



NACIONALNA INVENTURA ŠUMA HRVATSKE
CROATIAN NATIONAL FOREST INVENTORY



NATIONAL FOREST INVENTORY IN CROATIA (CRONFI)



NACIONALNA INVENTURA ŠUMA HRVATSKE
CROATIAN NATIONAL FOREST INVENTORY



1) Introduction

2) The first NFI system

(field work, forest delineation and classification, data processing and reporting)

3) Current situation

4) Looking forward



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1) Introduction

a large-scale forest survey (1948-1952)

since 1990 the State GFMPs (1996, 2006) based on stand-wise inventory

need for systematic, unique and comprehensive inventory (NFI)

-strategic level forest management planning

-result compatibility and exchanging on international level

decision to carry out 1th NFI and incorporation RH into global system of forest resources monitoring (begining of 2005)

-National program RH of joining the EU (2004),

-National forest policy and strategy (2003),

-Forest law (2006),

-Regulation on NFI in RH (2006)



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1) Introduction

Ideological and operative plan (IOP) of NFI in RH (February – May, 2005)

Pilot project of NFI: testing of IOP of NFI RH, (July – December, 2005)

Carry out of NFI RH (2006-2009)

- preparation for ground survey and assessment on projected field sample plots,**
- development of computer program (ANFORRES) for data storing, processing and reporting,**
- testing of the computer program,**
- control of data (data collection, data entry),**
- validation of field assessment,**
- interpretation of satellite images (delineation of forests, forest classification)**
- processing and connecting data of field assessment and spatial data of classification on satellite images**
- reporting and publication of obtained results**

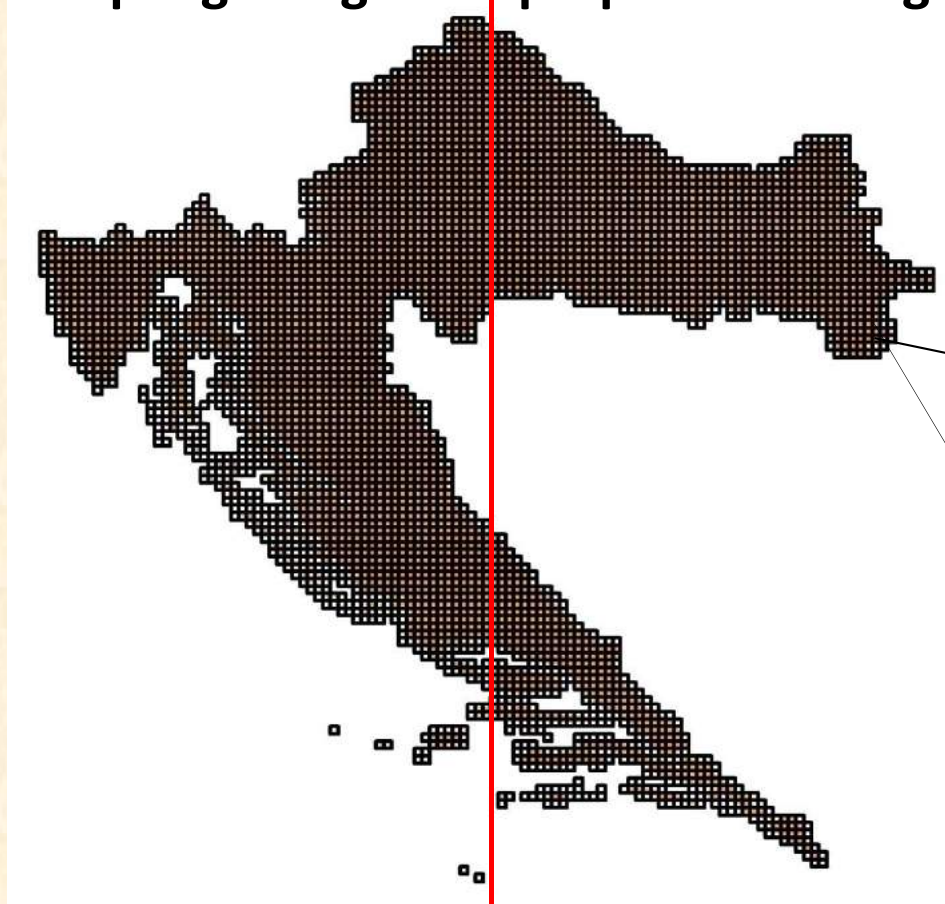


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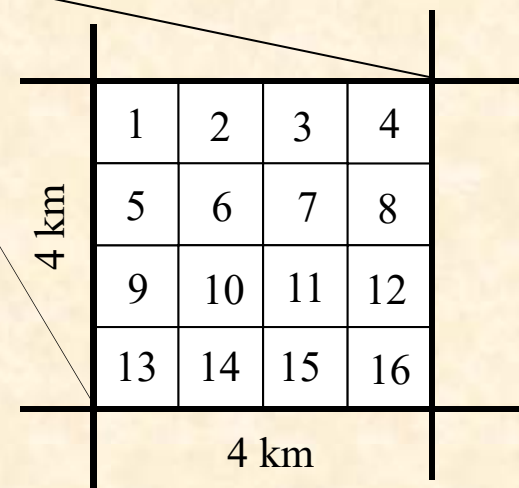
2) The first NFI system

Sampling design and preparation for ground survey



4km by 4km intersection
1- 4376 squares, NE-SW numeration

1km x 1km grid

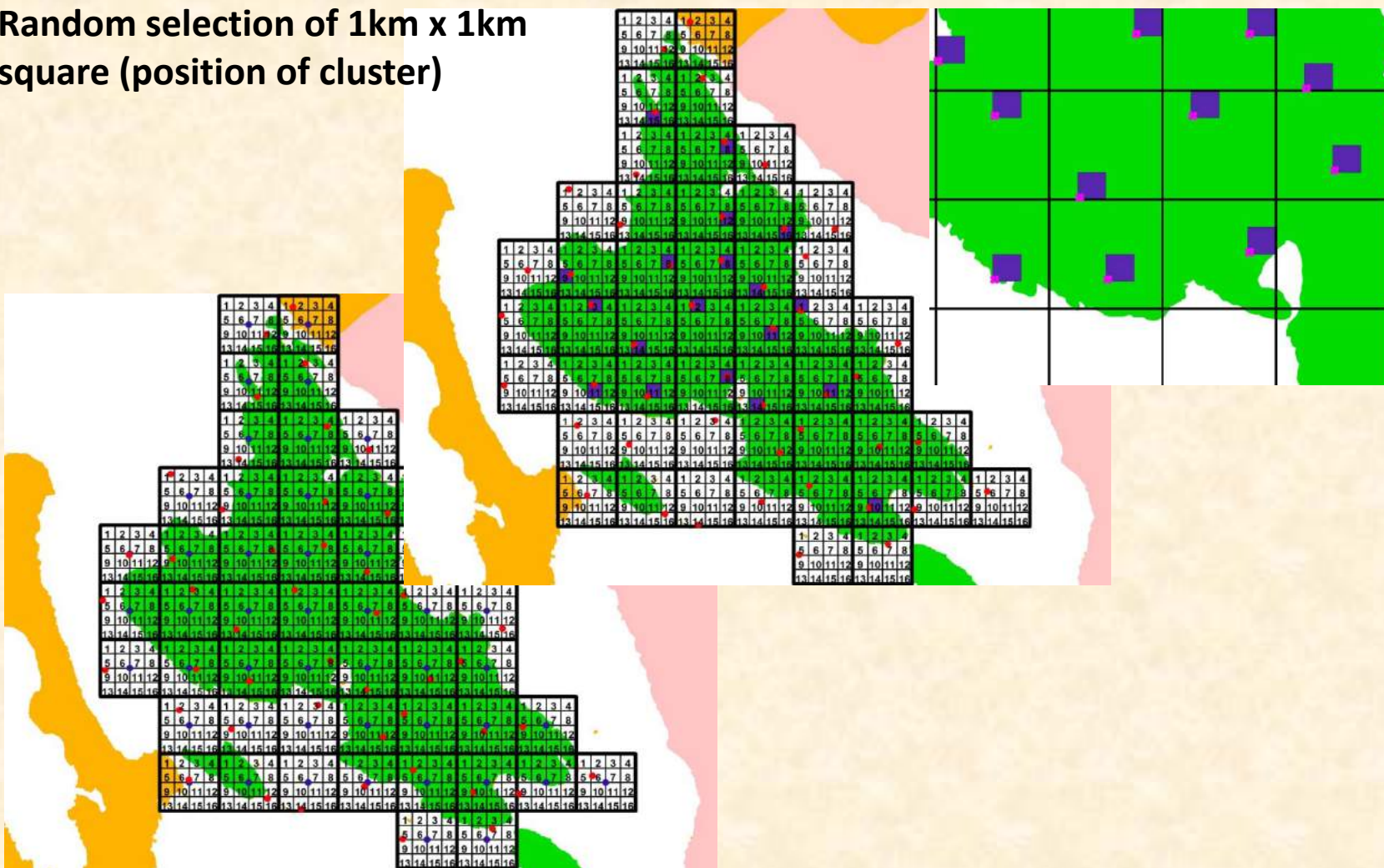




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Random selection of 1km x 1km
square (position of cluster)

