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A Satellite Based Study of Ust-Ilimsk Focusing on Clearcuts

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Foreword

IIASA, the Russian Academy of Sciences and several Russian governmental agencies, signed agreements in 1992 and 1994 to carry out a large-scale study on the Russian forest sector. The overall objective of the study is to focus on policy options that would encourage sustainable development of the sector.

The first phase of the study concentrated on the generation of extensive and consistent databases for the total forest sector in Russia.

In its second phase, the study encompassed assessment studies of greenhouse gas balances, forest resources and forest utilization, biodiversity and landscapes, non-wood products and functions, environmental status, transportation infrastructure, forest industry and markets, and socioeconomics.

The remote sensing activities within this project aims at the following three main objectives:

- To produce an up-to-date forest information database of the Russian forest sector;
- to develop and test methods to produce an up-to-date land use and land cover database for Russia; and
- to develop and test operative forest information and decision support system, with monitoring and revision capabilities, in a GIS environment.

This work, carried out by Gidske Andersen and Gebhard Banko during their participation in the 1998 Young Scientists Summer Program (YSSP), contains a remote sensing test-study in the area of Ust-Ulimsk.

Acknowledgements

We should like to thank Alf Öskog for his contribution to and supervision of our work during the summer months. A special thank you is extended to Professor Sten Nilsson and all the other colleagues in the Sustainable Boreal Forest Resources Project. Thanks is also extended to the Norwegian Research Council which funded Gidske Andersen's stay.

In addition to the scientific work undertaken during our stay at IIASA, a considerable amount of time was spent in discussion and communicating with our fellow YSSP friends. Thanks are due to all the YSSPers for this unique experience.

About the Authors

Both authors were participants in the 1998 Young Scientists Summer Program at IIASA.

Gidske L. Andersen is currently working on her master of science thesis in Botany at the Nansen Environmental and Remote Sensing Center in Bergen, and the Botanical Institute, University of Bergen, Norway. In her thesis she applies remote sensing to study vegetation changes in the Eastern desert of Egypt.

Gebhard Banko studied Forestry at the University of Agricultural Sciences in Vienna, and currently works as a graduate assistant at the Institute of Surveying, Remote Sensing and Land Information in this University. In his thesis, he discussed the opportunities for using Landsat-TM data for forest applications in Austria.

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1 Introduction

One of the objectives of the remote sensing activities of the forest resources project is to monitor changes in the Siberian boreal forest. In this study, a RESURS-O1 MSU-E image from September 1997 and a SPOT4 XS from July 1998 were applied to study changes in the forest in Irkutsk, a test area north of Ust-Ilimsk. In particular, the following two questions are of main interest:

- What is the total area of clearcuts?
- What is the area of new clearcuts in 1998?

2 Area

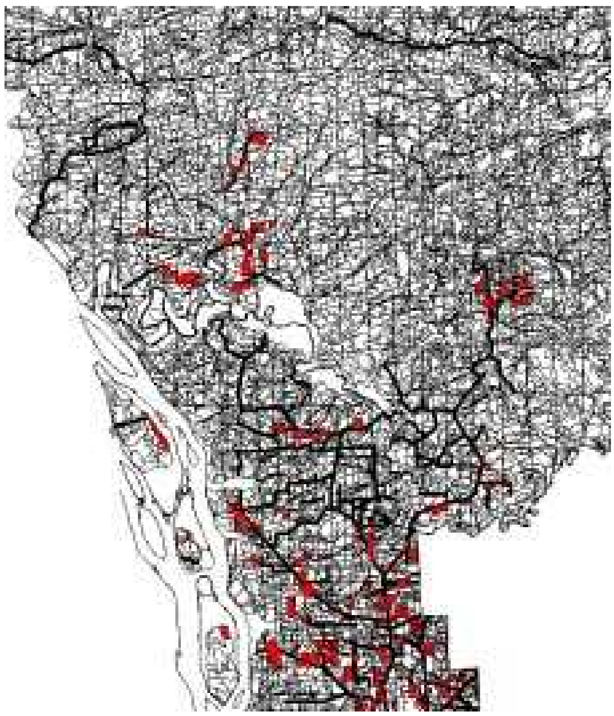
The area of interest is the Ust-Illimsk forestry enterprise, located about 100 kilometers north of the city of Ust Illimsk (59°N and 103°E). This is part of the Irkutsk Oblast located partly in the Angara river basin, in East Siberia north-west of the Bajkal lake, see *Figure 1.* The landscape is rolling and rises between 150 and 450 meters above sea level [1].

The forest enterprise is divided into two forest management districts, northern Katinsky and southern Zelendinsky. The entire territory is divided into 456 kvartals containing 15,223 forest compartments.

The transformation of old forests to clearcuts represents the major change in the structure of forests in the Ust Illimsk area [1]. This area has been exploited for several decades and is mostly affected in the southern and western part of the area [1]. These are areas where road density is very high due to quite intensive logging activities. *Figure 2* shows this area, the clearcuts and the roads as recorded in the forest inventory database from 1991.

Figure 1: Location of the Ust-Illimsk forest enterprise.

Figure 2: The southern part of the Ust Ilimsk forestry enterprise, showing road and clearcut density. (Data source: Forest Inventory from 1991.)



3 Material and Method

3.1 Satellite and reference data

RESURS-O1 MSU-E data and SPOT4 XS data were used in the study, see *Table 1*. The area of interest for these two images is shown in *Figures 3 and 4* and the acquisition dates for these are respectively 29 September 1997 and 12th July 1998, respectively. In both datasets, the central part of the image is covered by cumulus clouds. Maps used for visual comparison were extracted from the Ust-Ilimsk database, which is part of the Russian forest database at IIASA.

Table 1: Basic characteristics for the optical satellites used in the study.

Satellite Sensor	**Ground Resolution**	**No. of Visible Bands**	**No. of Infrared Bands**
RESURS-O1 MSU-E	45	2	1
SPOT XS	20	2	1–2[a]

[a] SPOT4 has a mid-infrared band.

Figure 3: The area of interest, RESURS dataset 1997.

