Assessment of *Willamette Valley Land Use / Land Cover Map* Accuracy for Portions of Seven Counties, Willamette Valley, Oregon

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Introduction

Accuracy assessment of landscape maps generated from remote-sensed data is currently practiced using a variety of techniques. Error in mapping can be generated in several ways; error in thematic classification, both by omission and by misclassification (commission) (Story and Congalton 1986), as well as error in cartographic delineation (location error). When attempting accuracy assessment of a mapping project, further error can be introduced by improper sampling and interpretation of statistical findings. Early on, investigators developed the confusion or error matrix, which permitted the calculation of simple test sample ratios: The number of land use classes incorrectly depicted divided by the number of correctly depicted land use classes (confirmed by field verification) (van Genderen et al. 1978, Fitzpatrick-Lins 1981). Since those efforts, a great variety of error matrix interpretations and new error metrics have been presented in the literature. The most important contributions of recent work have been the increase in statistical rigor and the decrease in confidence intervals of accuracy findings (Richards 1996).

Determination of the classification error in maps is accomplished by using an *a priori* target level for thematic map accuracy and designing the assessment procedure (number of sampling points, etc.) based on statistical parameters (Fitzpatrick-Lins 1981). There are various methods for setting the number of sample points, from the stratified systematic unaligned sampling technique (Rosenfield et al. 1982) to statistically derived sampling levels that are based on the assumption that the samples have normal distributions (Hord and Brooner 1976). Other options include decision-rules processes which can incorporate land-use class stratification, class abundance weighting, and differential sampling effort.

Study Area

The study area is located in the Willamette Valley which is in the northwestern region of Oregon. Portions of seven counties in Oregon were included in the mapping effort: Benton, Clackamas, Lane, Linn, Marion, Polk, and Yamhill. Portions of the Coast Range to the west and the Cascade Range on the eastern edge of the Willamette Valley were included in the mapping.

Methods

The Ecological Analysis Center of the Oregon Department of Fish and Wildlife utilized remote sensed data and ground reconnaissance to create habitat-based vegetation and land use cover class maps for the majority of the Willamette Valley, OR. The accuracy of the Willamette Valley maps was determined by field verification of sample points located in each county. The optimum number of sample points (random locations, 20 for each class, in each county) was based on tables with sample data represented as x = 1 for a correct interpretation and x = 0 where the map interpretation is found to be incorrect. Consequently, x has the probability density function for a single observation:

$$f(x) = p^{x} (1 - p)^{1-x}, \; 0 \leq p \leq 1, \; x = 0,1 \qquad (1)$$

(Rosenfield et al. 1982). With prior probability estimates we can establish sampling levels based on the cumulative binomial probability that are bracketed with confidence intervals:

$$P_B = {}^{n - k(n) - 1}\Sigma_{s = 0}\, C_s^{\,n}\, p_o^{\,n - s}(1 - p_o)^s \qquad (2)$$

where n = sample size, k(n) = largest integer less than or equal to n(po + *E*), *E* = the error of the estimate (the maximum error we can tolerate), and p_o = the *a priori* value based on experiential knowledge.

In order to determine relative sample size for each land cover class per county, the proportion of total county area for each land cover class was calculated. Any land cover class with fewer than 15 occurrences/county and a proportion of the total mapped county area ≤ 0.0015 was assessed for classification accuracy by examination of sample points from all of the polygons for that land cover class occurring on the for that county.

Each county map was stratified by creating a sampling buffer of ≤ 0.5 km from public road access. Map accuracy assessment data was recorded as vegetation/land use class (from remote-sensed data) versus actual vegetation/land use class for each sample point. Each sample point was ranked (0–5) according to the field investigator’s confidence in visual access and correct classification of vegetation/land use for the sample point.

An error matrix was generated for the Willamette Valley, OR, along with an analysis of each vegetation/land-use class accuracy and error type (Fig. 1.). Overall accuracy was calculated by dividing the matrix diagonal value by the total number of sample points. Vegetation/land use class accuracy (the number of correctly classified sample points for each class divided by the total points sampled for each class) was determined for the entire mapped area. Map accuracy is also presented as user’s (matrix diagonal values divided by matrix row totals) and producer’s (matrix diagonal values divided by matrix column totals) values for each class which are the converse of commission and omission error respectively.

Confidence Metrics

Map accuracy assessment can be handicapped by limitations in field verification procedures i.e., limited access to sample points can introduce error into the assessment; and there is a chance that interpretation of land use class will not be equivalent between the map producer and those performing the map accuracy assessment.

