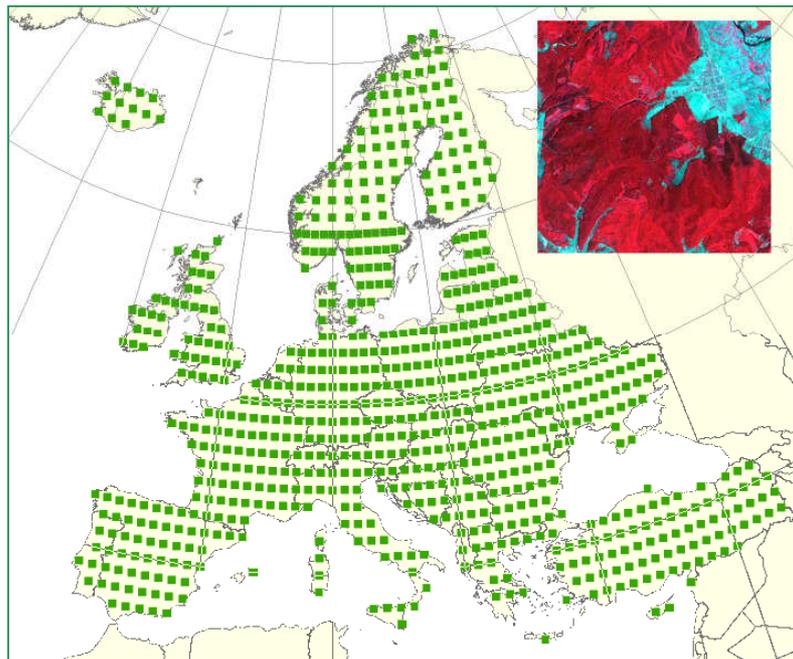




# Pilot Study in Europe

## for the Global Forest Remote Sensing Survey

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# 1 Introduction

## *1.1 General overview of the RSS of FRA2010*

The FRA 2010 Remote Sensing Survey (RSS) is using satellite remote sensing of the Earth's surface to improve information on worldwide tree cover and forest land use. The main goal is to obtain better information on the distribution and changes in forest cover and forest land use from 1990 to 2000 and 2005 at regional, ecozone and global levels. Satellite data enables consistent information to be collected globally and the analysis can be done in the same way for different times to get better estimates of change.

FAO has led remote sensing studies on forests in past FRA reports in 1990 and 2000, focussed on tropical forests. This new study will be more comprehensive with satellite images collected globally. JRC has also done extensive work on forest extent and change in Europe and across the tropics. FAO and JRC are working in partnership to implement the FRA Remote Sensing Survey globally building on their respective expertise and strengths in particular topics and regions. Of the global total 13,689 samples, JRC is processing samples covering European countries and across the humid tropics (approximately 40% of the total), and FAO is processing all other countries in the world (approximately 60%). This report outlines the work done in Europe by the JRC European FOREST group and a Pilot study to test the data and techniques that can be used for Europe for the FRA RSS.

## *1.2 The European Approach for FRA2010*

In Europe, the FOREST group of the Joint Research Centre (JRC) has recently developed high-resolution (25m) pan-European forest cover maps of the year 2000 (Pekkarinen, Reithmaier et al. 2009) and for years 1990 and 2006. The maps for 1990 and 2000 are based on Landsat imagery and Corine land cover information data (JRC 2005), which is available for most of the European area. Based on these spatial forest information data sets we are able to assess forest cover change in Europe using a post-classification approach. Post-classification change detection is a comparative analysis of classifications based on images from different years. It is reported to be less sensitive to spectral variations than direct image-to-image comparison (Mas 1999).

In order to focus on reliable forest changes and to reduce uncertainties e.g. due to input qualities or misregistration of the time series, the FOREST group has developed a new post-classification change detection approach. This approach provides robust forest cover change detection, less sensitive to input data quality, by integrating morphological spatial pattern analysis (MSPA) of the forest (Soille and Vogt 2009). The overall objective is to reliably detect forest cover loss or gain of more than about one hectare.

The pilot study in Europe was aimed to test and improve the change algorithm developed at the JRC based on years 2000 and 1990. For that reason a Task Force was created in which

remote sensing experts of seven countries participated (See ANNEX). Two meetings were held (March and June 2009) at the JRC where, with the help of the participants, the change algorithm was finalized. This change algorithm and the preceding steps are explained in this document.

The forest cover map for the year 2006 was still under development at the time of the pilot study. This map has been finalised in early 2010 based on a mixture of SPOT4/5 and IRS-P6 imagery. It will be used in the final RSS FRA2010 to detect forest cover change between the years 2000 and 2006.

## **2 Area of interest – Europe**

Based on the RSS global sampling grid of latitude and longitude junctions, Europe has 730 sample sites. Each of these sites covers a 10 by 10 kilometer square which is used for further analysis (FAO, JRC et al. 2009). In Europe, these samples are located in 36 countries and are spread over forests exposed to a variety of climatic, geographic and ecological as well as socio-economic conditions. Ecologically, forests in Europe belong to several biogeographic zones, ranging from subarctic to Mediterranean and from alpine to lowlands.

The samples for the pilot study were chosen in order to get a representative set from these different forest zones. However, some of the selected samples were not ideal for testing the forest change approach due to cloud cover or seasonality of the available data, therefore additional samples were selected (see Section 4). In total 44 sample locations spread over fifteen countries (Figure 1) were used for the testing of change detection methodology in Europe.