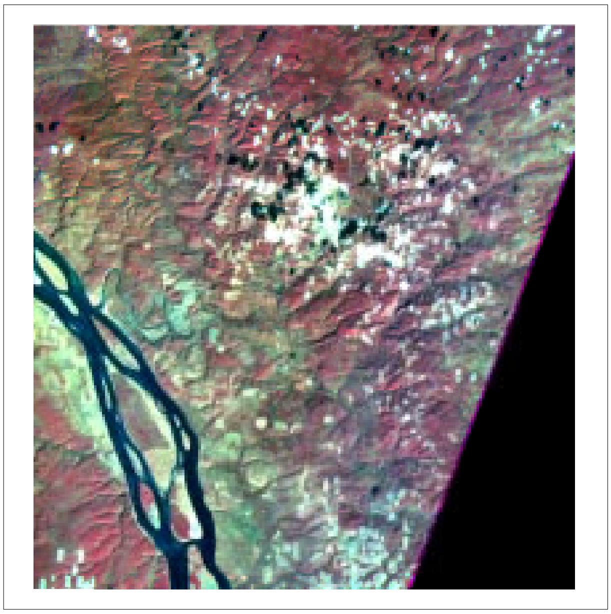
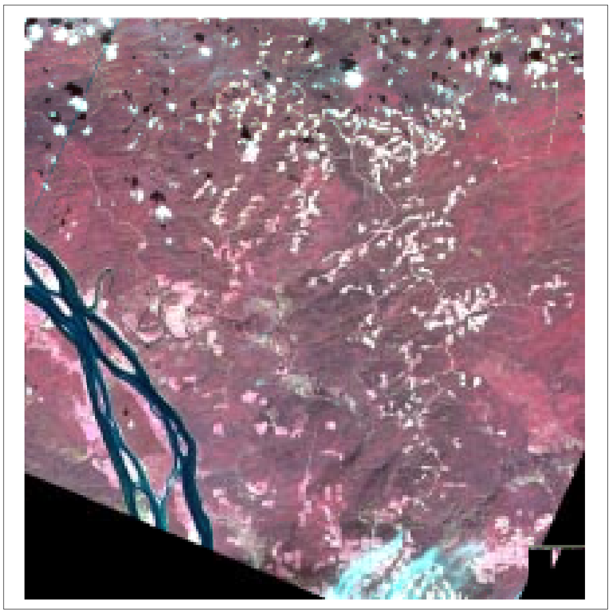


Figure 4: The area of interest, SPOT dataset 1998.



Software used in the study is ERDAS Imagine 8.3 for image processing and Arcview 3.0 for map production.

3.2 Image processing

One of the main requirements for completing a change analysis is that the studied image material is spatially and radiometrically comparable.

Geometric correction was done on an image to image basis. The RESURS dataset was used as the reference dataset and the SPOT data was resampled to the 45 meter pixel size of the RESURS data by bilinear resampling. Radiometric correction was done by a simple haze-correction.

The part of the images used for the study are referred to as Zelendinsky images, according to the forest management district. They were both classified by the unsupervised ISODATA algorithm. Eight classes were produced with the convergence threshold of 95% and an additional class containing unclassified pixels. A visual comparison of the resulting images was done and some broad features were recognized within and between the classes; these were water and shadow, forest, clouds and clearcuts, see *Table 2*.

Table 2: Labelling of the initial classes by visual comparison.

Class Number	**Visual Labelling**
0	Unclassified
1	Water and shadow
2–5	Forest
6–8	Clearcuts, roads and clouds

Only the latter classification is really interesting and the Zelendinsky images were processed by a cloud-filter to facilitate the differentiation between clouds and clearcuts. The basic idea is that a cloud has a shadow whereas a clearcut has no shadow. It is assumed that the clouds are at the same height and the relief lacks major height differences. Thus, each cloud is related to its own shadow in a special spatial manner and the cloud-filter takes advantage of this fact. The distance between the clouds and shadows are measured in the x- and y-direction in each of the images and filters are designed in accordance to these distances.

The RESURS filter is a 33x51 matrix weighting the cloud pixel by 10 and the shadow pixel by -20. The cloud pixel is located in the center while the shadowed pixel is in the upper left corner of the filter. The SPOT filter uses the same weight factors, however due to another geometry view the filter is only a 9x29 matrix. Due to this filter design the resulting image will show high values for cloud areas whereas non-cloud areas will be assigned very low values, see *Table 3*.

Table 3: DN (digital numbers) of clouds and clearcuts in the original SPOT-image (red band) and the *cloud-filtered* image.

	Filter		
	Center Pixel	**Upper Left Pixel**	**Result**
Cloud	255	56	1530
Clearcut	255	107	410

Both filters were executed only on the red bands. The filtered images show an increased difference between clouds and clearcuts, and thresholds were selected to produce binary cloud images. The thresholds for RESURS and SPOT were –333 and 1200, respectively; pixels above these thresholds are considered as clouds. The thresholds were decided by visual comparison and flickering of the original and an intermediate Zelendinsky image.

The classified image and the binary cloud image are combined to produce a new classified image where the clouds are in a single class. A logical if-expression selects pixels from the classes where there is confusion between clouds and clearcuts and recodes them as clouds if, and only if, these pixels as well as clouds are in the binary cloud image. The resulting classified image, therefore, has ten classes and are the basis for the final change analysis.

Production of the change image is done by a simple subtraction. However, the class numbers are recoded in the subtraction process to make interpretation of the resulting change image easier. The formula used for the change image is:

$$Change - imageclass = (10 * RESURS + 10) - (10 - SPOT) \quad (1)$$

This finally produces a change image consisting of 100 classes. Class number 19 means that pixels in this class were water/shadow (class 1) in 1997 and are clouds (class 9) in 1998. Image interpretation is further facilitated by a set of decision rules, which are discussed in more detail in the next section.

4 Results

The result of the image to image correction was a mean RMS error of 1.23 pixels which is approximately 55 meters.

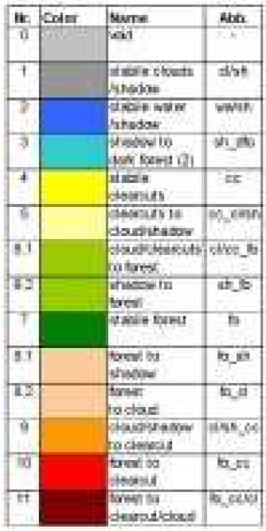
Image interpretation is facilitated by a set of rules, based upon a change matrix, *Figure 5*, derived from the change-image histogram. The rules are applied to extract stable (1997 = 1998) and new clearcuts. The colors, numbers, names and abbrevations used later and in the matrix are described in *Figure 6*.

Figure 5: Change matrix and colour scheme used to display the recognized classes. The numbers of the matrix represent the pixel counts within each combination of landcover class between 1997 and 1998.

1997 RESURS \ 1998 - SPOT	0 not classified	1 shadow and water	2 forest very dark	3 forest dark	4 forest medium	5 forest bright	6 forest very bright	7 clearcuts and roads	8 clearcuts and clouds	9 clouds
0 not classified	1056	29	600	1657	1438	1554	656	519	556	0
1 shadow and water	528	2043	204	206	135	46	65	45	60	28
2 forest_very dark	138	352	1332	1567	742	154	396	[illegible]	159	128
3 forest_dark	665	321	3935	4348	2336	382	604	[illegible]	258	340
4 forest_medium	686	138	822	2532	3486	1567	957	[illegible]	521	135
5 forest_bright	1146	149	993	3107	3047	544	644	[illegible]	279	215
6 forest_very bright	606	96	234	1596	3027	2333	1196	686	618	53
7 clearcuts and roads	296	17	77	202	508	1063	460	1146	1919	82
8 clearcuts and clouds	25	1	24	73	97	29	38	37	173	4
9 clouds	32	36	77	182	287	218	97	106	156	163

Total area: 68092 ha

Figure 6: Color modes for the different decision rules.