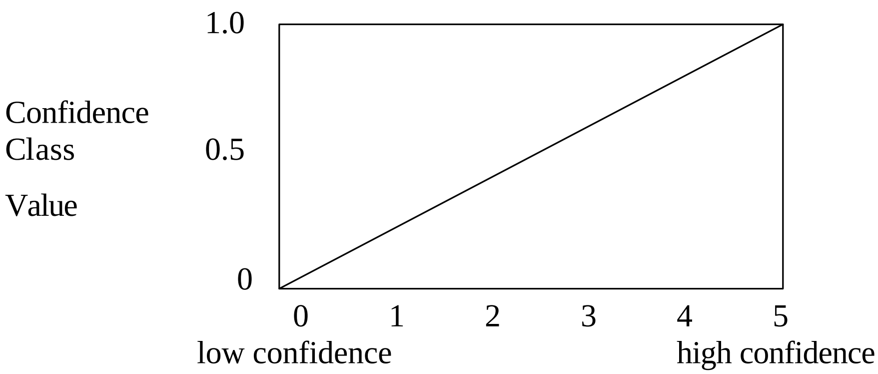
A confidence value was recorded for each sample point ranging from 0 to 5, with 5 representing absolute confidence in the finding. These integer confidence values for each sample point were based on linguistic information:

0 = no access to sample point

1 = very low confidence; very limited access to sample point or map class a very poor match to field-verified class
2 = low confidence; access incomplete or map class a poor match to field-verified class
3 = location of sample point not easily determined, field verification of class based on proximate class or problems with class match to map class
4 = confidence high in field-verification of sample point location and class match
5 = sample point is acquired and matches map class designation

The confidence values of 1, 2, 3, and 4 can be interpreted in two ways, either the access to the sample point was limited or the correspondence of the sample point class to the map class was questionable, whereas a confidence value of 5 reflects high confidence in correct classification and sample point capture. Additional field notes were recorded for factor(s) contributing to confidence values ≥ 3.

We generated a new value for each of the 5 confidence ranks by transformation of the linguistic information to values ranging form 0 to 1 with a simple linear function (monotonic function):



The new confidence class values (y axis) are now:

x	y
0 =	0
1 =	0.19
2 =	0.38
3 =	0.58
4 =	0.75
5 =	1.0

The new confidence class values can now be used to calculate a new set of values for map accuracy. Confidence class values are factored into the proportion that each confidence value contributed to the total individual vegetation/land use class sample. A new metric (Derived Accuracy Assessment Values (DAAV) consists of the weighted average overall accuracy value calculated for each vegetation/land use class (Table 1). For example, vegetation/land use class 1000.0 had 57 sample points, of which 56 were correct (had a confidence value of 5). The proportion of confidence value 5 of the total is 56/57 = 0.98. The value for confidence 5 is 1.0 so the class accuracy is the percentage of correct sample points in the class (56/57)(1.0)x100 = 98%). For a confidence value of 5 for vegetation/land use class 1000.0 the DAAV is 0.98(98%) = 96 %. The DAAV for the confidence value of 5 is then combined into an overall value based on the weighted average of all confidence values (overall vegetation/land use class accuracy = confidence value accuracy percentage x proportion of vegetation/land use class data for confidence value). The separate overall vegetation/land use class DAAV map accuracy's were averaged for a Willamette Valley accuracy value.

Results

The overall habitat map accuracy of 81 % was based on the field verification of 2319 sample points throughout portions of seven counties in the Willamette Valley, OR.
One hundred fifty five sample points (6 %) were not accessible and were not used in the analysis. Individual vegetation/land use class user's accuracy's ranged 56 – 98 %, and individual vegetation/land use class producer's accuracy's ranged 43 – 100 % (Fig. 1.).

Confidence Metrics

The derived accuracy assessment value for the Willamette Valley Land Use / Land Cover map ranged from 37 – 90 % and the average of the individual vegetation/land use class derived accuracy assessment value was 69 %, based on the field verification of 2319 sample points throughout portions of seven counties in the Willamette Valley, OR (Table 1).

Discussion

The assessment of map accuracy by field verification could benefit from methods which increase the precision of sample point capture. This could be accomplished by tagging the sample points with location information (UTMs or Latitude and Longitude) which could be targets for the field verification. Global Positioning System units could help in assessing variability encountered in accessing sample points. Proximity to sample point could be quantified (GPS error incorporated) and used in the determination of map accuracy.

Derived confidence metrics for this project appear to have made a significant difference in the map accuracy values calculated for the Willamette Valley habitat maps. A further improvement would be to record separate confidence ranks for location and categorical (class) error. Further tests incorporating confidence metrics into map accuracy assessment should be made on a variety of types of remote-sensed data representing diverse geographic regions.

References

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Table 1. Results of accuracy assessment of Willamette Valley Land Use / Land Cover map classifications for portions of seven counties in the Willamette Valley, OR. 1998.

