KATHOLIEKE UNIVERSITEIT LEUVEN

Church forests in Ethiopia

The conservation value of church forests is linked to historical deforestation patterns

Raf Aerts

Division Forest, Nature and Landscape
Department Earth and Environmental Sciences
K.U.Leuven

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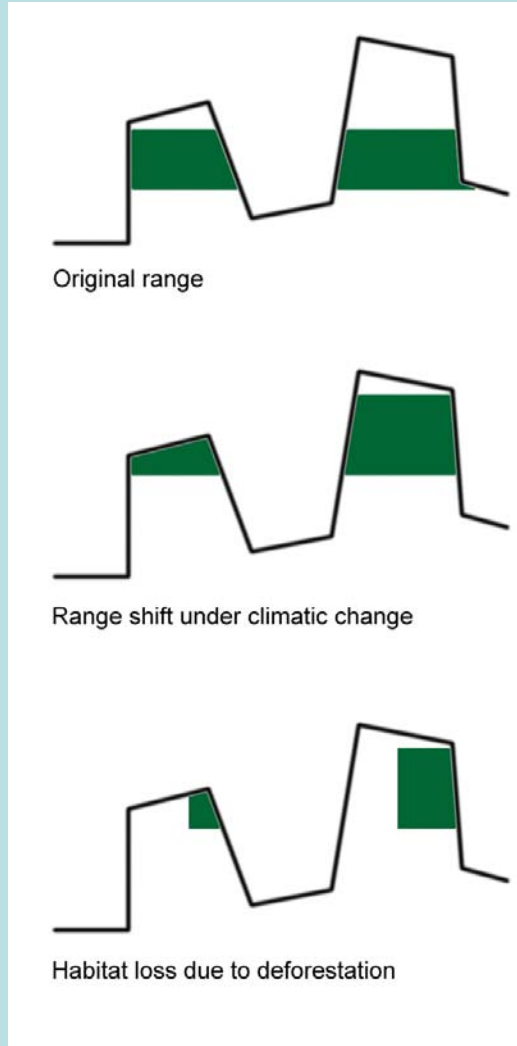
See also

http://www.biw.kuleuven.be/lbh/lbnl/forecoman/eng/publications.asp#1

Mountain forest plants

Nature Precedings : doi:10.1038/npre.2008.1786.1 : Posted 9 Apr 2008

- Limited capacity for migration
  - Altitudinal gradients limit species ranges
  - Physical barriers against dispersal
- Natural *islands* of biodiversity
  - Diversity ~ island size
- Vulnerability to species loss increases
  - Effects of climatic change
  - Effects of habitat fragmentation
- Conservation
  - Large fragments
  - Small habitat patches
  - Relictual vegetation



Ecological zones in Africa: (pre)montane zones in Ethiopia

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Forest and Protected Area Distribution within Ecological Zones
AFRICA

Legend

ECOLOGICAL ZONES
- Lowland wet
- Lowland very moist
- Lowland moist with short dry season
- Lowland moist with long dry season
- Lowland sub-dry
- Lowland very dry / sub-arid
- Premontane moist
- Premontane dry
- Montane moist
- Montane dry
- Alpine

