A spatial decision support system for renewable energy production in Alpine valleys: analysis of trade-offs between renewable energy and ecosystem services.

Workshop on balancing bioenergy production and sustainable forest management in Mountains Areas

16 – 18 May 2017, Sopron, Hungary

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Partners

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Austria

- Environment Agency Austria
- Institute for Geography, University of Innsbruck
- International Institute for Applied Systems Analysis
- Regional Development Vorarlberg
- Research Institute of Wildlife Ecology, lead partner

France

- Mountain Institute

Germany

- Bavarian electric power company
- blue! advancing european projects (sub-contracted by the lead partner)
- International Commission for the Protection of the Alps

Italy

- European Academy of Bozen/Bolzano
- Veneto Region / Office for Economics and the Development of Mountain Areas

Slovenia

- Agricultural Institute of Slovenia
- Department for forestry and renewable forest resources, University of Ljubljana
- Slovenia Forest Service
- Triglav National Park

Switzerland

- Agroscope – Swiss research into agriculture, nutrition and the environment

Presentation Outline

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1. Introduction

EURAC research

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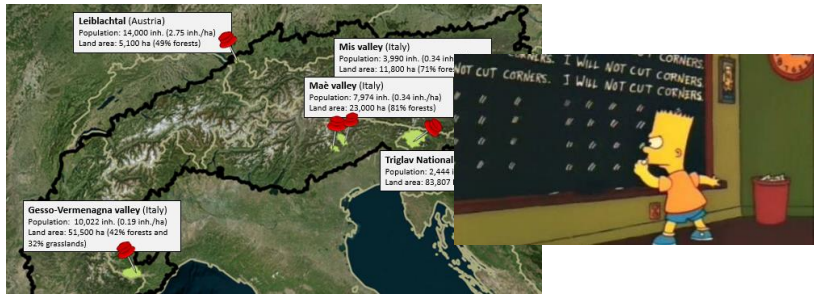
BALANCING ALPINE ENERGY AND NATURE

4. Case Studies application



2. Methodology

3. Software

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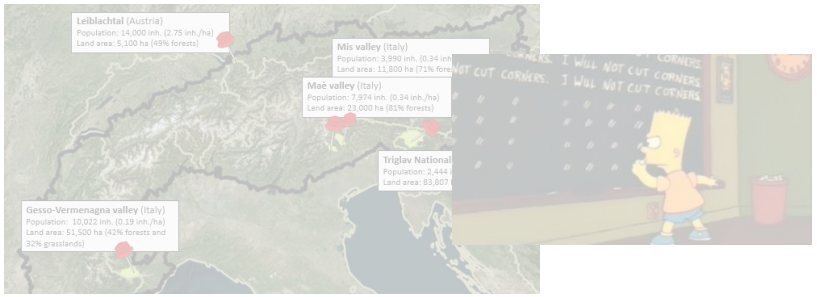

2. Methodology

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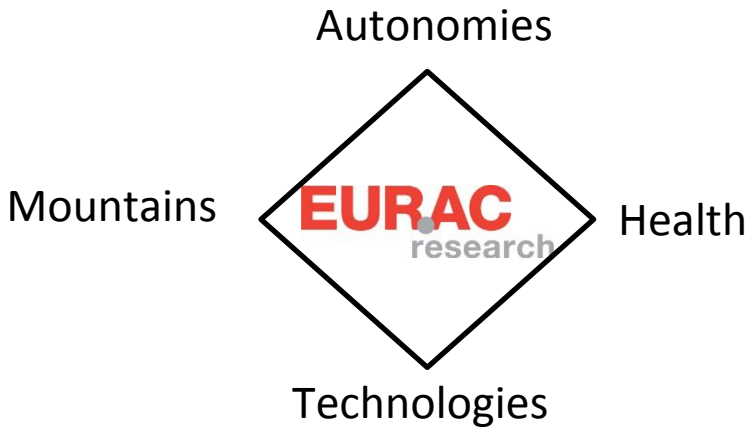
Research Academy - Bolzano

- Applied research
- Funded in 1992 – no profit
- 400 collaborators
- Currently partner in 65 EU funded projects (21 as Leader)
- 11 Institutes



EURAC research

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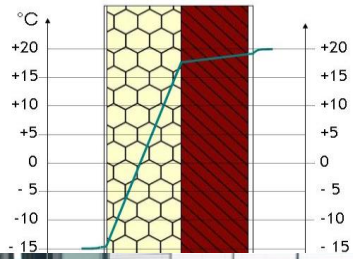

Institute for Renewable Energy

- Thermal Solar Systems
- Energy Efficiency in Buildings
- Photovoltaic Solar Systems
- Urban and Regional Energy Systems

International Cooperation

- Cooperation in 15 perennial projects of the international energy agency
- Cooperation in 25 European research and demonstration projects (as well with Mexico, Bangladesh, China, India)
- Cooperation with over 100 partners from research, industry and public administration

Eurac role in

recharge green

- Main Subcontractors

UNIVERSITY OF TRENTO - Italy

CRA AGRICULTURAL RESEARCH COUNCIL

EURAC research

Eurac role in

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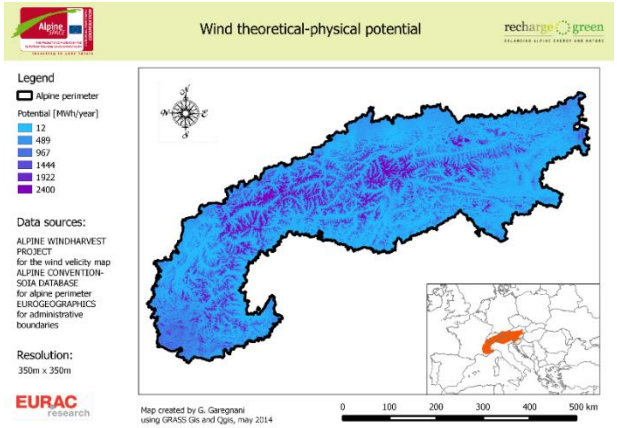
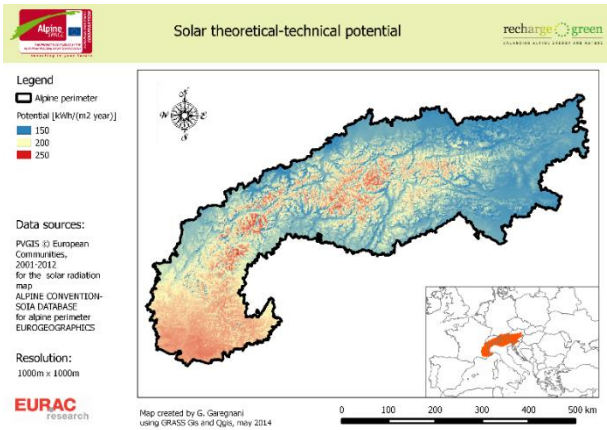
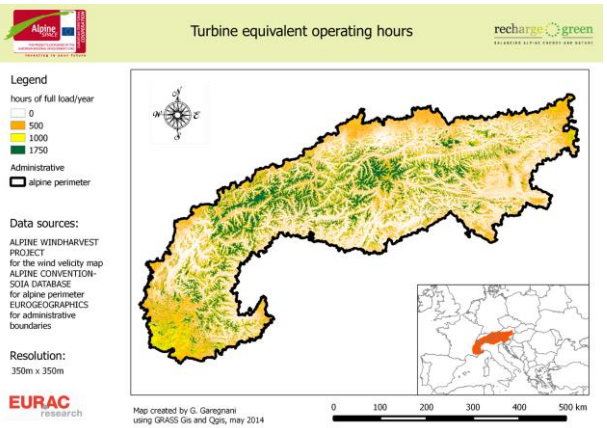
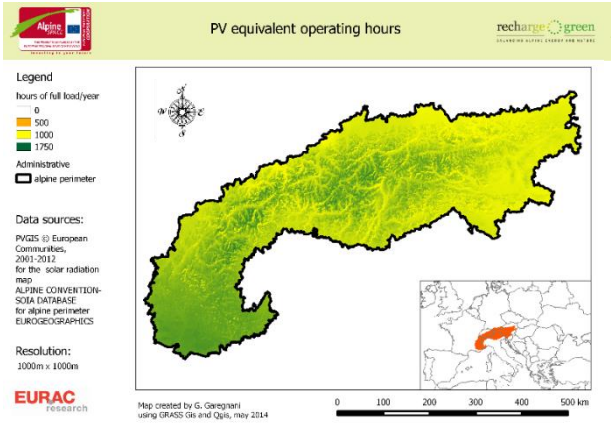
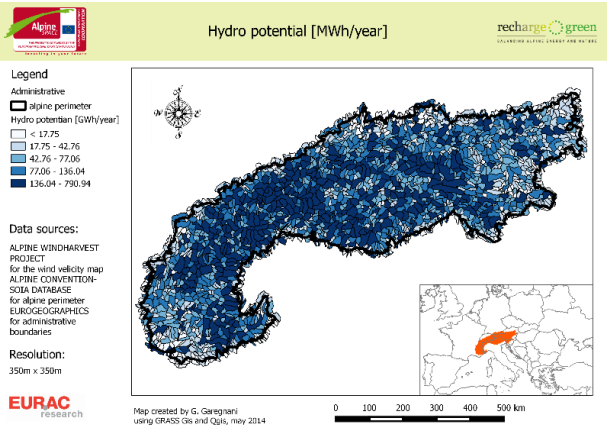
- Theoretical Potential Maps for the Alpine Area - Atlas