Nr.	Color	Name	Abb.
0		void	-
1		stable clouds /shadow	cl/sh
2		stable water /shadow	wa/sh
3		shadow to dark forest (2)	sh_dfo
4		stable clearcuts	cc
5		clearcuts to cloud/shadow	cc_cl/sh
6.1		cloud/clearcuts to forest	cl/cc_fo
6.2		shadow to forest	sh_fo
7		stable forest	fo
8.1		forest to shadow	fo_sh
8.2		forest to cloud	fo_cl
9		cloud/shadow to clearcut	cl/sh_cc
10		forest to clearcut	fo_cc
11		forest to clearcut/cloud	fo_cc/cl

4.1 Decision rules

Class 0: These are pixels that were unclassified in both images and thus no change detection is possible. Most of the unclassified pixels are black filled pixels outside the actual dataset.

Class 1: If pixels were clouds or shadows in 1997 and remain clouds or shadows in 1998, it is impossible to extract information about landcover changes. This can be a possible error source with respect to clearcuts; both new and old clearcuts can be hidden by shadows and clouds. This class is classified as a possible change.

Class 2: If pixels were water/shadow in 1997 and remain as such in 1998, it is most likely to be water and therefore a stable class.

Class 3: If shadow/dark forest in 1997 remains shadow/dark forest in 1998, it is forest. However, it can also be dark, mixed pixels of water and forest. This class is considered to be stable between the two years.

Class 4: If it was a clearcut in 1997 and remains so in 1998, it is a clearcut. Roads also fall into one of these classes but they can be considered as clearcuts and, as such, a feature which reports changes to the forest environment. There is also a small chance that the edges of clouds, which were possibly not detected by the cloud-filter in 1997 and remain clouds the following year, also falls into this class. This probability is low however. This class is considered to have no change.

Class 5: If it was a clearcut in 1997 and became water/shadow or cloud in 1998, it is probably a clearcut in 1998. It is thus considered to be stable.

Class 6.1: If it was a clearcut/cloud in 1997 and forest in 1998, it is likely to be forest or natural development from clearcut to forest and represents a class of change.

Class 6.2: If it was shadow in 1997 and forest in 1998, it is likely to be forest. It is possible that clearcuts could be located under the shadow, but like 6.1, it represents no mistake for the detection of clearcuts. It represents a class of change.

Class 7: If it was forest in 1997 and forest in 1998, it is forest; thus a stable class.

Class 8.1: If it was forest in 1997 and shadowed in 1998 it can be either forest or possibly a new clearcut located under the shadow. It is considered as a class of change, but a very uncertain class.

Class 8.2: If it was forest in 1997 and clouded in 1998, it is still forest, or possibly a new clearcut located under the cloud. This class is of the same category as 8.1.

Class 9: If it was a cloud/shadow in 1997 and clearcut in 1998, it is possibly a new clearcut. It is also possible that it was a clouded/shadowed clearcut in 1997. It is considered to be a class of change.

Class 10: If it was forest in 1997 and clearcut in 1998, it is a new clearcut. Some confusion with border pixels of clouds is also very likely. It is considered to be a class of change.

Class 11: If it was forest in 1997 and clearcut/cloud in 1998, it can be a new clearcut. However, the possibility is high that it is still forest covered by clouds. It is not possible to spectrally distinguish whether these pixels are clearcuts or clouds. It is, therefore, a class of change.

These rules divide the image into three different categories, reflecting the *change processes*:

- No change.
- Changes from clearcuts to forest.
- Changes from forest to clearcuts.

The results applying these rules are summed up in *Figure 7.* This figure also indicates the likelihood for the different classes to be assigned to the different change categories.

Figure 7: A process oriented change matrix.

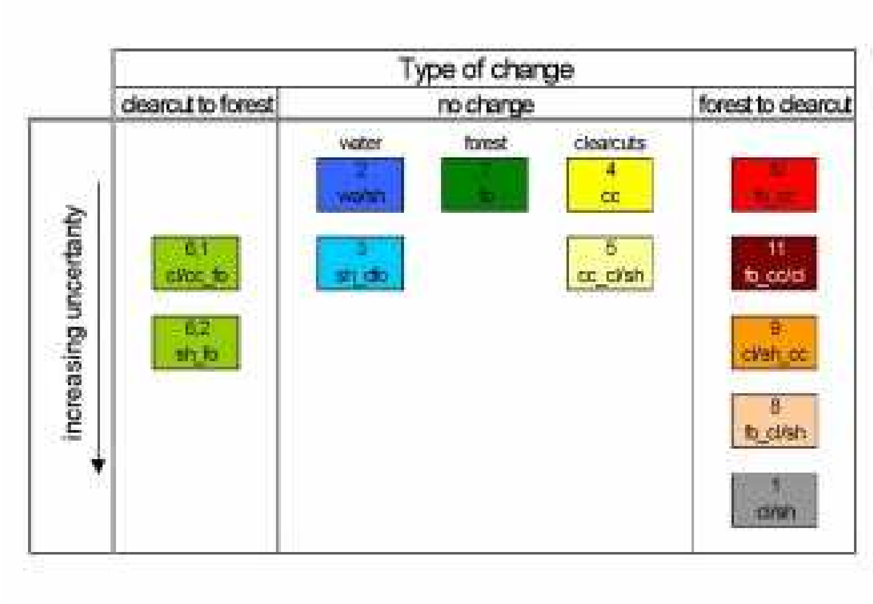
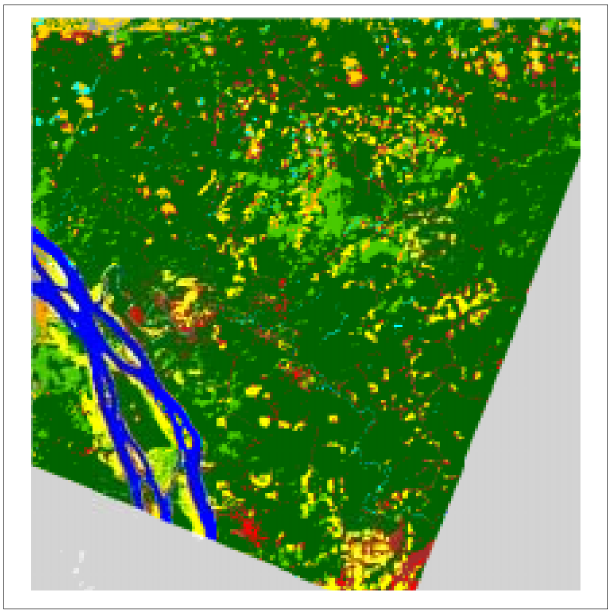