FORESTS
- Forest extent

PROTECTED AREAS
- IUCN categories I-VI

Atlantic Ocean

Indian Ocean

Compiled by
World Conservation Monitoring Centre
May 1997

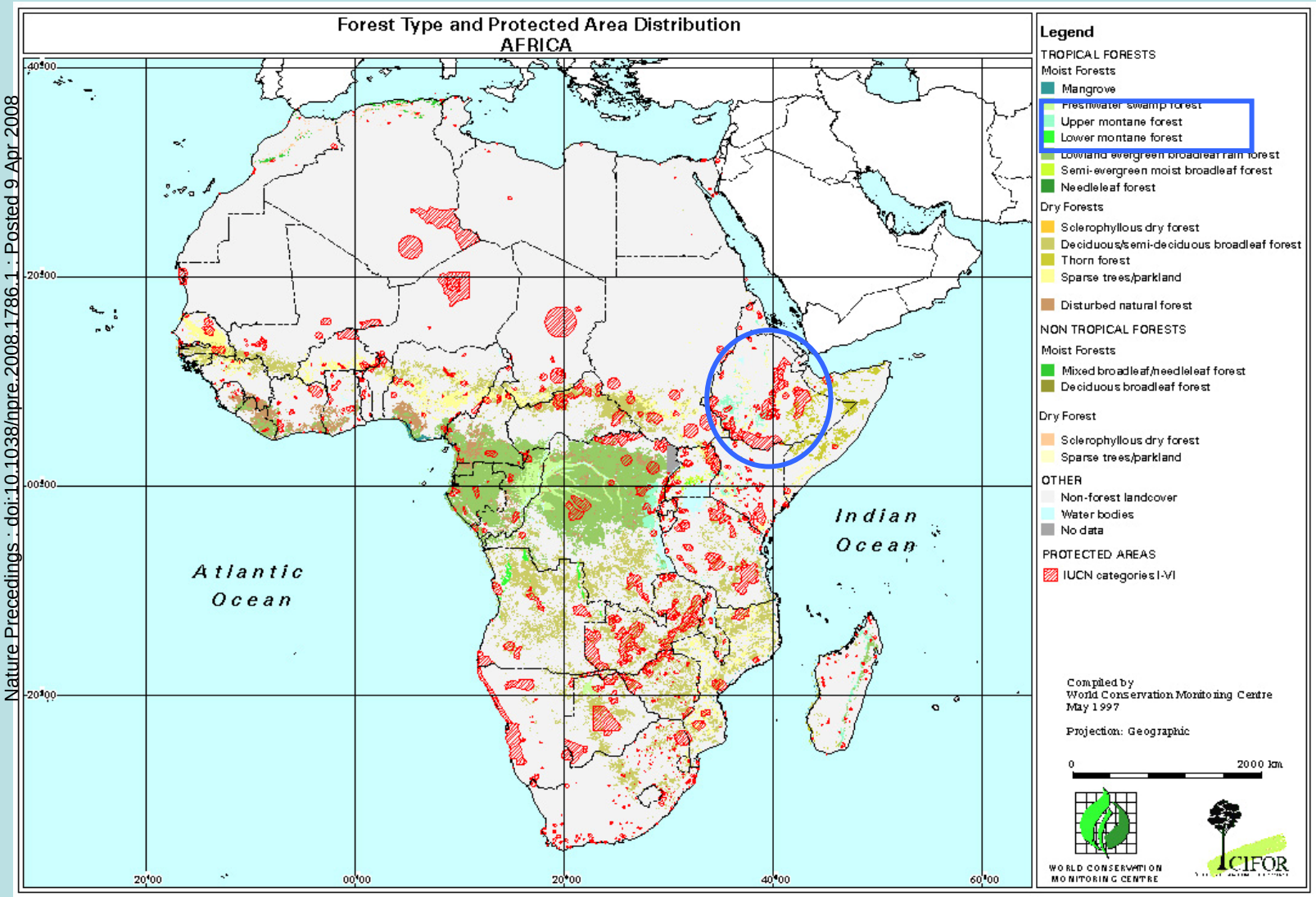
Projection: Geographic

0 2000 km

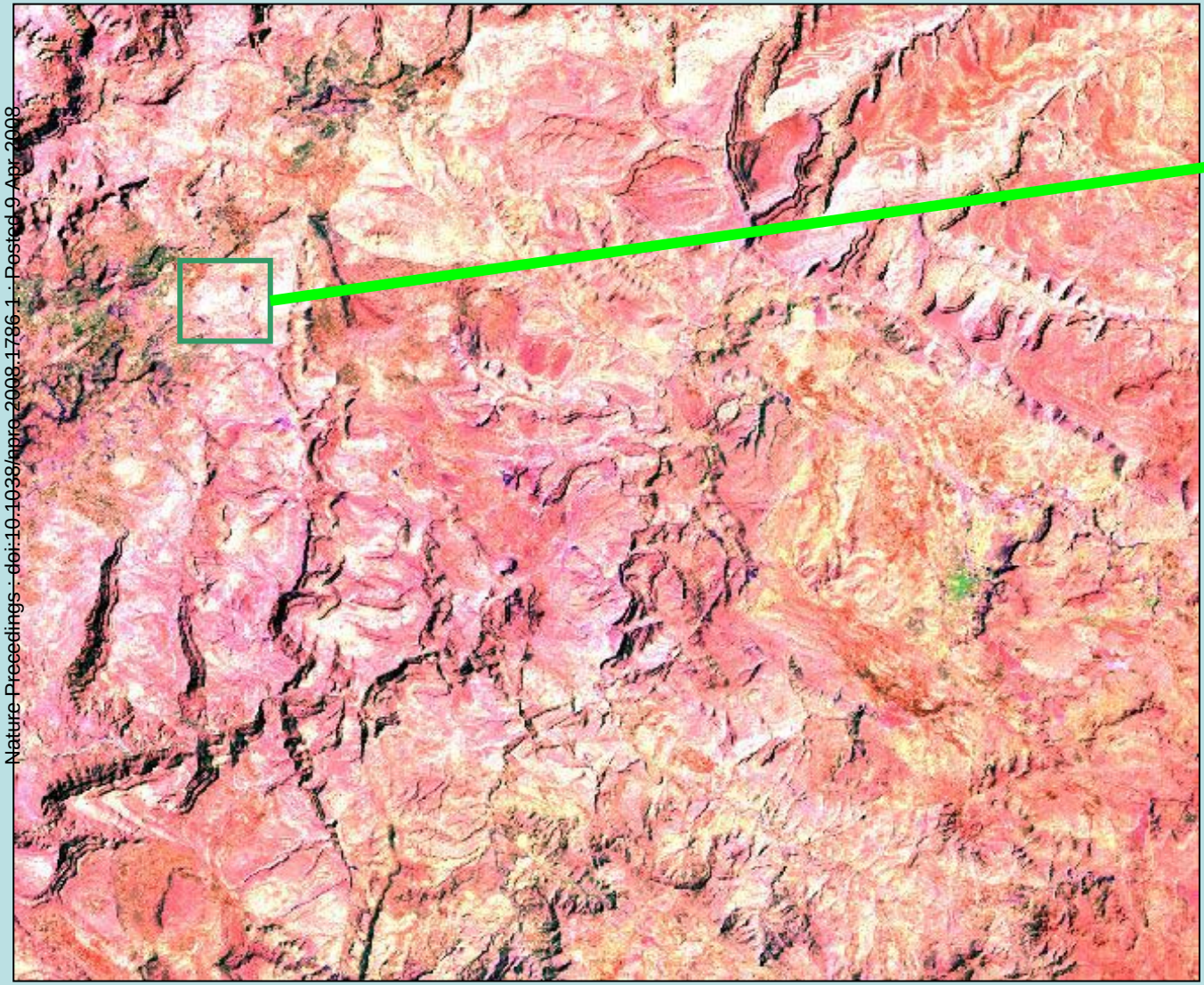
WORLD CONSERVATION MONITORING CENTRE

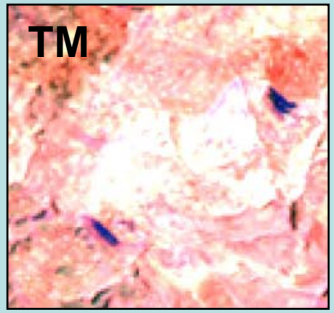
CIFOR

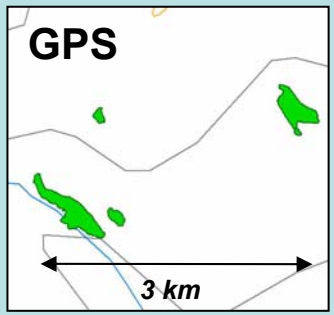
Ethiopia: where have the mountain forests gone?



