evropský sociální fond v ČR
EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Landscape functioning viewed by remote sensing

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ENKI, o.p.s. Třeboň

The functionality of the landscape can be viewed from many perspectives. One aspect is the so-called ECOLOGICAL EFFICIENCY (was introduced as Energy – Transport – Reaction model by W. Ripl (1995); ETR is an ecological model of dissipation of daily energetical pulses of solar radiation, in a relationship with matter and nutrient flow from the landscape.

ECOLOGICAL EFFICIENCY

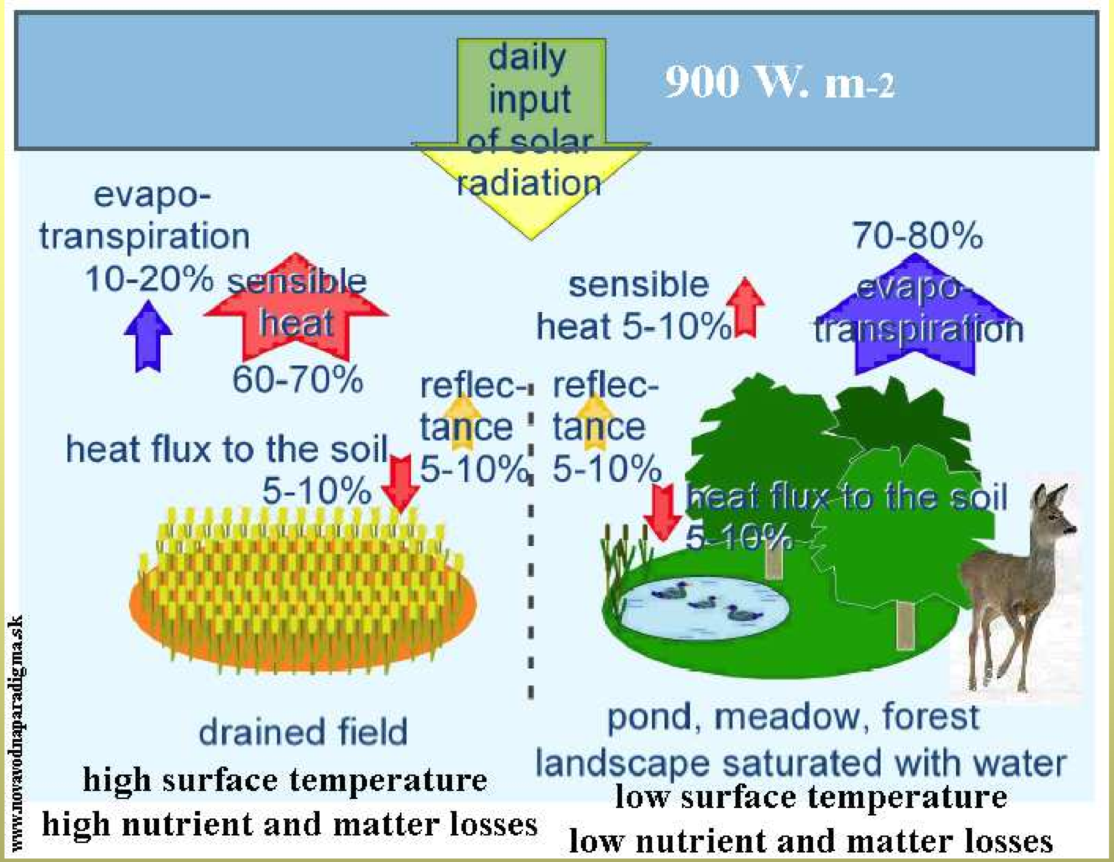
Chemical efficiency
viewed by ratio between nutrient and matter flow /gross production of ecosystem

Energy use efficiency
viewed by dissipation of solar radiation

Functional landscape is characterized by closed nutrient and mineral cycles and minimal matter losses through the discharged water.

Dissipation is understood as transformation of solar radiation energy into other forms of energy, with a significant role of living systems (especialy permanent and green vegetation as are the forest, wetlands) and water cycle.

Distribution of incident solar radiation in the landscape



- Relationship between living systems and water cycle - indicator of thermodynamic efficiency of the ecosystem and the level of solar energy dissipation.

-Vegetation and ecosystems respond to the amount of incident solar radiation in terms of photosynthesis and transpiration activity – damp energy pulses

- Mitigation temperature differences and low surface temperature are important factors in reducing nutrient, matter and water losses.

-Energy should be dissipated through water cycle in such a way to create a dynamic equilibrium of temperature, precipitation and chemical processes.

-The state of ecosystem (landscape) is determined by the amount of dissolved solids (nutrients, basic cations) from the top soil layer.

Chemistry of surface water

(conductivity, nutrients, basic cations, total organic carbon)

- water quality represents integral information about landscape functions in the catchment.

-Changes in the landscape affected mainly by human activities had, and still continue to have, an effect on the catchment's hydrology and landscape functioning.

-The data about spatial patterns of surface water chemistry allow to analyze the effects of land-use in terms of sustainability and reliable ecological potential of water bodies.

Radiation surface temperature

- High temperature amplitudes (daily and seasonal) negatively influence the balance of matter, nutrients and water in the landscape – high losses occur.

- Surface radiation temperature reflects the transformation of solar energy on the earth's surface - sensible heat, or latent heat

- Radiation surface temperature is extracted from thermal imaging systems, located on-board satellites (eg. Landsat, Terra Aster and MODIS, NOAA-AVHRR) or airplanes; for ground measurements thermal imaging cameras are used. The data are spatially continuous, and therefore do not require the use of interpolation methods. Thermal images are acquired in wavelengths (3-5 µm , 7 – 14 µm). There is a significant difference between thermodynamic temperature (e.g. air temperature measured in screen, used in climatology) and radiation surface temperature (based on basic´s laws of radiation).

Radiation surface temperature

- at the wavelenghts 3 – 20 µm (atmospheric windows above all) prevails the emitted energy of the objects over the reflected solar radiation
- 3 – 5 µm (night); 8 – 12 µm
- total amount of energy emitted by the object is a function of specific wavelength and its temperature
- Radiation temperature (measured by RS) x kinetic (meteorological, air temperature – standard measurement at 2m hight above surface) = manifestation the energy of the kinetic movement of the molecules

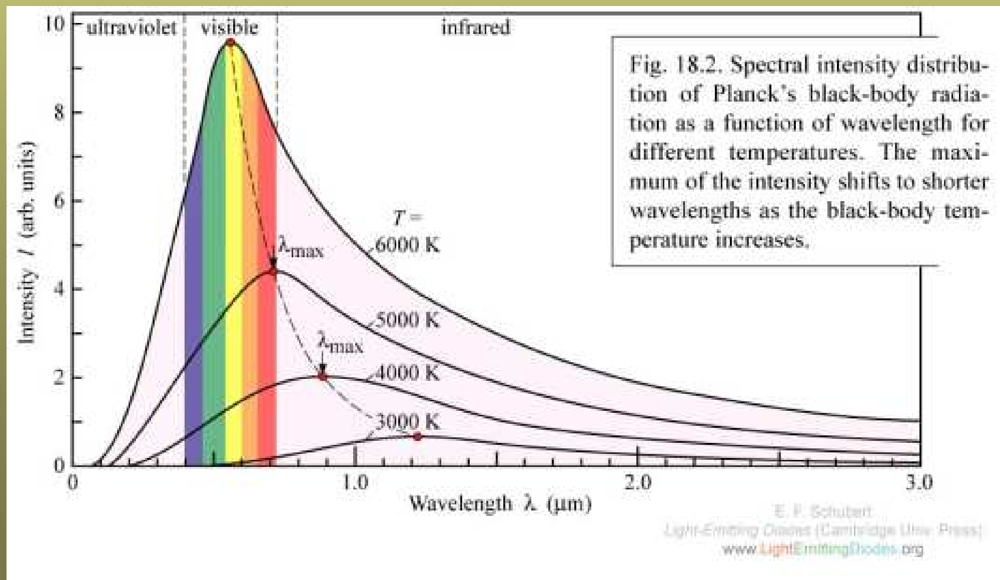


Fig. 18.2. Spectral intensity distribution of Planck's black-body radiation as a function of wavelength for different temperatures. The maximum of the intensity shifts to shorter wavelengths as the black-body temperature increases.

Remote sensing –
thermal scanning of radiation surface temperature

I. large-scale (several hundreds kms**) satellite images** (commonly in 7 – 14 µm)

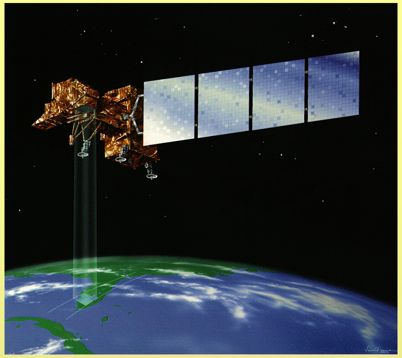
II. broad-scale monitoring (300 - 5000 m) by **aircraft** with photogrammetric equipment. Both aerial devices are equipped with FLIR thermographic cameras operating within a spectral range of 7.5 – 15 µm.

III. near-ground (up to 1 000 m) - an **airship** equipped with GPS was developed and successfully tested

IV. ground scanning

Enki, o.p.s. Třeboň, Airship Club.com - občanské sdružení, Praha. Soustava prostředků pro zjišťování energetických toků v přízemní vrstvě atmosféry. Původci: Jirka V., Pokorný J., Kobrzek F., Mareček P., Zicha J., Bíla J. Česká republika. Užitný vzor CZ 22671 U1. 12.9.2011

Enki, o.p.s. Třeboň. Zařízení pro měření energetických toků na rozhraní zemského povrchu a atmosféry. Původci: Jirka V., Zicha J. Česká republika. Užitný vzor CZ 22673 U1. 12.9.2011



Satellite

33 x 27 km

Landsat TM/ETM+ provide data each 16 day, at 9:38 GMT+1, with a spatial resolution of thermal channel (10.4-12.5 µm) of 120 meters / 60 m.

<u>Thermal image from Landsat TM</u>

Dark hues of grey = cold surfaces

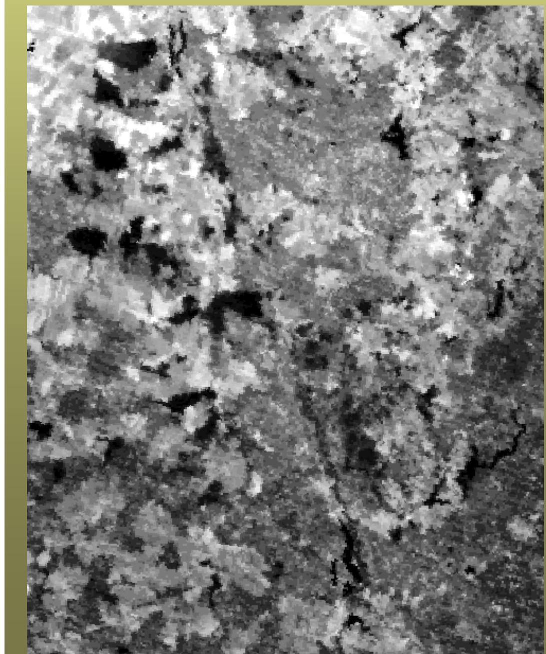
Light hues of grey = hot surfaces

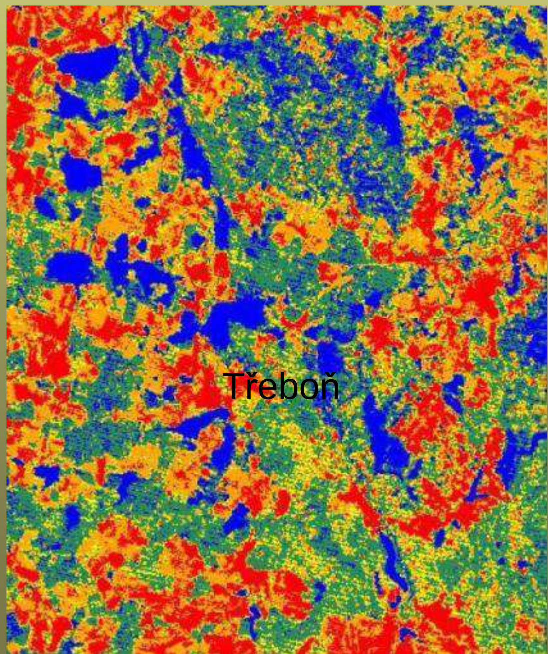
<u>Relative surface temperature; standardized</u>

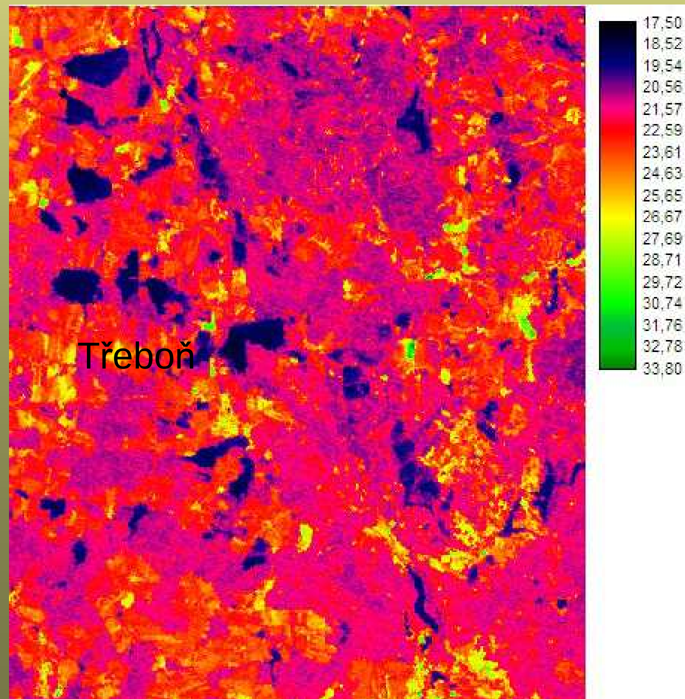
Used for comparative analyses highest temperature – lowest temperature

<u>Land surface temperature in °C</u>

Computed from specific algorithms for Landsat TM sensor







Airship

A helium-filled airship (**8 m long)** - equipped with an **inertial measurement unit** for direct measurements of the heeling angle and acceleration in all directions in relation to a coordinate system of the gondola, an accurate **altimeter**, short-wave **radio stations** with a range of at least 10 km and a **GPS** navigation device.

•Its operating **speed** is 5 m/s; **height** up to 1000 m and the maximum **duration** of the flight is 30 minutes.

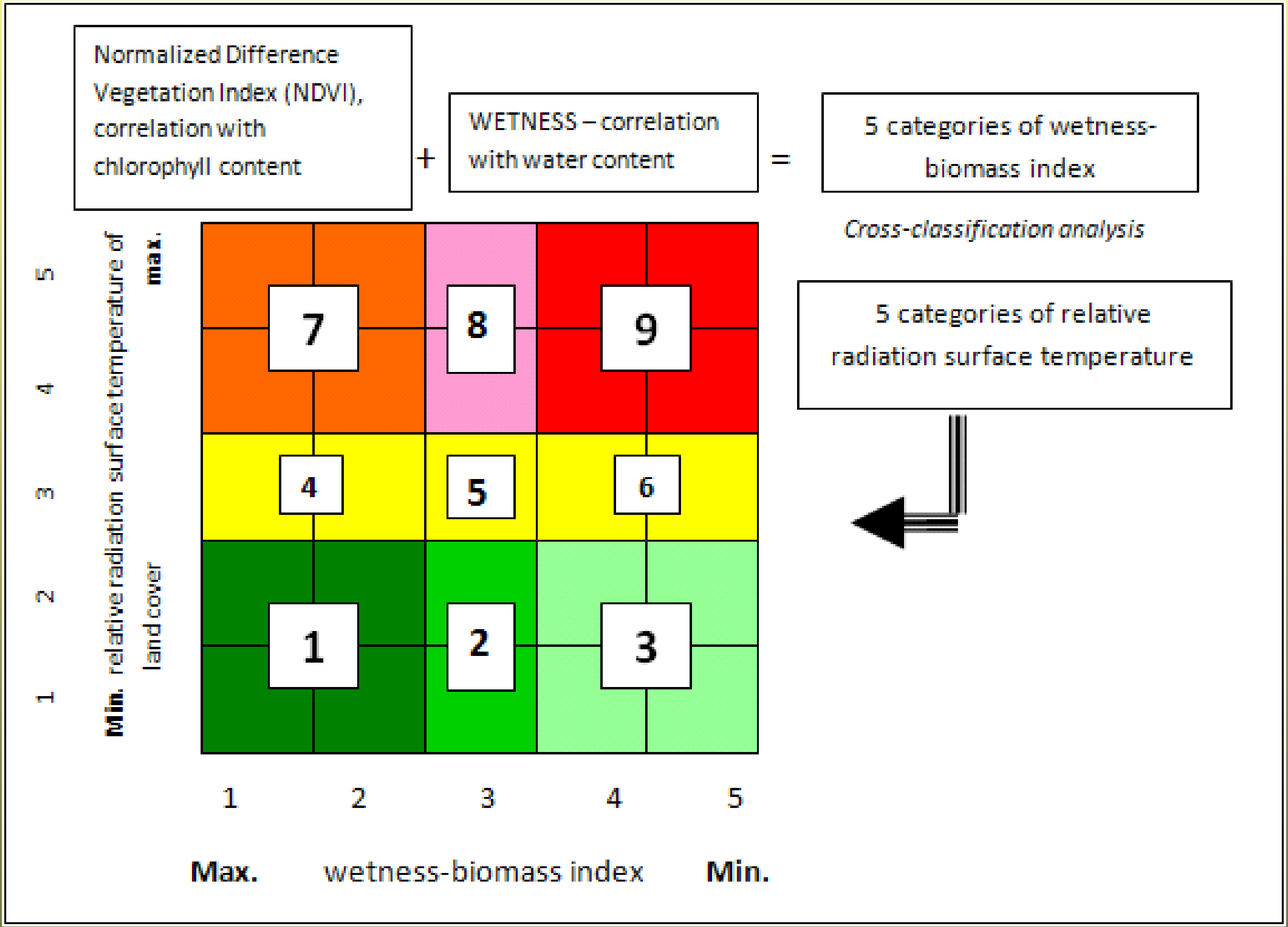
•A gravity suspension located on the gondola is balanced to keep at a right angle to the Earth's surface. Attached are cammeras operated with a common trigger. The frequency of photography is derived from the forward speed of the airship.

1. Study

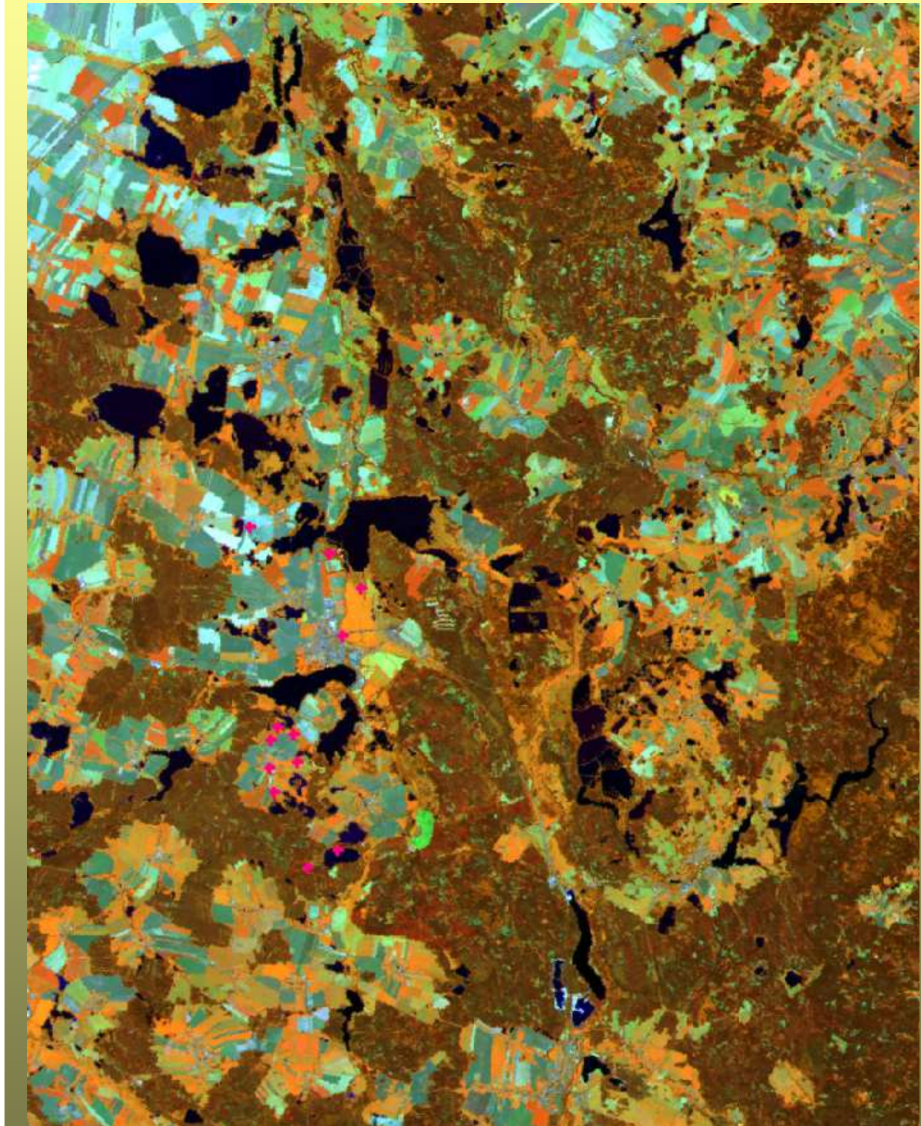
Dissipation ability assessment of the Třeboňsko landscape, based on Landsat satellite data

Indicators relevant for landscape functioning identified by RS

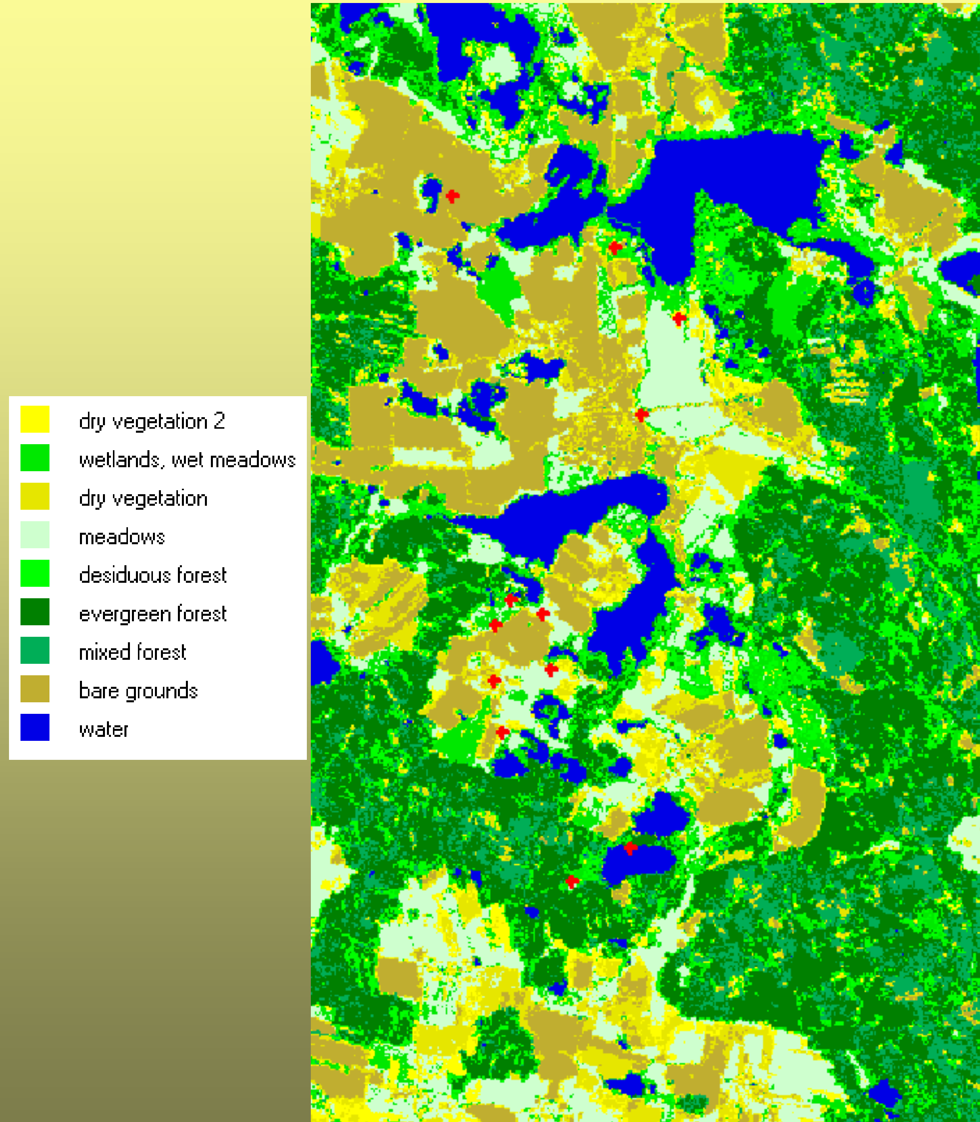
- Radiation surface temperature
- Green biomass
- Wetness