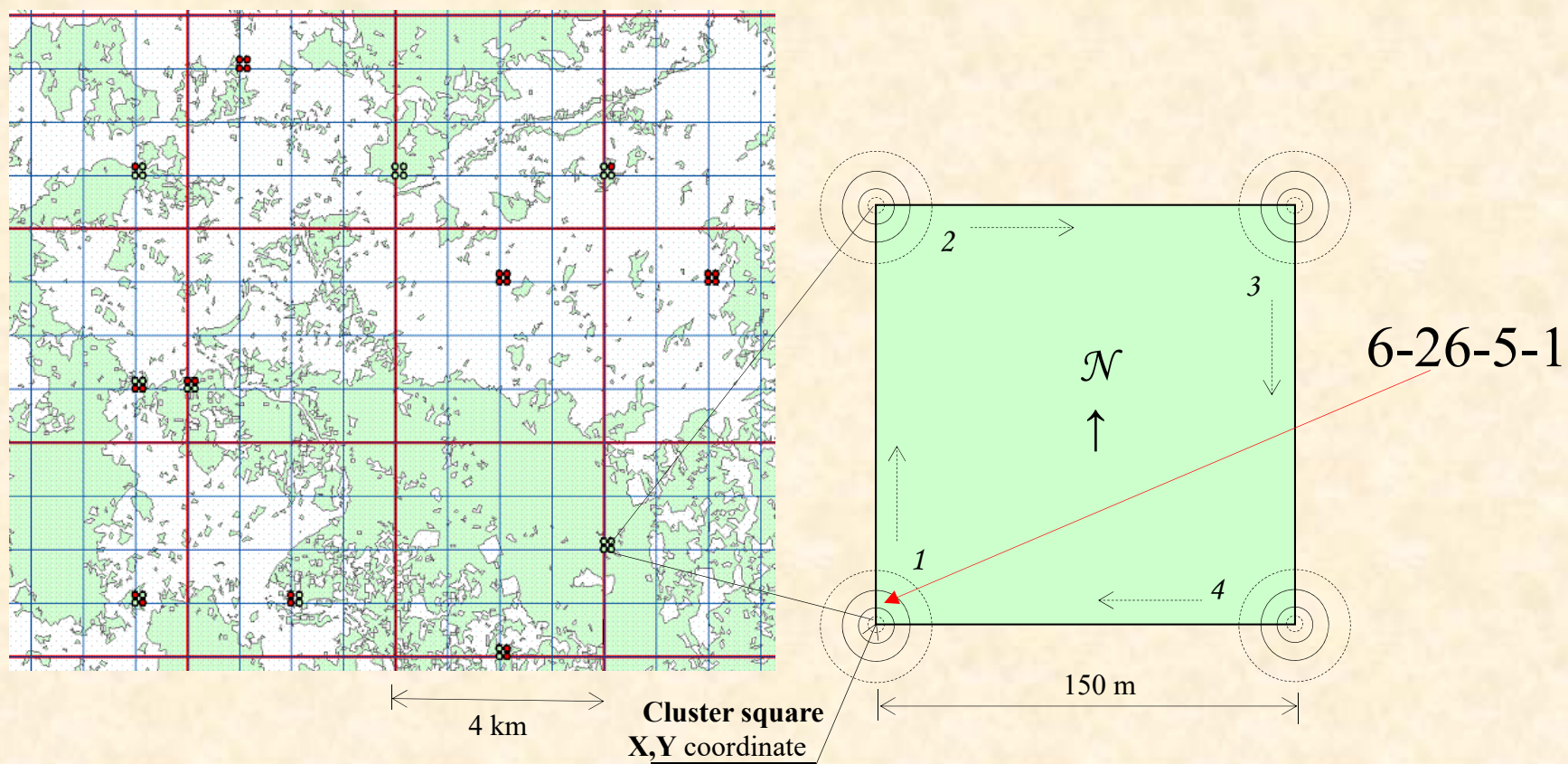




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Design of field sample plots