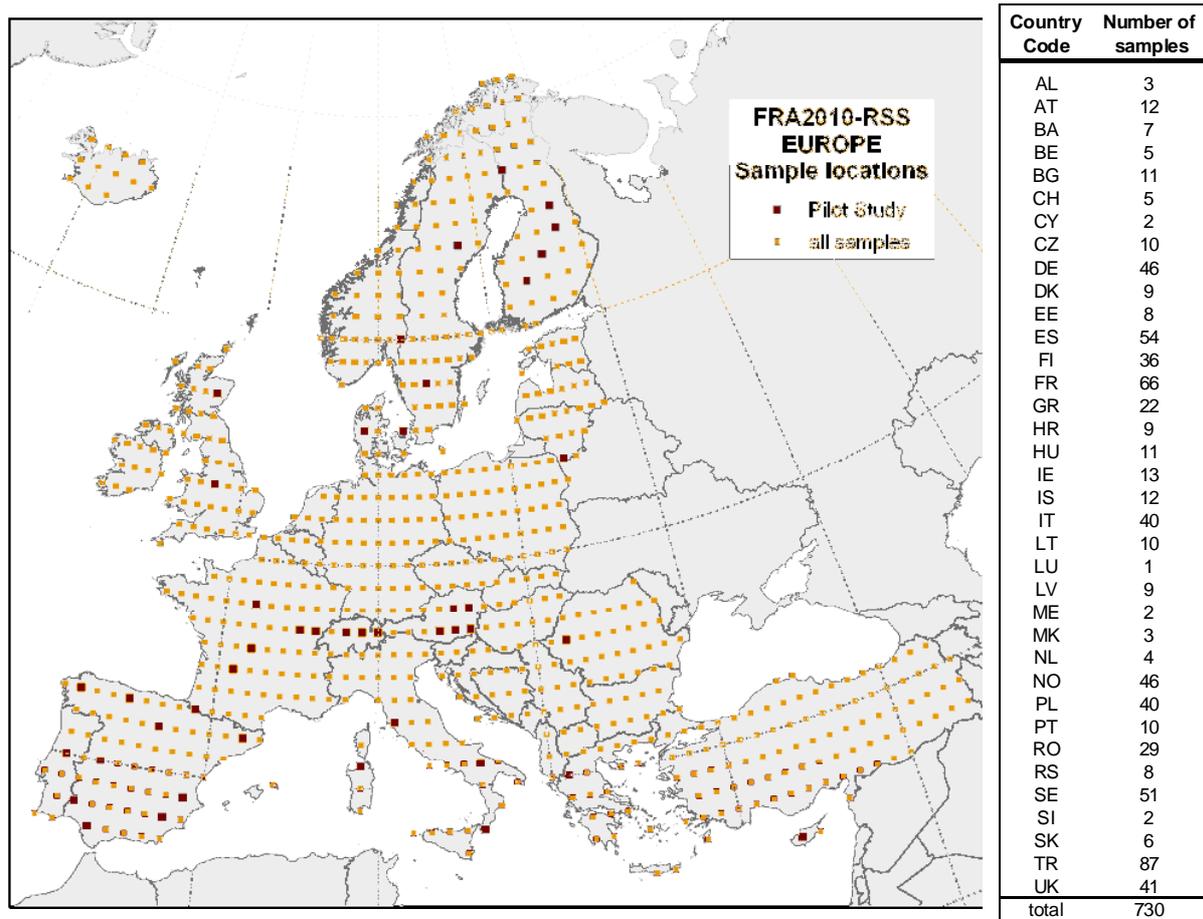


Figure 1: Coverage of FRA2010 sample areas in Europe processed by JRC FOREST Action

### 3 Input data

#### 3.1 Satellite imagery

For the interpretation and classification of forest cover in Europe in 1990 and 2000, freely available Landsat data sets with pan-European coverage were employed. For year 2000, two data sets were used, i.e. the NASA's Global Orthorectified Landsat Data Set (Tucker, Grant et al. 2004) available at the Global Land Cover Facility (GLCF)<sup>1</sup> and the IMAGE2000 data set<sup>2</sup> (EC-JRC 2005). Both data sets comprise Landsat 7 ETM+ scenes for the target year 2000 (time range 1999 – 2002). The final input image data set for Europe consists of 415 Landsat ETM+ scenes, 285 of which were downloaded from the GLCF and 130 of which were found in the IMAGE2000 set.

For the epoch 1990, only images from the GLCF were used. For the pan-European coverage of year 1990, 491 Landsat TM scenes from the years 1985–1995 were processed. Preference was given to scenes close to 1990 but the wider range of dates was needed to find scenes with less clouds or better season for forest detection.

<sup>1</sup> <http://www.landcover.org>

All the scenes were re-projected to European Terrestrial Reference System 1989 and Lambert Azimuthal Equal Area (ETRS-LAEA) projection (Annoni, Luzet et al. 2003) and resampled using a cubic convolution interpolation to 25m pixel size.

### *3.2 JRC Forest cover maps 1990 and 2000*

The high resolution pan-European forest cover maps 2000 and 1990 were developed by the JRC in order to address the current need for high resolution information on the spatial distribution of the European forests. The JRC forest cover maps provide forest cover information which is consistent over Europe, independent of national boundaries and with a higher spatial detail than previously available.

The processing which was first developed for year 2000 was based on a scene by scene approach and consisted of a preparatory phase and the actual mapping. Within the preparatory phase a cloud mask was computed for each input scene based on a two step approach. The first step aimed to detect all potential cloud and shadow pixels over the radiometric calibrated image using an in-house algorithm developed following the approach proposed by Baraldi et al. (2006). Due to the general high amount of commission as well as omission errors the direct use of the resulting cloud/shadow masks remained problematic and needed to be post-processed with an algorithm based on morphological and topological methods suitable to clean the result. The refined cloud masks were then used in the actual mapping phase.

The actual mapping consisted of several phases including image segmentation, clustering, adaptive spectral representativity analysis (ASRA) and training data extraction. As training data, CORINE Land Cover (CLC) 2000 and 1990 were used. The CLC nomenclature includes 44 land cover and land use classes covering the agricultural as well as the urban and natural sector. The smallest unit identified in CLC is 25 ha leading to a merge of all land cover patches smaller than 25 ha with the surrounding dominant land cover patches. The supervised classification of the input imagery was conducted at the segment-level using the extracted final training data set and a nearest neighbour classifier. The individual classified images were then merged into pan-European mosaics (Pekkarinen, Reithmaier et al. 2009).

For year 2000, the final forest cover map (Figure 2) was validated with an independent point data set, the LUCAS (European Land Use/Cover Area Frame Statistical Survey) field survey points for year 2001 which was provided by the Statistical Office of the European Communities (Eurostat) for 15 European Union (EU15) countries (Eurostat 2005). The underlying forest definition of the LUCAS2001 survey follows the forest definition of the Food and Agricultural Organization (FAO) of the United Nations: "Areas of more than 0.5 ha covered by trees with a tree-crown area density of more than 10% capable of achieving more than 5m in height" (Duhamel, Eiden et al. 2003). Based on 73917 samples the overall accuracy exceeded 90% and the user accuracy for forests reached 85% (Pekkarinen et al.