Veg/land Class	Total	Number Correct	Producers Accuracy (%)	Users Accuracy (%)	DAAV
2.1	108	80	76	74	67
2.2	109	61	71	56	51
2.3	112	85	59	76	64
2.4	116	95	84	82	76
2.5	114	100	64	88	73
2.6	82	61	97	73	66
3.0	115	111	87	97	90
9.0	99	84	96	85	58
20.0	106	83	76	77	59
21.0	111	103	95	93	71
21.3	11	9	90	82	43
22.0	88	65	93	74	53
30.0	104	93	89	88	70
31.0	63	42	95	67	37
39.0	17	13	100	77	49
463.0	115	98	80	84	64
463.3	34	24	86	71	60
476.0	116	82	98	71	59
476.3	46	30	97	64	54
505.0	118	92	78	78	60
505.3	58	38	78	66	54
506.0	56	46	42	81	73
510.0	113	99	77	88	70
510.3	31	30	87	97	82
512.0	113	101	88	88	66
512.3	48	35	95	73	52
999.0	59	53	97	90	66
1000	57	56	84	97	61

classes	2.1	2.2	2.3	2.4	2.5	2.6	3.0	9.0	20.0	21.0	21.3	22.0	30.0	31.0	39.0	463.0	463.3	476.0	476.3	505.0	505.3	506.0	510.0	510.3	512.0	512.3	999.0	1000.0		totals
2.1	80	12	11	1	3		1																							108.0
2.2	12	61	28	3	5																									109.0
2.3	2	5	85	4	12		2		2																					112.0
2.4	1	2	5	95	11		1		1																					116.0
2.5	2	2	2	3	100		1	1	3																					114.0
2.6				1	5	61	6													9										82.0
3.0	1					1	111									1											1			115.0
9.0	1	1	6	1				84	2				1							1			1		1					99.0
20.0	1		3	1	5		4		83	1		1				3							2		2					106.0
21.0							1			103	1	1				1							4							111.0
21.3											9						1						1							11.0
22.0	1	2	2	2	5				4			65				7														88.0
30.0	1	1	1		3			1	1				93	1		2														104.0
31.0									8			1	10	42		1			1											63.0
39.0				1	1							1	1		13															17.0
463.0	1		1		1					2						98	1					1	10							115.0
463.3																1	24						5	3				1		34.0
476.0	1		1		4				1							2		82		11		9	2	1	2					116.0
476.3																		1	30		8	7								46.0
505.0					1											4				92		19			1			1		118.0
505.3							1														38	10				2		7		58.0
506.0																		1				46	4	0	5					56.0
510.0					1				1	2						3				1		4	99		2					113.0
510.3																								30	1					31.0
512.0									1											4		6	1		101					113.0
512.3	1			1		1											2				2	4				35		2		48.0
999.0								2	2	1				1													53			59.0
1000.0									1																			56		57.0
totals	105.0	86.0	145.0	113.0	157.0	63.0	128.0	88.0	110.0	109.0	10.0	69.0	105.0	44.0	13.0	123.0	28.0	84.0	31.0	118.0	48.0	106.0	129.0	34.0	115.0	37.0	54.0	67.0	2319.0	2319.0

Error Matrix Analysis

Overall accuracy = dia tot/tot points sampled 1869/2319 = 0.81

	2.1	2.2	2.3	2.4	2.5	2.6	3.0	9.0	20.0	21.0	21.3	22.0	30.0	31.0	39.0	463.0	463.3	476.0	476.3	505.0	505.3	506.0	510.0	510.3	512.0	512.3	999.0	1000.0	Total
dia totals	80.0	61.0	85.0	95.0	100.0	61.0	111.0	84.0	83.0	103.0	9.0	65.0	93.0	42.0	13.0	98.0	24.0	82.0	30.0	92.0	38.0	46.0	99.0	30.0	101.0	35.0	53.0	56.0	1869.0
col totals	105	86	145	113	157	63	128	88	110	109	10	69	105	44	13	123	28	84	31	118	48	106	129	34	115	37	54	67	2319
row totals	108	109	112	116	114	82	115	99	106	111	11	88	104	63	17	115	34	116	46	118	58	56	113	31	113	48	59	57	2319

producers accuracy = dia tot/col tot

	2.1	2.2	2.3	2.4	2.5	2.6	3.0	9.0	20.0	21.0	21.3	22.0	30.0	31.0	39.0	463.0	463.3	476.0	476.3	505.0	505.3	506.0	510.0	510.3	512.0	512.3	999.0	1000.0
	0.762	0.709	0.586	0.841	0.637	0.968	0.867	0.955	0.755	0.945	0.9	0.942	0.886	0.955	1	0.797	0.857	0.976	0.968	0.78	0.792	0.434	0.767	0.882	0.878	0.946	0.981	0.836

users accuracy = dia tot/row tot

	2.1	2.2	2.3	2.4	2.5	2.6	3.0	9.0	20.0	21.0	21.3	22.0	30.0	31.0	39.0	463.0	463.3	476.0	476.3	505.0	505.3	506.0	510.0	510.3	512.0	512.3	999.0	1000.0
	0.741	0.56	0.759	0.819	0.877	0.744	0.965	0.848	0.783	0.928	0.818	0.739	0.894	0.667	0.765	0.852	0.706	0.707	0.652	0.78	0.655	0.821	0.876	0.968	0.894	0.729	0.898	0.982

Figure 1.