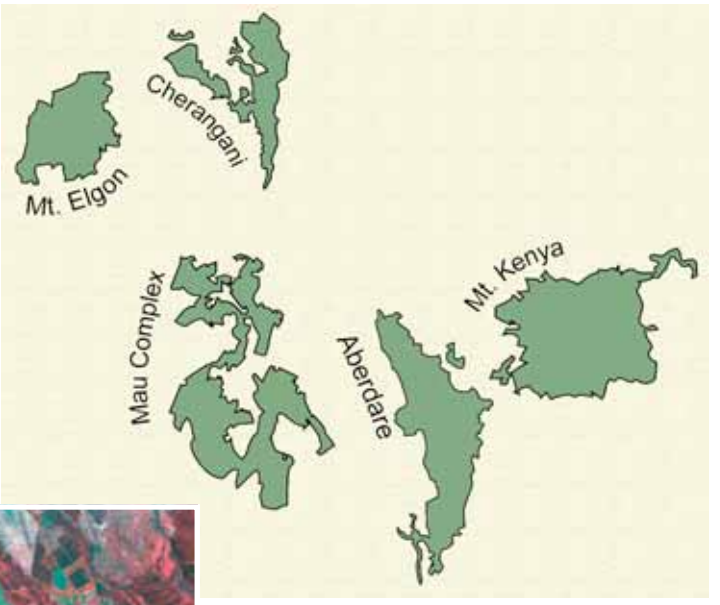

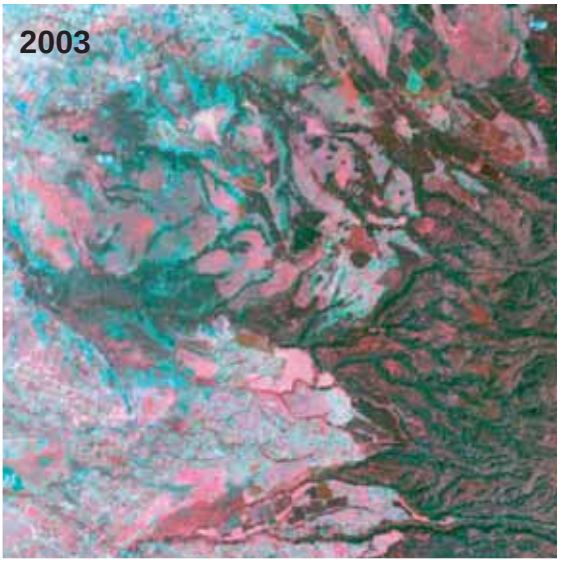

Changes in Forest Cover in Kenya's Five "Water Towers" 2000 - 2003

Report prepared by:

DRSRS

KFWG

With support from the Royal Netherlands Embassy

November 2004

Changes in Forest Cover in Kenya's Five "Water Towers" 2000 - 2003

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FOREWORD

The Forests of Mt. Kenya, the Aberdare Range, the Mau Complex, Mt. Elgon and Cherangani Hills are important water catchment areas for Kenya. They form the main water towers of the country from which most Kenyan river systems emanate. The rivers serve as sources of water for hydroelectric generation, irrigation, agriculture and industrial processes. The forests protect soil and water on which agriculture depend and form habitats for our wildlife on which our tourism industry depends. They act as reservoirs for biodiversity and serve as sinks for carbon. Their importance in supply of timber and non-timber products to the communities living within their surroundings cannot be over emphasized. As such these forests are important and support livelihoods for all Kenyans in one way or another.

The Ministry of Environment and Natural Resources is happy to be associated with the report on the changes in forest cover in the "water towers". This is a baseline report on a monitoring project whose aim is providing critical information on forest cover changes over time in these important forests. The report points out some reduction of forest cover in the Aberdares, Mt. Elgon and Cherangani Hills. This is at a time when the Government seeks to increase the forest cover in the country. It is my call that efforts should be redoubled to ensure that factors that influence such a negative change are dealt with to reverse the situation. It is encouraging to note that the report registers some improvement in Mt. Kenya forest over the period of assessment. I must express deep concern over the situation in the Mau Complex where serious degradation has been registered by the report.

Since the report is satellite image based, it forms a base for constant monitoring of temperal and spatial change over time in the five forests. It is on the basis of such information that the Ministry will put in place measures to reverse any adverse change on forest cover trends in the catchment areas. A new forest policy has been produced to inform the forest bill expected to pass through parliament soon. These new policy and legal instruments will go along way in strengthening forest management and addressing current forest management issues. The new forest policy and bill will address some of the issues identified in the report.

Let me call upon all Kenyans of good will and our development partners to support us in our conservation efforts not only for the five water towers but also for forest areas in the country. This is recognizing the contribution our forests give to the national economy.

HON. STEPHEN KALONZO MUSYOKA, EGH, MP
MINISTER FOR ENVIRONMENT AND NATURAL RESOURCES

ACKNOWLEDGEMENTS

The report on *Changes in forest cover in Kenya's five major "water towers" 2000-2003* 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, in particular through the office of Ms. Mita Manek, National Programme Officer, Environment.

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 who did the editing.

Eric Akotsi
DRSRS

Michael Gachanja
KFWG

1.0 INTRODUCTION

Forest ecosystems provide a continuous flow of essential goods and services that support, directly and indirectly, the Kenyan economy, whose main pillars are agriculture and unique natural ecosystems.

Although they cover only some 1.7[1] per cent of Kenya's total land area, closed forests are crucial water catchments, and harbour a disproportionate amount of Kenya's biodiversity. Among these forests, the five largest blocks are Mt. Kenya, the Aberdare Range, the Mau Complex, Mt. Elgon and the Cherangani Hills. These montane forests, constitute the main "water towers" of Kenya and form the upper catchment of all main rivers in Kenya (with the only exception being the Tsavo River whose upper catchment is Mt. Kilimanjaro in Tanzania). These catchments provide water to all installed hydro-power plants that produce some 70 percent of Kenya's total electricity output. These montane forests are surrounded by the most densely populated areas of Kenya, because they cause increased precipitation in the rainy seasons and ensure permanent river flow in the dry seasons.

Notwithstanding the services they provide to the people of Kenya, these forests have been and remain the target of uncontrolled and unplanned development activities. Over the last decades, Kenya's civil society has become much more vocal about forest destruction and has shown an increased ability to challenge bad environmental governance. But updated information on the status of, and on-going activities in, most of these forests is often unavailable. This limits the civil society and other concerned stakeholders' advocacy and lobbying efforts against unwise developments that could jeopardize the integrity of these ecosystems and the continuous flow of services they provide.

This report presents the findings of the detection of major forest cover changes between 2000 and 2003 in Kenya's five main forest blocks, namely Mt. Kenya, the Aberdare Range, the Mau Complex, Mt. Elgon and the Cherangani Hills. Based on satellite imagery (Landsat 7 Enhanced Thematic Mapper) with a resolution of 30 metres, the analysis of changes enables the detection of major forest cover changes, in particular encroachment. Such analysis will be undertaken every two years in order to provide all concerned stakeholders with an early warning system that will enable them: 1) to identify threatened forest areas in time; and, 2) to prioritize their interventions in these areas 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 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 the forest-adjacent communities and to the country.

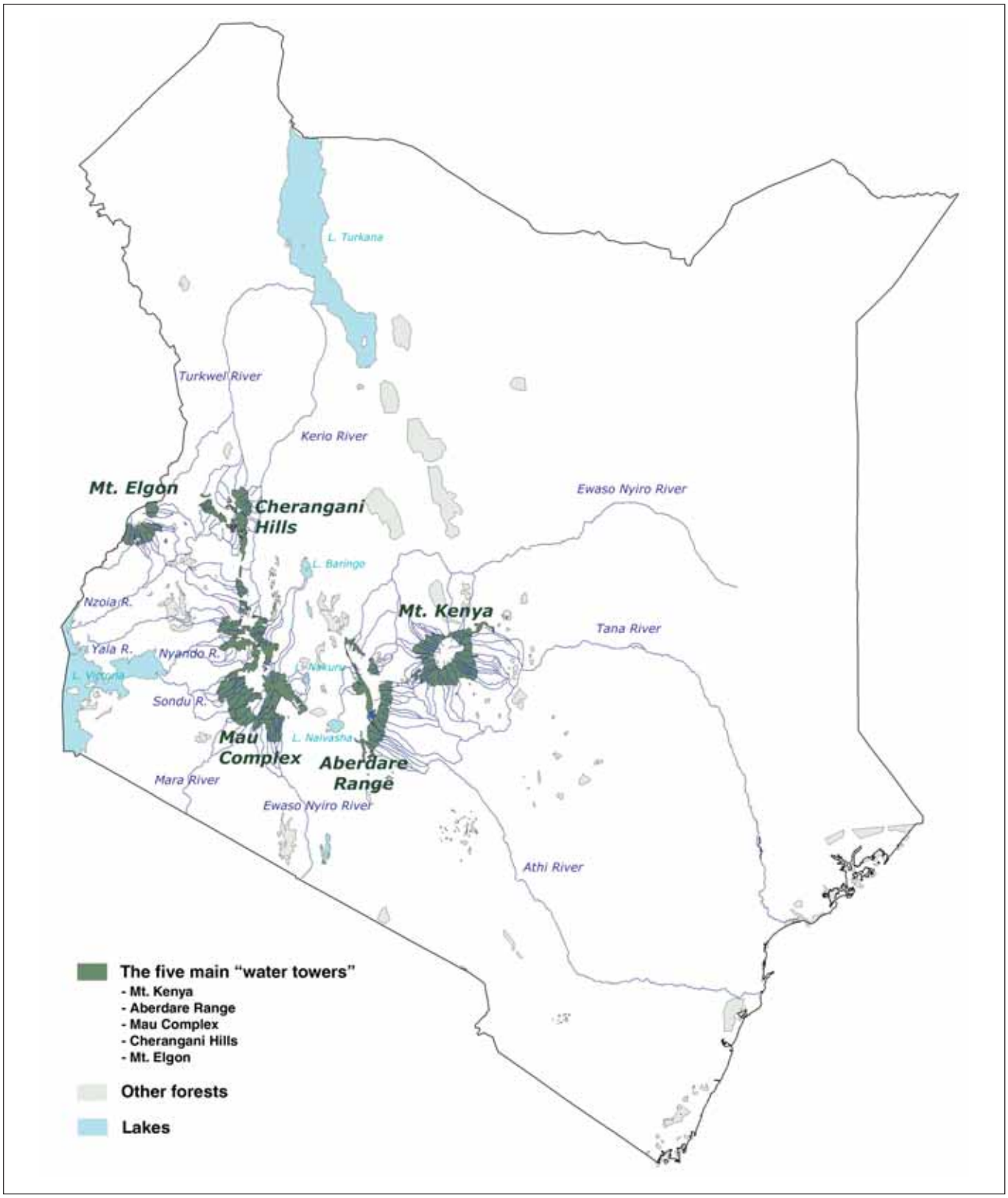
1.2.1 Aberdare Range forests

The Aberdare Range is located in central Kenya. The forest belt of the Aberdare Range comprises a number of forest reserves, including the 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 the upper catchment of the Tana River, Kenya's largest river, as

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

well as the 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.

Fig 1: Location of the five catchment areas



1.2.2 Mt. Kenya forests

Mt. Kenya forests are located on the equator, 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 and 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 montane 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 forest

Mt. Elgon forest is 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-farming area south of the mountain before entering Uganda.

The forest has species that are globally threatened, making the area a priority for species conservation and an attraction for tourists.

1.2.5 Cherangani forests

The Cherangani 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 2000 and 2003 (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.

Table 1 Landsat images used in the study

YEAR	Landsat images	Date of receiving	Forest of interest
2000	168 / 060	5th February 2000	Mt. Kenya / Aberdare
	168 / 061	21st February 2000	Aberdare
	169 / 059	27th January 2000	Cherangani
	169 / 060	12th February 2000	Mau Complex
	169 / 061	12th February 2000	Mau Complex
	170 / 059	6th March 2000	Mt. Elgon / Cherangani
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

2.2 Processing of the satellite images

2.2.1 Geo-referencing of the year 2000 images

Geo-referencing refers to the process of assigning map coordinates to satellite images. In this case, the satellite images of the year 2000 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 2003 images

The satellite images of the year 2003 were geo-referenced against the corresponding satellite images of the year 2000. 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 2003 conform with the corresponding images of the year 2000, 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 µm – 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 µm – 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.

In this report, the satellite images are false colour composition using band 4 (red), band 3 (green) and band 2 (blue). On these images, the red colour represents dense vegetation, whilst the green/blue colour means very scattered vegetation or no vegetation or bare ground.

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 2003 was compared with the situation in 2000. The method applied in this study is known as image differencing: the value of the pixels in one image (t1) is simply subtracted from the value of the corresponding pixels in the other image (t2).

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 minor 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 2000 images from the NDVI of the corresponding 2003 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.

Ground comparison

Because of the Kenya Forests Working Group's previous work in Mt. Kenya, Aberdare Range and the Mau Complex forests including the aerial surveys conducted in 2002 in these forests, it was possible to explain forest cover changes detected for this period. However, for Mt. Elgon and Cherangani Hills, a ground truthing mission was deemed necessary. The mission to Mt. Elgon was conducted on 26 and 27 May 2004, while that for Cherangani Hills was conducted on 9,10 and 11 June 2004.

2.2.5 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.

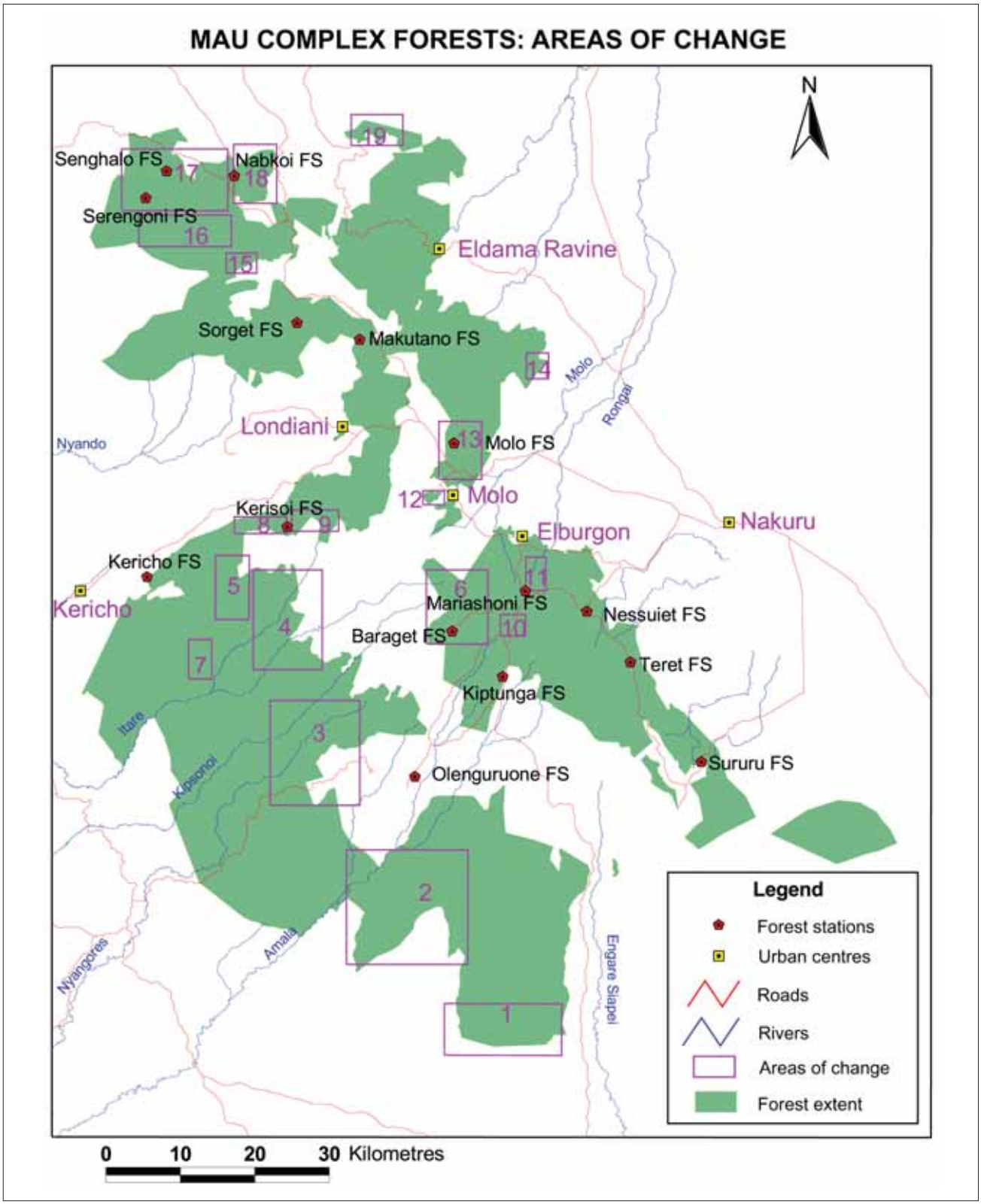
A number of key features, such as roads and rivers, were digitized from scanned topographic maps 1/50,000 from the Survey of Kenya. The boundaries of the protected forests were obtained from the KIFCON project (1991-1994). These layers were overlaid to produce the maps contained in the report. It should be noted that since 1994, a number of excisions have been made to the forests of the Mau Complex and Mt. Kenya.

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

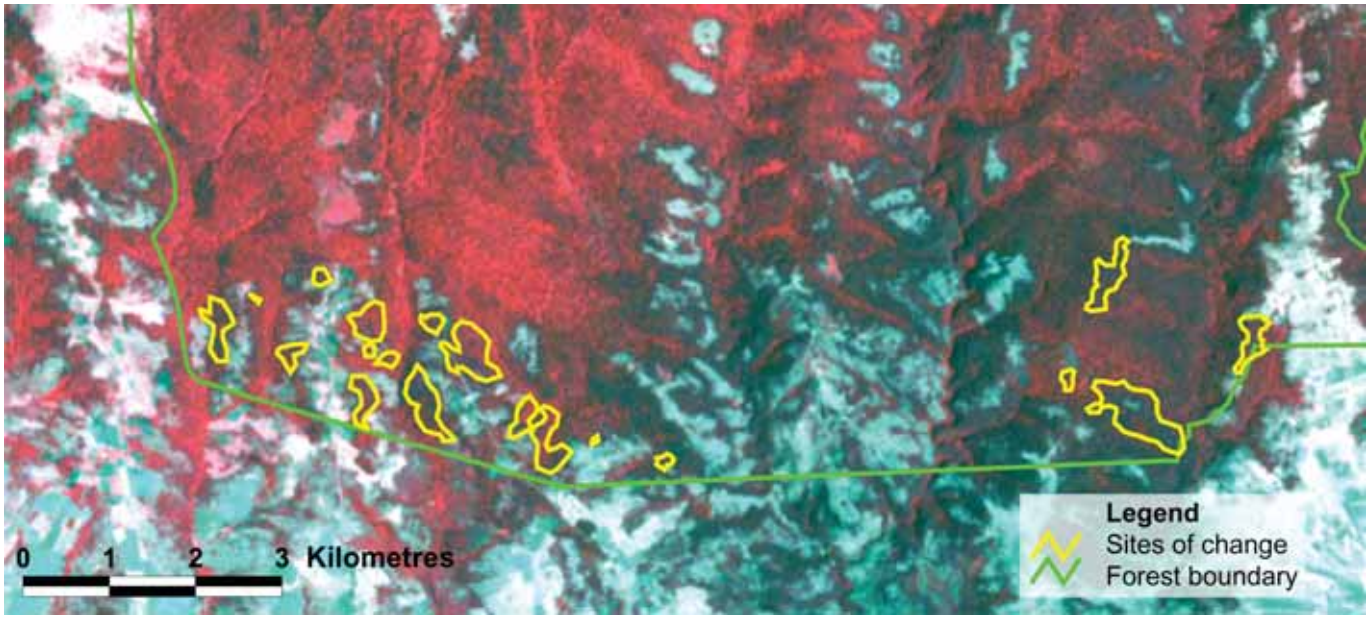
Fig. 2 Location of changes in the Mau Complex forests



The areas numbered 1 to 19 on the map are sites where significant changes have occurred between 2000 and 2003. The 2000 and 2003 satellite images for each of these 19 sites are presented below to help the reader visualize the changes.

Site 1: Narok North Constituency, Narok District

Situation in Year 2000; areas within the yellow outlined polygons are forested



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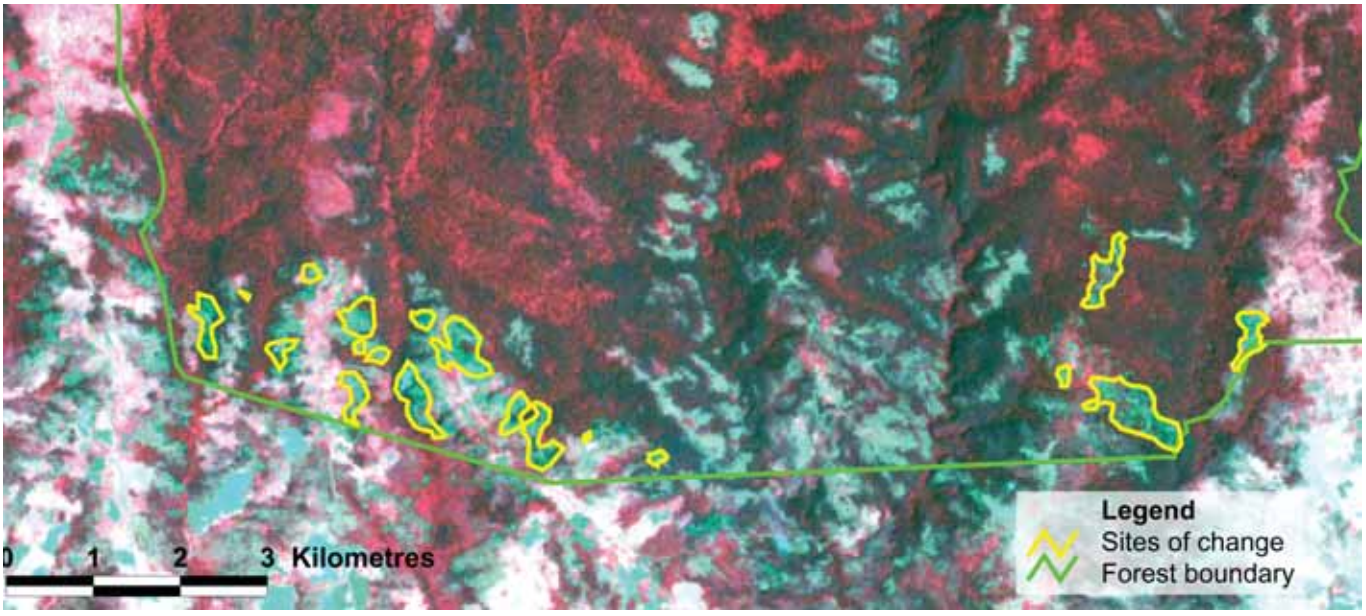

Site 2: Narok South Constituency, Narok District

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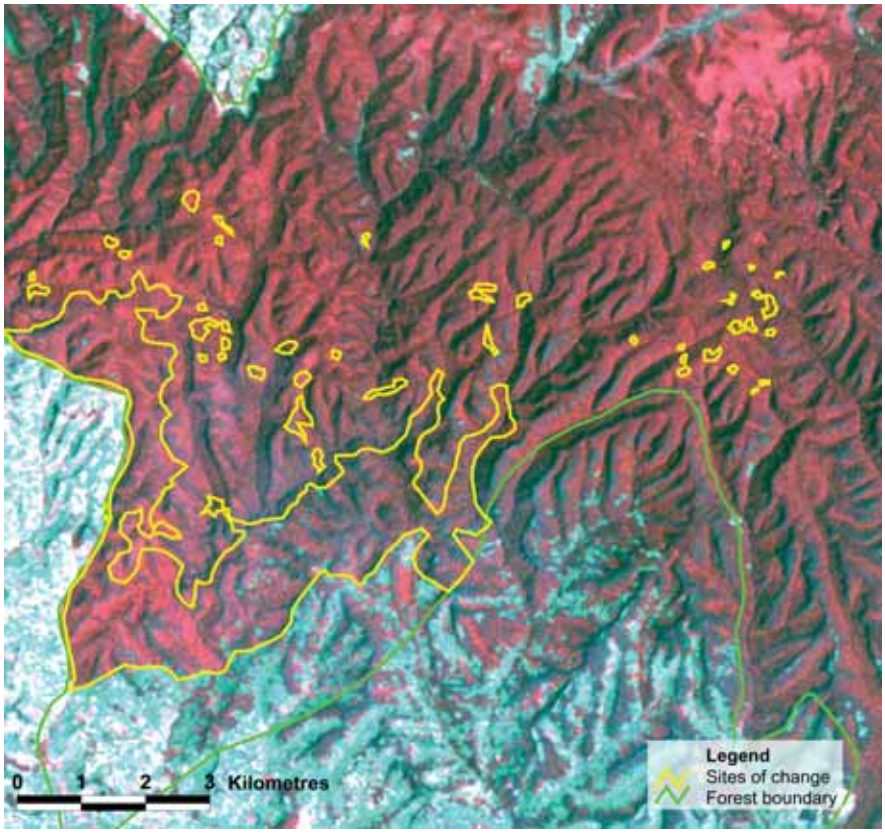