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<sup>2</sup> <http://image2000.jrc.it/>

2009). For the 1990 forest map so far no thorough validation could be carried out due to the lack of appropriate reference data set. Only for Germany (old West German states) a validation was performed based on National Forest Inventory data which resulted in an overall accuracy exceeding the target of 85%.

Since the JRC forest cover maps are produced in a fully automated manner from remote sensing, the forest delineated in the maps only represents forest as a land cover and not forest as a land use. Forest cover or land cover in general refers directly to biophysical attributes of the land surface which can be detected by satellites. Forest in FAO land use terms includes land such as “temporarily unstocked” or “regeneration areas”. Very small trees will be classified as non-forest using the remote sensing data and automated processing. In order to achieve a land use map of forests, local expert knowledge and often intensive manual post-processing is necessary.

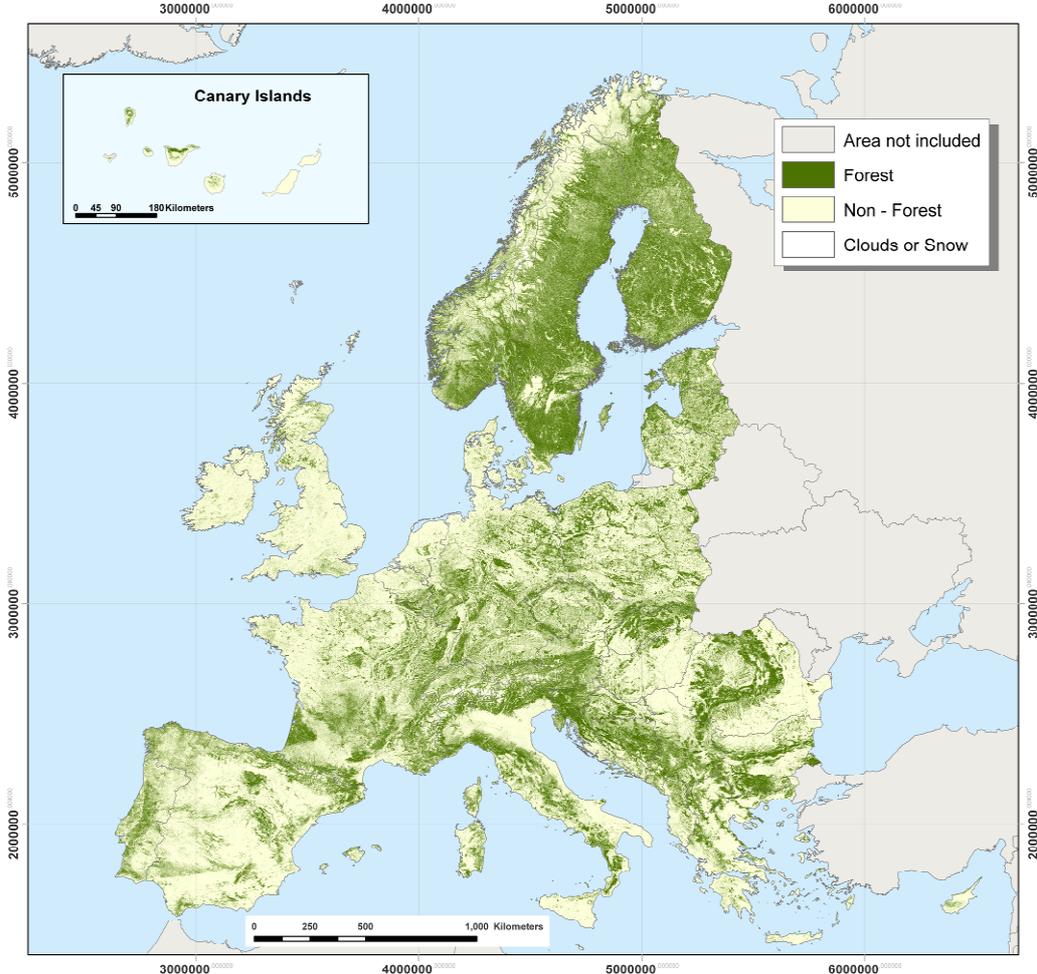


Figure 2: JRC Forest Cover Map 2000.

## 4 Forest cover change approach

### 4.1 Scene selection and tile extraction

For the forest cover change assessment, the best possible combination of forest cover map samples has to be selected according to the properties of the underlying satellite image scene. The impact of illumination and vegetation phenology differences on the change detection can be partially reduced by selecting data from the same time of the year (Mas 1999). However, the availability of imagery for this project was restricted to the database of GLCF. The presence of clouds in some of the images acquired at good? time conditions forced these images to be replaced with images from less appropriate acquisition dates. The final selection of the images was therefore based on the criteria: seasonality, cloud coverage within the sample tile and the sensor type.

We developed a set of guidelines for the selection of appropriate images for different zones in Europe. The definition of these zones was based on biogeographic regions (Eurostat 2003) and on the Global Administrative Unit Layers GAUL:(FAO 2006). As a final result (Figure 3) eleven regions were identified depending on their biogeographic region and geographic location.