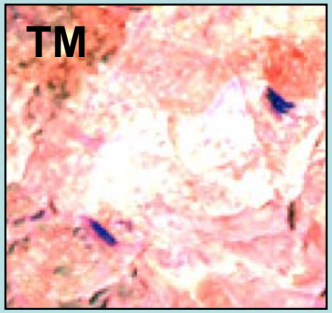
Northern highlands of Ethiopia: Landsat TM - blue is forest

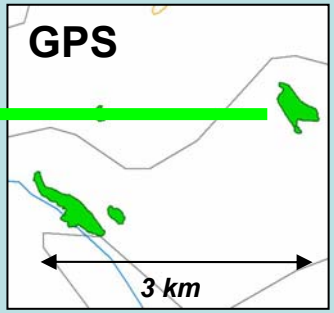






Forest fragments: church forests…



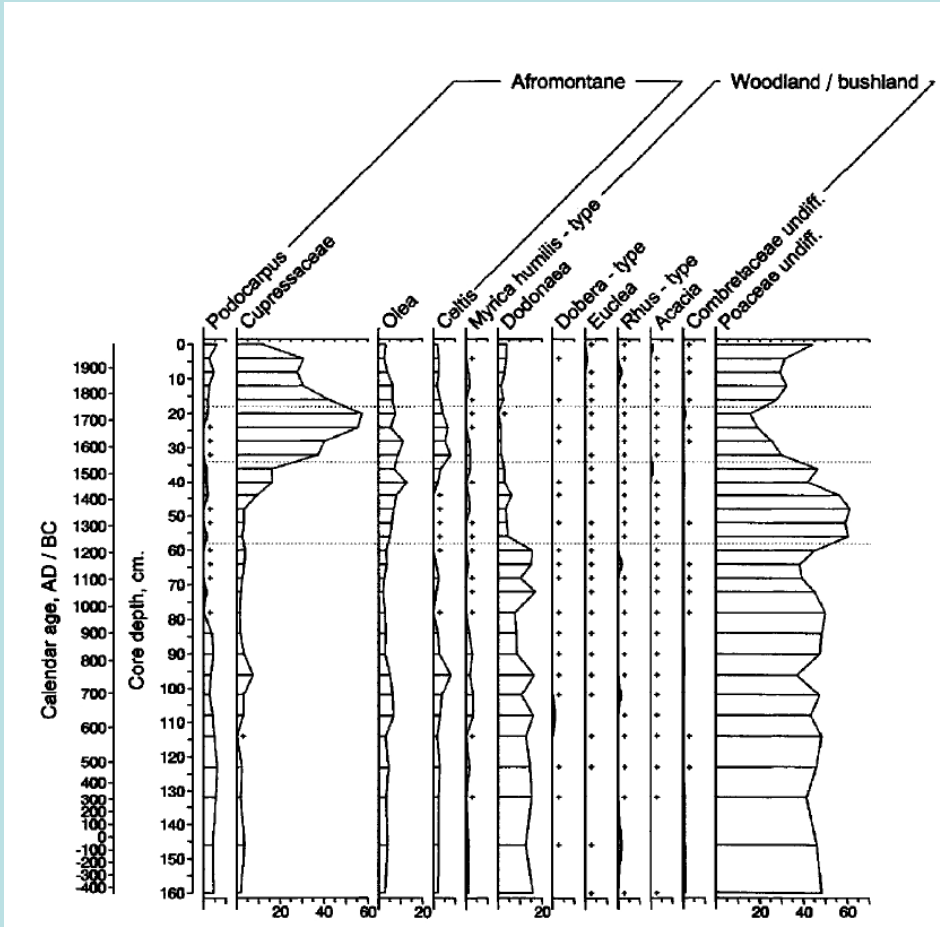


…in a matrix of cropland and degraded semiarid savanna

Historical plant communities

Nature Precedings : doi:10.1038/npre.2008.1786.1 : Posted 9 Apr 2008

- Until 2500 years ago
  - Undifferentiated or dry monodominant Afromontane forest (Friis 1992)
  - *Juniperus procera* with *Afrocarpus falcatus* (Pencil cedar-Yellowwood)
- 500 BC
  - Forest clearance
  - *Dodonaea* and *Rumex*
- 1200-1400 AD
  - Grass and frequent fires
- 1400-1700 AD
  - Secondary forest
  - *Juniperus* with *Olea* and *Celtis*