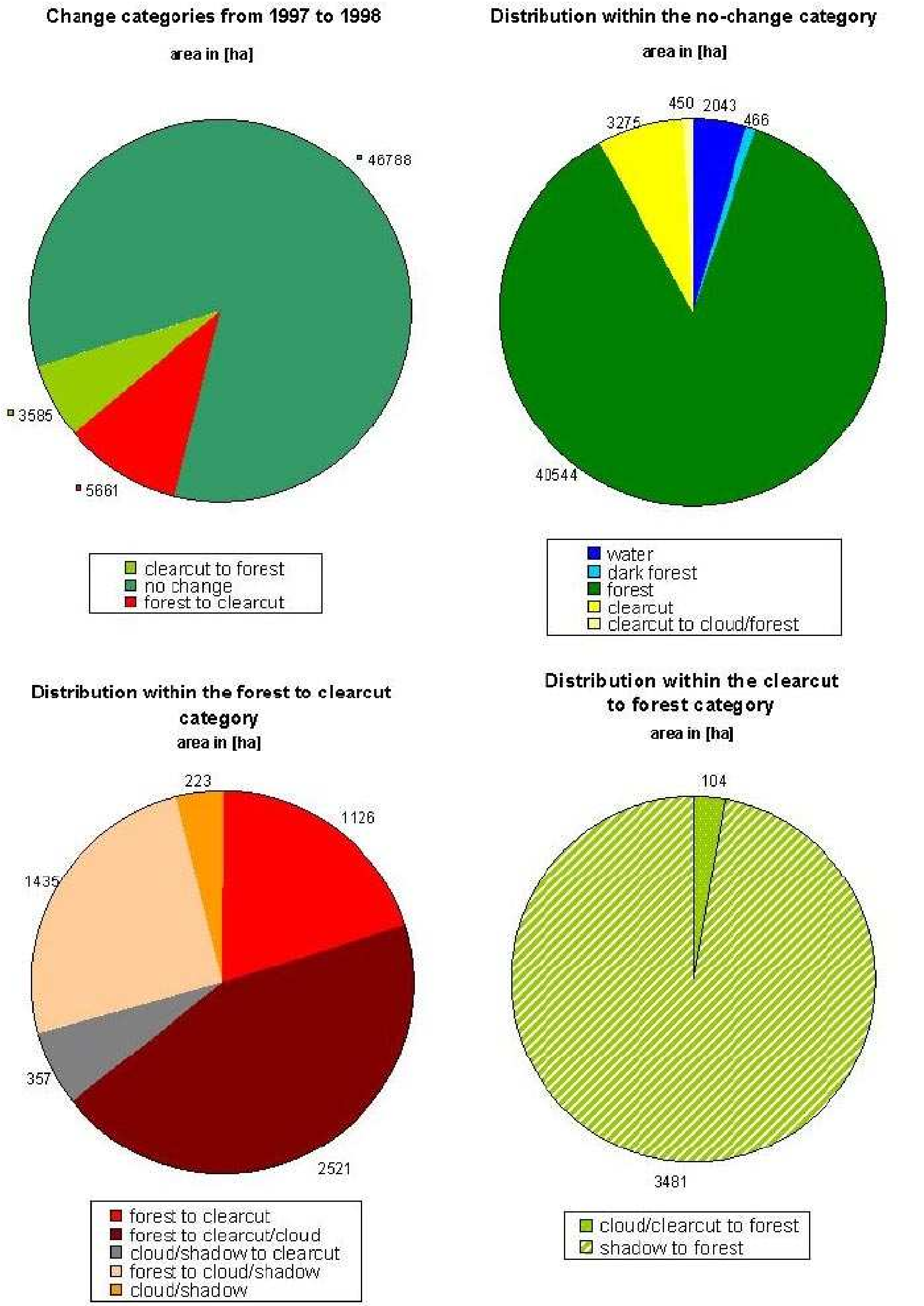
Figure 8 shows the final change image.

Figure 8: The final change image.



The distribution of classes within categories are illustrated in *Figure 9*.

Figure 9: Change categories and distribution of classes within each change category.



Based on these results the answers to two questions are as follows:

- In total (the sum of stable and new clearcuts) there are a maximum of 9,386 and a minimum of 4,401 hectares of clearcuts.
- The maximum of 5,661 and the minimum of 1,126 hectares of these clearcuts were made in 1998.

The minimum values are only based on the class with the highest certainty (first row in the change matrix of *Figure 7* while the maximum values are based on all the classes within each category.

4.1.1 Comparison to 1991 clearcuts

In addition to the analysis of the change process within the time period of the two image acquisition dates, a further comparison of the resulting clearcuts in 1998 with the inventory data from 1991 was undertaken. Due to the lack of detailed maps to reference both the satellite images and the inventory data, the comparison between the inventory data and the image analysis result can only be done on a visual basis.

Figures 10 and *11* show the changes between 1991 and 1998. The main changes, especially the logging and harvesting activities, took place in the transportation infrastructure surroundings. In many cases, existing clearcuts have been enlarged, as demonstrated in *Figure 10*, but most of the harvesting activities use the existing roads for additional clearcuts (*Figure 11*).

Figure 10: Comparison of clearcuts in 1991 (left image) and 1998 (right image) in the south-western part of the Zelendinsky area.