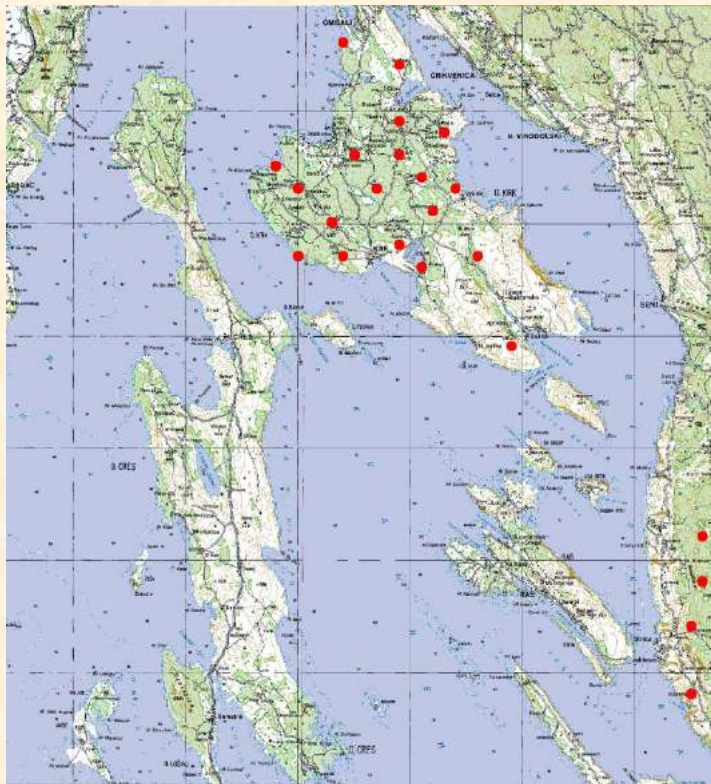


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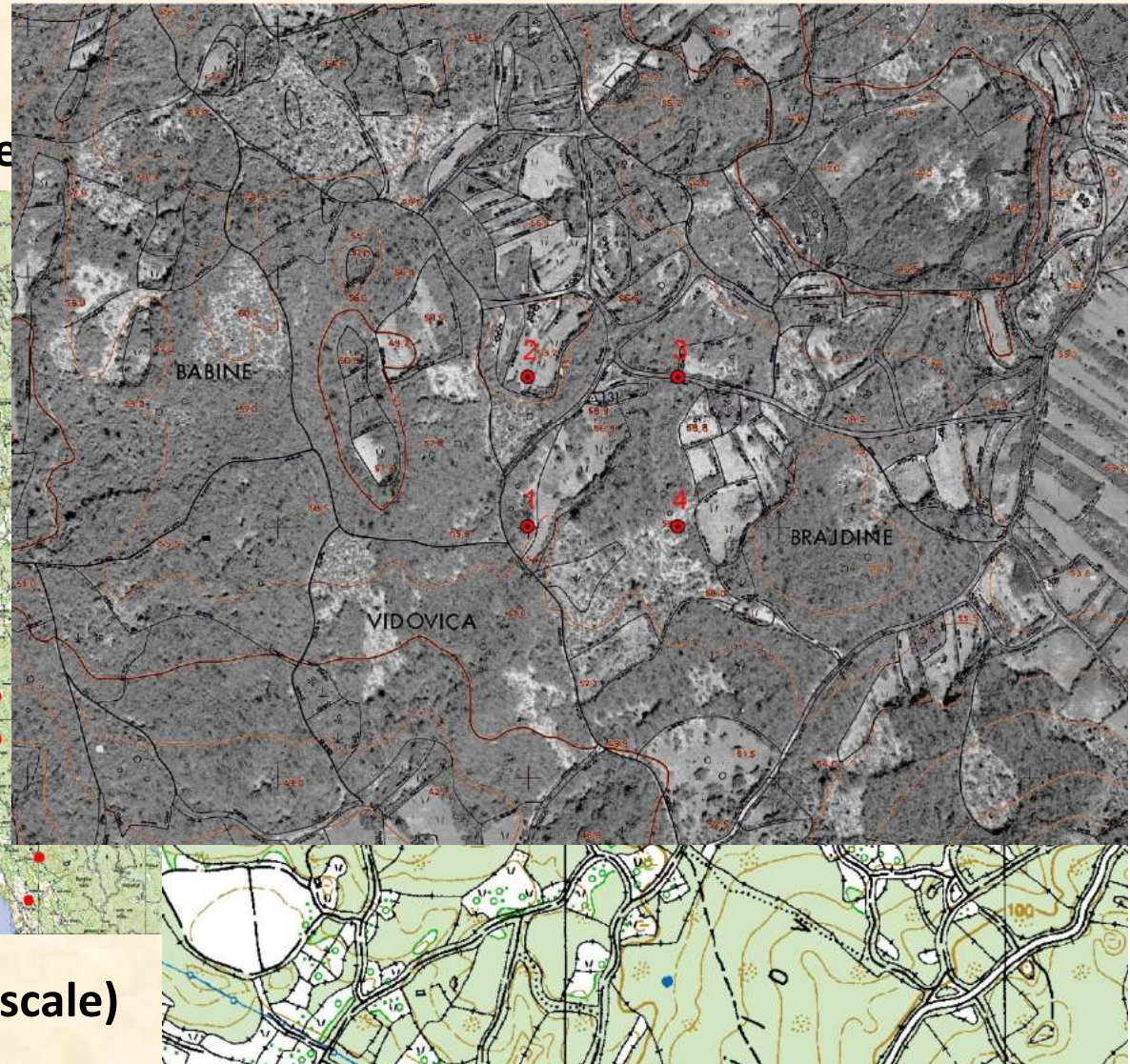


Preparation of background maps and information

Map 1:100,000 scale for general



Map of cluster (1:10,000 scale)





A) Identifikacija i položaj trakta

Terenski obrazac: OT-IŠ

(1) Broj trakta		(4) Broj Upr. šum		(7) Projektirane koordinate	x				
(2) Oblast		(5) Broj županije			y				
(3) Broj karte		(6) Broj gosp. jed.		(8) Stvarne koordinate (GPS)	x				
					y				

B) Podaci o terenskoj radnoj grupi

(9) Broj grupe		(10) Voda grupe		Potpis:	
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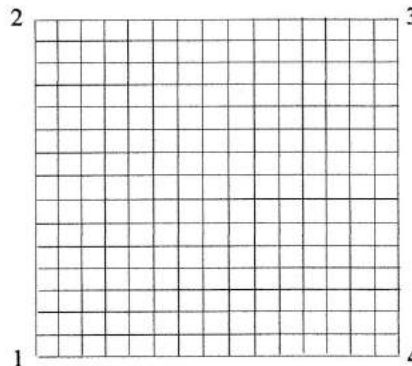
C) Datum i vrijeme snimanja

(11) Datum		d	m	g	d	m	g
(12) Vrijeme snimanja		sat	minuta	sat	minuta		
(12a) Odlazak							
(12b) Početak							
(12c) Završetak							
(12d) Povratak							

D) Kategorije zemljišta i linijski objekti

Kategorija	% površ. trakta
(13) Šuma	
(14) Ostalo šumsko zemljište (grmolika, zakržlj. veget, zemljište u zarašćivanju)	
(15) Ekstenzivni pašnjak	
(16) Drugo nešumsko zemljište (urbano, poljoprivredn, močvare, vode, stijene,...)	
(17) Linijski objekti (dalekovodi,	

E) Skica trakta i mjerenja

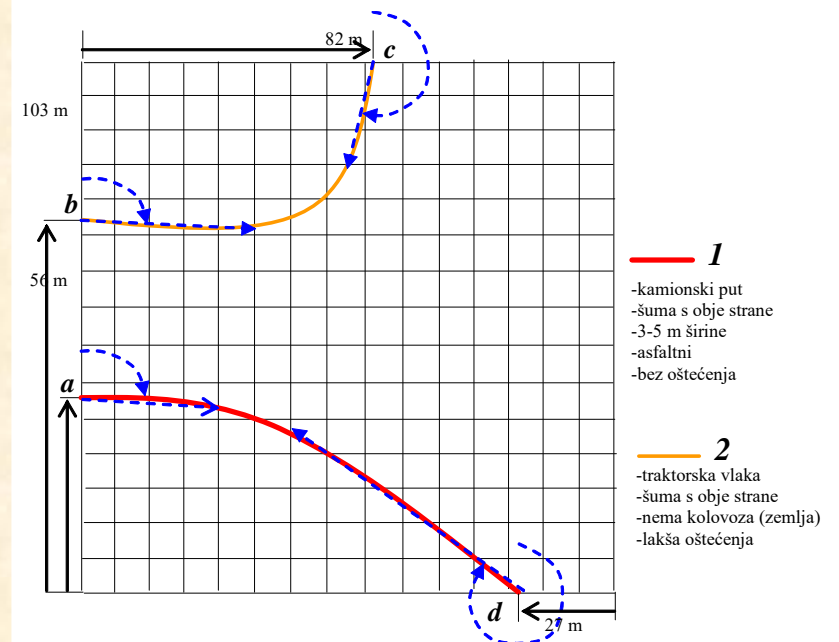


F) Putevi i ceste u funkciji gospodarenja šumom

Obilježja puta	Kategorije	Šifra kategorije
(18) Broj puta	Jedinstvena oznaka (broj) puta	
Traktna linija	Traktna linija u smjeru: 1: 1-2; 2: 2-3; 3: 3-4; 4: 4-1	
(19) Tip puta	1 - šuma s jedne strane prometnice 2 - šuma s obje strane prometnice	
Udaljenost u m od početne točke na traktnoj liniji	Udaljenost na traktnoj liniji od početne točke linije (središte plohe) do točke gdje put sječe traktnu liniju (sredina puta)	
(20) Kategorija puta	1 - Kamionski put - moguća upotreba čitavu godinu 2 - Kamionski put - nije moguća upotreba čitavu godinu 3 - Traktorska vlaka, izgrađena	
(21) Širina puta	1 - vlaka, cesta širine 2 - 3 m 2 - cesta širine 3 - 6 m 3 - cesta širine > 6 m	
(22) Kolovoz	0 - nema (zemlja) 1 - stabiliziran 2 - izgrađen (asfalt, beton, ...)	
(23) Stanje puta	0 - bez oštećenja 1 - lakše oštećen 2 - znatno oštećen, potreban popravak	
(24) Uzdužni nagib	Nagib u postotcima (%)	
(25) Dužina puta	Dužina puta kroz traktnu površinu u 10 m	

Assessments on cluster square

1,932 clusters (25 variables)





A) Identifikacija i položaj plohe

Terenski obrazac: OP-IŠ

(1) Broj trakta		(4) Projektirane koordinate	x		(5) Stvarne koordinate	x	
(2) Stratum			y			y	
(3) Broj plohe							

B) Podaci o terenskoj radnoj grupi

(6) Broj grupe		(7) Voda grupe		Potpis:	
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C) Datum i vrijeme snimanja

(8) Datum		d	m	g	d	m	g
(9) Vrijeme snim.		sat	minuta	sat	minuta		
(9a) Početak							
(9b) Završetak							

D) Osiguranje plohe

(10) Točka 1	(10 a) Azimut	(10 b) Udaljenost	(10 c) Opis
(11) Točka 2	(11 a) Azimut	(11 b) Udaljenost	(11 c) Opis
(12) Točka 3	(12 a) Azimut	(12 b) Udaljenost	(12 c) Opis

