Map accuracy assessment

- How to assess the accuracy of a map
- Issues we face when evaluating accuracy
- Field data collection – sample methods
- Different measurements of accuracy
MAP

ACCURACY ASSESSMENT

THIS MAP IS "GOOD ENOUGH"!

WHAT IS "GOOD ENOUGH"?

MAY BE GOOD ENOUGH FOR YOU!
IS NEEDED WHEN WE WANT TO COMPARE

* A MAP AND THE REALITY
* TWO DIFFERENT MAPS

NO WORRIES! ACCORDING TO THE MAP THERE IS A PUB 10M AWAY

KNOWLEDGE ABOUT MAP QUALITY IS ESSENTIAL!
REMEMBER!

GARBAGE IN — GARBAGE OUT

GIS
Field Sampling

THE (FIELD) SAMPLING IS VERY IMPORTANT

THE SAMPLE (TO REDUCE DATA AND COSTS)
HAS TO BE

- REPRESENTATIVE OF THE POPULATION
- RANDOMLY CHOSEN?
- COMPLETE (WE HAVE TO MINIMIZE DROP-OUT)
- POSSIBLE / PRACTICAL TO COLLECT
The size of the sample point has to be bigger than the error in positioning.

For positioning in field: use GPS!
HOW DO WE SELECT SAMPLING POINTS?

THE MORE SAMPLING POINTS THE BETTER!

IF POSSIBLE 50 IN EACH CLASS TO AVOID RISK OF A BIASED SAMPLE (OVERREPRESENTATION OF CORRECT OR NON-CORRECT POINTS)

IF SMALL SAMPLE, INCREASED RISK OF TYPE I ERROR: REJECTING A CORRECT MAP TYPE II ERROR: ACCEPTING A "BAD" MAP

NOTE: IF "TRUE TOTAL ACCURACY" = 0.9 AND N=100 "ESTIMATED TOTAL ACCURACY" = 0.83–0.94
Different sample designs

The sample has to be representative!

Different sample designs:

Simple random sampling: Each element has an equal chance of being selected
- Many points are needed to get 50 in each class
- "Very" representative

Systematic sampling: Elements are selected at some equal interval over space
- No equal chance of being selected
- Uniform spread of points

Stratified random sampling: Allocation into sub-populations (strata), and then random sampling in each stratum
- How to stratify? No equal chance of being selected
- Less points are needed to get 50 in each class
Different sample designs

**ROAD SAMPLING:** Systematic sampling in space or time along a number of (randomly selected) roads

- Not at all representative
- Fast

**TRANSECT SAMPLING:** Random selection of starting point and direction then systematic sampling in space or time

- Not representative
- Relatively fast (depending on terrain)

tfoot

* WE RECOMMEND SIMPLE RANDOM SAMPLING OR STRATIFIED RANDOM SAMPLING! 

I’LL CHECK THIS POINT!
Assessment of Classification Accuracy

- Most common form of expressing classification accuracy is the error matrix (confusion matrix or contingency table).

- Error matrices compare, on a class-by-class basis, the relationship between known reference data (ground truth) and the corresponding results of the classification procedure.
Assessment of Classification Accuracy

Simple error matrix

Realistic error matrix
Overall and Individual Class Accuracy

- **Overall / Total Accuracy**
  - Computed by dividing the total number of correctly classified pixels (i.e., the sum of the elements along the major diagonal) by the total number of reference pixels.

- **Individual Class Accuracy**
  - Calculated by dividing the number of correctly classified pixels in each category by either the total number of pixels in the corresponding column; **Producer’s accuracy**, or row; **User’s accuracy**.
Overall / Total accuracy

\[
(3 + 5) / 12 = 67%
\]

**TABLE 7.3 Error Matrix Resulting from Classifying Training Set Pixels**

<table>
<thead>
<tr>
<th>Classification Data</th>
<th>W</th>
<th>S</th>
<th>F</th>
<th>U</th>
<th>C</th>
<th>H</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row Total</td>
<td>480</td>
<td>68</td>
<td>356</td>
<td>248</td>
<td>402</td>
<td>438</td>
<td>1992</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column Total</th>
<th>480</th>
<th>52</th>
<th>313</th>
<th>126</th>
<th>342</th>
<th>359</th>
<th>481</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer's Accuracy</td>
<td>W  = 480/480 = 100%</td>
<td>S  = 052/068 = 76%</td>
<td>F  = 313/356 = 88%</td>
<td>U  = 126/248 = 51%</td>
<td>C  = 342/402 = 85%</td>
<td>H  = 359/438 = 82%</td>
<td></td>
</tr>
<tr>
<td>User's Accuracy</td>
<td>W  = 480/485 = 99%</td>
<td>S  = 052/072 = 72%</td>
<td>F  = 313/353 = 87%</td>
<td>U  = 126/142 = 89%</td>
<td>C  = 342/459 = 74%</td>
<td>H  = 359/481 = 75%</td>
<td></td>
</tr>
<tr>
<td>Overall accuracy</td>
<td>(480 + 52 + 313 + 126 + 342 + 359)/1992 = 84%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*W, water; S, sand; F, forest; U, urban; C, corn; H, hay.*
Producer’s Accuracy

- Producers Accuracy (Omission Errors)
  - Results from dividing the number of correctly classified pixels in each category (on the major diagonal) by the number of reference pixels “known” to be of that category (the column total)
  - This value represents how well reference pixels of the ground cover type are classified
Producer accuracy

**To estimate accuracy we need an error matrix (also called confusion matrix)**

<table>
<thead>
<tr>
<th>Ground Truth</th>
<th>Class I</th>
<th>II</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAP DATA</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>MAP</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>8</td>
<td>12</td>
</tr>
</tbody>
</table>