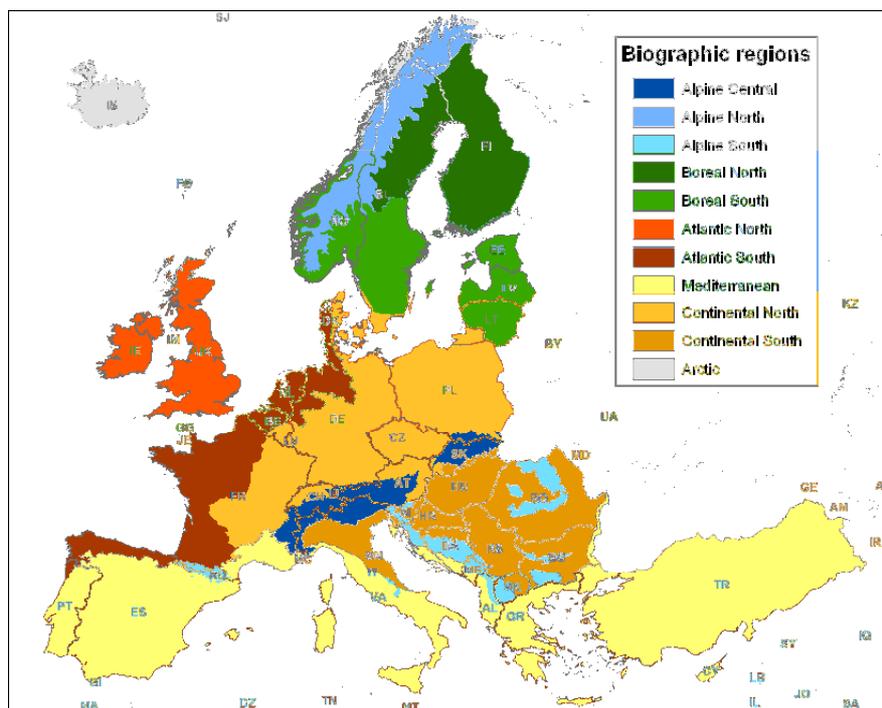


Figure 3: Enhanced biogeographic regions for Acquisition window definitions

For each zone three acquisition windows were defined representing ideal (narrow window), good (extended window) and acceptable (extreme window) acquisition dates for land cover classification (Table 1). The first two windows were adapted from national expert knowledge

of the Image2000 campaign (JRC 2005). Images falling outside of these three windows were considered not suitable for this project and labelled 'out of season'.

Table 1: Acquisition windows defined for enhanced biogeographic regions

ID	REGION	NARROW Window				EXTENDED Window				EXTREME Window			
		START		END		START		END		START		END	
		DAY	MONTH	DAY	MONTH	DAY	MONTH	DAY	MONTH	DAY	MONTH	DAY	MONTH
1	alpine_central	1	8	31	8	1	7	15	9	1	5	15	10
2	alpine_nord	15	7	15	8	15	6	1	9	1	6	15	9
3	alpine_south	1	7	15	8	1	6	30	9	1	5	15	10
4	boreal_north	1	7	15	8	15	6	31	8	15	5	15	9
5	boreal_south	1	6	15	8	1	6	15	9	15	4	31	9
6	atlantic_north	1	6	30	8	1	5	30	9	1	4	30	10
7	atlantic_south	1	7	15	9	15	6	30	9	1	5	30	10
8	mediterranean	15	6	15	7	1	6	30	9	1	5	15	10
9	continental_north	15	7	31	8	1	6	30	9	1	5	30	10
10	continental_south	15	6	15	8	1	6	30	9	1	5	30	10
11	arctic	1	7	15	8	1	7	15	8	15	6	1	9

First priority was given to cloud-free images within the narrow window and then within the extended window. When no cloud-free images were available within narrow and extended window, images within the extreme window were accepted. For 1990, Landsat 5 data was preferred over Landsat 4.

After the selection process, several images of the pilot study (14%) still remained with high cloud cover of (more than 5%) or were labelled 'out of season' (ANNEX). These images were therefore excluded for the pilot study.

Forest cover maps are produced from the selected images and the samples are extracted at each of the latitude and longitude junction in Europe by 10x10 km for each year. They were then checked for gross co-registration errors to reduce erroneous forest change using pixel wise cross-correlation. If the co-registration could be improved, shifts by integer number of pixels were performed.

## 4.2 Post-classification approach

### 4.2.1 General challenges for post-classification change detection

In post-classification change detection approaches, most problems associated with atmospheric and sensor differences are reduced (Mas 1999). But, the change identified between two classified maps will not be more reliable than the product of the accuracies of each of the individual classification (Singh 1989).

A major source for uncertainty for all change detection techniques is misregistration of the image pairs, in particular in very fragmented areas. The co-registration of image pairs is seldom better than half a pixel on average, going up to two pixels in several cases. In addition, image data are usually re-sampled and/or cropped to the region of interest of specific users. These processes inevitably introduce a displacement of the original image features. As a consequence they are likely to produce false changes (especially along edges) and a significant overestimation of total change.

An approach to account for this uncertainty along boundaries was proposed by (Serra, Pons et al. 2003). In order to eliminate these uncertain areas they applied an erosion procedure. This procedure increases the reliability of the resulting changes, but risks underestimation of the change area

For the present study, we intend to develop a robust post-classification change assessment. The major objective is to identify contiguous areas of forest cover change of 1 hectare or more. The method accounts for the uncertainty of the change estimates, while keeping the initial shape of changed objects. This is a more detailed analysis than used by the FRA RSS elsewhere in the world which is aiming for a 5 ha minimum mapping unit (FAO et al. 2009). The justification for using the smaller area in Europe is that due to the fine scale of fragmentation and small changes in many areas, the larger threshold would “hide” many of the changes in Europe and either shows no changes or significantly underestimating the change area.

#### 4.2.2 Methodology shown on synthetic samples

The principles of post-classification change detection method we applied to the forest maps are illustrated on simplified synthetic data samples showing simulated forest cover distribution for two years (1990 and 2000). The first two plates in the first row display ‘ideal’ forest cover maps for two periods. The corresponding plates in the second row correspond to a more realistic scenario in which some small patches have been added to maps from the two periods. These small patches represent noise, classification artifacts and/or non-relevant features (Figure 4). The rightmost plates show the corresponding changes as they result from a simple overlay of these two sets are displayed as forest gain (green), loss (red) constant forest (dark gray) and constant non-forest (light gray).