Land cover – Třeboňsko region – Landsat TM 29.7. 2008 RGB 453

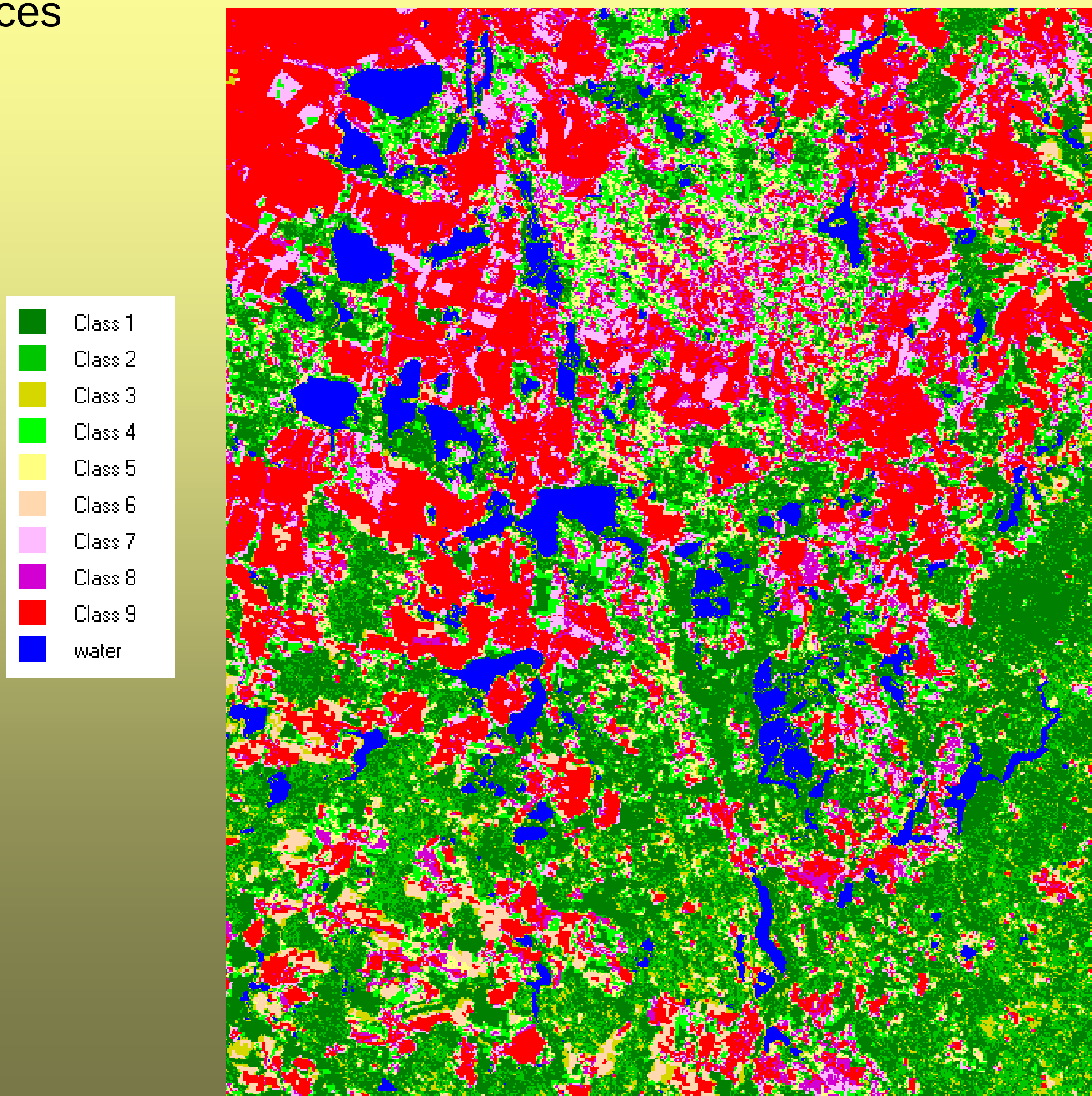


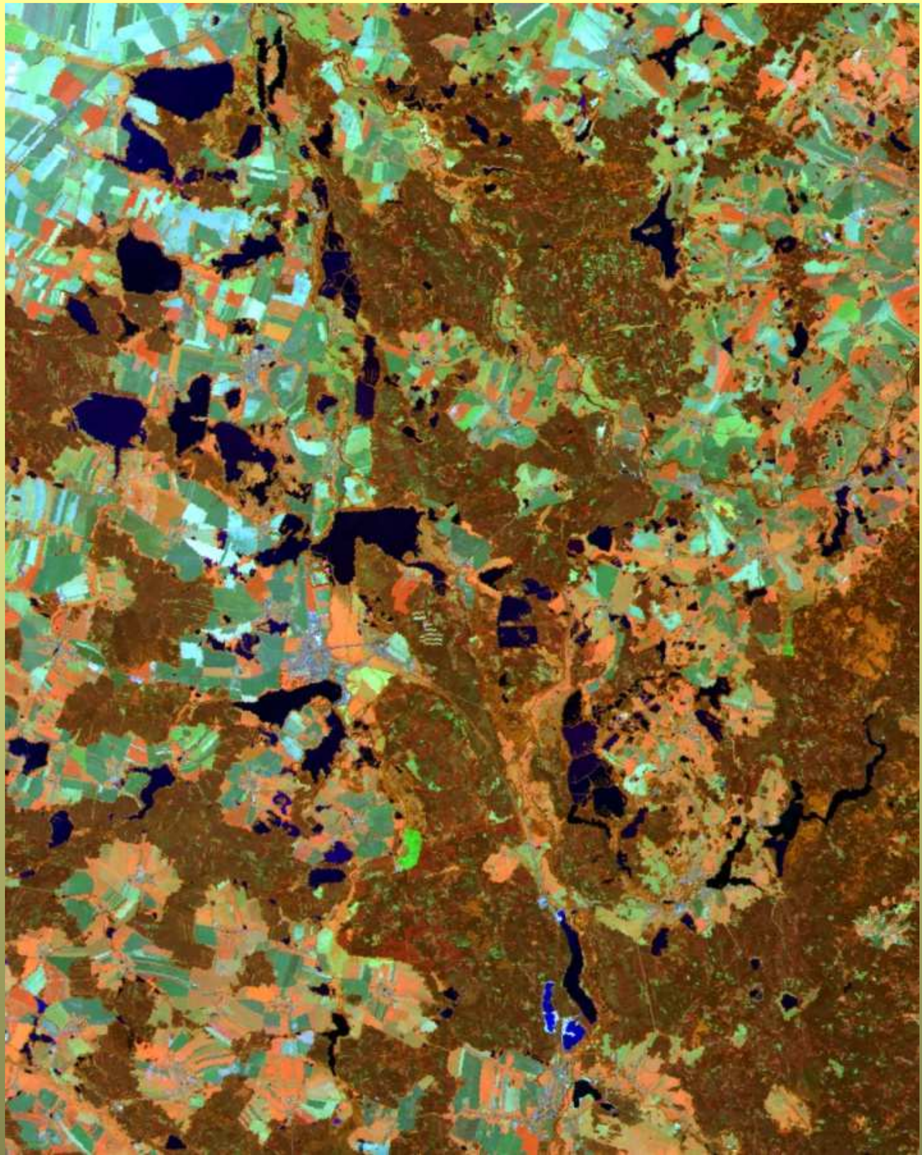
Land cover – Třeboňsko region

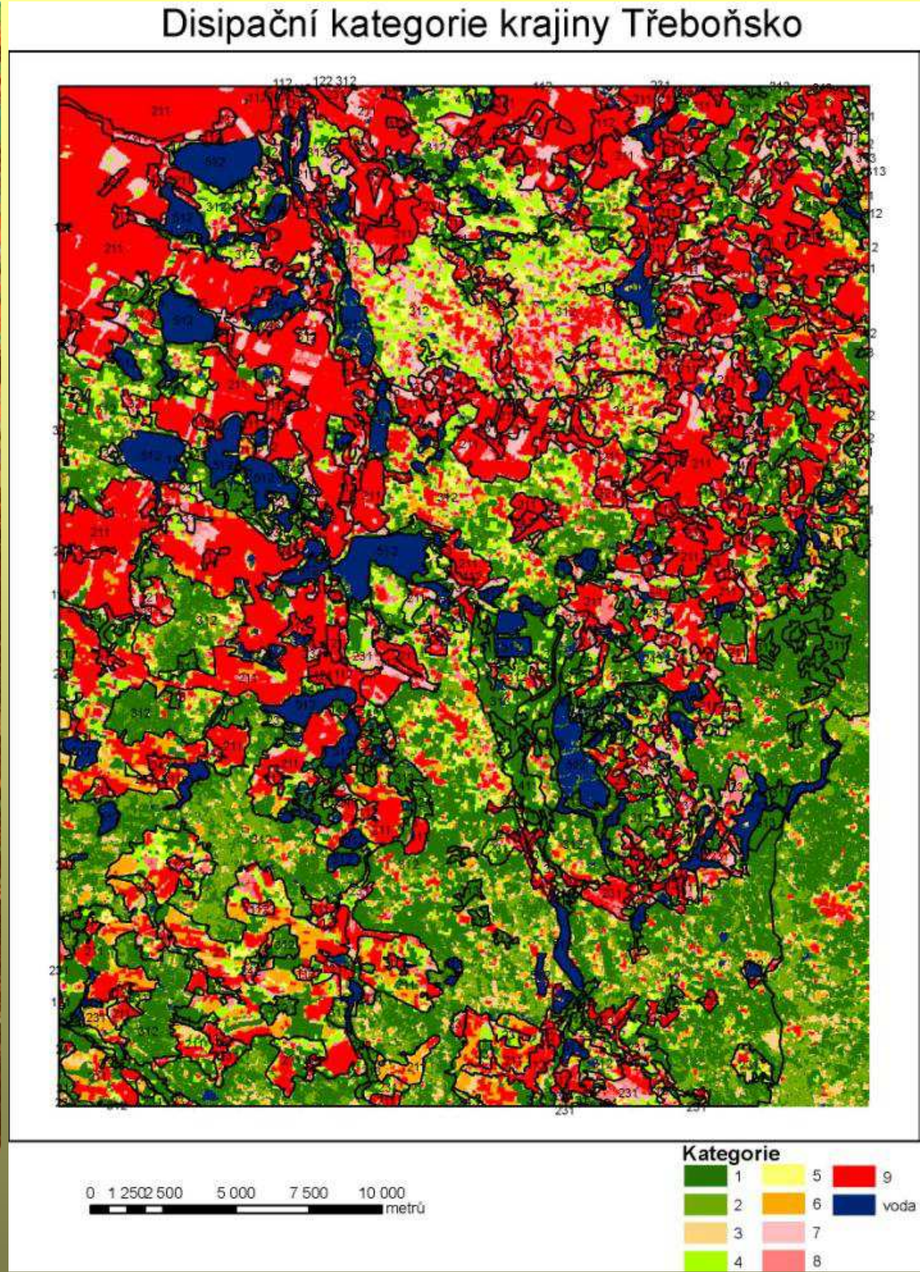


Dissipative categories of land cover

Thematic map based on cross-classification analysis of Landsat thermal image and NDVI+NDWI indices





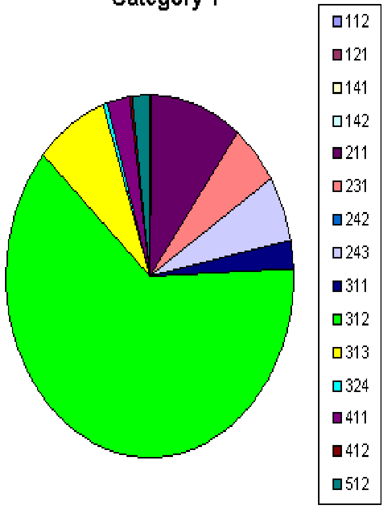


Dissipation categories of land cover
Valuing Ecosystem Functions and Services in the Czech Republic(Seják a kol. 2010)

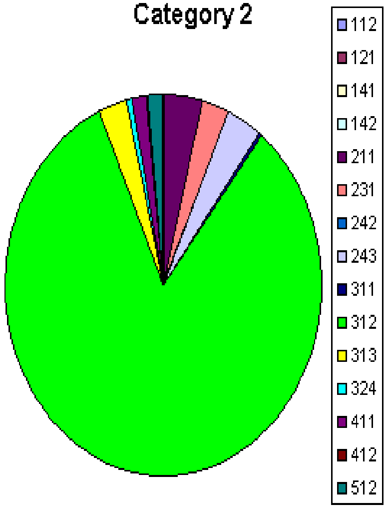
CORINE	Category_1	Category_2	Category_3	Category_4	Category_5	Category_6	Category_7	Category_8	Category_9
112	22.08	8.45	20.43	62.20	32.94	66.55	238.08	263.92	1691.64
121	1.86	0.64	1.45	3.07	1.40	5.97	8.60	8.51	149.76
122	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
141	6.94	2.37	2.58	4.16	2.61	3.08	4.25	1.52	4.51
142	43.55	6.32	5.90	23.65	5.14	2.55	12.76	9.28	19.31
211	2098.72	324.21	846.97	1467.22	546.91	2414.65	2511.97	1428.48	17859.26
231	1083.50	223.99	197.57	1067.33	289.75	301.94	1439.67	1117.11	2836.51
242	8.94	2.08	1.29	9.05	2.89	3.71	26.28	20.45	58.73
243	1229.03	274.53	311.80	655.48	236.41	256.99	922.97	589.21	1503.46
311	493.49	32.17	15.36	36.87	8.14	4.86	20.30	12.04	9.14
312	12691.84	6644.86	2192.56	3351.06	2298.61	1400.11	1846.67	1513.24	2190.53
313	1630.16	238.58	109.39	302.18	92.85	57.63	206.79	83.42	124.15
324	99.05	32.32	21.51	91.74	32.94	27.21	109.40	86.56	179.72
411	546.85	125.14	52.72	130.47	57.99	20.63	40.69	21.06	19.91
412	23.75	9.08	2.83	19.28	10.42	15.73	11.80	9.56	87.73
512	405.38	121.85	313.81	46.20	20.19	42.53	39.53	18.80	71.93

CORINE	
112	Discontinuous urban fabric
121	Industrial or commercial units
122	Road and rail networks and associated land
141	Green urban areas
142	Sport and leisure facilities
211	Non-irrigated arable land
231	Pastures
242	Complex cultivation patterns
243	Land principally occupied by agriculture, with significant areas of natural vegetation
311	Broad-leaved forest
312	Coniferous forest
313	Mixed forest
324	Transitional woodland-shrub
411	Inland marshes
412	Peat bogs
512	Water bodies

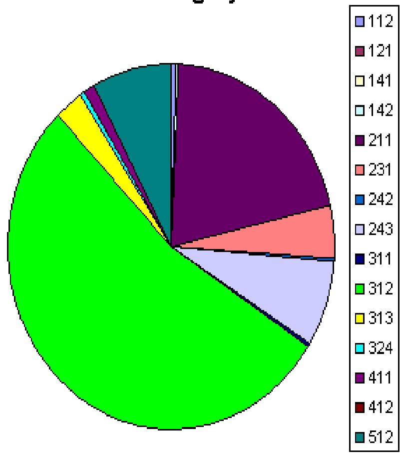
Category 1



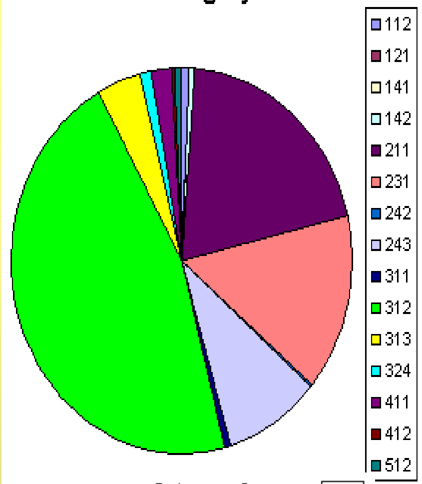
Category 2



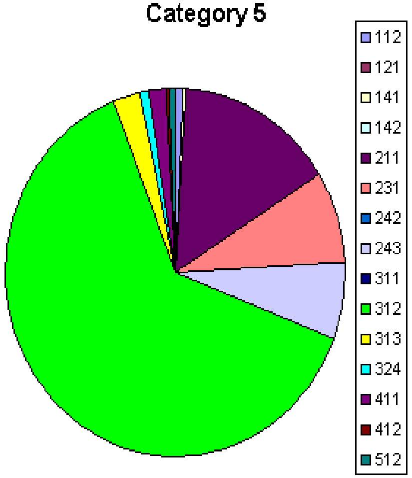
Category 3



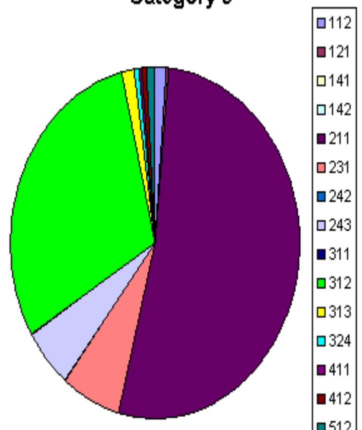
Category 4



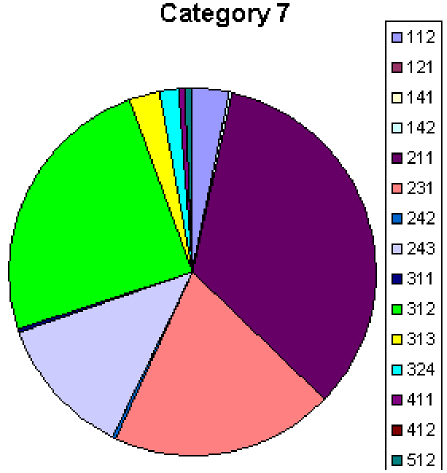
Category 5



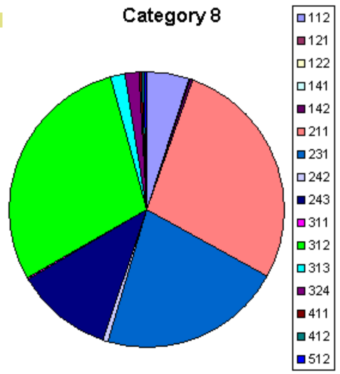
Category 6



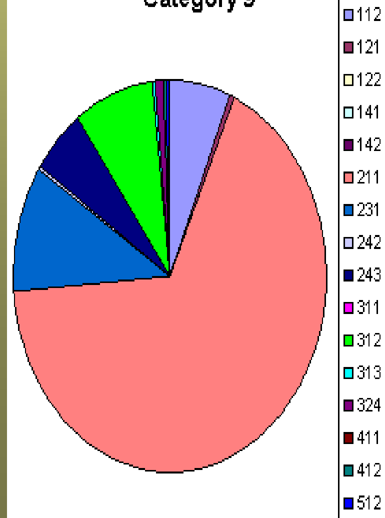
Category 7



Category 8



Category 9



CORINE	
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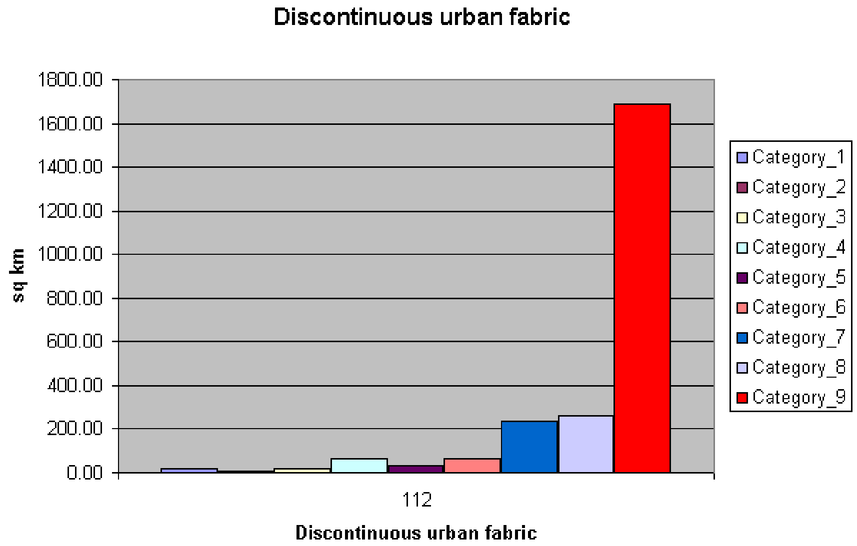

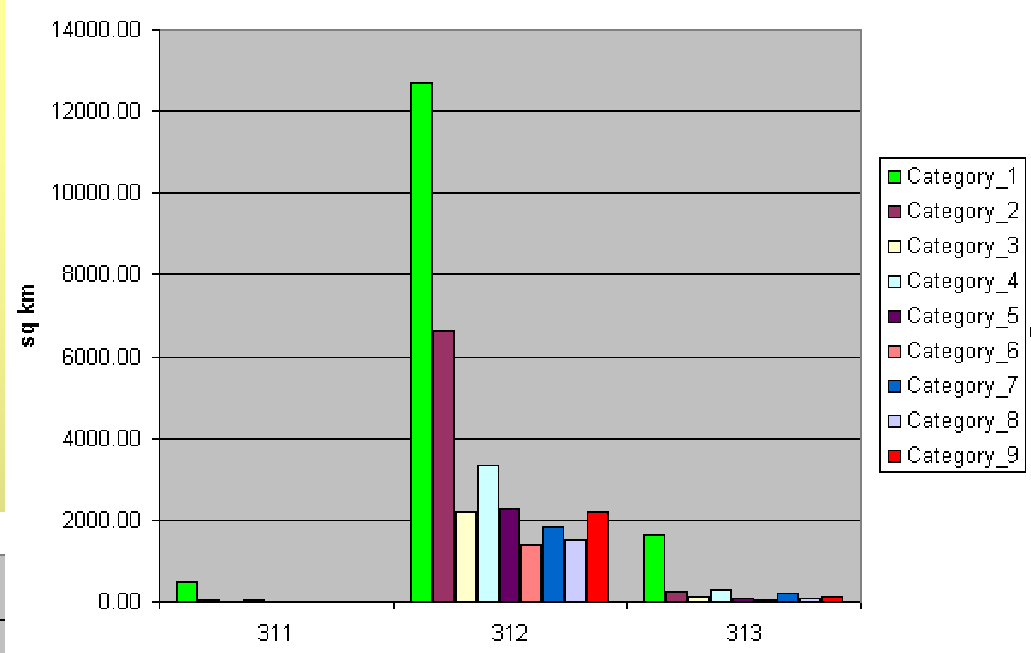

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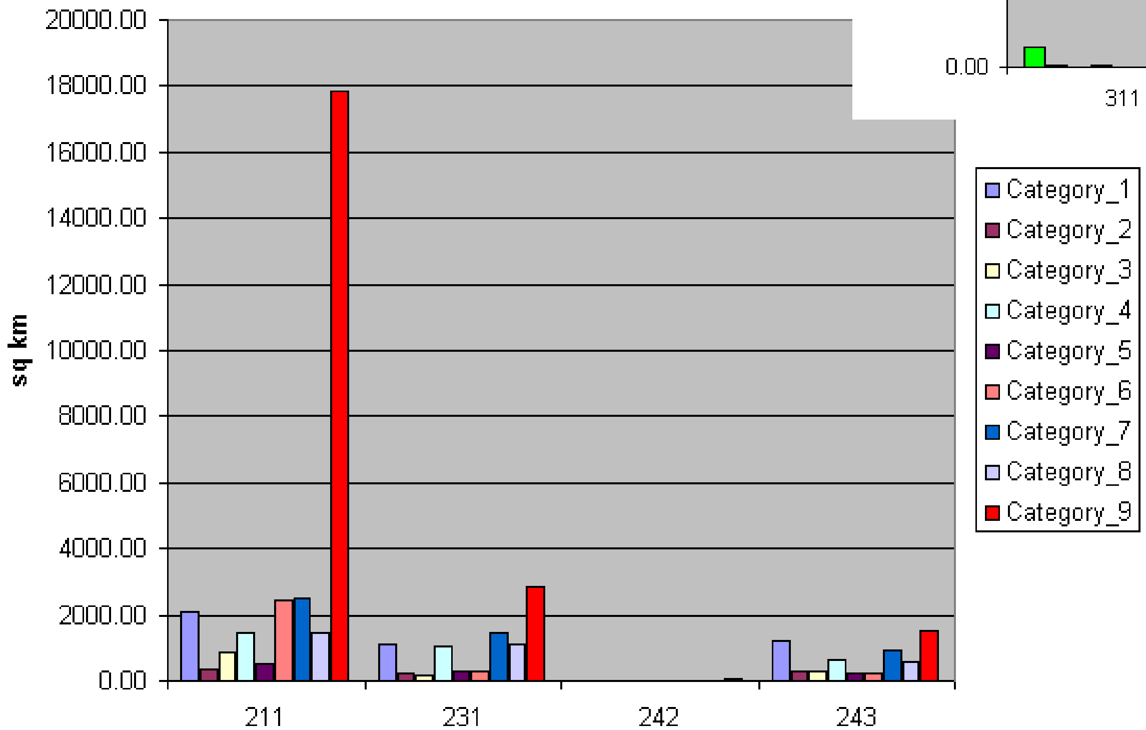