**Back to the error matrix and measurements of map accuracy**

- **User/Object accuracy**: For each class, the probability that a randomly chosen point on the map has the same class value in field.
  - For Class I (Land): \( \frac{3}{6} = 50\% \)
  - For Class II (Sea): \( \frac{6}{6} = 83\% \)

- **Producer/Classification accuracy**: For each class, the probability that a randomly chosen point in field has the same class value on the map.
  - For Class I (Land): \( \frac{5}{6} = 75\% \)
  - For Class II (Sea): \( \frac{6}{6} = 62\% \)

**The diagonal represents correctly mapped sampling points**

- A denote the number of correctly mapped points
- B denote the number of “Ground Truth Points”
- C denote the number of “Map Data Points”
- N denote the total number of points

- **Class I (Land)**: \( A = 3, B = 5, C = 6, N = 12 \)
- **Class II (Sea)**: \( A = 4, B = 8, C = 6, N = 12 \)
### Producer’s Accuracy

**TABLE 7.3** Error Matrix Resulting from Classifying Training Set Pixels

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<tbody>
<tr>
<td>W</td>
<td>480</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>485</td>
</tr>
<tr>
<td>S</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>72</td>
</tr>
<tr>
<td>F</td>
<td>0</td>
<td>0</td>
<td>313</td>
<td>40</td>
<td>0</td>
<td>0</td>
<td>353</td>
</tr>
<tr>
<td>U</td>
<td>0</td>
<td>16</td>
<td>0</td>
<td>126</td>
<td>0</td>
<td>0</td>
<td>142</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>38</td>
<td>342</td>
<td>79</td>
<td>459</td>
</tr>
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<td>H</td>
<td>0</td>
<td>0</td>
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**Notes:**
- W, water; S, sand; F, forest; U, urban; C, corn; H, hay.

**24% Omission error**
User’s Accuracy

- **Users Accuracy (Commission Error)**
  - computed by dividing the number of correctly classified pixels in each category by the total number of pixels that were classified in that category (the row total)
  - Represents the probability that a pixel classified into a given category actually represents that category on the ground.
User accuracy

To estimate accuracy we need an error matrix (also called confusion matrix).

The diagonal represents correctly mapped sampling points. We can let:

- A denote the number of correctly mapped points
- B denote the number of “ground truth points”
- C denote the number of “map data points”
- N denote the total number of points

Class I (Land): A=3, B=4, C=6, N=12
Class II (Sea): A=5, B=8, C=6, N=12

User/Object accuracy: For each class, the probability that a randomly chosen point on the map has the same class value in field.

For Class I (Land): \( \frac{A}{N} = 50\% \)
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Producer/Classification accuracy: For each class, the probability that a randomly chosen point in field has the same class value on the map.

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User’s accuracy

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</tr>
<tr>
<td>Row Total</td>
</tr>
<tr>
<td>-----------</td>
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28% Commission error
NOTE

DEPENDING ON SELECTED MEASUREMENT WE GET DIFFERENT ACCURACY ESTIMATIONS!

GOOD OR BAD? WHICH MEASUREMENT TO USE?
Kappa Estimation

This can be done by calculation of the coefficient of agreement, Kappa ($\kappa$)

$-1 \leq \kappa \leq 1$

-1 = No agreement
0 = Random agreement
1 = Perfect agreement

Kappa can be estimated according to

$$\hat{\kappa} = \frac{Nd - q}{N^2 - q}$$

Where
N = Total number of points

$D = \text{Sum of correctly mapped points}

q = \text{Sum of the products between B and C for each class}$
THE DIAGONAL REPRESENTS CORRECTLY MAPPED SAMPLING POINTS WE CAN LET

A = DENOTE THE NUMBER OF CORRECTLY MAPPED POINTS
B = DENOTE THE NUMBER OF "GROUND TRUTH" POINTS" C = DENOTE THE NUMBER OF "MAP DATA POINTS"

N = DENOTE THE TOTAL NUMBER OF POINTS

CLASS I (LAND): A = 3 B = 4 C = 6 N = 12
CLASS II (SEA): A = 5 B = 8 C = 6

KAPPA ESTIMATION

EXAMPLE 1: "OUR FIRST EXAMPLE"

N = 12, d = 3 + 5 + 8, \(q = (4 \times 6) + (4 \times 8) = 72\)

\[ \hat{\kappa} = \frac{(12 - 72)}{12^2 - 72} = \frac{24}{72} = 0.33 \]

MEANING THAT THE MAP IS 33% BETTER THAN CHANCE.

EXAMPLE 2: "CLASSIFICATION WITHOUT KNOWLEDGE"

N = 12, d = 1 + 3 + 4, \(q = (1 \times 4) + (4 \times 8) = 72\)

\[ \hat{\kappa} = \frac{(12 - 72)}{12^2 - 72} = \frac{-24}{72} = -0.33 \]

MEANING THAT THE MAP IS 33% WORSE THAN CHANCE.

This can be done by calculation of the COEFFICIENT OF AGREEMENT, KAPPA \(\hat{\kappa}\)

-1 ≤ \(\hat{\kappa}\) ≤ 1

-1 = NO AGREEMENT
0 = RANDOM AGREEMENT
1 = PERFECT AGREEMENT

KAPPA CAN BE ESTIMATED ACCORDING TO

\[ \hat{\kappa} = \frac{N_d - q}{N^2 - q} \]

WHERE

N = TOTAL NUMBER OF POINTS
\(d = \) SUM OF CORRECTLY MAPPED POINTS
\(q = \) SUM OF THE PRODUCTS BETWEEN B AND C FOR EACH CLASS