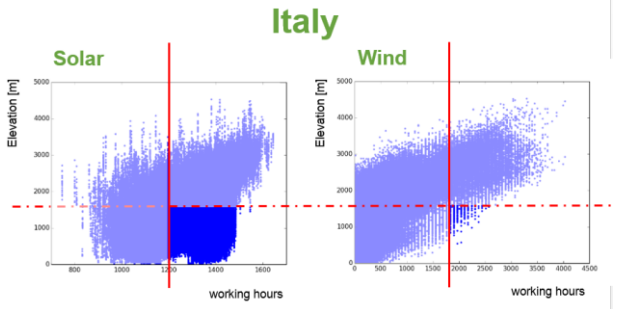












EURAC research

Eurac role in

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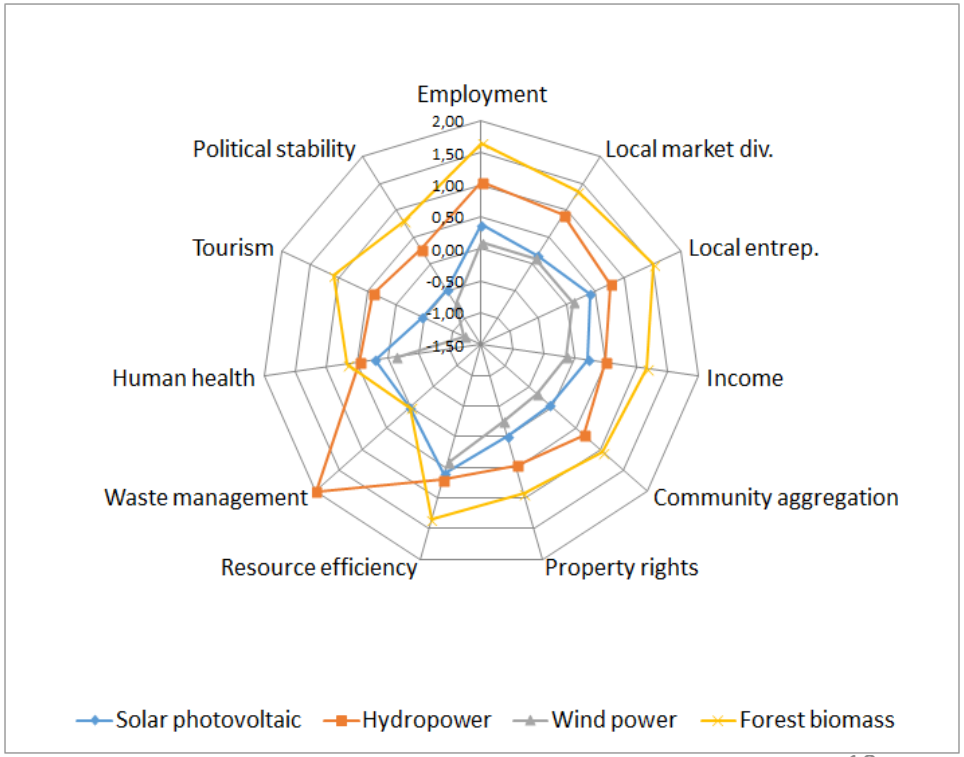
- Stakeholders involvement methodology and Expert Opinion

- Impact evaluation on Ecosystem Services



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Eurac role in

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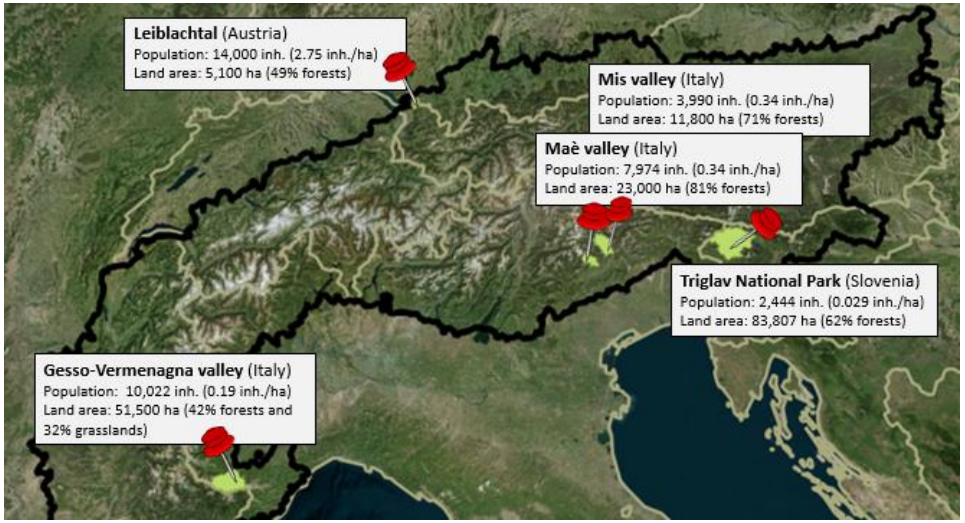
- Support to the Pilot areas



- Elaboration of the Spatial Decison Support System Software and test in Pilot Areas

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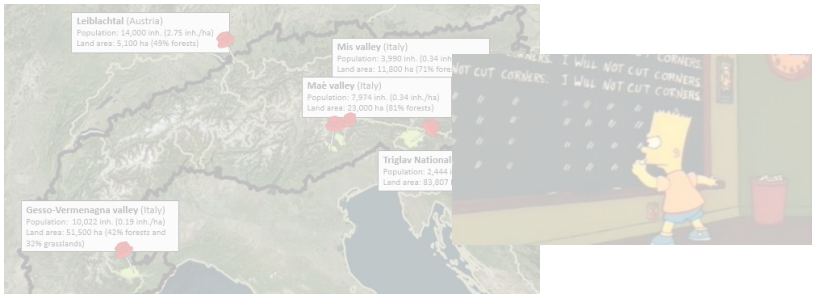

2. Methodology

3. Software

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Recharge.green objectives

- Create and test a methodology for **decision-making process** for sustainable energy production, ensuring:
- the preservation of Ecosystem Services,
- strong interaction with the stakholders from earliest decision moments,
- Development opportunities for local economies;

Recharge.green objectives

- Mitigation to climate changes;
- Enhancement and maintenance of biodiversity values, ecosystem services and human well-being;
- Social and territorial cohesion;
- Promotion of regional development potential;
- Innovation of the population;
- Promotion of environmental quality, landscape and cultural heritage and sustainable use of natural resources.

Recharge green follows the Strategic Environmental Assesment structure and aims

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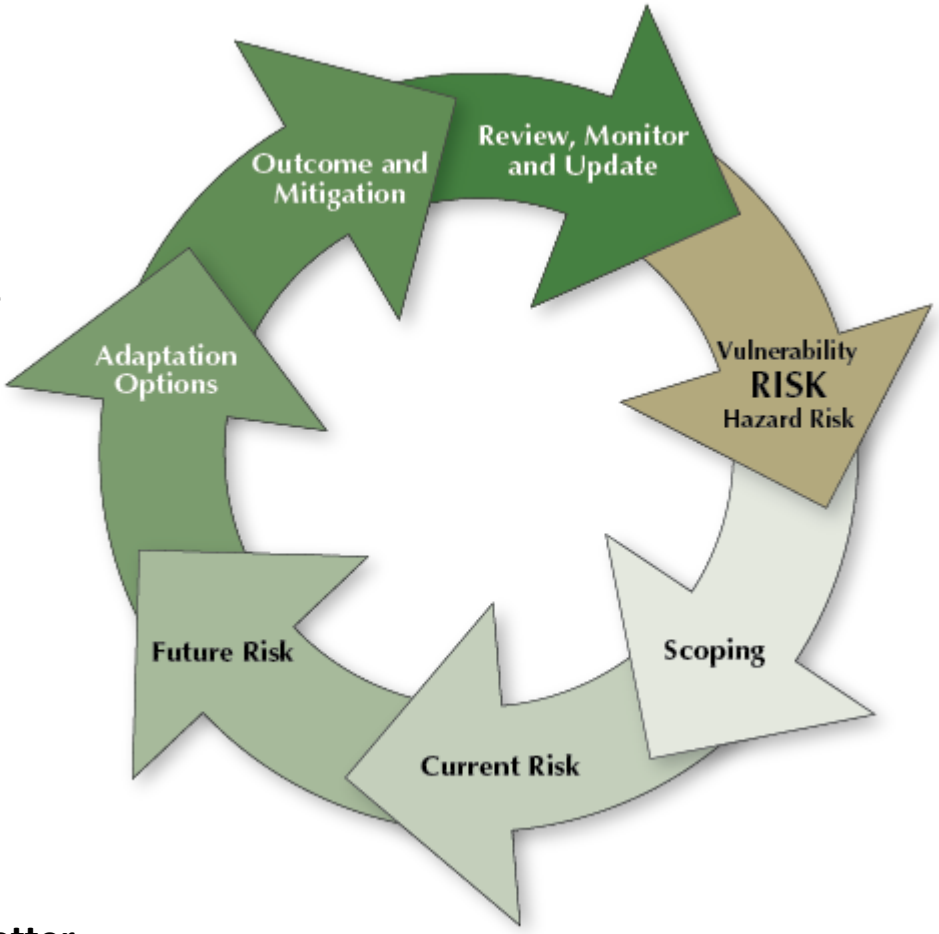
What is SEA?