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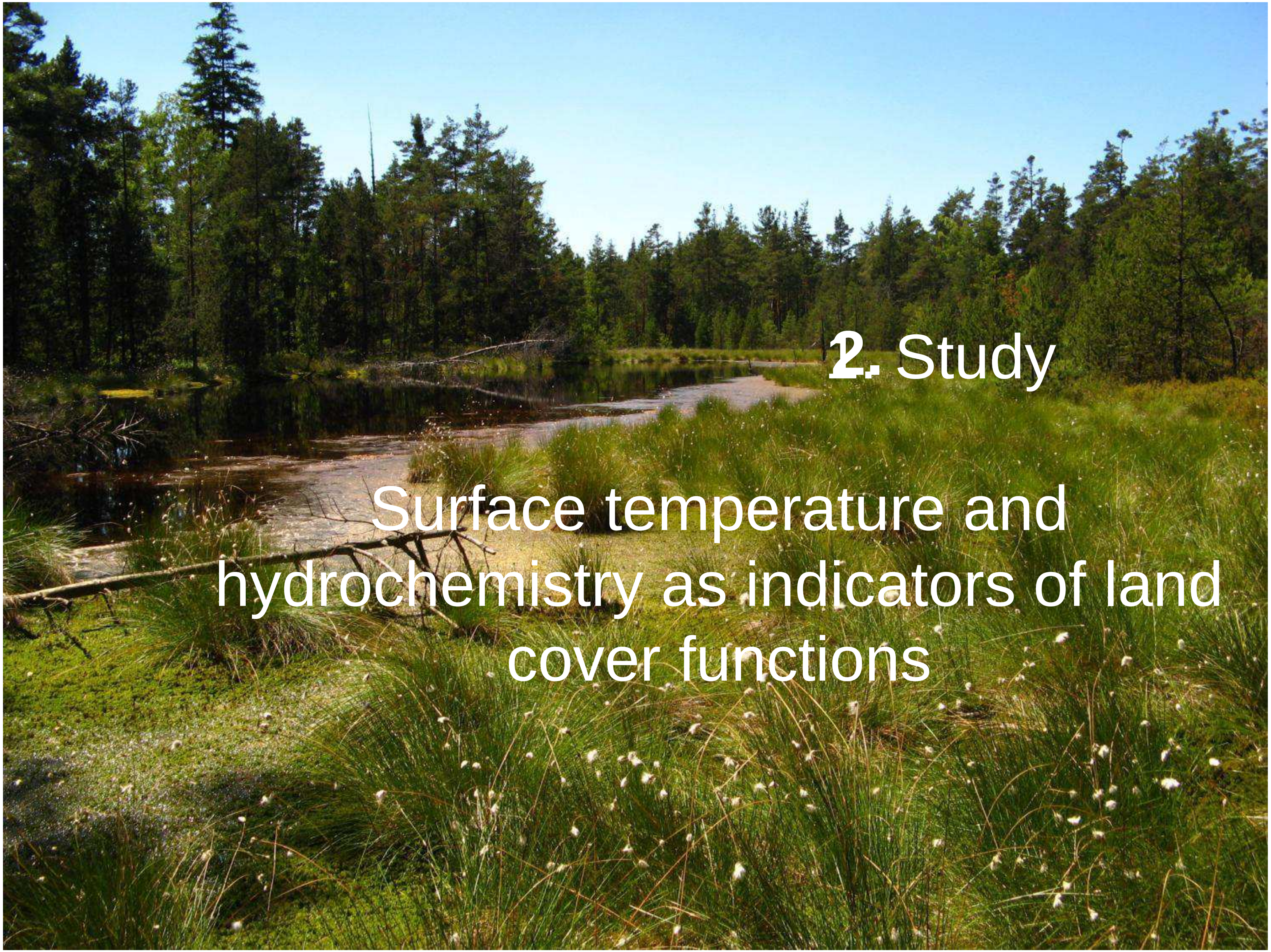


2. Study

Surface temperature and hydrochemistry as indicators of land cover functions

We expect:

The **watersheds** with higher proportion of **arable land and build-up** areas are expected to be characterized by **unbalanced temperature regime, higher average temperatures and conductivity** which is in sharp contrast with the watersheds, covered mainly by forests and permanent grass covers.

•The relationship between radiation surface temperature and selected chemical parameters, was analyzed in six watersheds in Třeboň region.

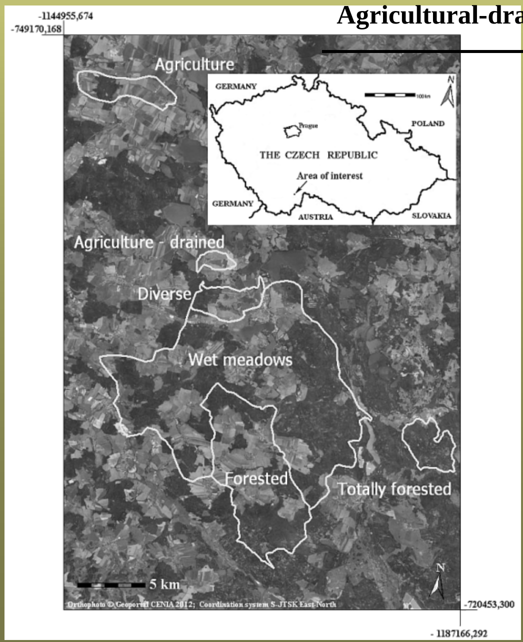
•the watersheds differ in ratio of land cover types (Corine land cover 2006) – agriculture – drained; agriculture; diverse; wet meadows; forested; totally forested

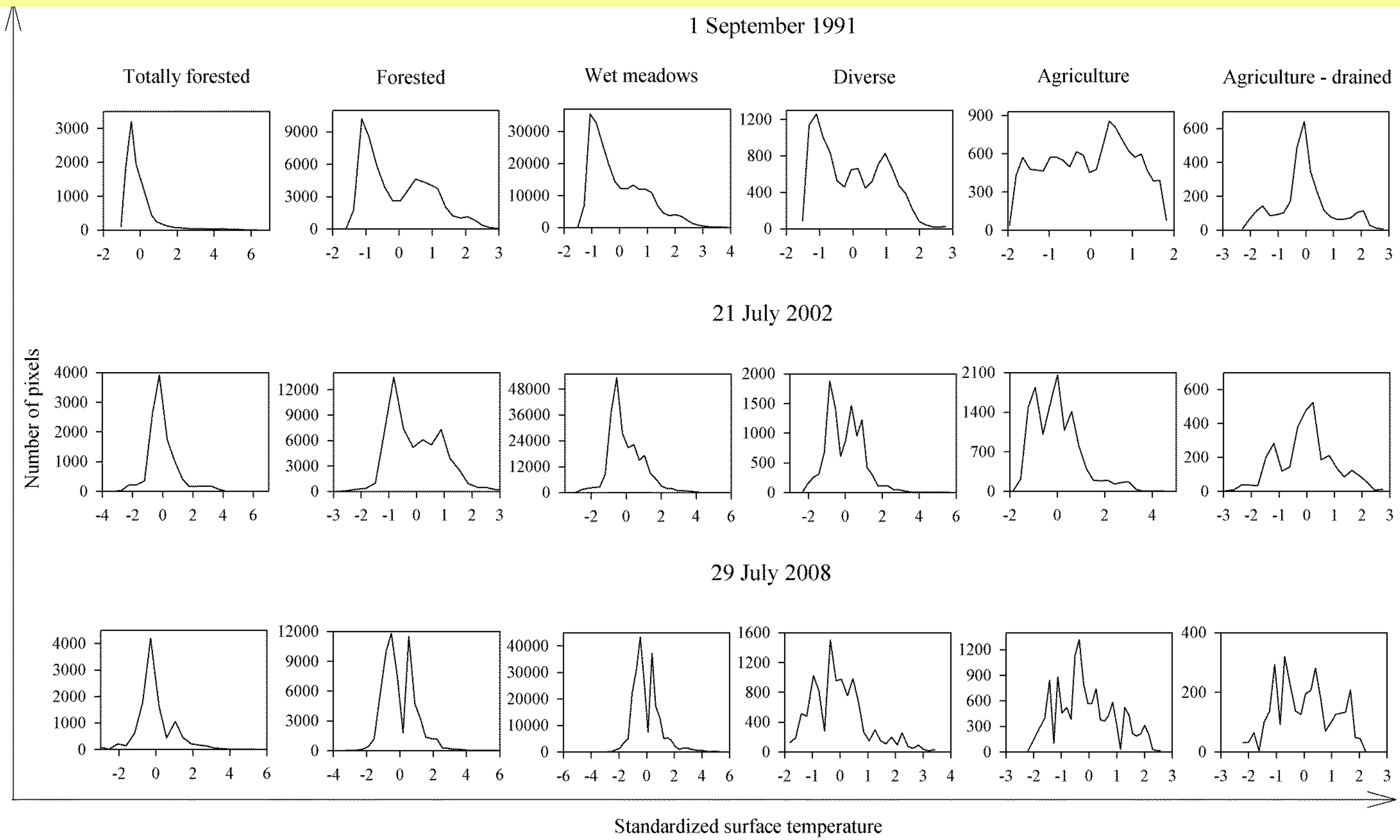
•The physical-chemical parameters were measured during three periods; 1990 -1991; 2001 - 2002; 2008 – 2009

The information about surface radiation temperature was calculated from the satellite Landsat TM thermal channel TM6. The assessed scene was acquired on; 1 September 1991; 21 July 2002; 29 July 2008

The description of the catchments

Type of catchment (based on predominant land cover)	Degree of human impact	Catchment characteristics
Totally Forested (TF)	Very low	Predominantly forested catchment (92%), with almost no agricultural cultivation. Purkrabský fishpond (32 ha) on the discharge profile belongs to the European important sites.
Forested (F)	Low	The catchment consists of natural forests with wet peat soil (50.3%) and 30% of arable land.
Wet Meadows (WM)	Low	Wet meadows (7.5%) with a high underground water level are seasonally flooded from two artificially constructed canals. To keep the same exposure and altitude the mountainous part was not considered and only three quarters of the catchment area were included in the surface temperature assessment. The sub-catchment is from more than 50% forested, arable land accounts for about 30 %.
Diverse (D)	High	The catchment with a predominance of arable land (51.3%) and 27.4% of forest. The system of eight fishponds is intensively used for fishery.
Agricultural (A)	High	The catchment consists of pastures (1.5%), forests (21%) and arable land (73%) with intensive agricultural activities.
Agricultural-drained (AD)	Very high	The catchment with a high proportion of arable land (91%), drained since the 1970s by an artificial canal.




1 September 1991
Totally forested
Forested
Wet meadows
Diverse
Agriculture
Agriculture - drained
21 July 2002
29 July 2008
Number of pixels
Standardized surface temperature

Average, maximum and minimum values of surface temperature in the catchments, calculated from Landsat thermal channel TM6 on 1 September 1991, 21 July 2002 and 29 July 2008 at 9:38 GMT+1.

Precipitation a week before scanning 46.4 mm

1.9.1991

Surface temperature	Totally forested	Forested	Wet meadows	Diverse	Agriculture	Agriculture - drained
Minimum	11.81	11.81	11.81	12.35	12.35	13.95
Maximum	26.06	22.66	25.1	23.15	24.61	24.61
Average	13.84	15.45	15.38	16.17	18.72	18.77
Standard deviation	1.93	2.28	2.37	2.51	3.25	2.1

21.7.2002

Surface temperature	Totally forested	Forested	Wet meadows	Diverse	Agriculture	Agriculture - drained
Minimum	24.12	24.12	23.04	24.12	25.72	24.12
Maximum	33.93	35.41	36.39	38.32	36.39	34.42
Average	27.51	28.53	28.16	28.27	28.85	29.44
Standard deviation	1.05	1.53	1.61	1.79	1.69	1.82

Precipitation a week before scanning 70 mm (10 days 124 mm)

29.7.2008

Surface temperature	Totally forested	Forested	Wet meadows	Diverse	Agriculture	Agriculture - drained
Minumum	13.42	12.3	6.8	14.48	14.5	16.1
Maximum	23.15	26.1	27.5	27.49	30.3	28
Average	16.9	17.3	17.4	19	21.8	22
Standard deviation	1.18	1.5	1.8	2.49	3.3	2.7

Precipitation a week before scanning 14,2 mm

Average values of electrical conductivity of water, the concentration of bicarbonate (HCO_3^-), nitrate nitrogen (NO_3-N), total nitrogen (TN), total phosphorus (TP), sodium cations (Na^+) and calcium cations (Ca^{2+})

		Average values of						
Period	**Catchment**	**El. conductivity ($\mu S.cm^{-1}$)**	**HCO_3^- ($mg.l^{-1}$)**	**NO_3-N ($mg.l^{-1}$)**	**TN ($mg.l^{-1}$)**	**TP ($mg.l^{-1}$)**	**Na^+ ($mg.l^{-1}$)**	**Ca^{2+} ($mg.l^{-1}$)**
1990-91	**Forested**	379,0	121,30	0,09	2,34	0,19	7,49	44,36
	Totally forested	240,0	75,76	0,22	2,39	0,17	6,91	26,25
	Diverse	470,5	164,87	0,01	2,42	0,27	15,88	41,66
2000-02	**Forested**	231,3	81,56	0,11	1,87	0,21	4,77	28,59
	Totally forested	162,9	53,80	0,01	2,44	0,39	5,60	21,12
	Diverse	318,3	112,37	0,07	2,60	0,31	7,70	32,88
2008-11	**Forested**	130,6	49,36	0,01	2,01	0,21	3,40	14,20
	Totally forested	132,8	47,08	0,02	2,20	0,22	4,97	15,09
	Diverse	344,7	161,53	0,04	1,98	0,18	6,06	46,89
	Agriculture - drained	624,8	140,71	9,98	16,94	0,51	14,98	64,83
	Wet meadows	222,8	98,58	0,02	3,48	0,20	10,90	23,55
	Forested (2)	138,0	79,64	0,38	1,52	0,14	4,59	16,78
	Agriculture	313,0	120,97	0,18	2,97	0,18	11,20	33,00

Turkey's post hoc test for selected hydro chemical parameters in the period 1990 – 1991 and 2000 - 2002. (NS - no statistically significant difference)

Period	Catchment	Catchment	El. conductivity	HCO_3^-	NO_3-N	TN	TP	Na^+	Ca^{2+}
1990-91	**Forested**	**Totally forested**	**P < 0,05**	NS	NS	NS	NS	NS	**P < 0,05**
	Forested	**Diverse**	**P < 0,05**	NS	NS	NS	NS	**P < 0,05**	NS
	Totally forested	**Diverse**	**P < 0,05**	**P < 0,05**	NS	NS	NS	**P < 0,05**	**P < 0,05**
2000-02	**Forested**	**Totally forested**	**P < 0,05**	NS	NS	NS	NS	NS	NS
	Forested	**Diverse**	**P < 0,05**	**P < 0,05**	NS	NS	NS	**P < 0,05**	NS
	Totally forested	**Diverse**	**P < 0,05**	**P < 0,05**	NS	NS	NS	NS	**P < 0,05**

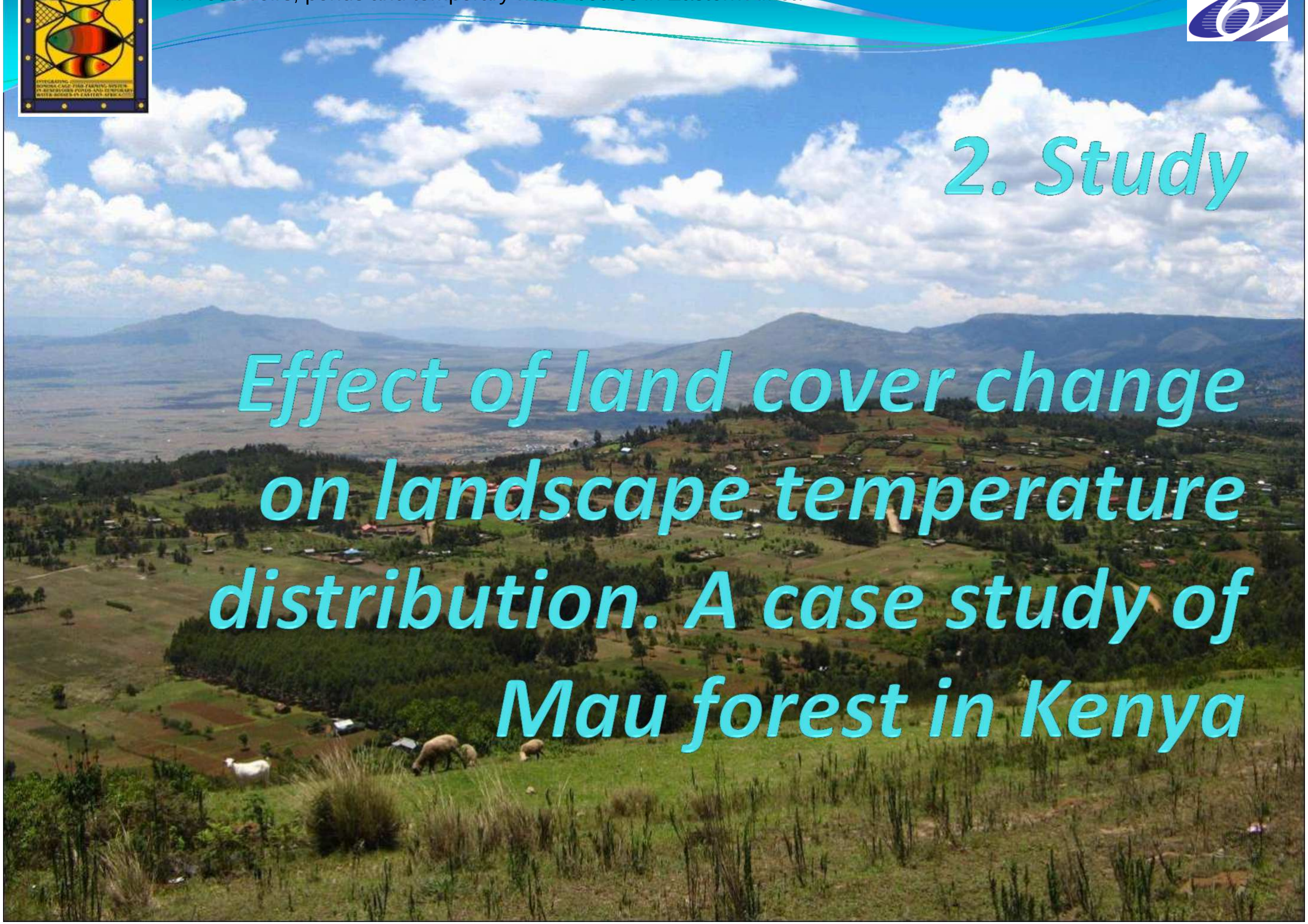
Turkey's post hoc test for selected hydro chemical parameters in the period 2008 - 2011 (NS - no statistically significant difference)

Catchment	Catchment	El. conductivity	HCO_3^-	NO_3-N	TN	TP	Na^+	Ca^{2+}
Forested	**Totally forested**	NS	NS	NS	NS	NS	NS	NS
Forested	**Diverse**	**P < 0,001**	**P < 0,001**	NS	NS	NS	NS	**P < 0,001**
Forested	**Agriculture**	**P < 0,001**	NS	NS	NS	NS	**P < 0,01**	NS
Forested	**Agriculture - drained**	**P < 0,001**	**P < 0,01**	**P < 0,001**	**P < 0,001**	**P < 0,05**	**P < 0,001**	**P < 0,001**
Forested	**Forested (2)**	NS	NS	NS	NS	NS	NS	NS
Forested	**Wet meadows**	NS	NS	NS	NS	NS	**P < 0,001**	NS
Totally forested	**Diverse**	**P < 0,001**	**P < 0,001**	NS	NS	NS	NS	**P < 0,001**
Totally forested	**Agriculture**	**P < 0,001**	**P < 0,05**	NS	NS	NS	**P < 0,05**	NS
Totally forested	**Agriculture - drained**	**P < 0,001**	**P < 0,01**	**P < 0,001**	**P < 0,001**	**P < 0,05**	**P < 0,001**	**P < 0,001**
Totally forested	**Forested (2)**	NS	NS	NS	NS	NS	NS	NS
Totally forested	**Wet meadows**	NS	NS	NS	NS	NS	**P < 0,01**	NS
Diverse	**Agriculture**	NS	NS	NS	NS	NS	NS	NS
Diverse	**Agriculture - drained**	**P < 0,001**	NS	**P < 0,001**	**P < 0,001**	**P < 0,05**	**P < 0,001**	**P < 0,05**
Diverse	**Forested (2)**	**P < 0,001**	**P < 0,05**	NS	NS	NS	NS	**P < 0,001**
Diverse	**Wet meadows**	**P < 0,01**	NS	NS	NS	NS	**P < 0,01**	**P < 0,01**
Agriculture	**Agriculture - drained**	**P < 0,001**	NS	**P < 0,001**	**P < 0,001**	**P < 0,05**	NS	**P < 0,01**
Agriculture	**Forested (2)**	**P < 0,001**	NS	NS	NS	NS	**P < 0,01**	NS
Agriculture	**Wet meadows**	NS	NS	NS	NS	NS	NS	NS
Agriculture - drained	**Forested (2)**	**P < 0,001**	NS	**P < 0,001**	**P < 0,001**	**P < 0,01**	**P < 0,001**	**P < 0,001**
Agriculture - drained	**Wet meadows**	**P < 0,001**	NS	**P < 0,001**	**P < 0,001**	**P < 0,05**	**P < 0,05**	**P < 0,001**
Forested (2)	**Wet meadows**	NS	NS	NS	NS	NS	**P < 0,001**	NS

Conclusion:

- temperature regime (average temperatures and amplitudes) is in the relationship with the losses of suspended and dissolved solids
- Dependance on land cover and water content/retention - key roles in distribution of energy fluxes and matter and nutrient flows
- Agriculture-drained x totally forested
- Sustainable management of landscape should integrate the aspect of closed water, matter and nutrient cycles.
- Higher temperature amplitudes results in turbulent fluxes decrease of evapotranspiration, drying-up of landscape, damage of vegetation, higher losses.
- Increase of temperature and matter losses could be efficiently controlled through closed water cycle which can be reached through maintenance and restoration of permanent vegetation into the landscape;