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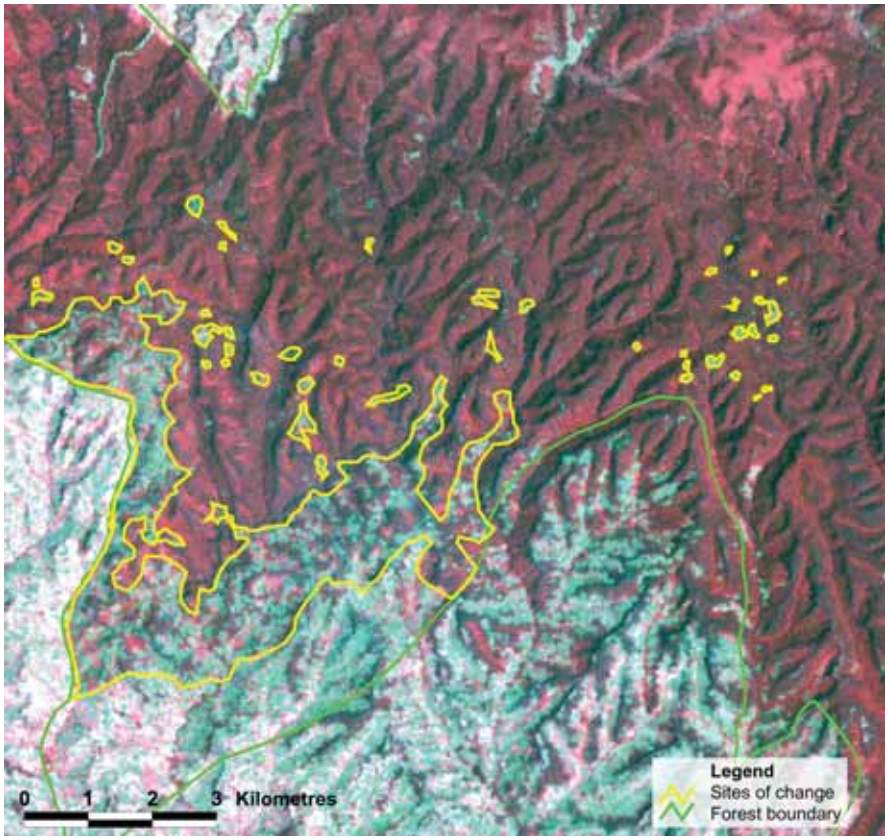
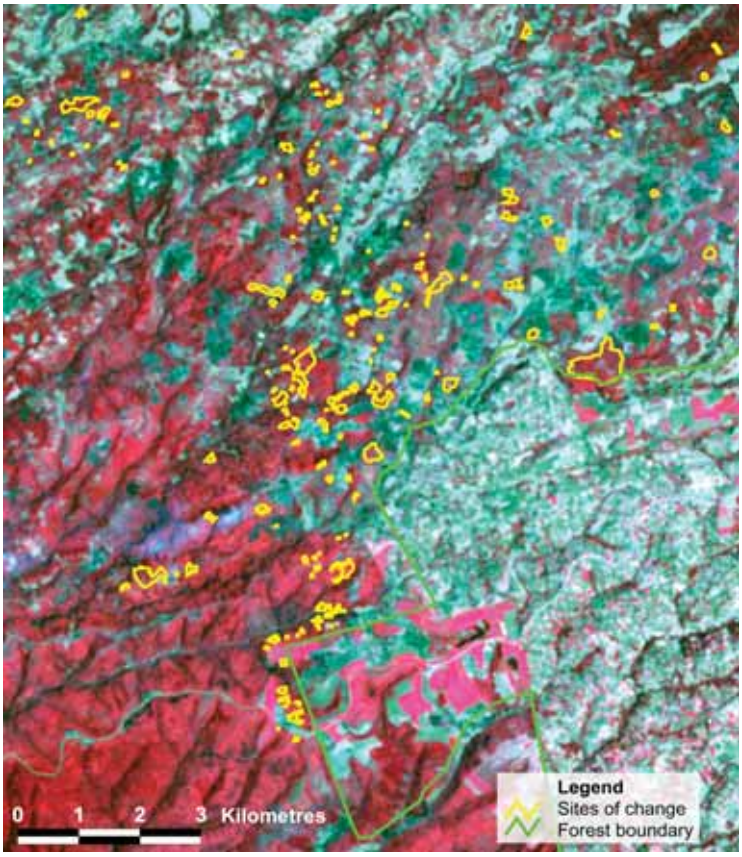


Site 3: Kuresoi Constituency, Nakuru District

Situation in Year 2000; areas within the yellow outlined polygons are forested



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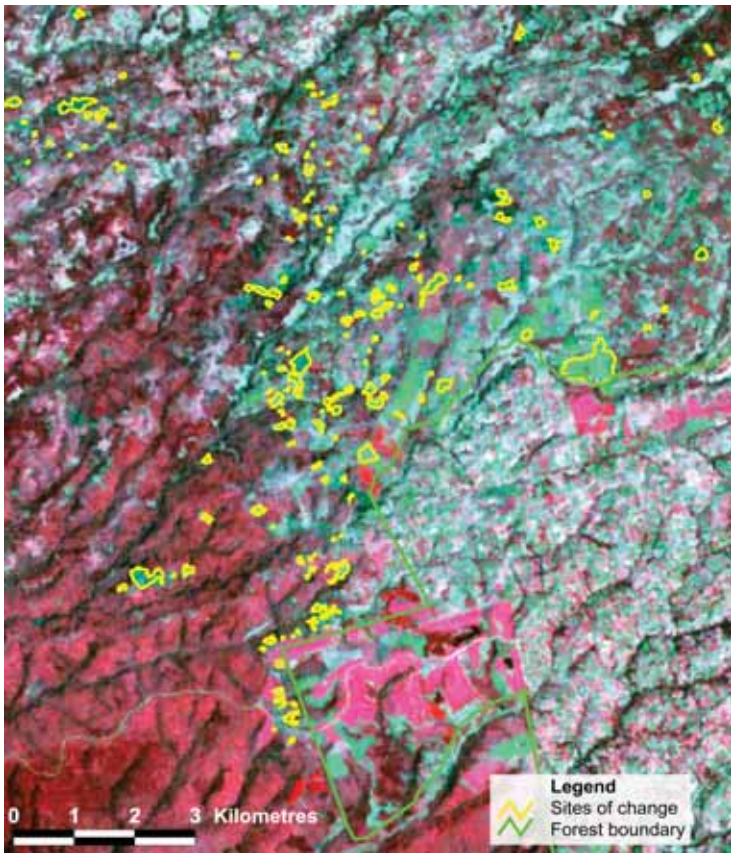

Site 4: Kuresoi Constituency, Nakuru District

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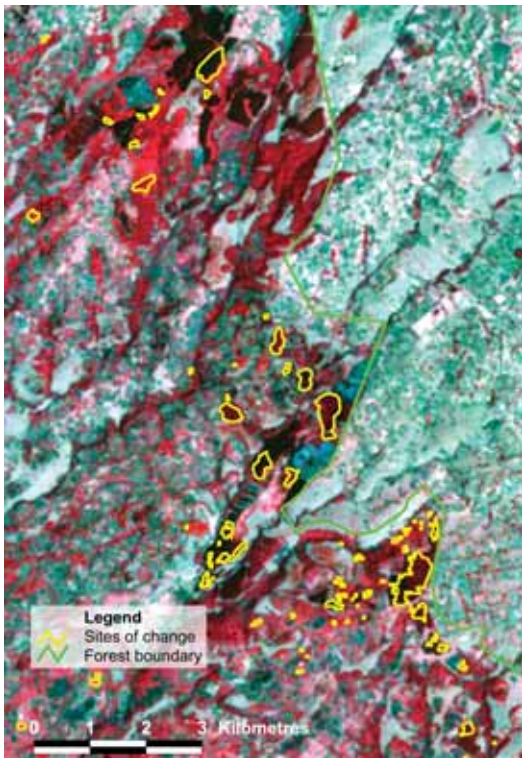

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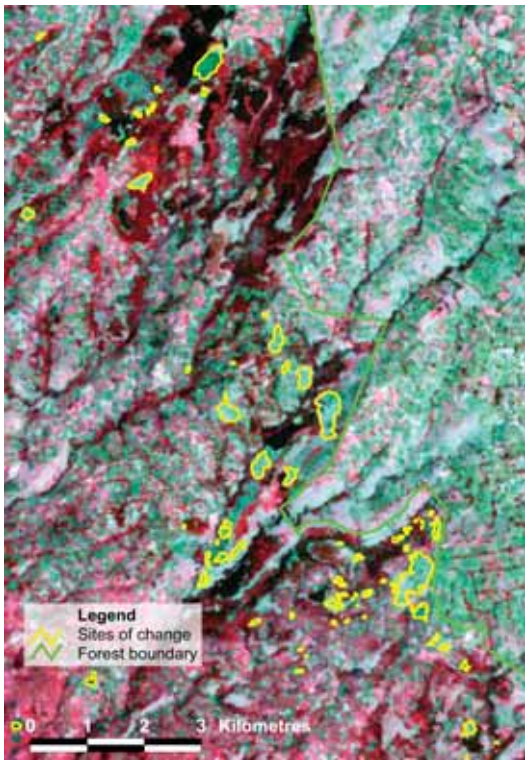

Site 5: Kuresoi Constituency, Nakuru District

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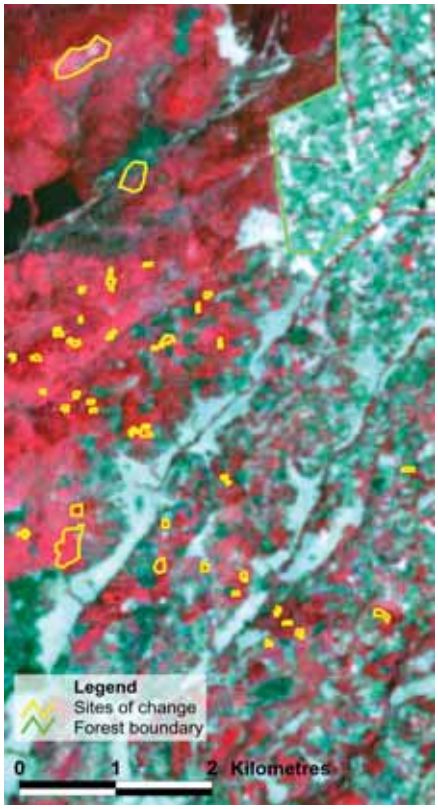

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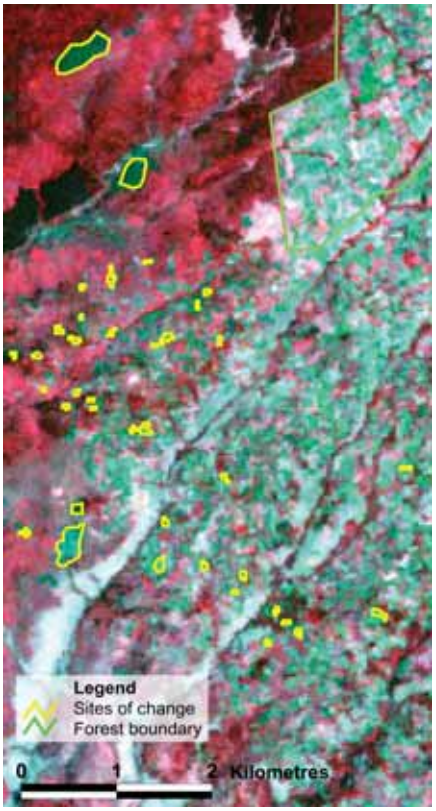

Site 6: Kuresoi/Molo Constituencies, Nakuru District

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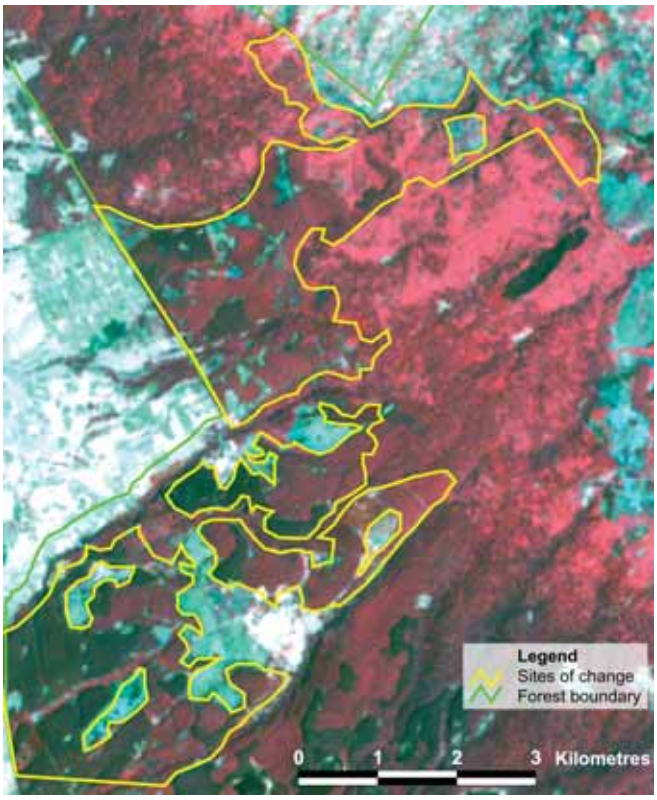

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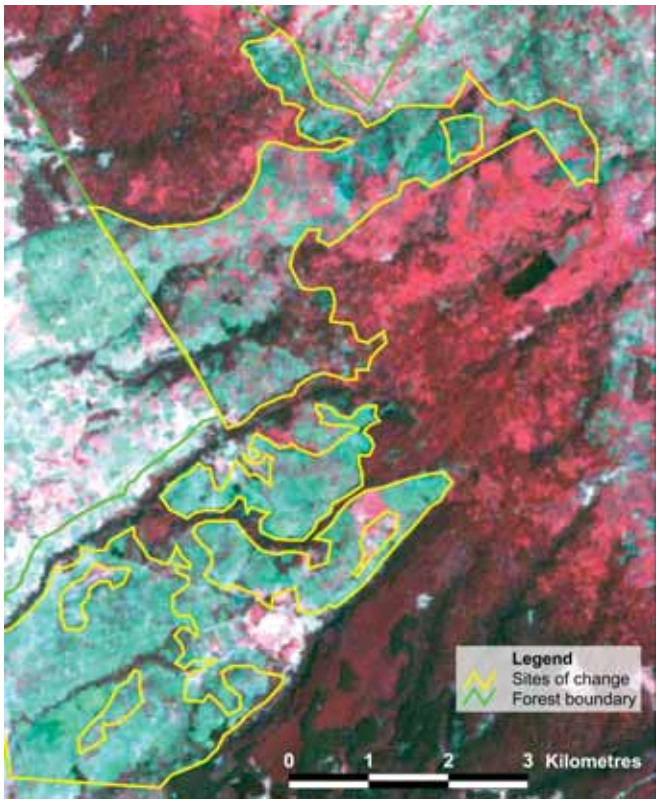

Site 7: Kuresoi Constituency, Nakuru District

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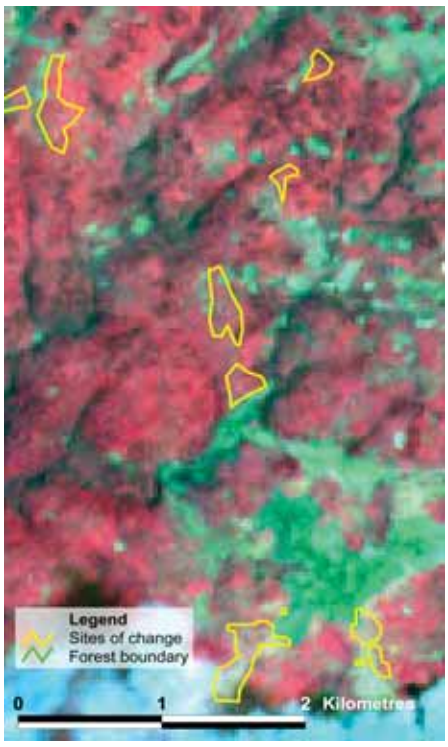

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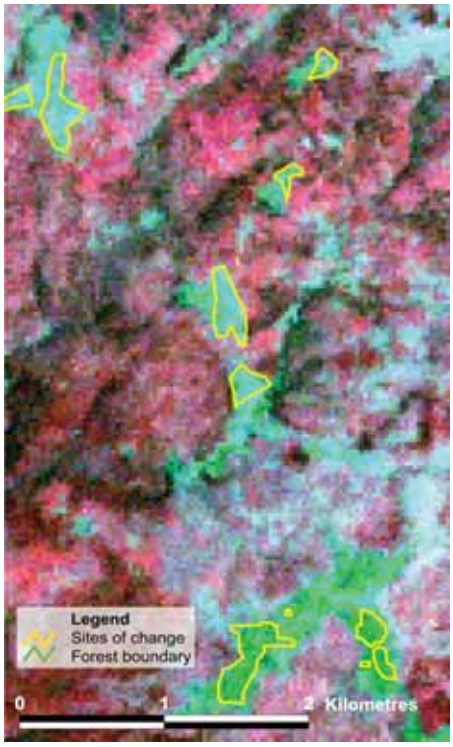
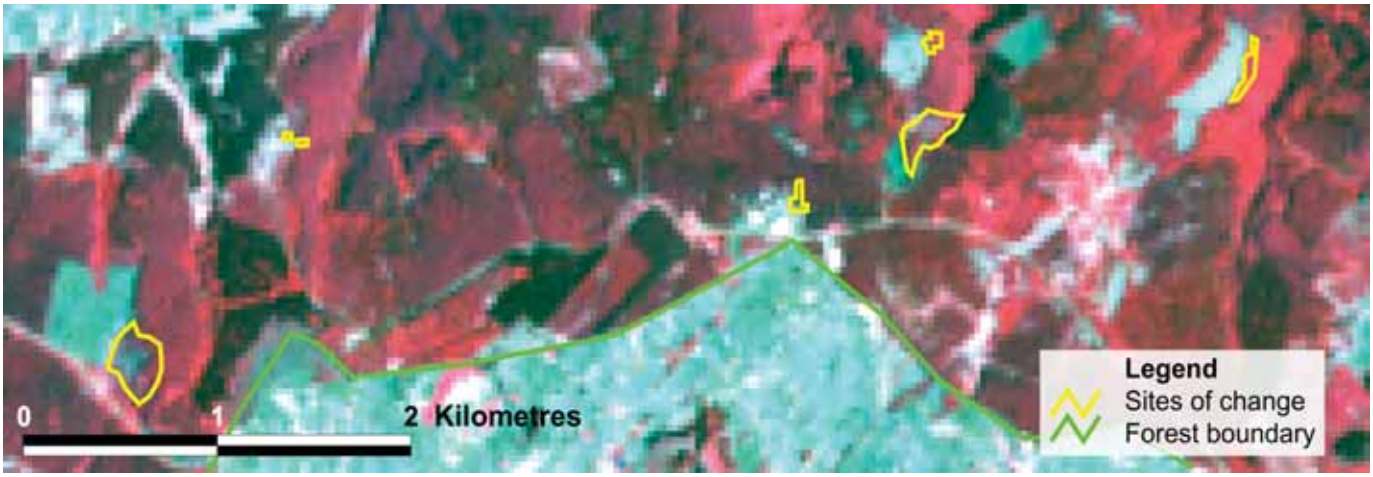


Site 8: Kuresoi Constituency, Nakuru District

Situation in Year 2000; areas within the yellow outlined polygons are forested



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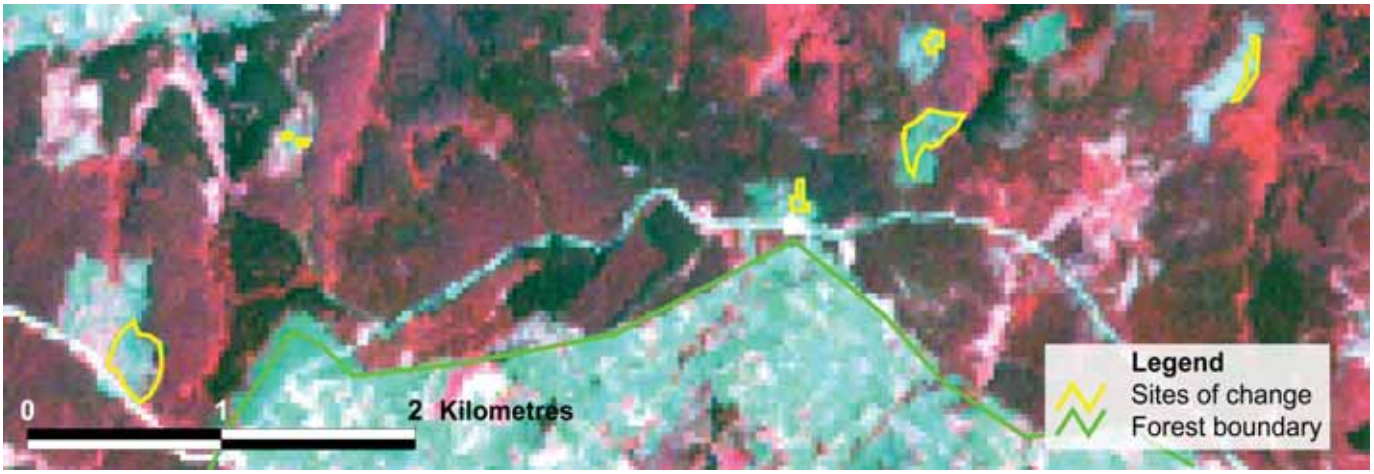
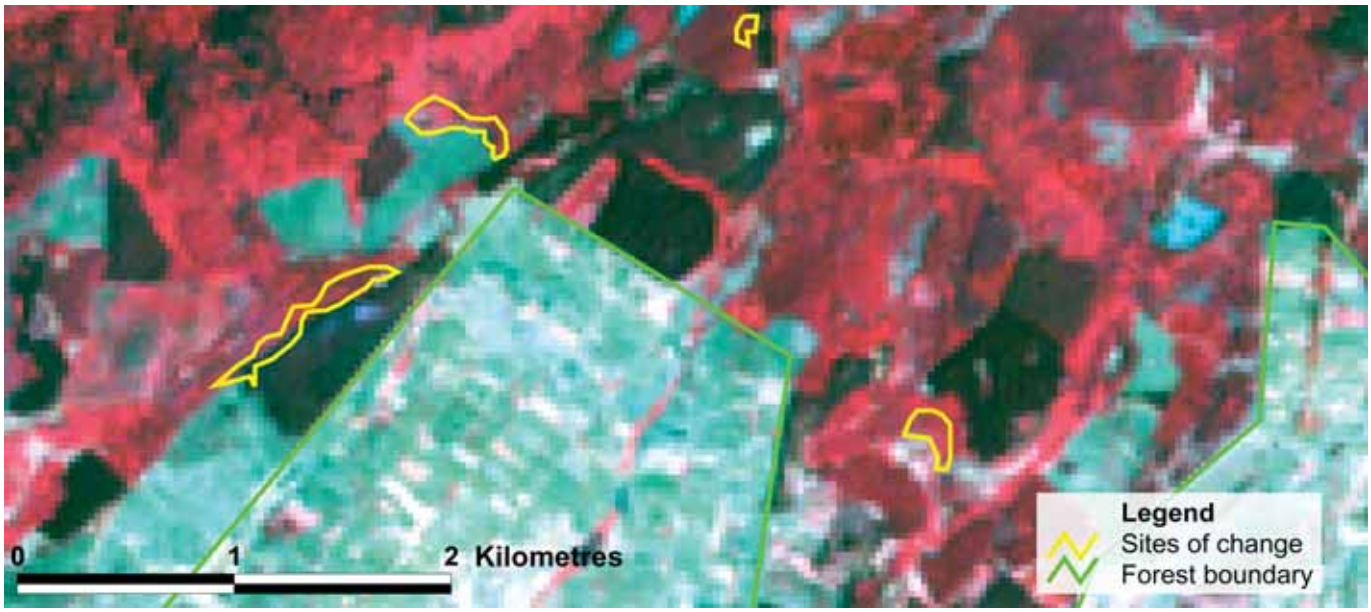