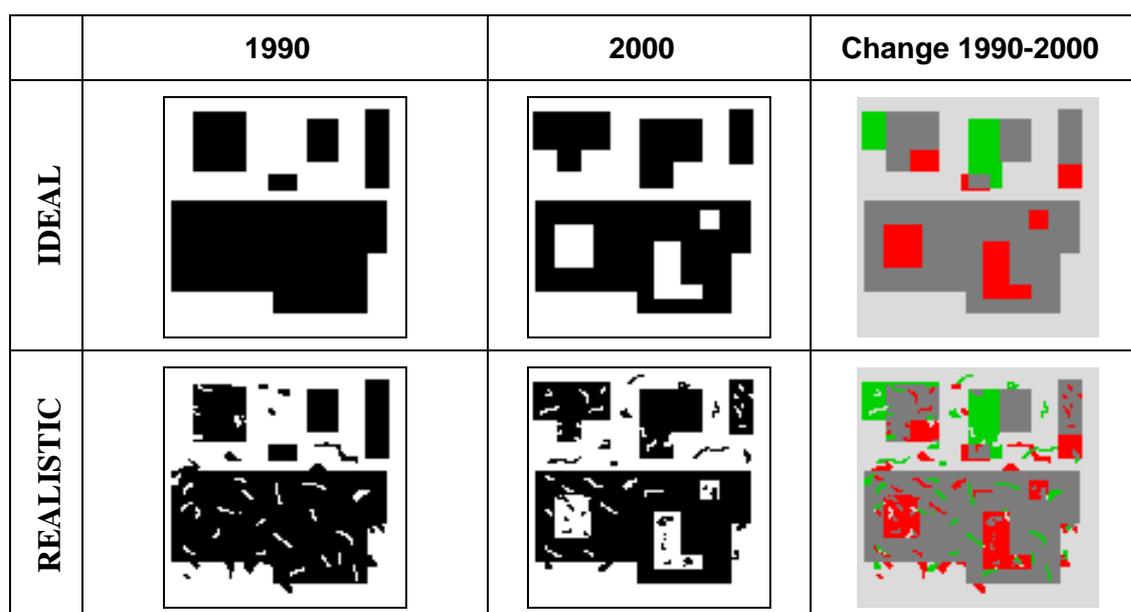


Figure 4: Synthetic samples of forest cover maps for year 1990 and 2000 and their changes resulting from their simple overlay (green: gain, red: loss, dark grey: constant forest, light grey: constant non-forest)

While the number of change objects (gains or losses) in the ideal case is limited to real cover change, the presence of noise in the realistic scenario results is a clear overestimation of the cover change area. A visual interpreter would be able to differentiate between areas of ‘relevant’ change and those of changes triggered by artifacts or negligible. However this is unfeasible for large amount of data across an area as large as Europe. We propose an automatic tool to screen large number of change patterns based on spatial and contextual properties from existing classified forest cover maps. The method proposed is aimed to detect and reconstruct change areas under realistic conditions discarding all noise related change objects.

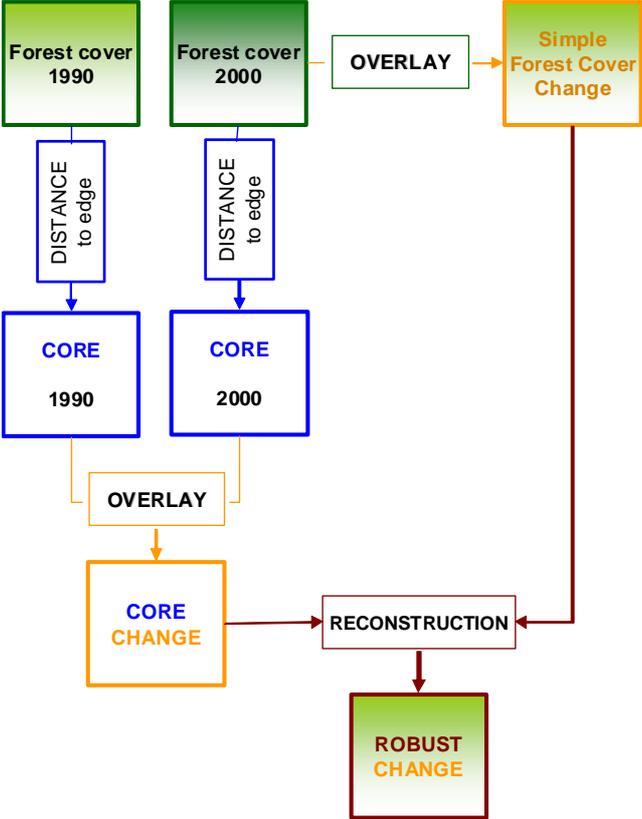


Figure 5: Flowchart of the post-classification change algorithm. First step: Core change identification, second step: Reconstruction of change areas

The methodology is based on morphological image processing and includes two consecutive steps (Figure 5). The first step accounts for the fact that changes detected close to object boundaries in classified images are more prone to be caused by misregistration or classification errors than those occurring within larger homogeneous areas. Therefore, all areas within a chosen distance to a boundary are excluded from the change analysis. This is implemented by morphological erosion which is applied to both forest and non forest areas in the map. Overlaying the remaining cores of forest and non-forest allows the identification of areas which have changed from one core type to the other. These core-to-core changes are considered to be the most reliable indication of a real change in the land cover. In the second step the core changes serve as seeds for the reconstruction of the full extent of the change areas.

Figure 6 displays the process for the reconstruction of the change map: As underlying image of the simple overlay of the original maps containing all real and irrelevant change objects (contiguous pixels) is used. All change objects of the underlying image are tagged and kept if a core change, i.e. seed intersects with objects of the simple change. The remaining ones are considered as noise and therefore discarded.

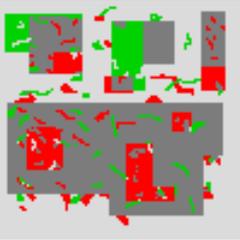
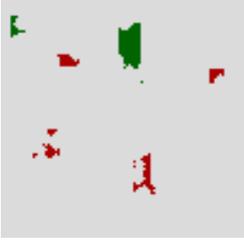
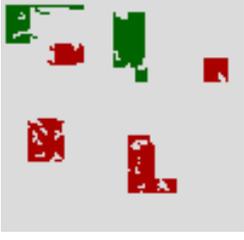
	Simple Change	Seeds	Reconstructed
<b>REALISTIC</b>			

Figure 6: Illustration of reconstruction of change objects using simple change images and core changes as seeds.

Small holes in the tagged change objects are then filled in order to create homogeneous contiguous objects. Those reconstructed objects are then considered as the final robust change product.

## 5 Results and Discussion

The newly developed change algorithm was applied to all pilot sample tiles. Figure 7 illustrates on Tile e022n46 the reduced amount of change objects. The remaining change objects showed to be contiguous forest cover changes. Small and linear change objects present in the simple change were filtered out.