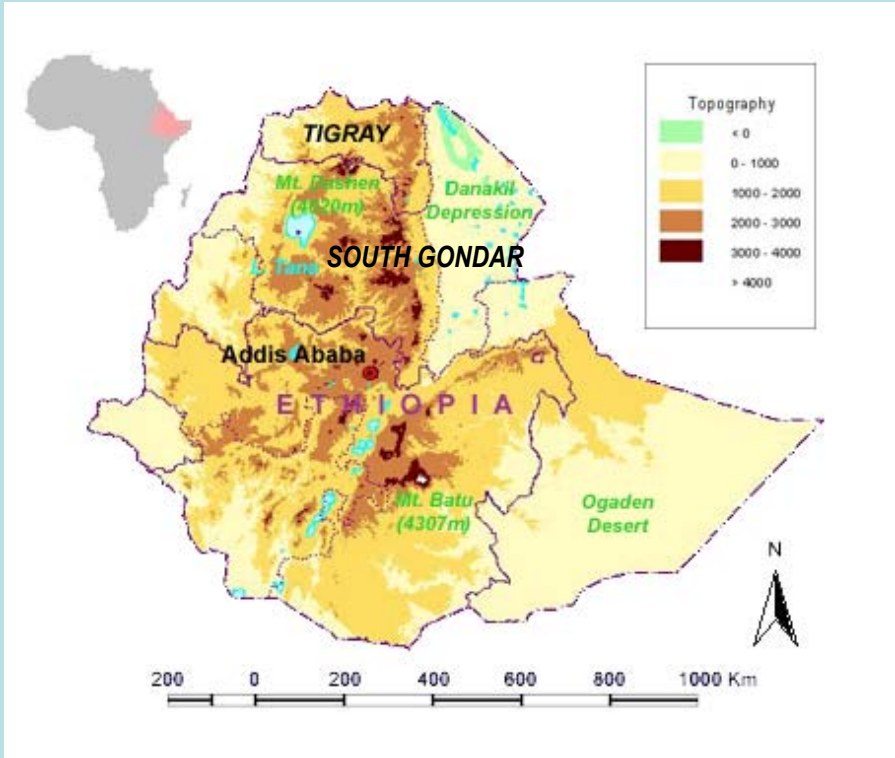
Percentage pollen and chlorophyte algal stratigraphy of Lake Hayk core HYK99–1.

Darbyshire et al. (2004) The Holocene 13(4):537-546
(DOI:10.1191/0959683603hl644rp)

Forest plant communities today

Nature Precedings : doi:10.1038/npre.2008.1786.1 : Posted 9 Apr 2008

- *North (Central Tigray)* secondary forest
  [Aerts et al. 2006: 10 forests]
  - Moist Afromontane forest with *Faidherbia*, *Celtis* and *Pterolobium*
  - Dry Afromontane forest with *Olea*, *Acacia* and *Combretum*
  - Shrub savanna with *Acacia* and *Echinops*
- *South (South Gondar)* degraded primary forest
  [Alemayehu Wassie 2007: 28 forests]
  - Afromontane forest with *Juniperus*, *Olea* and *Maytenus*



What is conserved in church forests?

- Conservation value and management
  - depend on what is actually conserved in church forests
  - e.g. conservation (primary forest) vs. restoration (secondary forest)
- Not all church forests are the same
  - not necessarily "*the original forest vegetation*" (often said so)
- Remarkable difference between north and south
  - Is this also reflected in fragment area and spatial allocation? (cfr. "*larger fragments or better connectivity = better conservation"*)
  - If so, is this a general trend (more and larger fragments in the south)?
- Things to know to solve this question:
  - Where are the forests in the highlands?
  - What are the forest sizes and how much forest is really left? (forest cover is usually estimated at 4%)
  - What are the spatial characteristics of the forests?

Methods: Google Earth/GIS

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- Northern highlands
- 8 sample blocks
- 0.5 million ha
- High-resolution satellite images (pixel resolution 0.8 m)
- Detected and digitized all 394 church forests
- (There were more churches than church forests – not all churches have old forest)

Example: Debre Tabor

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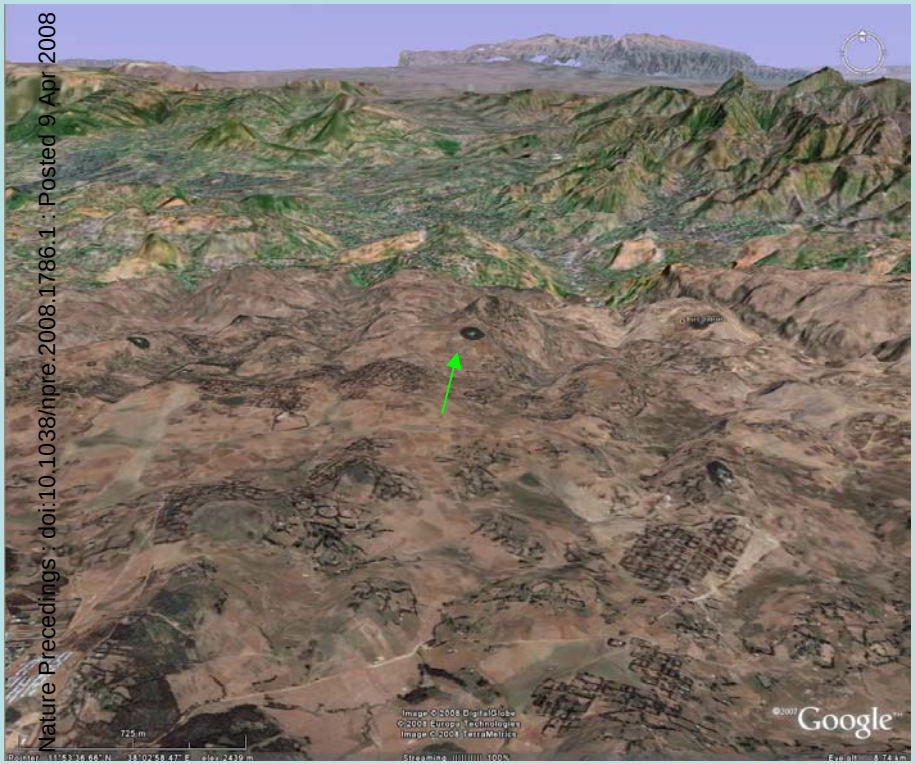