Site 9: Kuresoi Constituency, Nakuru District

Situation in Year 2000; areas within the yellow outlined polygons are forested



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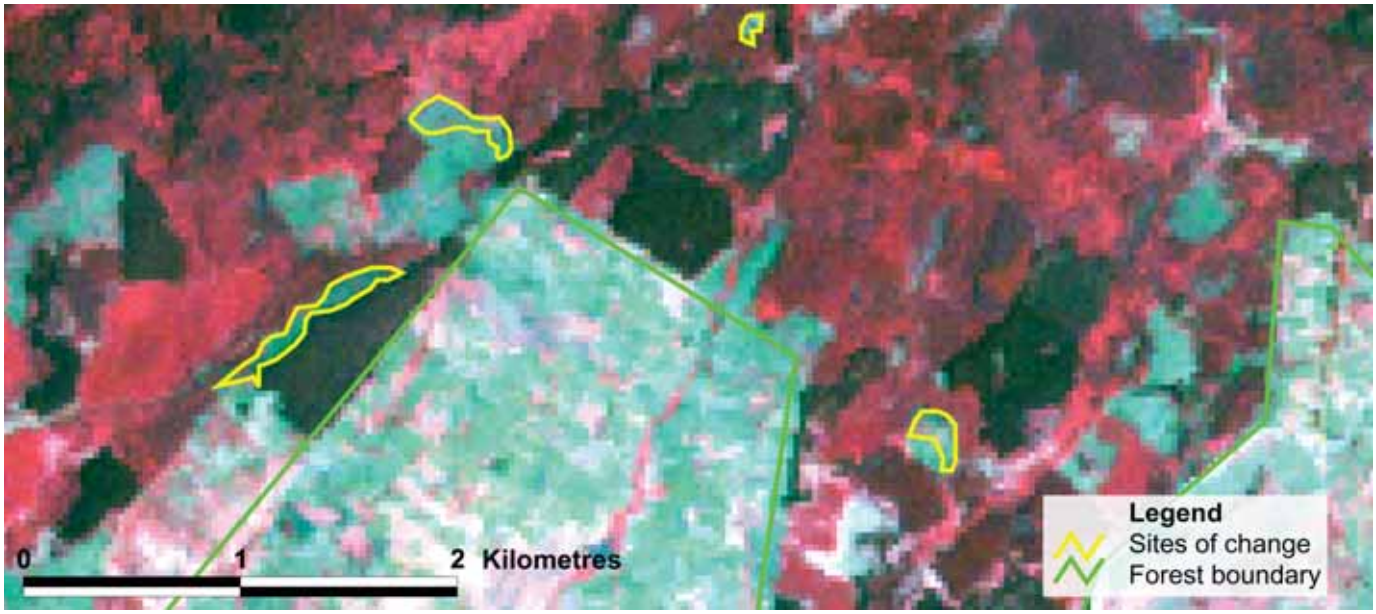

Site 10: Molo Constituency, Nakuru District

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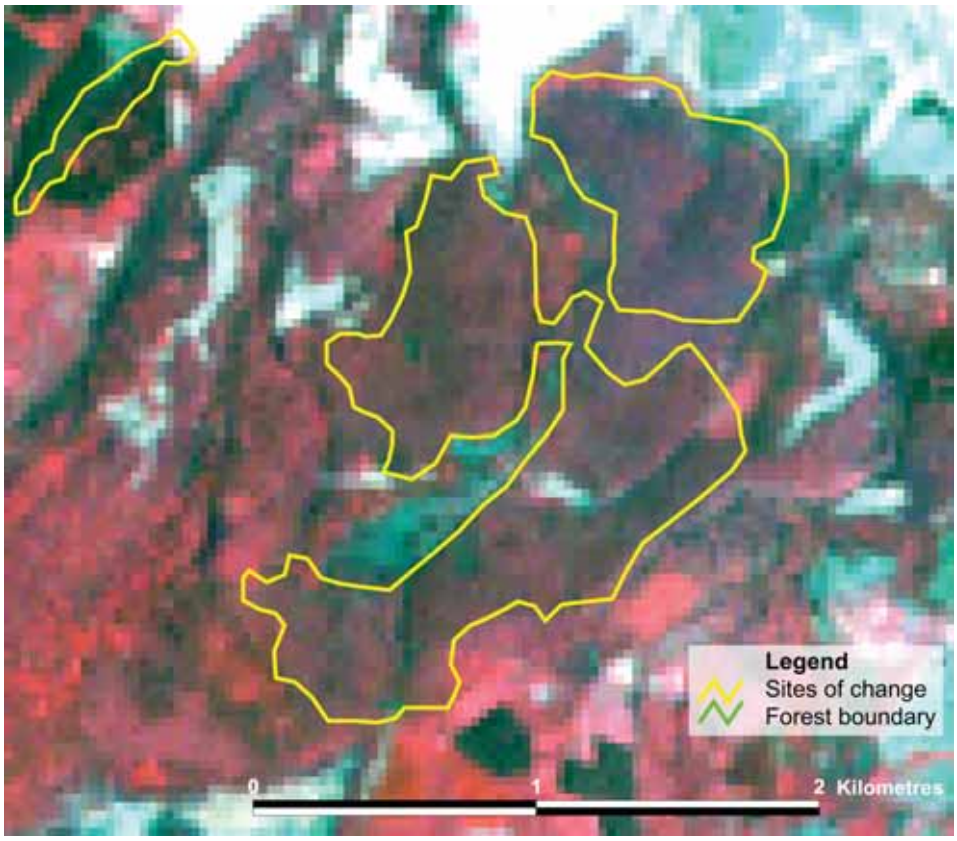

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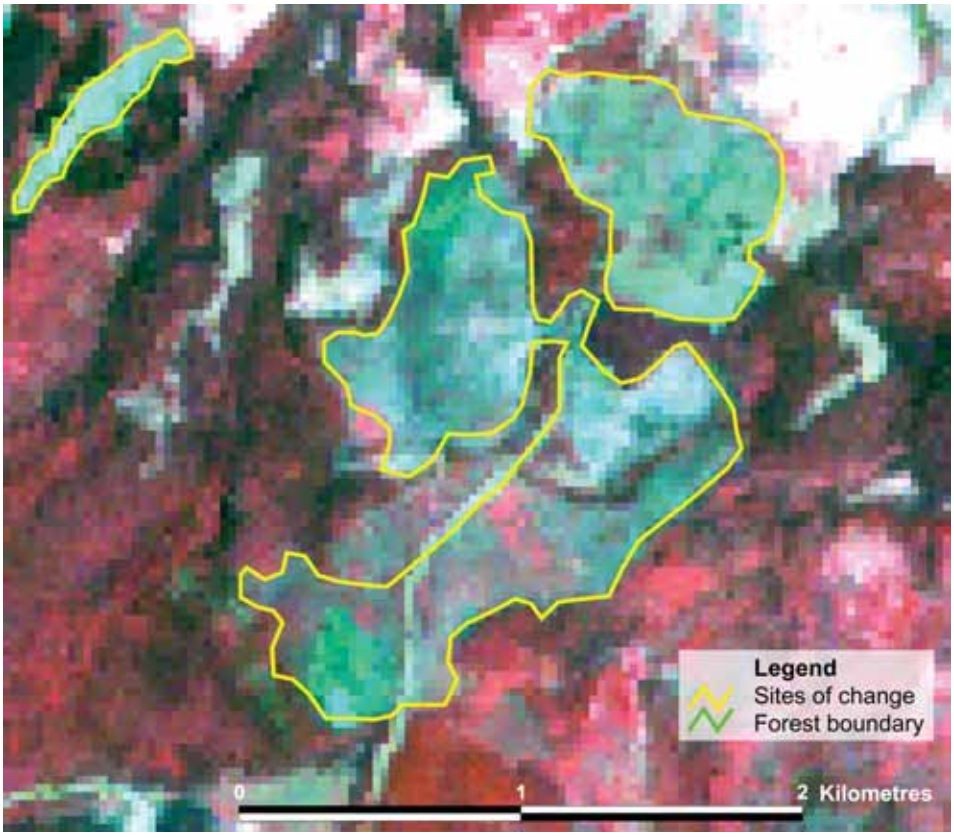
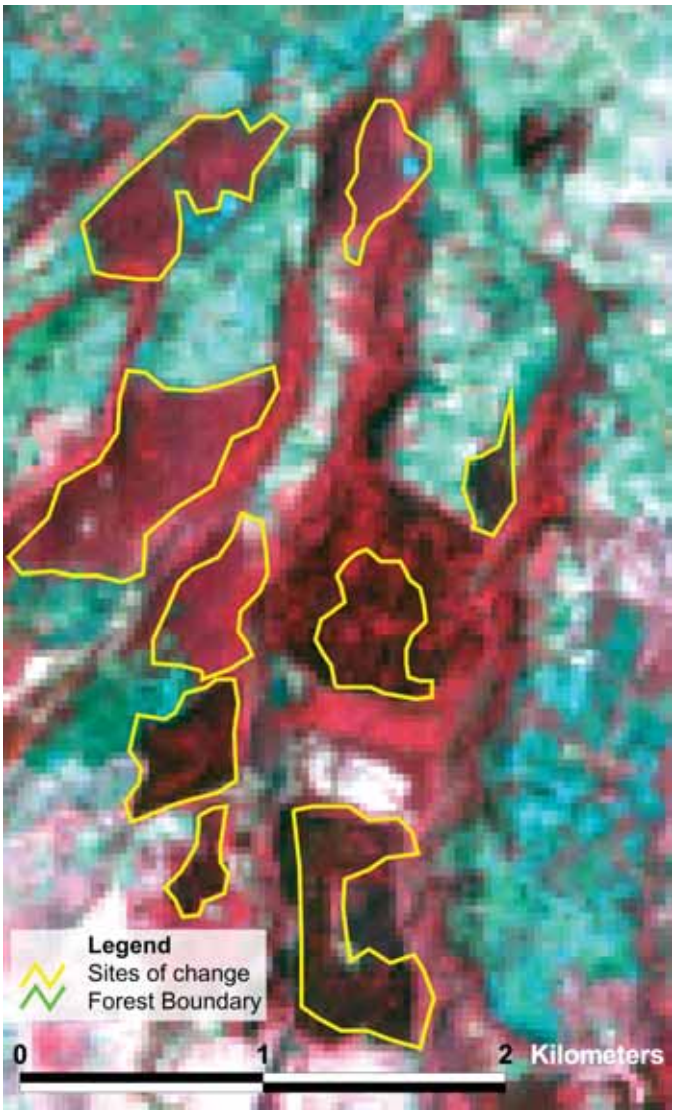


Site 11: Molo Constituency, Nakuru District

Situation in Year 2000; areas within the yellow outlined polygons are forested



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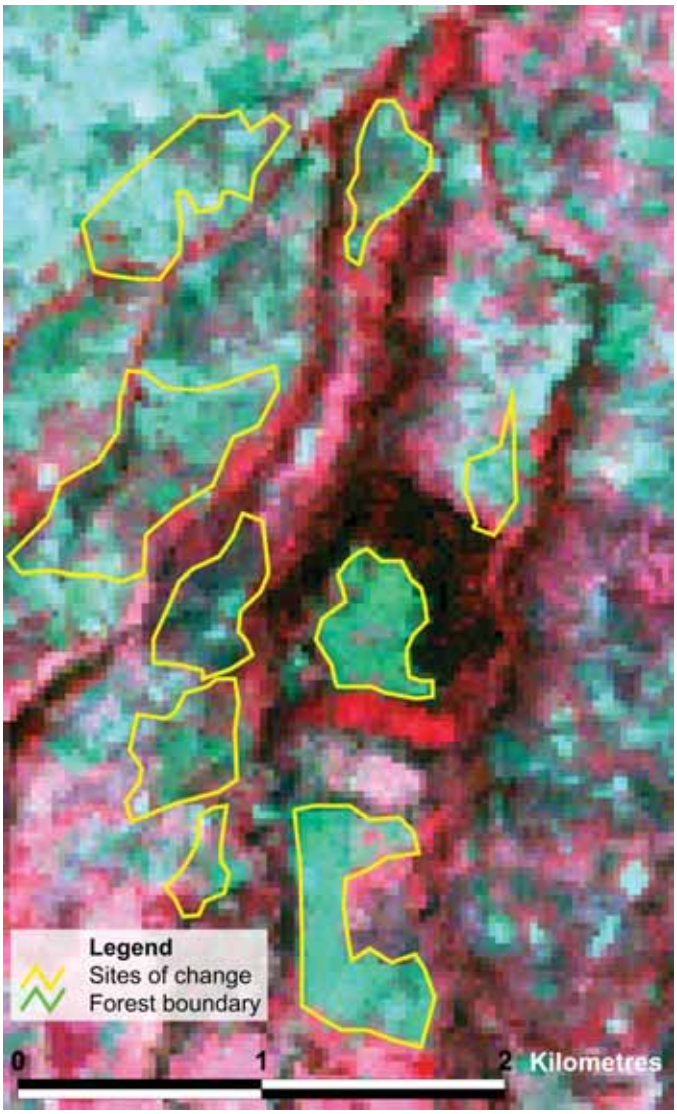
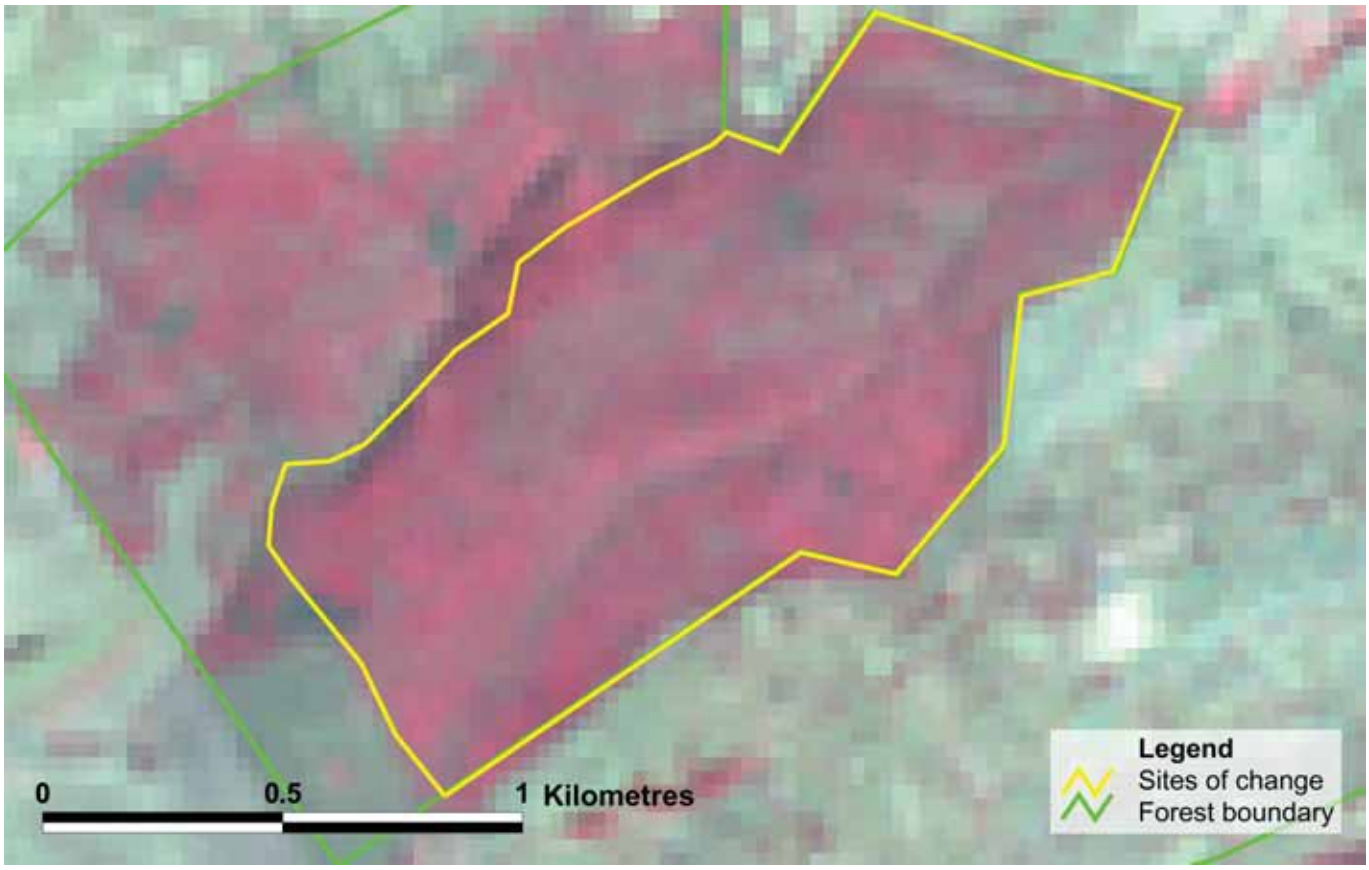


Site 12: Kuresoi Constituency, Nakuru District

Situation in Year 2000; areas within the yellow outlined polygons are forested



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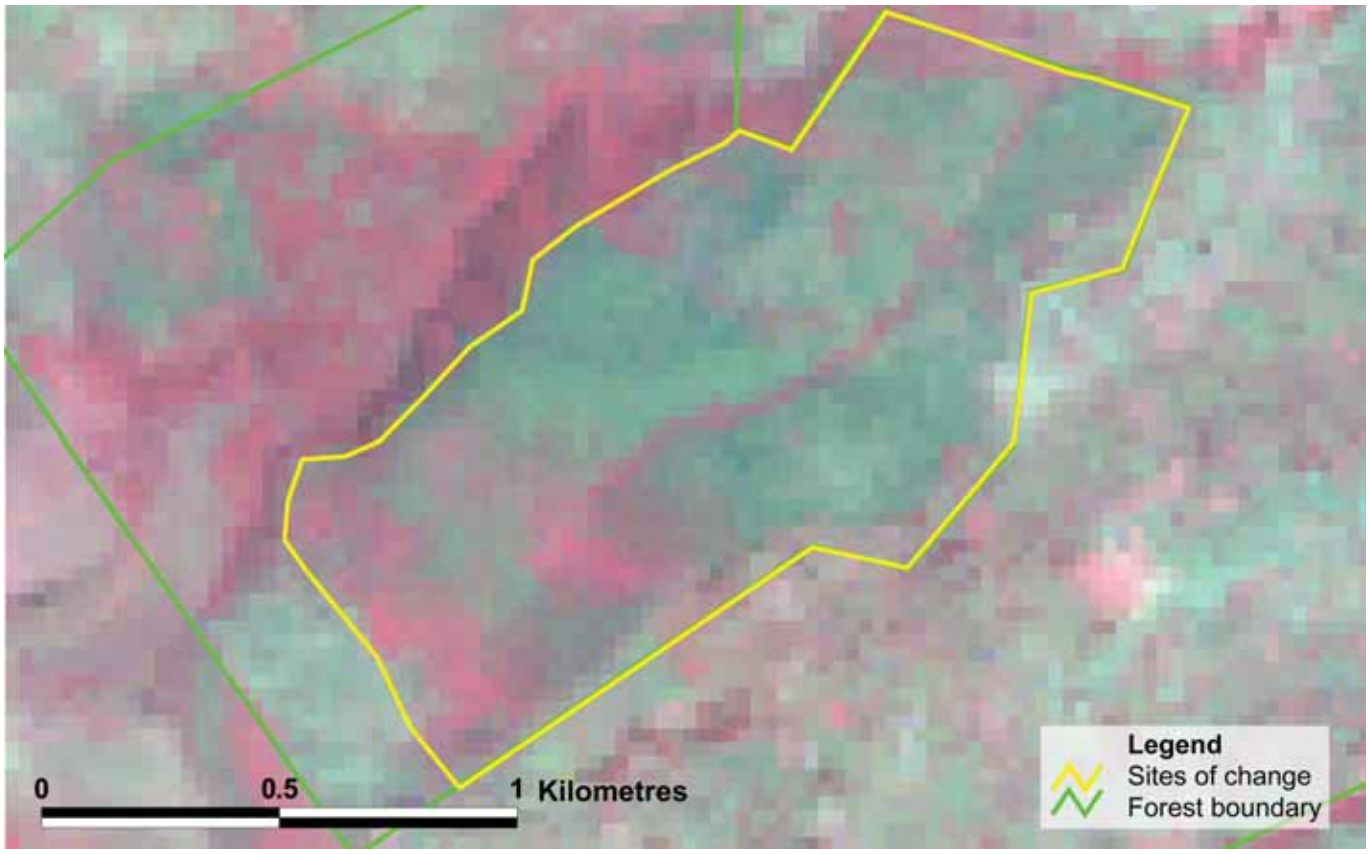
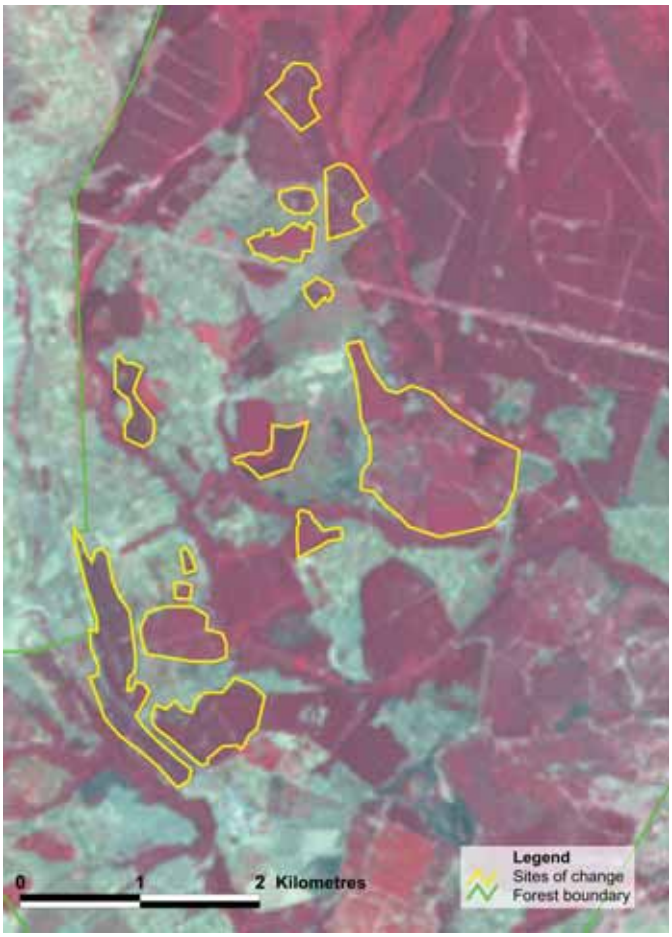
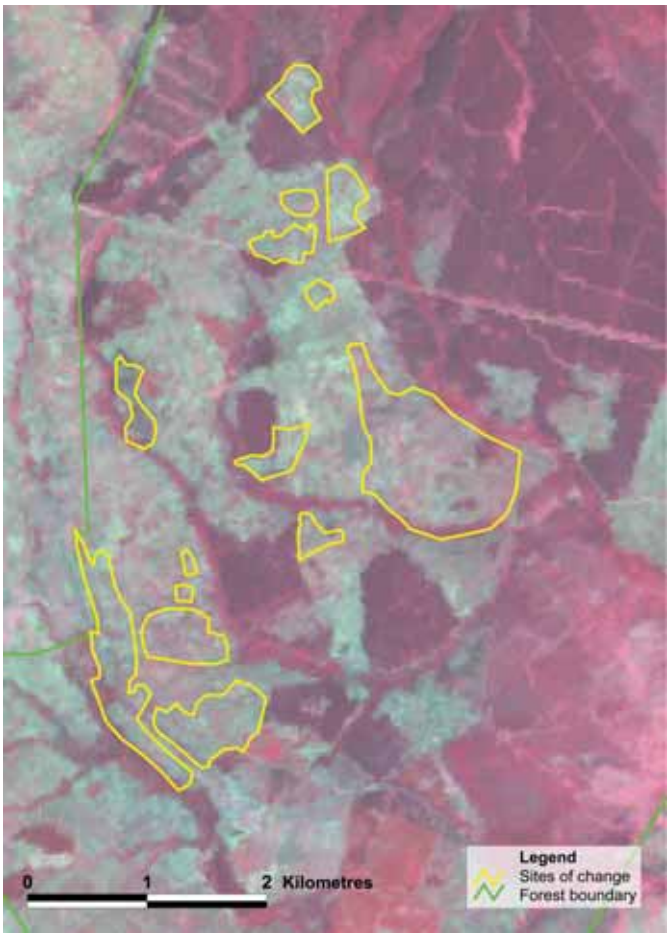