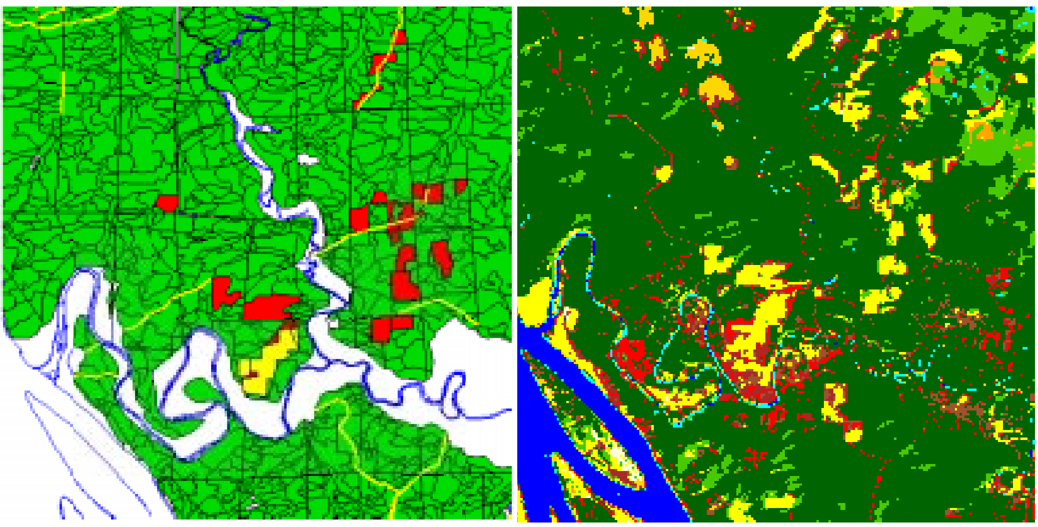
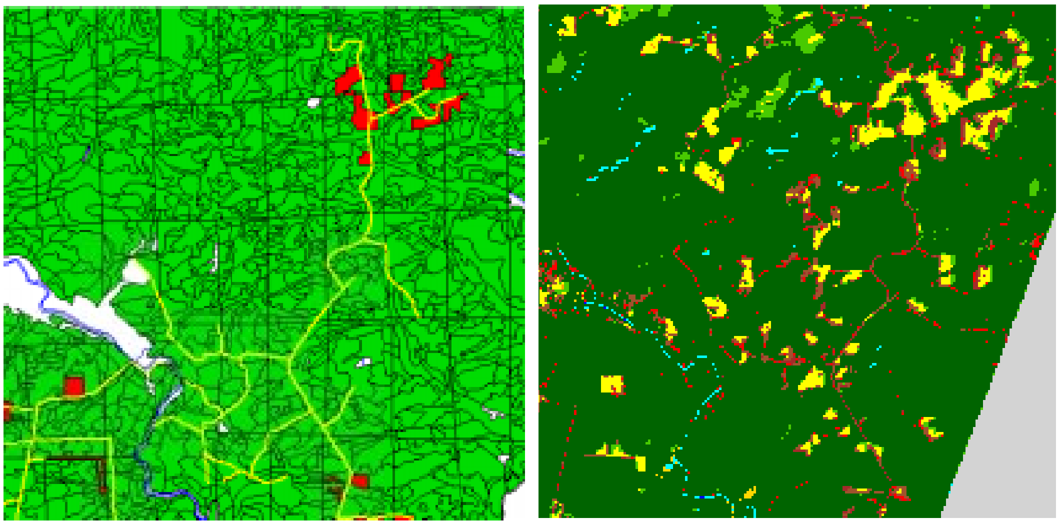
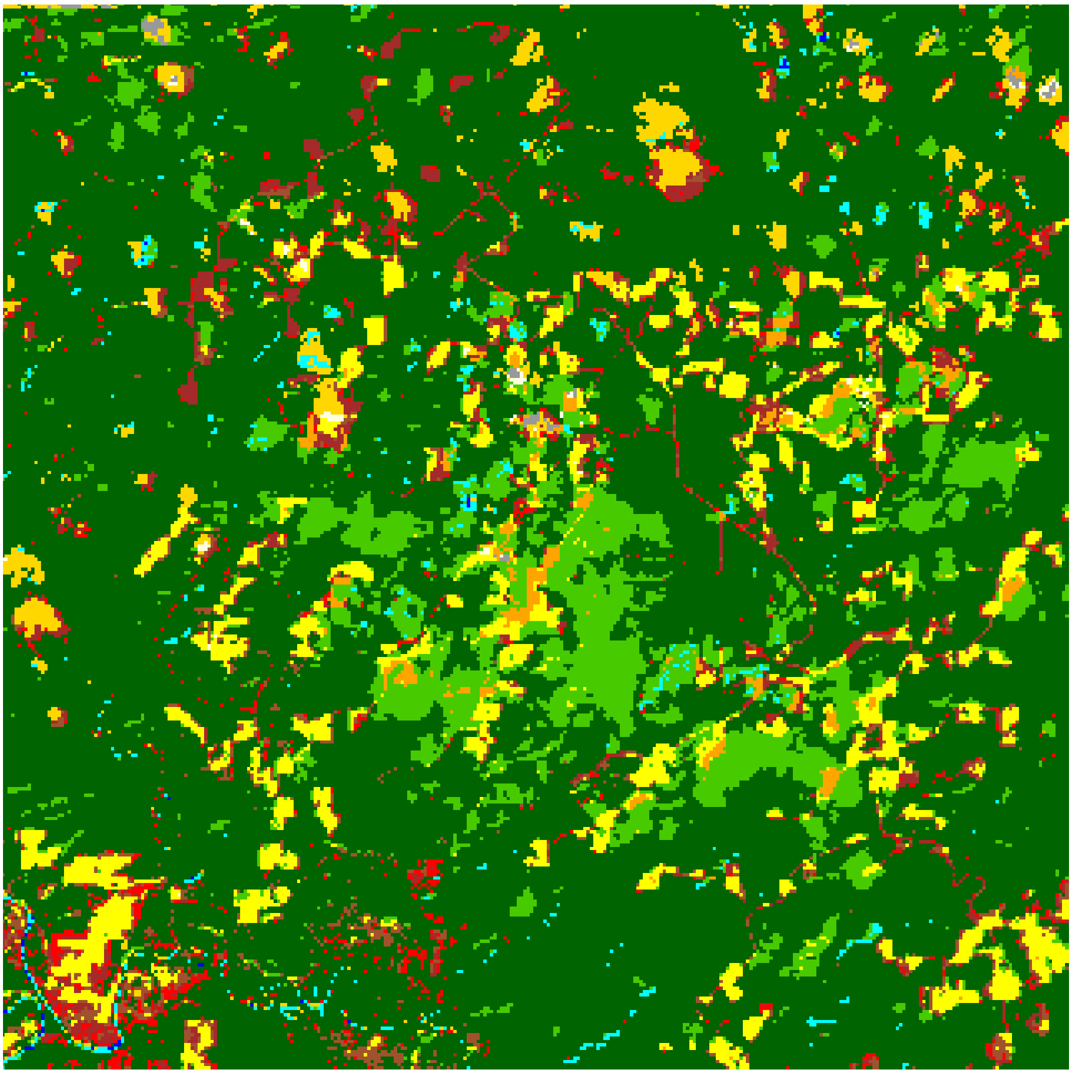


Figure 11: Comparison of clearcuts in 1991 (left image) and 1998 (right image) in the south-eastern part of the Zelendinsky area.



The clearcuts are not equally distributed over the whole forest management area but rather show a clumped distribution, as can be seen in *Figure 12*.

Figure 12: Area of mainly new clearcuts since 1991.



5 Discussion

The study should be seen in a wider context, because the aim of the satellite image analysis is to contribute to the design of a new forest inventory method and finally to the design of a new land information system. Therefore, the following aspects will be discussed:

1. Reliability of the results.
2. Information content of the different sensors.
3. Economic aspects.

5.1 Reliability of the results

It is obvious from the results that the uncertainties from this analysis are quite big. In percentage of total area, new clearcuts range between 26 and 60%. This uncertainty is primarily influenced by three factors:

- Radiometric differences.
- Spatial differences.
- Clouds.