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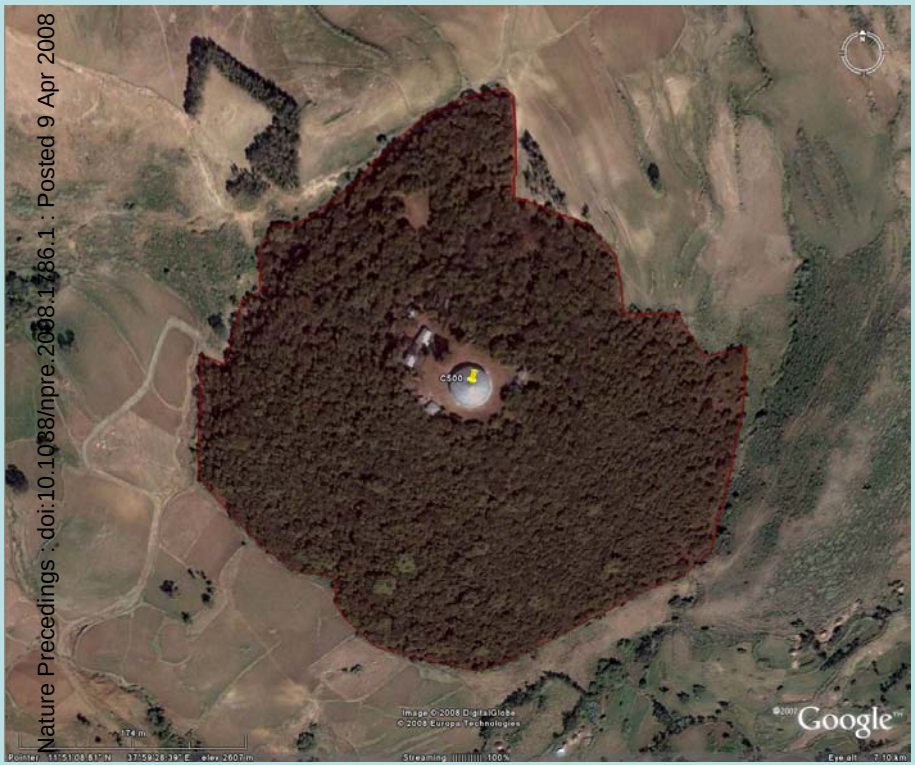
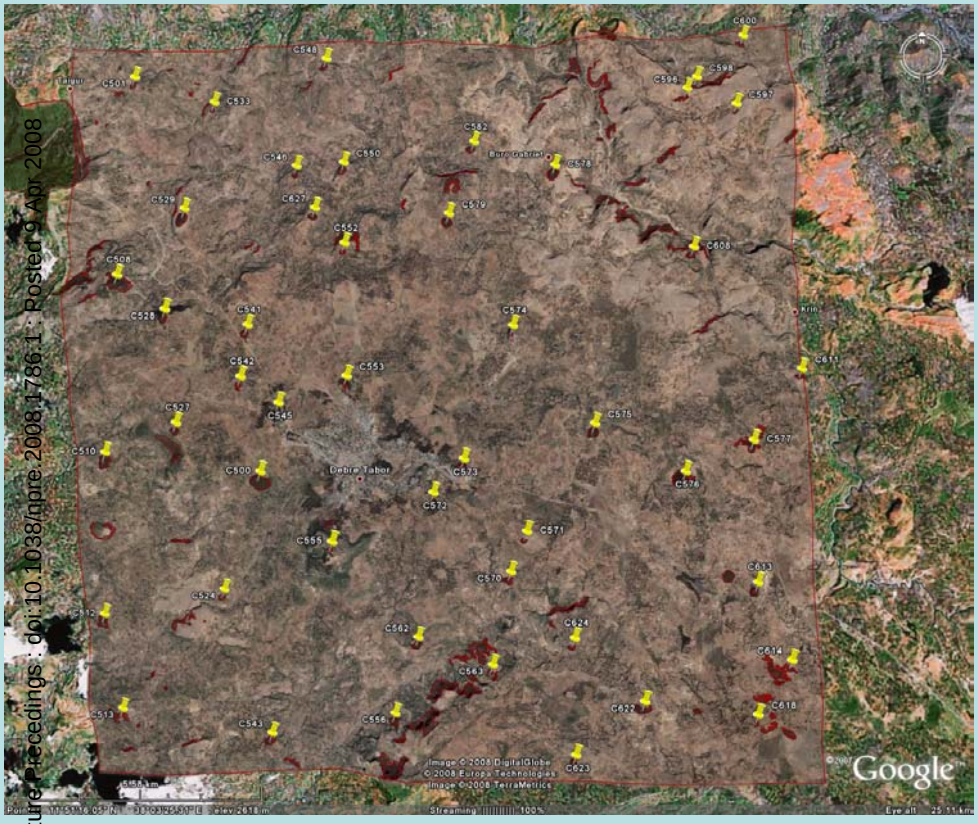
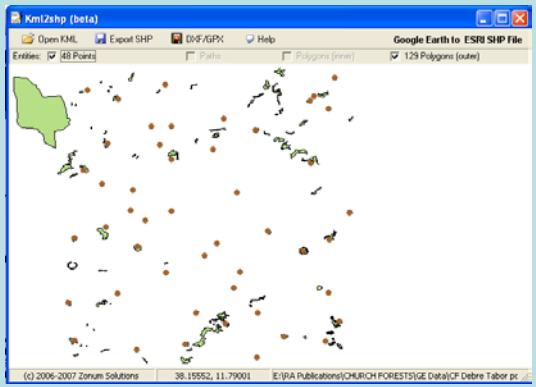
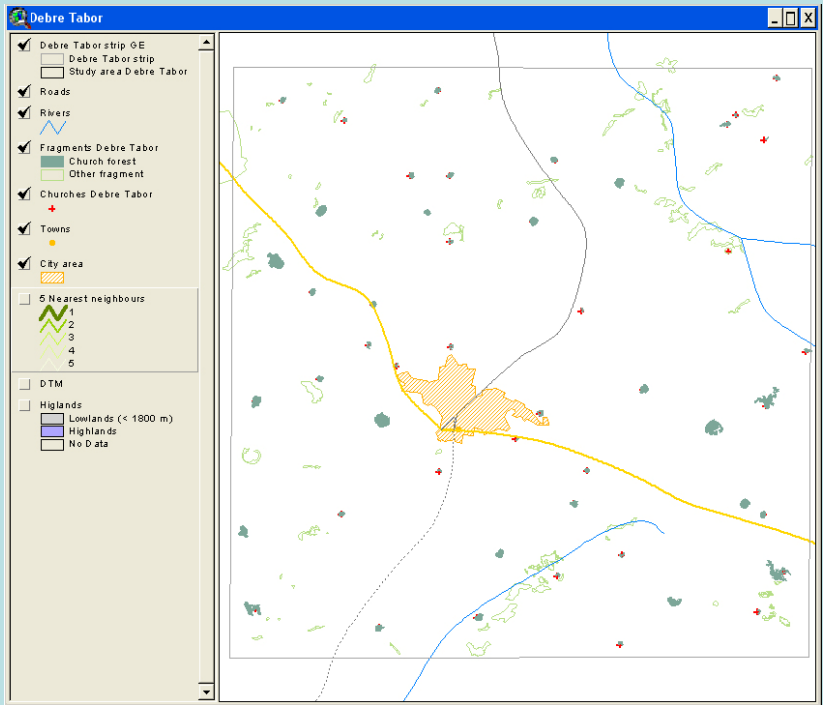