- Strategic is an attribute that qualifies ways of thinking, attitudes, actions related to strategies;
- It is a flexible framework of key elements, acting strategically in a decision process to enable a facilitating role, ensuring an added-value to decision-making



(**Strategic Environmental Assessment Better Practice Guide** - methodological guidance for strategic thinking in SEA – Partidario 2012)

Strategic Environmental Assesment

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SEA methodology

- Voluntary
- introduced as a concept in 1989

SEA EU Directive (2001/42/EC)

- Mandatory <u>in some cases (Plans evaluation)</u>
- in force since 2001 and should have been transposed by July 2004

Recharge green spatial explicit TOOLBOX for SEA

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screening
- State of the art
- Data collection
- Stakeholders involvement

scoping
- Defines the context, extent, conflicts

alternatives
- Scenarios development
- Alternative comparison
- Stakeholders involvement

monitor
- Able to update the state of the art during the scenarios implementation

Metohology

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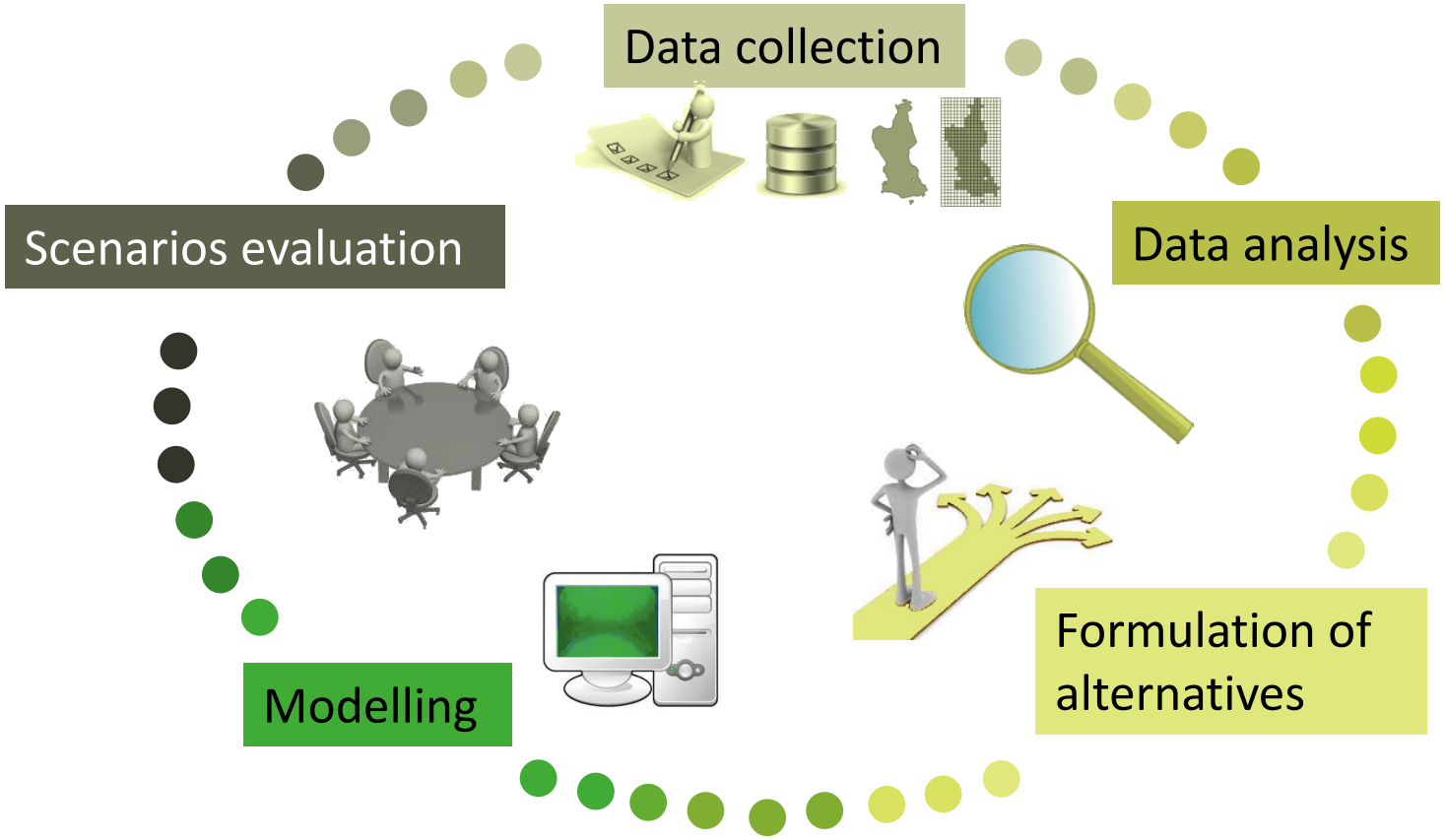
Balancing renewable energy exploitation and ecosystem services



Modelling framework

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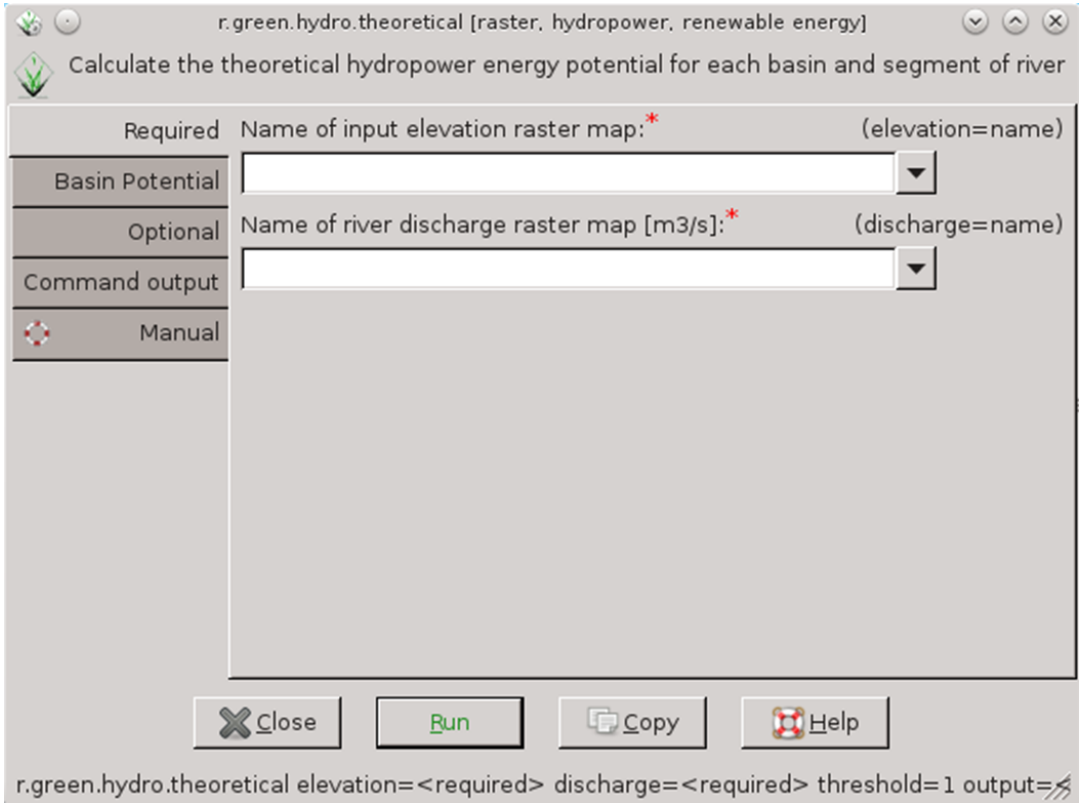
QGIS Trade



EURAC research

Alternatives Formulation and Evaluation

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Sustainable Energy potential

Theoretical	Resource availability and physical variables
Legal and/or “recommended ”	Legal values and/or planning recommended constrains
Technical	Technical parameters and limits
Economic	Realization cost and market price

EURAC research

HOW TO EVALUATE ALTERNATIVE SCENARIOS?

Ecosystem Service definition

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- Humankind benefits in a multitude of ways from all kinds of ecosystems: agroecosystems, forest ecosystems, grassland ecosystems, aquatic ecosystems, natural ecosystems, urban ecosystems, etc.
- **ecosystem services** are "the benefits people obtain from ecosystems".(Millennium Ecosystem Assessment 2006)
- i.e. clean drinking water, decomposition of waste, wood production, air purification etc…

Energy production on Ecosystem Services functionality

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Reduce GHG

Timber production

Energy production

Fire risk reduction

Landscape management

Water quality

Hydrogeological protection

Biodiversity

Soil fertility

Effects (Positive or Negative?

Ecosystem Services

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How to include the ES concept in energy planning in order to make sustainable choices?

Economic Approach

Economic valuation

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- **Even if strongly criticized… economic valuation of ES can be useful, by providing a way to justify and set priorities for programs, policies, or actions that protect or restore ecosystems and their services**
  - To justify and decide how to allocate public spending on conservation, preservation, or restoration initiatives.
  - To consider the public's values, and encourage public participation and support for environmental initiatives.
  - To compare the benefits of different projects or programs.
  - To prioritize conservation or restoration projects.
  - To maximize the environmental benefits per dollar spent.

Valuing ES

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Economic Approach

1. Market and Non-market evaluation of ES;
2. Benefit transfer;
3. Trade-off Analysis;

Inclusion of ES in the **Cost-Benefit analysis** of producing RE.

Total economic Value

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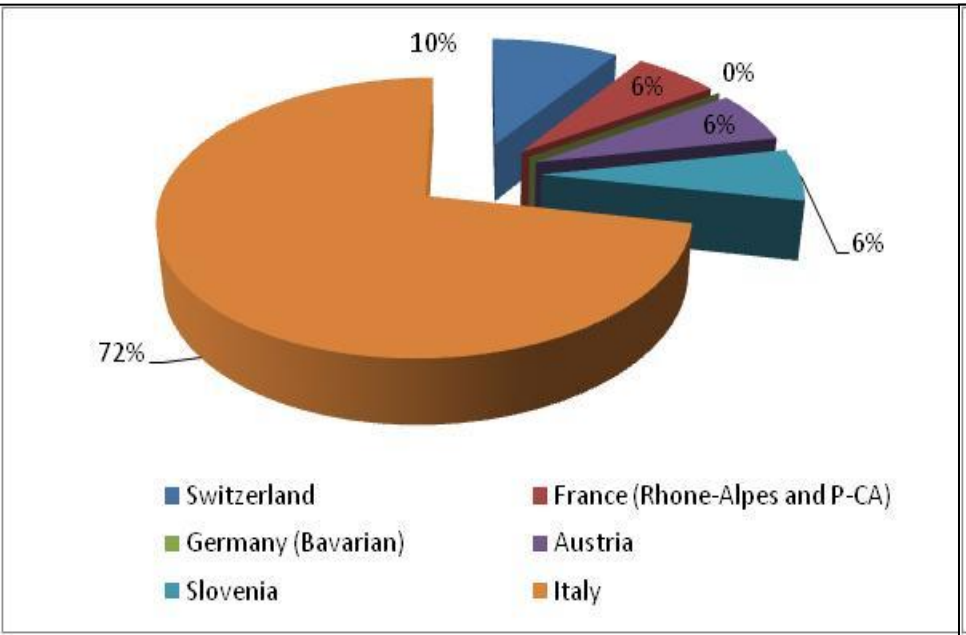
Total economic value (**TEV**) is a concept in cost–benefit analysis that refers to the value derived by people from a natural resource, a man-made heritage resource or an infrastructure system, compared to not having it.