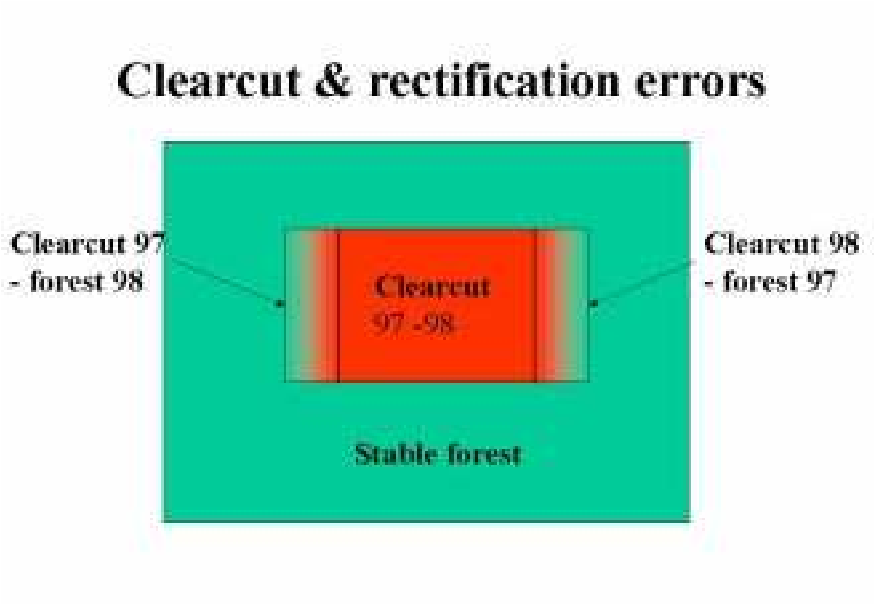
5.1.1 Radiometric differences

A haze correction is a very simple radiometric correction. In the comparison of relative radiometric normalization techniques, haze correction is on the lower part of the performance scale [3]. Most of the uncorrected differences are probably corrected automatically by the classification (reduction of digital levels). It is however possible that, for example, mixed pixels are classified differently between the two images. Clouds are a particularly difficult feature due to the very high internal variance and are discussed in more detail below.

5.1.2 Spatial differences

The RMS error from the rectification process amounts to about 55 meters. In practice, this means that the edges of features will be classified as change due to spatial distortion. To exemplify this further, we can consider a clearcut surrounded by forest. A very simple case is a rectangular clearcut and a distortion in the x-direction, see *Figure 13.*

Figure 13: The effect of rectification errors.



This will result in the left- and right-most pixels of that feature being classified as either forest-to-clearcut or clearcut-to-forest. This is relevant for the final classes 6.1, 10 and 11. For 6.1, it can mean that some pixels are still clearcuts, not forest as assumed by the rules. Hence, the total amount of clearcuts can be increased by a maximum of 104 hectares. This error is symmetrical and thus the effect in classes 10 and 11 can not be bigger than the area of 6.1. In the case of 10 and 11, an area that is actually a clearcut in 1997, will be classified as a new clearcut in 1998 due to the rectification error. Hence, it is a maximum of 104 hectares of these two classes that may not be clearcuts after all. The quantitative changes this causes is summarized in *Table 4*. The RMS-areas is the original calculated areas only included in the effect of the rectification (104 hectares added to the total area and 104 hectares subtracted from the new area).

Table 4: Changes caused by rectification error.

	$A, total_{RMS}$ *area [ha]*	B, new_{RMS} *area [ha]*	B/A *%*	$A/total_{original}$ *%*	$B/new_{original}$ *%*
Maximum	9490	5557	59	+2	–9
Minimum	4505	1022	23	+1	–2

The rectification error can easily be improved by using more, better distributed, and better defined ground control points.

5.1.3 Influence of clouds

Clouds are, however, presenting the biggest confusion compared to clearcuts. This is partly facilitated by the cloud-filter, but there are several situations were this filter does not give satisfactory results. If a cloud is very big it covers its own shadow and hence the value subtracted from the cloud pixel is not a low one (from a dark shadow pixel) but a high cloud pixel. The resulting value will be far lower than what is expected for a cloud.

On the other hand, there are small, thin clouds which do not produce any shadow at all. The resulting value will be more like what we expect from a clearcut and such clouds are likely to be a significant source of error. The same situation is expected for the edges of clouds; these are thinner and the shadow is thus weak or absent.

It is also possible that there are other dark objects close to relatively bright ones which are not clouds but will be detected as clouds by this filter. An obvious example is clearcuts but also earlier flooded areas which are now dry can give the same result due to the dark water that is always associated with floods. Problems due to water can be solved by masking away the water pixels. Water bodies are usually quite homogenous and can easily be delimited by a region-growing function.

5.2 Information content of the different sensors

The information content of satellite images is based on the following three features:

- radiometric resolution;
- spectral resolution; and
- spatial resolution.

5.2.1 Radiometric resolution

The radiometric resolution refers to the number of bits to be used for image acquisition. For the SPOT-sensor and the RESURS-MSU-E this number is given with 8 bits/band. This quantisation allows an image acquisitions with 256 different gray levels.

5.2.2 Spectral resolution

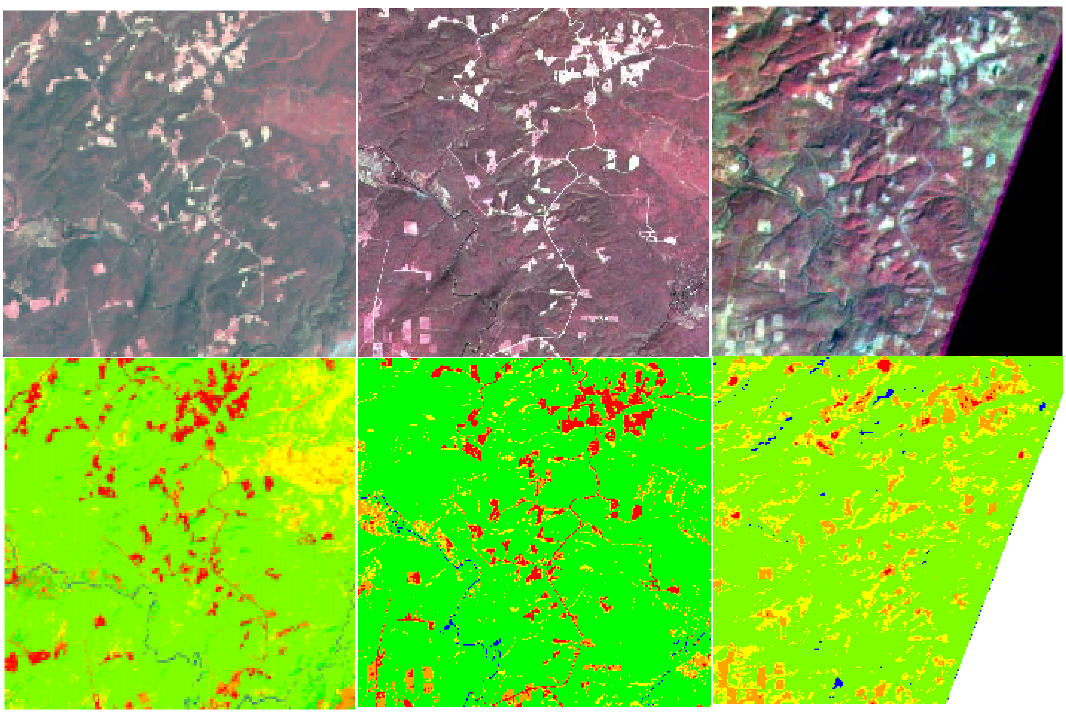
The spectral resolution refers to the number of bands in the different electromagnetic ranges. The SPOT-sensor shows an additional band in the wave length of the mid-infrared spectrum. This mid-infrared band is known to add very useful information for the differentiation of forest stands. However, due to lack of time, a detailed analysis of the potential of the image data to diffentiate between forest species, volume- and age-classes could not be fulfilled. The assumption that the SPOT-data with the mid-infrared band offers a higher potential for a detailed forest classification can not be proved, because of major differences in the sun elevation of the two image-data. The analysis of the RESURS-data is hampered due to the fact that the image was acquired at the end of September with a significantly lower sun elevation compared to the SPOT-image which was acquired in mid-June.