Site 13: Eldama Ravine/Molo Constituencies, Koibatek/Nakuru Districts

Situation in Year 2000; areas within the yellow outlined polygons are forested

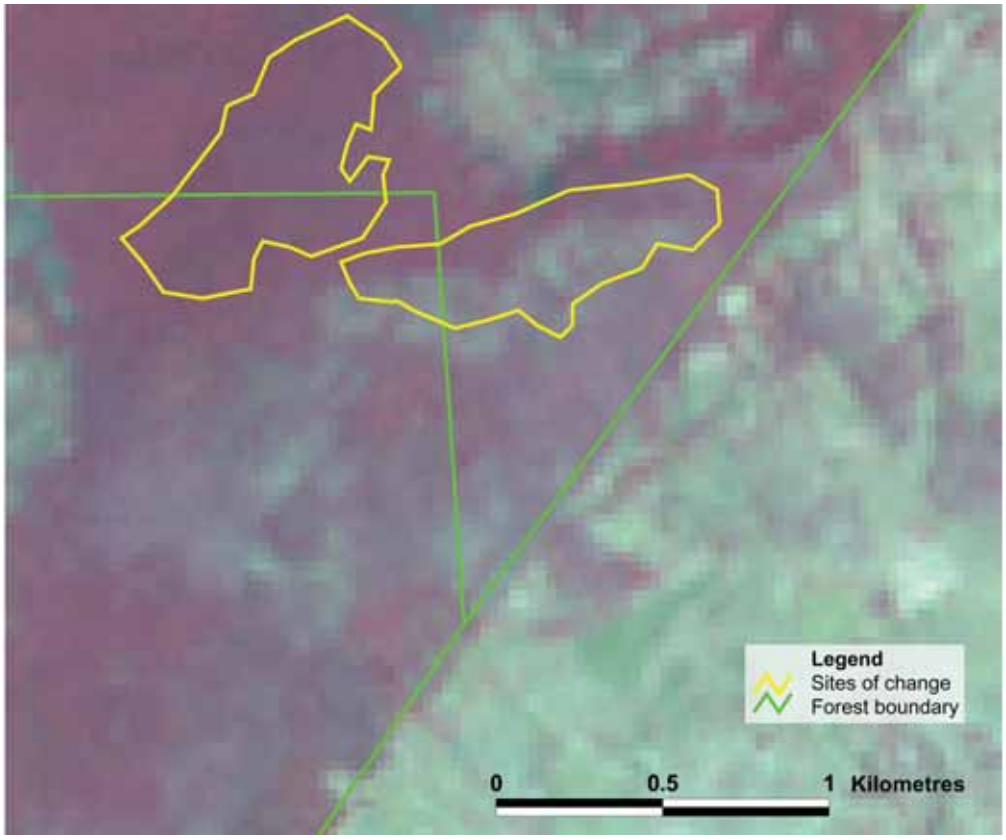


Situation in Year 2003; areas within the yellow outlined polygons have been cleared

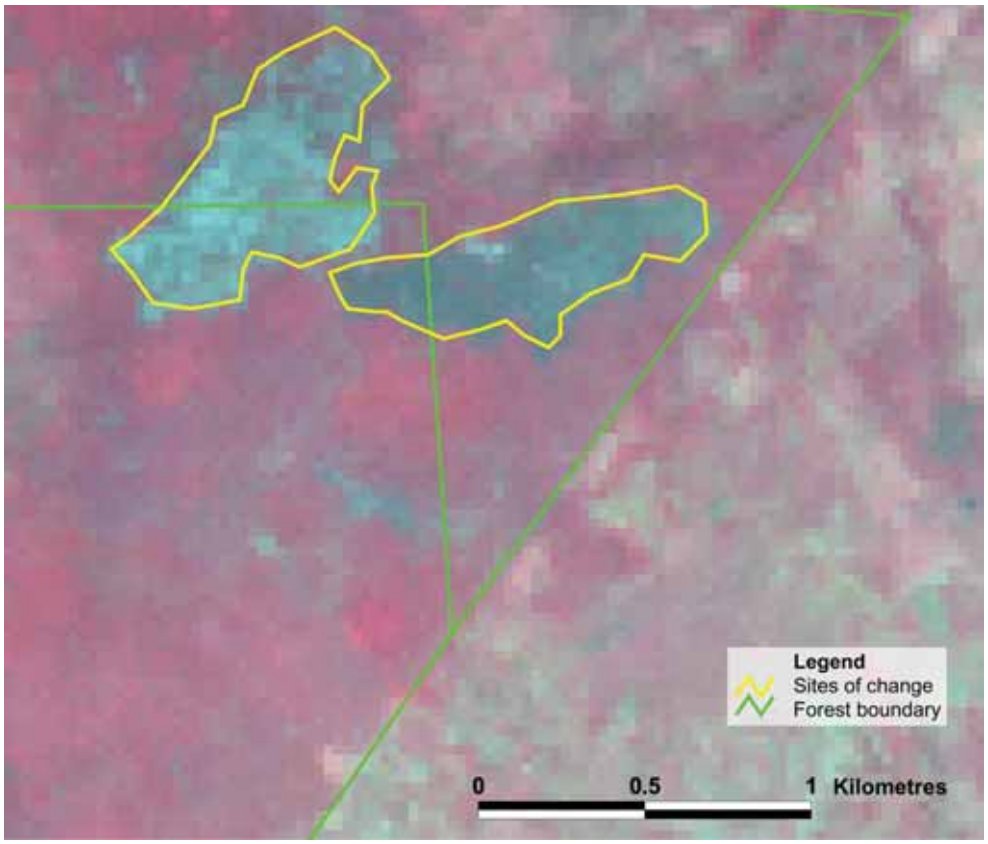


Site 14: Eldama Ravine Constituency, Koibatek District

Situation in Year 2000; areas within the yellow outlined polygons are forested

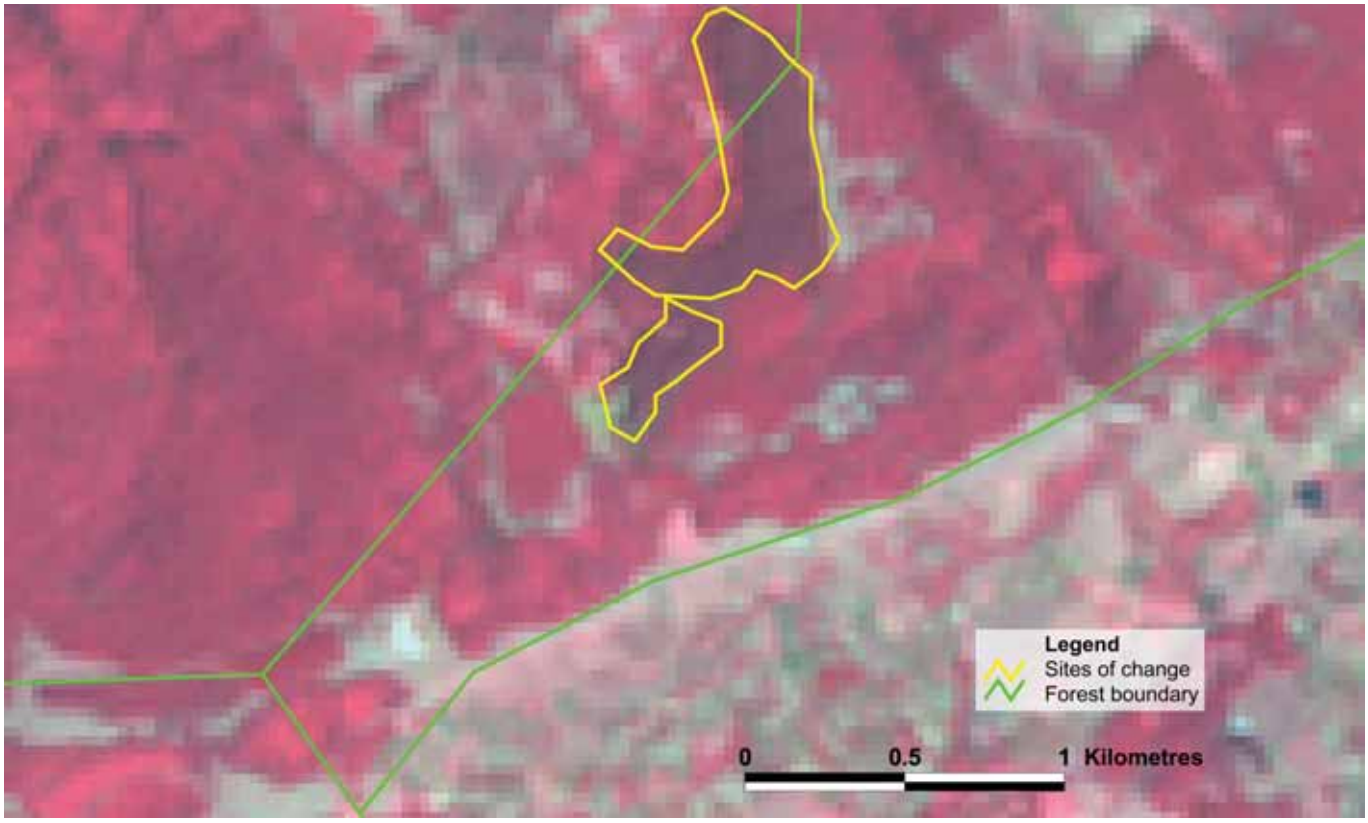


Situation in Year 2003; areas within the yellow outlined polygons have been cleared

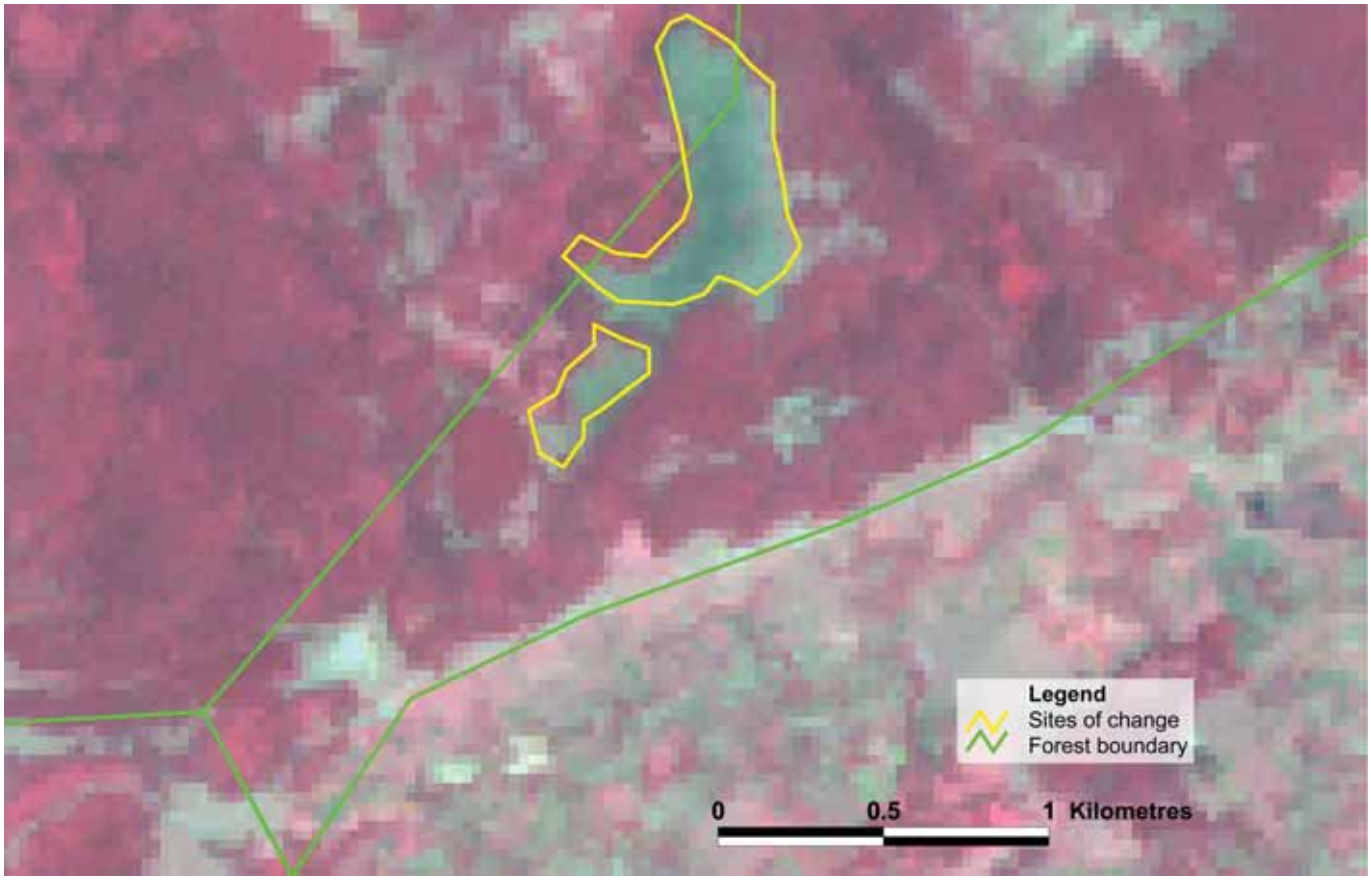


Site 15: Eldoret South Constituency, Uasin Gishu District

Situation in Year 2000; areas within the yellow outlined polygons are forested

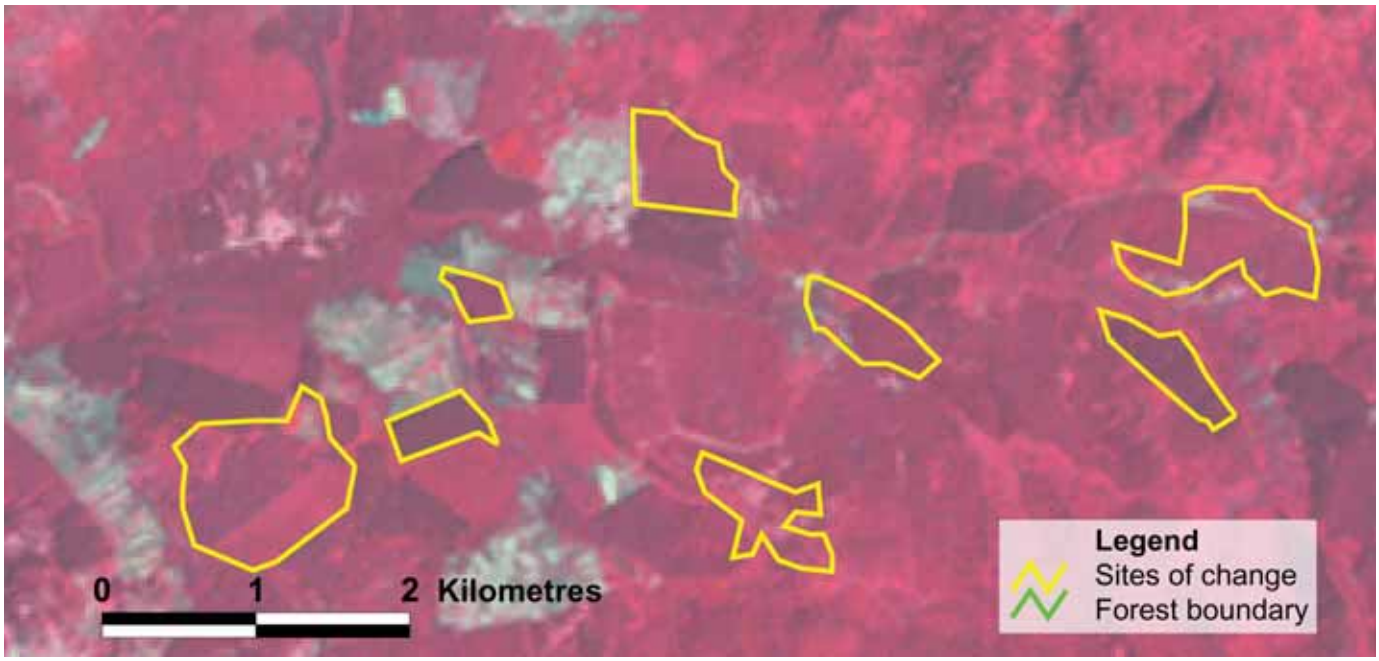


Situation in Year 2003; areas within the yellow outlined polygons have been cleared

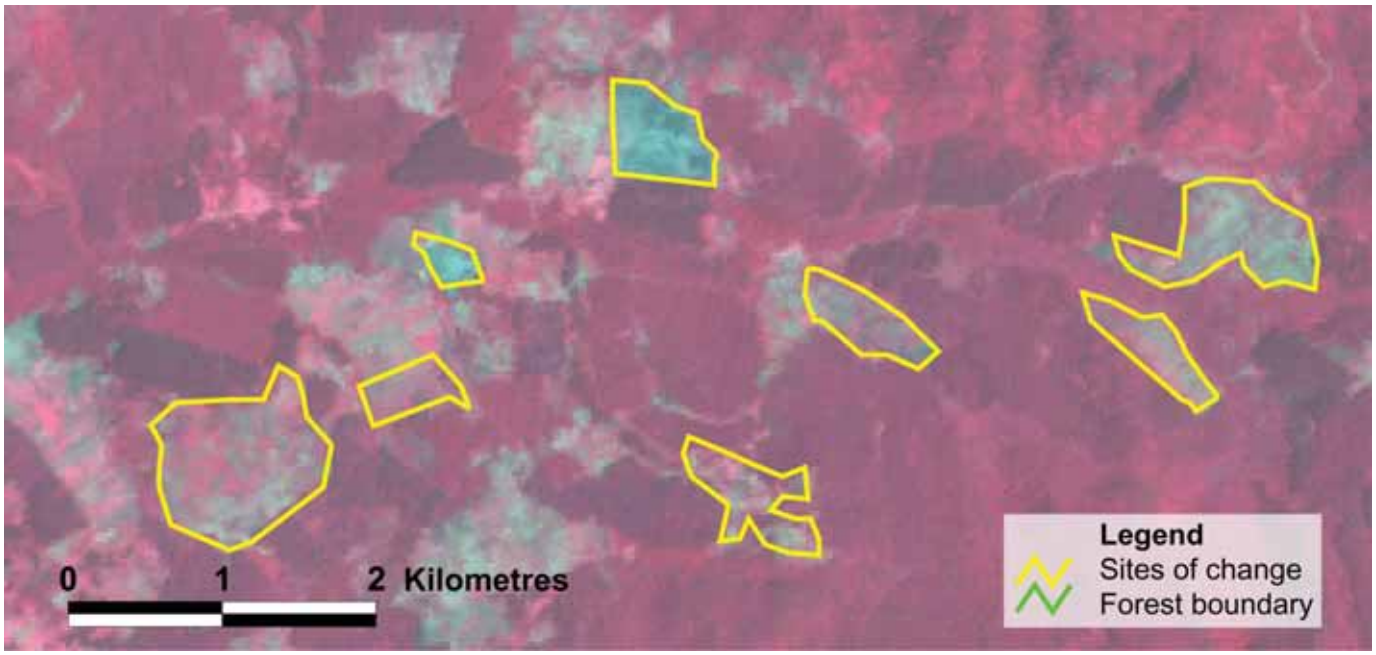


Site 16: Eldoret South Constituency, Uasin Gishu District

Situation in Year 2000; areas within the yellow outlined polygons are forested

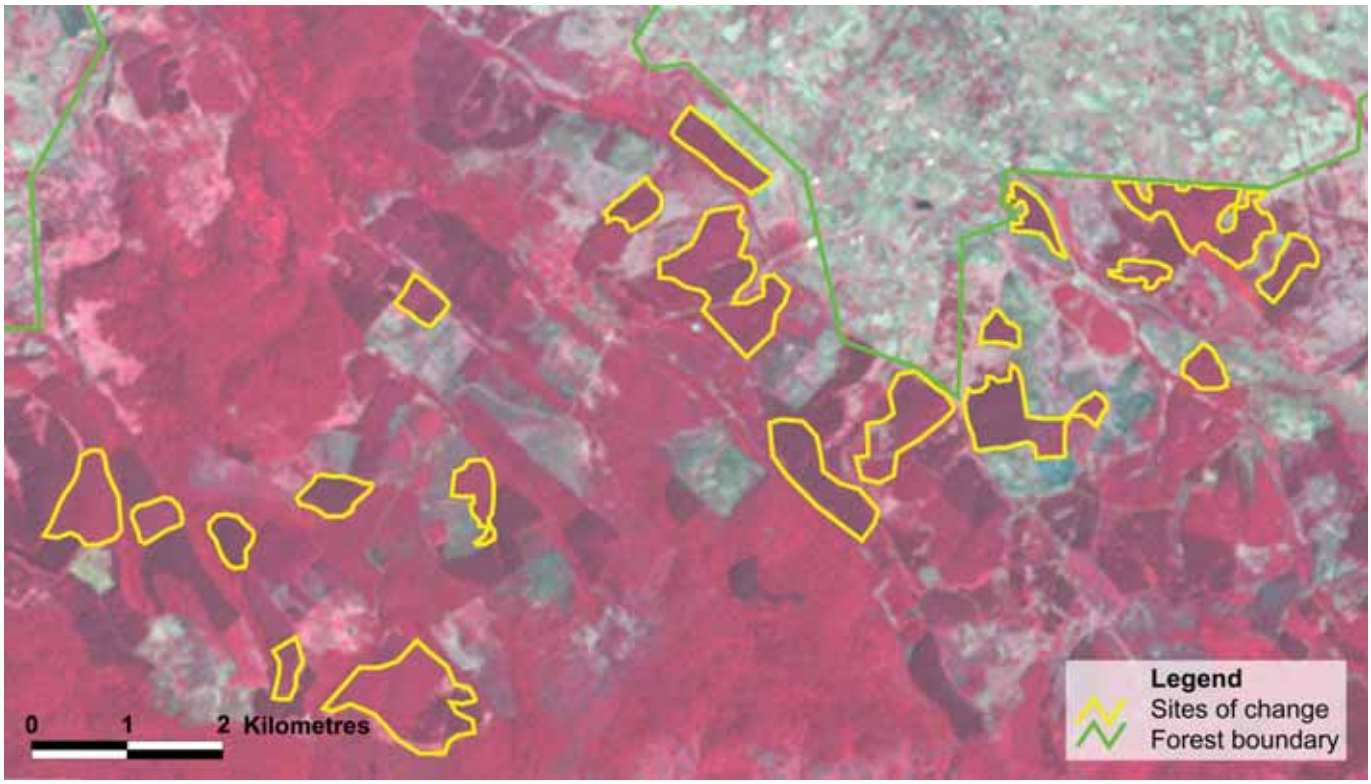


Situation in Year 2003; areas within the yellow outlined polygons have been cleared