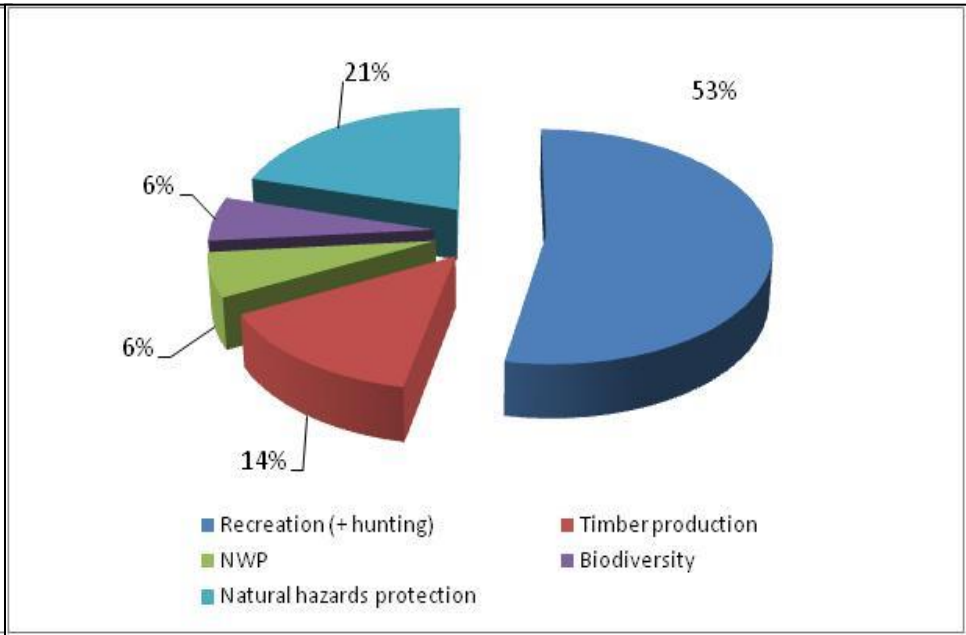
Total Economic Value – Meta Analysis

References identified:

29 references for the Alpine forests (and pastures) with a non-uniform distribution by geographical area and forest function considered

37 references for the mountain forests (and pastures) in Europe (Carpathians, Pyrenees, Apennines, etc..)





Total Economic Value – Meta Analysis

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Reference	Study area	Prot. Area	Altitude (m)	Forest types	Area (ha)	Good and services	Evaluation Methods	Current value (€/ha)	Year
Notaro et al.	Lavazè forest (Trentino)			Norway spruce	99,1	Timber Production	Market value	€ 168,51	2009
				European larch		Carbon Sequestration	Market value	€ 98,92	2009
				Silver fir		Hydrogeological Protection	Replacement cost	€ 149,72	2009
						Tourism-Recreation	CV	€ 346,01	2009
Notaro S., Paletto A.	Valdastico mountain forest		985 (620-1350)	Norway spruce	269	Hydrogeological Protection	Replacement cost	€ 284,20	2012
				European larch					
Gret-Ragamey A.et al.	Landschaft Davos		1560		25500	Avalanche protection	Cost of damage	€ 485,38	2008
						Scenic beauty	WTP	€ 279,85	2008
						Habitat suitability	Replacement cost	€ 0,03	2008
						Carbon sequestration		€ 37,67	2008
Goio et al.	Trento Province		1000	Norway spruce	345180	Total production	Market value	€ 80,49	2008
				European larch		(of which timber)	Market value	€ 49,64	2008
				Silver fir		landscape/recreational	CV	€ 51,88	2008
						carbon fixing value	market value	€ 13,68	2008
						Hydro-geological protection value	cost of substitute meadow	€ 229,59	2008
Hayha T. et al.	Fiemme e Fassa forests			Norway spruce	40000	Timber production	Market value	€ 239,43	2012
				European larch		Game products	Market value	€ 14,90	2012
				Scots pine/beech		Mushrooms/barries	Market value	€ 13,93	2012
						Carbon sequestration	Market value	€ 104,58	2012
						Hydro-geological protection	Replacement cost	€ 327,90	2012
						Tourism-Recreation	WTP	€ 32,00	2012
						Recreation hunting/picking	Market value	€ 15,30	2012
Marangon & Gottardo	Fusine forests (FVG)			Silver fir	1568,58	Timber production	Market value		1998
				European larch		Mushrooms/barries	Market value		
				Norway spruce		Tourism-Recreation	TCI, CV, DV		
Hackl & Pruckner	Kalkalpen national park	x		Coniferous	21500	Tourism-Recreation	CV	333,91	2006
Scolozzi R.	Parco Adamello-Brenta	x			19900	Timber production	Market value	201,55	2012
						Recreation hunting/picking	Market value	196,8	2012
						Tourism-Recreation	WTP	47,53	2012
						Carbon sequestration	Market value	333,57	2012
						Avalanche protection	Replacement cost	126,38	2012
						Hydro-geological protection value	Replacement cost	573,2	2012
Busch et al.	Veneto (Cansiglio)					Timber production	Market value		2011
						Carbon sequestration	Market value		
						Erosion protection	Replacement cost		
						Gene pool prot.	Benefit transfer		
						Tourism-Recreation	TCM		
Olschewski R. et al.	Andermatt (Svizzera)		1450	Norway spruce	24	Avalanche protection	Choice Experiment	€ 43,31	2012
				European larch					
				Swiss pine					
Bernasconi & Schroff	Berna				6300	Tourism-Recreation	CV	€ 81,85	2003

Expert Opinion for validation of values

In order to understand the impacts of renewable energy development in the Alpine context an **expert-based approach** was adopted.

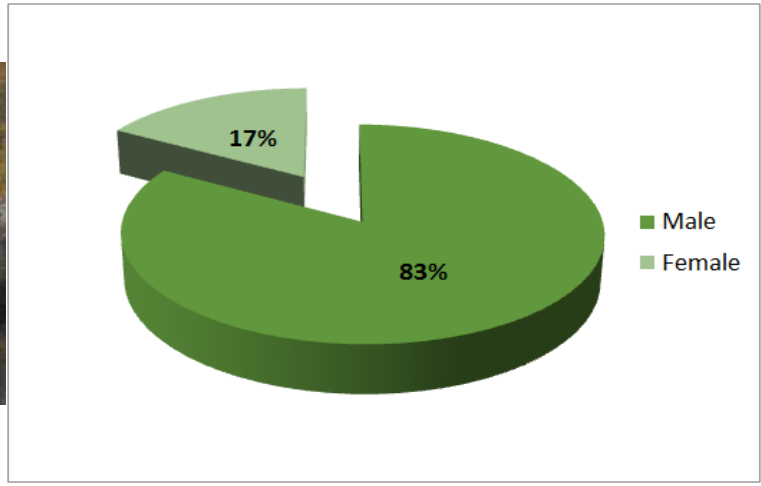
- Identification of a sample of experts considering the following aspects:
  a. Equitable geographical distribution
  b. Expertise and skills on ecosystem services and/or renewable energies
  c. Local knowledge of the context
- Face-to-face interviews to the experts using a semi-structured questionnaire.
- Trade-off analysis between renewable energy development, ecosystem services and local development

Results: profile of experts

Through a brainstorming session **40 experts** were identified by the partners of recharge.green project. All the experts were contacted and face-to-face interviewed.

Experts are representatives of public institutions, private organizations and associations with a long expertise in the following fields:

- Forestry and agriculture (about 40% of experts)
- Nature conservation and ecosystem services (about 20%)
- Renewable energy (about 40%)



Sample of experts

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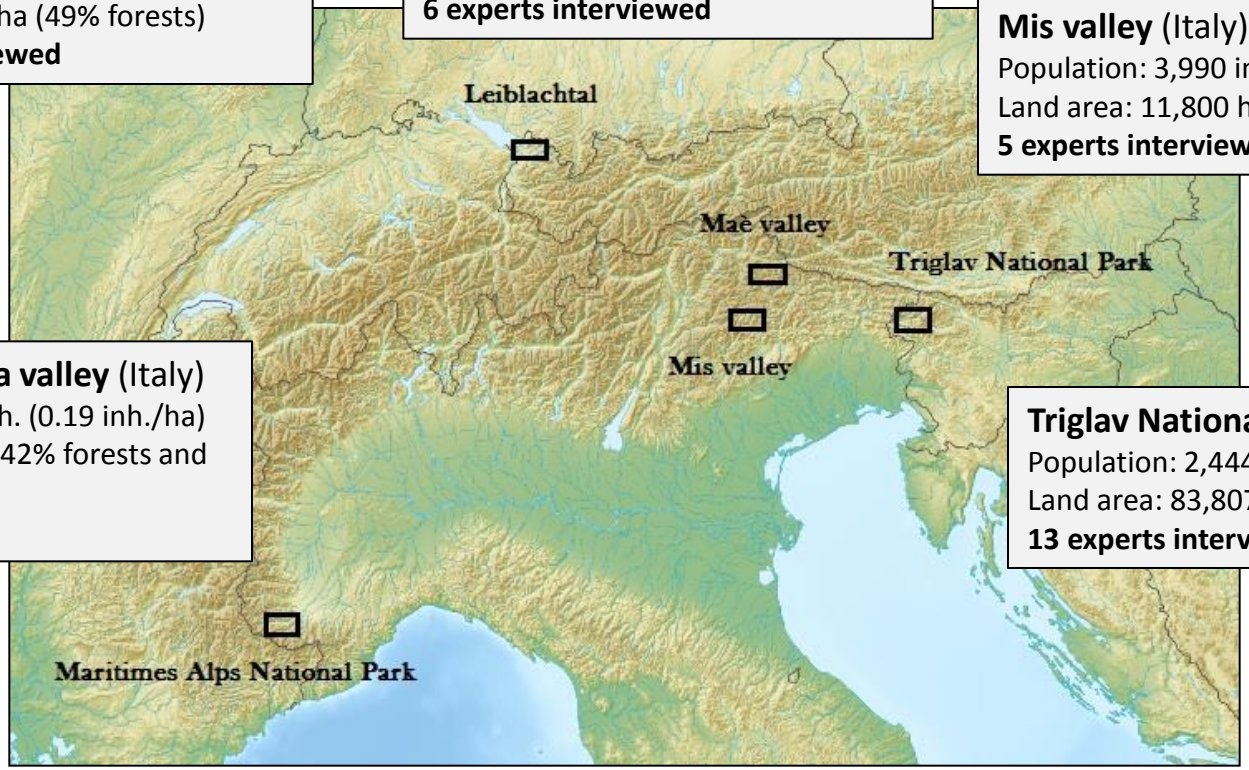
Leiblachtal (Austria)
Population: 14,000 inh. (2.75 inh./ha)
Land area: 5,100 ha (49% forests)
8 experts interviewed