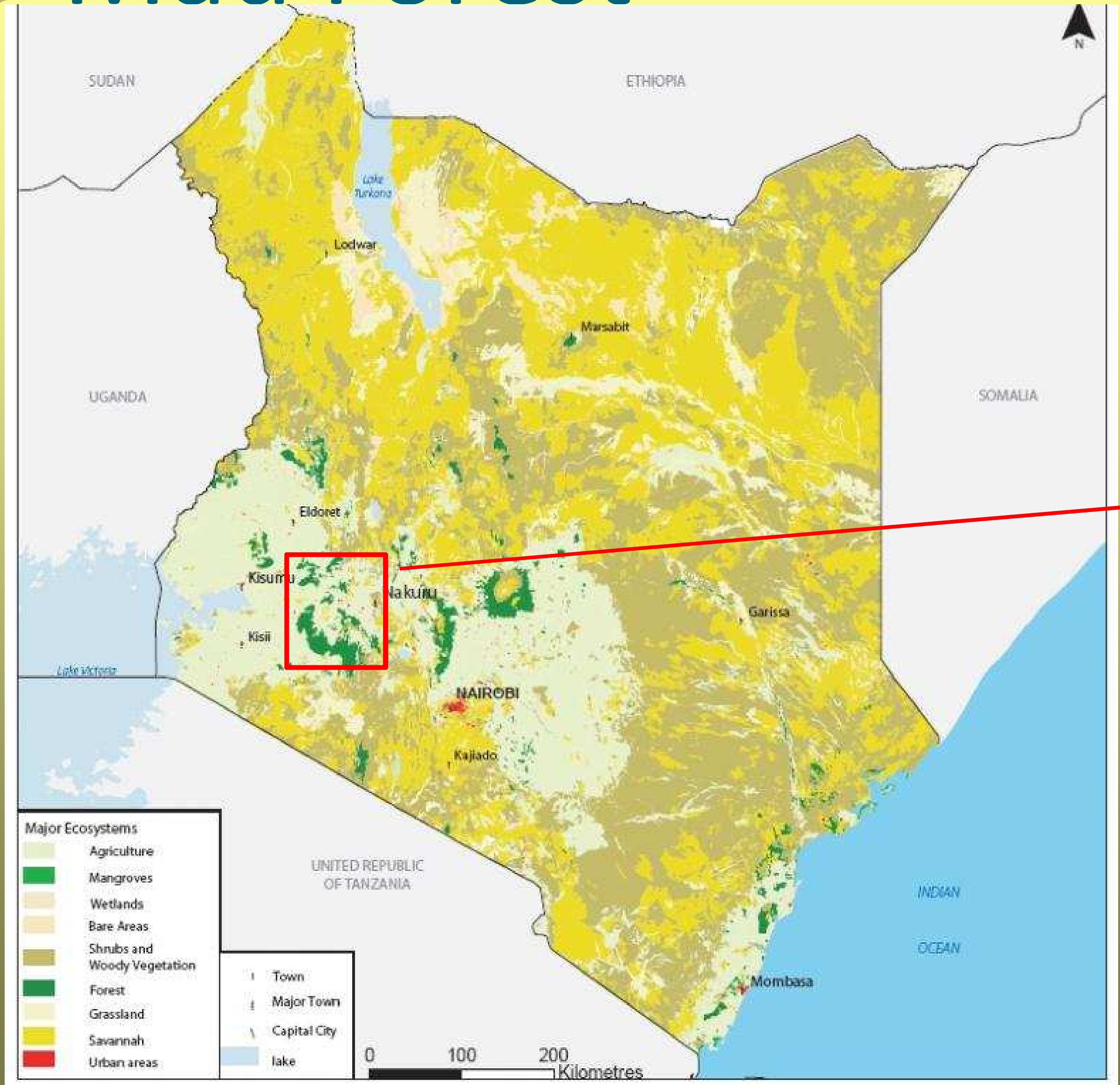
- That is how we can restore fundamental ecological functions of the landscape and simultaneously prevent climate changes.

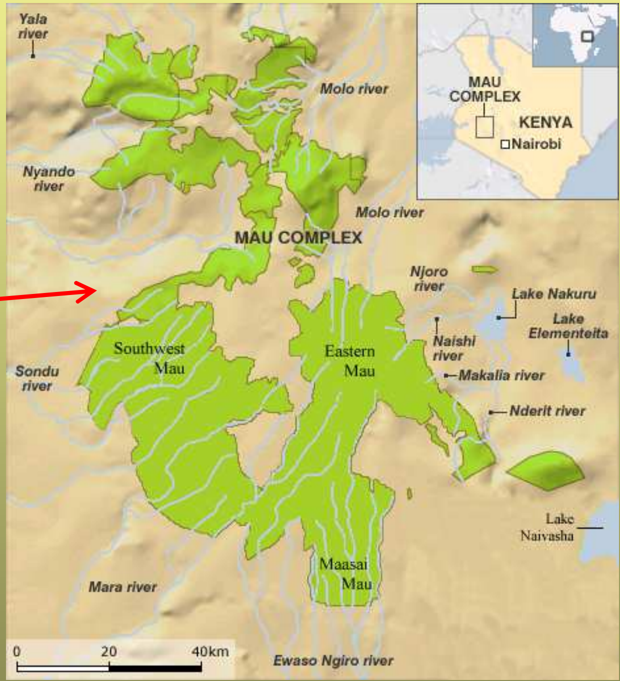


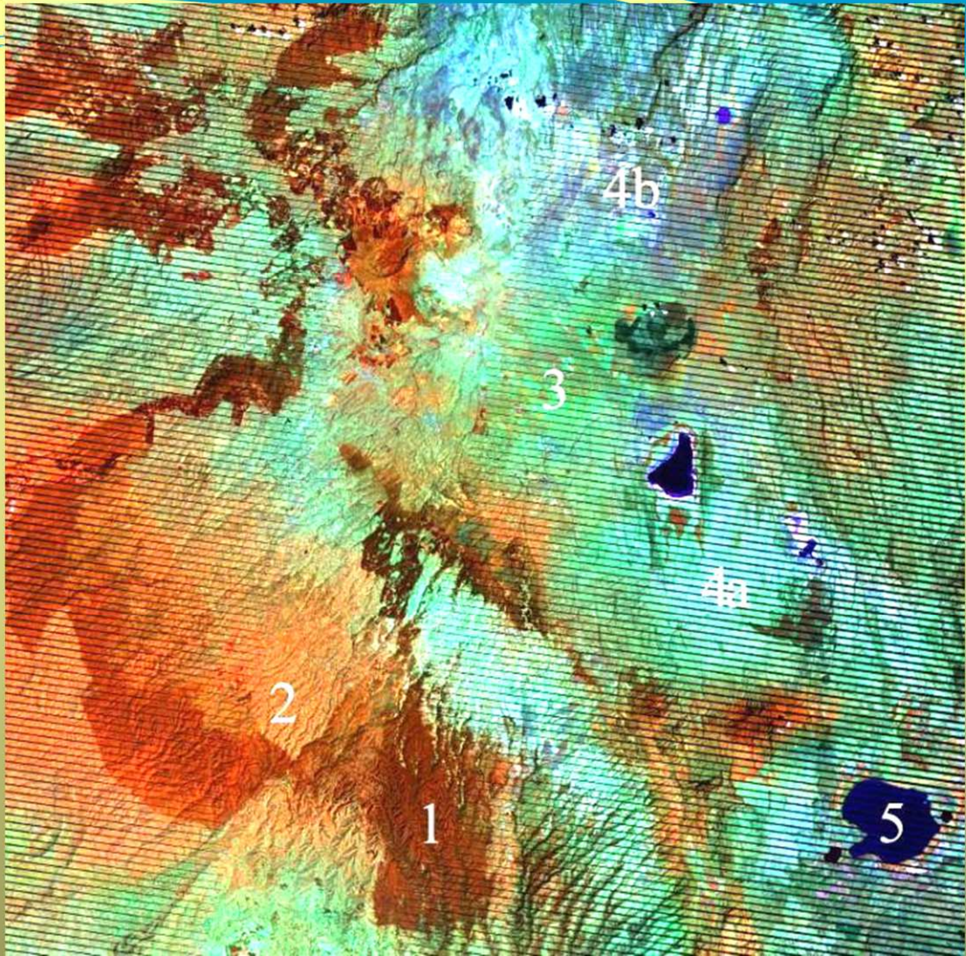
2. Study

Effect of land cover change on landscape temperature distribution. A case study of Mau forest in Kenya

Mau Forest

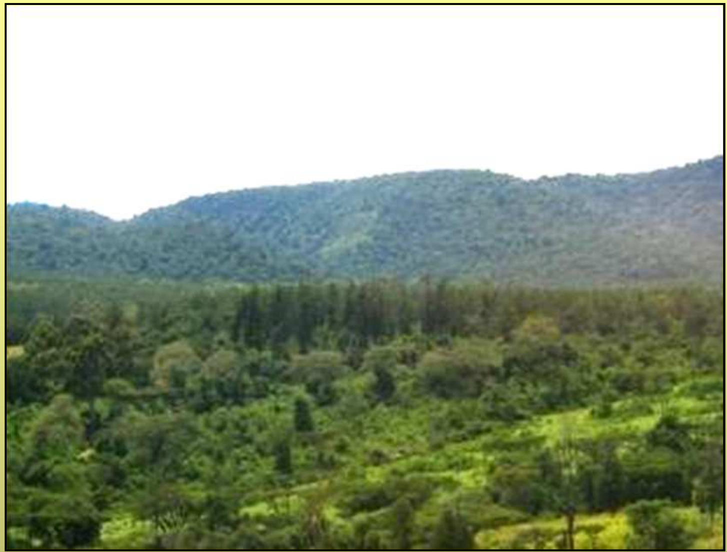

SUDAN
ETHIOPIA
UGANDA
SOMALIA
Lake Turkana
Lodwar
Marsabit
Eldoret
Kisumu
Nakuru
Kisii
Garissa
Lake Victoria
NAIROBI
Kajiado
Mombasa
UNITED REPUBLIC OF TANZANIA
INDIAN
OCEAN
N
Major Ecosystems
Agriculture
Mangroves
Wetlands
Bare Areas
Shrubs and Woody Vegetation
Forest
Grassland
Savannah
Urban areas
Town
Major Town
Capital City
lake
0
100
200
Kilometres


Yala river
Molo river
Nyando river
Molo river
MAU COMPLEX
Njoro river
Lake Nakuru
Lake Elementeita
Naishi river
Makalia river
Nderit river
Sondu river
Southwest Mau
Eastern Mau
Maasai Mau
Lake Naivasha
Mara river
Ewaso Ngiro river
0
20
40km
MAU COMPLEX
KENYA
Nairobi

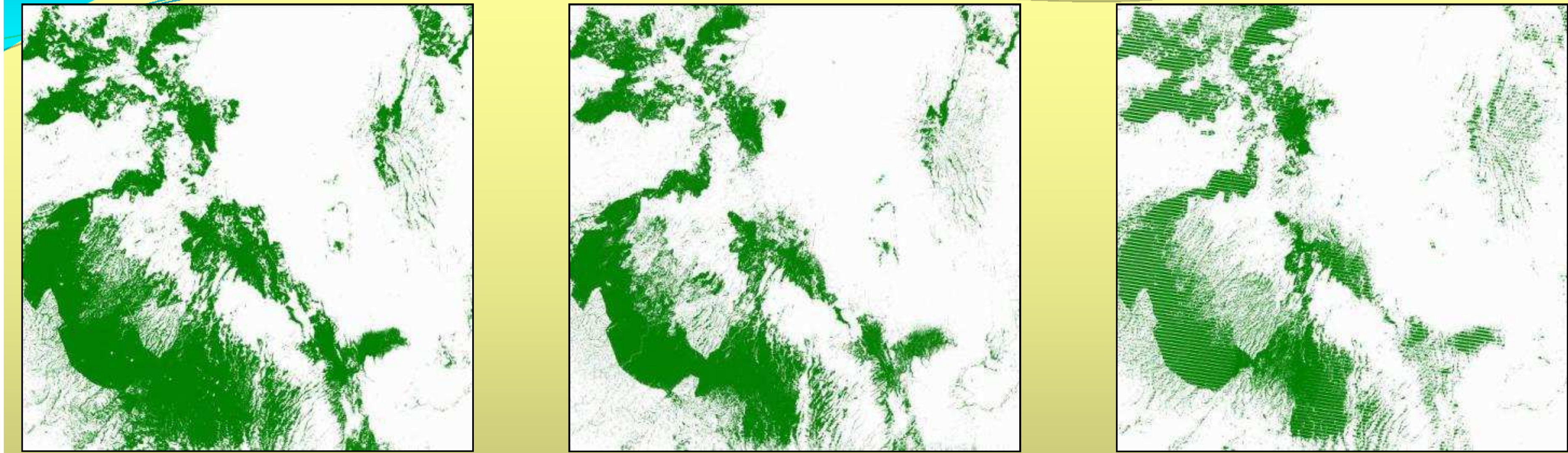


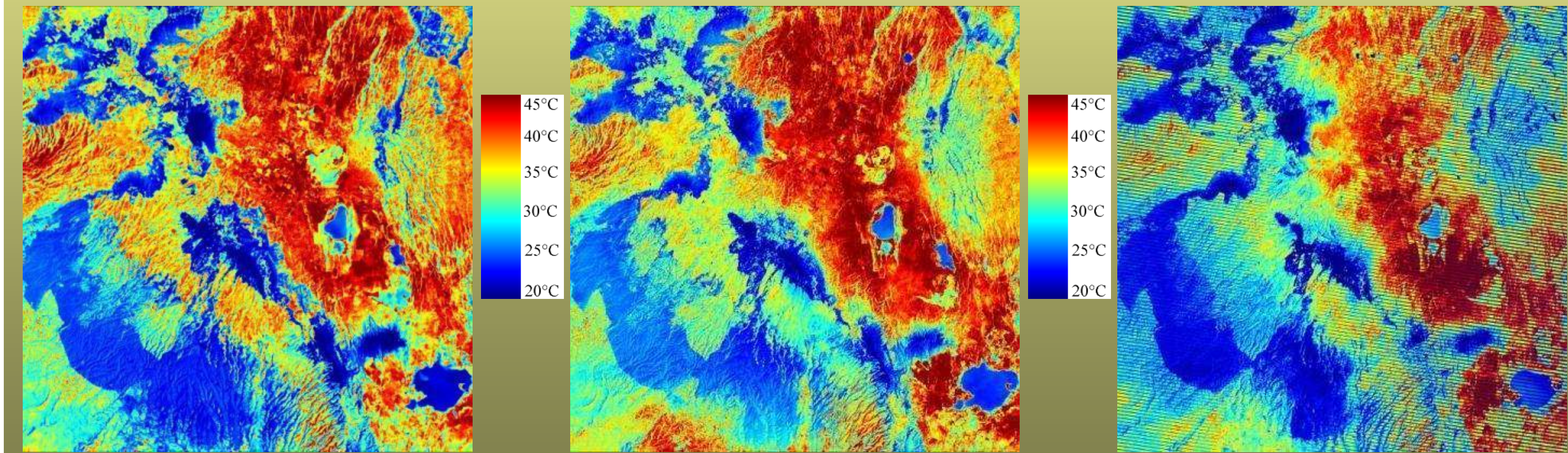
The extent of the forest in December 2009 can well detect the synthesis of the spectral channels of Landsat ETM +. The image is displayed in a false colour composition, since it contains mainly the near and mid infrared spectrum which are invisible for the human eye. Therefore, colours may not match the reality.

Colour image interpretation is as follows: 1 - dense, humid forest, 2 - Forest area converted to farmland with the remnants of forest, or plantations; 3 - dry non-forest vegetation, 4a, b – bare surfaces; 5 – lakes (water)

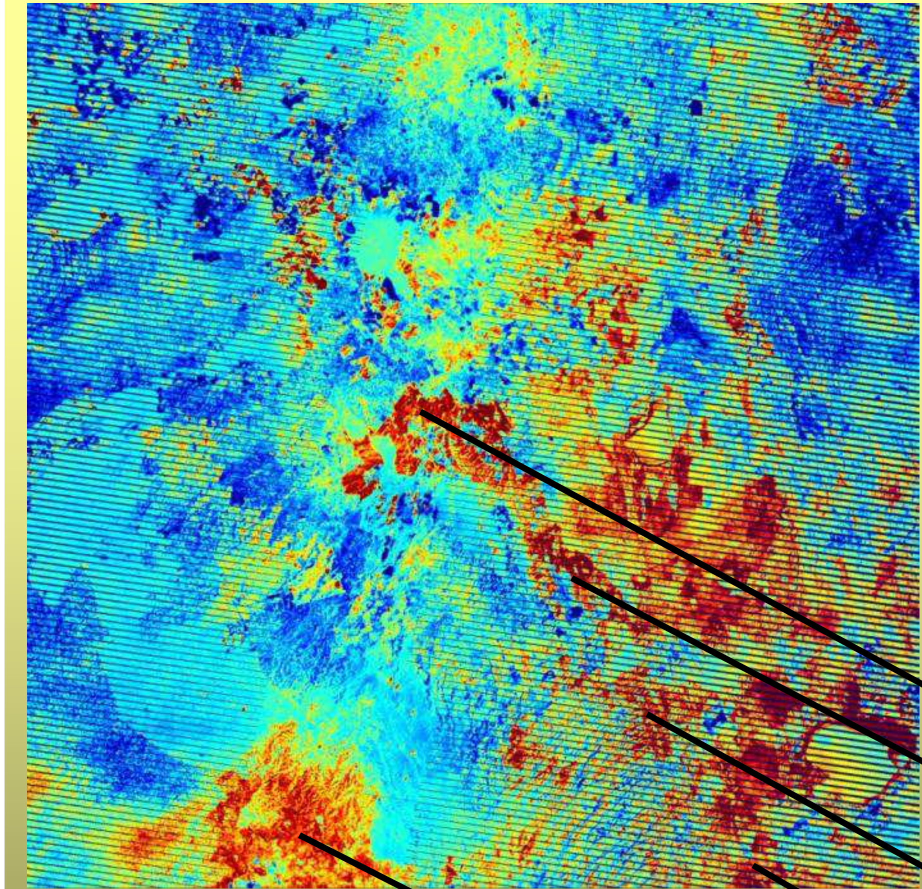



Figures show the extent of the Mau forest in the years 1986 (a), 2000 (b) and 2009 (c). The central part (Eastern Mau) and the eastern part of Maasai Mau are the areas, most affected by deforestation.

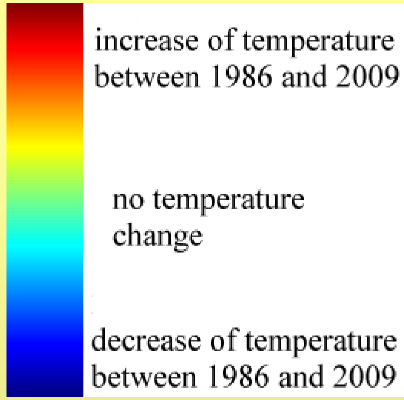


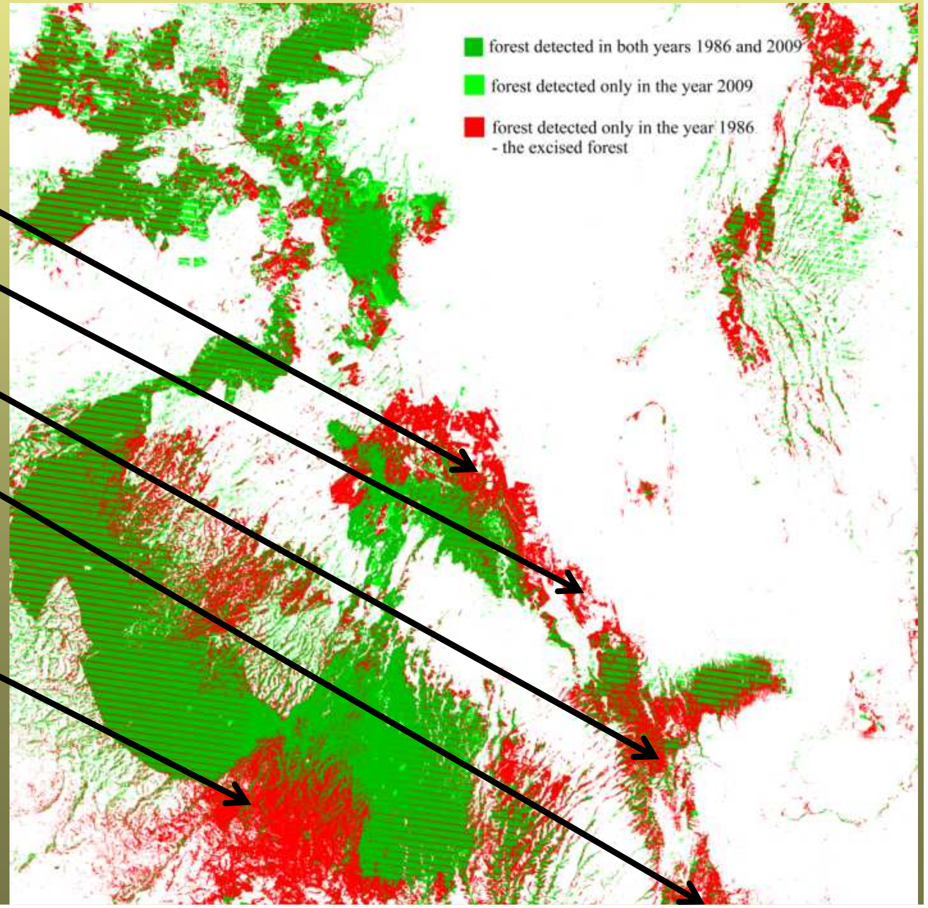


Land surface temperature distribution in the years 1986 (a), 2000 (b) and 2009 (c). The comparison with the figures above, confirms the forest belong to the coldest areas within the landscape. The temperature differences may reach even 30°C at very short distances.



Forest area covered in
1986 400 000 ha
2000 345 000 ha
2009 270 000 ha





Red – clear cuts between 1986 - 2009
Green –increase of forest area (plantation forests)
Yellow – no forest area change between 1986 and 2009

There are different greens in the landscape…

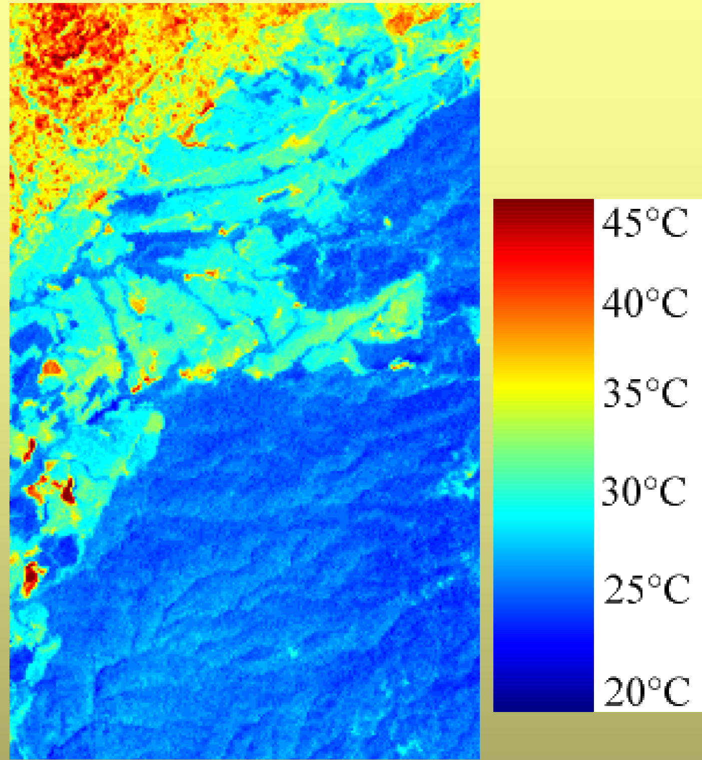
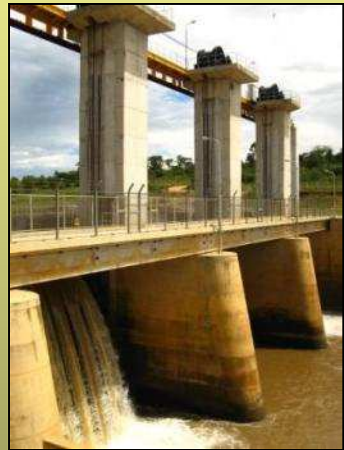


Figure (on left) is the RGB colour synthesis of Landsat ETM + channels 4-5-3 displaying different land cover types in the Kericho region (west edge of the image) in the year 2000. The scene size is 19 x 12 km. Bright and homogeneous red colour, caused by very high chlorophyll content is typical of the tea plantations; dark and light brown indicates rain forest; the patch of green display a farmland.