5.2.3 Spatial resolution

The spatial resolution refers to the area on the ground that is covered within one pixel. The spatial resolution used for a specific study should be linked to the size of the objects of interest within the scene. The objects of interest for this study are forest stands. So there is no need to identify single trees, for which a resolution of below 5 meters would be necessary.

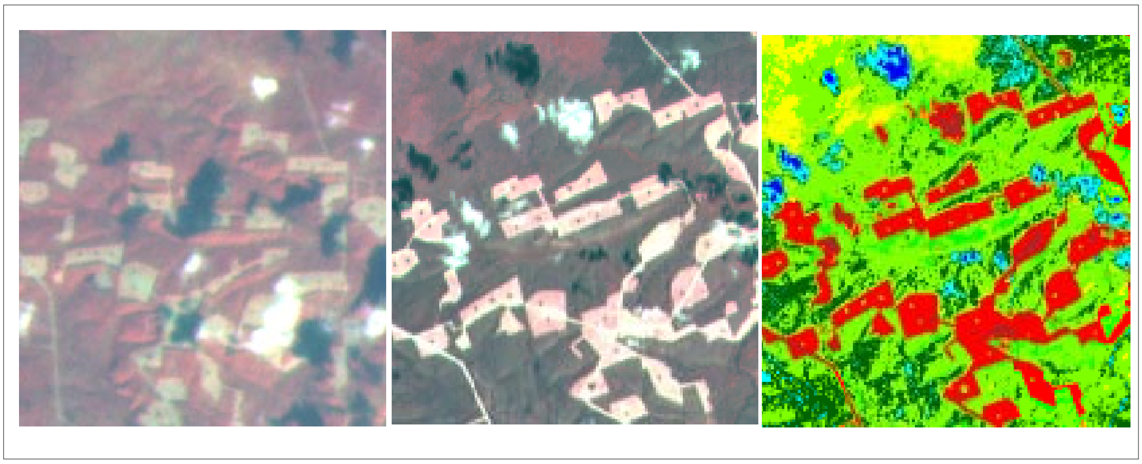
Nevertheless, there are substantial differences in the level of detailed information of the two images due to the differences in the spatial resolution of 20 meters (SPOT) and 45 meters (RESURS). In *Figure 14* special attention is given to demonstrate the different possibilities of forest road identification. Forest roads are of main interest, because preferably new logging activities take place in the neighborhood of existing forest roads. Whereas in the SPOT-image the roads can be classified sufficiently, the classification in the RESURS-data is almost impossible.

Figure 14: Comparison of the spatial resolution; images on the left: original SPOT-image (20 meter resolution); images in the middle: bilinear resampled SPOT-image (45 meter resolution); images on the right: RESURS-image (45 meter resolution).



As mentioned earlier, the problem of the mixture between clouds and clearcuts could be overcome with the use of additional information like the shape of the objects. Clearcuts can be identified because of their more or less regular shape and the collected branches in the middle of the area which causes small holes in the classification, see *Figure 15*. The number of holes is characteristic for clearcuts only and their number is related to the size of the clearcut which is useful information in a more sophisticated classification approach as proposed in the conclusion of this study. However, these features can be classified only in the SPOT-data with sufficient certainty.

Figure 15: Different levels of detailed information in the RESURS (left image) and the SPOT-image (middle image); right image: SPOT-classification result.



5.3 Economic aspects

As in every monitoring or information system, the proposed Russian forest inventory concept will have to be a compromise between the level of detailed information and the costs to acquire this information. Therefore, the satellite image data to be used within such a concept can not solely be evaluated due to the information content (see 5.2) or the spatial resolution. The financial evaluation will probably play a key-role for the implementation of such a new concept.

Table 5 shows the key features of the satellite systems that will favorably be used in the forest inventory concept. The sensors have a comparable spectral resolution. They acquire the image with two bands in the visible spectrum (green and red) and one band in the near infrared spectrum, except for SPOT-4 which acquires the image data in an additional mid-infrared band. The different costs for the images have to be weighted according to the area on the ground which is covered by one scene. Therefore, prices per square kilometer are calculated for the different sensors. As can be seen in *Table 5* there are two cost-groups. The first group consists of the RESURS and IRS-data, where the price/km^2 is approximately ECU 0.15. The second group consists of the SPOT-data which show prices above ECU 0.5.

Table 5: Cost of satellite image data in ECU.

Sensor	Spatial Resolution	Area	Costs per Scene	Costs per km²
SPOT-4-XS	$20 * 20$ m	$60 * 60$ km	2550	0.7
SPOT-1,2-XS	$20 * 20$ m	$60 * 60$ km	2025	0.56
RESURS MSU-E	$45 * 45$ m	$45 * 45$ km	340	0.17
IRS-LISS	$23 * 23$ m	$140 * 140$ km	2650	0.14
ERS-1	$10 * 10$ m	$100 * 100$ km	400	0.04

6 Conclusions

Despite cloud coverage the approach tested here makes an approximate quantification of stable and new clearcuts possible. A division of the classes into different levels of uncertainty is also automatically achieved. However, the cloud-filter used is still subject to several error sources and this should be improved. A distinction between edge-cloud pixels and clearcuts can be improved by applying a neighbor analysis to the derived clouds, however, it is more difficult to detect smaller clouds by this approach. Perhaps the best way of solving this problem would be to apply a segmentation-algorithm. Distinct features, such as the rectangular shape and black ‘holes’ caused by collected branches, makes it easy to separate clearcuts from clouds if the segments are already defined. Segmentation should be applied when a deeper analysis of forestry is the aim of the study.

Monitoring boreal forests requires a solution to the problem of cloud-clearcut confusion. A Swedish study calculates the probability of having cloud free images of a contingous area of 50 by 50 kilometers within the vegetation period to be 18% (referred to in [2]). In boreal areas cloud free images are the exception rather than the rule. Therefore, a multi-temporal approach could be a solution for this cloud cover problem. This approach should be a compromise between the costs for the acquistion of multiple images and the level of the information content of the image. For a certain area the costs for one SPOT-4 XS image is approximately three times as high as data from either RESURS MSU-E or IRS-LISS. In addition to using optical data, one should also consider using radar data. The possibilities these data sources offer are studied in the current SIBERIA project in which IIASA is one of the key partners.