Maè valley (Italy)
Population: 7,974 inh. (0.34 inh./ha)
Land area: 23,000 ha (81% forests)
6 experts interviewed

Mis valley (Italy)
Population: 3,990 inh. (0.34 inh./ha)
Land area: 11,800 ha (71% forests)
5 experts interviewed

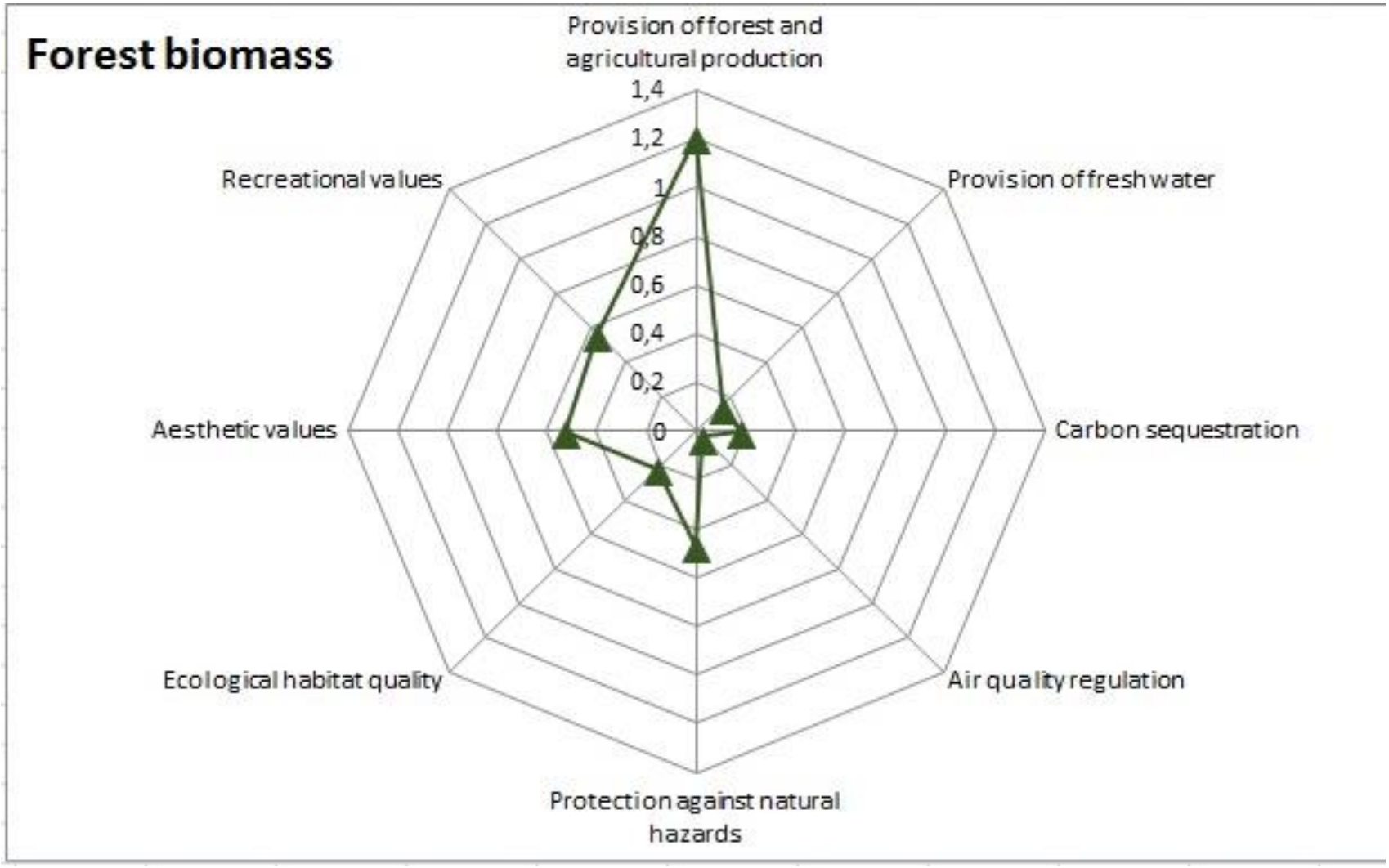


Gesso-Vermenagna valley (Italy)
Population: 10,022 inh. (0.19 inh./ha)
Land area: 51,500 ha (42% forests and 32% grasslands)
8 experts interviewed

Triglav National Park (Slovenia)
Population: 2,444 inh. (0.029 inh./ha)
Land area: 83,807 ha (62% forests)
13 experts interviewed

EURAC research

Results: evaluation of Forest ES



Economic evaluation of Ecosystem Services (ES) and economic impact assessment for FB

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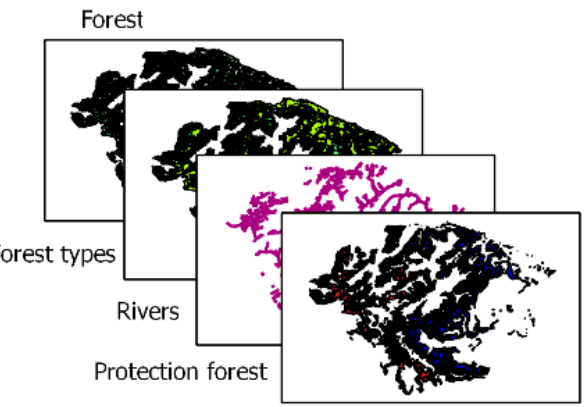
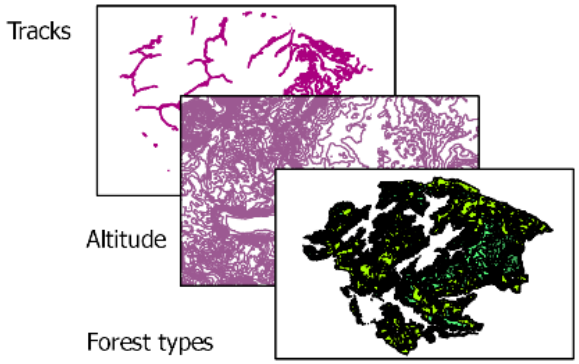
ES	Methodology	Formula	Description
Timber	Market Price	$Timber = \sum_{i=1}^{N} Q_i \, x \, P_i$	Timber = timber value N = number of tree species Q_i = quantity of the i-th tree species P_i = price of the i-th tree species
Hazard protection	Replacement cost	$V_p = \frac{C_0 \, x \, r}{(1+r)^t}$	V_c = protection value C_0 = Cost of substitution engineering work r = Discount rate t = lifetime of the engineering work
Carbon sequestration	Market Price	$V_c = Q_{carb} \, x \, P_{carb}$	V = value of carbon sequestration Q_{carb} = quantity of carbon annually stored by forests P_{carb} = carbon price in the voluntary carbon market
Recreation	Benefit Transfer	$V_r = N_t \, x \, BT_w$	Vr = Value of recreation Nt = Annual number of tourist in the area BTw = Average WTP value from a meta-analysis

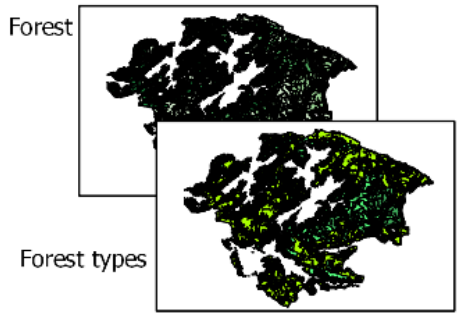
Mapping ES



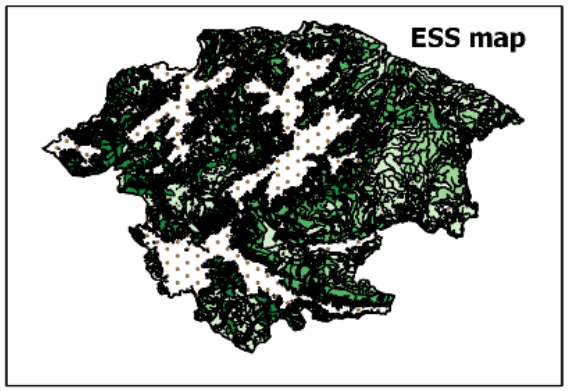
Regulating Services

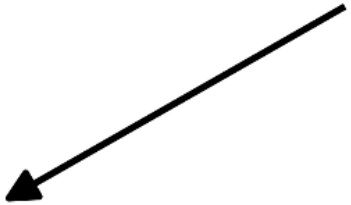


Cultural services



Provisioning services





Applications

- Cost-Benefit Analysis with environmental externalities included;
- Payment for ecosystem services loss (**strong** or **weak** Sustainabilty concept?);