Figure (on right) shows temperature differences between the three different vegetation types in the same region. Despite having the highest amount of chlorophyll (being the greenest), the temperature of tea plantations ranges between 30 – 35 °C, that is more than in case of forest. The highest temperature is characteristic for the crops (35 – 45°C), depending on the crop cover, type, wetness, and other factors. This fact shows that the surface temperature depends on the type of land cover and confirms forests as the coldest landscape segments.







… few numbers

- consider air at temperature 25 ° C contains approx. 22 grams/ m^3; at 40 ° C has a doubled capacity (50 g / m^3)
- Deforestation and the consequent rise of temperature lead to a transport of warm and relatively dry air into the upper atmosphere
- Hot air = higher capacity to suck up water = the transport of water vapour by the overheated air out of short water cycle
- Decrease in evapotranspiration of about 2 mm/ km2/day = decrease in evaporation of 2 000 000 litres
- To evaporate 1 liter we need 0,7 kWh (2 500kJ)
- Latent heat of vaporisation of 2 000 000 litres of water = 1.4 million kWh
- If there is no water = no latent heat - release of 1.4 million kWh of sensible heat/ day

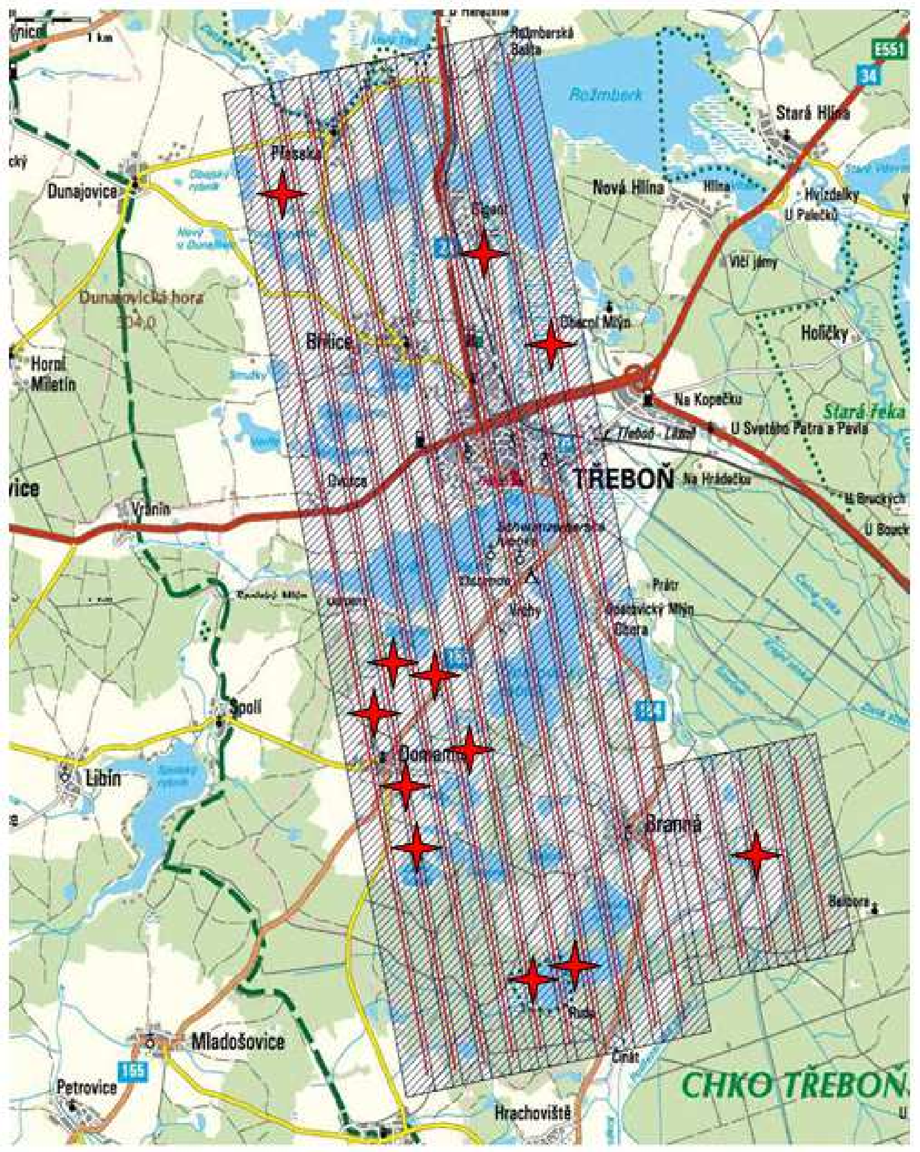
- The Mau Forest complex has lost 1800 km^2 in 23 years

- This means 2,6 billion kWh released from this area a day

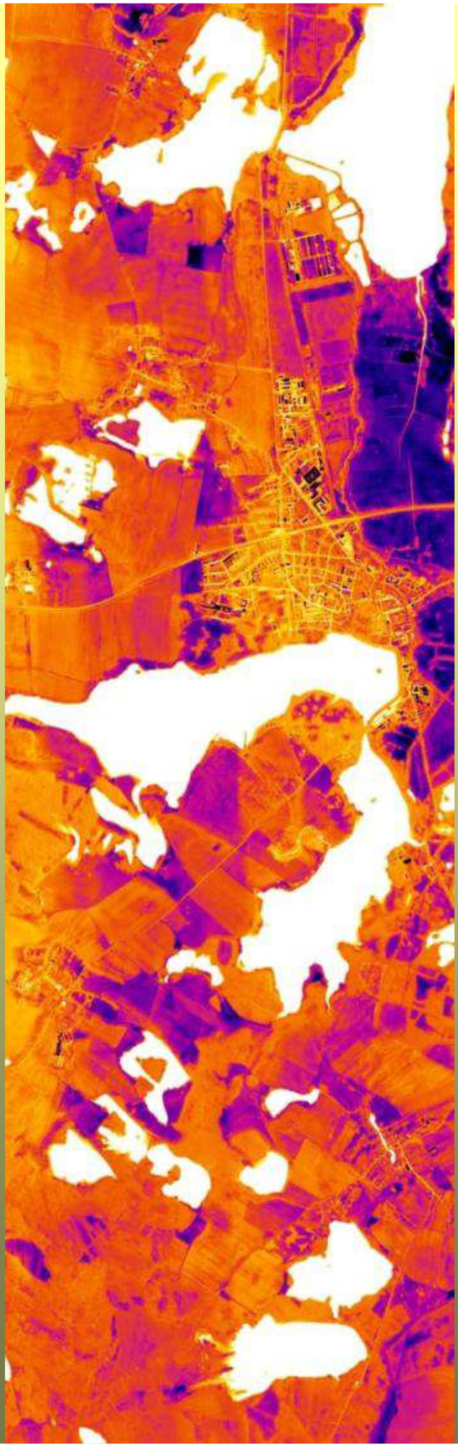
- For comparison, a quarterly production of the well-known Czech nuclear power plant Temelin (2000 MW) in 2012 was 4,4 billion kWh

II. Aerial thermovision scanning

Area of interest



29. 7. 2008
12 axis of flight x 235 images

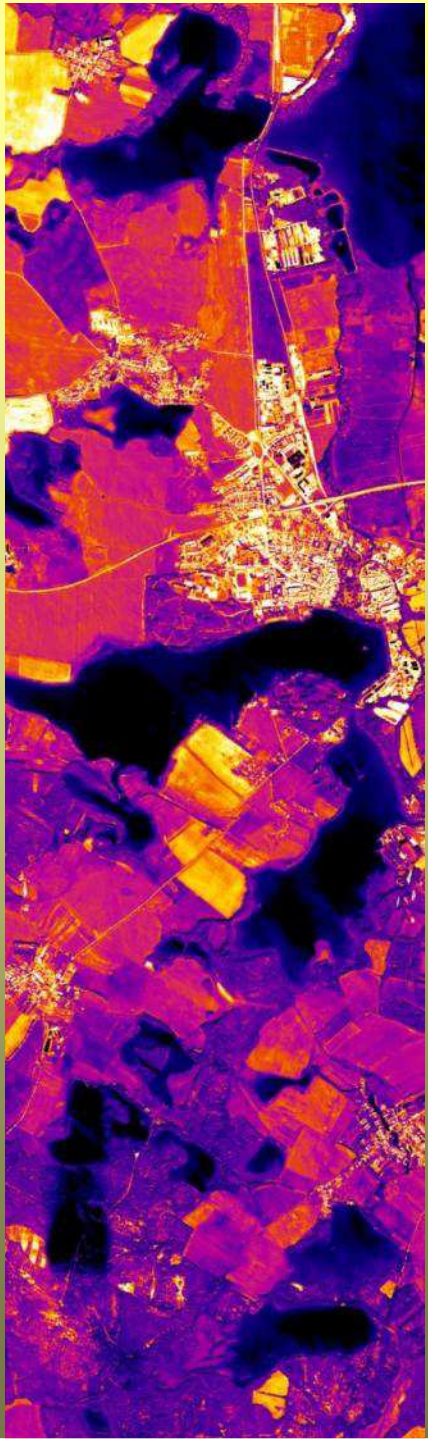


• daily surface temperature dynamics of different biotopes

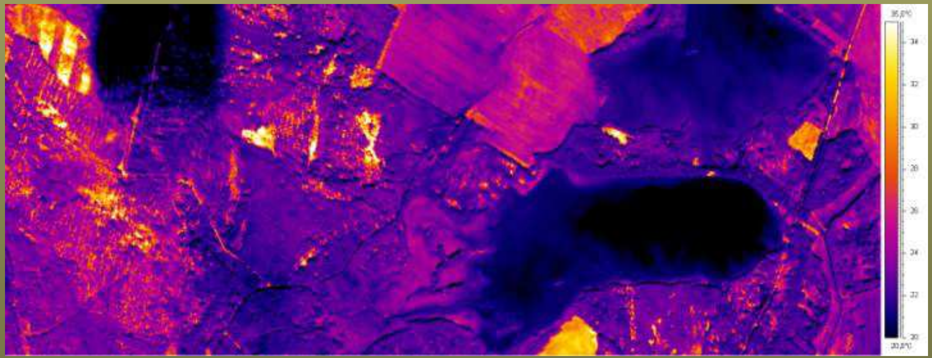
• calculation of evapotranspiration

• calculation of radiation and energy balance and fluxes

•Network of screens

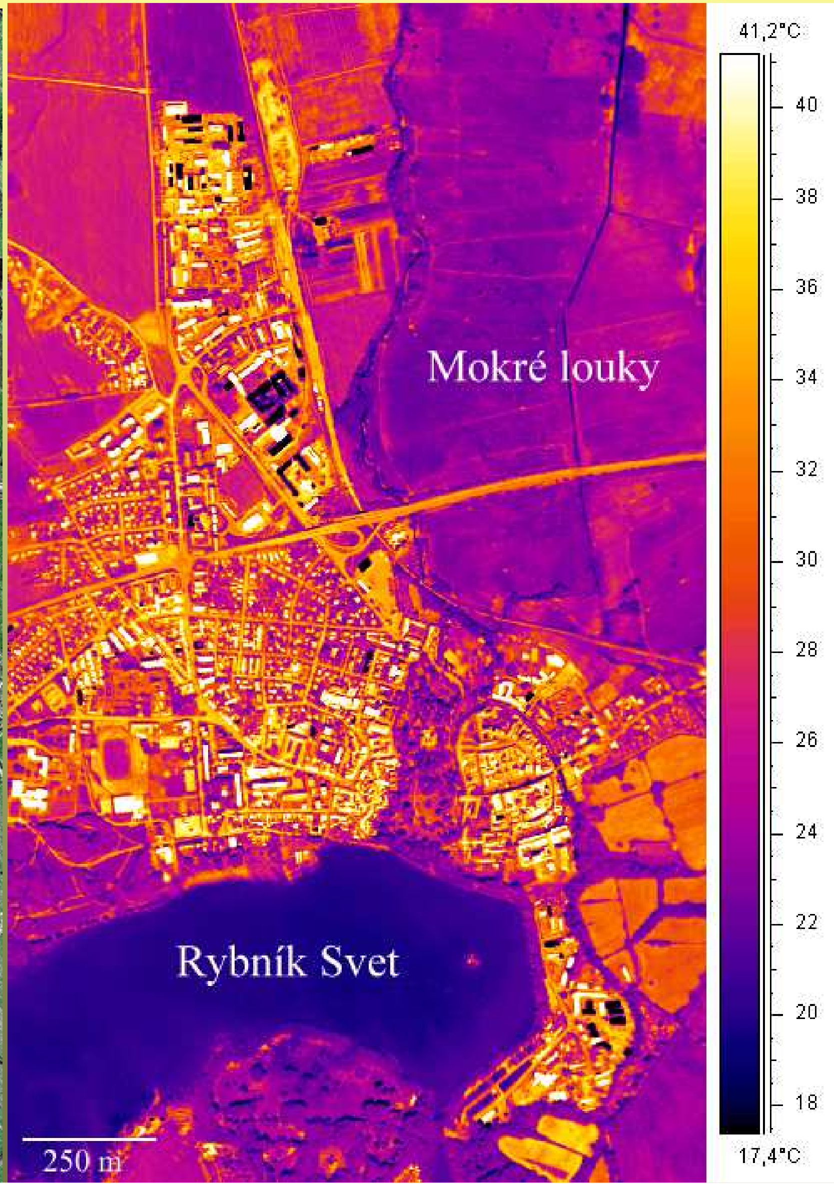


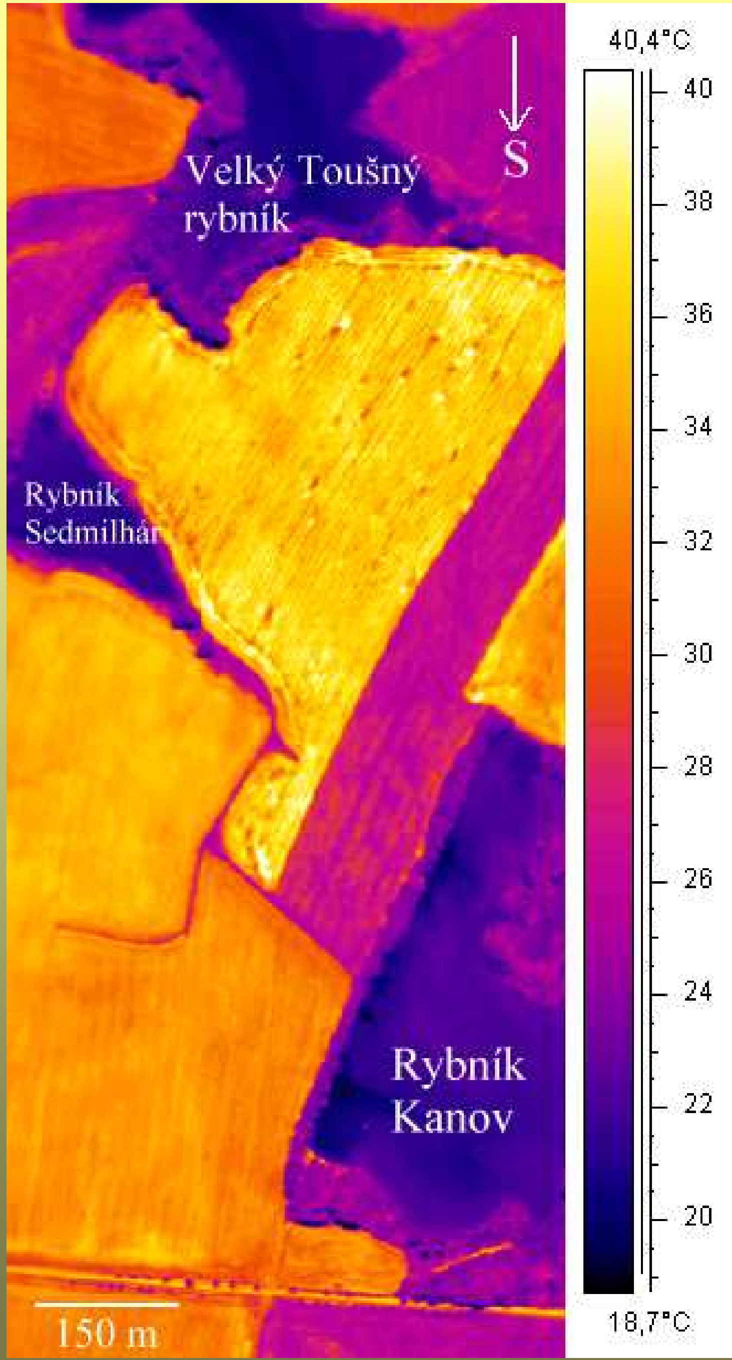
Forest damage caused by
the huricane Kyrill January 2007

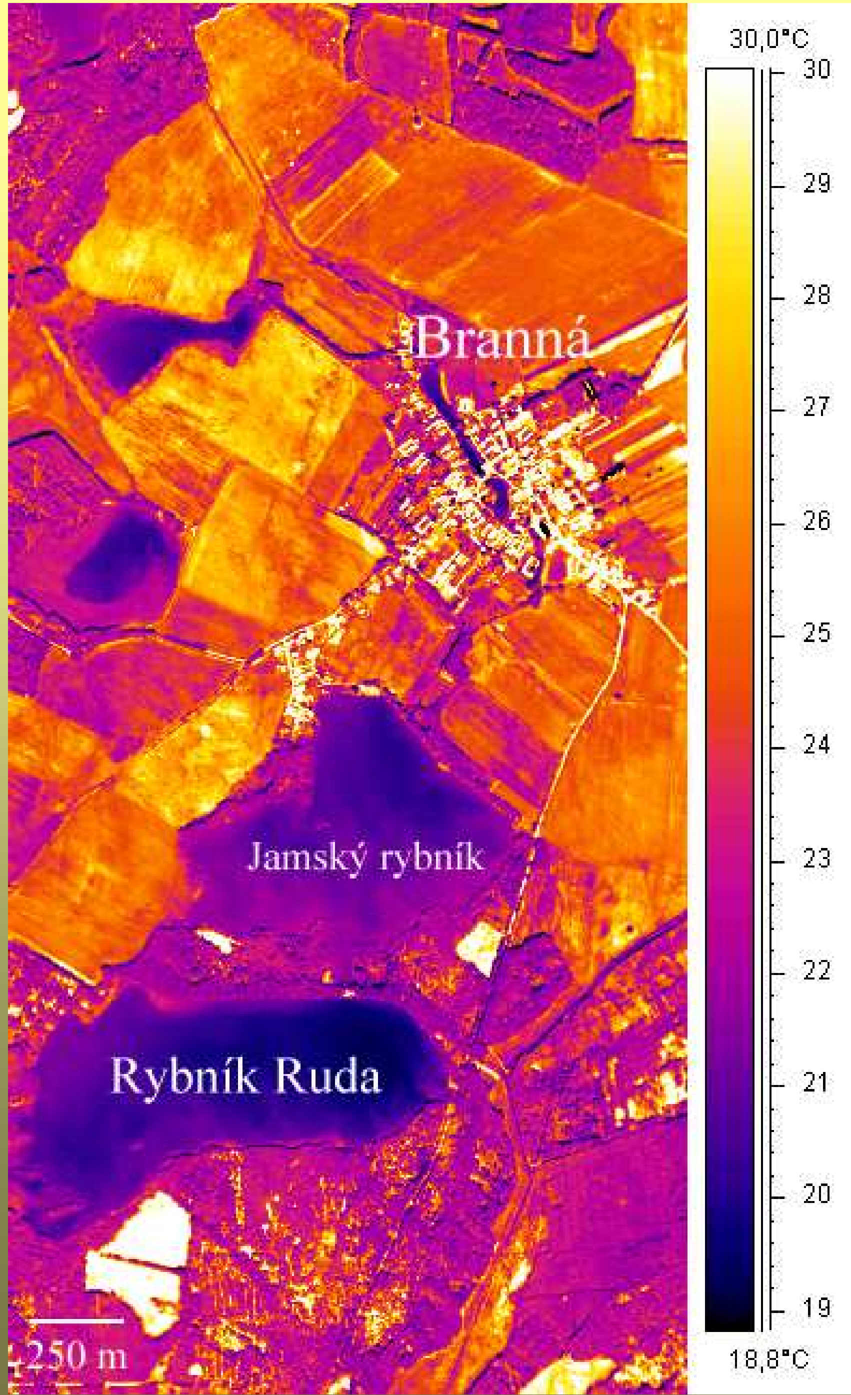


Aerial thermovision monitoring

Data from thermography system FLIR ThermaCam S65.
Aerial photographs aquisited on 29.7.2008 (11a.m.),
2m spatial resolution

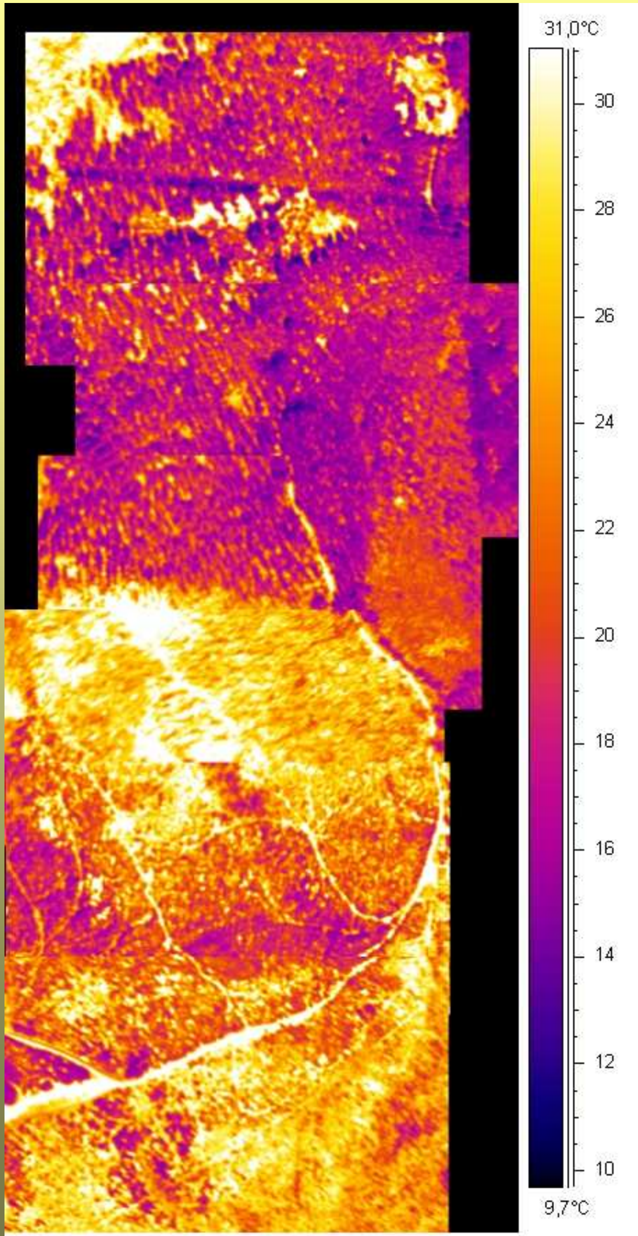


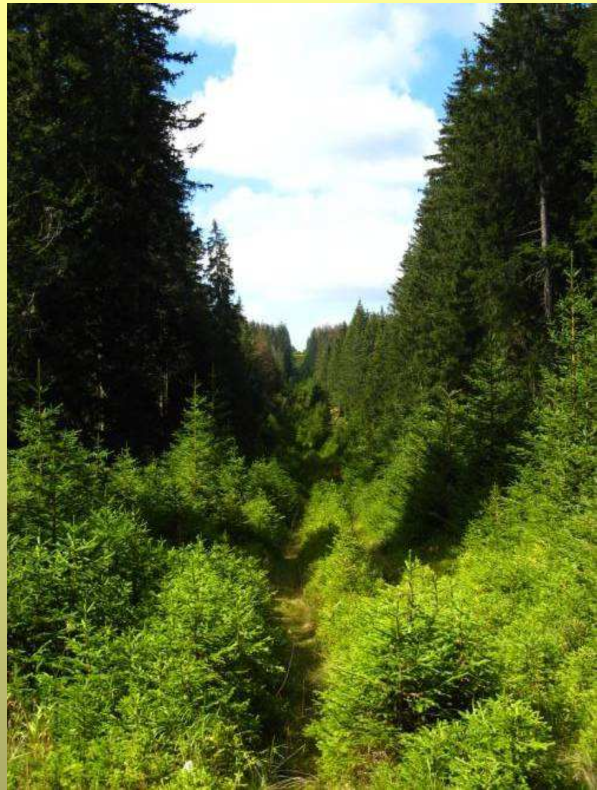

S
Velký Toušný rybník
Rybník Sedmilhár
Rybník Kanov
150 m
40,4°C
40
38
36
34
32
30
28
26
24
22
20
18,7°C