E) Zamj. središte F) Vlasništvo i elem. gosp. G) Dostupnost i status plohe H) Elementi staništa

(12) Odstupanje od zamj. sred.	Varijable	šifra	(18) Dostupn.		(20) Nadmorska visina (m)	(21) Nagib (°)	(22) Ekspoz. (°)	(23) Reljef (°)	(24) Dubina tla
(12a) Azimut	(13) Vlasništvo		(19) Status p.	%					
(12b) Udaljenost	(14) Ogranič.		(19a) R 3,5 m						
	(15) Tehnika		(19b) R 7 m		(25) Degradacija tla			(26) Erozija	(27) Otpad u šumi
	(16) Udaljenost		(19c) R 13 m		(25a) listinac	(25b) humus	(25c) kamenit.		
	(17) Namjena		(19d) R 20						

I) Elementi sastojine

Elementi sastojine	Kategorija	Šifra
(29) Postanak sastojine	1- visoke, 2- srednja šuma, 3- panjače, 4- plantaže, 5- kulture	
(30) Uzgojni oblik	1- jednodobne, 2- raznodobne	
(31) Starost	u 10 godina	
(32) Strukturni oblik	1 - jednodobna jednoetažna, 2 - jednodobna dvoetažna, 3 - preborna stablična, 4 - preborna grupična, 5 - stablično grupična, 6 - prašuma	
(33) Stadij razvitka	1- mlade sastojine, 2- letvik, 3- stadij odraslih stabala, 4- srednjodobne sastojine, 5- starije sastojine, 6 - stare sastojine, 7 - panjače < 10 cm, 8 - panjače 10-20 cm, 9 - panjače > 20 cm, 10 - šikara, šibjak, 11 - makija, garig	
(34) Smjesa	1 čiste-bjelogorica, 2- mješovite bjelogorične, 3- mješovite bjelog-crnog., 4- čiste crnogorica, 5- mješovite crnog.	
(35) Sklop	1- potpun sklop, 2- nepotpun sklop, 3- rjedadak sklop, 4- progoljen sklop	
(36) Kakvoća sastojine	1- vrlo dobre kakvoće, 2- dobre kakvoće, 3- srednje kakvoće, 4- loše kakvoće	
(37) Prizemna vegetac.	1- nema, 2- rijetka, 3- srednje gusta, 4- gusta	
(38) Štete u šumi		
(38a) Abiotske	1. vjetroizvale, 2. požar, 3. mraz, 4. tuča, 5. abiotske - ostalo	
(38b) Biotske	1. insekti 2. bolesti, 3. divljač, 4. biotske-ostalo,	
(38c) Utjecaj čovjeka	1. eksploatacija, 2. drugo	
(39) Prirodnost	1. prašume, 2. gospodarene šume s prirodnom obnovom, 3. gosp. šume s potpomognutom obnovom, 4. kulture	
(40) Homogenost plohe	1. sastojina na plohi, 2. dvije ili više sastojina, 3. nehomogena sastojinska struktura	
(41) Sloj grmlja	1. nema, 2. rjedad, 3. srednje gust, 4. gust	

J) Stanje i struktura obnove sastojine

(42) Pomladena površina (u 10%)	(43) Nastanak	(44) Smjesa	(45) Udio glavne vrste	(46) Kakvoća	(47) Uzrok oštećenja	(48) Stupanj oštećenosti (u 10%)
			(45a) Vrsta (šifra)		(47a) I. (47b) II.	
	šifra		(45b) Postotni udio (%)		šifra	

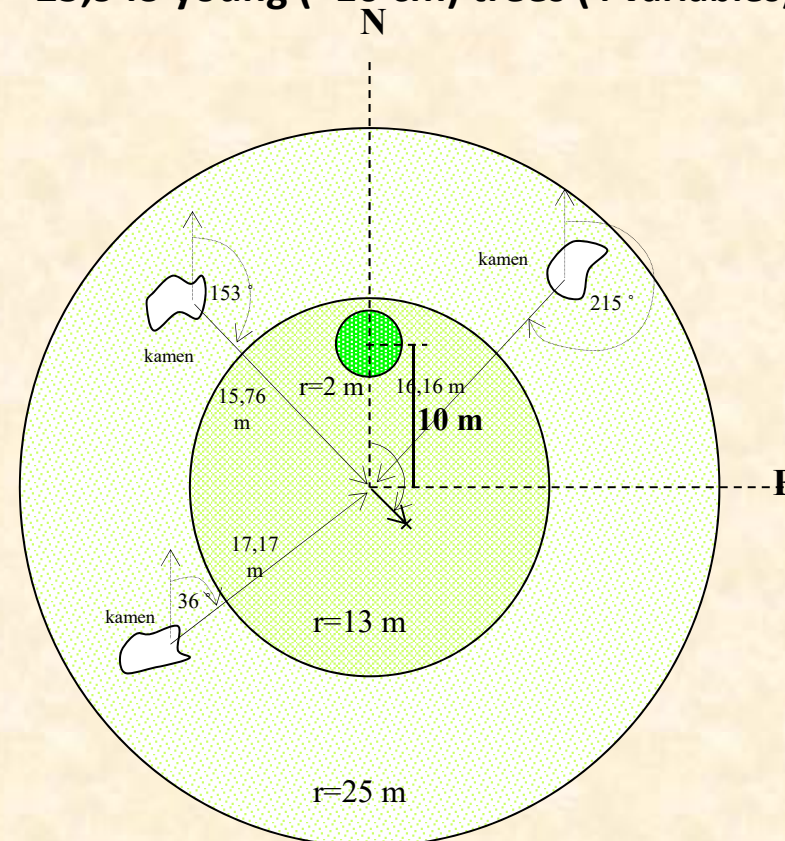
K) Tanka stabla (ispod taksacijske granice)

(49) I. debljinski razred (1-3.9 cm)			(50) II. debljinski razred (4-6.9 cm)			(51) III. debljinski razred (7-9.9 cm)		
(49a) Vrsta drveća	(49b) Broj stabala	(49c) Srednja visina (m)	(50a) Vrsta drveća	(50b) Broj stabala	(50c) Srednja visina (m)	(51a) Vrsta drveća	(51b) Broj stabala	(51c) Srednja visina (m)

Assessments on base ("interpretat.") plots (r = 25 m)

6,232 plots (50 variables)

25,943 young (<10 cm) trees (4 variables)





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Assessments (delineation) of forest area (classification of satellite images)

13 scenes IRS P6 LISS III multispectral satellite images

resolution: 20 m

scene size: 140 km x 140 km

ORTHORECTIFICATION OF S. IMAGES

→ **Digital ortophoto (DOP)**

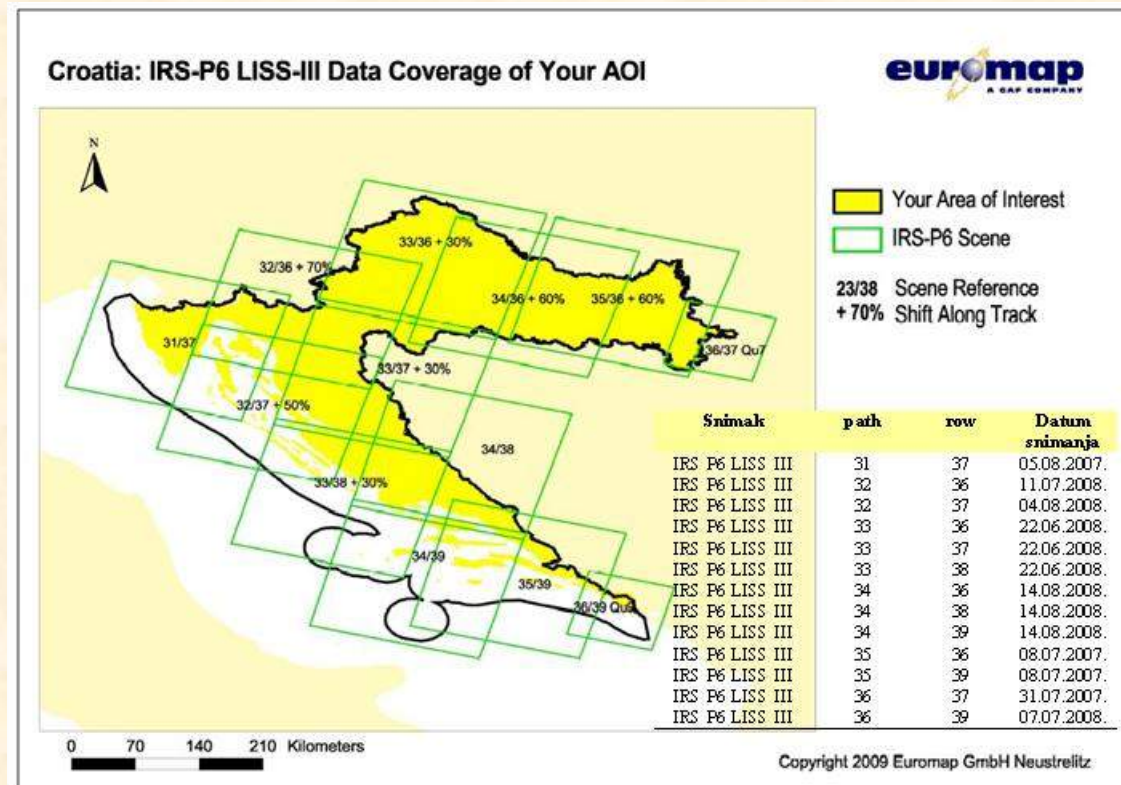
Parameters of DOP preparing:

Software: Erdas Imagine 9.3, model for RESOURCESAT-1

Entry data: individual images with appurtenant RPC files

Reference points sources: TK25, TK50, archive of satellite images (Gisdata Ltd)

Digital elevation model: raster DEM (20 m resolut.) owned by Gisdata Ltd





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DOP characteristics:

Satellite, sensor: IRS-P6, LISS-III

Spatial resolution: 20 m

Format: 4-channel TIFF

Coordinate system: Gaus-Krüger,
5th zone





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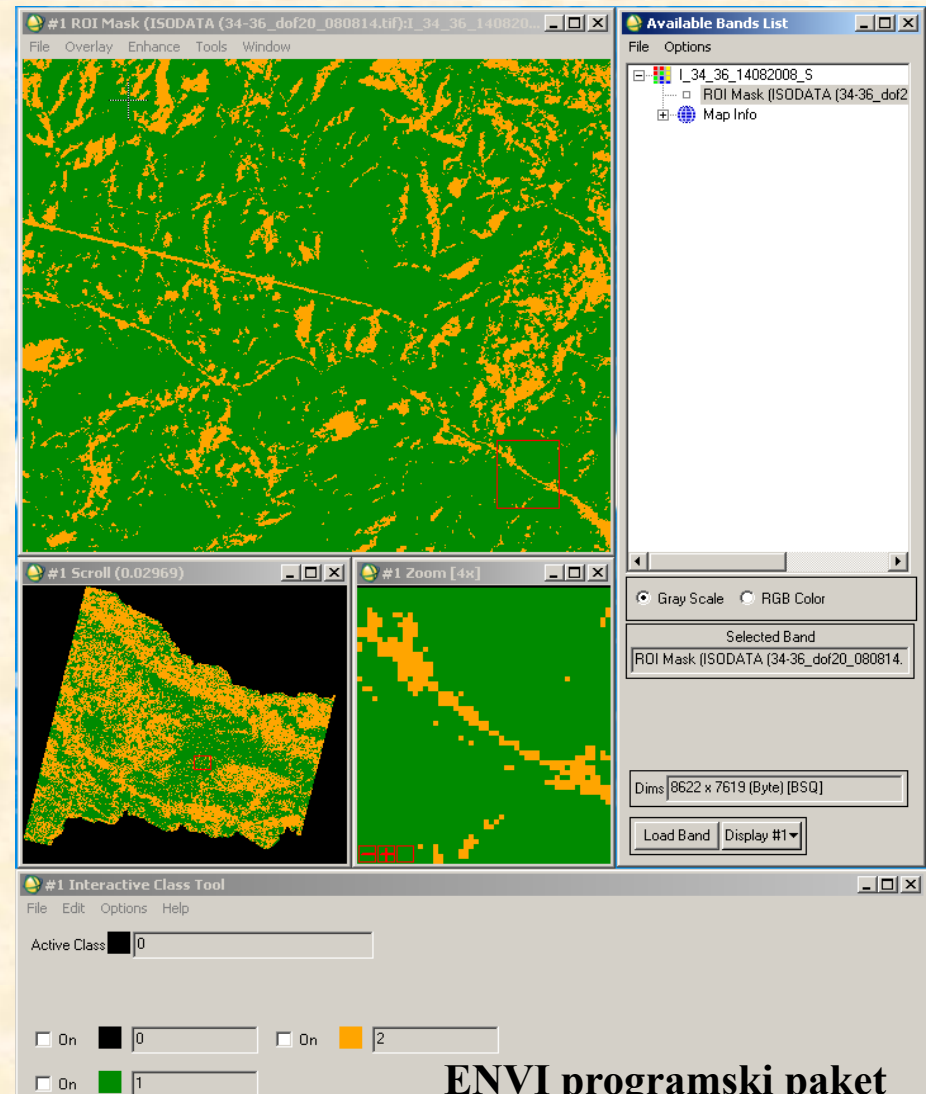
Classification *forest / non-forest* (forest border delineation and forest area assessment)

Classification (ISODATA method),
interpretation in 30 categories
categories sorting into two aimed (forest/non-forest),
joining into unique raster data base

Conversion raster to vector format data
base (delineation of forest border)
ESRI shape and ESRI filegeodatabase format
(min. mapping unit of 0.2 ha, 5 pixels)

Control of classification
-visually by overlapping vector data base and images
-using field data (5,767 sample plots)

Assessment of classification accuracy
-accord. Error Matrix (524 randomly selected sample
plots for comparison)



ENVI programski paket



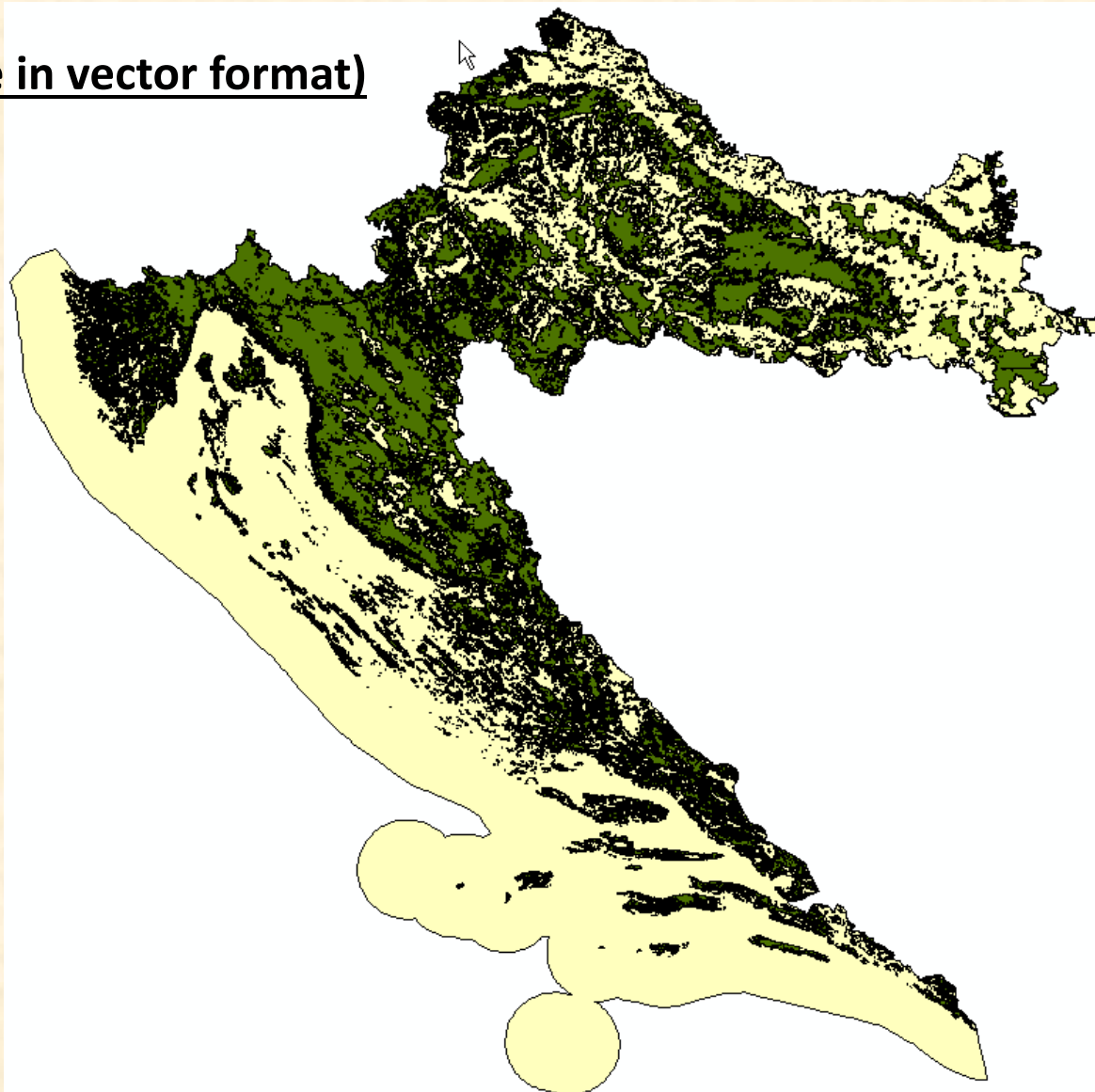
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Forest map (spatial data base in vector format)