Presentation Outline

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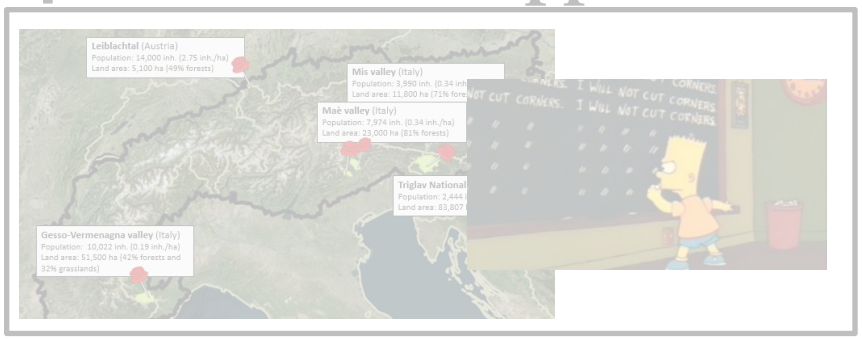
1. Introduction

4. Case Studies application



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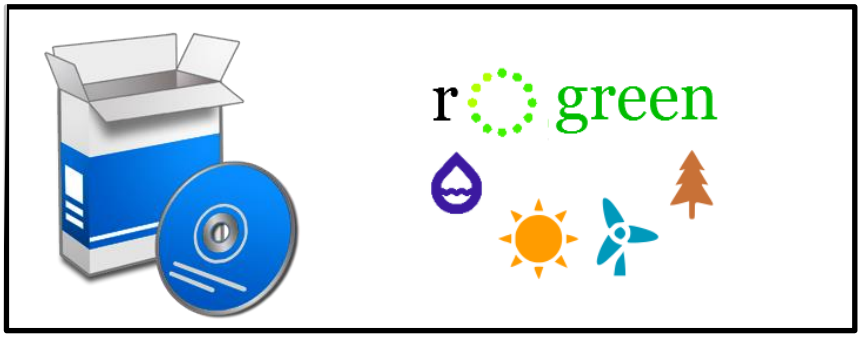


Desktop version is Open source: free and customizable !!!

recharge green

r green

python

R.GREEN SPATIAL DECISION SUPPORT SYSTEM

HOW TO INSTALL

The Decision Support System (DSS) r.green is available as add-on in GRASS-GIS and Plugin for QGIS. It works on different Operation Systems (Linux, Windows, Mac).

The main steps to follow to install GRASS or QGIS and use r.green DSS are:

To install r.green as add-on of GRASS:

- Download and install GRASS7: http://grass.osgeo.org/grass7/.
  For some help about how to use GRASS, tutorials in different languages are available online: http://grass.osgeo.org/documentation/tutorials/.
- Install the add-on with the following command "g.extension r.green" from GRASS Command Console or Terminal.
  Technical manuals about the commands are available online: http://grass.osgeo.org/grass70/manuals/addons/

To install r.green as Plugin in QGIS:

- Download and install QGIS 2.8: http://www.qgis.org/en/site/forusers/index.html
  For some help about how to use QGIS, tutorials in English are available online: http://www.qgistutorials.com/en/
- In the Plugins tab, choose "Manage and Install Plugins…" and install r.green which will be soon in the list.

A Manual for each add-on is available as on-line help of the software (in the Manual tab of each interface).

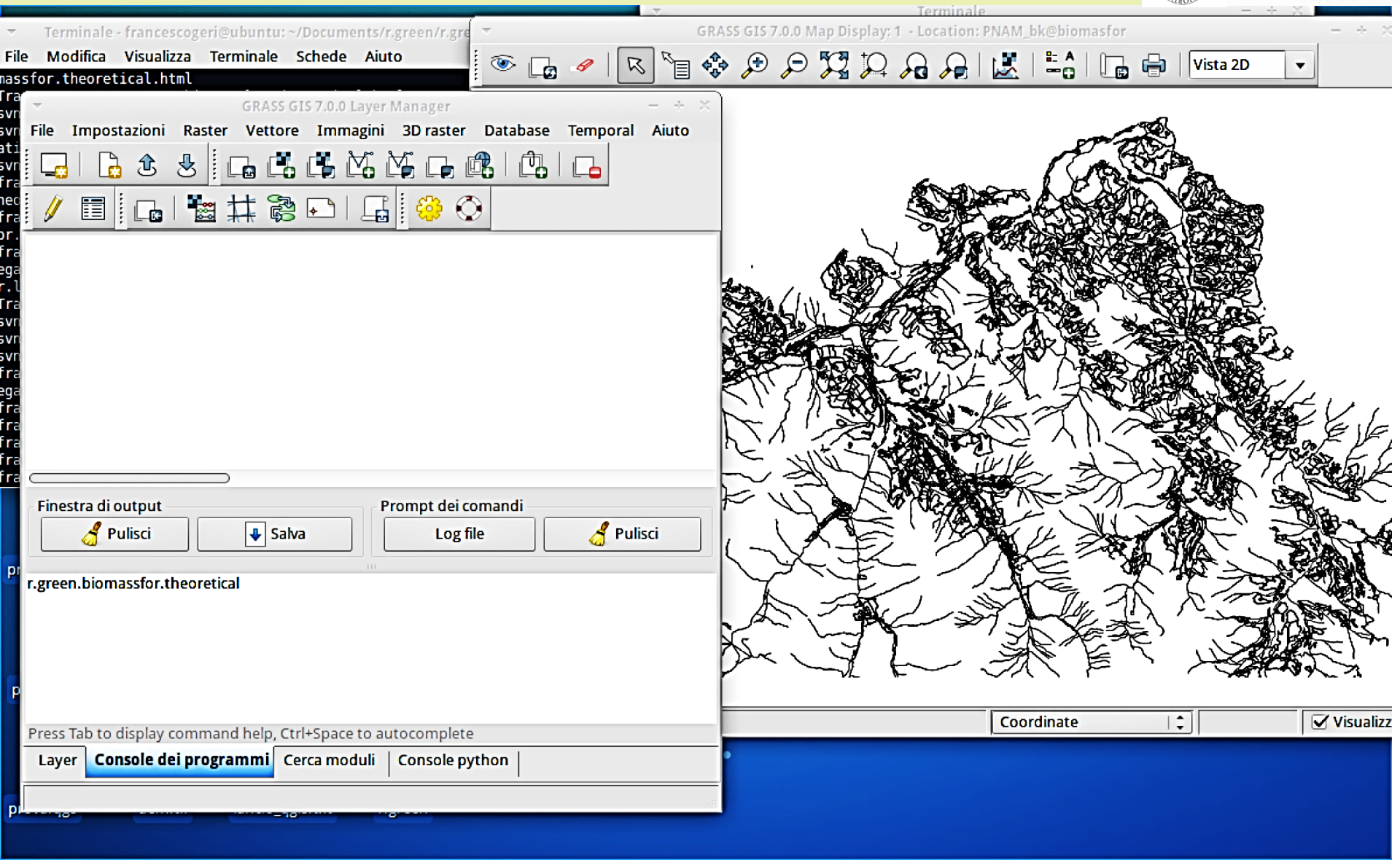
More information are available at this email contact: r.green@eurac.edu

The project website: http://www.recharge-green.eu/

The developers website: http://www.eurac.edu/en/research/technologies/renewableenergy/ → Urban and Regional Energy Systems

EURAC research

General overview of Open Source GRASS and QGIS environment



Spatial Decision Support System

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Sustainable Energy potential

Theoretical — Resource availability and physical variables

Legal and/or "recommended" — Legal values and/or planning recommended constrains

Technical — Technical parameters and limits

Economic — Realization cost and market price

r green




Desktop version

recharge green

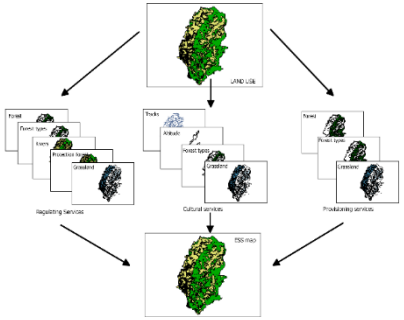
r green biomassfor

r green wind

r green hydro

r green solar

r green - impact



Multi platform:

- Windows
- Linux
- Mac

4 modules + 1

The energy section with calorific parameters

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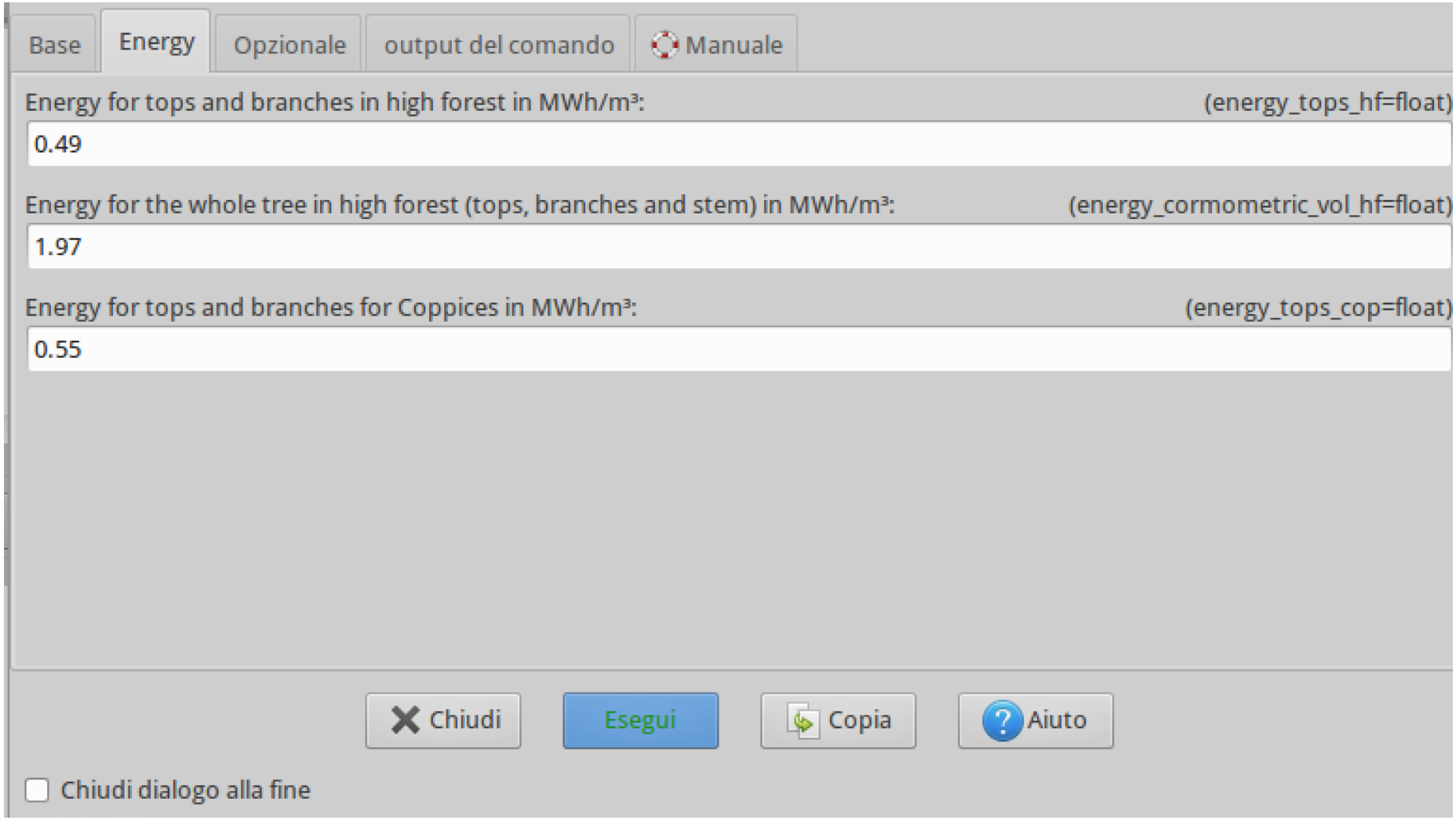

r.green.biomassfor.technical: cable crane parameters

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Richiesto | Opt files | Cable Crane | Forwarder | Other | Energy | Opzionale

Percent slope lower limit with Cable Crane: (slp_min_cc=float)

30.

Percent slope higher limit with Cable Crane: (slp_max_cc=float)

100.

Maximum distance with Cable Crane: (dist_max_cc=float)

800.

EURAC research

r.green.biomassfor.technical: forwarder parameters

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Richiesto | Opt files | Cable Crane | Forwarder | Other | Energy | Opzionale

Percent slope higher limit with Forwarder: (slp_max_fw=float)

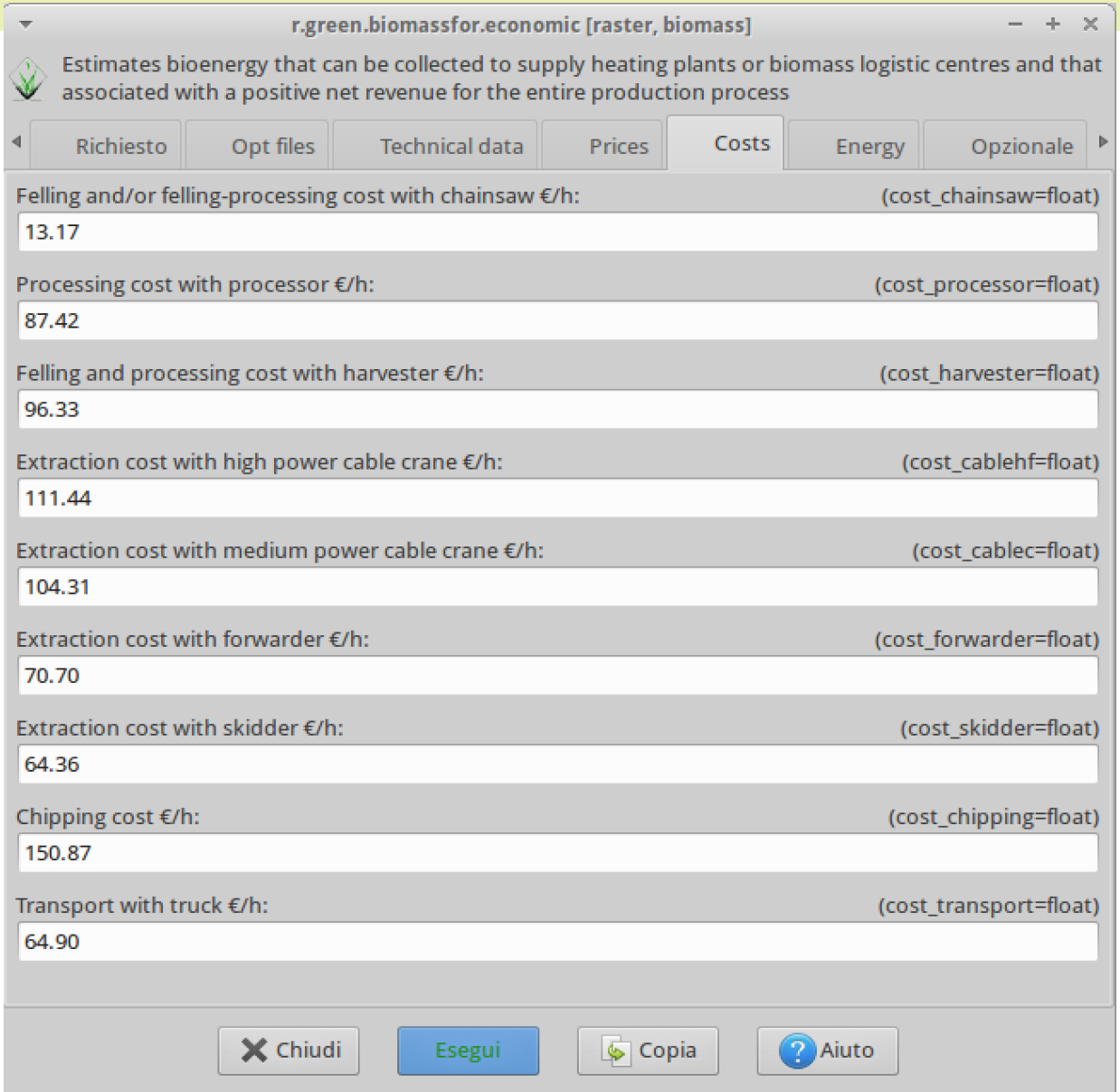
30.

Maximum distance with Forwarder: (dist_max_fw=float)

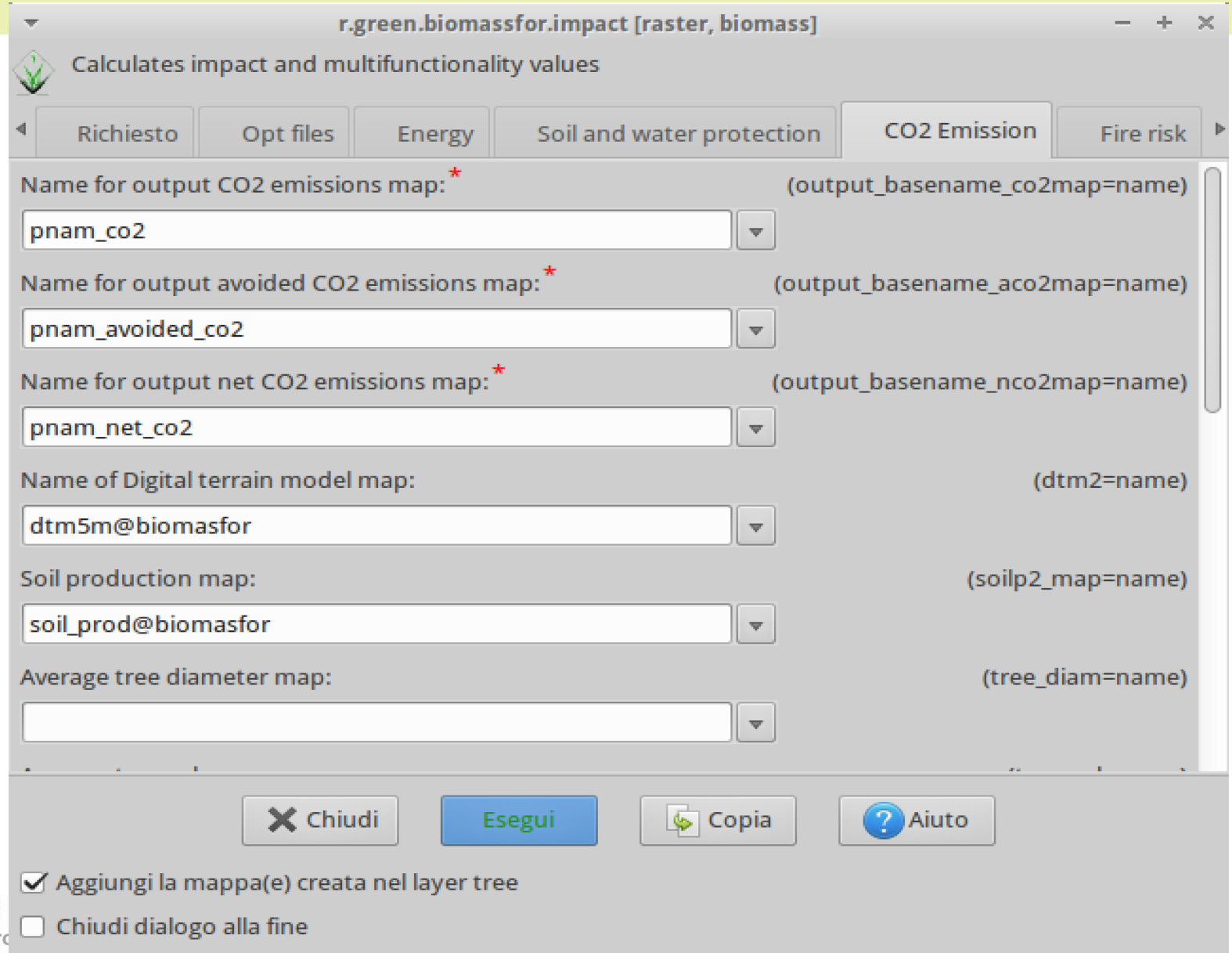
600.

