accuracy of SPOT 5 and Landsat 7 imagery to identify critical sources of erosion in the riparian corridor of the perennial streams.

- Compare land cover percentages between images
- Develop method to quantify misclassified areas
- Generate images to illustrate location and magnitude of errors
- Perform cost comparison
- Evaluate riparian corridor width for impacts on accuracy

Methodology

The accuracy of the available stream data was evaluated. Initially, stream data from the National Hydrography Dataset (NHD) were used to differentiate perennial and intermittent streams. However, these data were clearly mislabeled because all streams in Major County were identified as perennial. To reconcile this issue, Digital Raster Graphs (DRGs) were used to modify the NHD data. The perennial streams were manually adjusted to the aerial photographs to account for stream migration.

The aerial photography was used to digitize land cover within the ninety meter riparian buffer. Twenty four hundred hectares of land area were digitized. The seven land cover categories were: water, shrub, bare soil, crop, forest, pasture, and urban. Ground truthing guided the manual classification process. Ninety, 60, and 30 meter riparian buffer layers were created based on the updated perennial GIS layer.

Applied Analysis, Inc. (AAI) obtained raw Landsat 7 and SPOT 5 satellite images and performed an unsupervised land cover classification on both. Once the two satellite images were georeferenced, the three buffers were clipped. Table 1 shows the costs per scene and processing costs for this study. Figure 3 is a cost analysis of all three imagery types based on study size.

Image type	Raw imagery cost per scene	Processing cost	Number of scenes	Total cost
Aerial Photography	$9,000	$2,600	N/A	$11,600
Landsat 7	$600	$20,000	1	$20,600
SPOT 5	$7,000	$30,000	2	$44,000

Table 1. Associated Imagery Costs for Turkey Creek Study

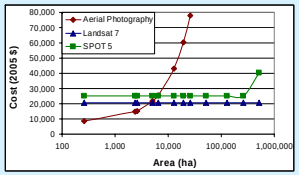
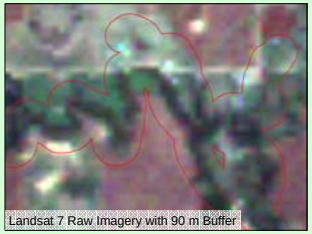
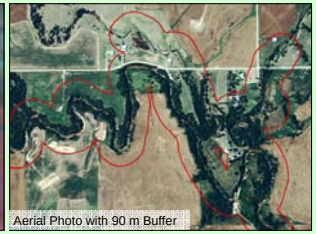


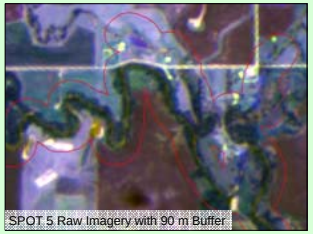
Figure 3. Total Cost Comparison for Three Imagery Types.



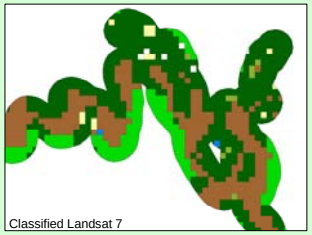
Landsat 7 Raw Imagery with 90 m Buffer



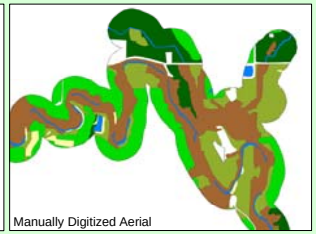
Aerial Photo with 90 m Buffer



SPOT 5 Raw Imagery with 90 m Buffer



Classified Landsat 7

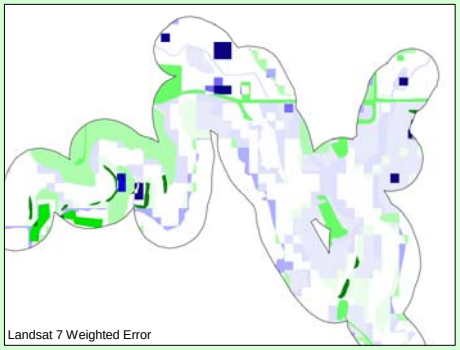


Manually Digitized Aerial

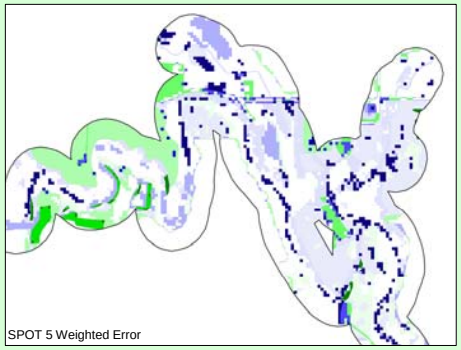
Classified SPOT 5

Turkey Creek, Oklahoma

Turkey Creek, Oklahoma



Landsat 7 Weighted Error

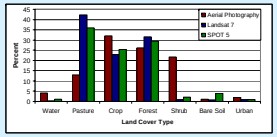


SPOT 5 Weighted Error

Results

Area Calculations: Land cover areas were calculated and summed for each land classification for all three image types: aerial photography, Landsat 7 and SPOT 5 (Figure 4). The unsupervised classification of the satellite images resulted in similar land cover percentages compared to the manual classification of the aerial photography.

Figure 4. Comparison of each imagery's land cover percentages for a 90 meter buffer.