forest: 2,580,825 ha (45.6 %)
non-forest: 3,078,615 ha (54.4 %)
5,659,440 ha

Classification accuracy:
90.84 %





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Classification of forest area (broadleaved, conifers, mixed, young, open forest)

Classification into 5 aimed categories (ENVI),

- MAXIMUM LIKELIHOOD classification (broadleaved, conifers, mixed, young, open forest)**
- grouping and eliminating <0,2 ha pixel groups (CLUMP, ELIMINATE)**
- joining of classification results (unique raster data base)**

Conversion raster data base to vector format (ESRI ArcINFO)

- ESRI shape and ESRI filegeodatabase format**

Control of classification

- visually by overlapping vector data base and images**
- using field data (5,767 sample plots)**

Assessment of classification accuracy

- accord. Error Matrix (1,050 randomly selected sample plots for comparison)**

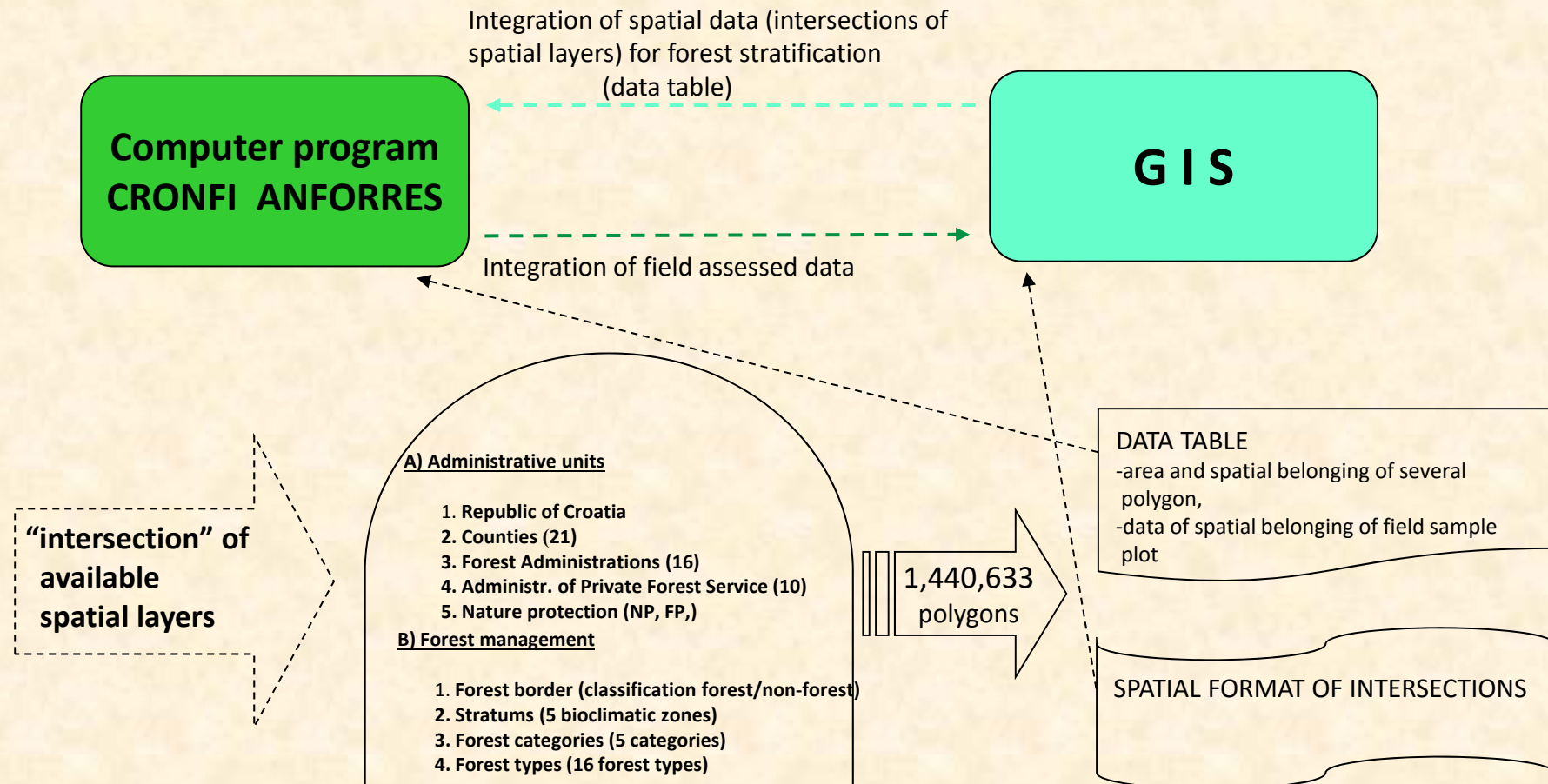
Category	Area (ha)	Proportion (%)
1 Broadleaved	1,475,826	57.18
2 Conifer	153,419	5.94
3 Mixed	441,882	17.12
4 Young growth	306,559	11.88
5 Open forest	203,140	7.87
TOTAL	2,580,826	100.00