Branná
Jamský rybník
Rybník Ruda
250 m
30,0°C
30
29
28
27
26
25
24
23
22
21
20
19
18,8°C

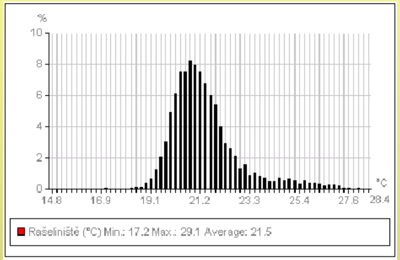
Monitoring of bark beetle calamity – Šumava NP

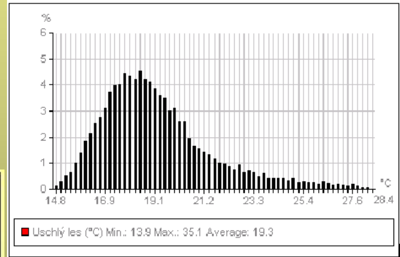


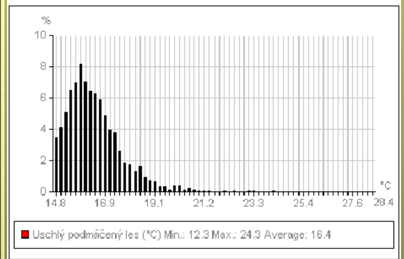


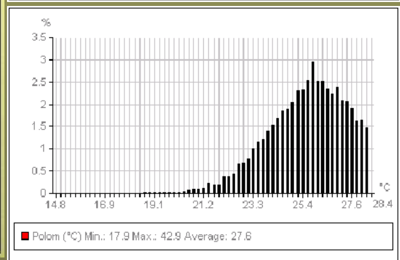

Polom po orkánu Kyrill

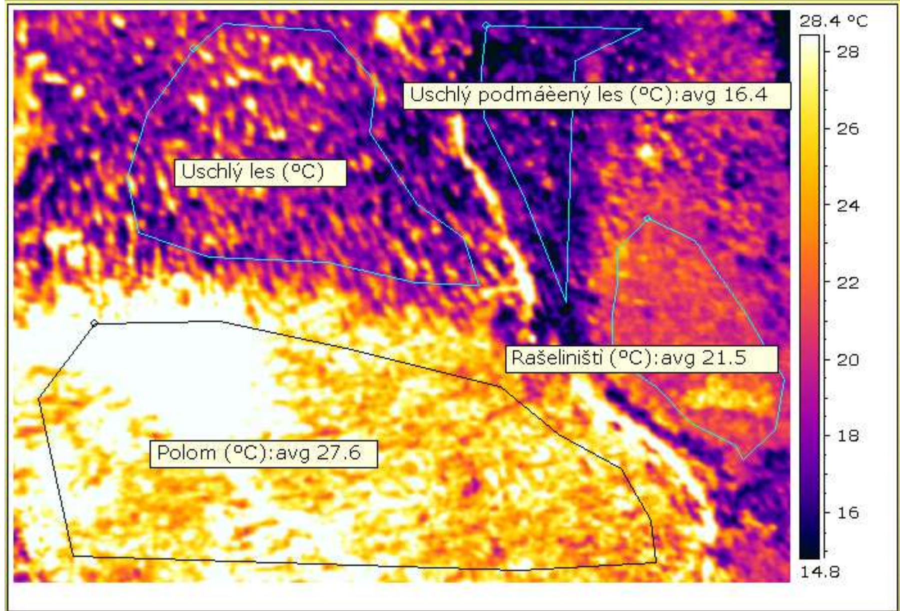

Černá hora
1315
hora
Pramen Vltavy
- I. zóna
1295
pramen Vltavy
Pramen Vltavy
Stráž
1308
Pod Stráží
U Pramene Vltavy
Siebensteinkopf
1258
Siebensteinkopf
ká vyhl.

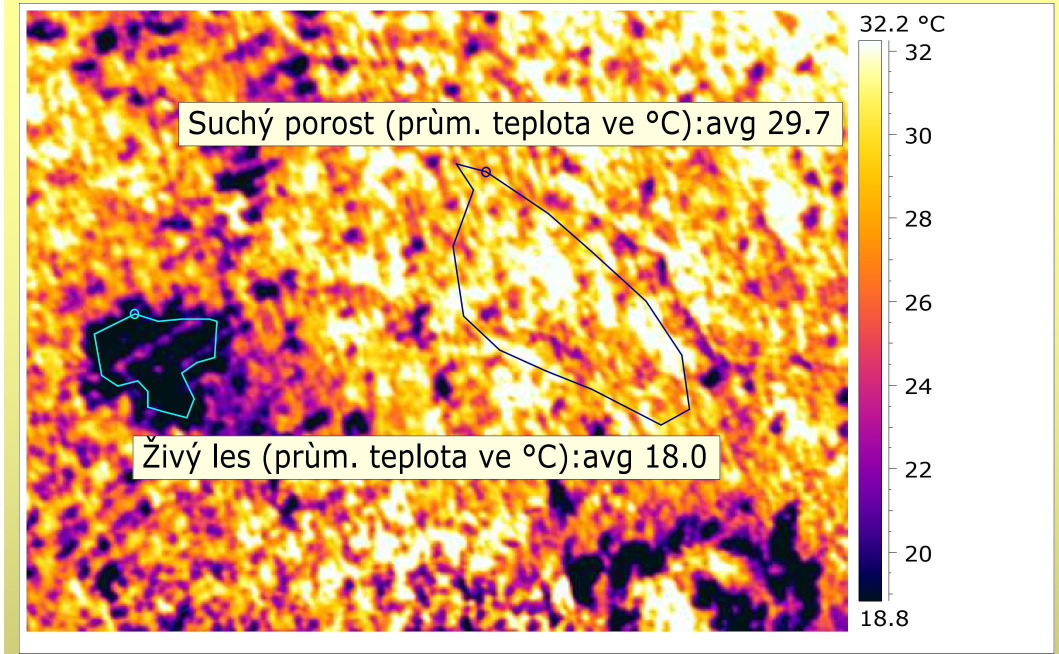

%
10
8
6
4
2
0
14.8
16.9
19.1
21.2
23.3
25.4
27.6
28.4
°C
Rašeliniště (°C) Min.: 17.2 Max.: 29.1 Average: 21.5


%
6
5
4
3
2
1
0
14.8
16.9
19.1
21.2
23.3
25.4
27.6
28.4
°C
Uschlý les (°C) Min.: 13.9 Max.: 35.1 Average: 19.3

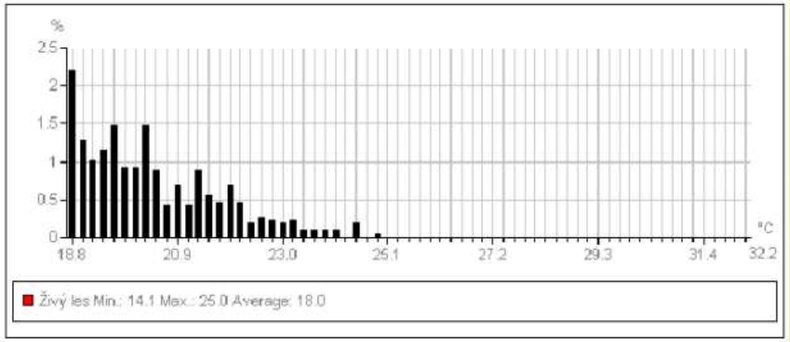

%
10
8
6
4
2
0
14.8
16.9
19.1
21.2
23.3
25.4
27.6
28.4
°C
Uschlý podmáčený les (°C) Min.: 12.3 Max.: 24.3 Average: 16.4


%
3.5
3
2.5
2
1.5
1
0.5
0
14.8
16.9
19.1
21.2
23.3
25.4
27.6
28.4
°C
Polom (°C) Min.: 17.9 Max.: 42.9 Average: 27.6

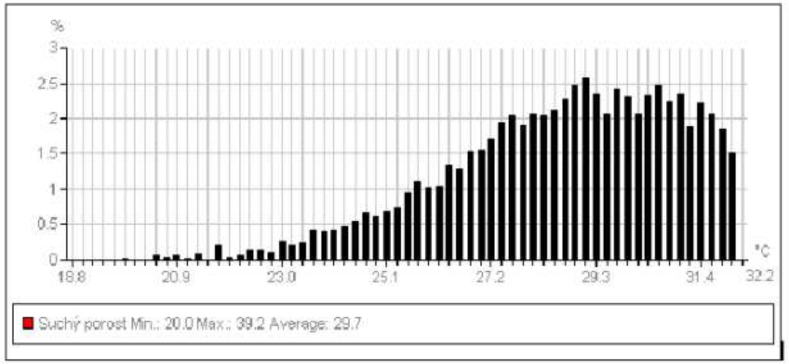

28.4 °C
28
26
24
22
20
18
16
14.8
Uschlý podmáèený les (°C):avg 16.4
Uschlý les (°C)
Rašeliništì (°C):avg 21.5
Polom (°C):avg 27.6



32.2 °C
32
30
28
26
24
22
20
18.8
Suchý porost (prùm. teplota ve °C):avg 29.7
Živý les (prùm. teplota ve °C):avg 18.0



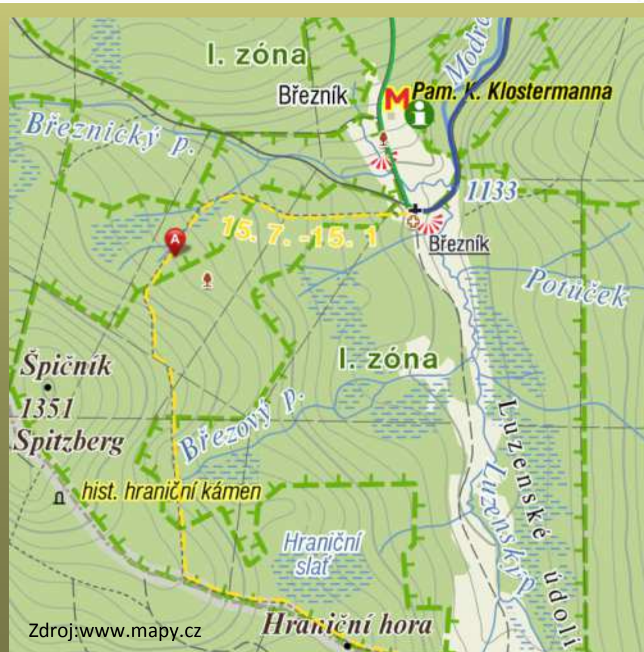
%
2.5
2
1.5
1
0.5
0
°C
18.8
20.9
23.0
25.1
27.2
29.3
31.4
32.2
Živý les Min.: 14.1 Max.: 25.0 Average: 18.0



%
3
2.5
2
1.5
1
0.5
0
°C
18.8
20.9
23.0
25.1
27.2
29.3
31.4
32.2
Suchý porost Min.: 20.0 Max.: 39.2 Average: 29.7

Suchý les
Živý les
Zdroj:www.mapy.cz

Lokalizace termovizního snímku



I. zóna
Březník
Pam. K. Klostermanna
Modrý
Březnický p.
1133
15. 7. -15. 1
Březník
Potůček
Špičník
1351
Spitzberg
I. zóna
Březový p.
Luzenské údolí
Luzenský p.
hist. hraniční kámen
Hraniční slať
Hraniční hora
Zdroj:www.mapy.cz

III. Airship thermal scaniing

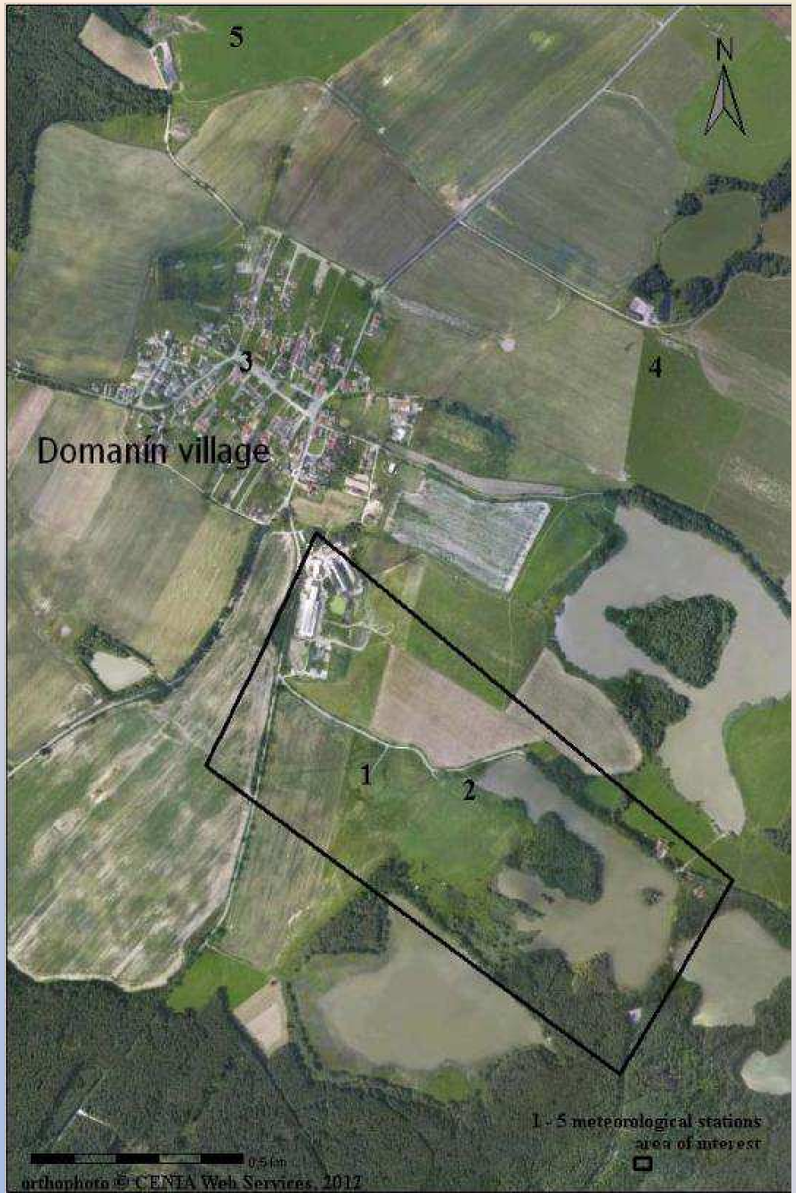
Daily dynamics of radiation surface temperature of different land cover types in a temperate cultural landscape

- to record the differences in **spatial and temporal dynamics of *surface temperature T_s* during a hot summer day** in a diverse cultural landscape

- What is the **relation between the *surface temperature T_s*** daily dynamics **and the *air temperature T_a*,** i.e. one of the main climate indicators?

surface temperature T_s = radiation temperature; emitted energy, **manifestation of the object´s state**; measured by the systems detecting radiation reflected or emitted in the thermal part of the electromagnetic spectrum (commonly in 7 – 14 µm); reflects the surface characteristics ; interacts with biosphere

air temperature T_a = kinetic temperature; is an internal manifestation of the average translational energy of the molecules constituing a body; measured in a screen (2 meters above the ground) by a standardized method, the **purpose of which is to minimize the effect of surface characteristics** on the measured T_a

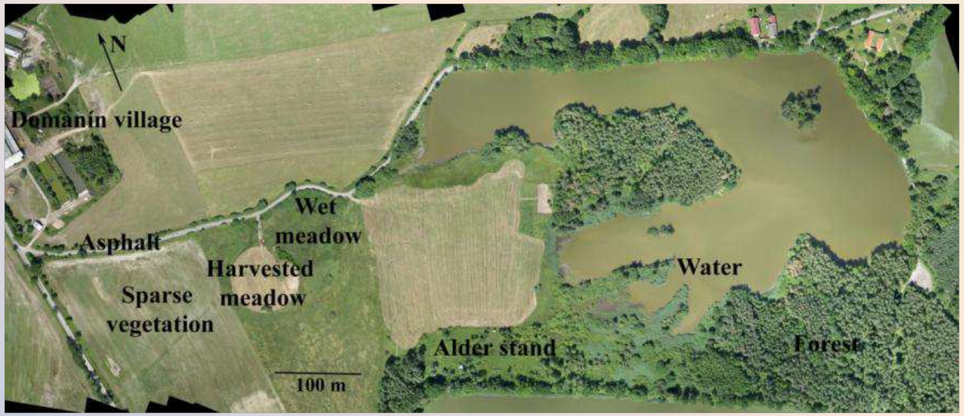


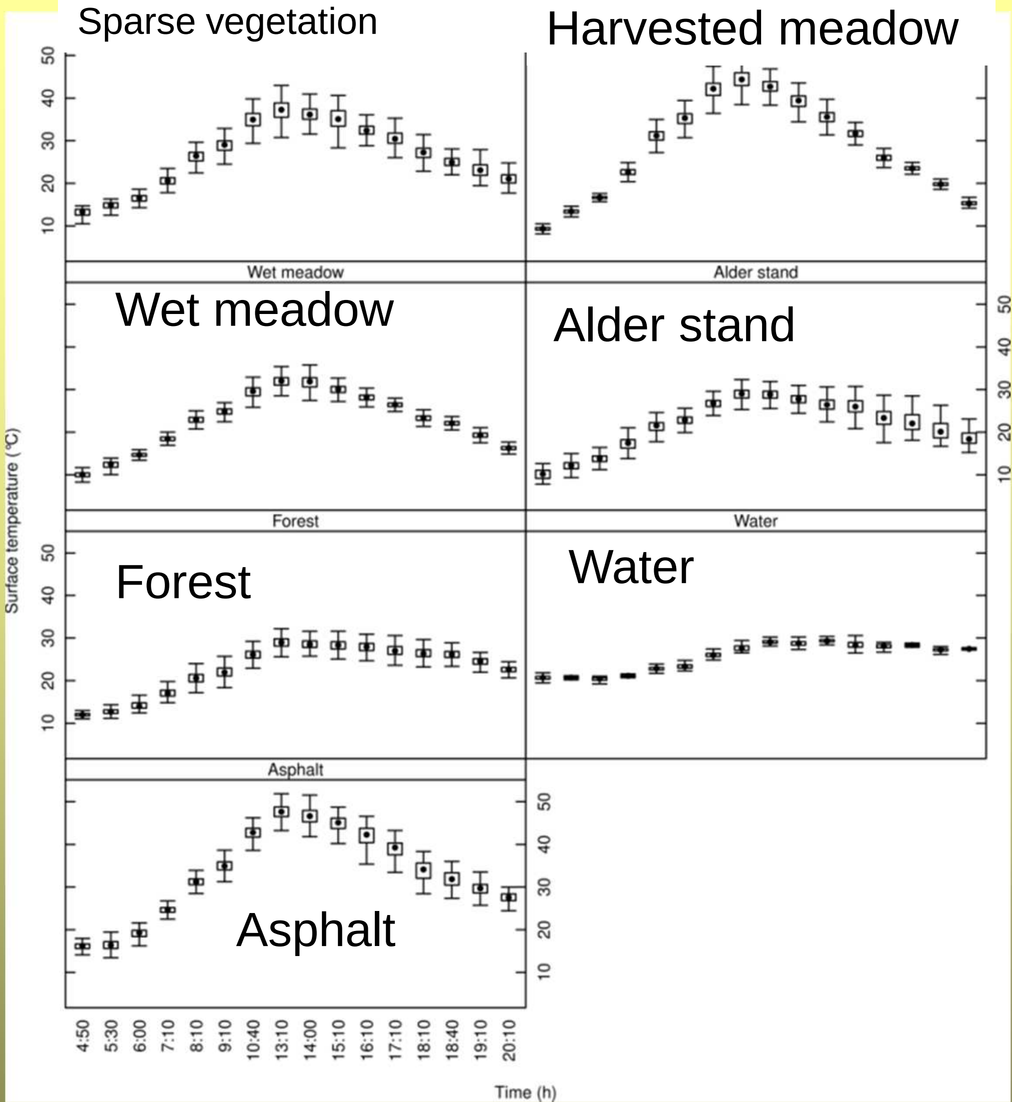
Airship Club, s.r.o.

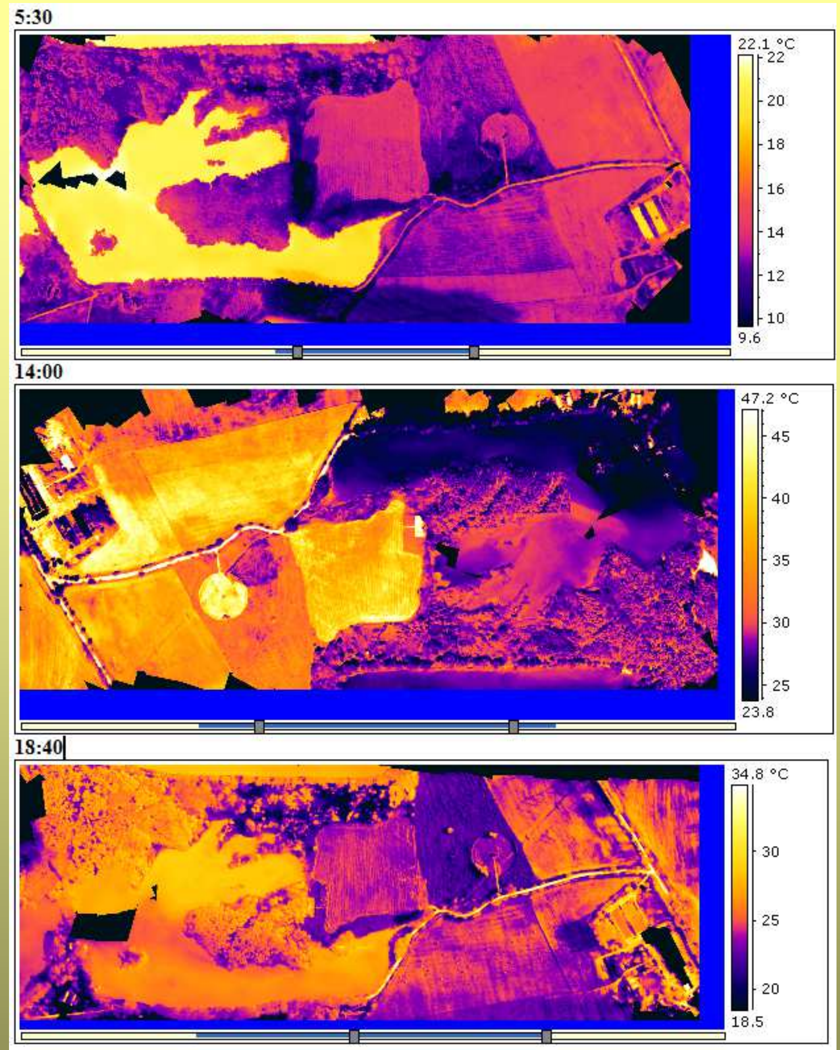
• 9 July 2009 vicinity of Třeboň

•16 scanning times / day in 2-3 hour interval (4:30 – 19:20 GMT + 1)
•5 screens

•Hight of flight 250 m
•Spatial resolution 30 cm
•Sampling area 1000 (pixelů)– wet meadow, harvested meadow, alder stand, forest, sparse vegetation, fishpond, asphalt







Daily courses of *surface temperature*

Daily courses of T_s of the studied localities. Each point is calculated from 1000 randomly selected pixel values. Points describe the median of the data, boxes are lower and upper quartiles and whiskers show 1.5 times of inter-quartile range of the data or maximum and minimum values if extremes did not occur. Extreme values are not shown in the graph.

Table Mean surface temperature (T_s) characteristics measured by the thermal camera from 4:50 to 20:10 in sixteen scanning times. T_{smin} temperature minimum, T_{smax} temperature maximum, D_s temperature difference, T_{savrg} mean temperature, SD_{sd} surface temperature variability throughout the day

Locality	T_{smin}	T_{smax}	D_s	T_{savrg}	SD_{sd}
HM	9.3	44.2	34.8	28.0	10.98
WM	10.0	31.9	21.9	22.6	6.78
AS	10.1	28.9	18.8	21.7	5.95
F	12.0	29.0	17.0	22.8	5.77
SV	13.2	37.2	24.0	26.4	7.70
W	20.4	29.3	8.9	25.6	3.41
A	16.1	47.6	31.4	33.0	10.19

HM – harvested meadow, **WM** – wet meadow, **AS** – alder stand, **F** – forest, **SV** – sparse vegetation, **W** – water, **A** - asphalt

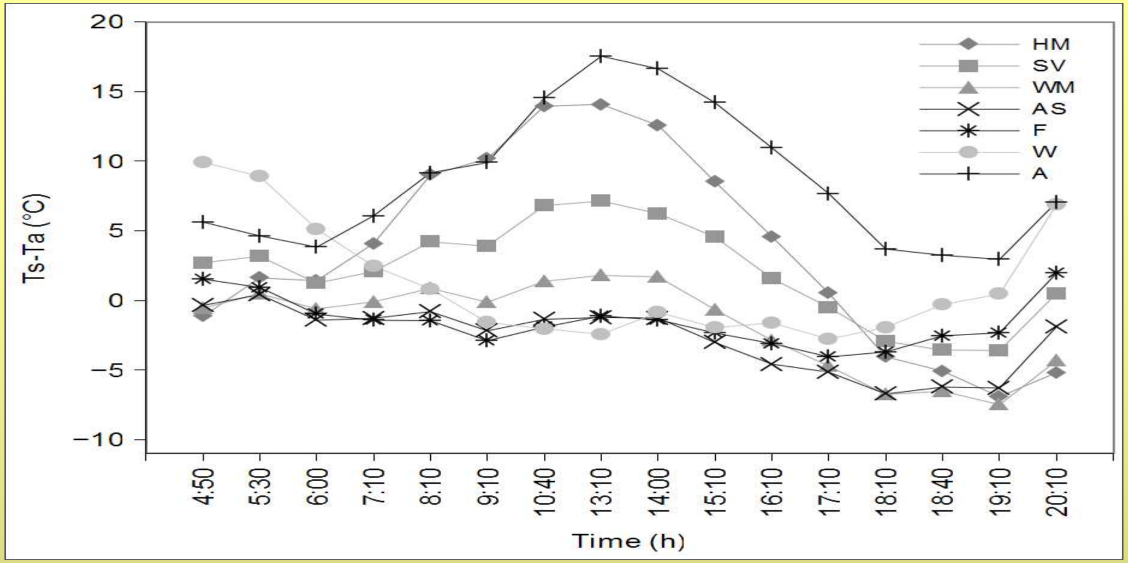


Figure Differences between Ts and Ta at 2m above ground.

Table Differences between Ts and Ta at 2m above ground. *Negative values – Ts is lower than Ta, positive (red) values – Ts is higher than Ta*

	Air temperature	**Difference of mean surface temperature (T_s) of the localities (remote sensing) [°C]**						
Time	**Mean T_a at 2m [°C]**	**Harvested meadow**	**Wet meadow**	**Alder stand**	**Forest**	**Sparse vegetation**	**Water**	**Asphalt**
4:50	10.5	-1.15	-0.55	-0.37	1.52	2.70	9.92	5.62
5:30	11.8	1.61	0.47	0.42	0.93	3.16	8.90	4.63
6:00	15.2	1.41	-0.61	-1.43	-0.99	1.23	5.12	3.82
7:10	18.5	4.08	-0.11	-1.29	-1.43	2.07	2.45	6.07
8:10	22.0	9.00	0.86	-0.81	-1.46	4.20	0.82	9.16
9:10	25.0	10.17	-0.14	-2.19	-2.90	3.89	-1.59	9.89
10:40	28.0	13.94	1.37	-1.36	-1.92	6.80	-2.04	14.52
13:10	30.1	14.07	1.79	-1.23	-1.13	7.13	-2.44	17.53
14:00	30.0	12.57	1.69	-1.27	-1.39	6.23	-0.86	16.63
15:10	30.7	8.51	-0.67	-3.03	-2.35	4.55	-1.96	14.19
16:10	31.0	4.58	-2.87	-4.58	-3.10	1.57	-1.62	10.95
17:10	31.1	0.51	-4.72	-5.16	-4.06	-0.50	-2.78	7.66
18:10	30.1	-4.05	-6.76	-6.72	-3.71	-2.95	-1.94	3.68
18:40	28.6	-5.08	-6.52	-6.23	-2.54	-3.57	-0.30	3.24
19:10	26.7	-6.92	-7.49	-6.29	-2.34	-3.60	0.45	2.94
20:10	20.6	-5.19	-4.33	-1.90	1.95	0.49	6.87	7.05

Effect of drainage on surface temperature is not reflected by standard method (air T at 2m)

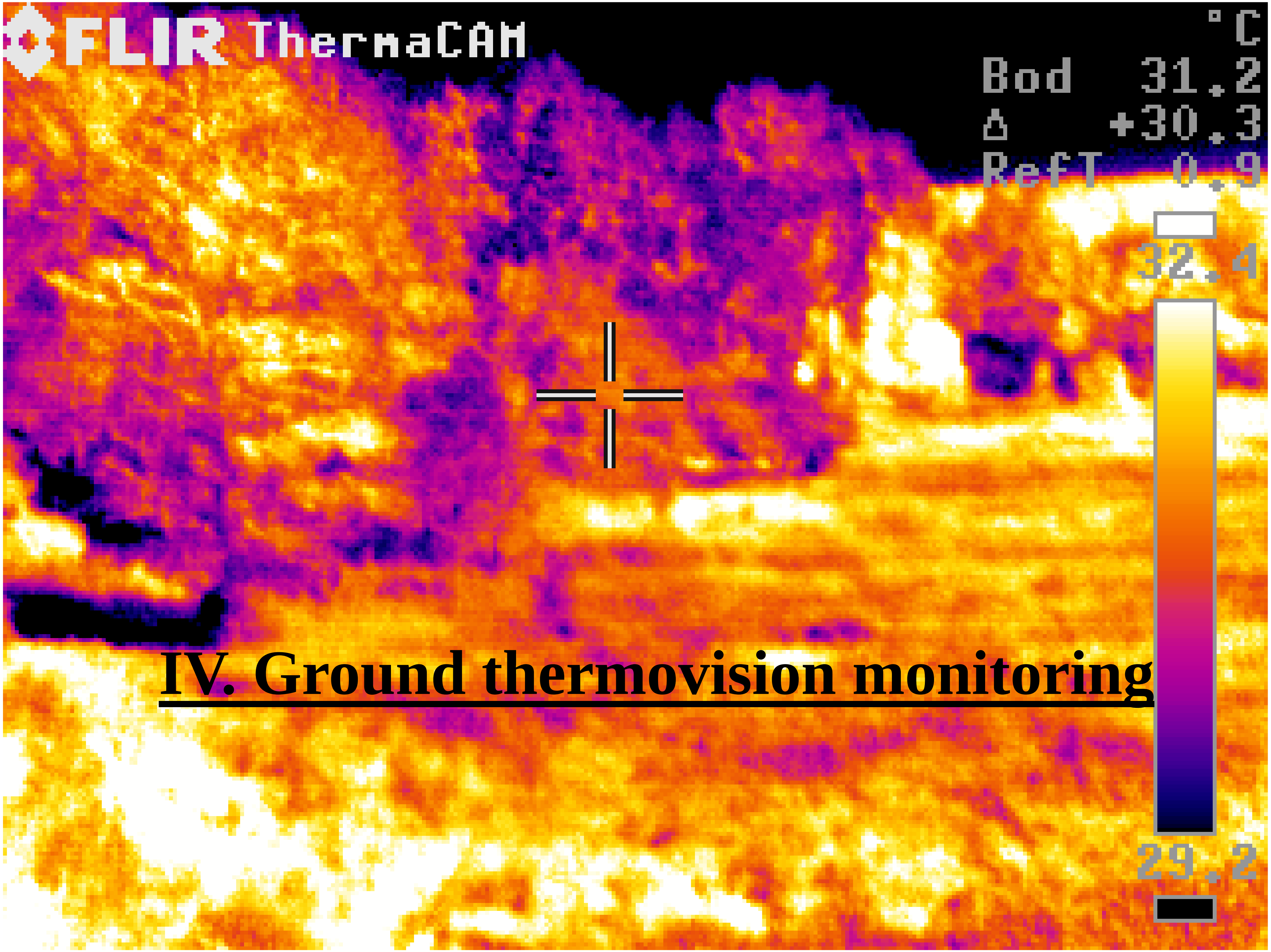
- Maximum surface temperature of forest (**29.0 °C**), **water (29.3 °C)** **wet meadow (31.9 °C)** differ evidently from **asphalt (47.6 °C)** and **harvested meadow (44.2 °C).**

- Maximum surface temperature of dry surfaces (asphalt, harvested meadow) are **significantly higher (up to 17 °C) than** their **air temperature measured at 2m height in a screen.**

- Vegetation and water mitigate surface temperature fluctuations. Drainage, and removal of permanent vegetation cause surface temperature to rise. This isn’t directly reflected by standard measurements of air temperature, which is evaluated in climatology.

Hesslerová, P., Pokorný, J., Brom, J., Rejšková – Procházková, A. *Daily dynamics of radiation surface temperature of different land cover types in a temperate cultural landscape.* Submitted.

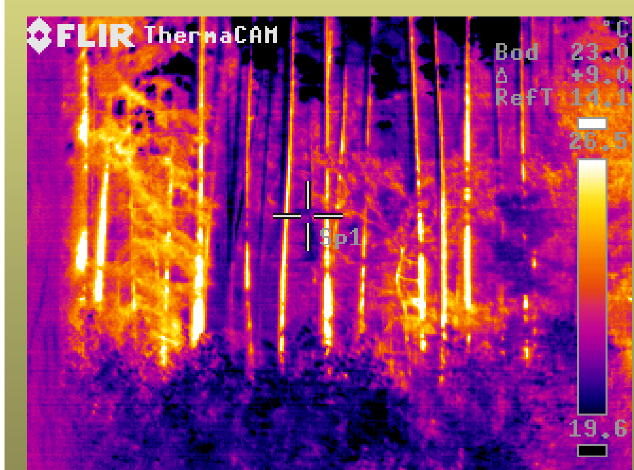
IV. Ground thermovision monitoring

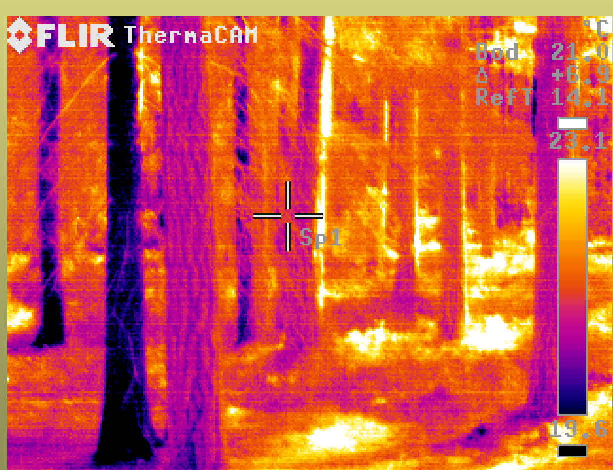


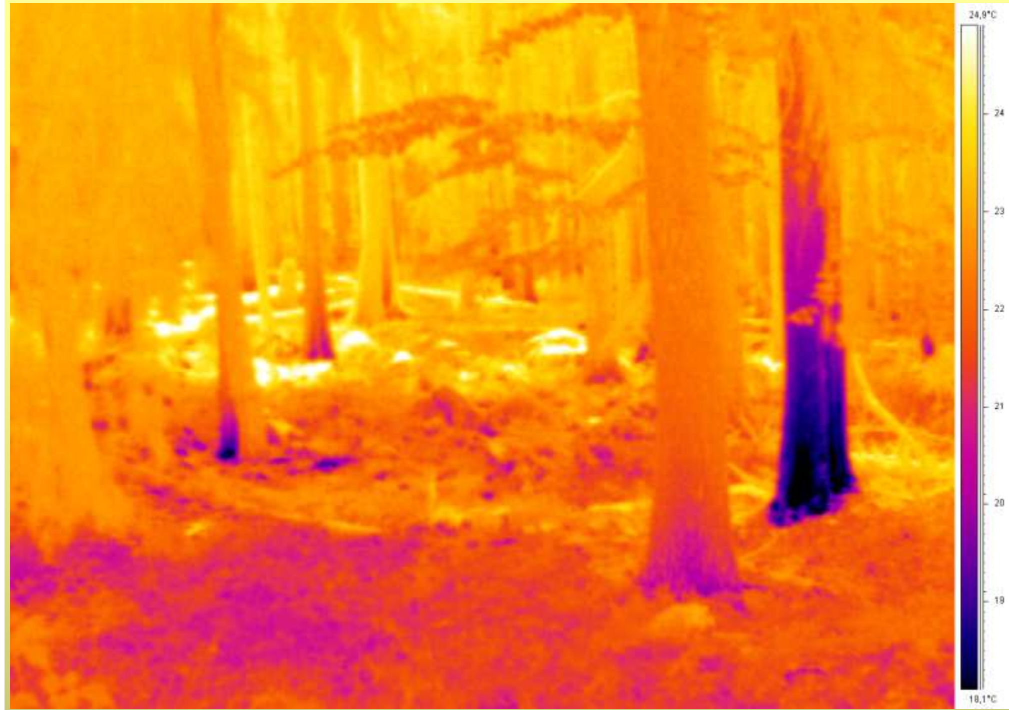
Ground thermovision monitoring

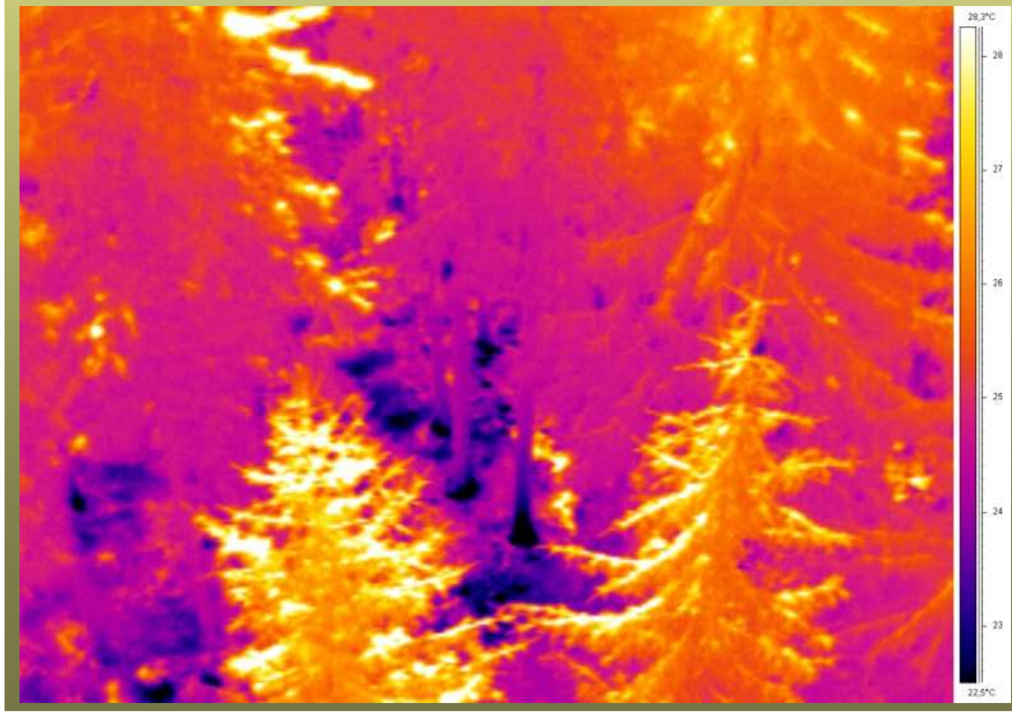
Thermal images acquired on 25.8.2009 at 1 p.m. in a hot sunny day show the temperature differences in biotopes

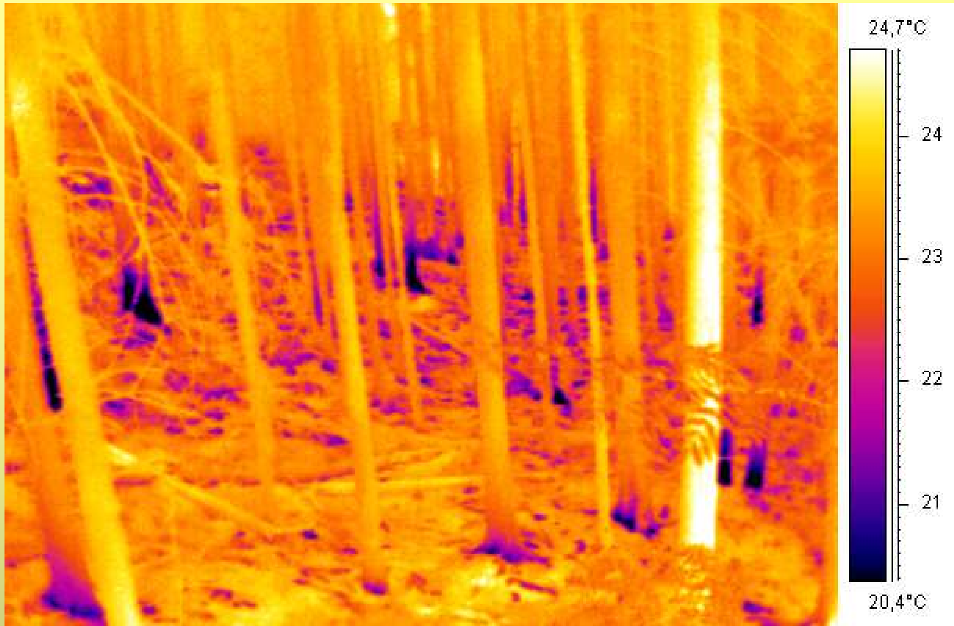
High-grown pine forest. The temperature in the forest ranges around 20°C , with amplitudes of 4 °C. Notice the vertical temperature stratification/profile. The temperatures of undergrowth are often lower than in canopies. Due to such a temperature inversion the moisture rich and cold air stays at the bottom of stand.

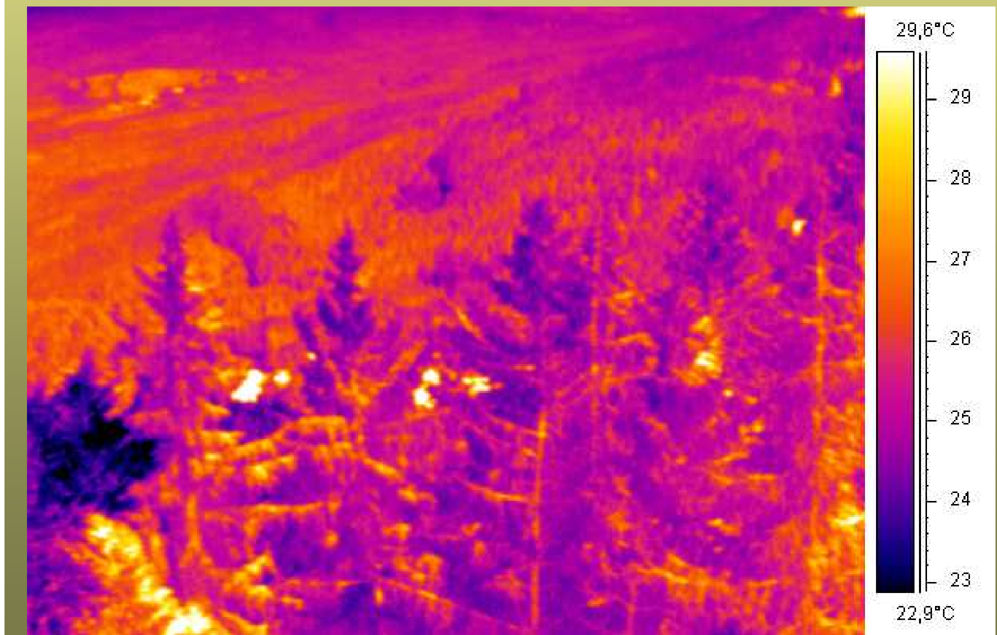




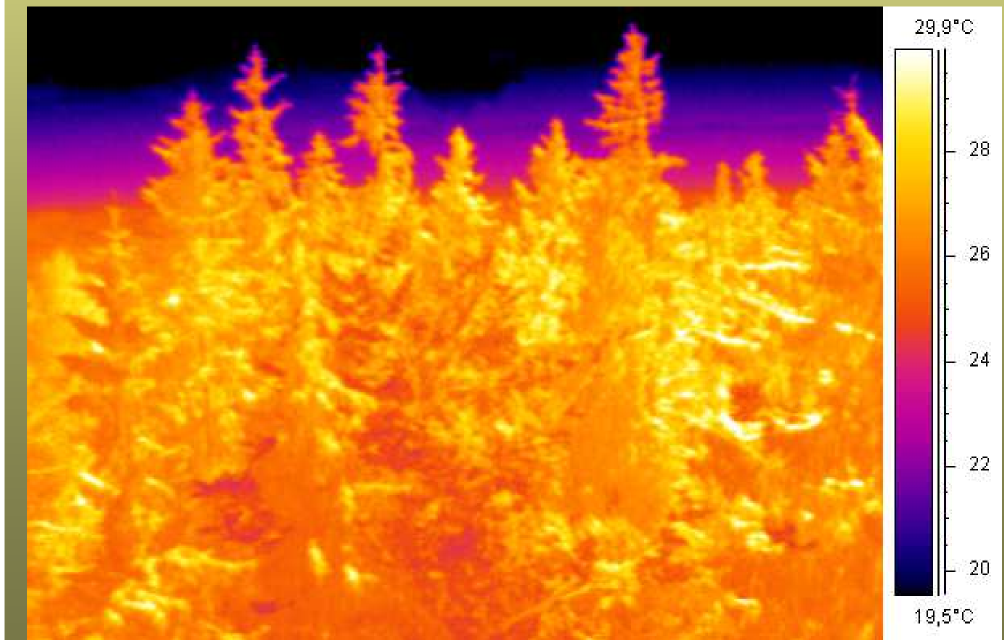

24,9°C
24
23
22
21
20
19
18,1°C

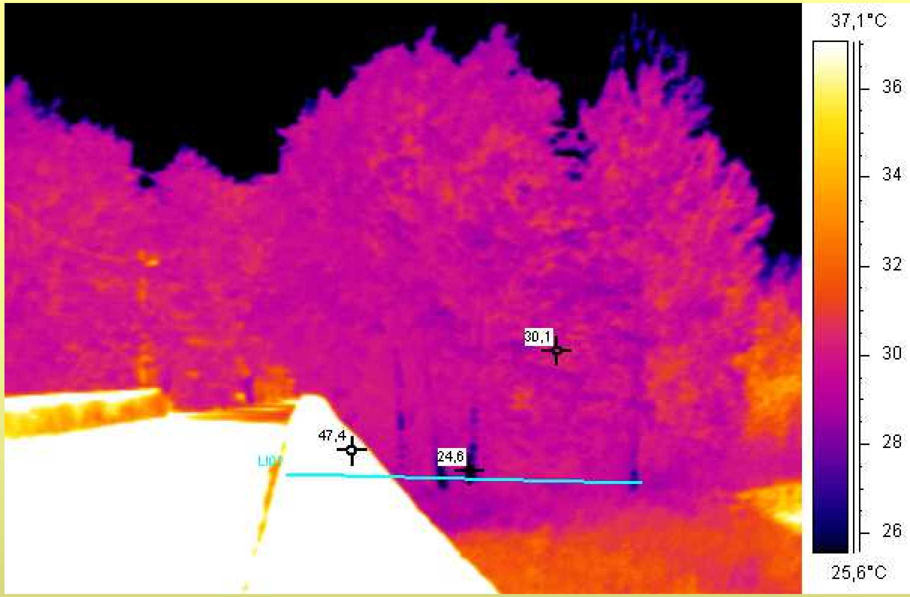

28,3°C
28
27
26
25
24
23
22,5°C

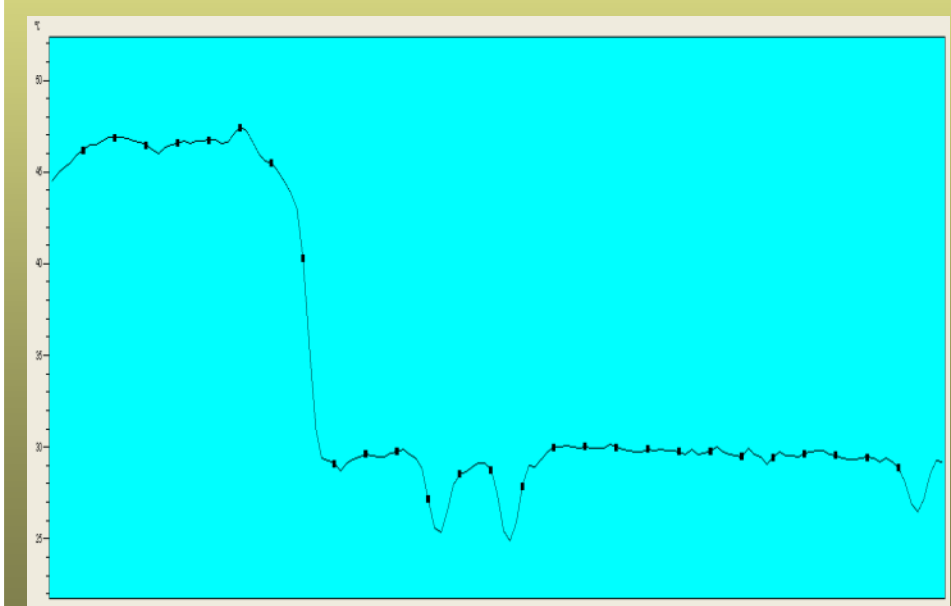

24,7°C
24
23
22
21
20,4°C

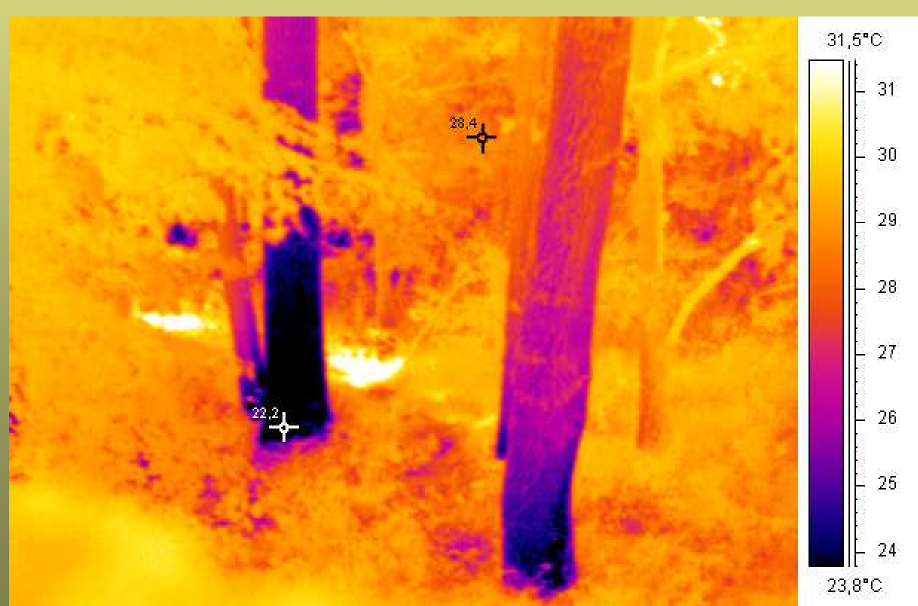

29,6°C
29
28
27
26
25
24
23
22,9°C

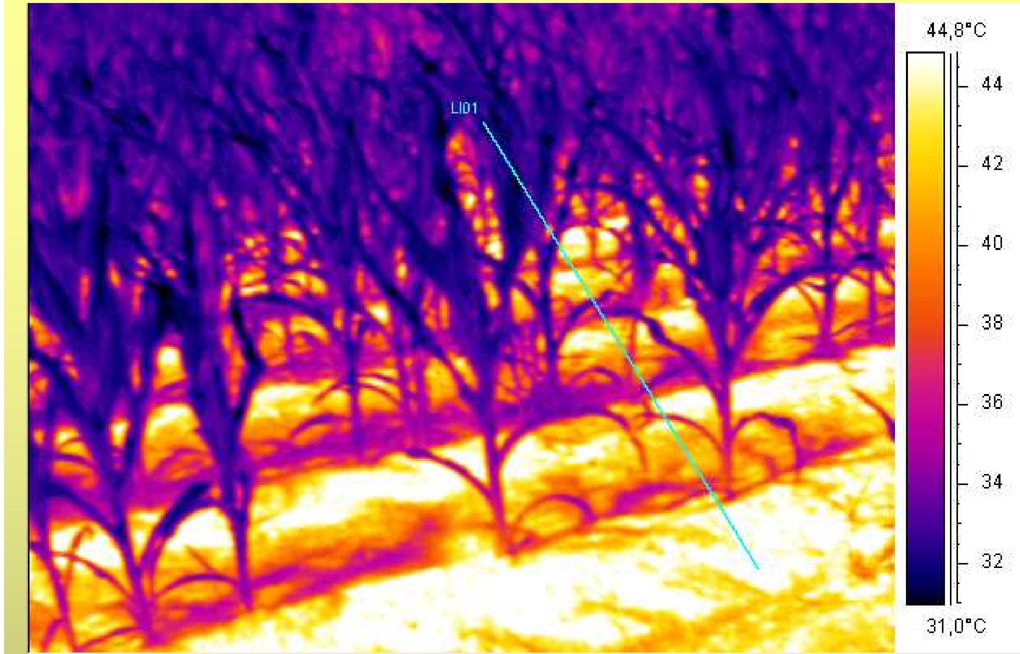

31,9°C
31
30
29
28
27
26
25
24,9°C

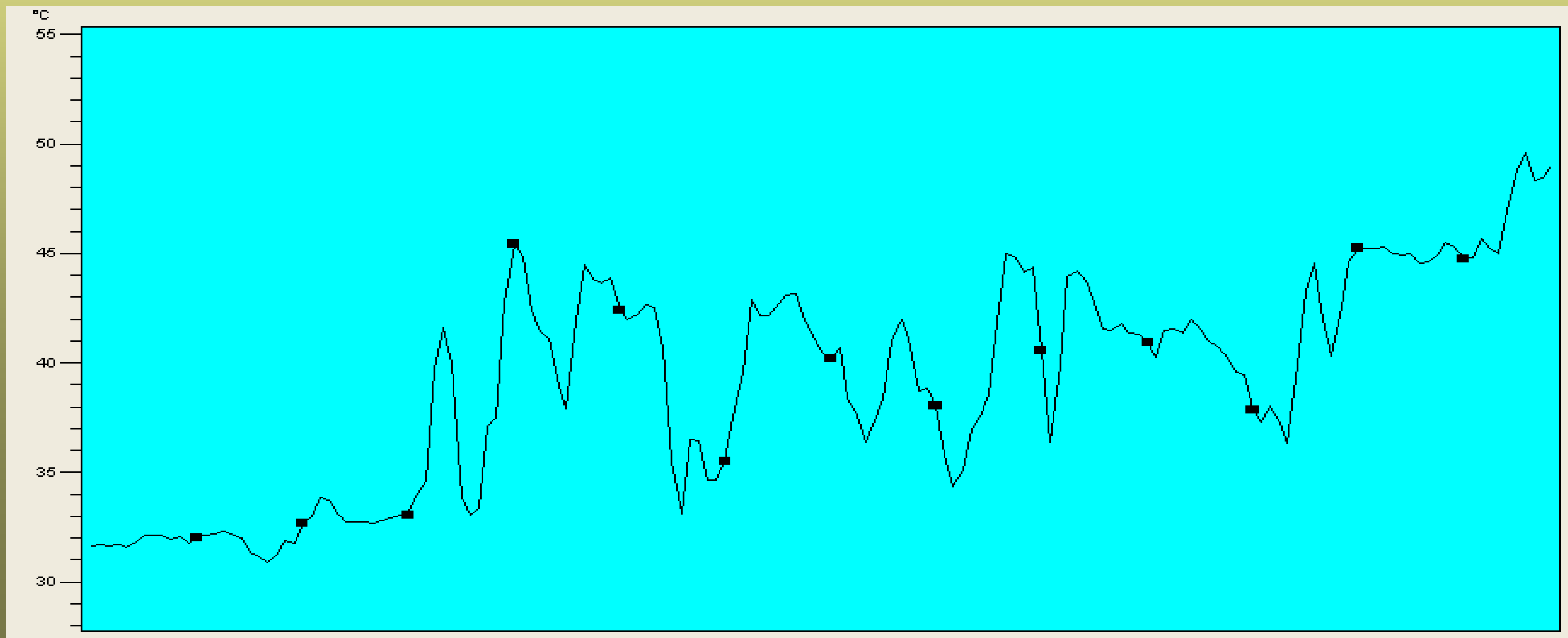

29,9°C
28
26
24
22
20
19,5°C

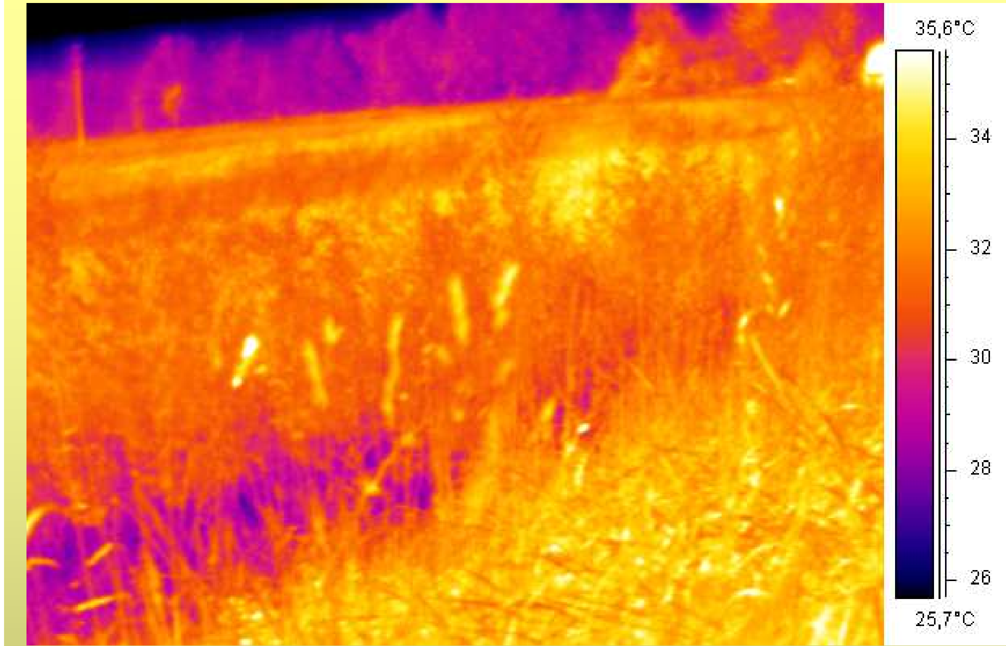

37,1°C
36
34
32
30
28
26
25,6°C
30,1
47,4
24,6

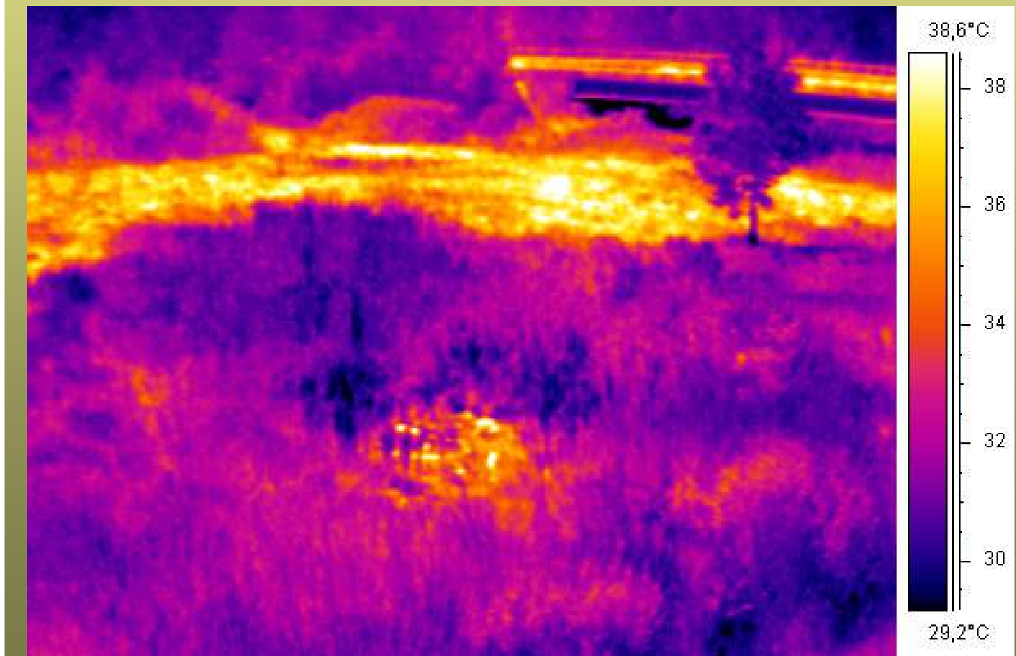



31,5°C
31
30
29
28
27
26
25
24
23,8°C
28,4
22,2

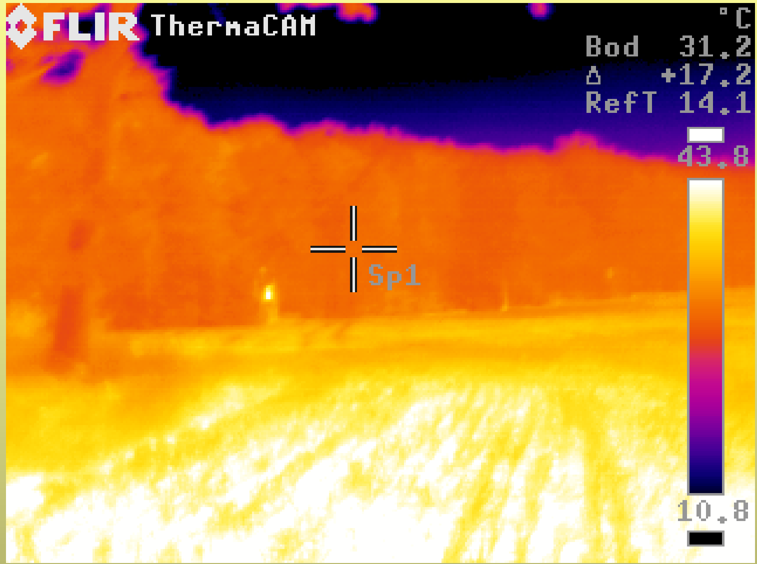

LI01
44,8°C
44
42
40
38
36
34
32
31,0°C

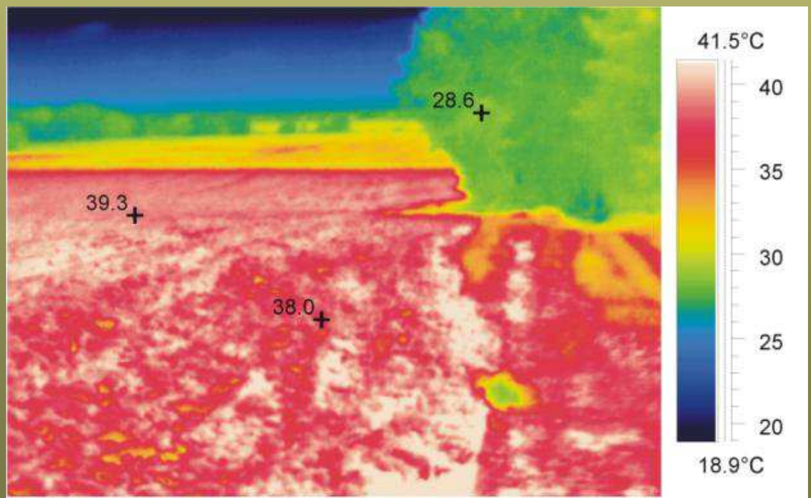

°C
55
50
45
40
35
30


35,6°C
34
32
30
28
26
25,7°C

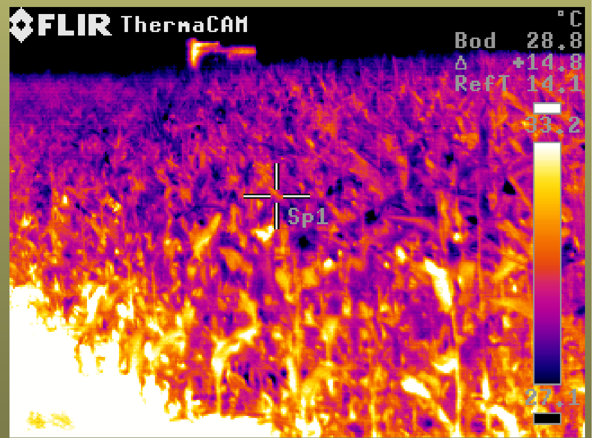

38,6°C
38
36
34
32
30
29,2°C


Stubble and bare fields with threes on the edges. The temperature of bare grounds is around (or even more) than 40 °C. In the neighbouring forest the temperature is about 20°C lower.



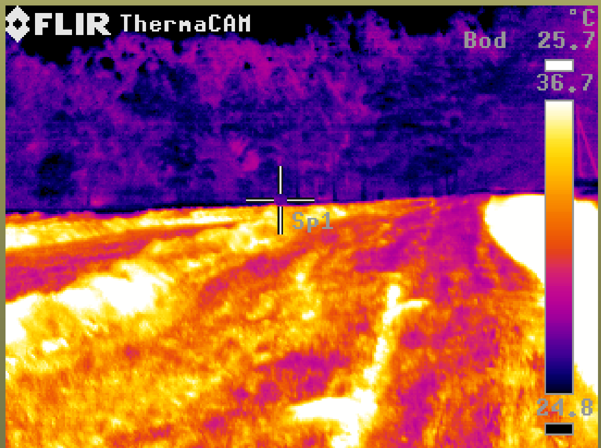


Corn field temperatures ranges between 27 -33 °C. Soil temperature at the bottom of the growth is higher than the growths surface temperature. The hot air raise and transports water vapour away

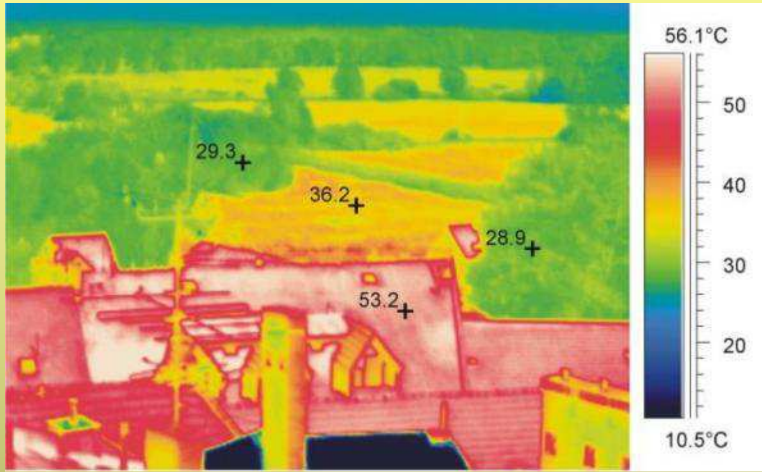


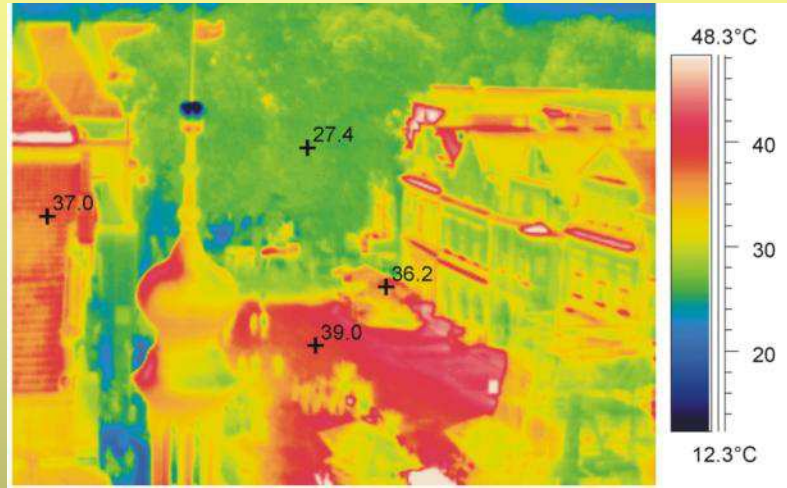
Tree within the build-up area has the surface canopy temperature around 27 °C; a shade temperature is even lower. The temperature of the roofs is higher than 44 °C. The tree functions as a very cheap and excellent air-conditioning unit.

The effect of mown meadow is evident from the temperature differences between hay (more than 35 °C) and green (a little dry) grass (25 °C)



Thermal image aquisited on 29. 7. 2008 (at 4 p.m.) by FLIR ThermaCam TM PM 695 from the city-council tower in Trebon. See the effect of trees and wet meadows vegetation in a contrast to build-up areas.





The presented studies were published as:

Hesslerová, P., Pokorný J. (2010): The synergy of solar radiation, plant biomass, and humidity as an indicator of ecological functions of the landscape: A case study from Central Europe. Integrated Environmental Assessment and Management Volume 6, Issue 2 , Pages 249 - 259.

Seják, J., Cudlín, P., Pokorný, J., Zapletal, M., Petříček, V., Guth, J., Chuman, T., Romportl, D., Skořepová, I., Vacek, V., Vyskot, V., Černý, K., Hesslerová, P., Burešová, R., Prokopová, M., Plch, R., Engstová, B., Stará, L. (2010): Hodnocení funkcí a služeb ekosystémů ČR. Univerzita J. E. Purkyně v Ústí nad Labem, Fakulta životního prostředí, Ústí nad Labem. s. 52 - 57 ISBN 978-80-7414-235-2

- Pokorný, J., Brom. J., Čermák, J., Hesslerová, P., Huryna, H., Nadyezhdina, N., Rejšková, A. (2010): How water and vegetation control solar energy fluxes and landscape heat. *International Journal of Water.* Vol. 5, No. 4, pp. 311-336
- Hesslerová, P., Pokorný, J. (2010): Forest clearing, water loss, and land surface heating - the cost of development in Kenya. *International Journal of Water.* Vol. 5, No. 4, pp. 401-418
- Pokorný, J., Hesslerová, P., Jirka, V. (2011): Změny povrchové teploty lesa jako následek ztráty vody a poklesu evapotranspirace. Lesnická práce. (12), 26-29. 2011. 0322-9254.
- Hesslerová, P. Chmelová, I., Pokorný, J, Kröpfelová, L., Šulcová, J., Pechar, L. (2012): Surface temperature and hydrochemistry as indicators of land cover functions. Ecological Engineering 49, 146 – 152.

INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Thank you for your attention...

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