GE > KML2SHP > ArcView GIS







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Spatial analysis

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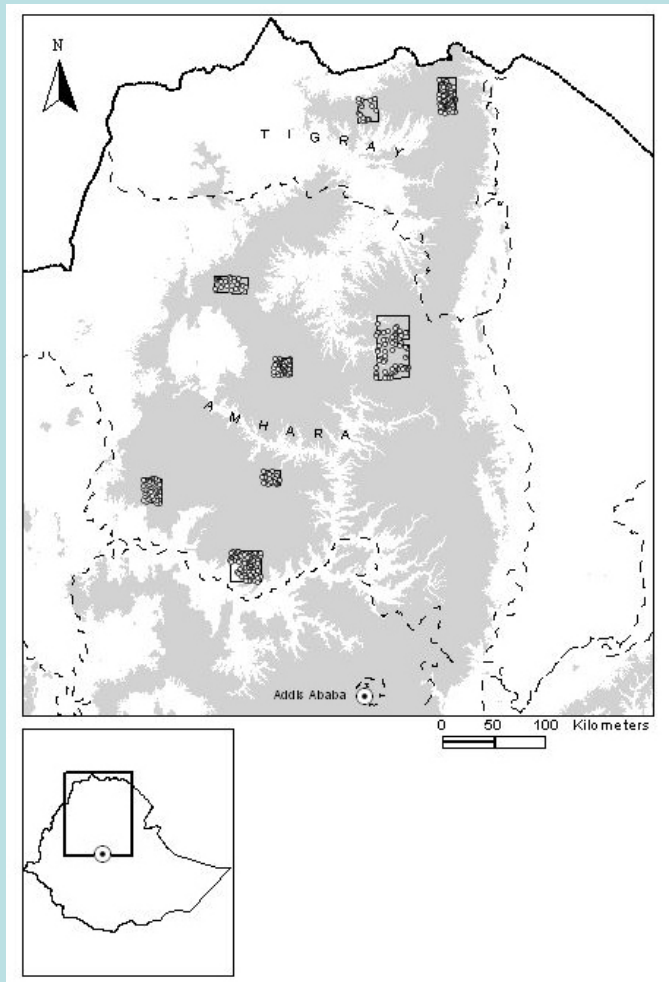
- Fragment and landscape metrics (Arcview GIS: Spatial Analyst, Patch Analyst)
  - Area
    - Patch area (ha)
    - Patch core area (ha; 50 m internal buffer from edge and church)
  - Density
    - Patch density (patches per ha)
    - Edge density (m/ha)
    - Core index (%)
    - Forest index (%)
  - Shape
    - Perimeter-area ratio (m/m²; PAR; 0.02 for a circle with r = 100 m)
    - Shape index (~P/√A: 1 circle; >1 more complex shapes)
    - Fractal dimension (~2lnP/lnA: 1 simple – 2 complex)
  - Isolation
    - Nearest neighbor distance (m)
  - Configuration
    - Aspect (via overlay with DTM)
    - Slope (°)
    - Church to patch centroid distance (m)



Results

	North (n = 155)		South (n = 239)	P
Mean patch size (ha)	2.81 (0.69)		2.26 (0.31)	0.271
Mean patch core area (ha)	0.59 (0.18)		0.32 (0.14)	0.238
Patch density (patches per ha)	0.43 (0.11)		0.46 (0.08)	0.801
Edge density (m/ha)	342 (55)		317 (43)	0.727
Core index (%)	23 (12)		5 (10)	0.308
Forest index (%)	0.18 (0.10)		0.31 (0.08)	0.346
Mean perimeter:area ratio (m/m^2)	**0.066 (0.003)**	**>**	**0.048 (0.002)**	**< 0.001**
Mean shape index	**1.65 (0.04)**	**>**	**1.4 (0.03)**	**< 0.001**
Mean fractal dimension	**1.38 (0.01)**	**>**	**1.33 (0.01)**	**< 0.001**
Patch isolation (m to nearest neighbor)	1993 (92)		1887 (74)	0.329
Aspect	**F(NW>SE; P<0.05)**		**F(NW=SE; P>0.05)**	
Slope (°)	**8.3 (0.5)**	**>**	**4.7 (0.4)**	**< 0.001**
Church-patch centroid distance (m)	**66 (6)**	**>**	**36 (5)**	**< 0.001**

Results

- Northern forests
  - More complex shape (PAR, SI, FD)
  - On steeper slopes
  - More on NW slopes
  - Ex-centric churches (churches at the edge)
- Southern forests
  - Simple shape, often circular, often with a radius of ~100m
  - On small mountain tops
  - Church central
  - Almost on a regular grid in the landscape

Results

Typical northern church forest

Typical southern church forest

Discussion

- Shape, not size, reflect historical deforestation pattern
- North: church forest protected remnant forest patches after large scale deforestation of the landscape (thus, on steep, drier slopes)
- South: church forests protected designated forest patches in a forested landscape, prior to large scale deforestation
- Results consistent with ‘roaming capitals of Ethiopia’

Discussion

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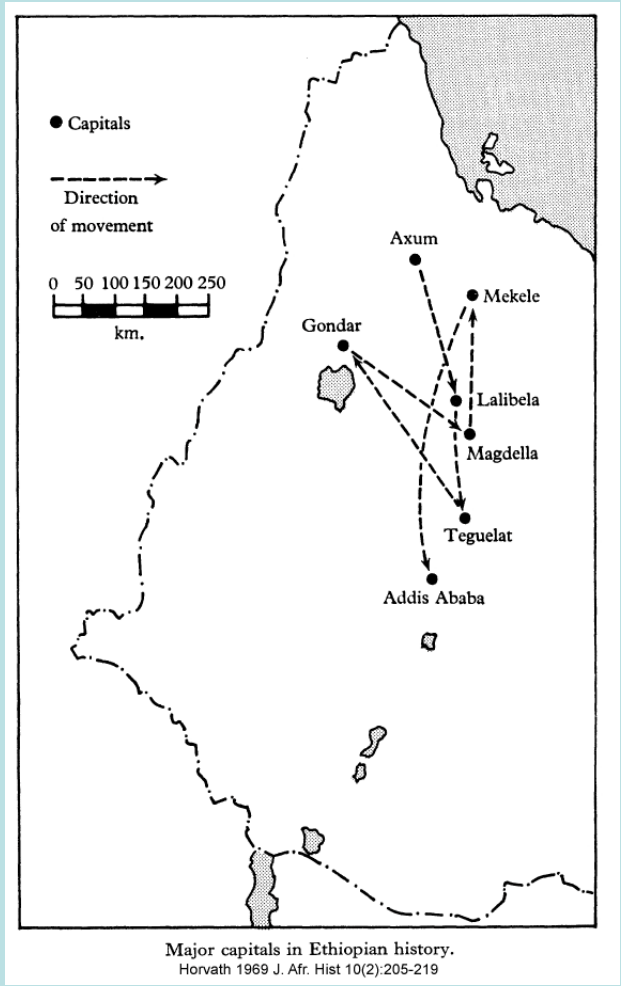
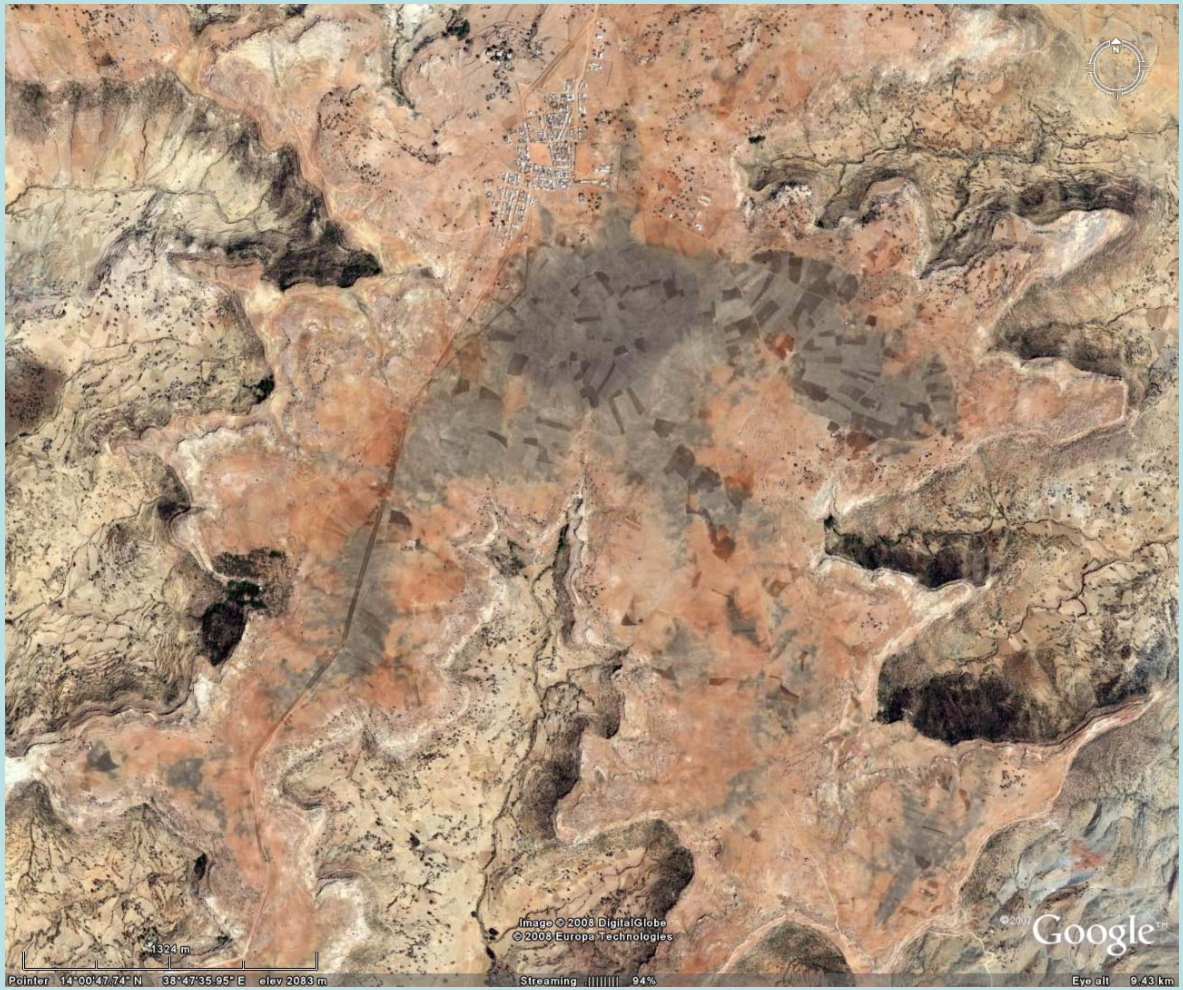
- 'Old capitals': *Axumite period*
  - Large deforestation prior to arrival of Christianity
  - Churches were established in deforested land
  - Church forests protected 'what was left'
  - Mainly secondary forest
- 'Newer capitals': *Gondarine period*
  - Colonization of the land
  - Church as a means to control the land
  - Regular pattern of regular churches
  - More likely to represent primary forest



