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Forest cover of Czech Republic



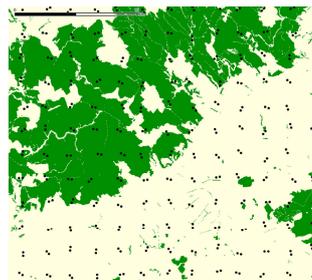
An estimation of total forest area is one of the key tasks within a National Forest Inventory (NFI) adopting a continuous population approach. Within this framework an estimation of any total quantity is obtained by multiplication of an estimate of total forest area by an estimate of per area mean value of the variable of interest. Hence the resulting confidence intervals are significantly influenced by the variance of the estimate of total forest area. This poster compares precision gains of three thematic maps in respect to their usage as poststratification layers to estimate relative forest cover of the whole Czech Republic as well as its NUTS3 administrative units.

As a ground truth a set of 39432 individual plots from the First Czech National Forest Inventory 2001-2004 was taken. The ground truth data was used to evaluate error matrices for the three layers, which served as a basic measure of classification accuracy. The main purpose of the Czech NFI1 ground truth data was to unbiasedly estimate the relative forest cover. This was done with and without the usage of auxiliary information represented by the three maps.

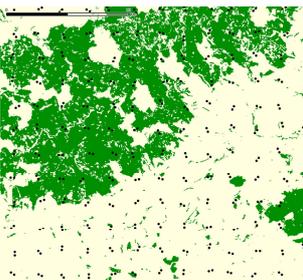
The aggregated results are shown in the following table:

ESTIMATION TECHNIQUE	RELATIVE FOREST COVER [%]	99% confidence interval	
		Lower bound [%]	Upper bound [%]
no poststratification	36.06	35.27	36.85
OLIL_2006	35.75	35.51	36.00
FMap_2000	35.88	35.46	36.26
TM_UHUL_2000	35.93	35.59	36.27

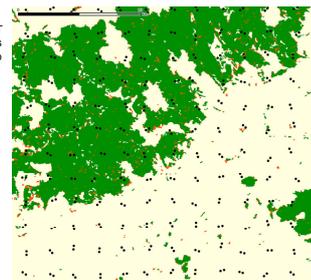
Comparison of the three forest maps



OLIL_2006 was obtained by manual delineation of forested areas using aerial orthophoto maps with 0.5 m pixel size. Minimum forest area was set to 0.04 ha, no constraints on width of forest stands. Uncertain class was not considered. The black spots correspond to Czech NFI1 sample plots.



FMap_2000 was produced from pre-processed LANDSAT 5/7 images by the JRC IES as the Pan-European forest map (Pekkarinen et al., 2009). Although the object-based approach was used, there is an apparent salt-and-pepper structure of forest class, e.g. clearcuts are often classified into Other land class, and small patches of woody vegetation in cropland assigned to Forest. Uncertain class is used only for the unclassifiable parts of the image (clouds).



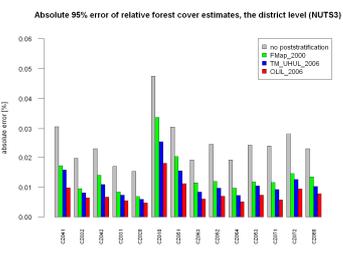
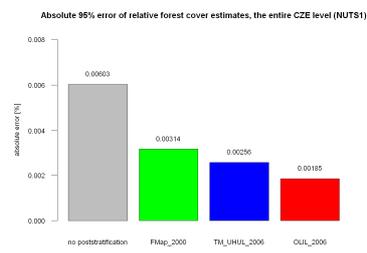
TM_UHUL_2006 was derived by FMI from the pre-processed LANDSAT 5 images using an object-based image classification. Unlike the FMap_2000 layer the occurrence of Uncertain class is not limited to unclassifiable parts of the image. It is primarily used for areas, where the assignment to the Forest/Other land classes was in doubt. Minimum mapping unit for Forest class was 0.5 ha. Also areas of Other land below 0.5 ha and surrounded by Forest were reassigned to Uncertain class.

ERROR MATRIX	OLIL_2006 map layer			Producer's accuracy
	Other land	Forest	Total	
Czech NFI1 ground truth	24712	502	25214	98.0%
	850	13368	14218	94.0%
Total	25562	13870	39432	Overall accuracy 96.6%
User's accuracy	96.7%	96.4%	NA	

ERROR MATRIX	FMap_2000 map layer				Producer's accuracy
	Other land	Forest	Uncertain	Total	
Czech NFI1 ground truth	23153	2033	28	25214	91.8%
	1794	12401	23	14218	87.2%
Total	24947	14434	51	39432	Overall accuracy 90.2%
User's accuracy	92.8%	85.9%	NA	NA	

ERROR MATRIX	TM_UHUL_2006 map layer				Producer's accuracy
	Other land	Forest	Uncertain	Total	
Czech NFI1 ground truth	23381	1292	541	25214	92.7%
	1053	12617	548	14218	88.7%
Total	24434	13909	1089	39432	Overall accuracy 91.3%
User's accuracy	95.7%	90.7%	NA	NA	

Classical and poststratified estimates of relative forest cover



The principle of poststratification

Poststratification is a technique that uses auxiliary information to improve precision of parameter estimates. As auxiliary information we used three forest cover maps combined with ground truth data to unbiased estimate the forest cover. The better is the concordance among map classes (strata) and ground truth classes (terrestrial NFI data), the more precise are the resulting estimates. Poststratification is used after the terrestrial data has been collected, so the maps do not effect the sample size nor its allocation to strata.

$$\hat{y} = \sum_{h \in H} \hat{y}_h \cdot W_h \quad (1)$$

$$\hat{V}(\hat{y}) = \sum_{h \in H} W_h^2 \cdot \hat{V}(\hat{y}_h) \quad (2)$$

An estimate of a mean per hectare value (\hat{y}) is obtained as weighted sum of within strata estimates (eq. 1). The weight W_h is defined as relative size of stratum h . The variance as a measure of precision is obtained as weighted sum of within strata variances (eq. 2).

Effect of forest cover estimation error on the estimates of total quantities

Estimation of total quantities, principles used within Czech NFI
 The Czech NFI survey uses a continuous paradigm approach to aerial sampling. The estimation of any total quantity is obtained by a multiplication of two random variables – a mean per hectare estimate of the particular parameter and an estimate of total forest cover. Thus the resulting precision is influenced by the precision of both input estimates. A relative standard and any other percentile error can be evaluated using equation (3).

$$\delta_{\text{tot}} = \sqrt{\delta_{\text{cov}}^2 + \delta_x^2 - \delta_{\text{cov}} \cdot \delta_x} \quad (3)$$

Where δ_{tot} is an estimated relative error of total quantity x , δ_x is an estimated relative error of spatial mean (per hectare value) of x , δ_{cov} is an estimate of relative error of forest cover. It is worth noting, that δ_x takes the same value no matter if the forest cover is expressed relatively (in % of total study area) or absolutely (in ha) as the total forest cover in hectares is obtained by a multiplication of relative forest cover by an exactly known constant i.e. the extent of the study area (spatial domain) without any influence to precision.

As an example the effect of forest cover estimation error on estimates of the total growing stock are shown:

