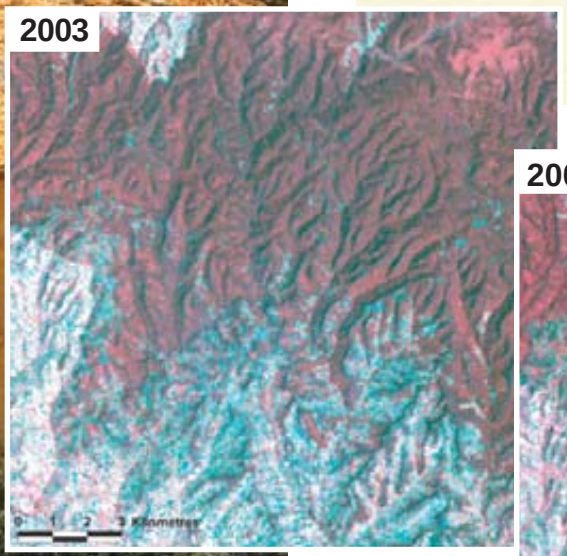
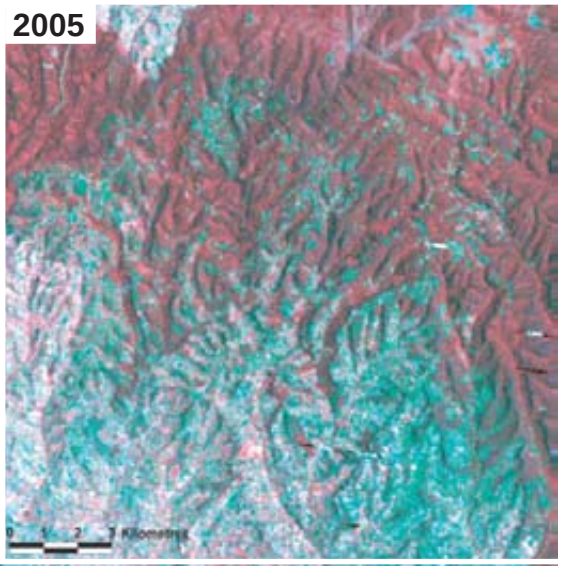




Changes in Forest Cover in Kenya's Five "Water Towers" 2003 - 2005

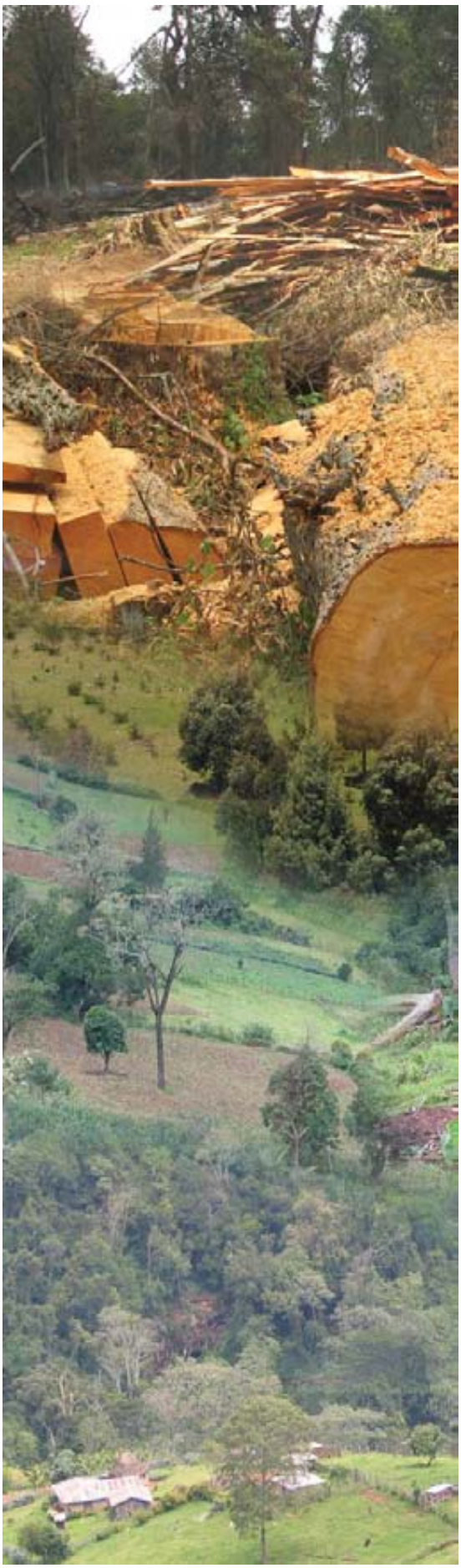
Report prepared by:

DRSRS

KFWG

With support from the Royal Netherlands Embassy

November 2006



Changes in Forest Cover in Kenya's Five "Water Towers" 2003 - 2005

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November 2006

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FOREWORD

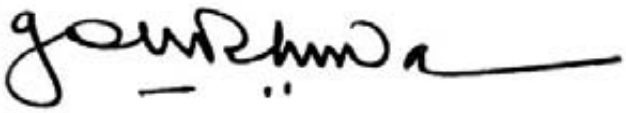
It is with great pleasure that I foreword this second volume of Changes in Forest Cover in Kenya's Five "Water Towers, namely Mt. Kenya, the Aberdare Range, the Cherangani Hills, the Mau Complex and Mt. Elgon forests. These forests are the lifeline of the Nation. They are the upper catchments of our main rivers that support the country's key economic sectors, including energy (hydropower generation covers 70% of our electricity needs), water, agriculture, livestock and tourism (our prestigious conservation areas depend on those rivers). These forests are also important in terms of carbon sequestration, soil conservation, provision of timber and non-timber products, as well as for their social, cultural and spiritual values.

The first volume that covered the period 2000-2003, revealed indigenous forest destruction in three of the five" water towers", amounting to a loss of 6,032 hectares over the three years. Improvements were, however, recorded on Mt. Kenya whilst in the Aberdares Ranges extensive cloud hindered detection of forest cover changes.

I am pleased to note from this second volume that illegal forest clearing has been contained in the forest reserves of Cherangani Hills and Mt. Elgon during the period 2003-2005 while Mt. Kenya forests are improving. The Mau Complex is currently the "water tower" experiencing unabated destruction. In terms of acreage, indigenous forest destruction increased from 6,032 hectares during the 2003-2005 period to 9,334 hectares in the 2003-2005 monitoring period. The Ministry is, therefore, committing to fully contain the continued forest destruction in the Mau and to restore the critical catchment value of that 'water tower". In this regard, I appreciate that the findings of this report will facilitate the Ministry to focus on areas that need urgent remedial measures.

I am confident that with the Forests Act 2005 in place and the current forest sector reform initiatives, forest protection and conservation in the country will attain optimal levels.

On behalf of the Ministry, I take this opportunity to thank DRSRS, KFWG and Royal Netherlands Embassy for their involvement in forest cover changes analysis and urge them, to continuously generate and share with us such invaluable information.



Prof. George O. Krhoda, CBS
PERMANENT SECRETARY
MINISTRY OF ENVIRONMENT & NATURAL RESOURCES

ACKNOWLEDGEMENTS

This report on *Changes in Forest Cover in Kenya's Five "Water Towers" 2003 – 2005* is the second in a series of reports from monitoring studies aimed at providing information on changes in forest cover on the five key catchment forests in Kenya dubbed as the "water towers". The first report in this series was published in November 2004. This monitoring project arose from the need, underlined by key stakeholders, to promote good governance in forest management in Kenya. The Dutch Embassy, a close development partner of the Kenyan Government, has been instrumental to the project by providing the necessary funds and on-going support.

The project would not have been possible without the support of Mr. Christian Lambrechts, Policy and Programme Officer from the Division of Early Warning and Assessment, United Nations Environment Programme, who developed the project proposal and supervised its implementation.

Finally our gratitude goes to Liz Mwambui, Outreach Officer, KFWG, who prepared the final layout of the report and Fleur Ng'weno for editorial work.

Eric Akotsi
DRSRS

Michael Gachanja
KFWG

1.0 INTRODUCTION

Closed canopy forests cover only 1.7 per cent of Kenya's land area, yet provide crucial services to the people, the nation, and the environment. At a time when the world is confronted by climate change, forest cover can help to mitigate the effects of droughts and floods. Forests trap, store and slowly release rain water, the life blood of the economy. They support agriculture, fisheries, electricity production and urban and industrial development. Forests also produce wood and medicines, moderate climate, reduce erosion, shelter a disproportionate share of Kenya's biodiversity, and have religious and cultural significance. Yet Kenya's forests have been and remain the target of over-exploitation and uncontrolled and unplanned development.

This report is the second in a series of monitoring studies being undertaken on the five "water towers" of Kenya – Mount Kenya, the Aberdare Range, the Mau Forest Complex, Mount Elgon, and the Cherangani Hills. These are the five largest forest blocks in the country, and are all montane forests. They form the upper catchments of all the main rivers in Kenya (except the Tsavo River originating on Kilimanjaro). The "water towers" provide water to all installed hydro-power plants, producing some 70 percent of Kenya's electricity output. These montane forests are also surrounded by the most densely populated areas of Kenya, because they provide enough water for intensive agriculture and urban settlements.

The 2003-2007 economic recovery strategy paper recognizes that Kenya faces serious environmental challenges due to previous forest mismanagement, and that deforestation is a key symptom of environmental damage. Kenya's civil society now also has a strong voice, willing to challenge poor environmental governance. Up to date information on the condition of the forests, however, is often lacking, limiting the ability of concerned stakeholders inside and outside government to lobby or direct actions against illegal exploitation and destructive development.

In order to remove such obstacles to advocacy towards good forest governance, this report presents the findings of the detection of major forest cover changes between 2003 and 2005 in Mt. Kenya, the Aberdare Range, the Mau Complex, Mt. Elgon and the Cherangani Hills. The initiative to monitor the five "water towers" began in the year 2003 with the support of the Dutch embassy. Results were published as *Changes in Forest Cover in Kenya's Five "Water Towers" 2000 – 2003*. Using satellite imagery (Landsat 7 Enhanced Thematic Mapper) with a resolution of 30 metres, the analysis of temporal scenes enables the detection of major forest cover changes, in particular encroachment. This analysis is undertaken in a two-year interval in an effort to provide all concerned stakeholders with an early warning system that will enable them:

1) to identify threatened forest areas in due time; and,
2) to prioritize their interventions in these areas in order to reverse detrimental forest cover changes.

1.1 Objective

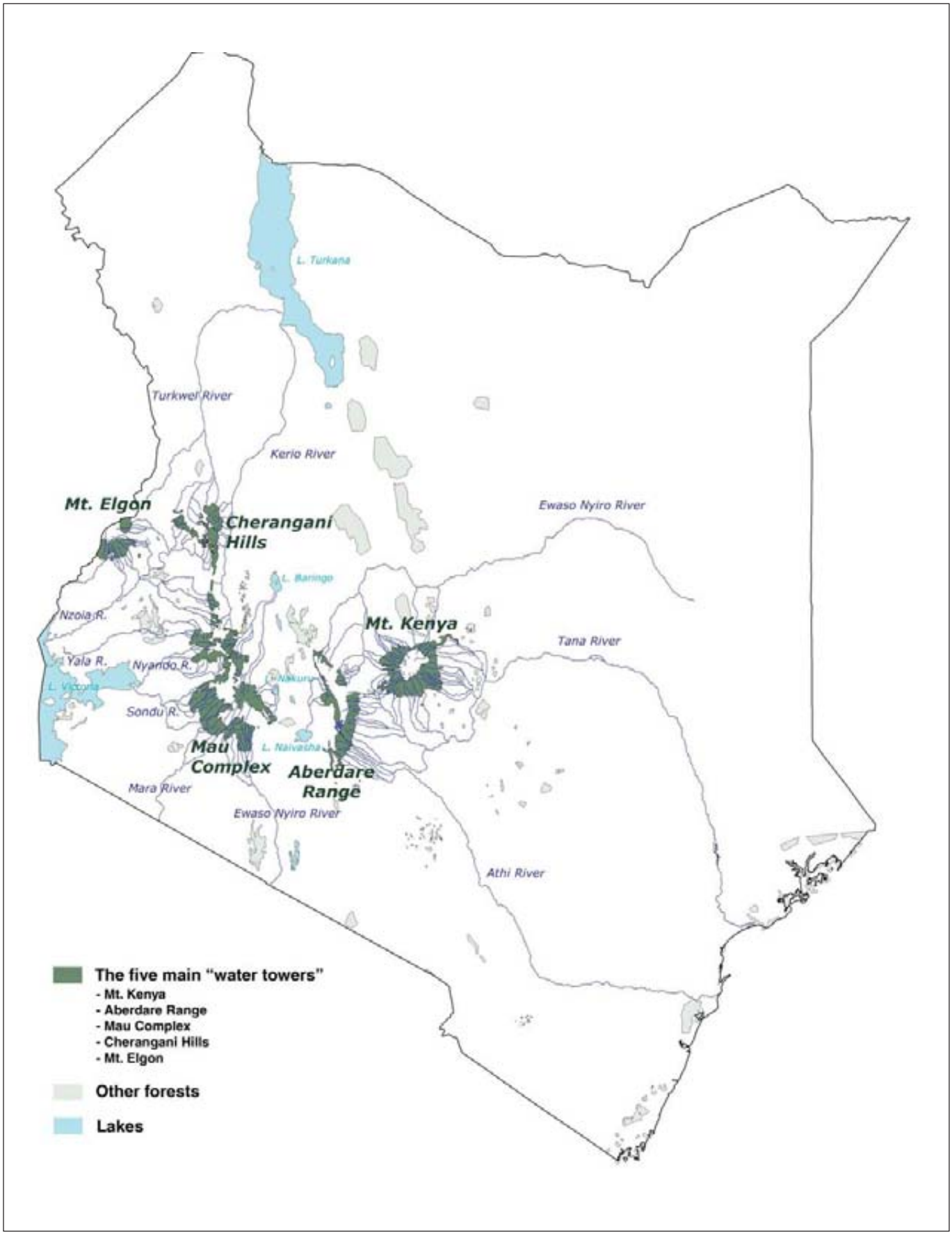
To alert key stakeholders in forest management and conservation about current and critical forest cover changes in the main catchments of the country and to provide them with the necessary information to prioritize interventions towards addressing these changes in good time.

1.2 Study Area

The study area comprises of the five "water towers" of the country: the Aberdare Range, Mt. Kenya, Mt. Elgon, Mau Complex and the Cherangani Hills forests. In total, they cover over 1 million ha and form the upper catchments of all main rivers of Kenya except Tsavo River. In addition they provide goods and services to both forest-adjacent communities and to the country. These forests are presented in figure 1.

[1] UNEP (2001). *An Assessment of the World 's Remaining Closed Forests*

Fig 1: Location of the five main catchment areas - the "water towers"



1.2.1 Aberdare Range forests

The Aberdare Range is located in central Kenya, on the eastern edge of the Rift Valley. The forest belt of the Aberdare Range comprises a number of forest reserves, including Aberdare, Kikuyu Escarpment, Kijabe Hill, Kipipiri and Nyamweru, as well as some forest areas in the Aberdare National Park. The forests cover over 250,000 ha. These forests form part of the upper catchments of Tana River, Kenya's largest river, as well as Athi, Ewaso Nyiro (North) and Malewa rivers. They are also the main catchments for the Sasumua and Ndakaini dams, which provide most of the drinking water to Nairobi. The forests are characterized by a high diversity of vegetation types, because of the wide altitudinal range (from 1,800 to 3,600 metres) and the climatic differences between the slopes. In addition, the Aberdare Range offers spectacular scenery for tourism.

1.2.2 Mt. Kenya forests

Mt. Kenya forests are located on the equator, 180 km north of Nairobi and on Africa's second highest mountain. Most of the forest belt is protected as National Reserve with some forest areas located within the National Park. They cover over 220,000 ha and form the upper catchments of the Tana and Ewaso Nyiro rivers. Mt. Kenya forests alone are estimated to meet more than 40% of the country's water needs.

Like the Aberdare Range, the forest vegetation is characterized by a high diversity of forest types. Mt. Kenya forests are rich in terms of species, in particular plant species. Mt. Kenya has a very attractive scenery that is highly appreciated by tourists. It therefore has great potential for domestic and foreign tourism.

1.2.3 Mau Complex forests

The forests of the Mau Complex when combined cover an area of over 400,000 ha. The Mau Complex is the largest remaining closed canopy forest block in Eastern Africa. It forms the upper catchments of all, but one, rivers that drain west of the Rift Valley, including Nzoia, Yala, Nyando, Sondu and Mara, which drain into Lake Victoria. It is also the main catchment of critical lakes and wetlands in the Rift Valley, including lakes Baringo, Nakuru, Naivasha, Natron and Turkana. The forests of the Mau Complex are also very rich in flora and fauna.

1.2.4 Mt. Elgon forests

Mt. Elgon forests are located north of Lake Victoria on the border between Kenya and Uganda. The forest belt is protected as National Park and Forest Reserve; the latter covers 73,706 ha. Mt. Elgon forms the upper catchment area for two major rivers: Nzoia and Turkwel rivers. It also provides water to the Malakisi River that crosses the small scale farming area south of the mountain before entering Uganda. The forest has species that are globally threatened including Kenyan endemics, making the area a priority for species conservation and an attraction for tourists.

1.2.5 Cherangani Hills forests

The Cherangani Hills forests comprise a number of forest reserves covering the Cherangani hills on the western ridge of the Great Rift Valley. The forests cover an area of some 120,000 ha and form the upper catchments of the Nzoia, Kerio and Turkwel rivers.

2.0 METHODOLOGY

2.1 Selection of satellite images

Satellite images from Landsat-7 Enhanced Thematic Mapper were used for the detection of changes in the forests. Images from the dry season January-March were selected for the years 2003 and 2005 (see Table 1). The bands 2 (green), 3 (red) and 4 (near-infrared) of the selected images were used in the change detection process. These bands have a resolution of 30 x 30 metres, enabling the detection of critical changes in the forests, such as clear-felling of forest, illegal settlements or conversion of forest land into agricultural land. The logging of individual trees, however, cannot be detected with such resolution. It would require aerial photography or aerial survey.

The Landsat data collected in the year 2005 have gaps due to failure of the satellite's Scan Line Corrector (SLC) on 31st May 2003. The SLC is a device that compensates for the forward motion of the satellite to avoid a zigzag striped data (with gaps). The gaps were filled up using data from other images taken during the same year and period. However, some gaps still remain after the gaps filling process. They appear as short straight strips on the 2005 images.

Table 1 Landsat images used in the study

Year	Landsat images	Date of receiving	Forest of interest
2003	168/060	1st March 2003	Mt. Kenya / Aberdare
	168/061	12th January 2003	Aberdare
	169/059	4th February 2003	Cherangani
	169/060	4th February 2003	Mau complex
	169/061	4th February 2003	Mau complex
	170/059	10th January 2003	Mt. Elgon / Cherangani
2005	168/060	18th February 2005	Mt. Kenya / Aberdare
	168/061	25th February 2005	Aberdare
	169/059	29th March 2005	Cherangani
	169/060	29th March 2005	Mau complex
	169/061	9th February 2005	Mau complex
	170/059	16th February 2005	Mt. Elgon / Cherangani

2.2 Processing of the satellite images

2.2.1 Geo-referencing of the year 2003 images

Geo-referencing refers to the process of assigning map coordinates to satellite images. In this case, the satellite images of the year 2003 have been geo-referenced against the topographic maps at scale 1/50,000 of Survey of Kenya using a number of ground control points. The projection used is the Universal Transverse Mercator (UTM) with WGS84 as datum. Second order polynomial transformation and nearest neighbour resampling method were selected for this process.

2.2.2 Image to image registration for the year 2005 images

The satellite images of the year 2005 were geo-referenced against the corresponding satellite images of the year 2003. This process, called image to image registration, is usually used for time-series images. It ensures that the pixel grids of the images of the year 2005 conform with the corresponding images of the year 2003, hence enabling pixel by pixel comparison of the images.

2.2.3 Normalized Difference Vegetation Index

Normalized Difference Vegetation Index (NDVI) is a ratio often used to determine the density of vegetation in an area based on visible and near infra-red (NIR) sunlight reflected by plants. The pigment in plant leaves, chlorophyll, strongly absorbs visible light (from 0.4 to 0.7 ìm – band 3 of Landsat-7) for use in photosynthesis. The cell structure of the leaves, on the other hand, strongly reflects near-infrared light (from 0.7 to 1.1 ìm – band 4 of Landsat-7).

The more leaves a plant has, the more these wavelengths of light are affected. The normalized difference is preferred to the simple index as it compensates for illumination conditions such as surface slope and orientation. Vegetated areas will give positive values due to their high reflectance in NIR and low reflectance in the visible spectrum. On the other hand, bare areas or areas with very sparse vegetation cover have higher reflectance in the visible spectrum than in NIR, leading to negative and near zero NDVI values.

2.2.4 Change detection

The detection of changes involves the comparison of satellite images taken in different years. In this case, the situation in 2005 was compared with the situation in the 2003. The method applied in this study is known as image differencing: the value of the pixels in 2003 image is simply subtracted from the value of the corresponding pixels in the 2005 image. In areas with no significant change, the difference value will be close to zero. On the other hand, in areas where major changes occurred, the difference will give large negative or positive values. In order to distinguish areas of significant changes from areas with no significant changes, a meaningful threshold of changes must be applied. In this study the threshold was put at 15 percent. Image differencing was performed by subtracting the NDVI of the 2003 images from the NDVI of the corresponding 2005 images. Positive changes (increase in vegetation density) were assigned a green colour whilst negative changes (decrease in vegetation density) were assigned a red colour. The areas with no significant changes remain black.

2.2.5 Ground truthing

A team of experts was sent to Mau forests where major forest changes were observed to ascertain the cause of the forest cover changes observed between 2003 and 2005. The team visited selected sites between 15th and 17th October 2006.

2.2.6 Digitizing and map composition

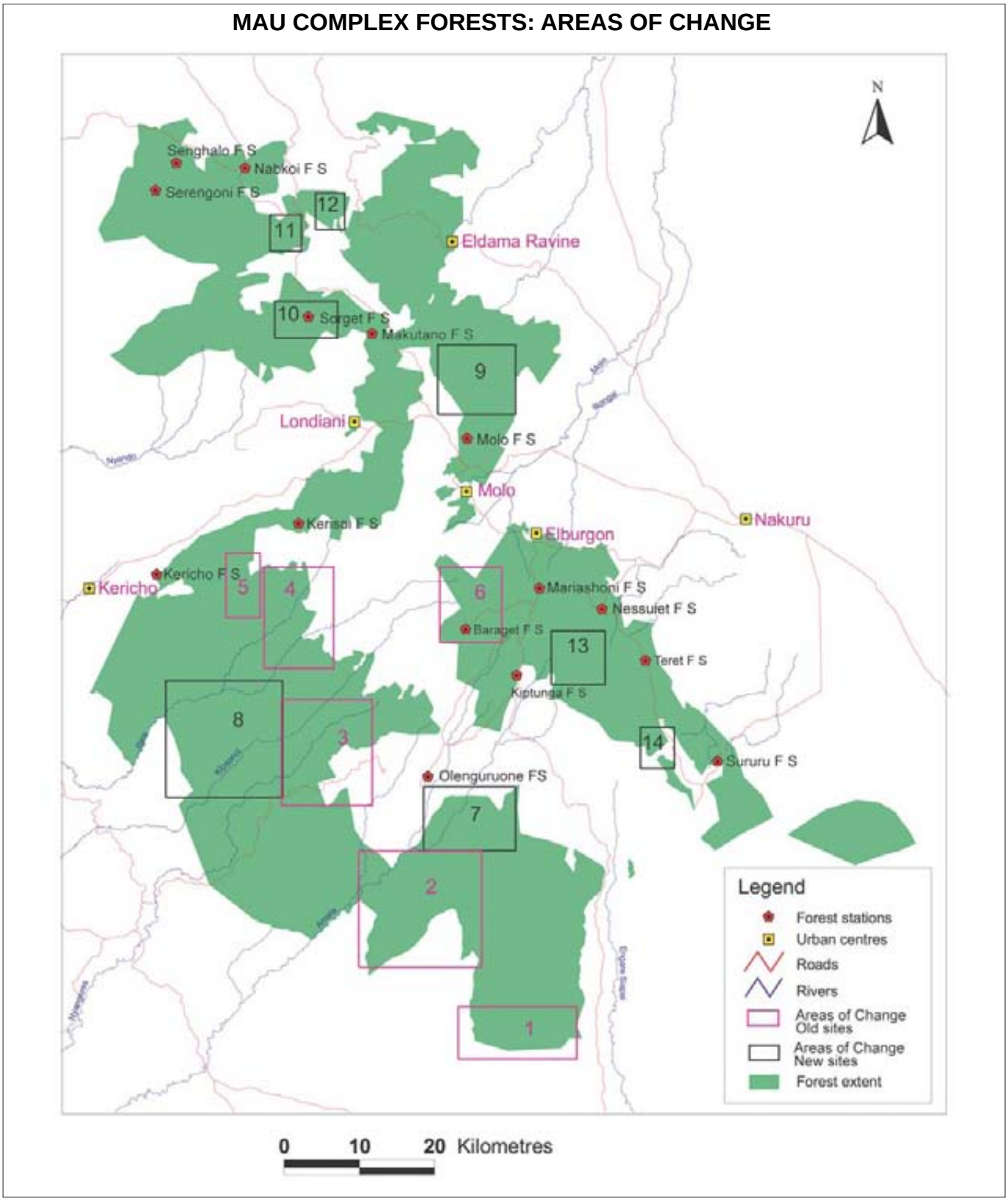
The areas where significant changes occurred were digitized on screen using the software ArcView 3.2. The total area was then calculated using the extension Xtools. A number of key features, such as roads and rivers were digitized from scanned topographic maps 1/50,000 from Survey of Kenya. The boundaries of the protected forests were obtained from the KIFCON project (1991-1994). These layers were overlaid to produce the maps contained in the report.

3.0 RESULTS

The results of the detection of changes in the five “water catchments” of Kenya are given below. They are supported with maps, tables and time-series satellite images. The satellite images are false colour composition using band 4 (red), band 3 (green) and band 2 (blue). On these images, the red colour is associated with dense vegetation, whilst the green/blue colour means very scattered vegetation or no vegetation or bare ground.

3.1 Mau Complex forests

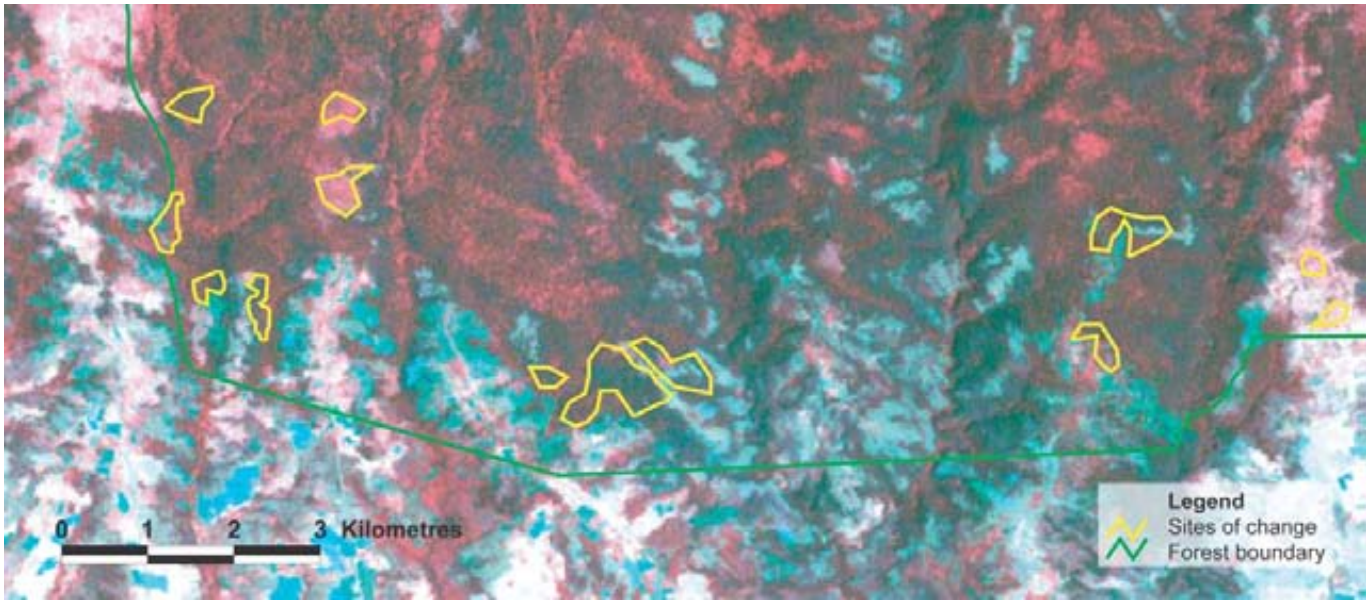
Fig. 2: Location of changes in the Mau Complex forests



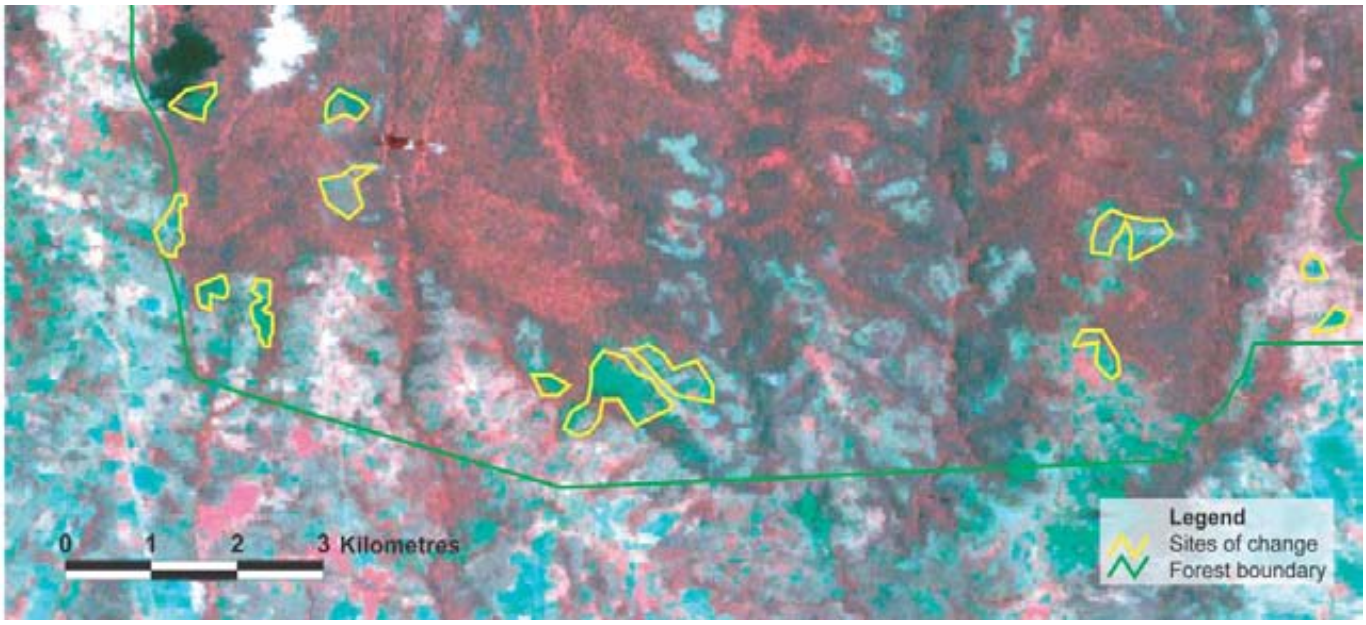
The boxes numbered 1 to 14 show sites where significant changes occurred between 2003 and 2005. Sites 1 to 6 are old sites which also showed changes between 2000 and 2003 while the rest are new sites where changes occurred between 2003 and 2005. The 2003 and 2005 satellite images of these 14 sites are presented below to help the reader visualize the changes.

Site 1: Narok North Constituency, Narok District

Situation in Year 2003; areas within the yellow outlined polygon are forested

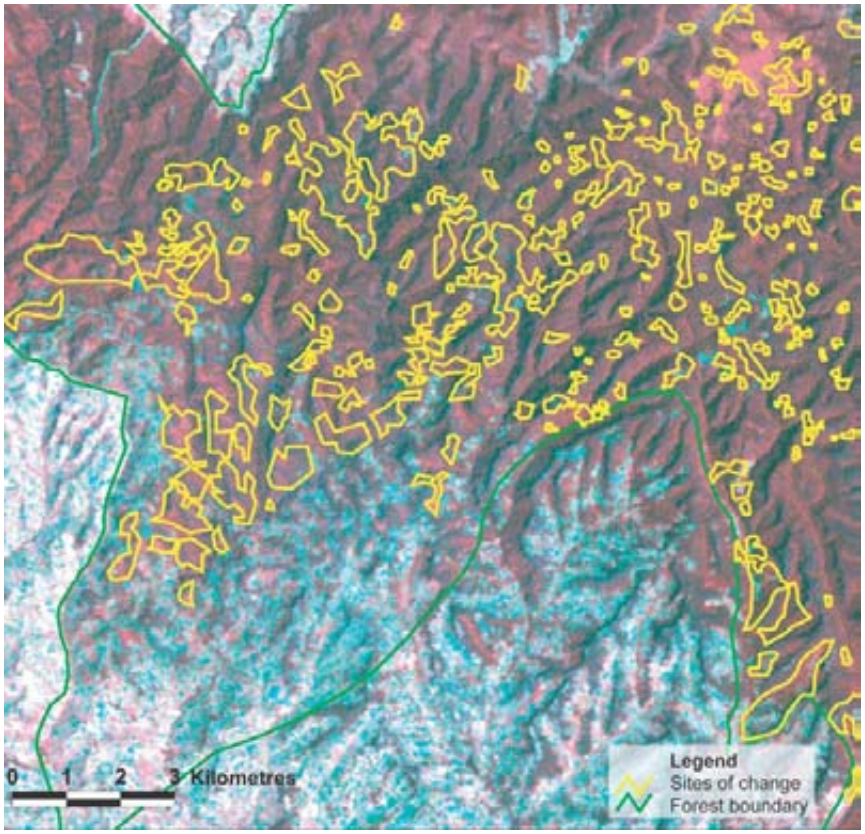


Situation in Year 2005; areas within the yellow outlined polygon have been cleared

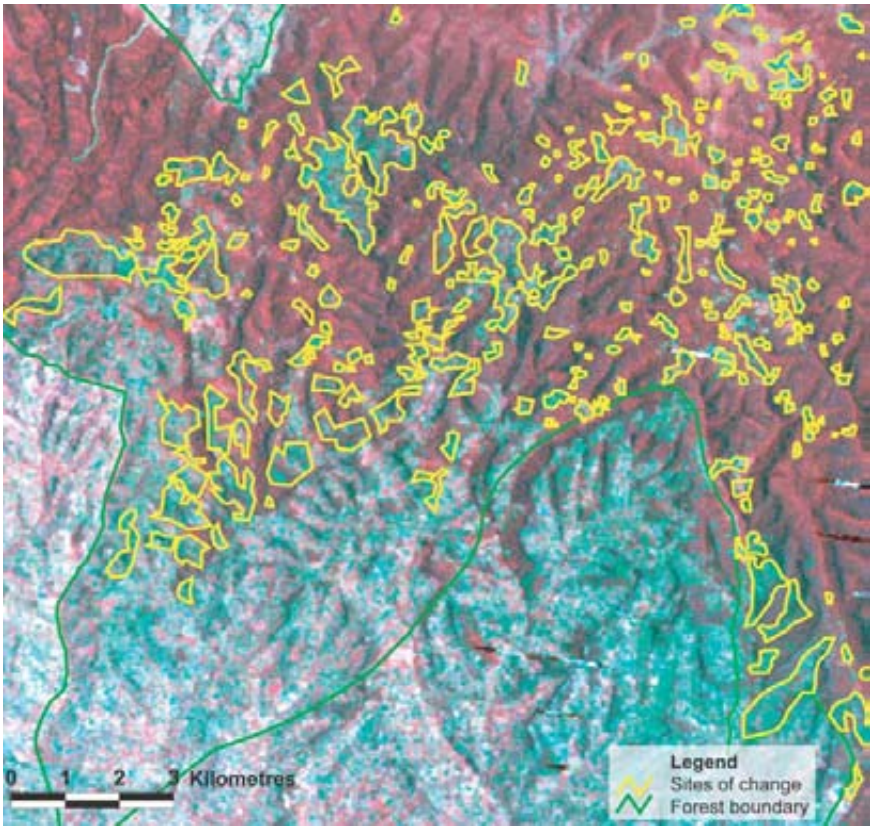


Site 2: Narok South Constituency, Narok District

Situation in Year 2003; areas within the yellow outlined polygons are forested

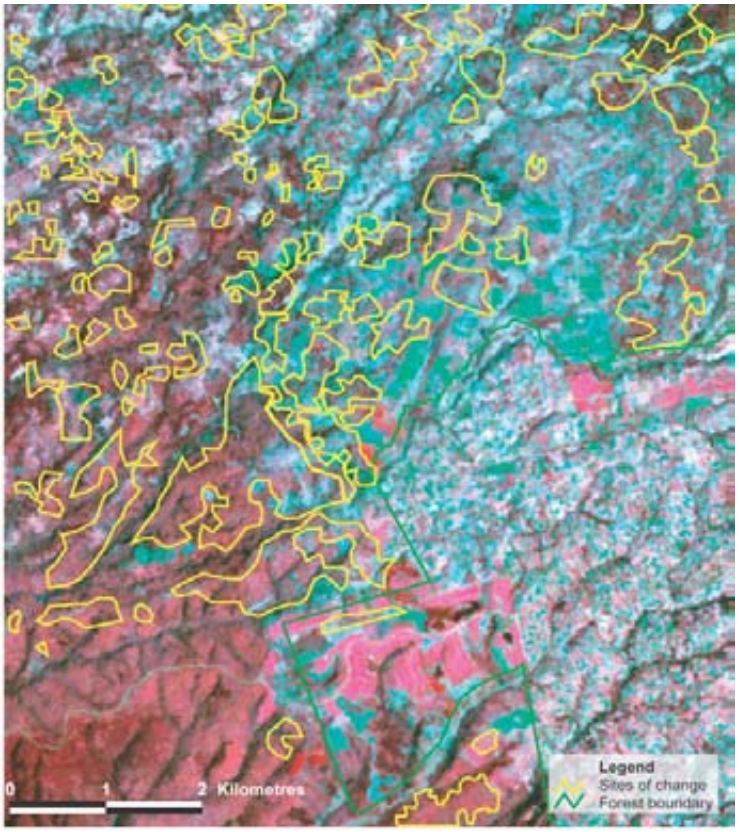


Situation in Year 2005; areas within the yellow outlined polygon have been cleared

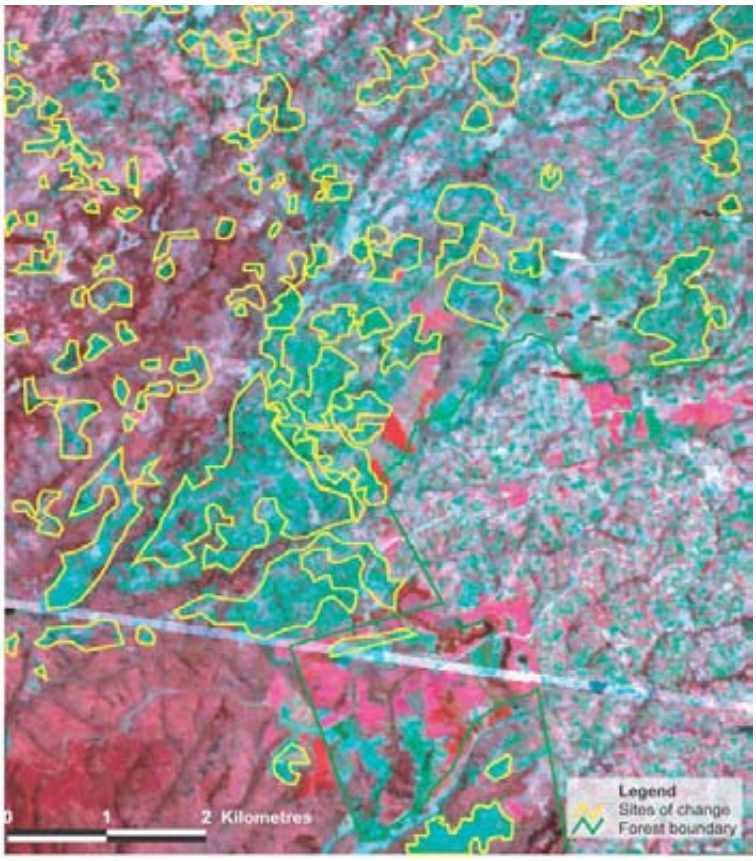


Site 3: Kuresoi Constituency, Nakuru District

Situation in Year 2003; areas within the yellow outlined polygons are forested

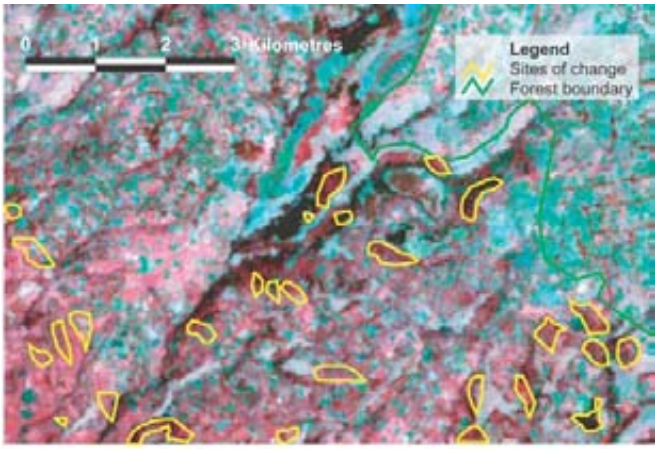


Situation in Year 2005; areas within the yellow outlined polygons have been cleared



Site 4: Kuresoi Constituency, Nakuru District

Situation in Year 2003; areas within the yellow outlined polygons are forested



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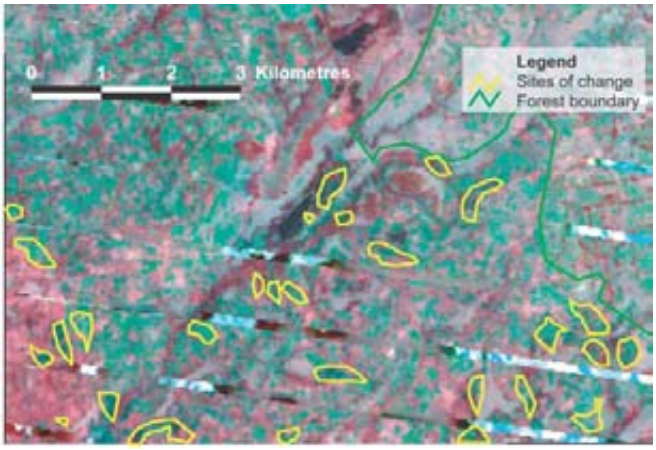
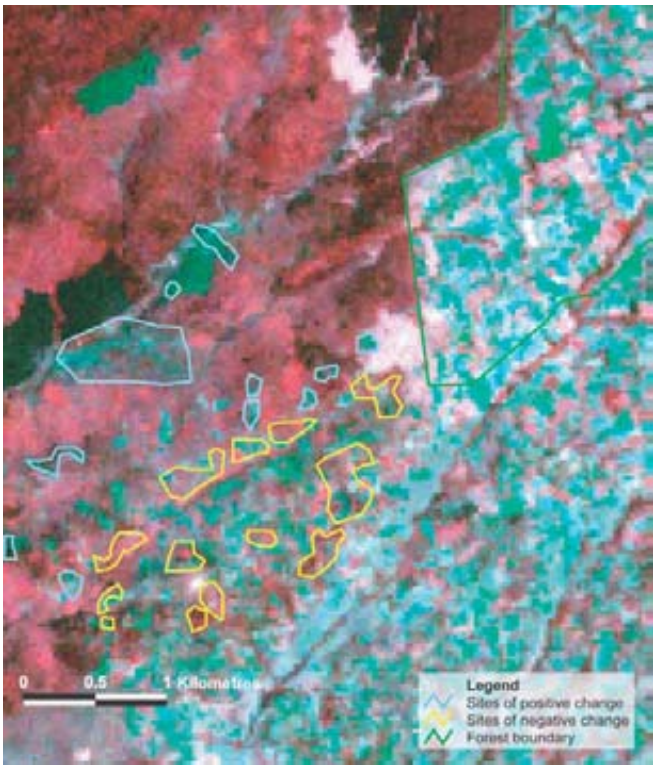
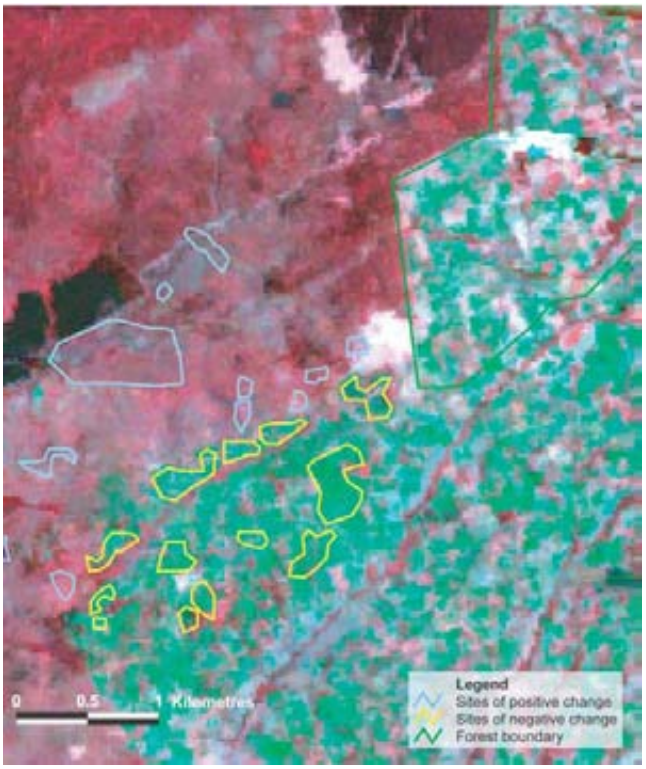


Site 5: Kuresoi Constituency, Nakuru District

Situation in Year 2003; areas within the yellow outlined polygons are forested

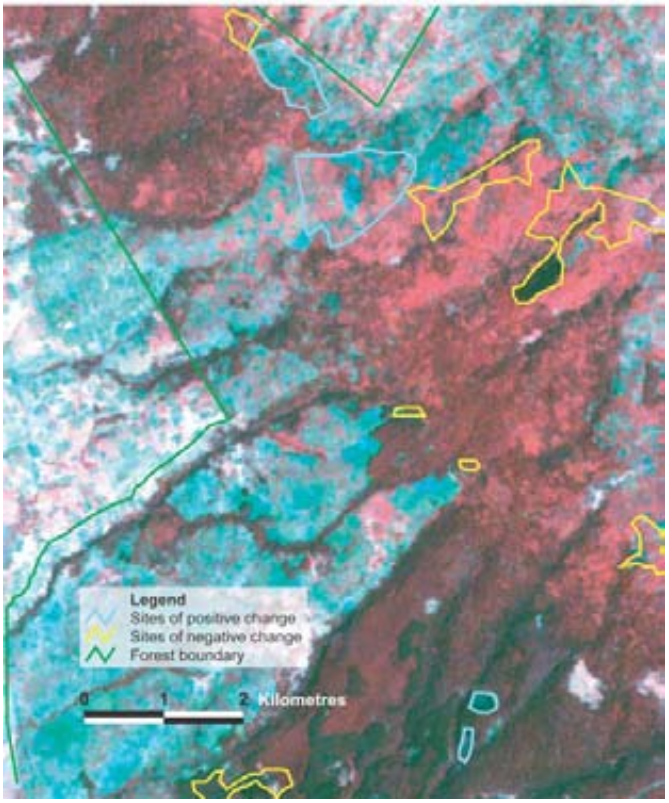




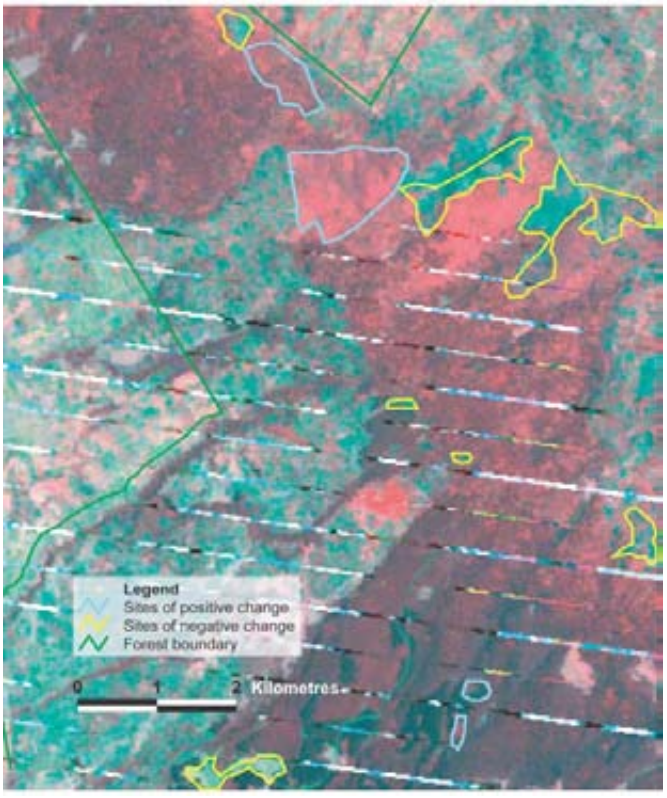
Sites outlined in blue show a reverse trend (vegetation regeneration)

Site 6: Kuresoi/Molo Constituencies, Nakuru District

Situation in Year 2003; areas within the yellow outlined polygons are forested



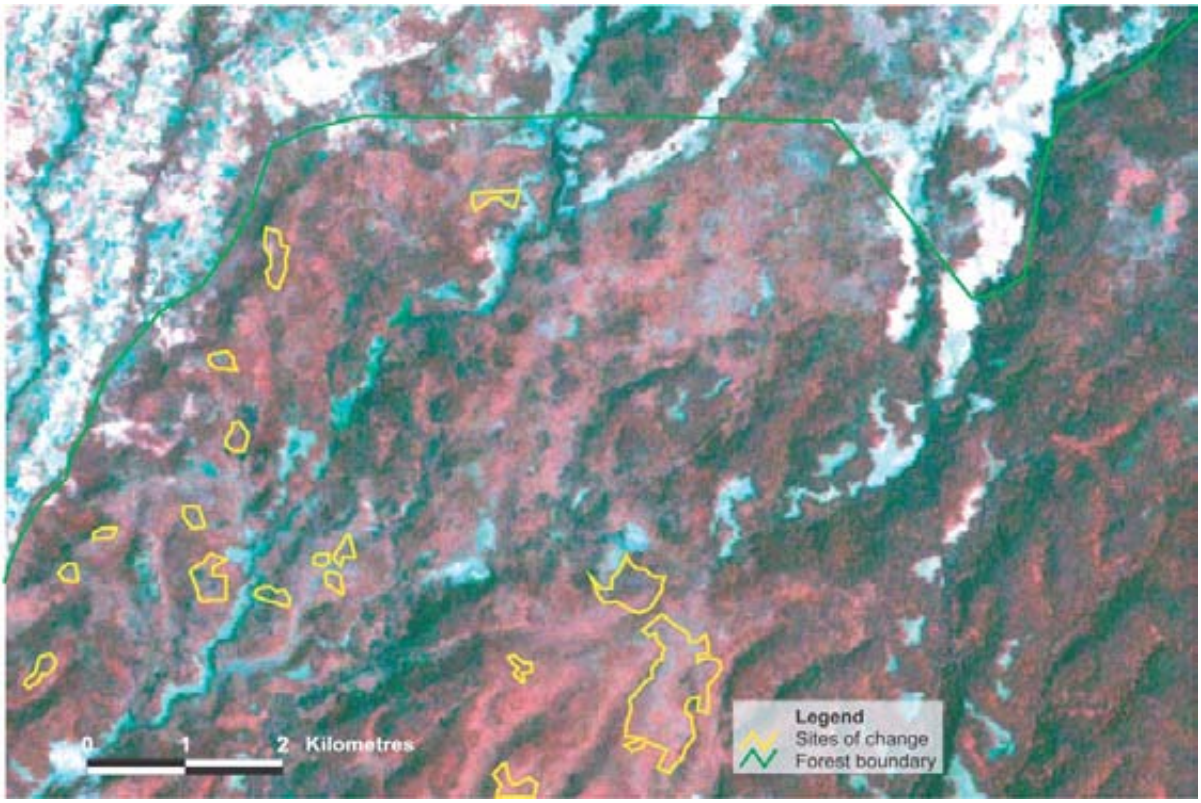
Situation in Year 2005; areas within the yellow outlined polygons have been cleared



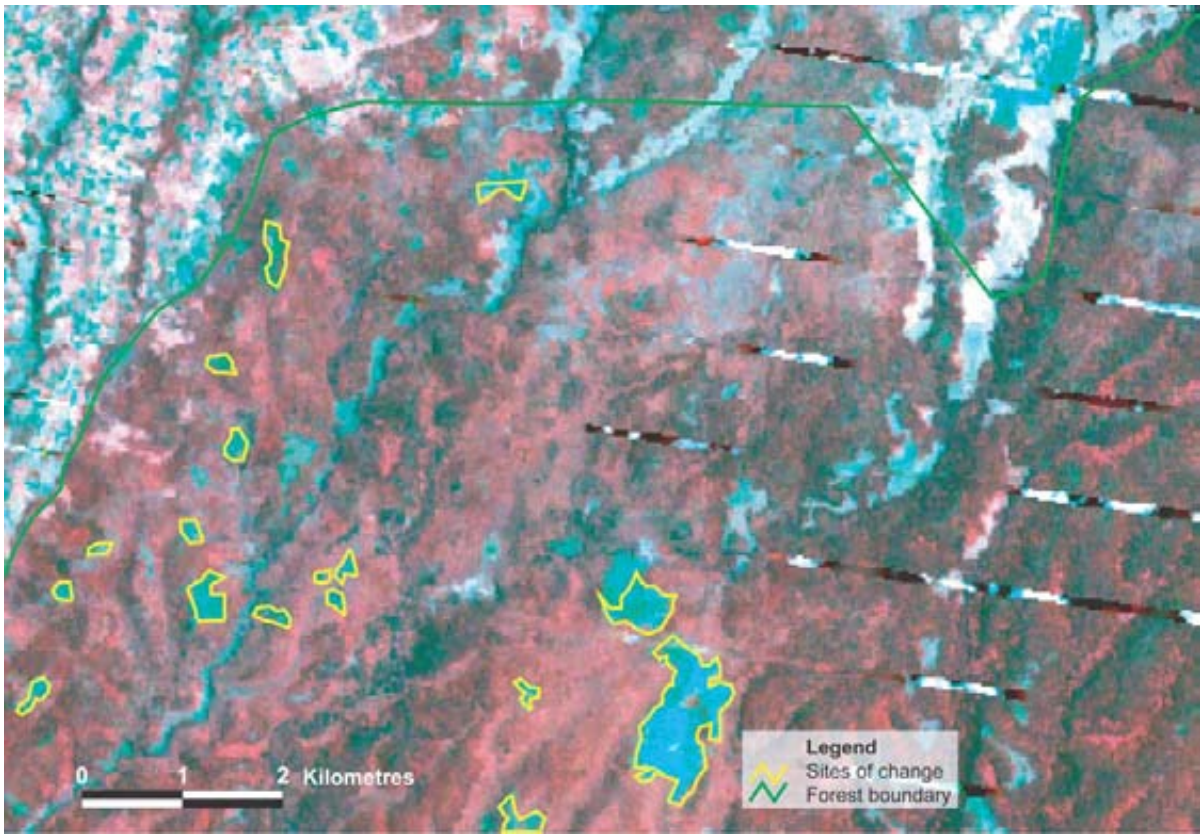
Sites outlined in blue show a reverse trend (vegetation regeneration)

Site 7: Narok North Constituency, Narok District

Situation in Year 2003; areas within the yellow outlined polygons are forested

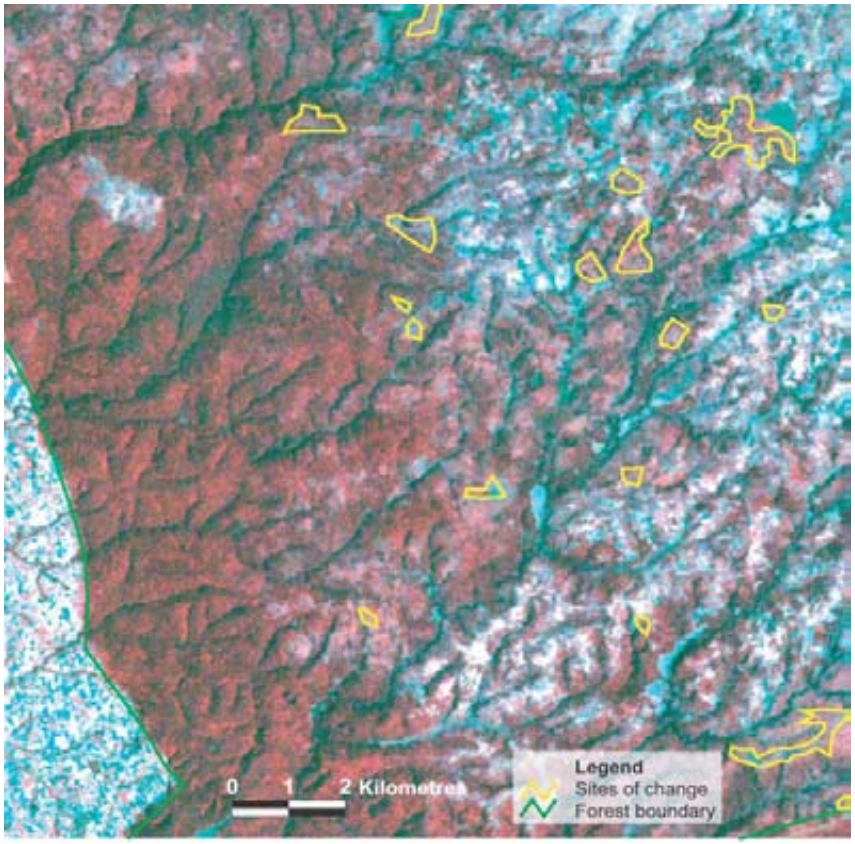


Situation in Year 2005; areas within the yellow outlined polygons have been cleared

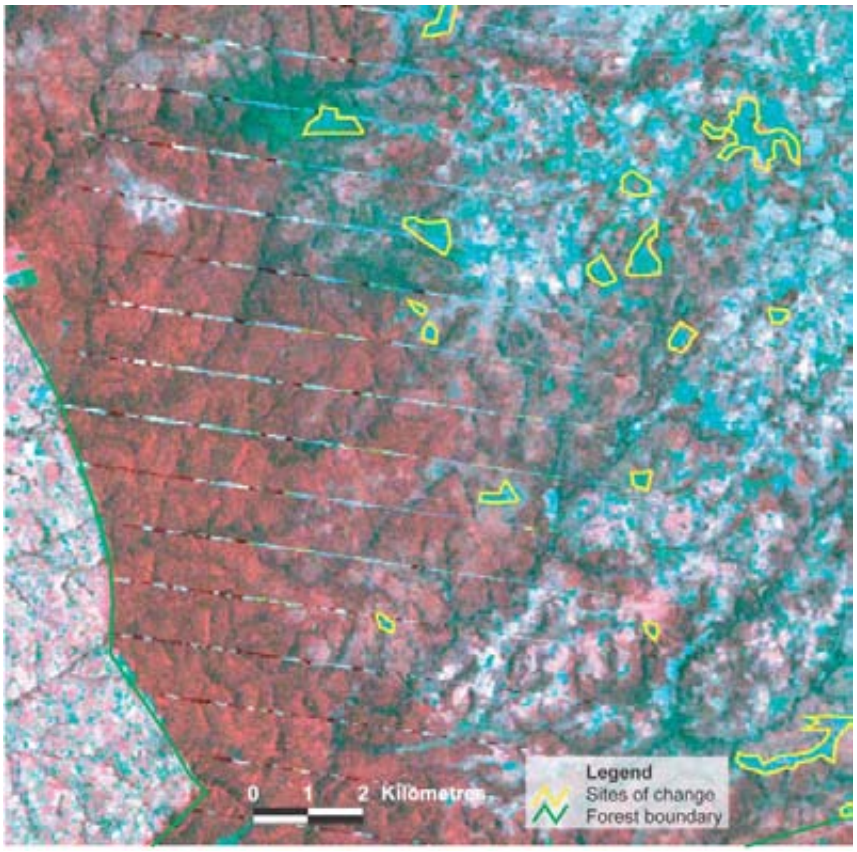


Site 8: Konoin Constituency, Bureti District

Situation in Year 2003; areas within the yellow outlined polygons are forested



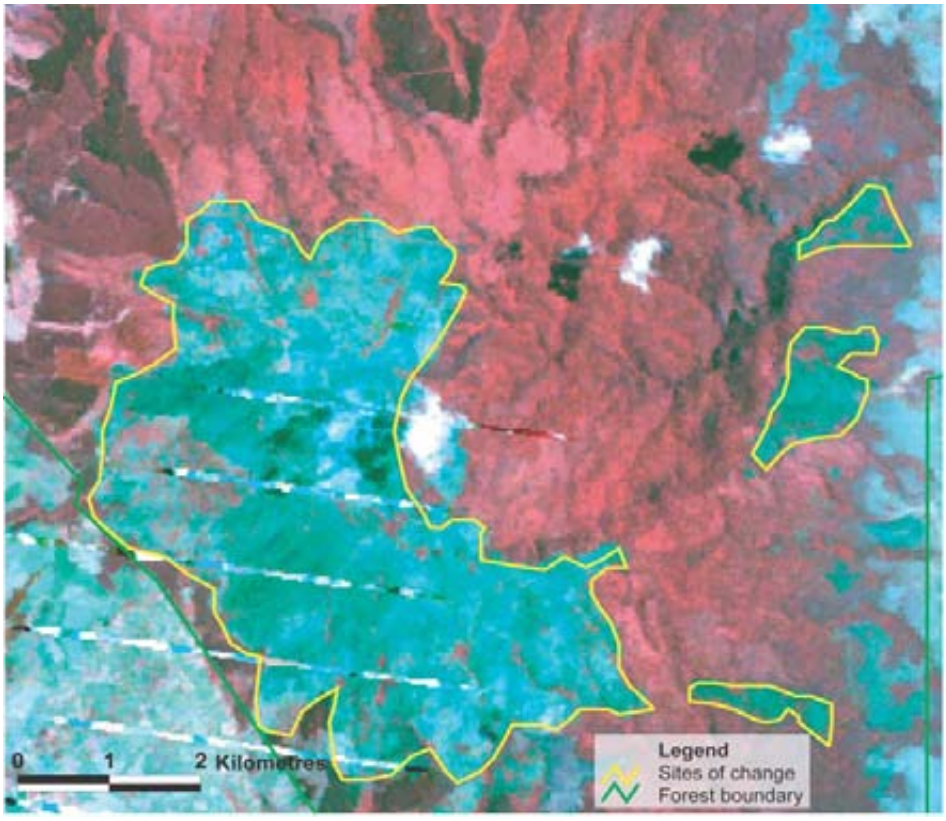
Situation in Year 2005; areas within the yellow outlined polygons have been cleared



Site 9: Eldama Ravine Constituency, Koibatek District

Situation in Year 2003; areas within the yellow outlined polygons are forested

Situation in Year 2005; areas within the yellow outlined polygons have been cleared



Site 10: Kipkelion Constituency, Kericho District

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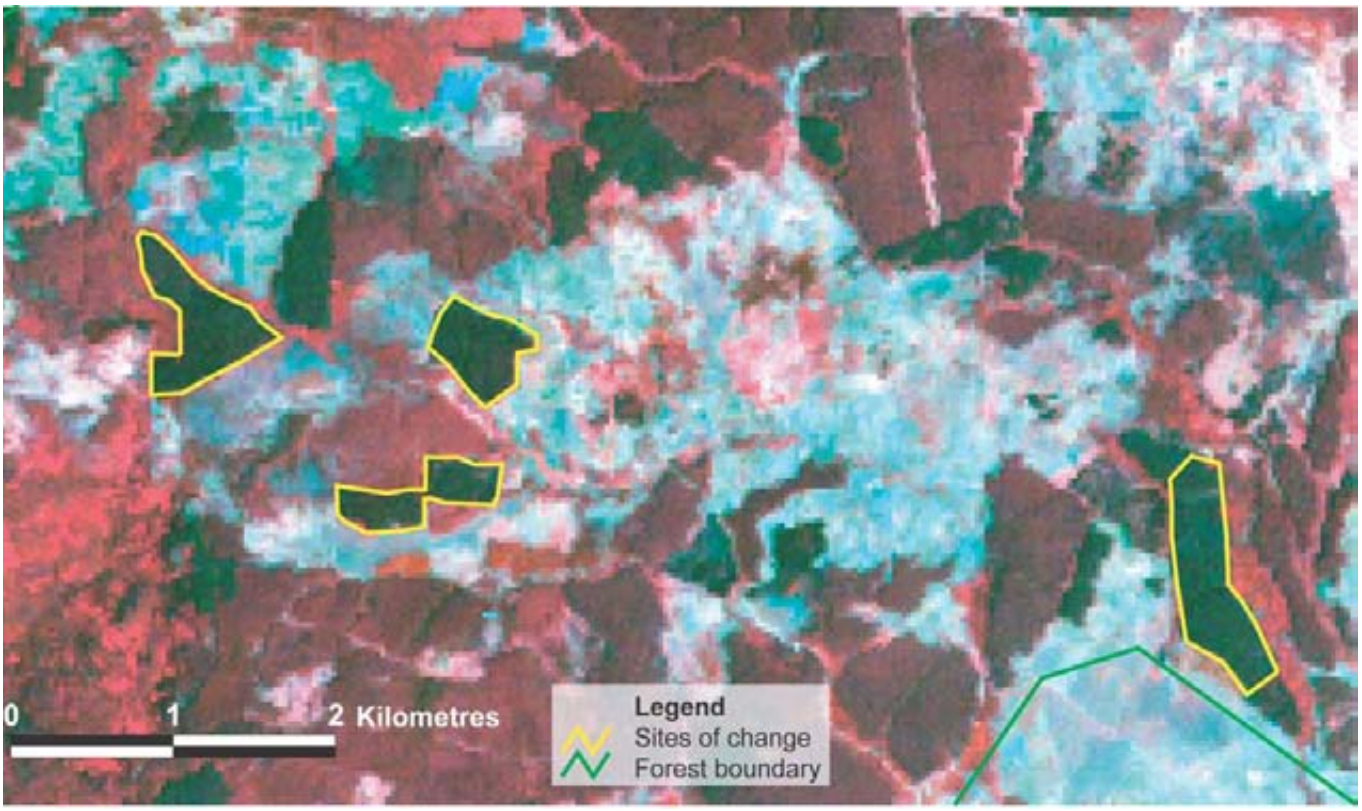
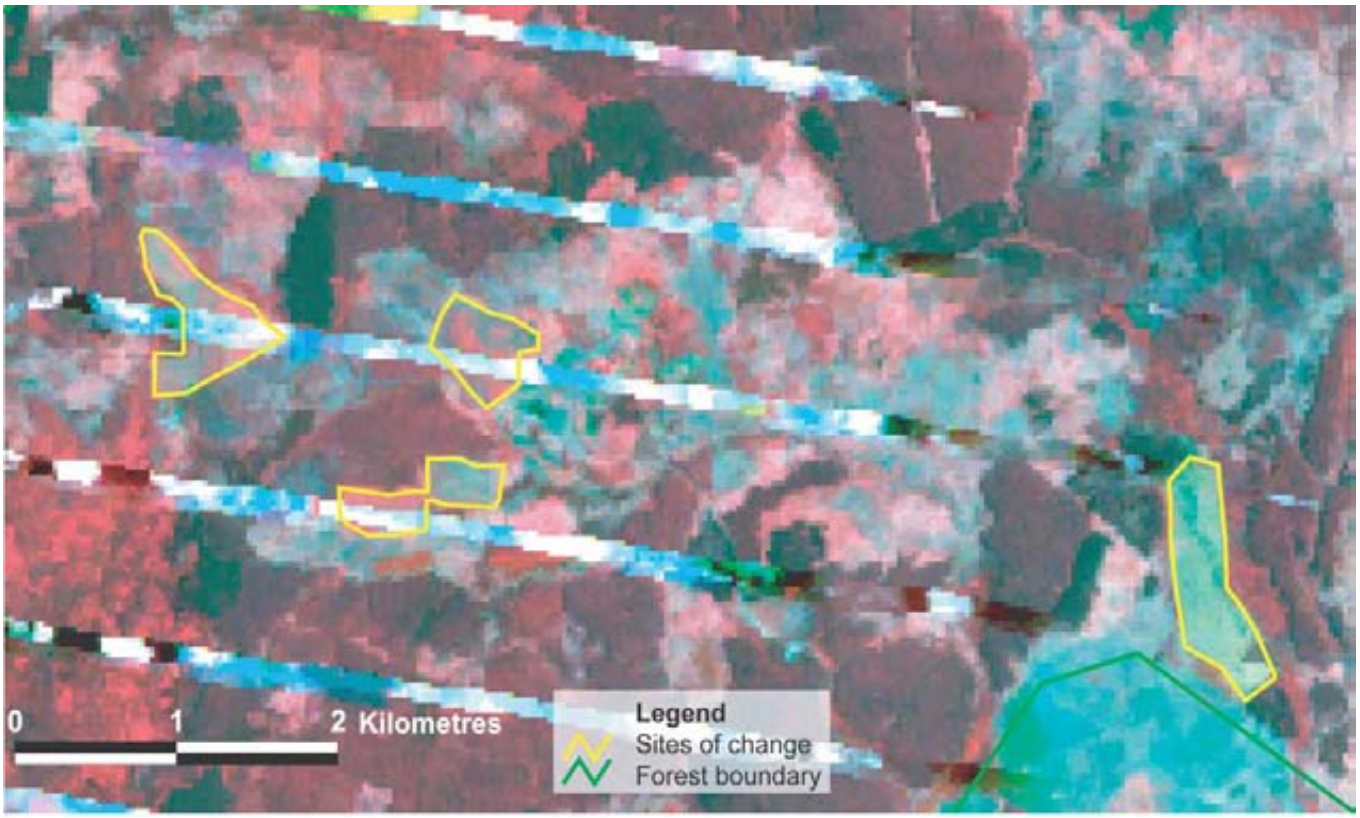
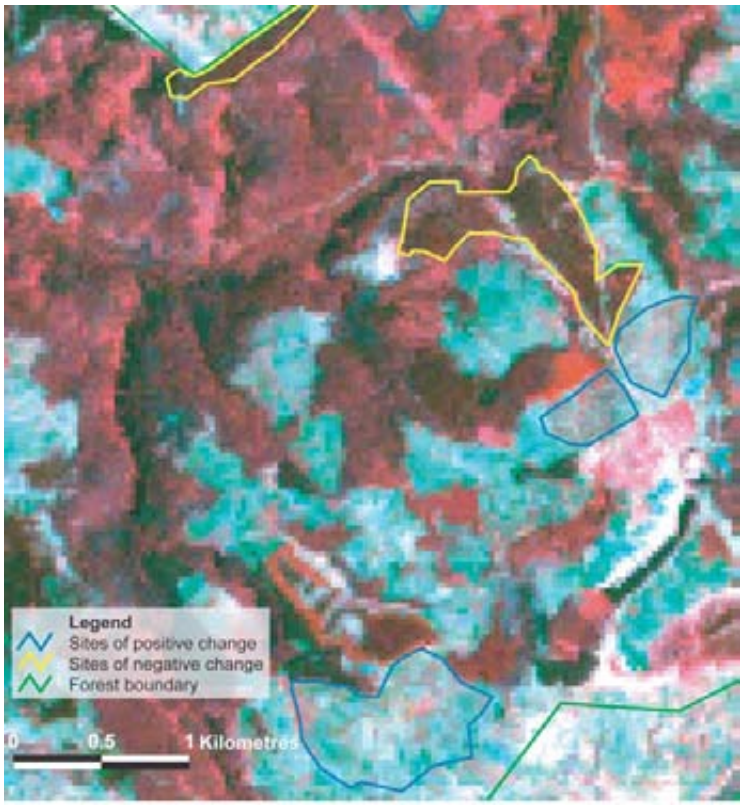


Situation in Year 2005; areas within the yellow outlined polygons have been cleared



Site 11: Eldoret South Constituency, Uasin Gishu District

Situation in Year 2003; areas within the yellow outlined polygons are forested

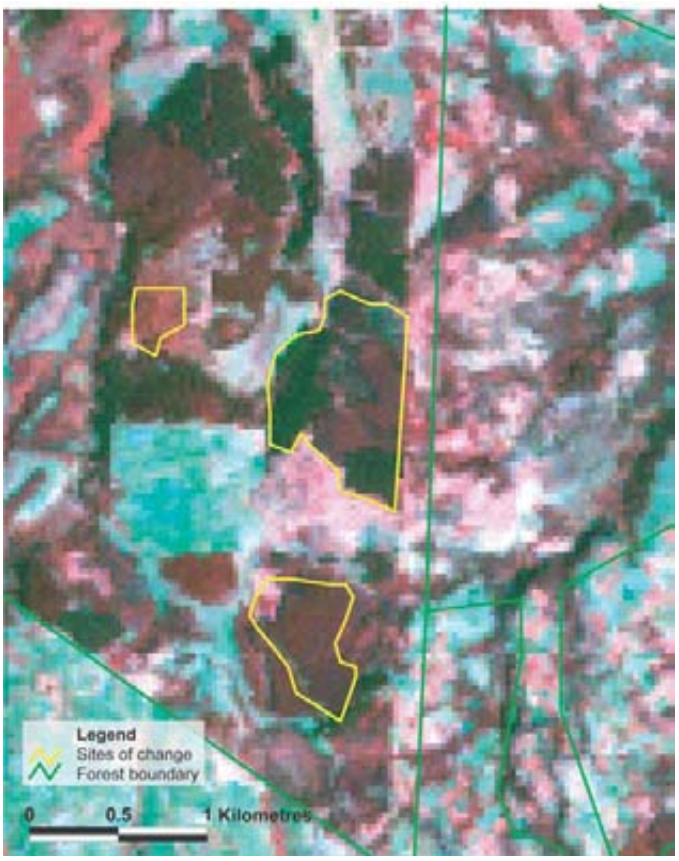


Situation in Year 2005; areas within the yellow outlined polygons have been cleared

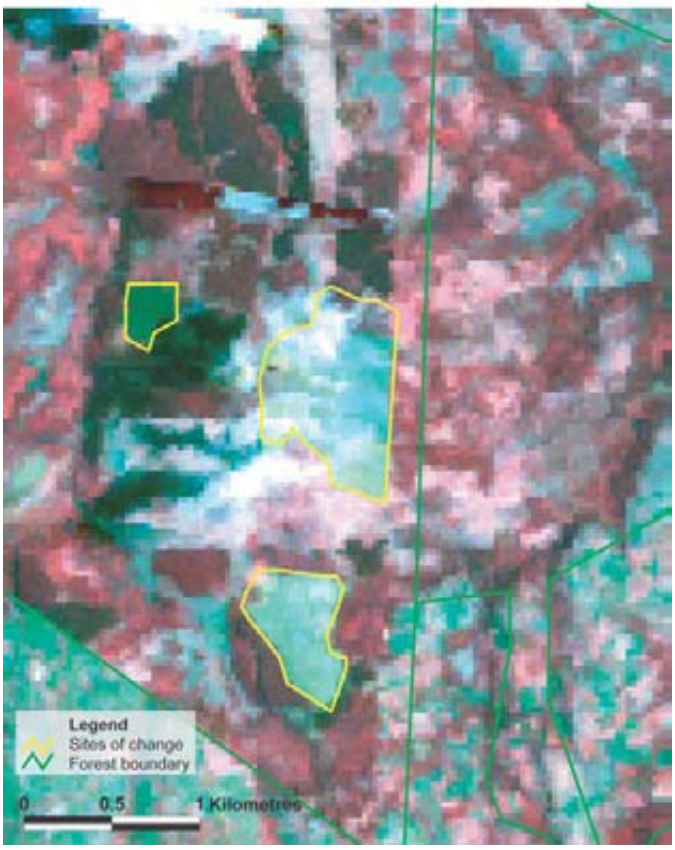
Sites oulined in blue show a reverse trend (vegetation regeneration)

Site 12: Eldoret East / Eldama Ravine Constituencies, Uasin Gishu / Koibatek Districts

Situation in Year 2003; areas within the yellow outlined polygons are forested

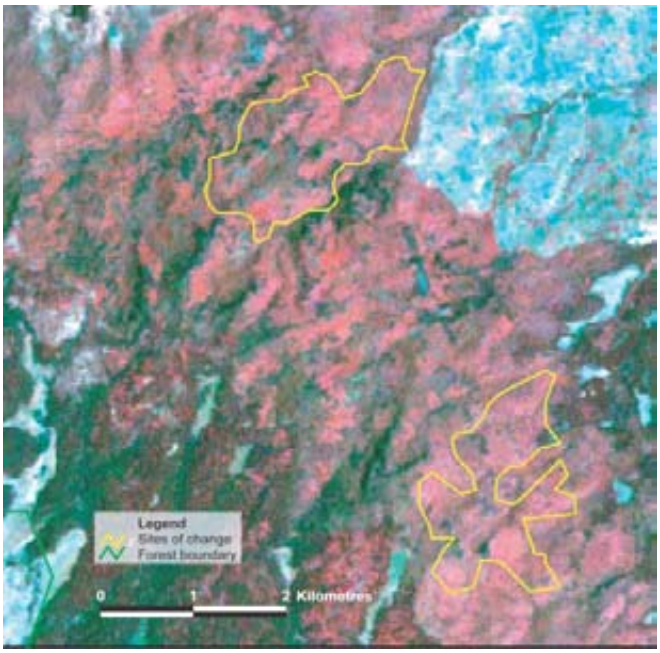


Situation in Year 2005; areas within the yellow outlined polygons have been cleared

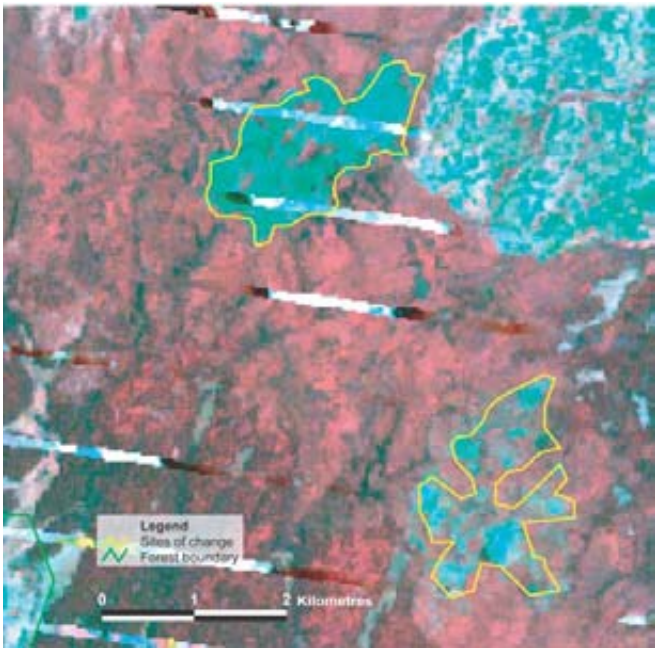


Site 13: Molo Constituency, Nakuru District

Situation in Year 2003; areas within the yellow outlined polygons are forested

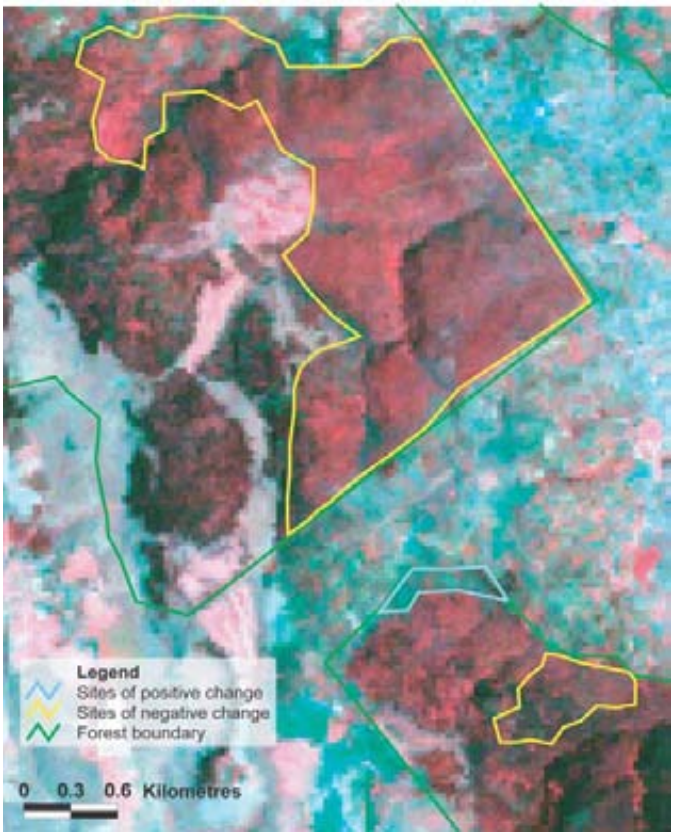


Situation in Year 2005; areas within the yellow outlined polygons have been cleared

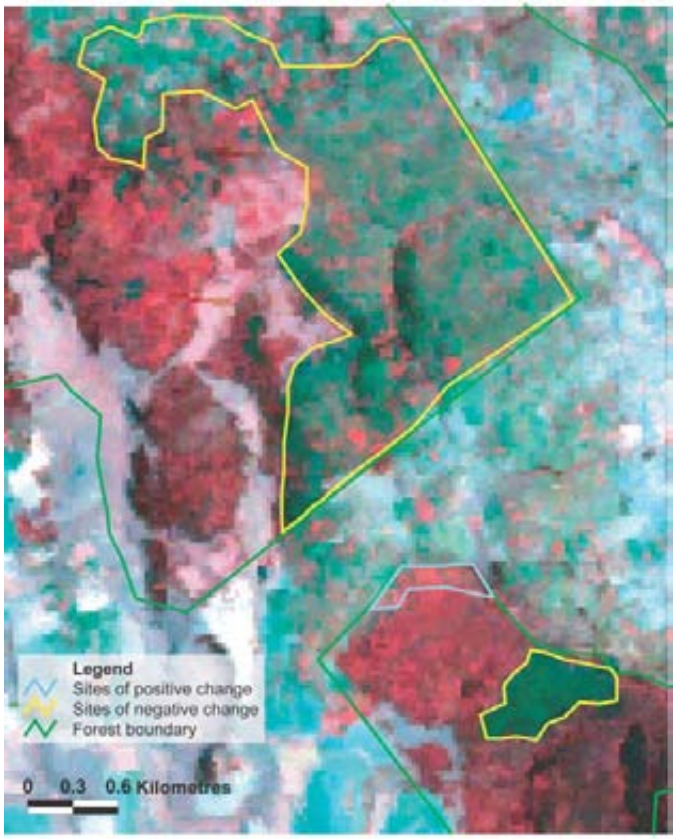


Site 14: Molo Constituency, Nakuru District

Situation in Year 2003; areas within the yellow outlined polygons are forested

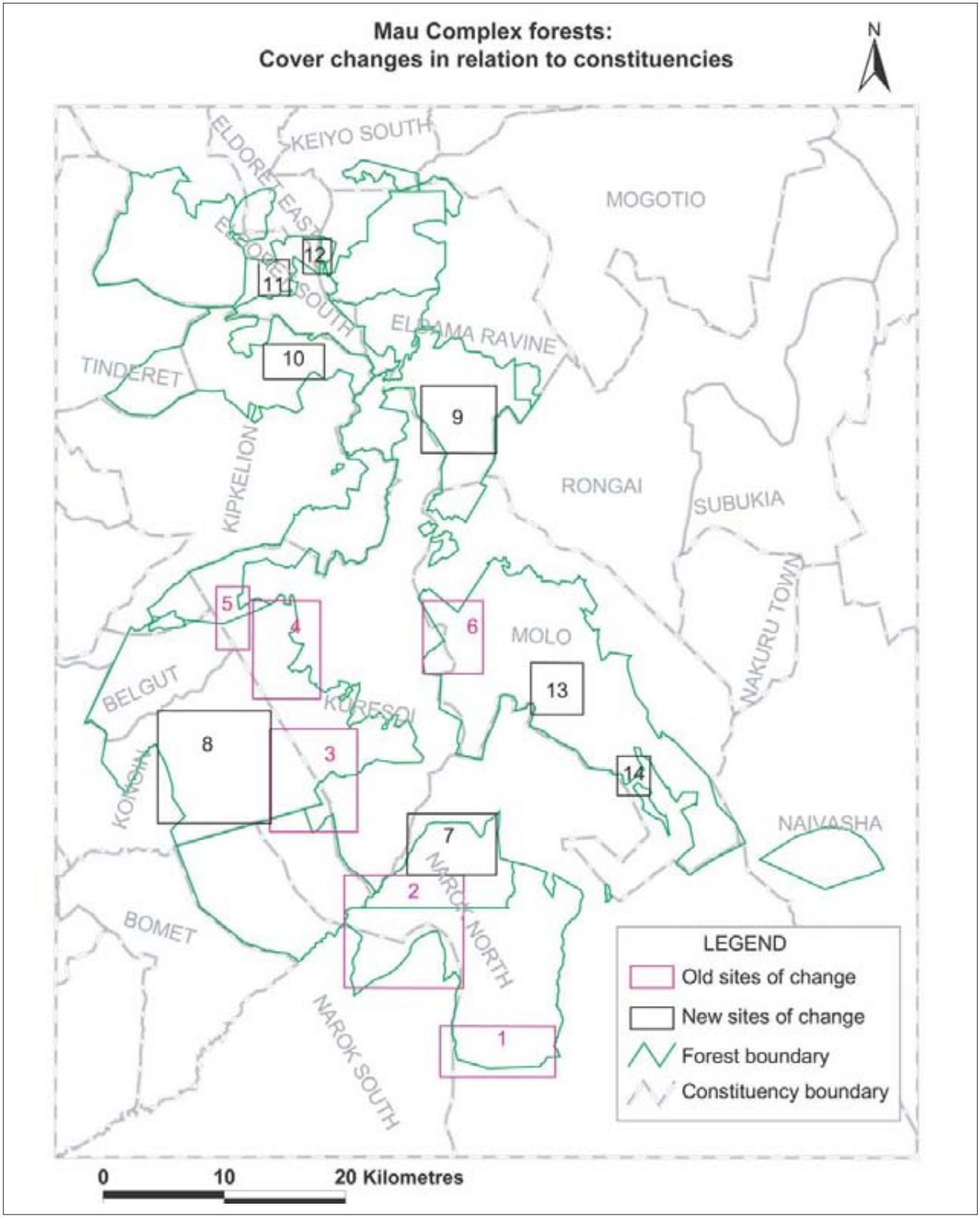


Situation in Year 2005; areas within the yellow outlined polygons have been cleared



Site oulined in blue show a reverse trend (vegetation regeneration)

Fig. 3: Sites with changes in the Mau Complex forests per constituency



The boxes numbered 1 to 14 show sites of changes in relation to constituencies. Sites 1 to 6 are old sites where changes also occurred between 2000 and 2003, while the rest are new sites where changes occurred between 2003 and 2005.

Table 2. Forests constituting the Mau Complex

FOREST RESERVE	GAZETTED AREA (HECTARES)
MOLO	912.65
SOUTH WEST MAU	83847.87
TRANSMARA	34344.15
SOUTHERN MAU	128.06
MAASAI MAU	46240.77
OL PUSIMORU	17207.08
EBURU	8718.12
EASTERN MAU	65889.44
MAU NAROK	808.09
KILOMBE HILL	1530.20
MOUNT LONDIANI	30062.74
MAJI MAZURI	7784.74
LEMBUS	16875.90
CHEMOROGOK	1333.98
METKEI	1951.99
TINDERET	28073.06
TIMBOROA	5794.34
WEST MOLO	275.75
WESTERN MAU	22673.71
NABKOI	3022.53
NORTHERN TINDERET	26194.33
LONDIANI	105.23
	403774.68

The area given in table 2 above was obtained from the KIFCON project (1991-1994), Forest Department.

Table 3. Areas of significant change in the Mau Complex forests (2003 –2005)

Site No	Forest	Constituency	Nearest forest station*	District	Area affected (ha)	Nature of Site	Forest type	Change type
1	Maasai Mau	Narok North	Olenguruone	Narok	212.23	Old	Indigenous	Deforestation
2	Maasai Mau	Narok South	Olenguruone	Narok	2312.72	Old	Indigenous	Deforestation
3	SW Mau	Kuresoi	Olenguruone	Nakuru	2755.67	Old	Indigenous	Deforestation
4	SW Mau	Kuresoi	Kerisoi	Nakuru	219.43	Old	Plantation	Deforestation
5	SW Mau / W Mau	Kuresoi	Kerisoi	Nakuru	53.35	Old	Indigenous	Deforestation
					50.14	Old	Indigenous	Regeneration
6	Eastern Mau	Kuresoi / Molo	Baraget	Nakuru	212.74	Old	Indigenous	Deforestation
					181.07	Old	Indigenous	Regeneration
7	Ol Pusimoru	Narok North	Olenguruone	Narok	177.27	New	Indigenous	Deforestation
8	SW Mau	Konoin	Olenguruone	Nakuru	355.56	New	Indigenous	Deforestation
9	Mt. Londiani	Eldama Ravine	Nabkoi	Koibatek	2317.53	New	Indigenous	Deforestation
10	Tinderet	Kipkelion	Sorget	Kericho	133.20	New	Plantation	Deforestation
11	Timboroa	Eldoret South	Serengoni	Uasin Gishu	61.51	New	Plantation	Deforestation
					91.25	New	Plantation	Regeneration
12	Lembus	Eldoret East / Eldama Ravine	Nabkoi	Uasin Gishu	103.73	New	Plantation	Deforestation
13	Eastern Mau	Molo	Kiptunga	Nakuru	442.91	New	Indigenous	Deforestation
14	Eastern Mau	Molo	Sururu	Nakuru	455.74	New	Indigenous	Deforestation
					11.53	New	Indigenous	Regeneration
	Total Deforested				**9813.59**			
	Total Regenerated				**333.99**			

** The forest stations shown on the table were obtained from the Survey of Kenya toposheets.*

The results in Table 3 show that a total of 9,813 hectares were cleared while about 334 ha regenerated in the Mau Complex forests between 2003 and 2005. Of the 9,813 ha. cleared, 3,749 ha. were in new sites of indigenous forests cleared between 2003 and 2005. The remaining 5,546.71 represent continued deforestation since 2003.

Some polygons in site 6 were observed as regenerating. It was observed from ground truthing that the upper polygon in this site is comprised of bamboo which in 2003 may have been cleared or burnt and which currently have re-sprouted. Within the same site, the ground truthing witnessed clear felling of indigenous vegetation (at GPS position E0806161 and N9957034) as reflected in photos 1 and 2.

The upper polygons in site 11 showing regeneration was during the ground truthing observed to be comprised of young plantation Cypress, about 3 years old. The lower polygon with bright red colouring also showing regeneration consists of a mixed Eucalyptus plantation planted in 2000 which is surrounded by a Cypress plantation planted in 1998, (photos 3 and 4).

The ground truthing revealed that some of the areas in site 14 (Likia) observed as regenerating were comprised of weeds and were under maize plantation in January/February 2005 when the satellite images were taken. The cultivation was stopped early in 2006 and people evicted (Photos 5 and 6). The other area within the same site reflected as having been cleared may have been opened up for cultivation and not planted.

Photo 1

Photo 2

Photos 1 and 2: Clear felling of indigenous vegetation at GPS position E0806161 and N9957034

Photo 3

Photo 4

Photos 3 and 4: Young Eucalyptus and Cypress plantation (6 and 8 years old respectively) at site 11

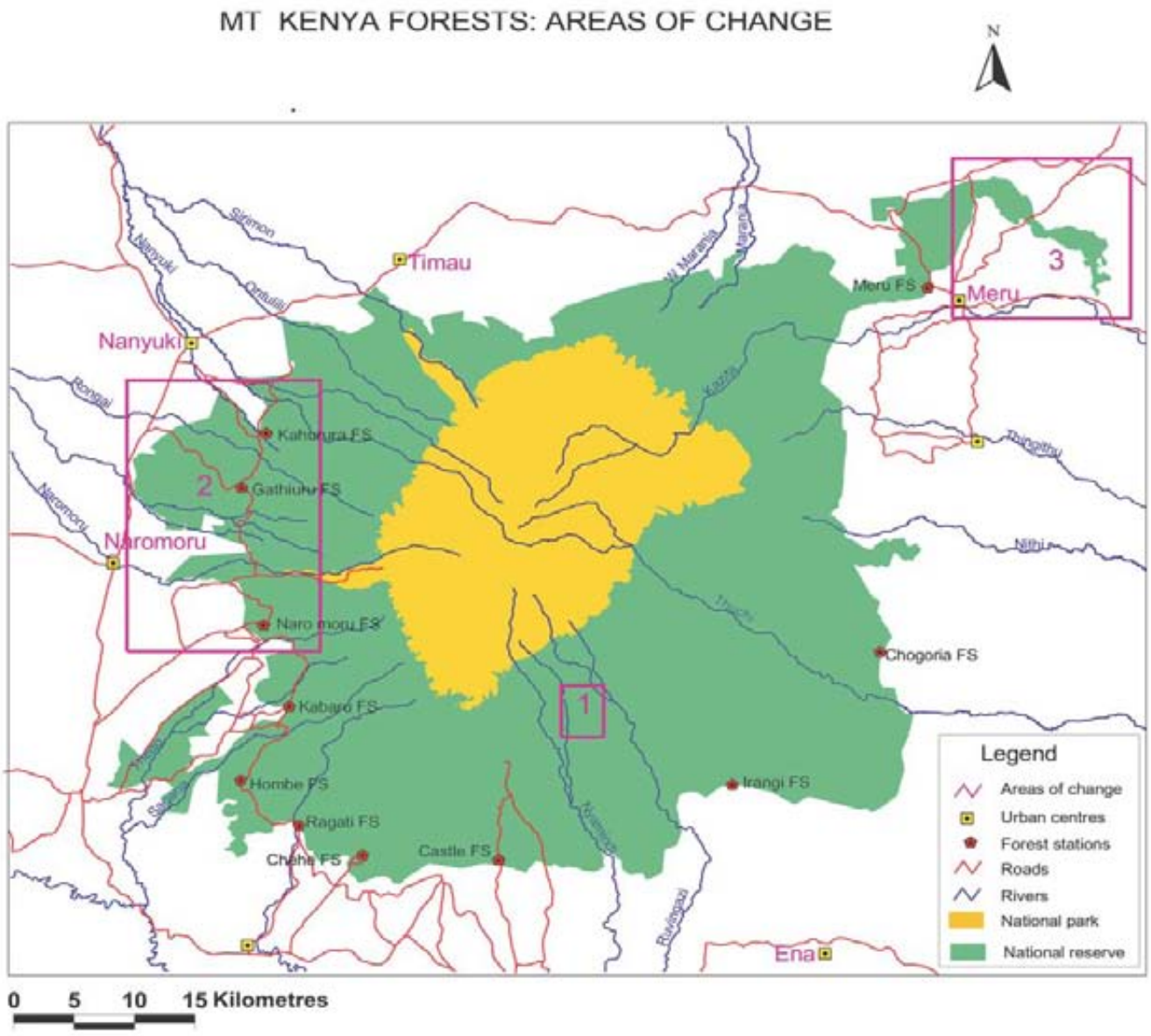
Photo 5

Photo 6

Photos 5 and 6: Weedy vegetation at site 14, under maize cultivation in 2005

3.2 Mt. Kenya forests

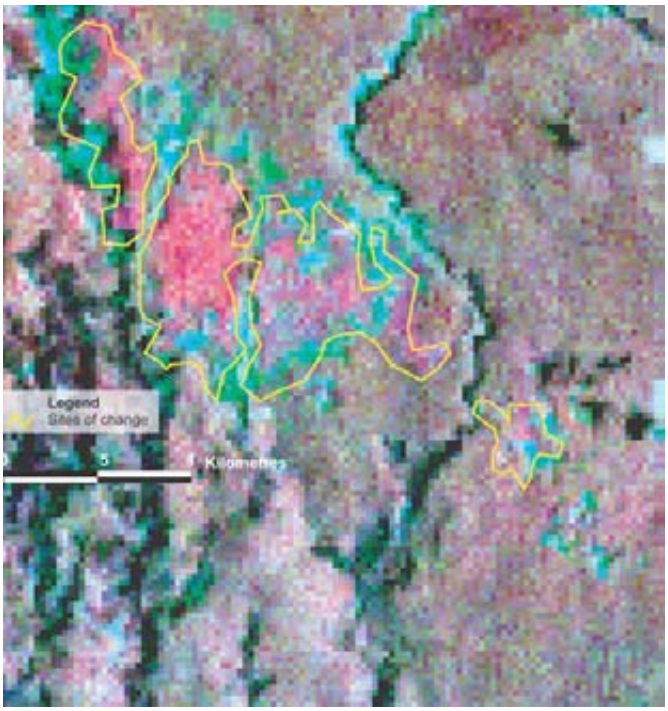
Fig. 4: Location of changes in Mt. Kenya forests



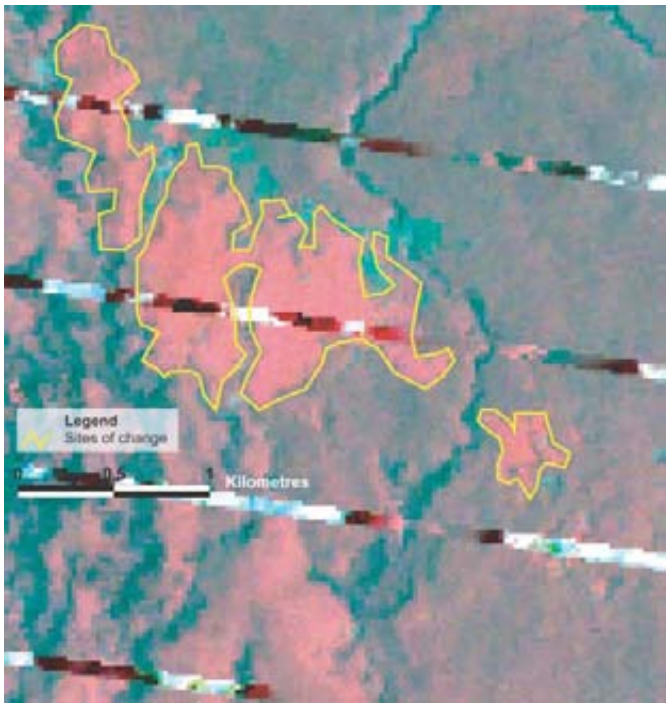
The areas numbered 1 to 3 on the map are sites where significant changes have occurred between 2003 and 2005. The 2003 and 2005 satellite images for each of these 3 sites are presented below to help the reader visualize the changes. Two of the sites that showed changes between 2000 and 2003 had no signs of significant change that could be detected in the year 2005. The forest generally continues to improve.

Site 1: Manyatta Constituency, Embu District

Situation in Year 2003; areas within the yellow outlined polygons show slight improvement (indicated by a higher notch of reddish shade)

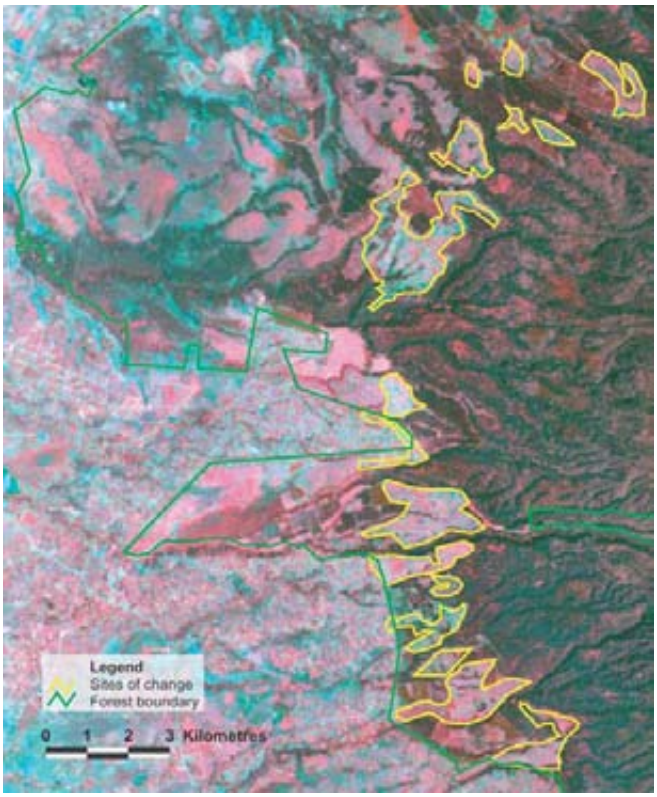


Situation in Year 2005; areas within the yellow outlined polygons show continued improvement (indicated by increased reddish shade)

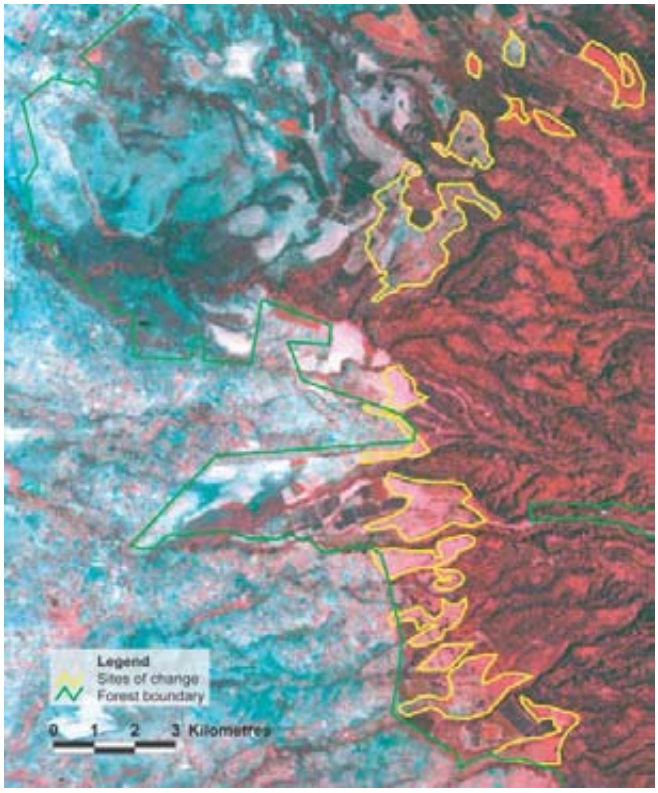


Site 2: Kieni Constituency, Nyeri District

Situation in Year 2003; areas within the yellow outlined polygons show slight improvement

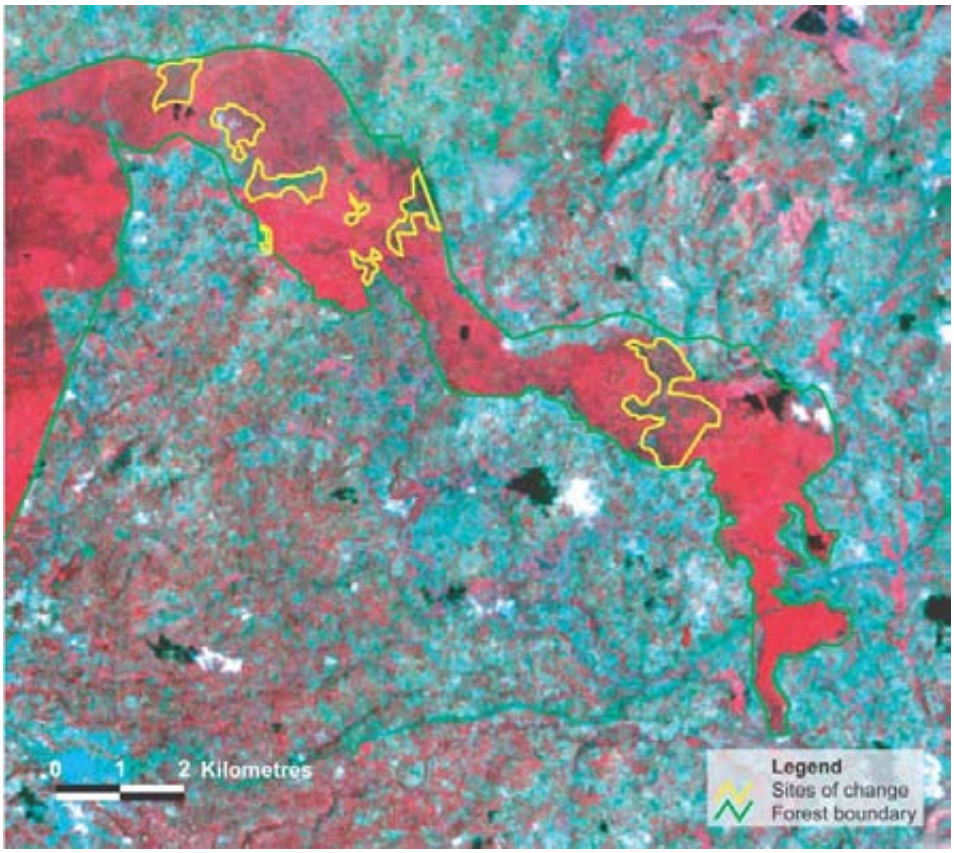


Situation in Year 2005; areas within the yellow outlined polygons show continued improvement



Site 3: North Imenti Constituency, Central Meru District

Situation in Year 2003; areas within the yellow outlined polygons show slight improvement



Situation in Year 2005; areas within the yellow outlined polygons show continued improvement

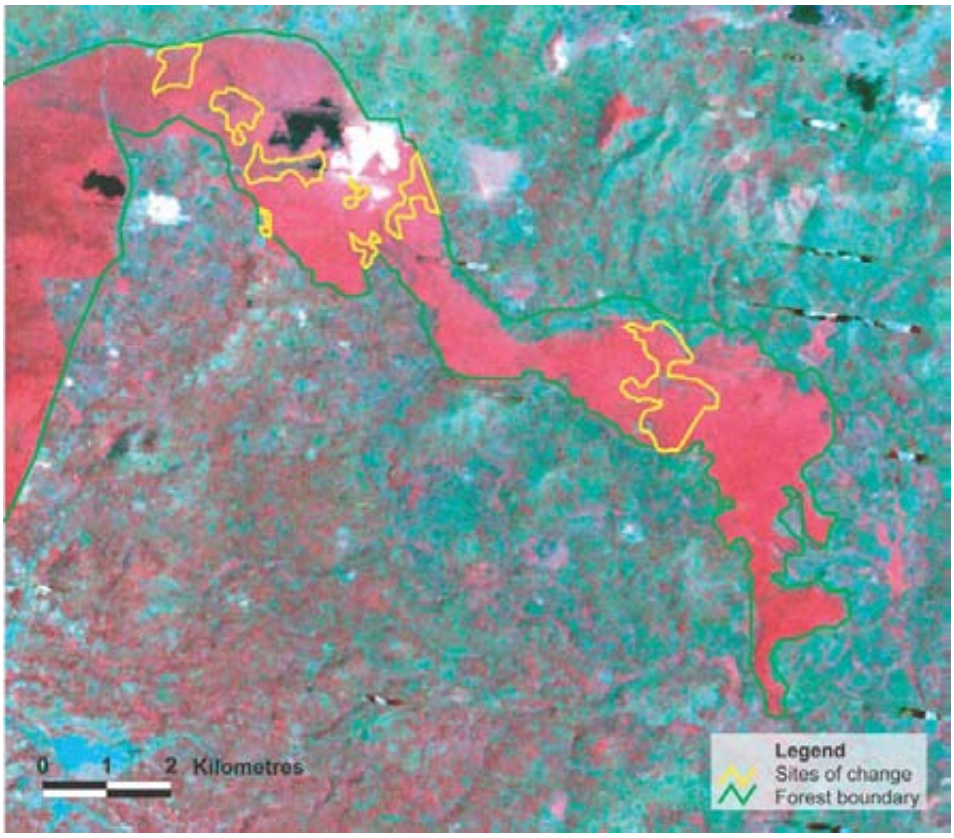


Fig. 5: Sites with changes in Mt. Kenya forests per constituency

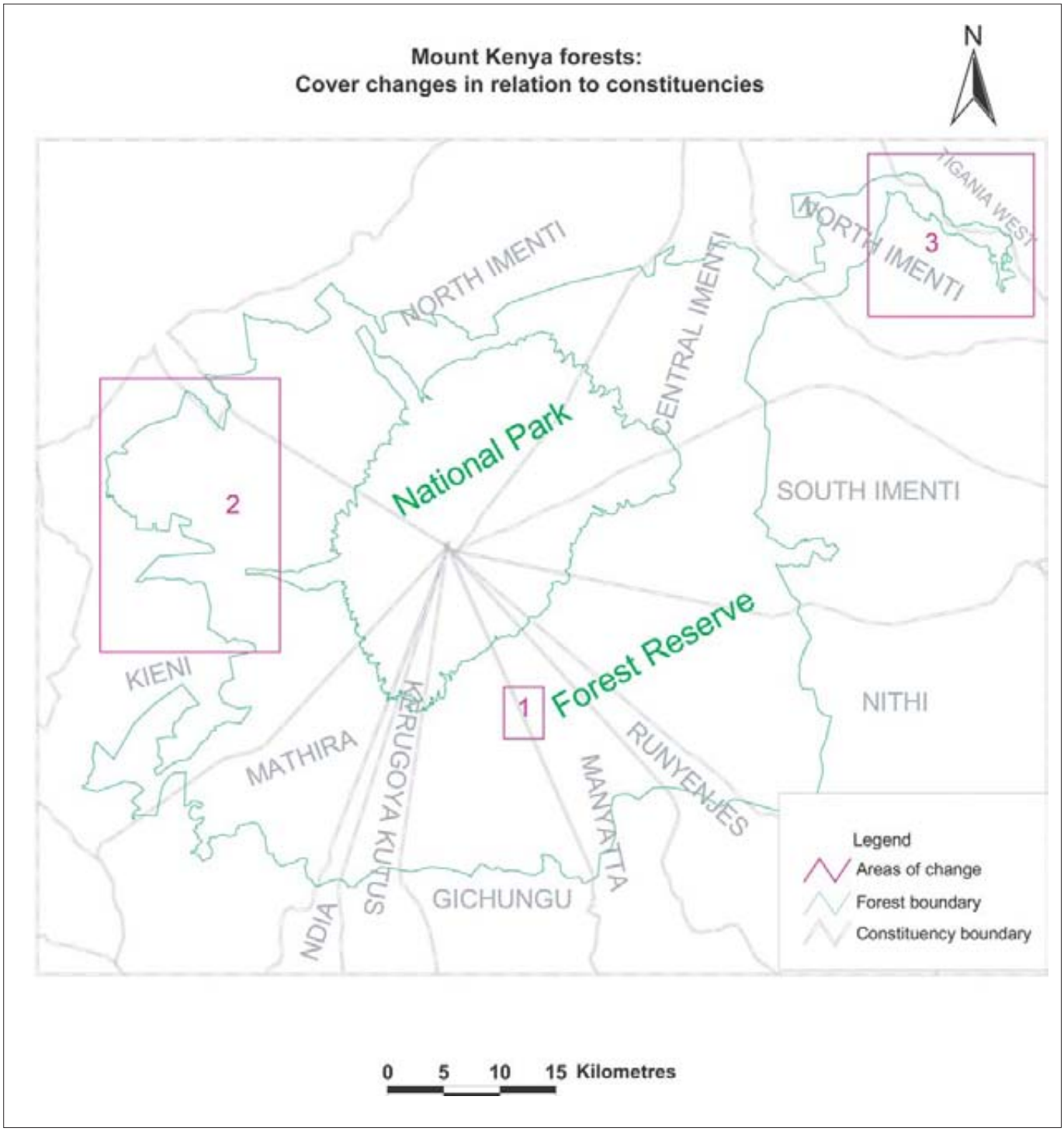


Table 4: Protected forests in Mt. Kenya

Forest category	Area (Hectares)
National Park	Approx. 20000
National Reserve	212047.2
Total	**232047.2**

Mt. Kenya forests are mainly located in the National Reserve with some forest areas falling within the National Park.

Table 5: Areas of significant changes in Mt. Kenya forests (2003 – 2005)

Site No.	Constituency	Nearest forest station*	District	Affected Area (ha)	Forest type	Change type
1	Manyatta	Irangi	Embu	159.81	Indigenous	Regeneration
2	Kieni	Kahurura, Gathiuru & Naromoru	Nyeri	1687.41	Plantation	Regeneration
3	North Imenti	Meru	Meru Central	300.10	Indigenous	Regeneration
Total				**2147.32**		

** The forest stations shown on the table were obtained from the Survey of Kenya toposheets.*

Satellite image analysis shows significant improvements in Mt. Kenya forests between 2003 and 2005.

Some 2147 hectares of degraded forest mostly plantation, were seen to be closing up within the areas that showed regeneration between 2000 and 2003. 6013.5 ha have been recovering since year 2000.

3.3 Mt. Elgon forests

Fig. 6: Location of Mt. Elgon forests

Analysis of Mt. Elgon satellite images for 2003 and 2005 showed that there were no sites showing significant changes within the two year period. It is however important to note that the 2005 landsat images used had data gaps caused by the loss of the SLC device as explained in section 2.1.

Fig. 7: Mt. Elgon Forest and Constituencies

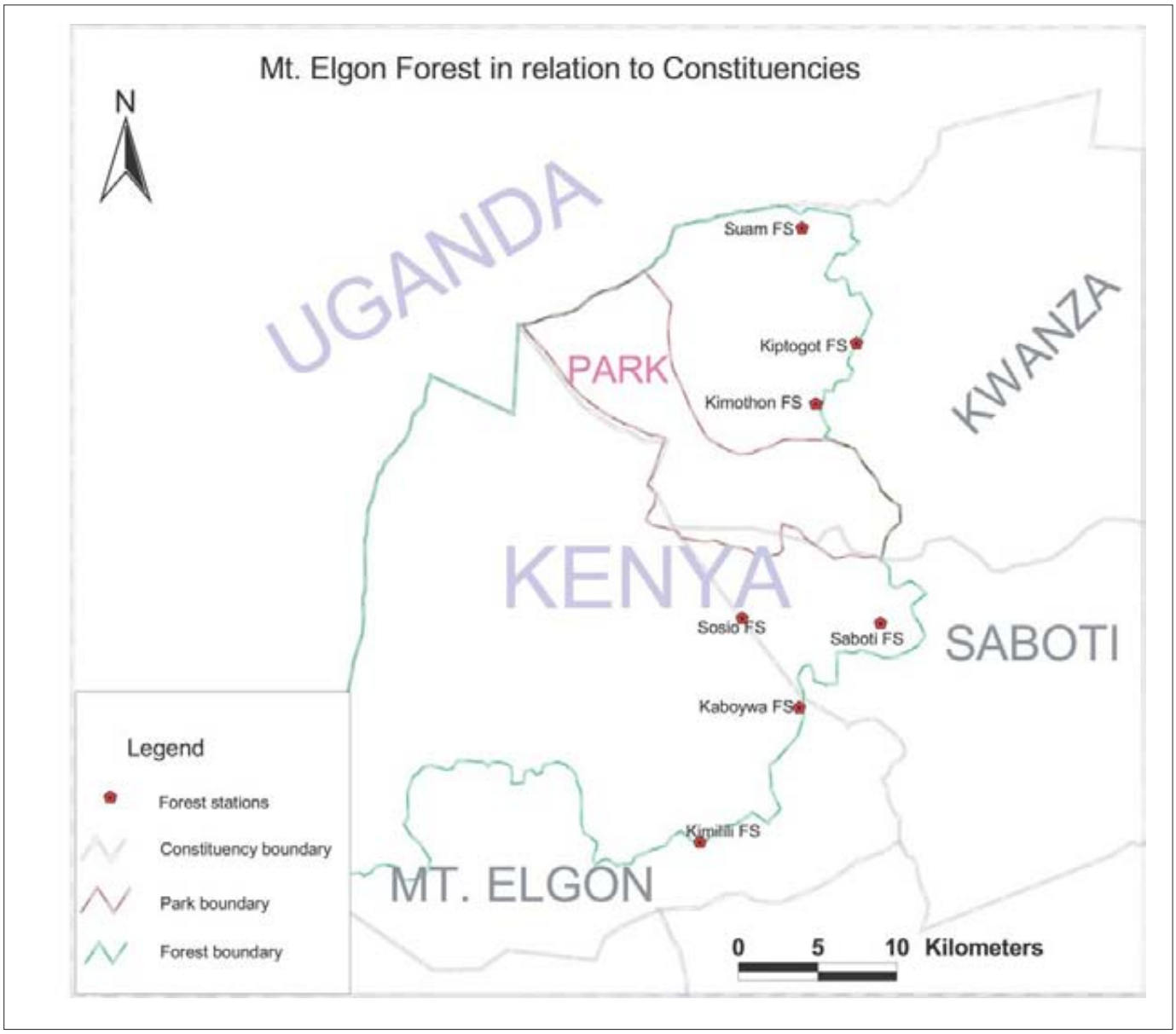


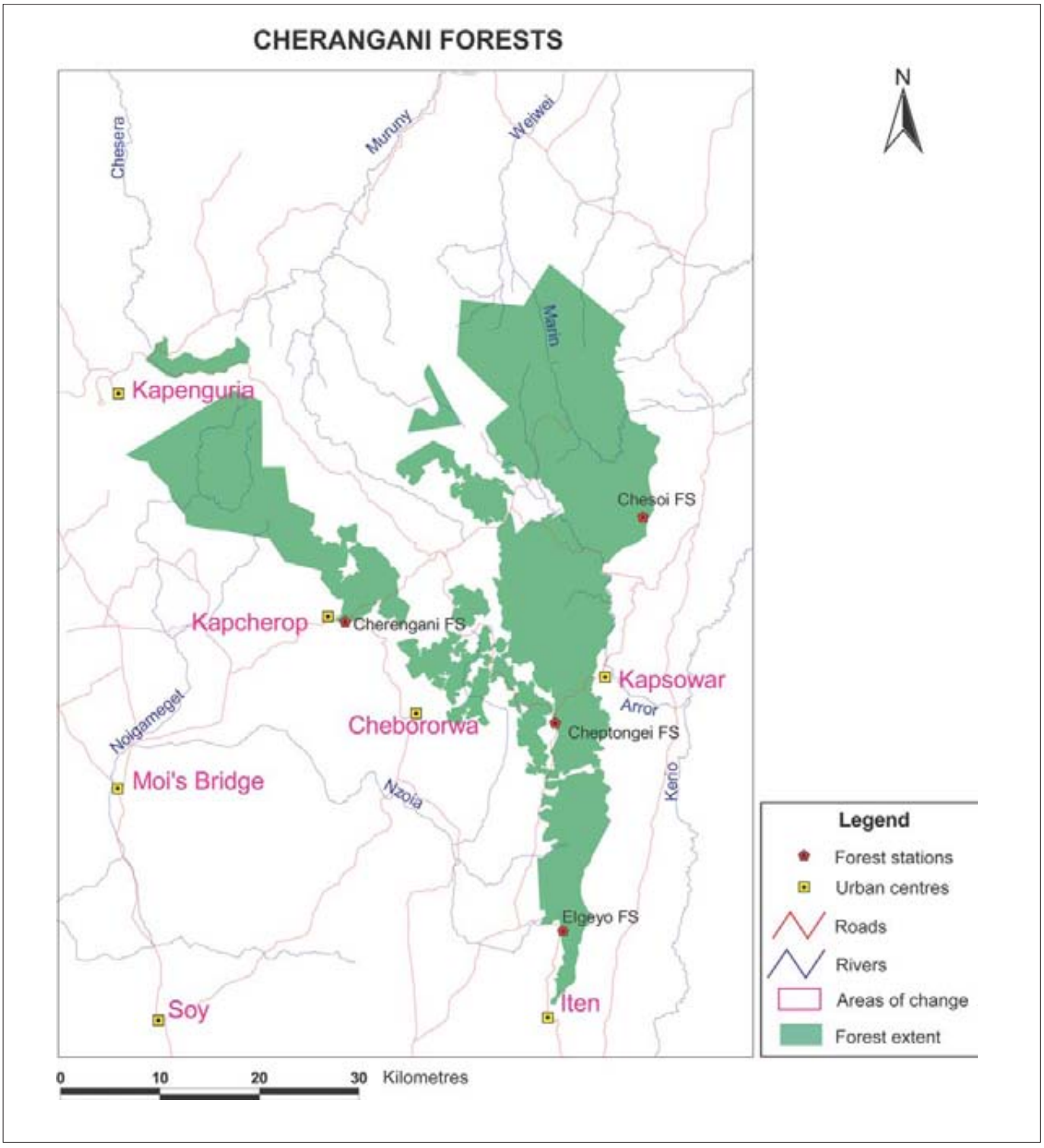
Table 6: Protected forests on Mt. Elgon

Forest Category	Area (hectares)
Forest Reserve	87,209.7
National Park	15,485.9
Total	**102695.6**

The bulk of the forest belt of Mt. Elgon in Kenya is protected as Forest Reserve, with a wide tract of forest located within the National Park.

3.4. Cherangani forests

Fig. 8: Cherangani forests



Analysis of Cherangani forests satellite images of 2003 and 2005 showed that there were no sites showing significant changes between the two year period. It is however important to note that the 2005 landsat images used had data gaps caused by the loss of the SLC device as explained in section 2.1.

Fig. 9: Cherangani forests and Constituencies

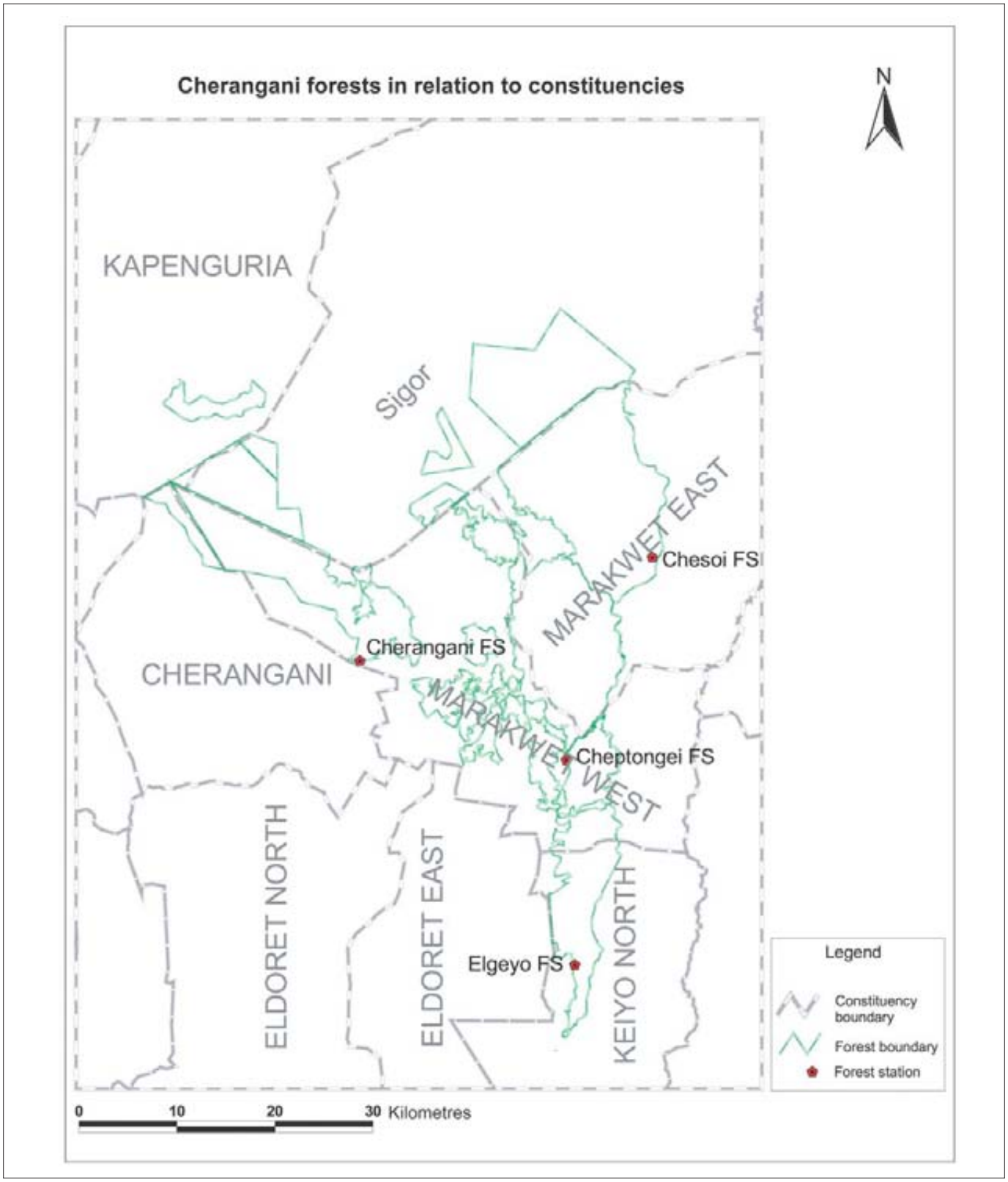


Table 8: Protected forests in the Cherangani Hills

Forest block	Area (Hectares)
Kamitira	1942.53
Kapolet	1624.01
Kiptaberr	12788.79
Kapkanyar	6670.71
Kaisungor	1087.22
Chemurokoi	3973.61
Kipkunurr	15868.77
Cheboit	2523.60
Sogotio	3549.70
Kapchemutwa	8860.41
Embobut	21655.65
Lelan	14495.14
Kerrer	2237.82
Toropket	119.48
Total	**97397.44**

3.5 Aberdare Range forests

Fig. 12: The Aberdare Range forests

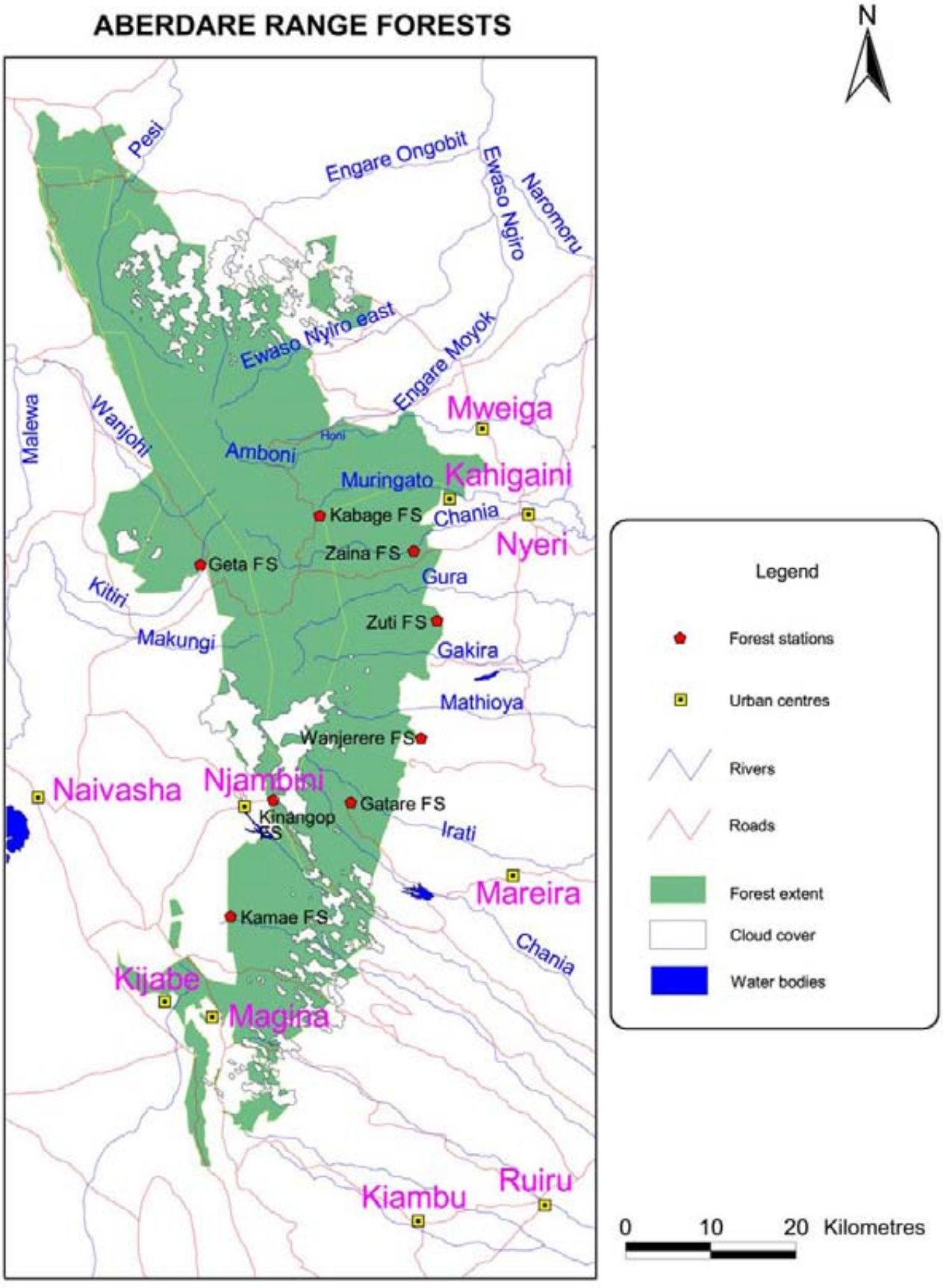
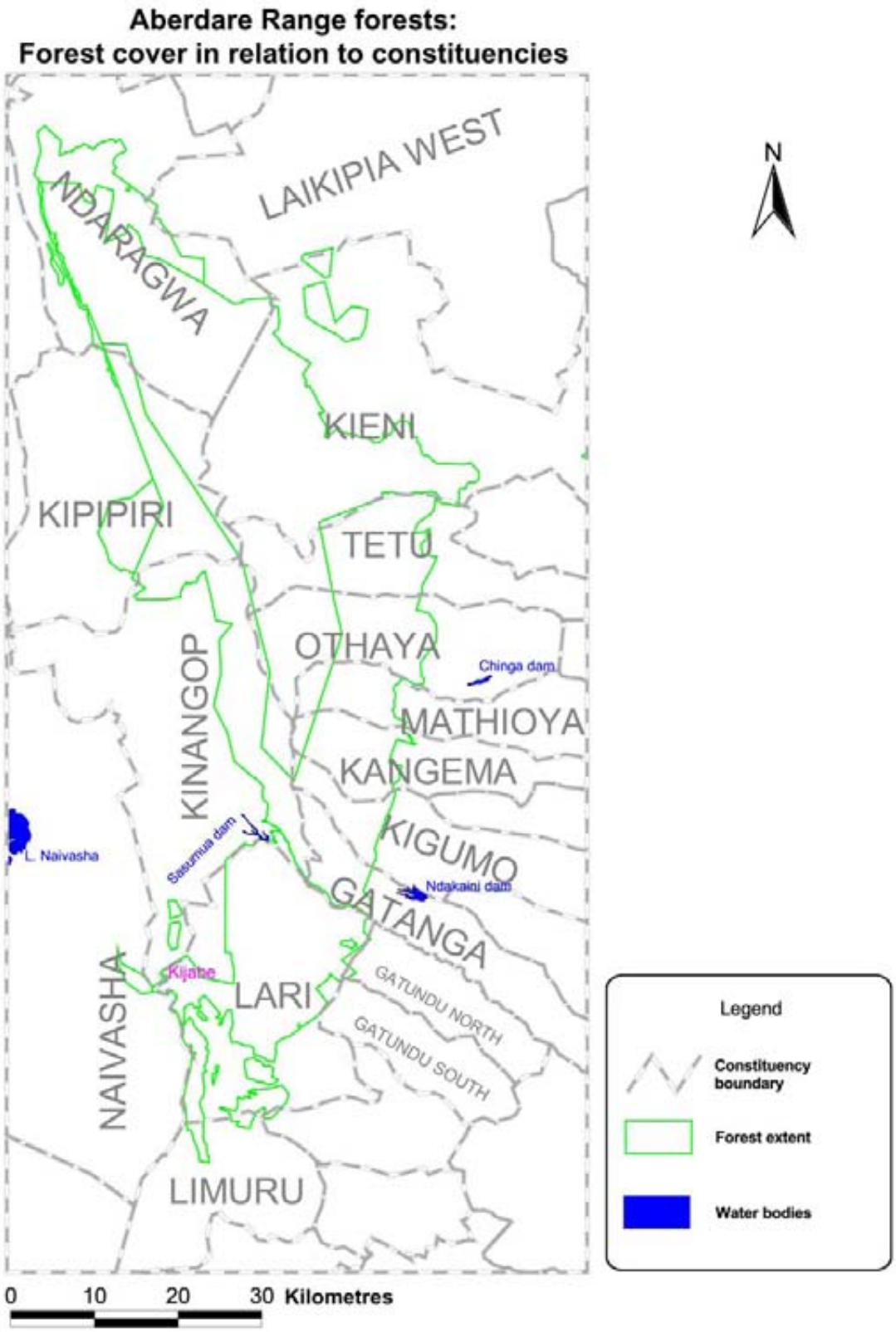


Fig. 10: Aberdare Range forests and constituencies



As reported in the 2004, *Changes in Forest Cover in Kenya's Five "Water Towers"*, there was much cloud cover in the 2003 satellite image thus affecting the analysis of change in the Aberdare Range forests between 2000 and 2003. However, the analysis of the satellite images of 2000 and 2005 showed that there were no sites showing significant changes between the five year period. It is however important to note that the 2005 landsat images used had data gaps caused by the loss of the SLC device as explained in section 2.1.

Table 9: Protected forests in the Aberdare Range

Forest	Area (Hectares)
NYERI HILL	199.6
NYERI	1208.9
KIGANJO	171.1
SOUTH LAIKIPIA	3487.1
KIPIPIRI	5060.0
MAGUMO NORTH	239.1
MAGUMO SOUTH	363.1
KIJABE HILL	737.2
KINGATUA	61.9
MURUAI	714.8
NYAMWERU	800.5
KIKUYU ESCARPMENT	37485.1
KIRIMA	510.5
ABERDARES	103315.0
NATIONAL PARK	**102161.4**
TOTAL	**253375.3**

4.0 DISCUSSION

The 2003 –2005 forest cover change analysis findings reveal that Mau forests continue to be destroyed at an alarming rate. About 9,813 hectares (9,295.72 hectares indigenous forest and 517.87 hectares plantation forests) were cleared, compared to 7,084.24 hectares (most of it plantation) between 2000 and 2003. The other disturbing observation from Mau is that there are a number of new sites that show deforestation. Out of the 14 sites identified, eight were new, meaning that destruction is spreading. Most of the indigenous clearings, totaling 5,546.71 hectares, occurred in old sites. Loss in new sites amounted to 3,749.01hectares. The Mau Complex forests therefore are clearly an ecosystem that requires urgent attention to curb rampant destruction of indigenous forest.

The results indicate that only 334 hectares showed signs of recovering. This implies that over the period from 2000 to 2005 a total of 16,563.83 hectares of forest were cleared in the Mau Complex forests.

The continued destruction of the Mau forests threatens the livelihood of many people. Most of the loss is attributed to continued irrational settlement of people within Mau in areas including those which are prone to erosion and unsuitable for agriculture.

The forests in the other four “water towers” show no signs of deforestation between the years 2003 and 2005 even though deforestation activities on these forests cannot be completely ruled out since the 2005 images used had some gaps. It can however be said that even if present, the destruction in these forests is at a minimal level.

Mt. Kenya forest showed signs of improvement in some areas totaling to about 2147 hectares in the old sites that were already showing recovery between the 2000 to 2003 period. Mt. Kenya forest is generally improving.

REFERENCES

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UNEP (2001): "An Assessment of the World's Remaining Closed Forests"

Vanleuwe et al, (2002): "Changes in the state of conservation of Mt Kenya forests: 1999 - 2002". DICE - University of Kent at Canterbury, KWS, UNEP, KFWG.

ACRONYMS

DICE:	Durell Institute for Conservation and Ecology of the University of Kent
ETM:	Enhanced Thematic Mapper
FR:	Forest Reserve
GPS:	Global Positioning System
KFWG:	Kenya Forests Working Group
KIFCON:	Kenya Indigenous Forest Conservation Programme
KWS:	Kenya Wildlife Service
NDVI:	Normalized Difference Vegetation Index
NIR:	Near Infra Red
UNEP:	United Nations Environment Programme

The Kenya Forests Working Group, KFWG, is a gathering of individuals and organizations (government and non-government, local, national and international) concerned with forests, their conservation and management. KFWG was formed in 1995 to provide a forum for exchanging and sharing information and experiences among members. It is a sub-committee of the East African Wild Life Society. KFWG's goal is to improve the status of Kenya's forests and increase the benefits from them through sound management and conservation practices.

The Department of Resource, Survey and Remote Sensing, DRSRS, is one of the departments in the Ministry of Environment and Natural Resources. It was established in 1975. It is mandated with the collection, storage, analysis and dissemination of data on natural resources with the major aim of alleviating poverty. The department's programmes and activities are executed in four major themes: Aerial Surveys, Ground Surveys, Remote Sensing and Data Management.

The Royal Netherlands Embassy is one of Kenya's development partners**.** The Netherlands Development Programme for Kenya started just after independence in 1963. Poverty alleviation within a framework of sustainable development has always been the cornerstone of the Netherlands developmental policy in Kenya. Since the start of the developmental programme a number of projects have been supported including those in environmental conservation.