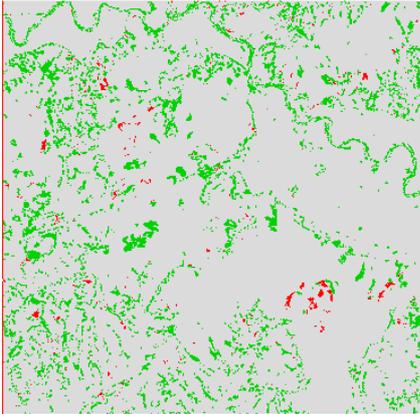
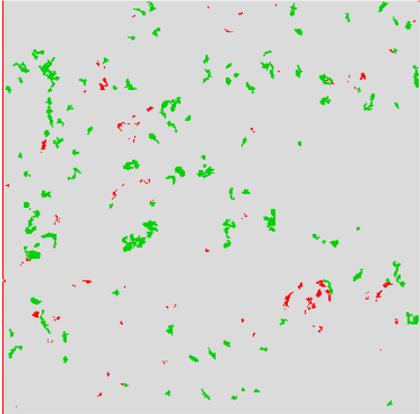
	Simple Change	Reconstructed change
Tile e022n46		

Figure 7: Differences in the amount of change objects between simple change overlay and the reconstructed change. Green: forest gain, red: forest loss

In Table 2 the amount of reduction due to the new change algorithm is shown. While the simple change overlay created, for all pilot sample tiles, more than 1600 change objects on average, the reconstructed change algorithm delivered only 90 objects. This represents a reduction of about 93% with major benefits for checking the results. For all sample tiles the major part (~80%) of all change objects in the simple overlay were less than 1 hectare. The new change algorithm filtered all these small change objects out. Still, the new change algorithm is preserving a high number (50%) of changed objects of less than 5 hectares. This is important, since we expect the forest cover changes in Europe to be on a small scale.

However, it should be noted that this reduction of small objects is not equivalent to a simple filtering. The small objects are reduced if they do not contain a core forest of about one hectare. Therefore, change objects with linear structures (more likely to be caused by misregistration) are neglected, while contiguous forest change areas are kept as they are considered to be reliable changes.

Table 2: Resulting change objects of the simple change and reconstructed change.

TILE	Simple Change - Objects			Reconstructed Change - Objects			Reduction [%]
	Number	< 1ha [%]	< 5ha [%]	Number	< 1ha [%]	< 5ha [%]	
e001n45	3095	85.2	97.0	107	0.0	55.1	96.5
e002n42	1591	84.5	97.0	58	0.0	50.0	96.4
e002n46	3252	87.0	98.5	117	0.0	71.8	96.4
e002n48	1701	83.8	95.5	110	0.0	43.6	93.5
e005n47	1469	84.3	95.8	81	0.0	35.8	94.5
e006n47	1301	78.9	93.2	132	0.0	43.2	89.9
e008n47	3409	90.6	99.2	59	0.0	66.1	98.3
e009n41	1810	84.0	95.6	95	0.0	45.3	94.8
e009n47	1702	85.5	98.0	39	0.0	64.1	97.7
e009n56	1723	84.9	96.7	97	0.0	46.4	94.4
e010n47	2386	85.8	97.3	63	0.0	63.5	97.4
e011n43	1343	77.1	93.5	149	0.0	51.0	88.9
e012n56	1128	80.8	94.2	93	0.0	37.6	91.8
e014n47	1129	77.5	94.9	89	0.0	53.9	92.1
e014n58	909	89.4	97.2	45	0.0	48.9	95.0
e015n47	2634	87.4	98.4	89	0.0	70.8	96.6
e015n48	2572	81.8	96.3	118	0.0	62.7	95.4
e016n38	1189	82.8	94.5	112	0.0	40.2	90.6
e016n41	1167	81.7	95.6	80	0.0	52.5	93.1
e016n47	2541	88.7	99.4	35	0.0	74.3	98.6
e016n48	2244	86.9	96.8	92	0.0	42.4	95.9
e018n64	1874	83.3	96.4	104	0.0	57.7	94.5
e021n40	744	86.7	98.0	40	0.0	62.5	94.6
e022n46	3128	90.2	97.5	77	0.0	28.6	97.5
e024n54	244	77.5	93.9	24	0.0	45.8	90.2
e024n62	1801	88.5	96.8	122	0.0	31.1	93.2
e024n67	1248	82.1	93.5	112	0.0	39.3	91.0
e026n63	2209	83.1	95.3	162	0.0	51.2	92.7
e028n64	2027	85.8	95.7	139	0.0	38.8	93.1
e028n65	1471	83.7	96.0	99	0.0	37.4	93.3
e033n35	2322	83.5	96.1	135	0.0	51.1	94.2
w001n39	1251	81.0	93.8	115	0.0	36.5	90.8
w001n43	507	76.9	95.5	40	0.0	50.0	92.1
w002n38	1510	88.5	97.7	55	0.0	45.5	96.4
w002n53	1181	81.3	95.2	86	0.0	52.3	92.7
w003n42	418	80.1	94.5	45	0.0	53.3	89.2
w003n57	1577	80.9	95.2	122	0.0	45.1	92.3
w005n43	231	81.4	99.1	8	0.0	75.0	96.5
w006n37	558	66.5	93.5	73	0.0	57.5	86.9
w006n40	1112	83.4	95.6	138	0.0	38.4	87.6
w007n38	1454	83.8	93.6	156	0.0	32.1	89.3
w008n40	1606	79.1	93.8	178	0.0	51.7	88.9

Figure 7 illustrates an expected output for a sample tile. Change ‘to’ and ‘from’ forest cover are delineated. For tile e022n46 the resulting forest cover changes were visually checked and proved to be created due to forest management activities such as clear-cuts. However, in some areas of very open forest covers and mountainous areas the detected forest changes were overestimated due to spectral confusion with agricultural areas and illumination effects respectively. In addition, within the pilot study the major source of false changes was related to the forest cover maps for 1990.

The input data for the production of the forest map for 1990 had severe limitations. The quality of the imagery was far from ideal. Furthermore the spatial coverage of the training

data was limited (Corine 1990 does not cover the Scandinavian countries and the UK). For areas in which Corine 1990 was not available, Corine 2000 was used as training data. However, in particular in Scandinavian countries, land cover changes between the two Corine datasets are larger and negatively influenced the training data extraction.