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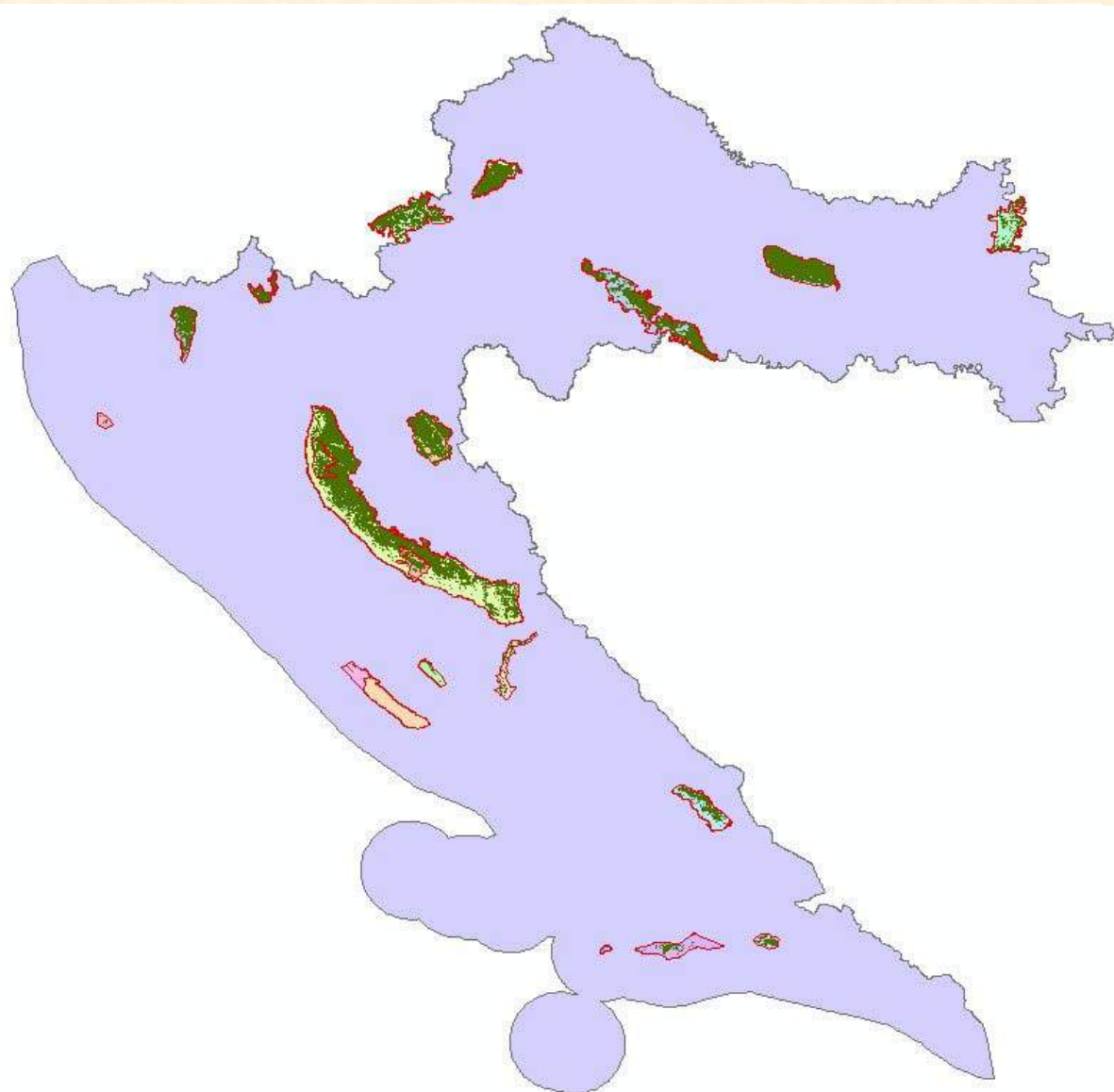


Integration of spatial and field data for stratification, presentation and analysis of forest resources





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Screenshot of the ArcMap software interface showing a forest inventory data layer and a corresponding photograph.

Layers Panel:

- PLOHE_SVE_ATRIBUTI
 - <all other values>
 - SUMA_ID
 - 0
 - 1
 - 2
- RH_granica_GRP1

Attributes of PLOHE_SVE_ATRIBUTI Table:

Y_nrcnl	X_GPS	Y_GPS	X_koordr	Y_koordr	ZUP_RB	UPRAVA_ID	PODRUZNICA_ID	NP_PP_ID	STRATUM_ID	SUMA_ID	PODSTRATUM_ID	UR_RAZRED_ID	ID_GIS	DOSTUPNOST	PAZU
4981790	5550405	4981793	5816992,50	4989153,05	16	1	1	0	1	1	5	3	405272594	1	D:\TRAKTOVI_SLIKE\2558-416-2558-4-2.jpg
4981790	5550556	4981788	5817143,15	4989153,61	16	1	1	0	1	1	5	3	405272595	1	D:\TRAKTOVI_SLIKE\2558-416-2558-4-3.jpg
4981840	5550559	4981837	5817151,75	4989002,65	16	1	1	0	1	1	5	3	405272596	1	D:\TRAKTOVI_SLIKE\2558-416-2558-4-4.jpg
4981528	5553400	4981533	5819997,67	4989003,95	16	1	1	0	1	1	1	3	405273613	1	D:\TRAKTOVI_SLIKE\2559-316-2559-3-16-2559-3-1.jpg
4981679	5553398	4981676	5820146,74	4989146,95	16	1	1	0	1	1	1	3	405273614	1	D:\TRAKTOVI_SLIKE\2559-316-2559-3-216-2559-3-2.jpg
4981679	5553554	4981676	5820146,74	4989152,73	16	1	1	0	1	1	1	3	405273615	1	D:\TRAKTOVI_SLIKE\2559-316-2559-3-316-2559-3-3.jpg
4981528	5553549	4981527	5820147,26	4989003,48	16	1	1	0	1	1	1	3	405273616	1	D:\TRAKTOVI_SLIKE\2559-316-2559-3-416-2559-3-4.jpg
4979459	5555334	4979455	5822009,97	4989696,64	16	1	1	0	1	1	1	3	405274661	1	D:\TRAKTOVI_SLIKE\2560-916-2560-9-16-2560-9-1.jpg
4979459	5555476	4979458	5822151,83	4987004,90	16	1	1	0	1	1	1	3	405274664	1	D:\TRAKTOVI_SLIKE\2560-916-2560-9-416-2560-9-4.jpg
4976095	5558205	4976098	5804997,67	4983003,36	16	1	1	0	1	1	1	4	405322801	1	D:\TRAKTOVI_SLIKE\2607-126-2607-12-116-2607-12-1.jpg
4976095	5558162	4976098	5804997,67	4983003,36	16	1	1	0	1	1	1	4	405322800	1	D:\TRAKTOVI_SLIKE\2607-126-2607-12-216-2607-12-2.jpg

Map View: A photograph of a forest plot is displayed above a map showing the plot's location. The plot is marked with a yellow polygon and numerous blue dots representing individual trees. The photo shows a dense forest with many thin trees and a forest floor covered in fallen leaves and branches.

Status Bar: 6034393,692; 5180750,831 Meters



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Data processing and reporting

Computer program CRONFI ANFORRES

(Microsoft SQL Server 2005)

- data entry and storing (data base)**
- data accession (interface)**
- ad-hoch and dynamic inquiries**
- data processing, calculation of derivative variables and reporting**

3 basic functional moduls:

- module for direct entry, evaluation and correction of data**
- module for data "import" from EXCEL (*.xls) files**
- module for inquiry creation and report of results**



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ANFORRES - Analiza šumskih resursa

Izbornik

Unos podataka

Uvoz iz XLS datoteka

Upiti u bazu podataka

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Analysis of Forest Resources (ANFORRES)
Analiza šumskih resursa