References

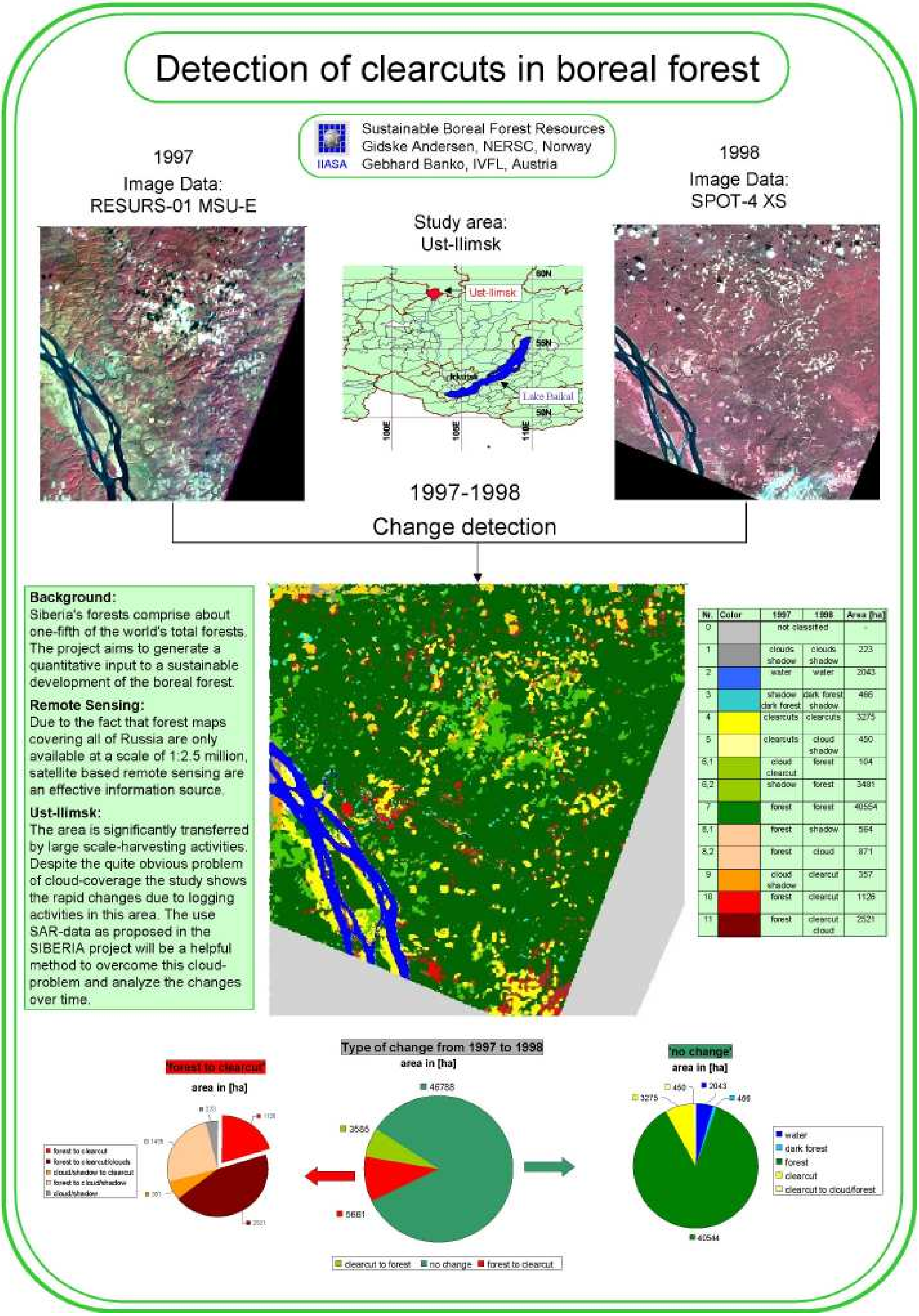
[1] Carlsson, M. (1996) “Biodiversity Implications of Timber Management in the South-central Siberian Forest Enterprise: The Ust-Ilimsk Case Study.” In: Duinker, P. (Ed.) Biodiversity of Siberian Forests: Concepts, Preliminary Anal-

ysis, and Proposed Research Directions. IIASA Working Paper, WP-96-79, pp. 101–129.

[2] Holmgren, P. and Thuresson, T. (1998) "Satellite Remote Sensing for Forestry Planning — A Review." *Scandinavian Journal of Forest Research,* 13(1):90–110.

[3] Yuan, D. and Elvidge, C.D. (1996) "Comparison of Relative Radiometric Normalization Techniques." *ISPRS Journal of Photogrammetry and Remote Sensing,* 51(1996):117–126.

7 APPENDIX A


Detection of clearcuts in boreal forest
IIASA
Sustainable Boreal Forest Resources
Gidske Andersen, NERSC, Norway
Gebhard Banko, IVFL, Austria
1997
Image Data:
RESURS-01 MSU-E
1998
Image Data:
SPOT-4 XS
Study area:
Ust-Ilimsk
Ust-Ilimsk
60N
55N
50N
Irkutsk
Lake Baikal
100E
105E
110E
1997-1998
Change detection
Background:
Siberia's forests comprise about one-fifth of the world's total forests. The project aims to generate a quantitative input to a sustainable development of the boreal forest.
Remote Sensing:
Due to the fact that forest maps covering all of Russia are only available at a scale of 1:2.5 million, satellite based remote sensing are an effective information source.
Ust-Ilimsk:
The area is significantly transferred by large scale-harvesting activities. Despite the quite obvious problem of cloud-coverage the study shows the rapid changes due to logging activities in this area. The use SAR-data as proposed in the SIBERIA project will be a helpful method to overcome this cloud-problem and analyze the changes over time.
Nr. Color 1997 1998 Area [ha]
0 not classified -
1 clouds shadow clouds shadow 223
2 water water 2043
3 shadow dark forest dark forest shadow 466
4 clearcuts clearcuts 3275
5 clearcuts cloud shadow 450
6,1 cloud clearcut forest 104
6,2 shadow forest 3481
7 forest forest 40554
8,1 forest shadow 564
8,2 forest cloud 871
9 cloud shadow clearcut 357
10 forest clearcut 1126
11 forest clearcut cloud 2521
'forest to clearcut'
area in [ha]
forest to clearcut
forest to clearcut/clouds
cloud/shadow to clearcut
forest to cloud/shadow
cloud/shadow
Type of change from 1997 to 1998
area in [ha]
46788
3585
5661
clearcut to forest
no change
forest to clearcut
'no change'
area in [ha]
450
2043
3275
466
40544
water
dark forest
forest
clearcut
clearcut to cloud/forest