**Tile e022n46: Romania forest cover change 1990 -**

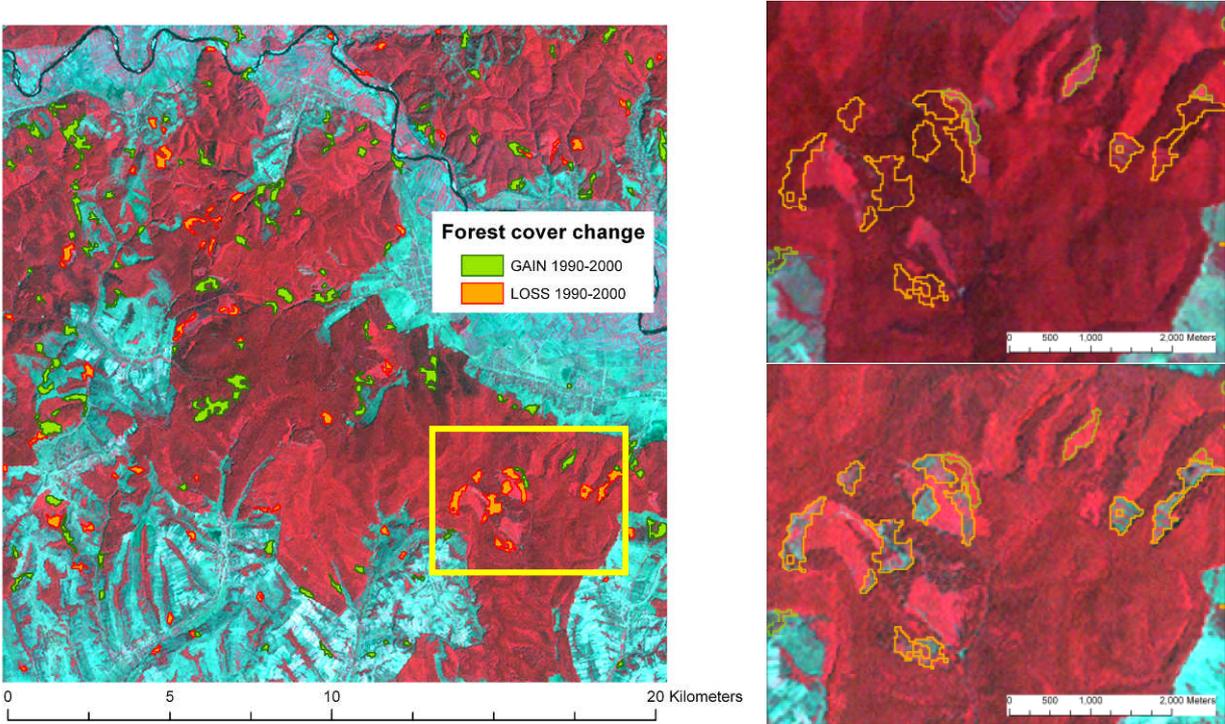


Figure 8: Forest cover change objects shown in one false colour image tile (left), right: Zoom of one change area (top) image 1990 and (bottom) image 2000 with overlay of change objects. .

Because of these limitations, and in the follow-up of the pilot study, the forest cover map of 1990 was reprocessed with a new more robust algorithm.

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## ANNEX A – European countries representatives in the Pilot Study Task Force

Name	Institute	Country
<i>Christian Ginzler</i>	Swiss Federal Research Institute WSL	Switzerland
<i>Annemarie Bastrup-Birk</i>	Danish Centre for Forest, Landscape and Planning	Danemark
<i>Guillermo Fernandes Centeno</i>	Subdirección General de Inventario del Patrimonio Natural y de la Biodiversidad	Spain
<i>Anssi Pekkarinen</i>	Finnish Forest Research Institute	Finland
<i>Christoph Bauerhansl</i>	Federal Research and Training Centre for Forests	Austria
<i>Nicolas Stach</i>	Direction de l'espace rural et de la forêt	France
<i>Claude Vidal</i>	Direction de l'espace rural et de la forêt	France
<i>Nico Bonora</i>	Instituto Superiore per la Protezione e la Ricerca Ambientale	Italy
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## ANNEX B – Technical Specifications of Forest/Non-Forest Map 2000

<b>Forest/Non-Forest Map Specification</b>	<b>Minimum Mapping Unit</b>	full pixel resolution
	<b>Map Classes</b>	1 - forest 2 - non-forest 3 - clouds 0 - no data
	<b>Thematic Accuracy</b>	> 85% (against FAO definition, reference data LUCAS 2001)
	<b>Format</b>	GeoTIFF 8-bit LZW compressed.
<b>Data Basis</b>	<b>Satellite Imagery</b>	Landsat ETM+
	<i>Source</i>	- Global Land Cover Facility (GLCF) <a href="http://glcfapp.umiacs.umd.edu:8080/esdi/index.jsp">http://glcfapp.umiacs.umd.edu:8080/esdi/index.jsp</a> - Image2000 <a href="http://image2000.jrc.it/">http://image2000.jrc.it/</a>
	<i>Spatial Resolution</i>	original 30m resolution resampled to 25m (proposed INSPIRE standards)
	<i>Geometric Accuracy</i>	RMS error less than 25m
	<i>Map Projection</i>	ETRS89 Lambert Azimuthal Equal Area (ETRS-LAEA)
	<i>Acquisition date</i>	1999 - 2002
	<b>Ancillary data</b>	CORINE Land Cover 2000 (seamless Vector layer rasterized to 25m)
	<b>Coverage</b>	EU27 plus BA, CH, CS, HR, MK, LI
	<b>Validation data</b>	- independent dataset (ortho-photos, googleEarth) - LUCAS data 2001 (EU15) - national forest inventories (NFI) (where available)

## ANNEX C - Definition of ETRS-LAEA Coordinate Reference System

<b>Coordinate Reference System</b>	<b>Projection_name</b>	ETRS-LAEA
	<b>Projection</b>	Lambert Azimuthal Equal Area
	<b>GEOGCS</b>	
	<b>Datum</b>	ETRS89
	<b>Spheroid</b>	GRS80
	<i>semi-major axis</i>	6378137
	<i>inverse flattening</i>	298.2572221
	<b>Parameters</b>	
	<i>False easting</i>	4321000.0
	<i>False northing</i>	3210000
	<i>Central_Meridian</i>	0.0
	<i>Latitude_of_origin</i>	52N
	<i>Longitude_of_origin</i>	10E
	<i>Unit</i>	"Meter", 1.0
<b>epsg code</b>	<3035>	
Reference	Annoni, A., C. Luzet, et al. (2003). Map Projections for Europe, A joint initiative of Eurogeographics and the Institute for Environment and Stability. Workshop 14-15 December 2000, Mame-La Vallée, Proceedings and Recommendations; European Commission EUR 20120 EN	