MINISTARSTVO REGIONALNOG RAZVOJA,
ŠUMARSTVA I VODNOG GOSPODARSTVA
REPUBLIKA HRVATSKA

CROFI
ANFORRES



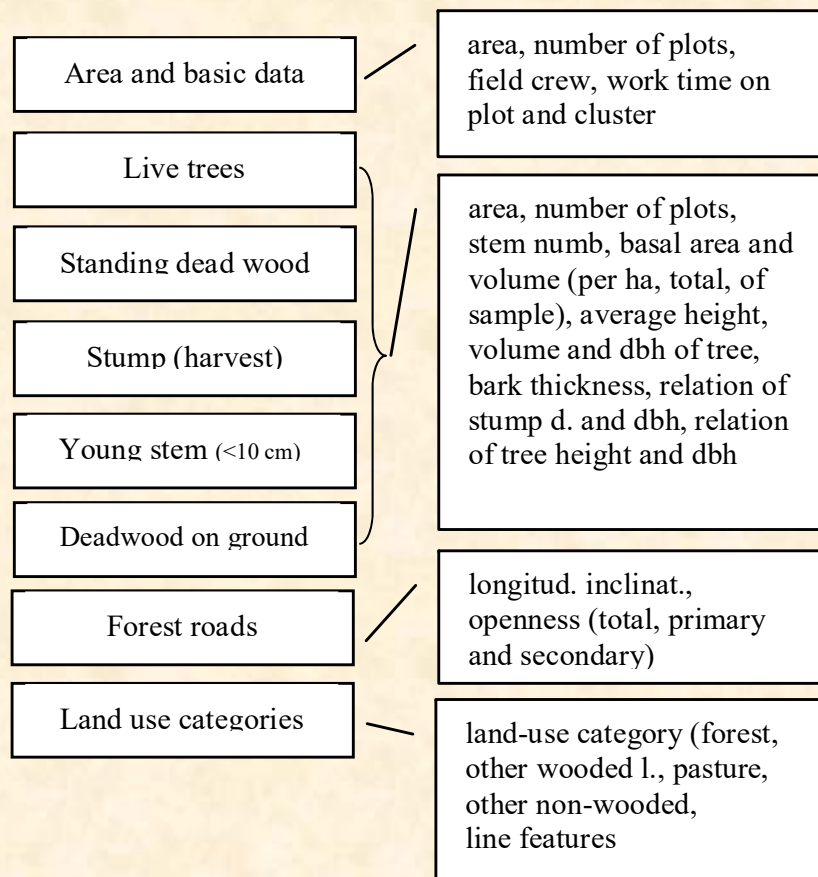
SVEUČILIŠTE U ZAGREBU
ŠUMARSKI FAKULTET



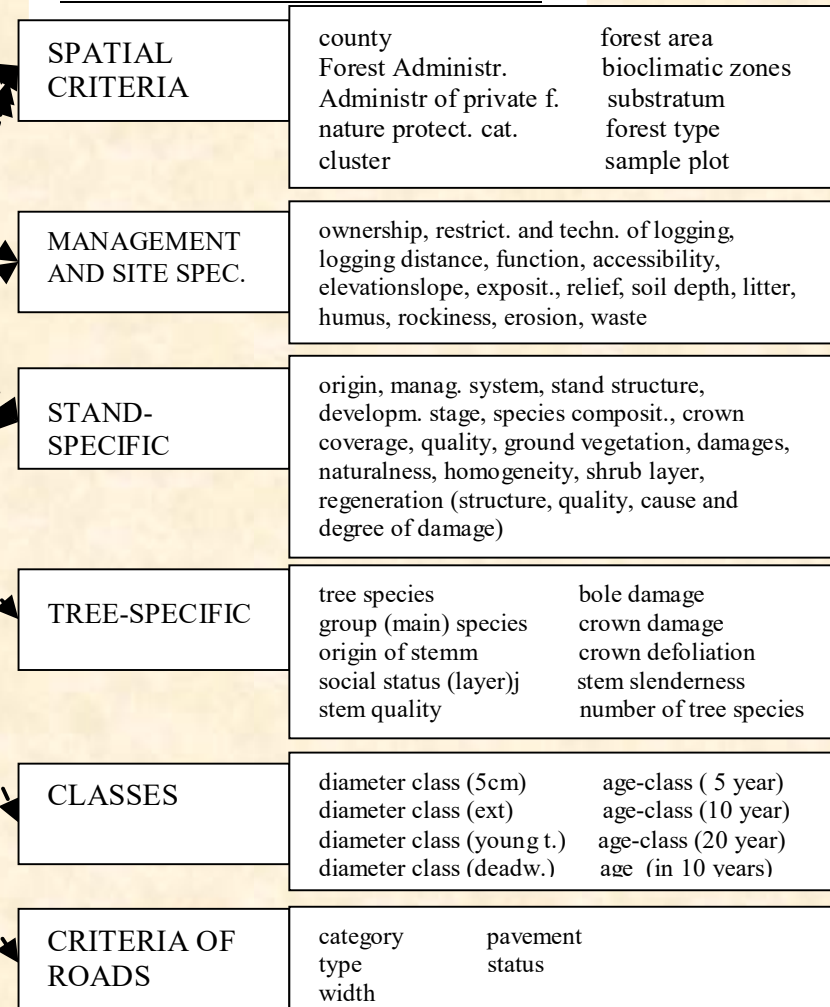
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MAIN INQUIRY WITH OUTPUT VARIABLES



VARIABLES OF GROUPING





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Processing and calculation of derivative variables

-means of measured tree variables (height, dbh, stump diameter, bark thickness)

-modeled variables:
(felled trees) $h_d = b_0 \times e^{\frac{-b_1}{d}} + 1,3$ $d_{1,3} = 0,78571 + 0,856509 \times d_{panj}$

-derivative variables:

	<i>standing</i>	<i>felled</i>
<i>tree volume</i>	$v_d = A \times d^B \times h_d^C \times f$ $v_d = \frac{d^2 \times \pi}{40000} \times h_d \times 0,5$	$v_d = A \times d^B \times \left(b_0 \times e^{\frac{-b_1}{d}} + 1,3 \right)^C \times f$

<i>tree number per ha</i>	$N_S = \sum_{p=1}^k \sum_{v=1}^l \sum_{d=1}^m \left(\frac{n_{mv}}{P_p} \times 10.000 \right)$	$N_{SPrasp} = \frac{\sum_{q=1}^i N_{S_i}}{i}$
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<i>basal area per ha</i>	$G_S = \sum_{p=1}^k \sum_{v=1}^l \sum_{d=1}^m \left(\left(\frac{n_{mv}}{P_p} \times 10.000 \right) \times \frac{dv^2 \times \pi}{40.000} \right)$	
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<i>volume per ha</i>	$V_S = \sum_{p=1}^k \sum_{v=1}^l \sum_{d=1}^m \left(\left(\frac{n_{dv}}{P_p} \times 10.000 \right) \times \left(A_l \times dv^{B_l} \times hv^{C_l} \times f \right) \right)$	
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<i>volume of annual felling per ha</i>	1) $vgS_1 = \frac{vps_{1-2}}{2}$	2) $vgS_2 = \frac{vps_{3-5}}{3}$	3) $vgS_3 = \frac{vps_{1-5}}{5}$
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stand, site and management -specific category variables:

$$ps_{kat} = \frac{bp_{kat}}{ubp_{PU}} \times P\check{S}_{PU}$$

road density

$$ot_{PS} = \frac{\sum_{t=1}^r \left(\frac{lp}{2,25} \right)_r}{r}$$

estimation of carbon sequestration:

above ground biomass

$$SC_{NB} = \sum_{v=1}^l DZ_l \times pfb_l \times pfst_l \times Cst_l$$

below ground biomass

$$SC_{PB} = \sum_{v=1}^l \sum_{c=1}^e (dz_{el} \times pfb_l \times pfst_l \times kpn_{el} \times Cst_l)$$

dead wood

$$SC_{MD} = \sum_{v=1}^l \sum_{f=1}^g (vmd_{gl} \times pfstm_{gl} \times Cstm_{gl})$$

forest litter

$$SC_{\check{S}S} = \sum_{v=1}^l \check{s}Cref_l \times P\check{S}s_l$$

forest soil

$$SC_{\check{S}T} = \sum_{s,d} (sCref_s \times mf_{s,d} \times P\check{S}t_{s,d})$$

variability and estimation of mean values:

$$P = \frac{CV \times t}{\sqrt{n}}$$



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Results:

- a) Forest area**
- b) Species composition**
- c) Tree description**
- d) Stand structures**
- e) Growing stock**
- f) Management features**
- g) Dead wood**
- h) Carbon sequestration**
- i) Stand regeneration**
- j) Health and vitality**
- k) Site characteristics**



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3) Current situation

Institutional framework

legislation (forest law, 2006; regulations on NFI in RH, 2006)

forestry model

absence of coherent and consistent public forest service

national level forest resources assessment based on stand-wise inventory system

National system for international reporting

Increasing needs and requirements for NFI data



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4) Looking forward

2nd NFI during period 2017-2019

Remote assessment

aerial photo

higher quality delineation of forest and non-forest area and assessment of open forest area (gaps, roads, water lines,...)

design of new field sample plots on areas cleaned from mines

design of temporary field sample plots

aerial photo assessment of OWL and OLwTC as separate categories

comprehensive landscape monitoring (1km x 1km grid) of all the national territory



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Field assessment

new field sample plots on areas cleaned from mines

temporary field sample plots

inclusion of new tree-specific variables (e.g. age, growth class, height to the living crown base, crown radius, tree assigned for felling)

more detailed procedure of assessment timber by stem quality and assortment

assessment of type of harvesting (regeneration fellings, thinnings, single stem and small area felling, clear cuts, salvage fellings, natural losses land-use change)

new stand variables (type/urgency of next silv. operat., stand stability, resistance, stress)

new site variables (ph-value of top soil, fire, snow movement, landslides)

assessments of site-, stand- and tree-specific variables on OWL and OLwTC



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Changes estimation

volume increment calculation (method of concentric plot sample)

estimation of harvested volume (forest conversion to other land-uses)

estimation of land use change (area, growing stock, increment, drain)

single tree volume/biomass functions

nationally valid BEFs

upgrade of CP ANFORRES