Percent Land Covers: The digitized layer of the aerial photography was assumed to be correct. This truth layer was used as the basis for the error calculations. To identify the amount of area misclassified by each satellite, Arc View's tabulate area function was used. This returned a contingency table displaying the area of the riparian zone in each classification. For example, Table 2 shows that out of the entire 90 meter buffer, 7.0% was forest and classified by Landsat 7 as pasture, while 3.6% was forest and classified by SPOT 5 as pasture. If all of the correct classifications are summed, Landsat 7 total accuracy is 45% while SPOT 5 total accuracy is 50%. Temporally coincidental effects such as variations between climate and season are sources of error.

(a)

Truth	Landsat 7 Satellite							
	Crop	Pasture	Shrub	Forest	Urban	Bare Soil	Water	Total
Crop	17.66	10.03	0.19	3.53	0.42	0.14	0.06	32.02
Pasture	0.57	9.93	0.20	1.98	0.08	0.16	0.04	12.96
Shrub	2.06	12.90	0.24	5.89	0.23	0.25	0.08	21.65
Forest	1.98	7.00	0.13	16.90	0.09	0.10	0.05	26.25
Urban	0.21	1.13	0.08	0.26	0.14	0.03	0.02	1.88
Bare Soil	0.17	0.50	0.02	0.42	0.01	0.05	0.02	1.18
Water	0.32	0.91	0.02	2.67	0.02	0.07	0.04	4.06
Total	**22.96**	**42.41**	**0.88**	**31.65**	**0.98**	**0.80**	**0.32**	**100.00**

(b)

Truth	SPOT 5 Satellite							
	Crop	Pasture	Shrub	Forest	Urban	Bare Soil	Water	Total
Crop	16.52	10.34	0.15	1.32	0.17	0.46	0.03	31.00
Pasture	0.77	9.13	0.59	1.91	0.06	0.52	0.02	13.00
Shrub	2.00	11.52	0.96	5.95	0.19	0.88	0.24	21.74
Forest	1.25	3.60	0.38	19.75	0.05	0.86	0.22	26.10
Urban	0.30	0.87	0.01	0.05	0.45	0.21	0.01	1.90
Bare Soil	0.53	0.32	0.01	0.09	0.02	0.13	0.09	1.19
Water	1.34	0.56	0.02	0.80	0.01	0.88	0.47	4.09
Total	**25.70**	**36.35**	**2.13**	**29.87**	**0.95**	**3.94**	**1.07**	**100.00**

Table 2. Percents of 90 meter riparian buffer classified by truth and either Landsat 7 (a) or SPOT 5 (b). Differences in the total area column are due to cloud cover in the SPOT data.

Weighting Factors: Next, sediment yields were used as weighting factors in an error matrix to emphasize the difference in magnitude between errors (Table 3). Sediment yields for shrub, pasture, water, and urban were based on Storm et al. (2003b), and sediment yields for crop, forest, and bare soil were based on Storm et al. (2003a) and Haan et al. (1994).

Truth	Satellite Imagery						
	Crop (6.38)	Pasture (0.40)	Shrub (0.20)	Forest (0.01)	Urban (13.3)	Bare Soil (28.7)	Water (0.00)
Crop (6.38)[a,b]	0	5.98	6.18	6.37	-6.92	-22.3	6.38
Pasture (0.40)[c]	-5.98	0	0.2	0.39	-12.9	-28.3	0.4
Shrub (0.20)[c]	-6.18	-0.2	0	0.19	-13.1	-28.5	0.2
Forest (0.01)[b]	-6.37	-0.39	-0.19	0	-13.3	-28.7	0.01
Urban (13.3)[d]	6.92	12.9	13.1	13.3	0	-15.4	13.3
Bare Soil (28.7)[d]	22.3	28.3	28.5	28.7	15.4	0	28.7
Water (0.00)	-6.38	-0.4	-0.2	-0.01	-13.3	-28.7	0

Table 3. Error matrix, in Mg/ha, with sediment yields in parenthesis.
[a] Land cover (weighting factor in units of Mg/ha)
[b] Storm et al. 2003a
[c] Storm et al. 2003b
[d] Haan et al. 1994

Weighted Errors: When the error matrix in Table 3 is multiplied by Table 2, area weighted errors result. The net sum represents each satellite's error in sediment yield. Landsat 7 under predicts sediment while SPOT 5 over predicts sediment for all buffer widths (Table 4).

Table 4. Sediment prediction differences, in Mg/ha, based on area weighted errors.

Image Type	Buffer Width		
	30 meter	60 meter	90 meter
Landsat 7	0.12	0.49	0.73
SPOT 5	-2.00	-0.84	-0.32

Conclusions

- Landsat 7 is a better satellite option compared to SPOT 5 based on accuracy and cost.
- Manual classification cost is proportional to area, while satellite imagery classification cost remains constant assuming a fixed image number. Therefore,
  - Areas < 5000 ha, aerial images are recommended
  - Areas > 5000 ha, Landsat 7 images are recommended.
- There was not enough available data to make substantial conclusions regarding riparian corridor width effects on accuracy. It was determined that the accuracy was driven more by the size and type of features rather than the width of the buffer.

Acknowledgements

Funding provided by the National Science Foundation. Special thanks to Dr. Michael Myers, Dr. Thomas Wikle, and Bruce Battles from the OSU Geography Department. Also, thanks to Scott Stoodley at AAI and Dan Butler with the OCC. Finally, this project could not have been completed without support from the OSU Biosystems and Agricultural Engineering Department.

References

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3. Haan, C.T., B.J. Barfield and J.C. Hayes. 1994. *Design Hydrology and Sedimentology for Small Catchments.* San Diego: Academic Press.