## ANNEX D: Metadata of Pilot samples

TILE_ID	CNTR	LONG	LAT	YEAR 1990					YEAR 2000				
				SEASON	pCL%	sCL%	PathRow	DATE	SEASON	pCL%	sCL%	PathRow	DATE
e001n45	FR	1	45	3	0.0	1.2	199029	19910528	1	0.0	0.0	199029	20000909
e002n42	ES	2	42	2	0.0	0.0	197031	19890719	2	0.0	0.2	197031	20000810
e002n46	FR	2	46	3	0.0	0.0	198028	19911004	1	0.0	0.0	199028	20000909
e002n48	FR	2	48	3	0.0	2.0	199027	19870509	1	0.0	0.7	199027	20000824
e005n47	FR	5	47	1	0.0	0.0	196027	19920805	1	0.0	0.0	197027	20010813
e006n47	FR	6	47	1	0.0	0.0	196027	19920805	3	0.0	16.2	196027	20001022
e008n47	CH	8	47	2	0.0	1.4	195027	19920518	1	0.0	3.0	195027	20010815
e009n41	IT	9	41	1	0.0	0.0	193031	19920715	1	0.0	0.0	193031	20020617
e009n47	CH	9	47	1	0.7	0.7	194027	19890831	1	16.5	7.2	194027	20010824
e009n56	DK	9	56	2	0.0	0.0	196021	19920517	2	0.0	0.1	196021	20000515
e010n47	AT	10	47	1	0.0	0.7	194027	19890831	1	0.6	7.2	194027	20010824
e011n43	IT	11	43	2	0.0	0.2	192030	19880814	1	0.0	0.1	192030	20000620
e012n56	DK	12	56	2	0.0	0.0	194021	19920519	1	1.7	6.7	194021	19990904
e014n47	AT	14	47	1	0.1	1.7	191027	19880807	2	36.4	15.4	191027	19990915
e014n58	SE	14	58	1	0.0	0.0	195019	19920611	2	0.0	1.9	194020	19990904
e015n47	AT	15	47	1	0.3	1.7	191027	19880807	2	0.0	0.4	190027	20000910
e015n48	AT	15	48	1	0.0	1.7	191027	19880807	2	0.0	0.4	190027	20000910
e016n38	IT	16	38	2	0.0	0.0	188034	19870613	2	0.0	0.1	188034	20000726
e016n41	IT	16	41	2	0.0	0.0	188032	19870613	2	0.0	0.2	188032	19990926
e016n47	AT	16	47	2	0.0	0.5	189027	19920828	1	0.0	0.1	189027	20000802
e016n48	AT	16	48	2	0.0	0.0	190027	19910910	2	0.0	0.4	190027	20000910
e018n64	SE	18	64	3	0.6	0.6	195015	19920526	1	0.0	0.0	195015	20000727
e021n40	GR	21	40	2	0.0	0.2	185032	19880829	1	0.0	0.2	185032	20000705
e022n46	RO	22	46	1	0.0	0.0	186028	19920730	2	0.0	0.0	185028	20000822
e024n54	LT	24	54	1	0.0	0.0	187022	19920806	1	0.0	0.2	186022	20010715
e024n62	FI	24	62	3	0.0	0.0	189017	19890524	1	66.1	25.7	189017	20010704
e024n67	FI	24	67	2	0.0	0.0	192013	19880627	1	0.0	0.2	193013	20000729
e026n63	FI	26	63	1	0.0	0.0	189016	19890727	1	0.0	5.1	189016	19990731
e028n64	FI	28	64	2	0.0	0.0	188015	19900621	1	0.0	1.2	188015	20000726
e028n65	FI	28	65	2	0.0	0.0	188015	19900621	1	0.0	1.2	188015	20000726
e033n35	CY	33	35	2	0.0	0.2	176036	19900804	0	0.0	2.0	176036	20010130
w001n39	ES	-1	39	0	RP	0.6	199033	19920420	2	0.0	0.1	199033	20010608
w001n43	FR	-1	43	1	0.0	0.0	200030	19880806	1	0.0	1.6	200030	20000730
w002n38	ES	-2	38	1	0.0	0.8	199034	19870626	2	0.0	0.2	199034	20000808
w002n53	UK	-2	53	2	0.0	0.1	203023	19920518	2	0.2	12.2	203023	20020404
w003n42	ES	-3	42	1	0.0	0.0	201031	19890715	1	0.0	0.1	201031	20000619
w003n57	UK	-3	57	1	0.0	0.2	205020	19950626	1	0.0	42.7	205020	20000717
w005n43	ES	-5	43	2	0.0	0.4	202030	19910813	1	0.0	9.5	202030	20010629
w006n37	ES	-6	37	0	RP	0.6	202034	19890417	1	0.0	0.6	202034	20000712
w006n40	ES	-6	40	2	0.0	0.0	202032	19870802	1	0.0	0.3	202032	20000712
w007n38	ES	-7	38	2	0.0	0.6	203034	19870521	1	0.0	0.6	202034	20000712
w008n40	PT	-8	40	2	0.0	0.1	203032	19910524	1	0.0	0.0	203032	20010620
w008n43	ES	-8	43	1	0.0	0.3	204030	19910811	1	0.0	3.5	204030	19990724

European Commission

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**Abstract**

In Europe, the FOREST group of the Joint Research Centre (JRC) has recently developed high-resolution (25m) pan-European forest cover maps of the year 2000 and for years 1990 and 2006. The maps for 1990 and 2000 are based on Landsat imagery and Corine land cover information data, which is available for most of the European area. Based on these spatial forest information data sets we are able to assess forest cover change in Europe using a new developed post-classification approach. This algorithm was tested in a pilot study for the Remote Sensing Survey of the Global Forest Resource Assessment (FRA2010) within Europe.

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