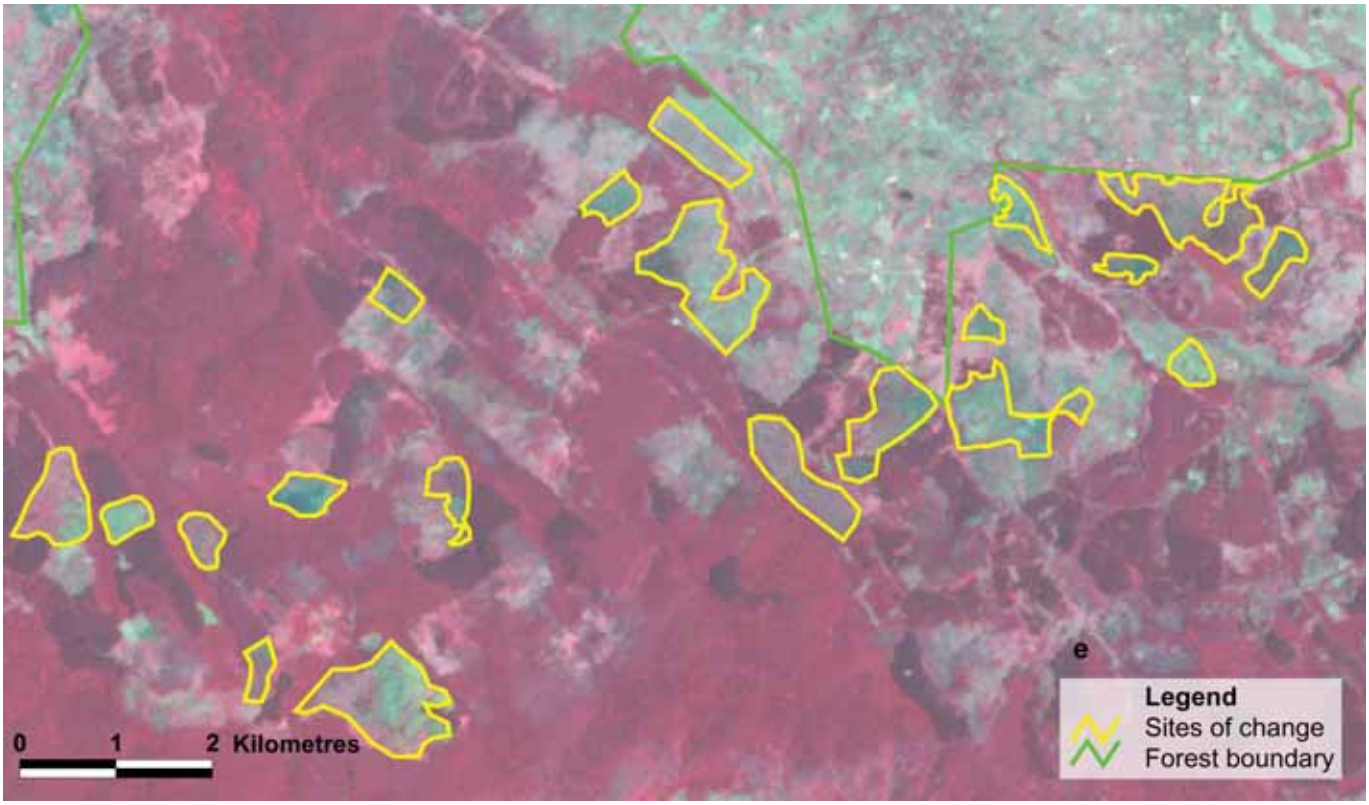


Site 17: Eldoret South Constituency, Uasin Gishu District

Situation in Year 2000; areas within the yellow outlined polygons are forested

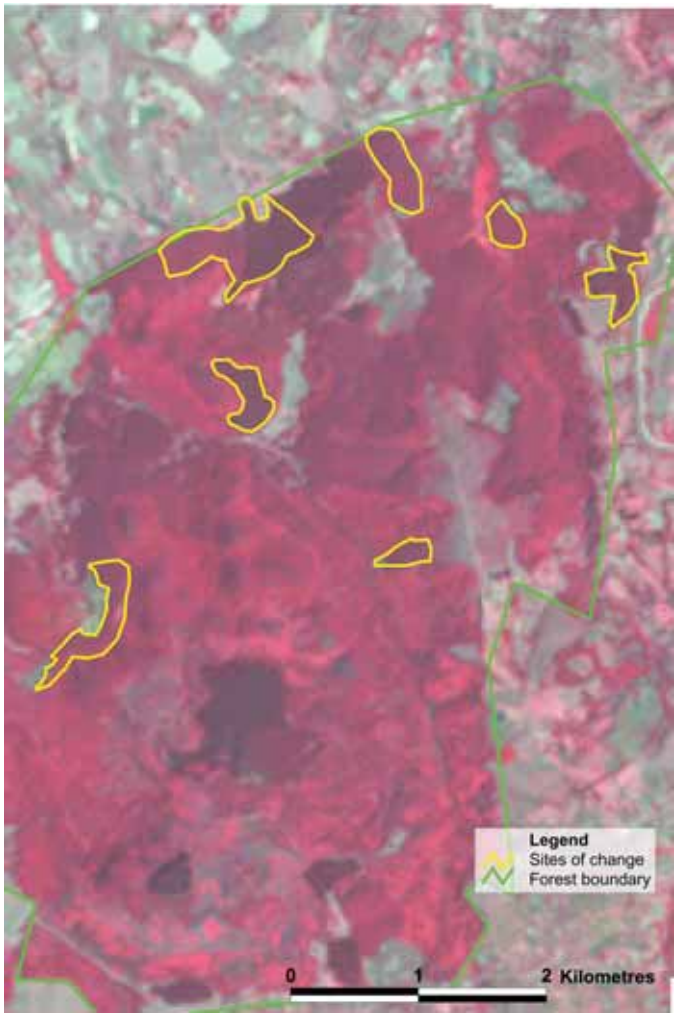


Situation in Year 2003; areas within the yellow outlined polygons have been cleared

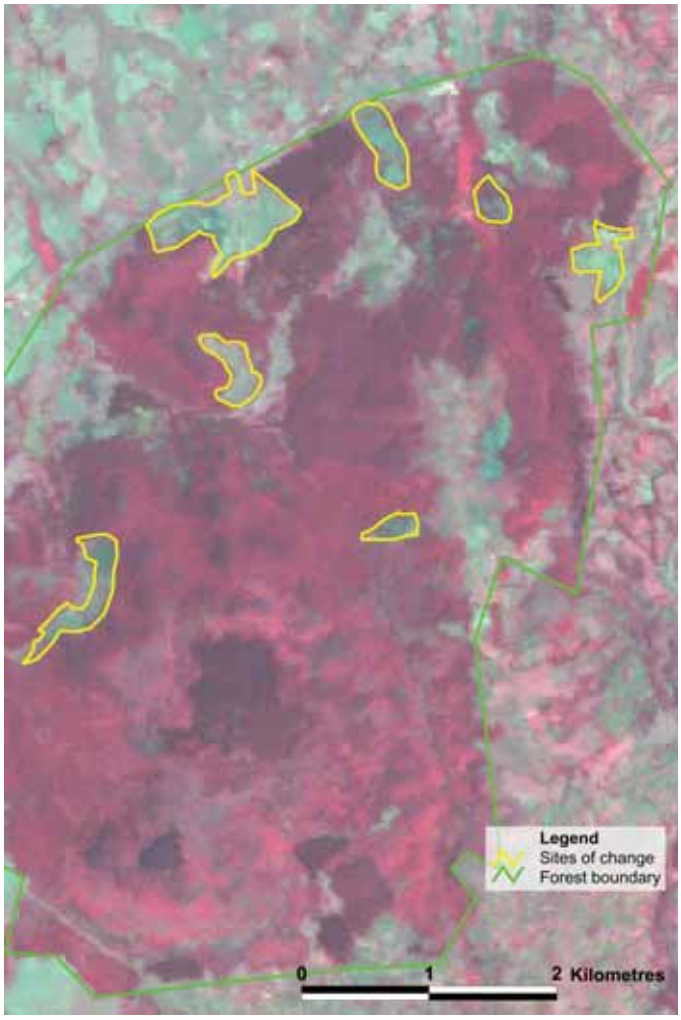


Site 18: Eldoret East Constituency, Uasin Gishu District

Situation in Year 2000; areas within the yellow outlined polygons are forested

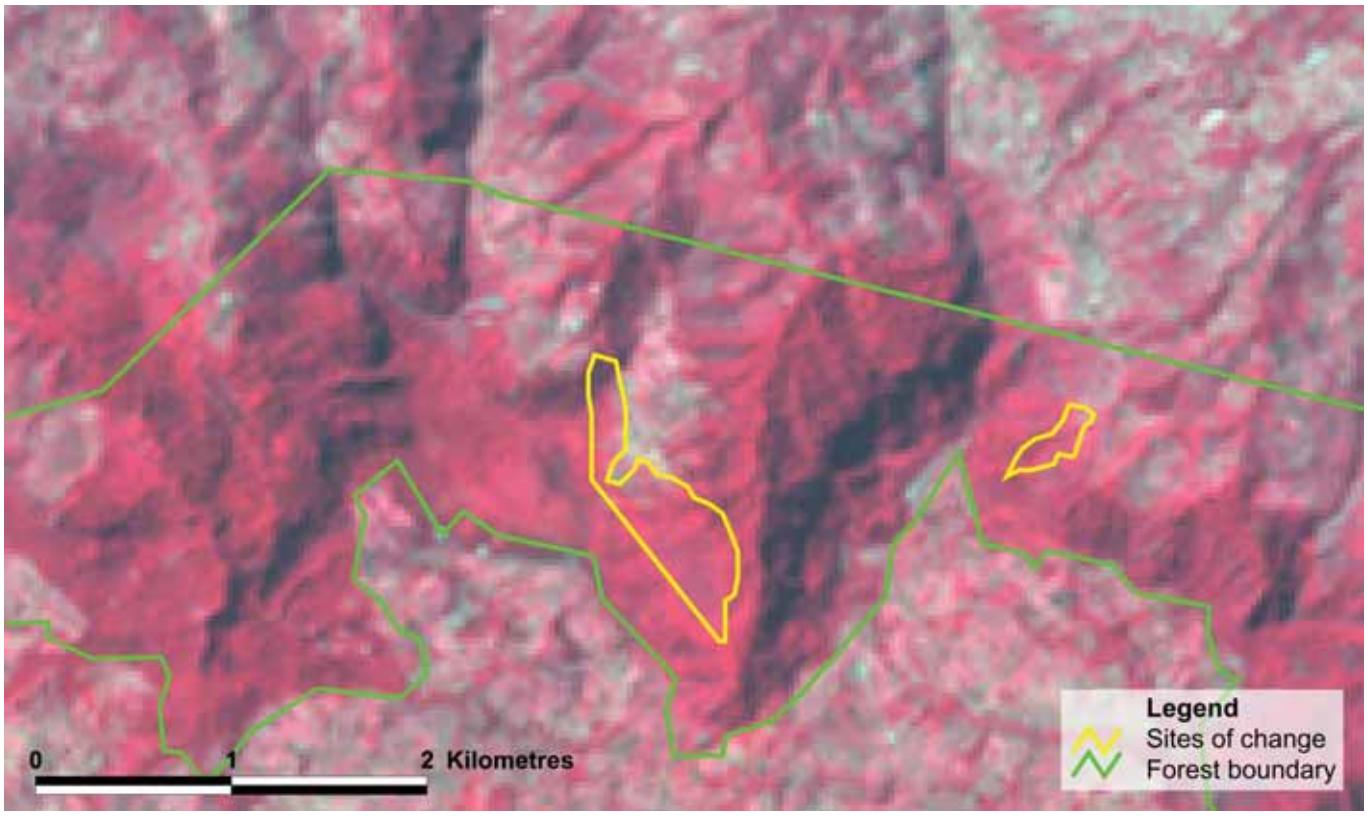


Situation in Year 2003; areas within the yellow outlined polygons have been cleared



Site 19: Keiyo South Constituency, Keiyo District

Situation in Year 2000; areas within the yellow outlined polygons are forested



Situation in Year 2003; areas within the yellow outlined polygons have been cleared

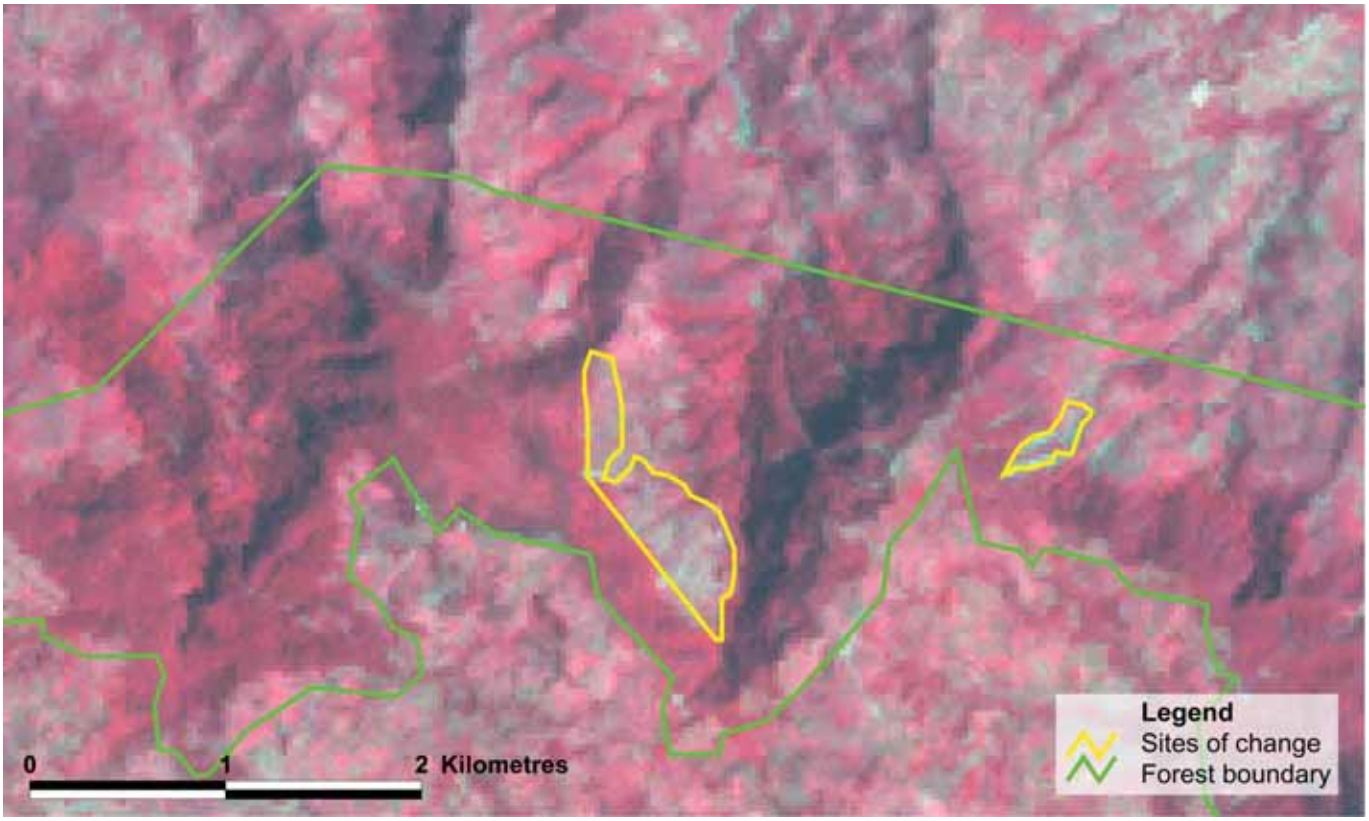


Fig.3. Sites with changes in the Mau Complex forests per constituency

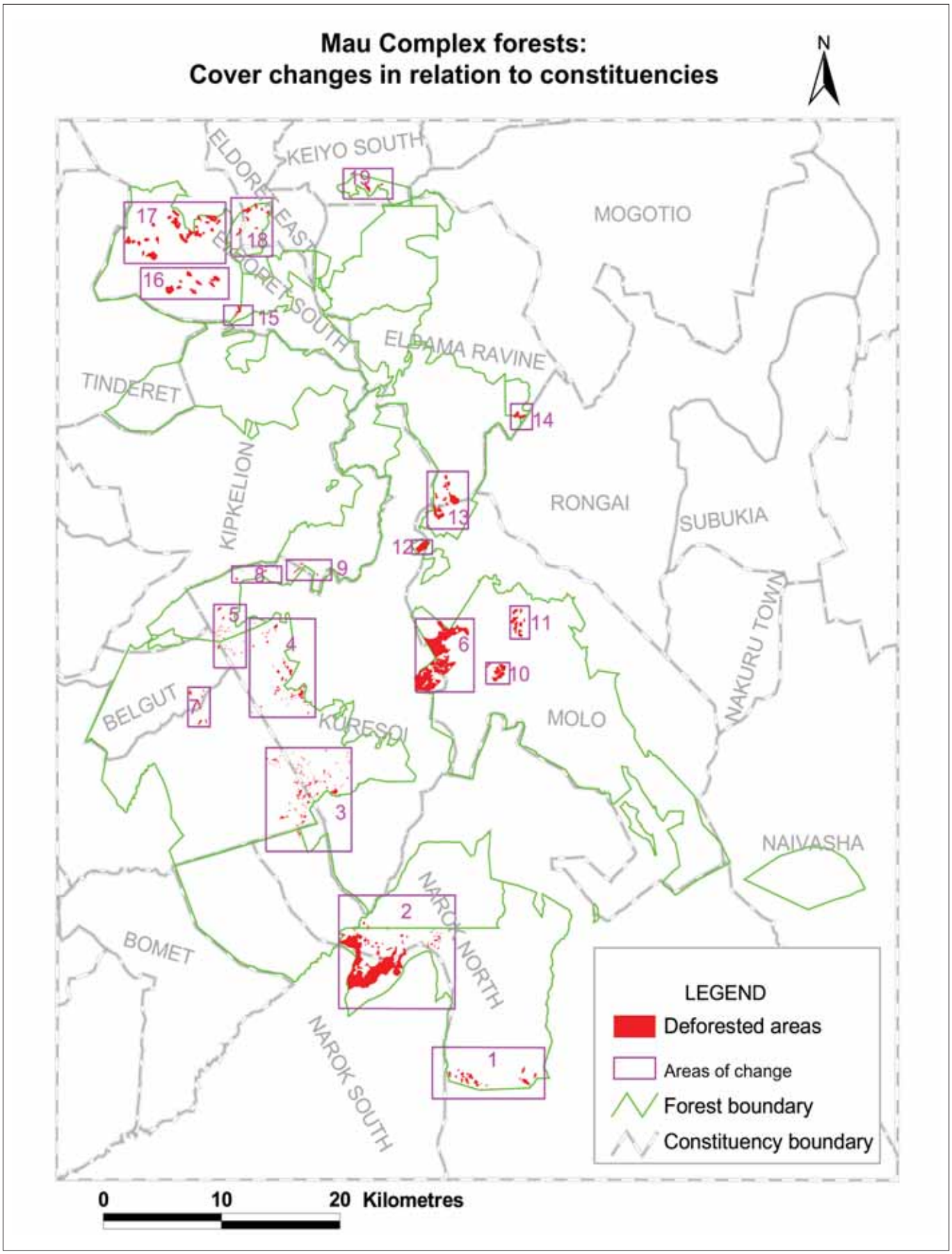


Table 2. Forests constituting the Mau Complex

FOREST RESERVE	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.

Since that time, a number of excisions to these forests have been gazetted, in particular those in 2001. The 2001 excisions are the subject of an ongoing court case brought by three organizations - the East African Wild Life Society, Kenya Alliance of Resident Associations, and Environment Liaison Centre International - and two individuals.

Table 3. Areas of significant change in the Mau Complex forests (2000 –2003)

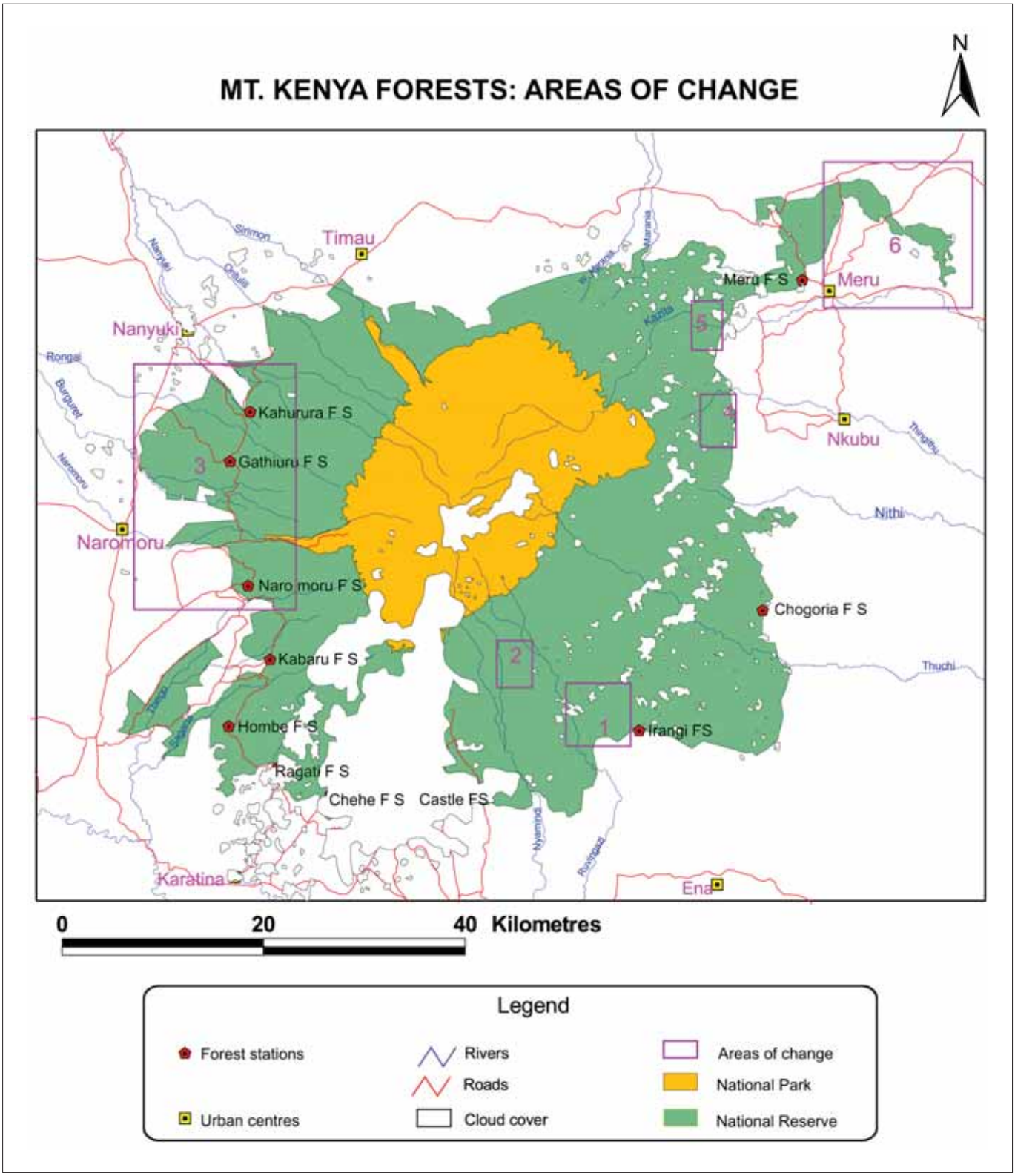
Site No.	Forest	Constituency	Nearest forest station*	District	Area affected (ha)	Forest type	Change Type
1	Maasai Mau	Narok North	Olenguruone	Narok	195.15	Indigenous	Deforestation
2	Maasai Mau	Narok South	Olenguruone	Narok	2291.19	Indigenous	Deforestation
3	SW Mau	Kuresoi	Olenguruone	Nakuru	190.49	Indigenous	Deforestation
4	SW Mau	Kuresoi	Kerisoi	Nakuru	167.38	Plantation	Deforestation
5	SW Mau / W Mau	Kuresoi	Kerisoi	Nakuru	42.15	Indigenous / Plantation	Deforestation
6	Eastern Mau	Kuresoi /Molo	Baraget	Nakuru	1971.81	Indigenous / Plantation	Deforestation
7	SW Mau	Kuresoi	Kerisoi	Nakuru	46.34	Indigenous	Deforestation
8	W Mau	Kuresoi	Kerisoi	Nakuru	14.06	Plantation	Deforestation
9	W Mau	Kuresoi	Kerisoi	Nakuru	15.97	Plantation	Deforestation
10	Eastern Mau	Molo	Mariashoni	Nakuru	201.03	Plantation	Deforestation
11	Eastern Mau	Molo	Mariashoni	Nakuru	182.80	Plantation	Deforestation
12	West Molo	Kuresoi	Molo	Nakuru	145.97	Plantation	Deforestation
13	Mt. Londiani	Eldama Ravine/Molo	Molo	Nakuru	331.85	Plantation	Deforestation
14	Kilombe hill	Eldama Ravine	Molo	Koibatek	64.55	Indigenous	Deforestation
15	Northern Tinderet	Eldoret south	Serengoni	Uasin Gishu	35.15	Plantation	Deforestation
16	Northern Tinderet	Eldoret south	Serengoni	Uasin Gishu	287.08	Plantation	Deforestation
17	Northern Tinderet	Eldoret south	Senghalo	Uasin Gishu	732.35	Plantation	Deforestation
18	Nabkoi	Eldoret east	Nabkoi	Uasin Gishu	120.49	Plantation	Deforestation
19	Metkei	Keiyo south	Nabkoi	Keiyo	48.43	Indigenous	Deforestation
Total					**7084.24**		

** The forest stations shown on the table were obtained from the Survey of Kenya toposheets and may not exactly represent the situation on the ground where changes occurred after production of the maps.*

The results in table 3 show that a total of 7084.24 hectares were cleared in the Mau Complex forests between 2000 and 2003. This amounts to approximately 1.8% of the total forest area in the Mau. The two sites in Narok District comprise some 35 percent of the changes detected in the Mau Complex.

3.2 Mt. Kenya forests

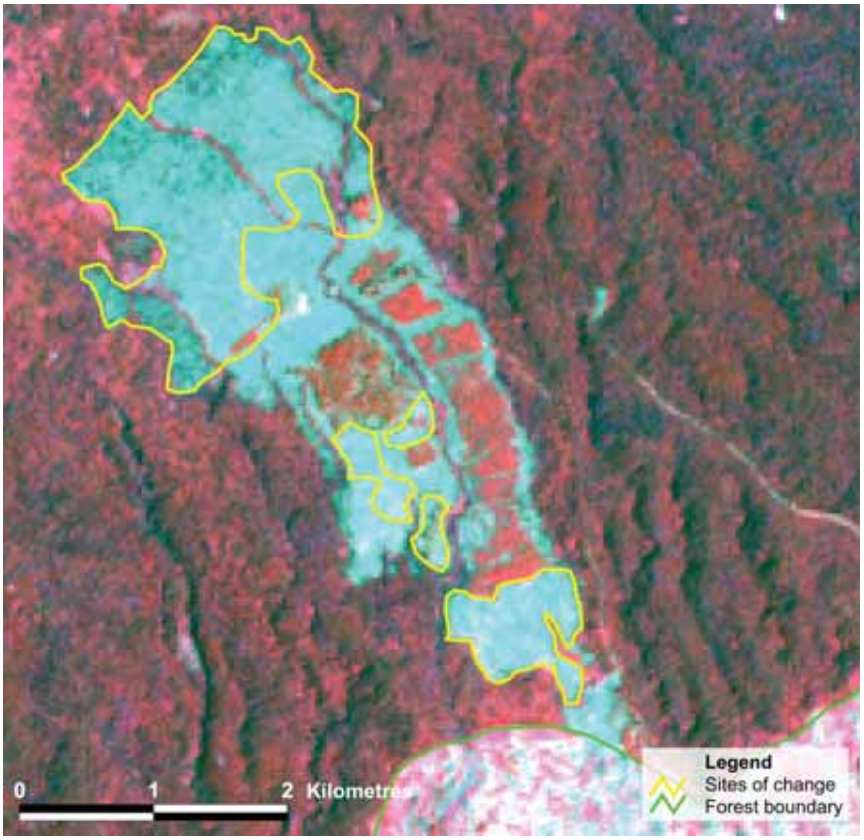
Fig.4. Location of changes in Mt. Kenya forests



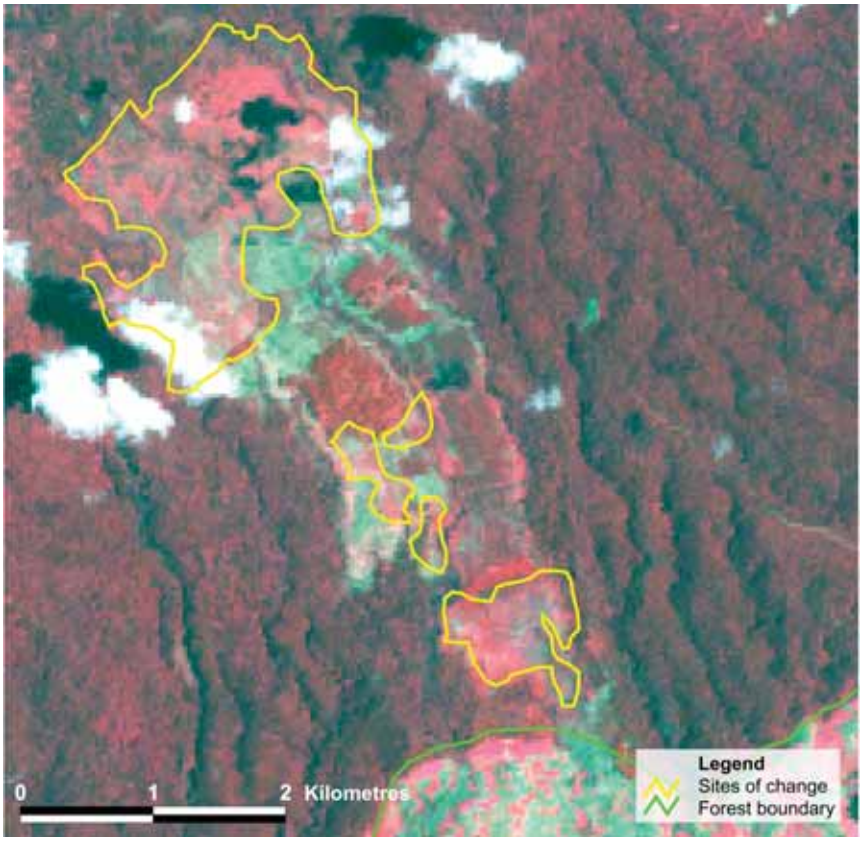
The areas numbered 1 to 6 on the map are sites where significant changes have occurred between 2000 and 2003. The 2000 and 2003 satellite images for each of these 6 sites are presented below to help the reader visualize the changes.

Site 1: Manyatta Constituency, Embu District

Situation in Year 2000; areas within the yellow outlined polygons are deforested

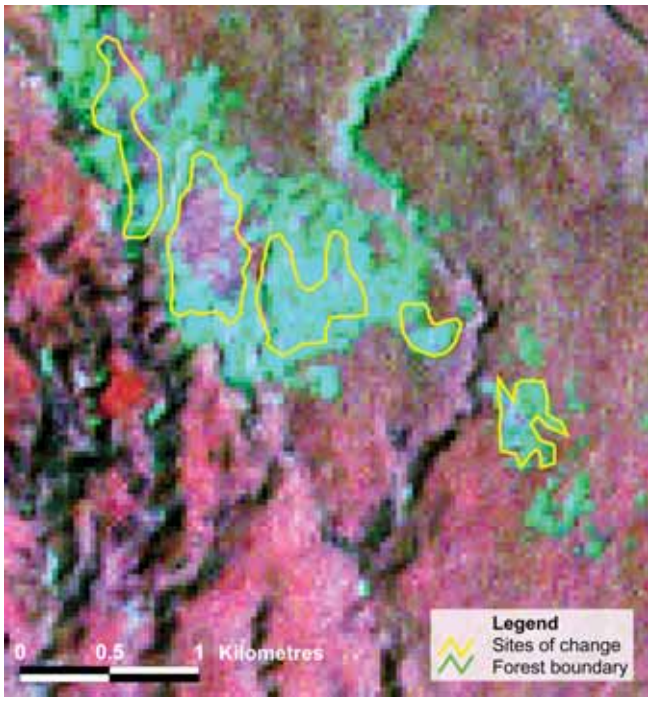


Situation in Year 2003; areas within the yellow outlined polygons are regenerating

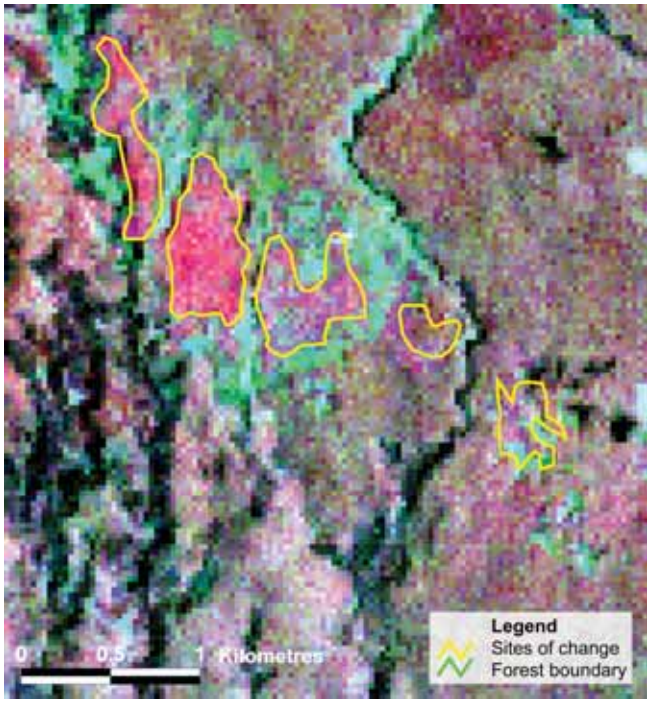


Site 2: Manyatta Constituency, Embu District

Situation in Year 2000; areas within the yellow outlined polygons are deforested

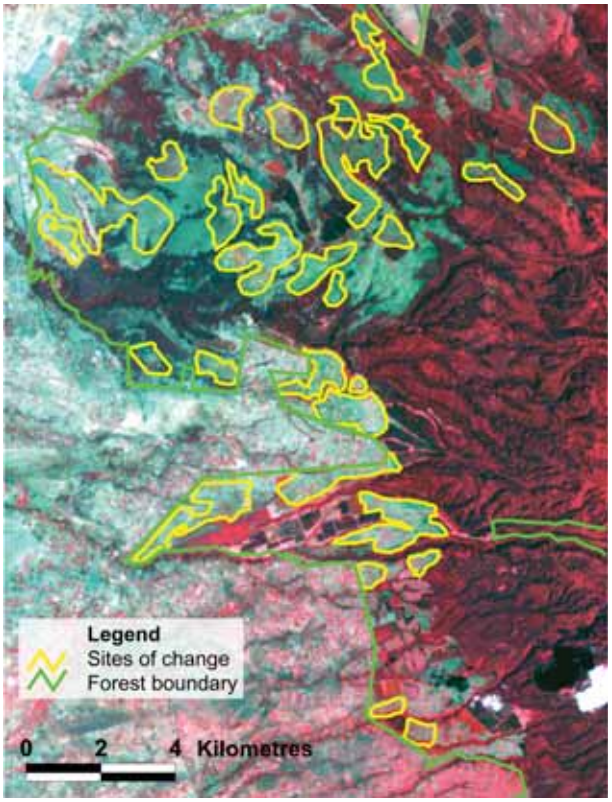


Situation in Year 2003; areas within the yellow outlined polygons are regenerating

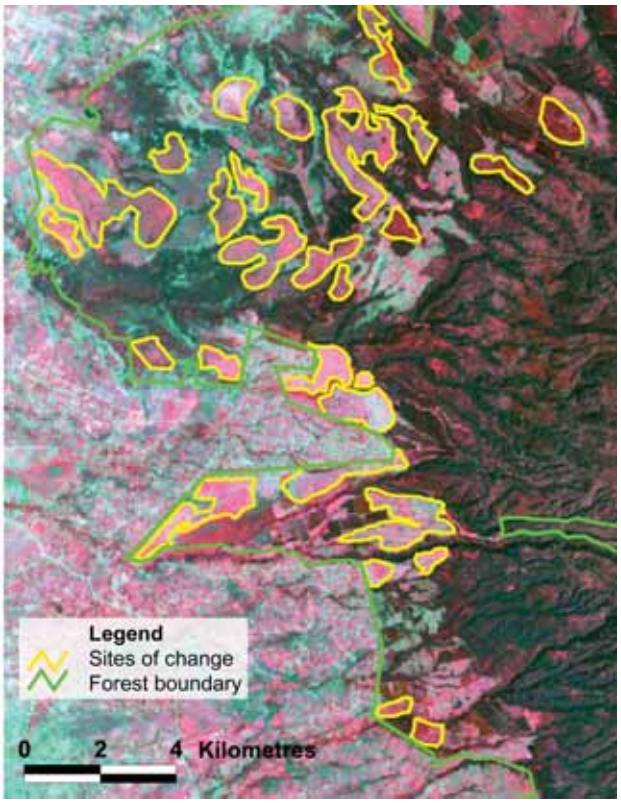


Site 2: Kieni Constituency, Nyeri District

Situation in Year 2000; areas within the yellow outlined polygons are deforested



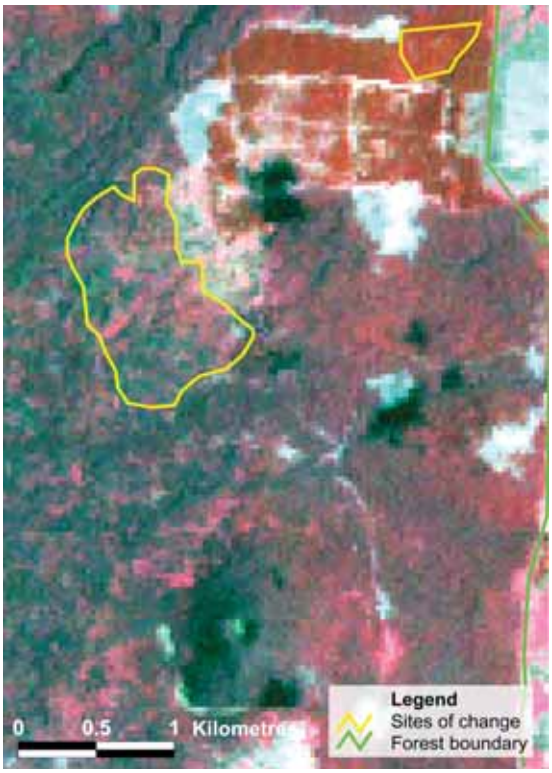
Situation in Year 2003; areas within the yellow outlined polygons are regenerating



Site 4: South Imenti Constituency, Central Meru District

Situation in Year 2000; areas within the yellow outlined polygons are deforested

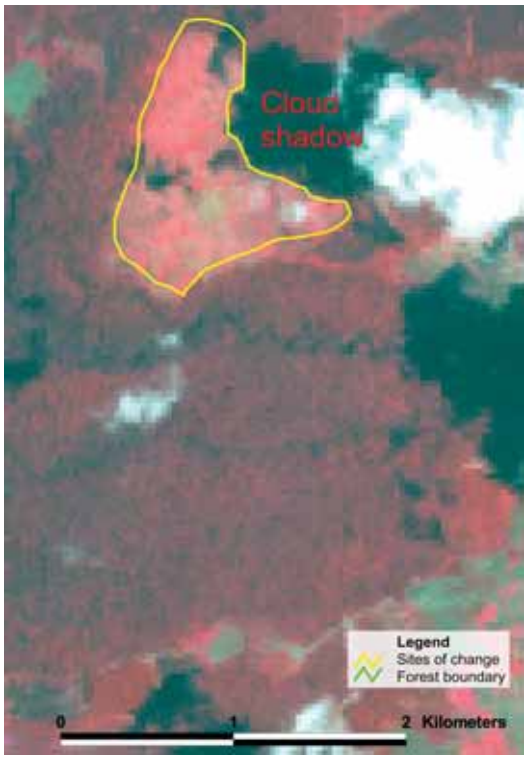
Situation in Year 2003; areas within the yellow outlined polygons are regenerating



Site 5: Central Imenti Constituency, Central Meru District

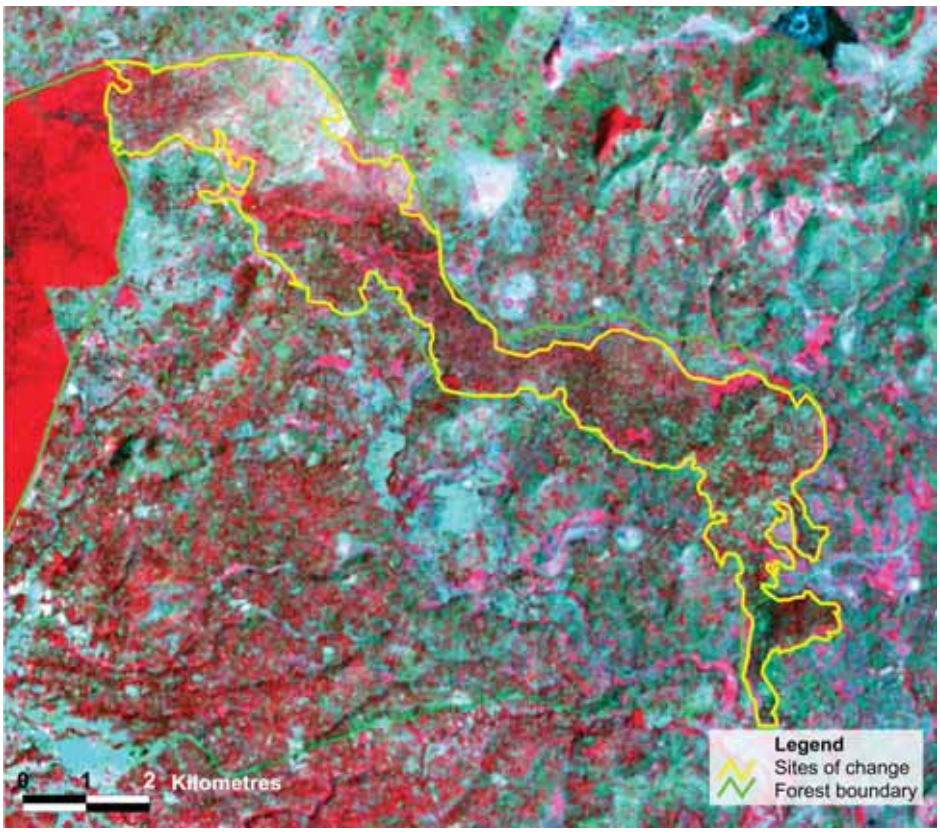
Situation in Year 2000; areas within the yellow outlined polygons are deforested

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



Site 6: North Imenti Constituency, Central Meru District

Situation in Year 2000; areas within the yellow outlined polygons are deforested



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

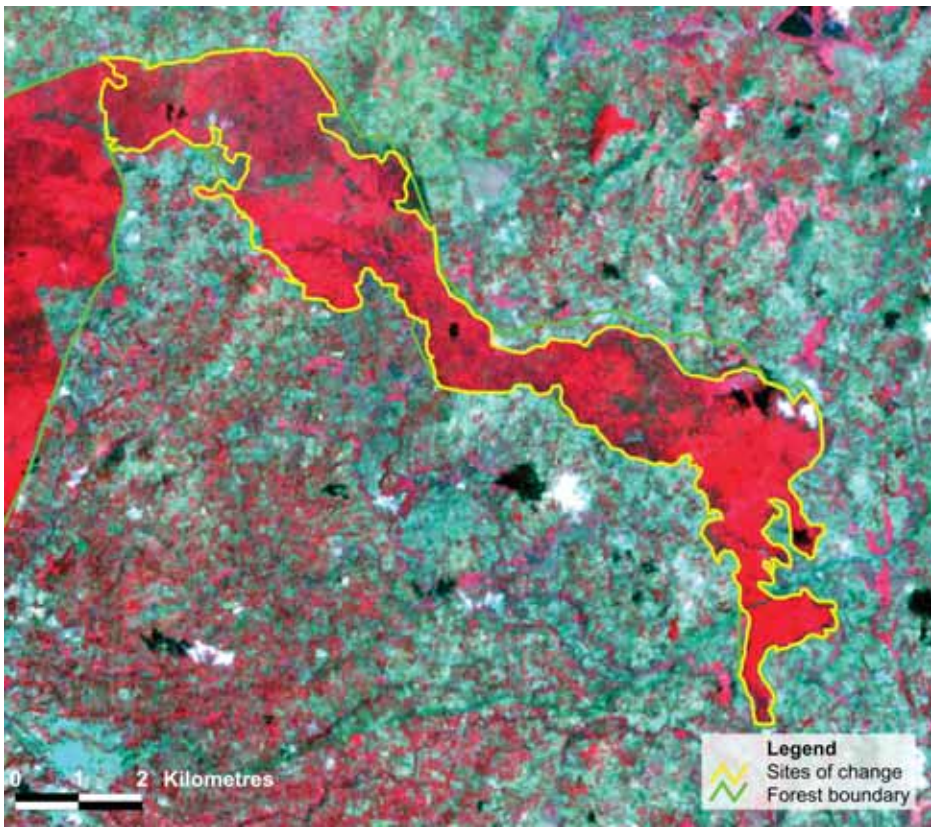


Fig. 5. Sites with changes in Mt. Kenya forests per constituency

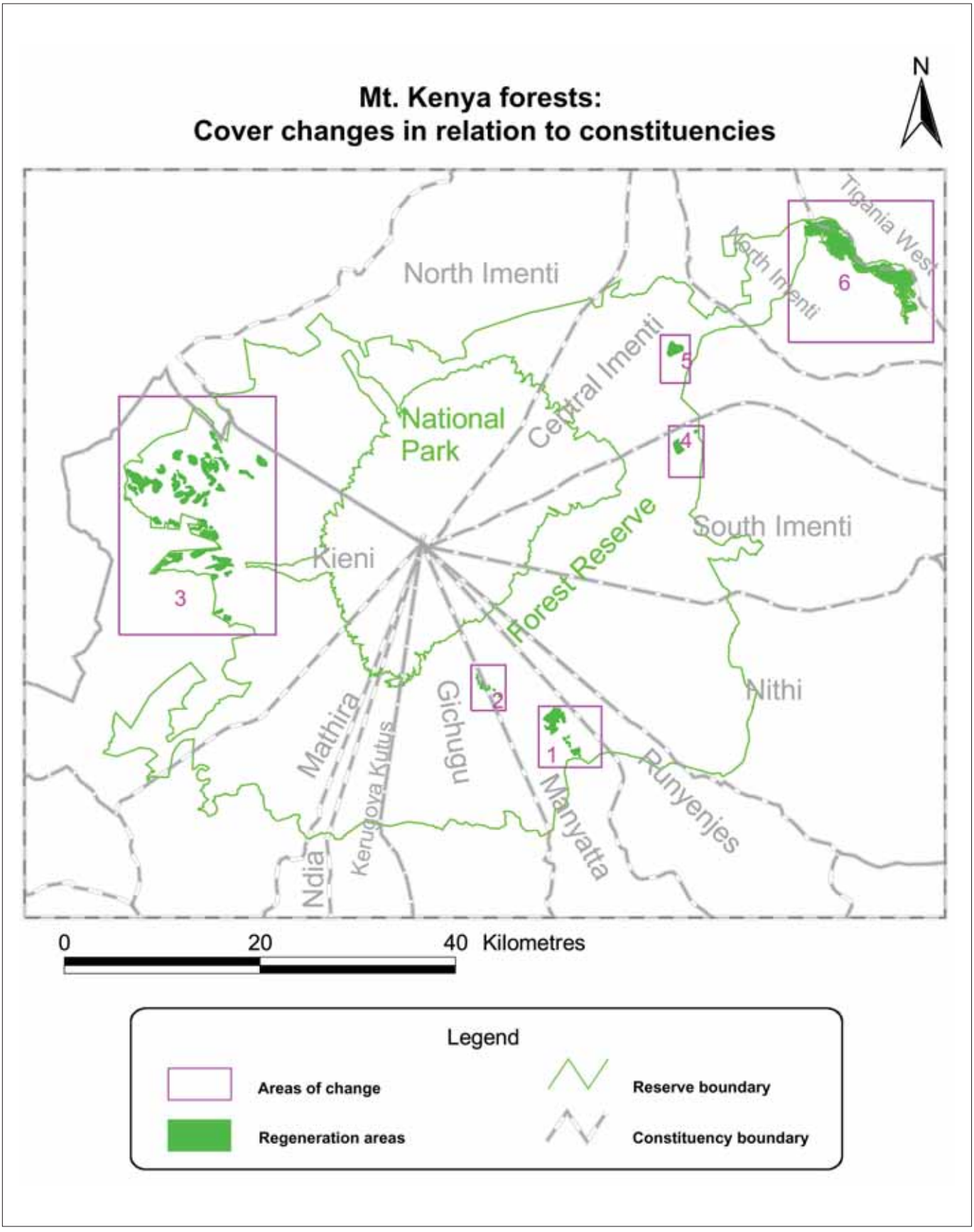


Table 4: Protected forests in Mt. Kenya

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. (Figure 4)

Table 5: Areas of significant changes in Mt. Kenya forests (2000 – 2003)

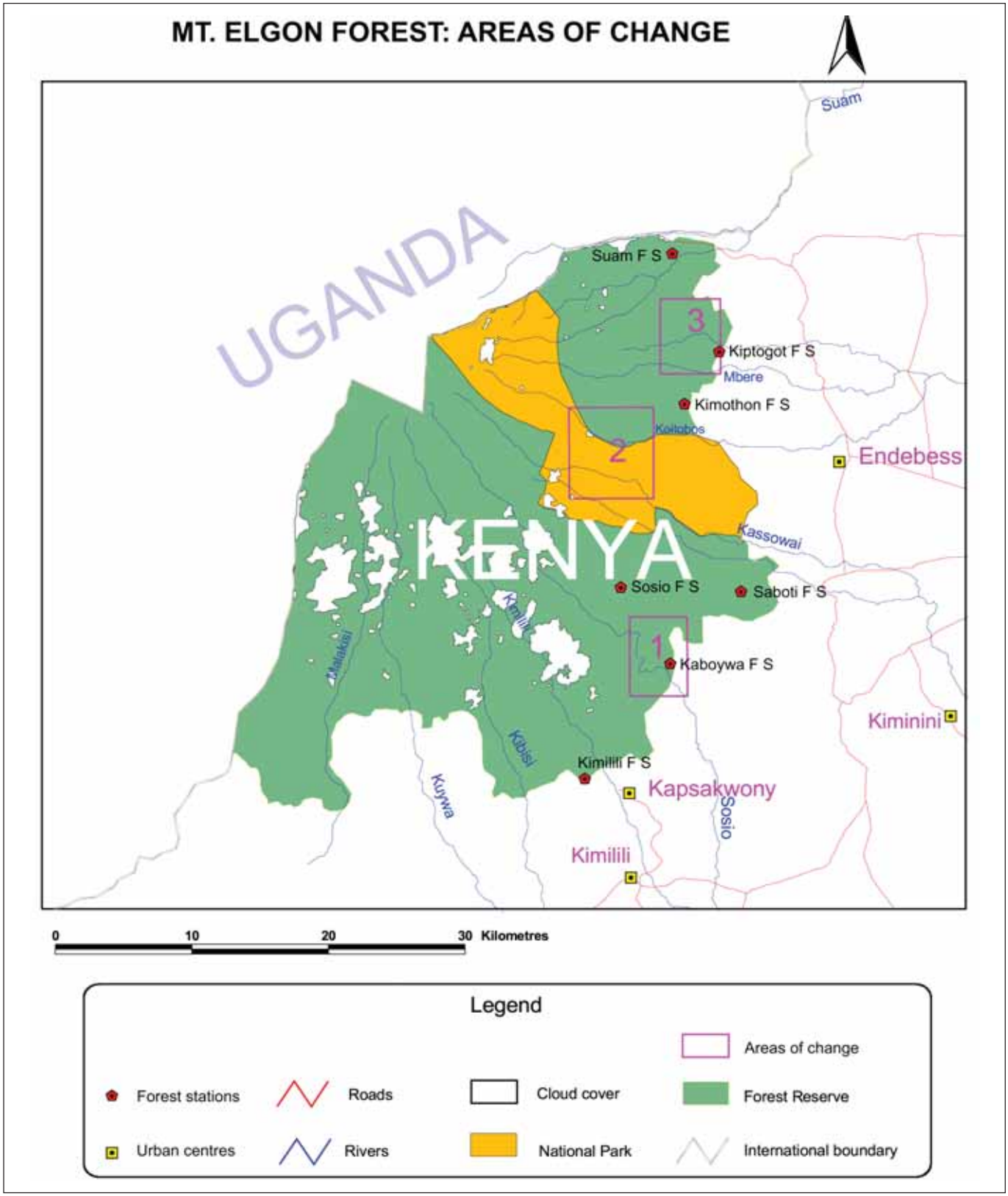
Site no.	Constituency	Nearest forest station*	District	Area Affected (hectares)	Forest type	Change type
1	Manyatta	Irangi	Embu	426.4	Plantation	Regeneration
2	Manyatta	Irangi	Embu	91.1	Indigenous	Regeneration
3	Kieni	Kahurura, Gathiuru & Naromoru	Nyeri	2886.6	Plantation	Regeneration
4	South Imenti	Meru	Meru Central	115.1	Indigenous / Plantation	Regeneration
5	Central Imenti	Meru	Meru Central	167.0	Plantation	Regeneration
6	North Imenti	Meru	Meru Central	2327.3	Indigenous	Regeneration
Total				**6013.5**		

** The forest stations shown on the table were obtained from the Survey of Kenya toposheets and may not exactly represent the situation on the ground where changes occurred after production of the maps.*

Satellite image analysis shows significant improvements in Mt. Kenya forests between 2000 and 2003. Some 6013.5 hectares of degraded forest are regenerating, which constitutes about 2.6 percent of the entire forest area. The nature of vegetation regenerating in these sites, however, has not been assessed through ground survey.

3.3 Mt. Elgon forests

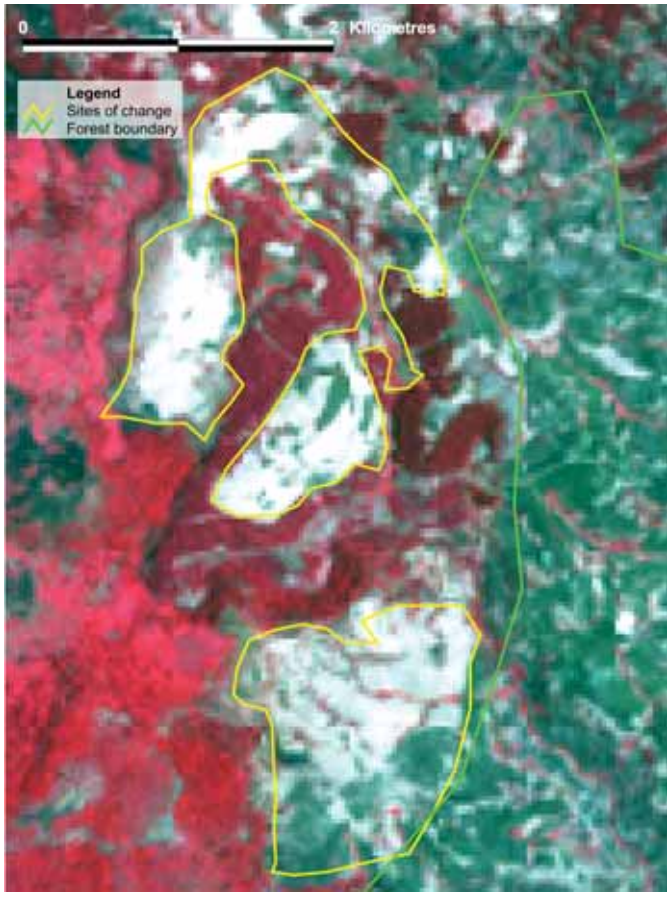
Fig. 6. Location of changes in Mt. Elgon forests



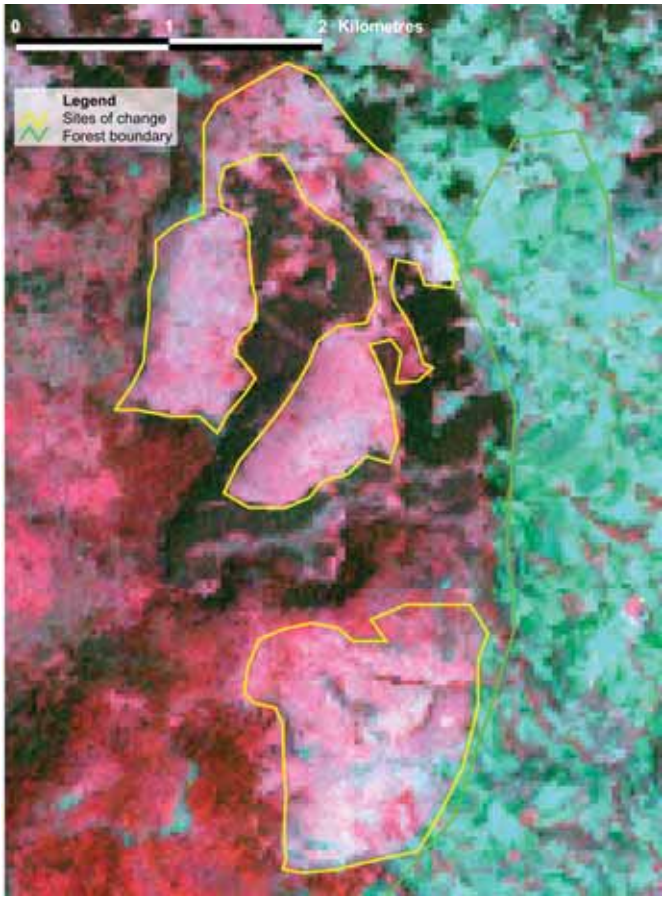
The areas numbered 1 to 3 on the map are sites where significant changes have occurred between 2000 and 2003. The 2000 and 2003 satellite images for each of these three sites are presented below to help the reader visualize the changes.

Site 1: Mount Elgon Constituency, Mount Elgon District

Situation in Year 2000; areas within the yellow outlined polygons are deforested

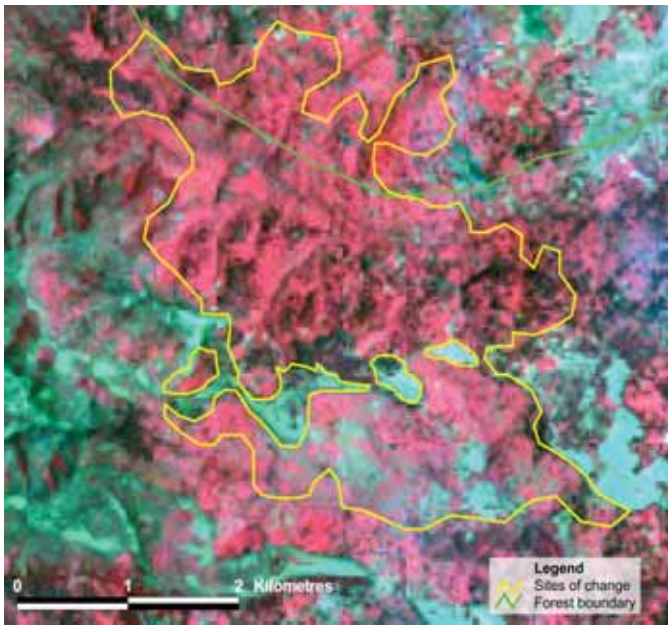


Situation in Year 2003; areas within the yellow outlined polygons are regenerating

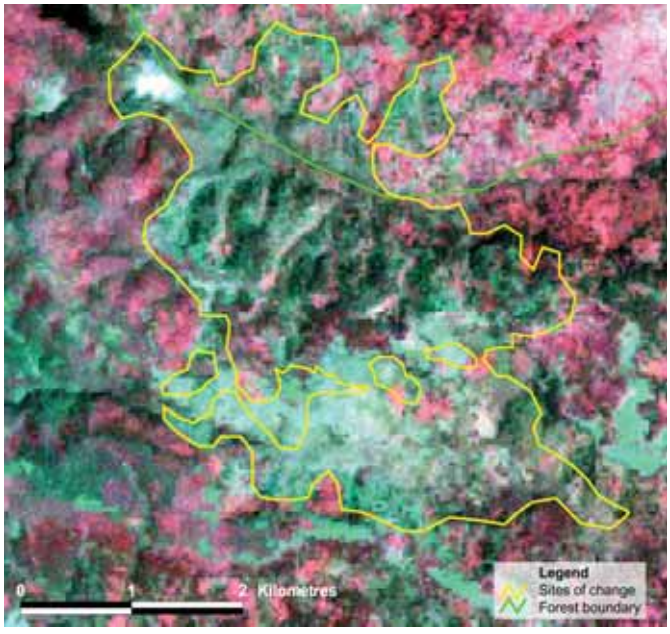


Site 2: Kwanza Constituency, Trans-Nzoia District

Situation in Year 2000; areas within the yellow outlined polygons are forested

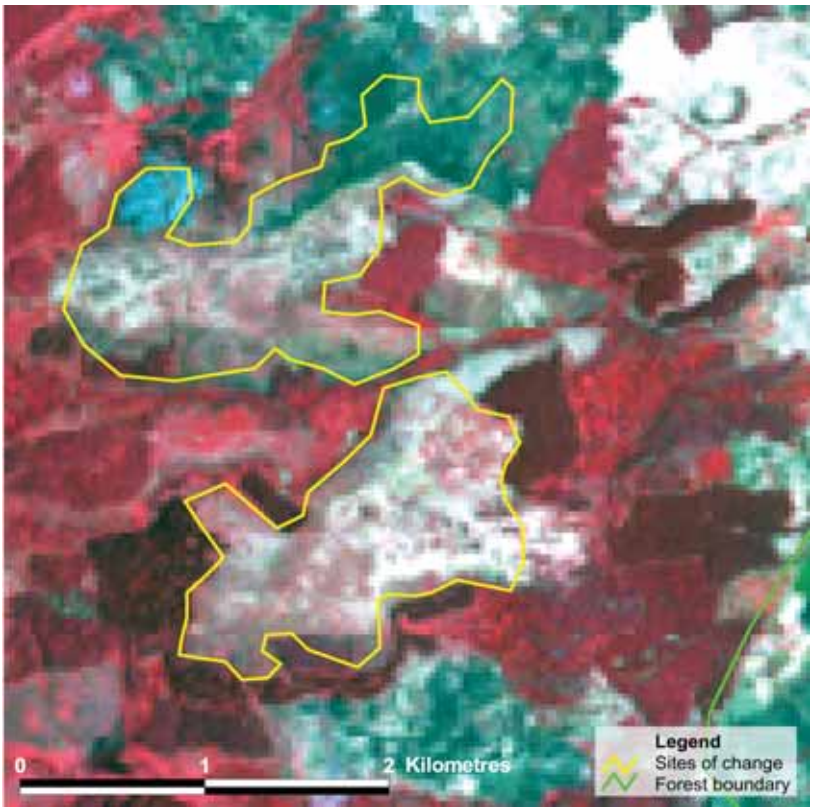


Situation in Year 2003; areas within the yellow outlined polygons have been cleared

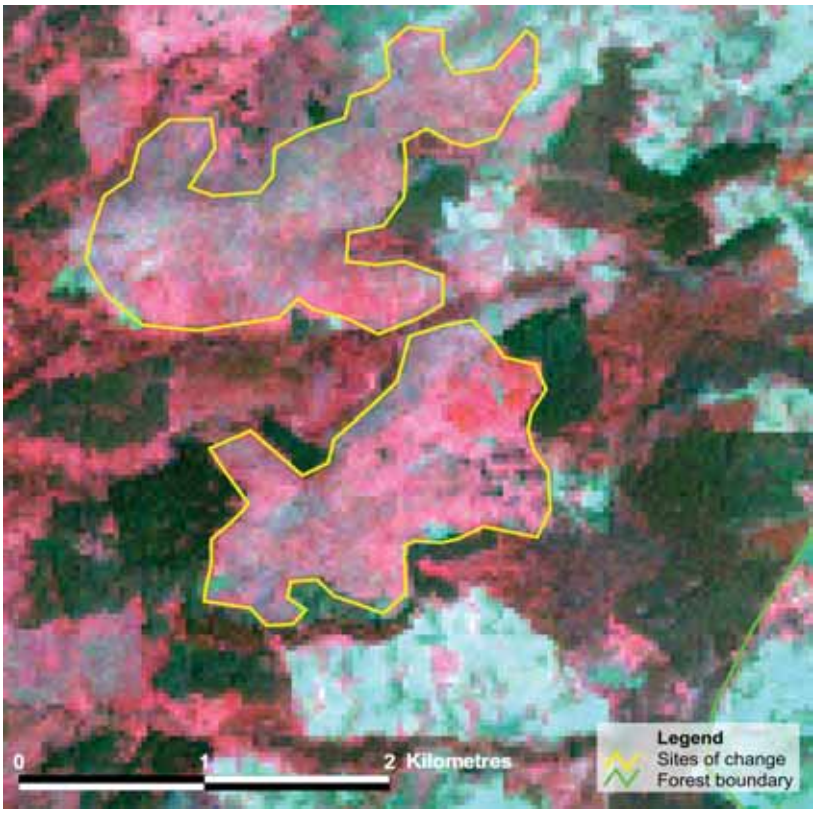


Site 3: Kwanza Constituency, Trans-Nzoia District

Situation in Year 2000; areas within the yellow outlined polygons are deforested



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



Among the three sites, site 2 was deforested by fire whilst sites 1 and 3 show regeneration.

Fig. 7. Sites with changes in Mt. Elgon forest per constituency

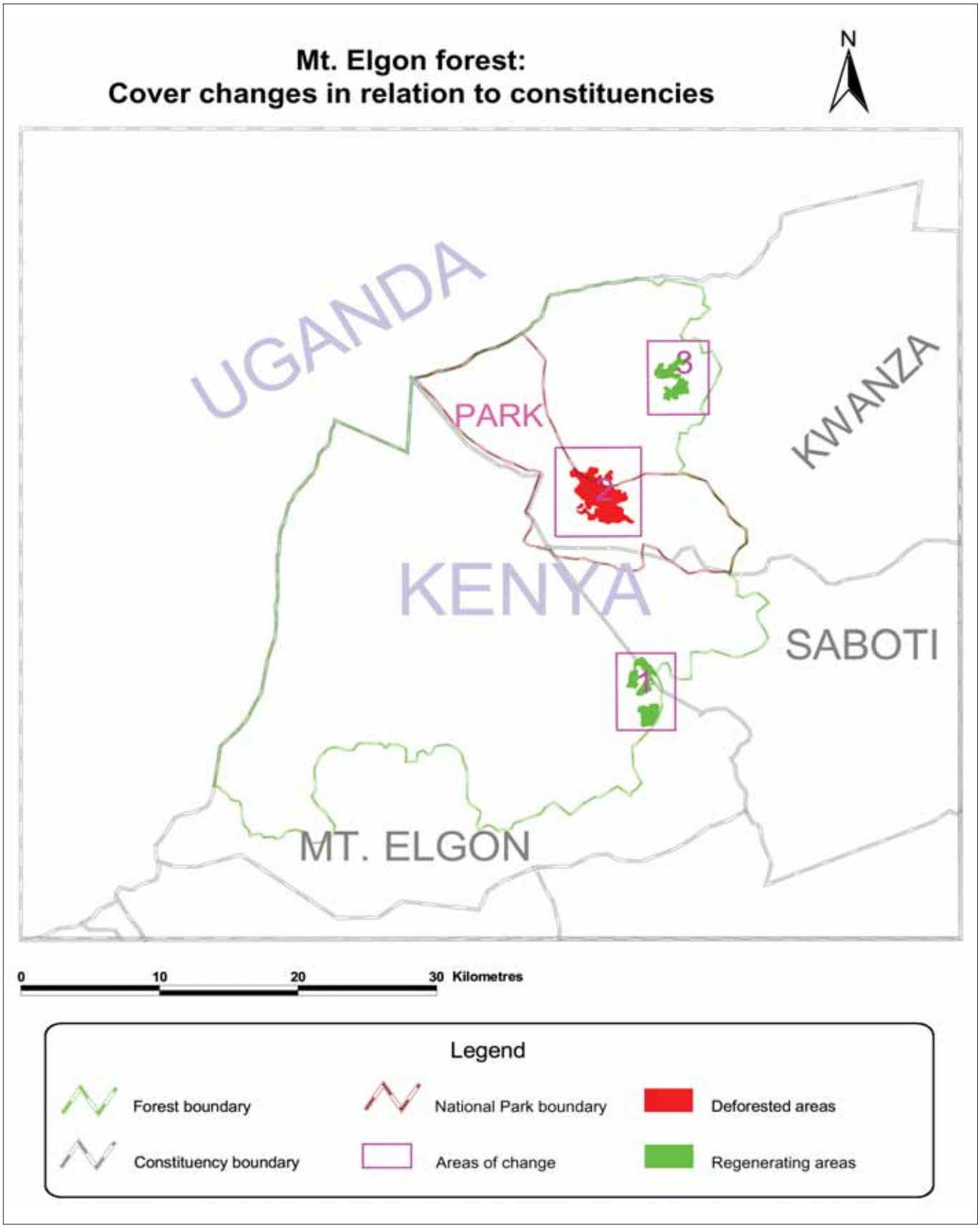


Table 6: Protected forests on Mt. Elgon

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.

Table 7 Areas of significant changes in Mt. Elgon forest (2002 – 2003)

Area	*Constituency*	*Nearest forest station*	*District*	*Area Affected (hectares)*	*Forest type*	*Change Type*
1	Mt. Elgon	Kaboywan	Mt. Elgon	471.8	Plantation	Regeneration[2]
2	Kwanza	Kimothon	Trans-Nzoia	1029.5	Indigenous	Deforestation[3]
3	Kwanza	Kiptogot	Trans-Nzoia	373.1	Plantation	Regeneration[2]
Total				**1874.4**		

Three sites showed significant changes between 2000 and 2003. As there was some cloud cover in the 2003 satellite image, it could be that some sites affected by significant changes were under cloud and change could not be detected. Of the three sites, site 2 (figure 6 and table 7) show deforestation whilst the other two sites show regeneration (see photo 1). It was observed from groundtruthing that the deforestation on site 2 was caused by fire. The loss of vegetation in site 2 is critical as it was originally covered by indigenous forest.

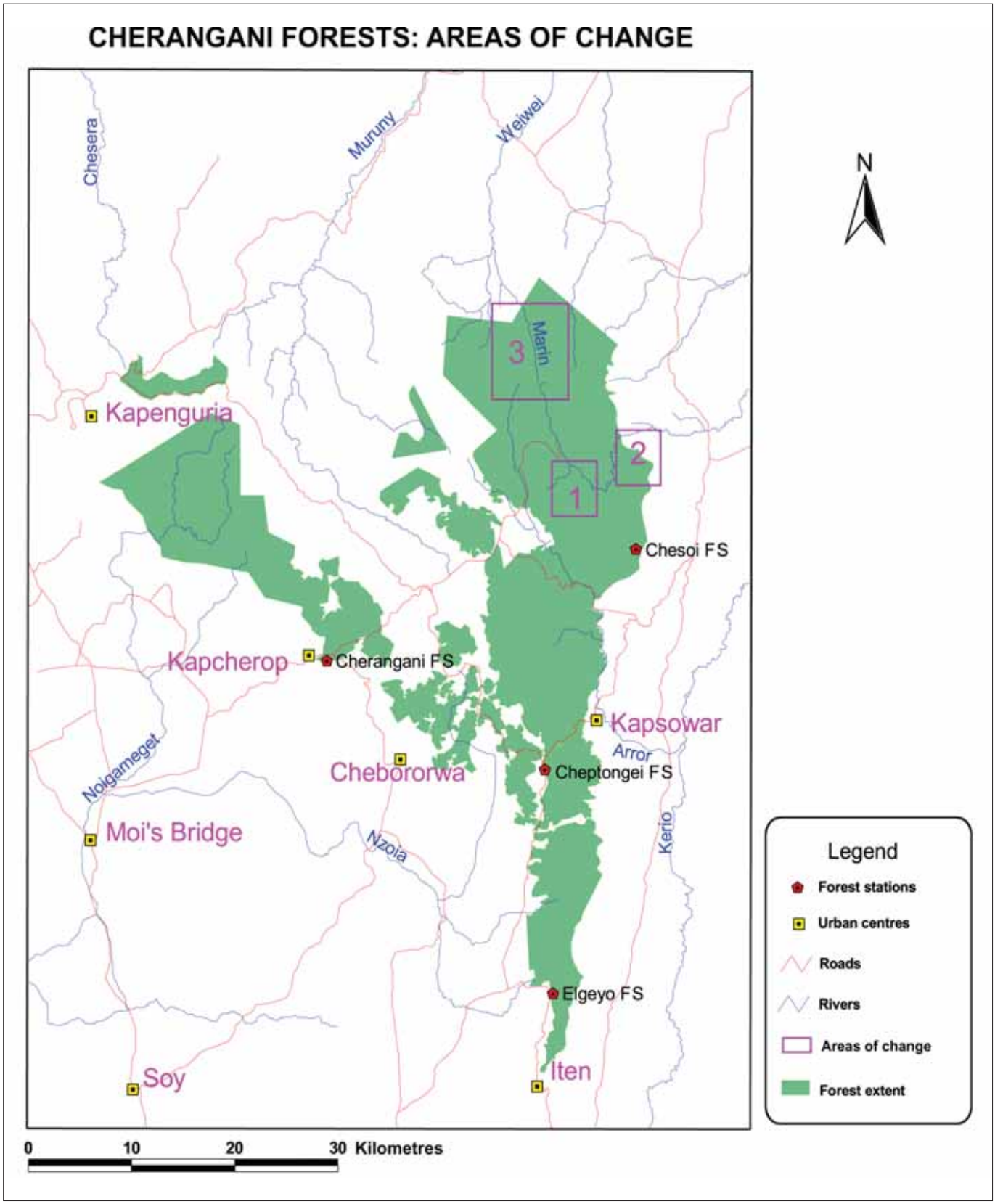
[2] Regenerating bush in sites that were previously encroached.
[3] Area burnt to encourage lush vegetation after the rains. Animals that are attracted to the vegetation can then be easily poached.

Photo 1: Forest regenerating in previously settled areas of Mt. Elgon forest (Site 1). May 2004.

Photo 2: Encroachment in Kabeywan forest area, Mt. Elgon. May 2004. This is an area that has been encroached since the early 1990s. It is however not among the listed sites since the settlement occured long before the base year for change detection in this report.

3.4. Cherangani forests

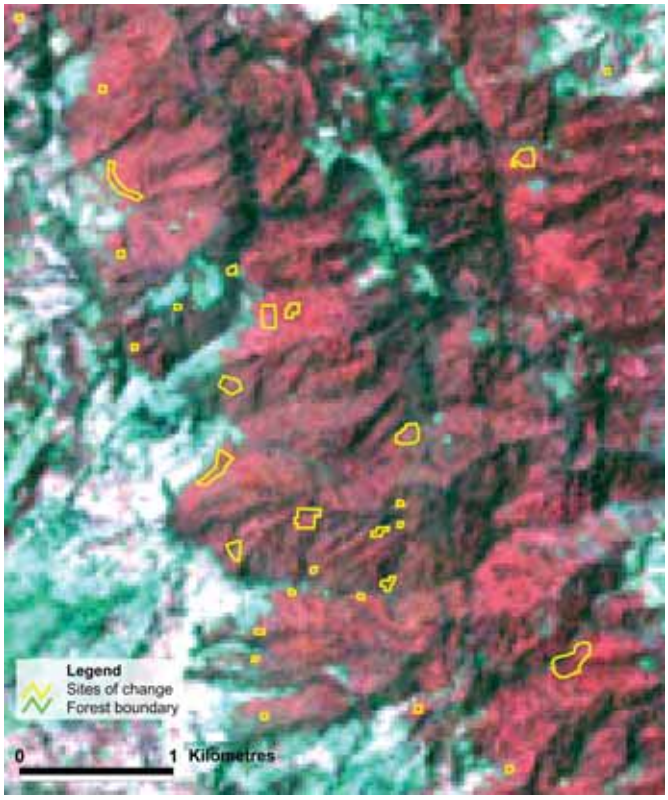
Fig. 6. Location of changes in the Cherangani forests



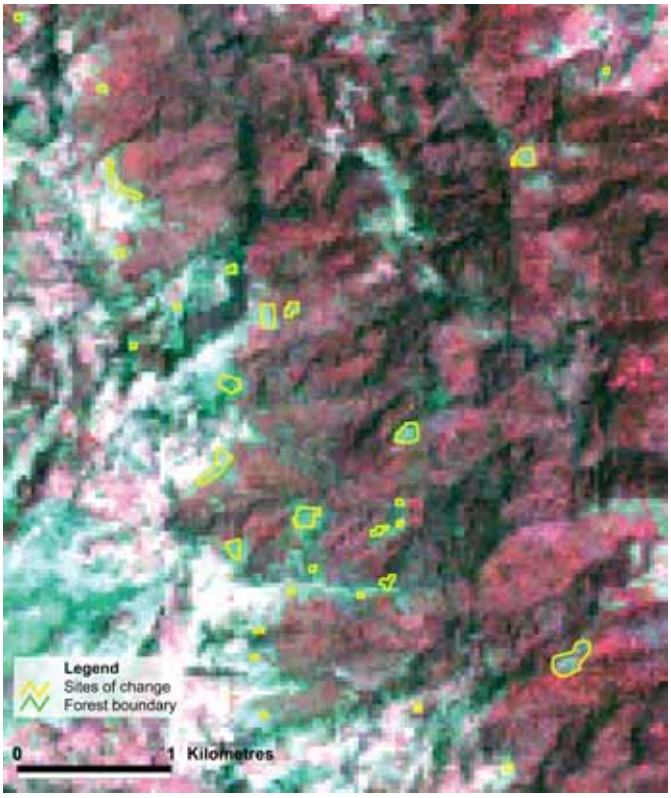
The areas numbered 1 to 3 on the map are sites where significant changes have occurred between 2000 and 2003. The 2000 and 2003 satellite images for each of these three sites are presented below to help the reader visualize the changes.

Site 1: Marakwet East Constituency, Marakwet District

Situation in Year 2000; areas within the yellow outlined polygons are forested

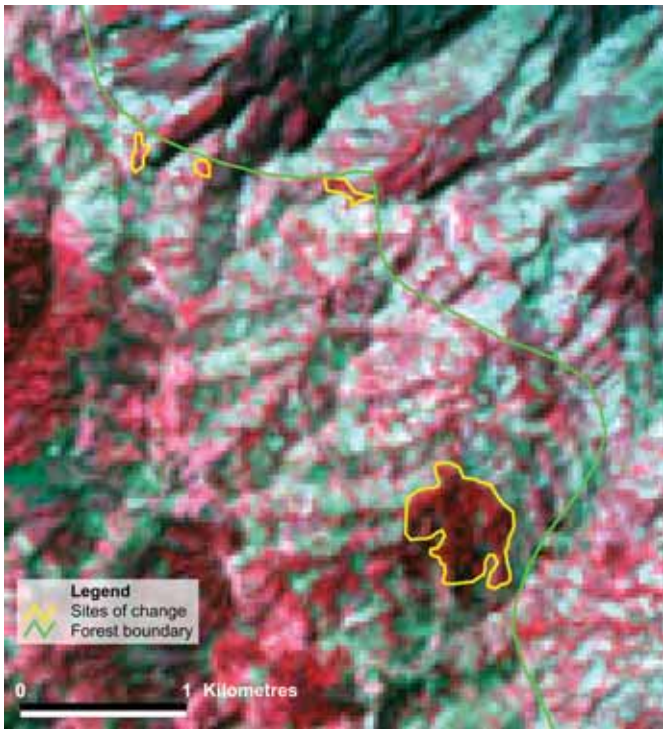


Situation in Year 2003; areas within the yellow outlined polygons have been cleared

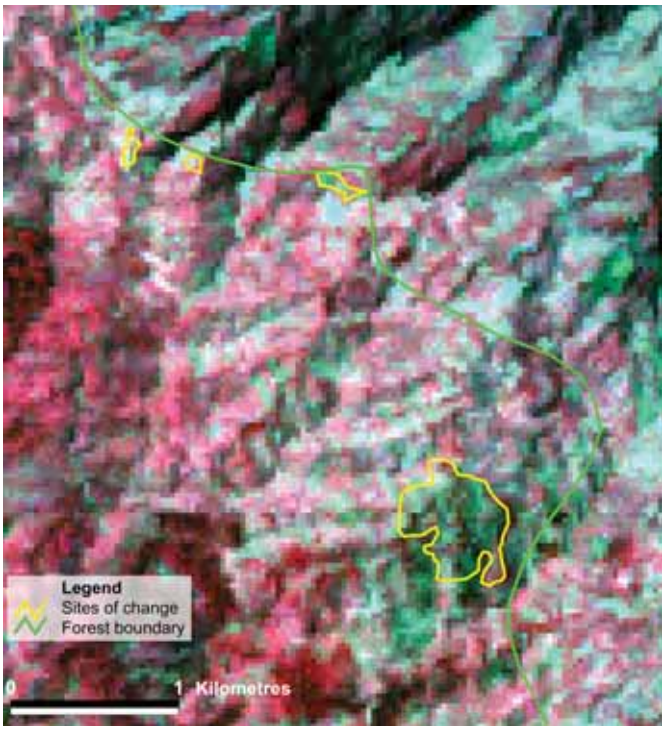


Site 2: Marakwet East Constituency, Marakwet District

Situation in Year 2000; areas within the yellow outlined polygons are forested

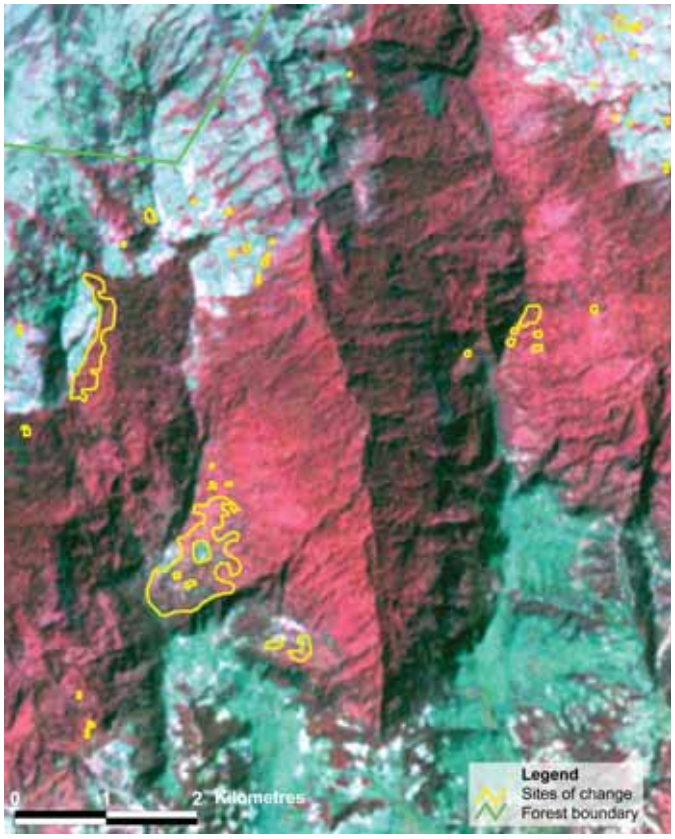


Situation in Year 2003; areas within the yellow outlined polygons have been cleared



Site 3: Sigor Constituency, West Pokot District

Situation in Year 2000; areas within the yellow outlined polygons are forested



Situation in Year 2003; areas within the yellow outlined polygons have been cleared

Fig. 9. Sites with changes in the Cherangani forests per constituency

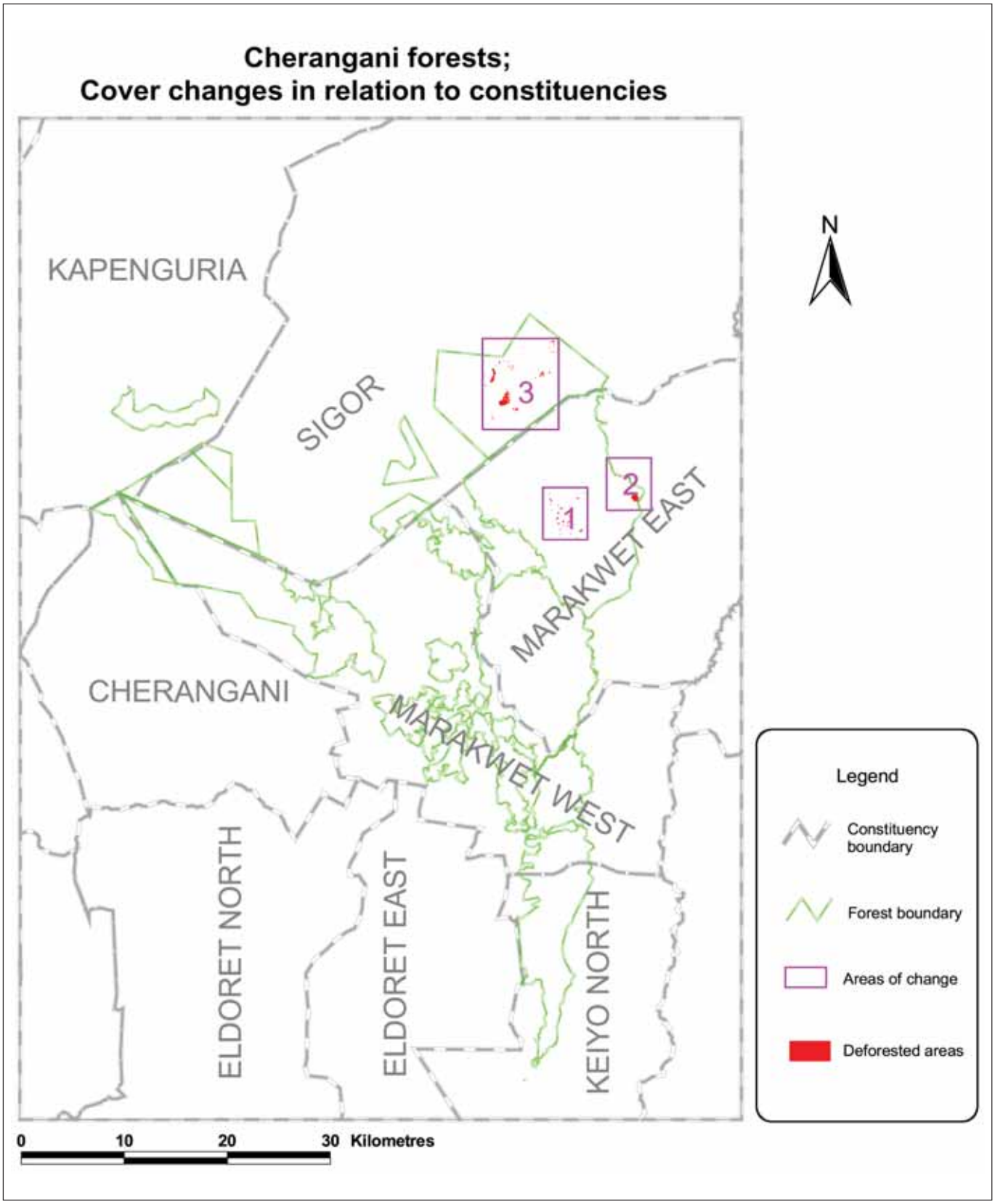


Table 8: Protected forests in the Cherangani Hills

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**

Table 9 Areas of significant change in the Cherangani forests (2000 – 2003)

Area	*Constituency*	*Nearest forest station*	*District*	*Area Affected (Hectares)*	*Forest type*	*Change Type*
1	Marakwet East	Chesoi	Marakwet	17.33	Indigenous[4]	Deforestation
2	Marakwet East	Chesoi	Marakwet	34.59	Indigenous[4]	Deforestation
3	Sigor	Chesoi	West Pokot	100.79	Indigenous[5]	Deforestation
	Total			**152.71**		

The results in table 9 show that about 153 hectares in the Cherangani Forest Reserve have been deforested between 2000 and 2003. It should be noted that there are large areas deforested prior to 2000. In areas outside the Forest Reserve, there was deforestation in the range of 20 hectares between 2000 and 2003.

[4] Encroachment on forest whose historical background dates back to colonial times when local people were given permits to graze livestock in forest glades. Since then, people have been encroaching onto the forest from the glades.
[5] Encroachment on forest attributed to cattle rustling. The forest provides a refuge to people running away from frequent cattle raids between the Marakwet and West Pokot people.

Encroachment on forests in Kapyegon and Sinen areas of Cherangani hills (Site 3). June 2004.

3.5 Aberdare Range forests

Fig. 10. The Aberdare Range forests

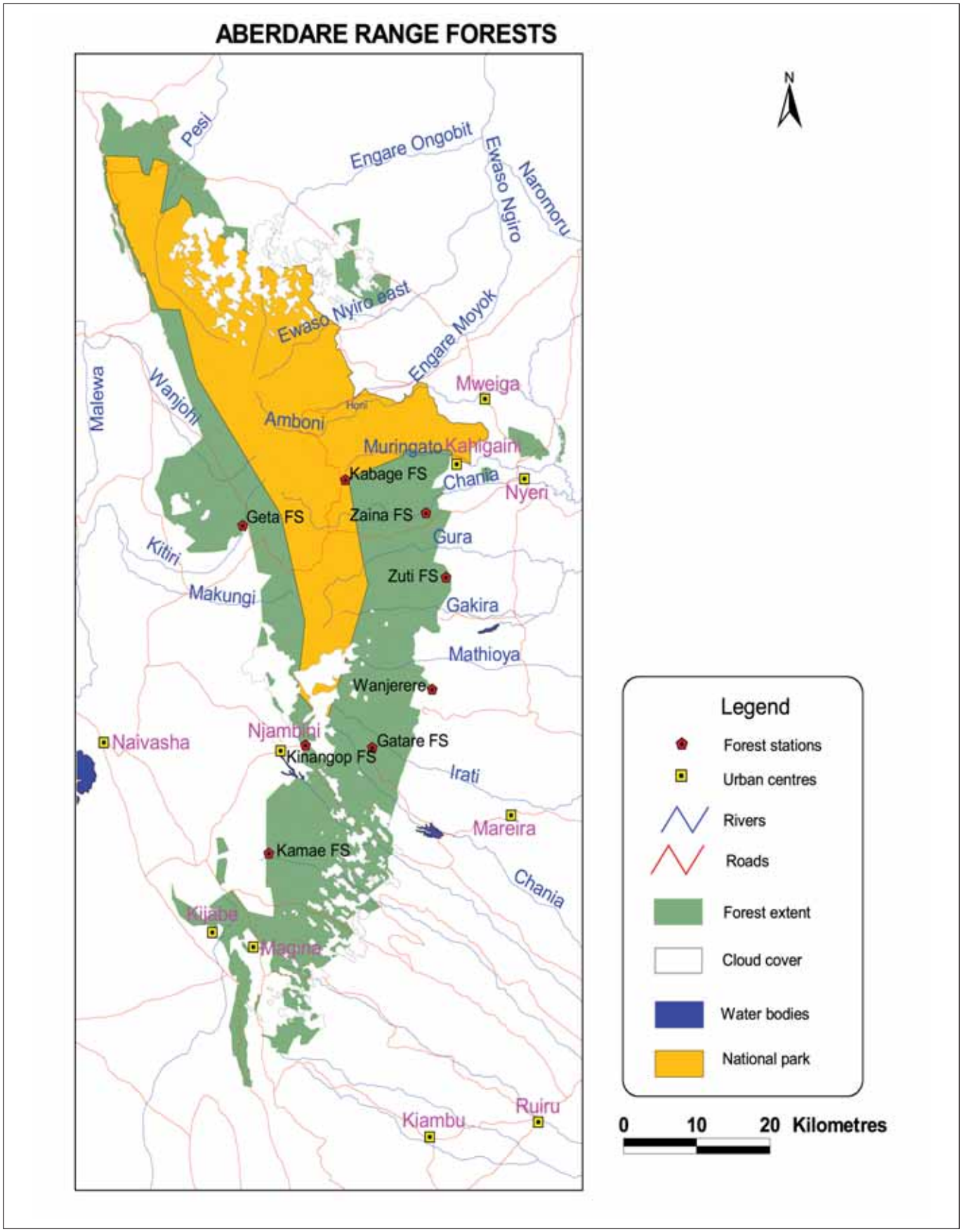


Fig 11. Aberdare Range forests and constituencies

The analysis of the satellite images of Aberdare Range forests did not enable the detection of significant changes such as encroachment and clearfelling due to high cloud cover in the 2003 image above the areas where most changes were likely to occur. However, it is known that these forests have been the focus of extensive destruction, through illegal felling of indigenous trees and charcoal production, as revealed during an aerial survey undertaken in 2002 (Lambrechts *et al*, 2003).

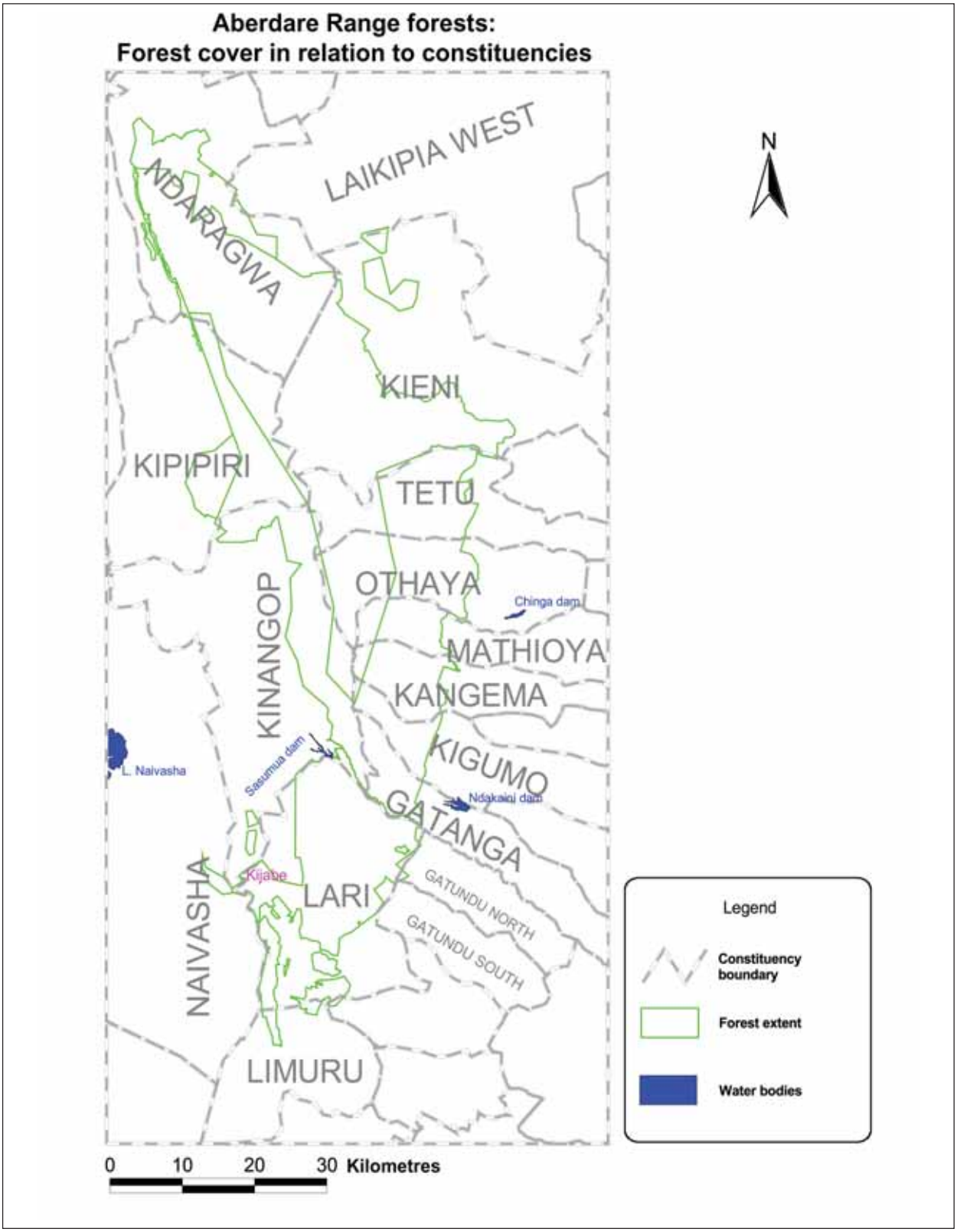


Table 9: Protected forests in the Aberdare Range

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	**256515.3**

4.0 DISCUSSION

The results show a number of important changes in the forest cover in the main upper catchment areas of the country over a period of three years (2000-2003). It should be noted that only changes occuring in the three years, 2000-2003, are discussed in this report. The report does not discuss severe deforestation of previous years which has remained unchanged.

The most affected catchment is the Mau Complex where some 7084.24 hectares of forest have been clear-felled, representing 1.8 percent of the total area. Much of the areas cleared were under indigenous cover. The Mau is clearly an ecosystem that requires urgent attention to curb rampant destruction of indigenous forest.

Mt. Kenya forest showed signs of significant improvement. 6013.5 hectares of previously deforested areas seem to be regenerating. The impression that the results give is that the conservation strategies in place over this period are likely to be effective. The 2003 satellite image for Mt. Kenya had some cloud cover, so that other changes cannot be absolutely ruled out.

The satellite images for Mt. Elgon were also cloudy and as a result, only three sites were detected with significant changes. Of these, one site shows a loss of 1029 hectares of indigenous forest caused by a fire. The other two sites located in the forest plantations show regeneration.

The least affected forests are those on the Cherangani hills with only 174.3 hectares deforested. However this loss is occurring in indigenous forest cover. This area should be checked urgently to prevent further destruction.

The aerial survey report on the Aberdares of April 2003 showed destruction of the forest through illegal logging, charcoal production and grazing by cattle. Unfortunately Image differencing could not detect these changes due to high cloud cover above the affected areas in the 2003 image.

REFERENCES

Lambrechts et al, (2002): "Aerial survey of the destruction of the Aberdare Range forests". UNEP, KWS, Rhino Ark, KFWG

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 Cantebury, KWS, UNEP, KFWG.

ACRONYMS

DICE:	Durell Institute for Conservation and Ecology of the University of Kent
ETM:	Enhanced Thematic Mapper
FR:	Forest Reserve
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 Surveys 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.