Major capitals in Ethiopian history.
Horvath 1969 J. Afr. Hist 10(2):205-219

Discussion



Northern forests on NW slopes (Axum)

Discussion

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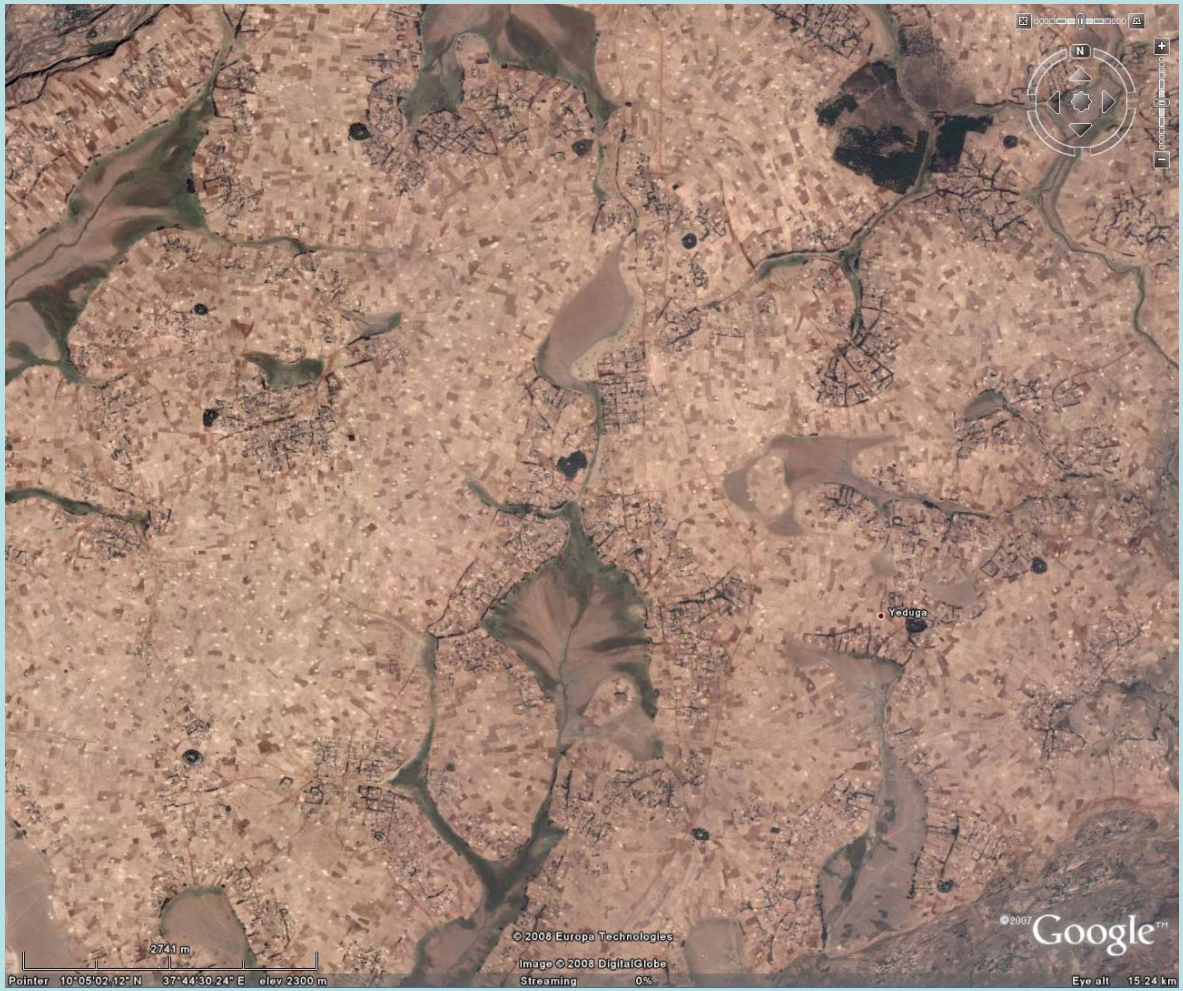
Southern forests, regularly spaced (Debre Markos)

Discussion



Southern forests: churches on 3 x 3 km² grid

Discussion

Nature Precedings : doi:10.1038/npre.2008.1786.1 : Posted 9 Apr 2008

Southwestern forests: 3 x 3 km² grid and remnant of the original forest

Conclusion

- Historical deforestation patterns
  - Linked to historical development of the highlands
- Church forests have different origins
  - North and northeast: conservation after fragmentation
  - South and southwest: conservation before fragmentation
- Differential conservation status requires differential management
- Conservation of primary species a focus in the SW
- Restoration of primary species in secondary forest a focus in the NE
- Forest expansion needed in all regions: fragments very small (2.5 ha) and forest cover too low (0.2%)