Chiudi | Esegui | Copia | Aiuto

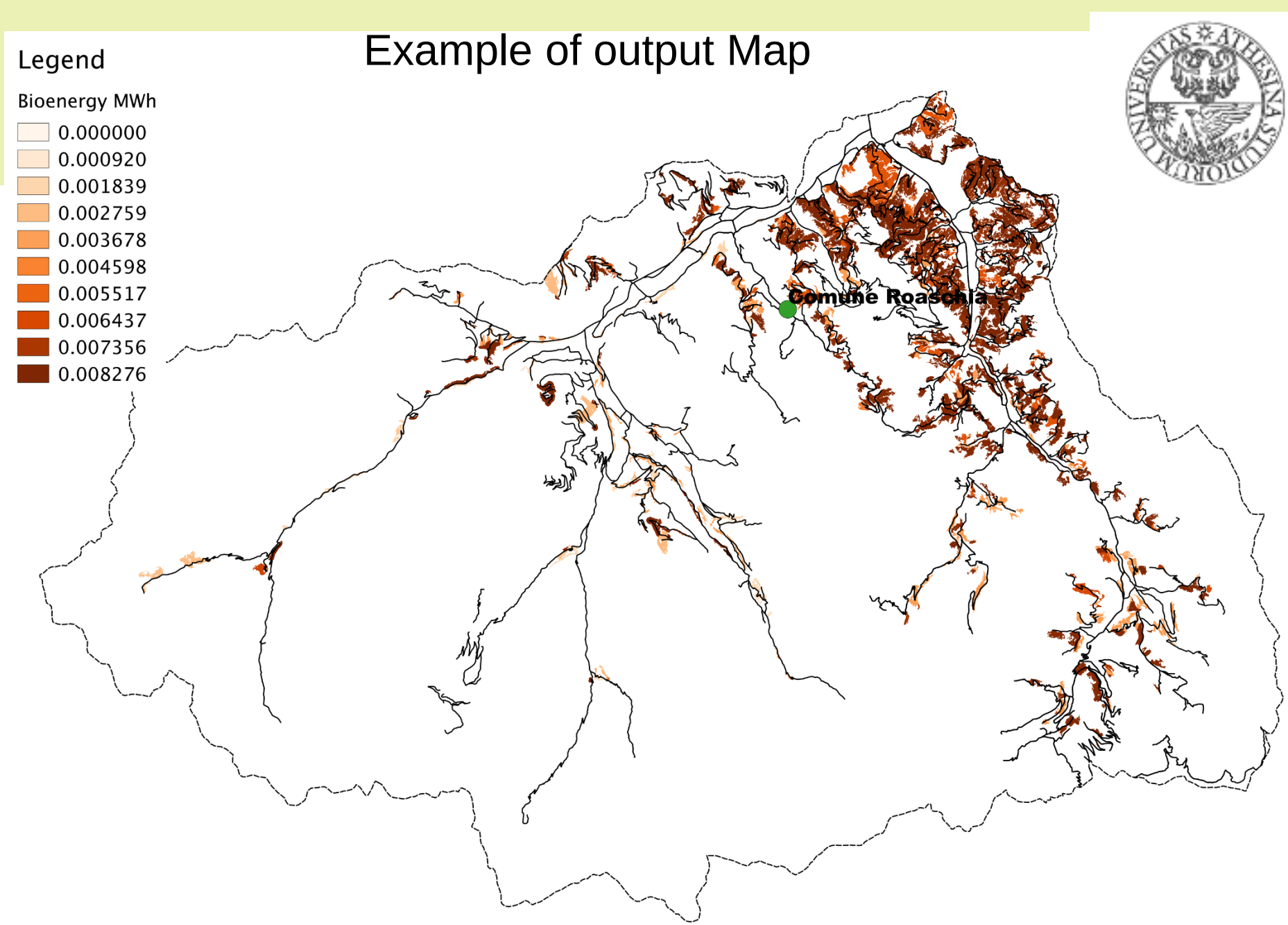
r.green.biomassfor.economic: list of costs



r.green.biomassfor.impact: co2 emissions



Example of output Map



Tot. economical viable and low impact potential bioenergy production : 12170 MWh/y

Presentation Outline

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1. Introduction

EURAC research

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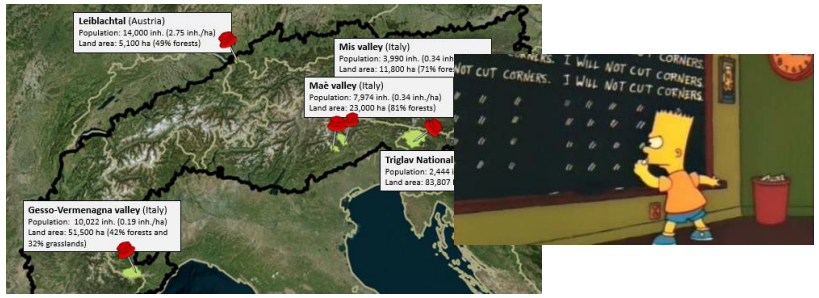
BALANCING ALPINE ENERGY AND NATURE

4. Case Studies application



2. Methodology

3. Software

r green

DSS in pilot areas

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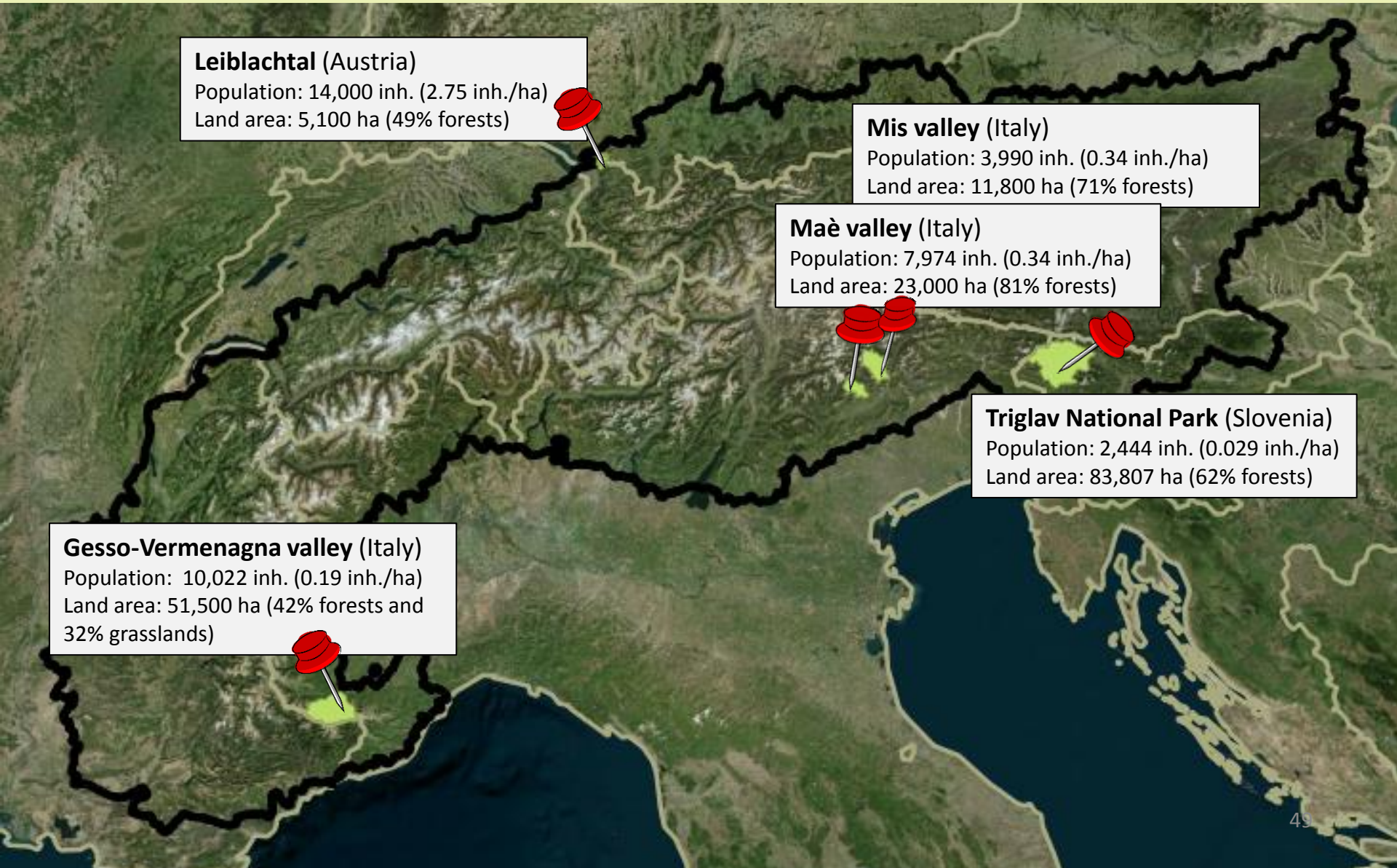

DSS in pilot areas

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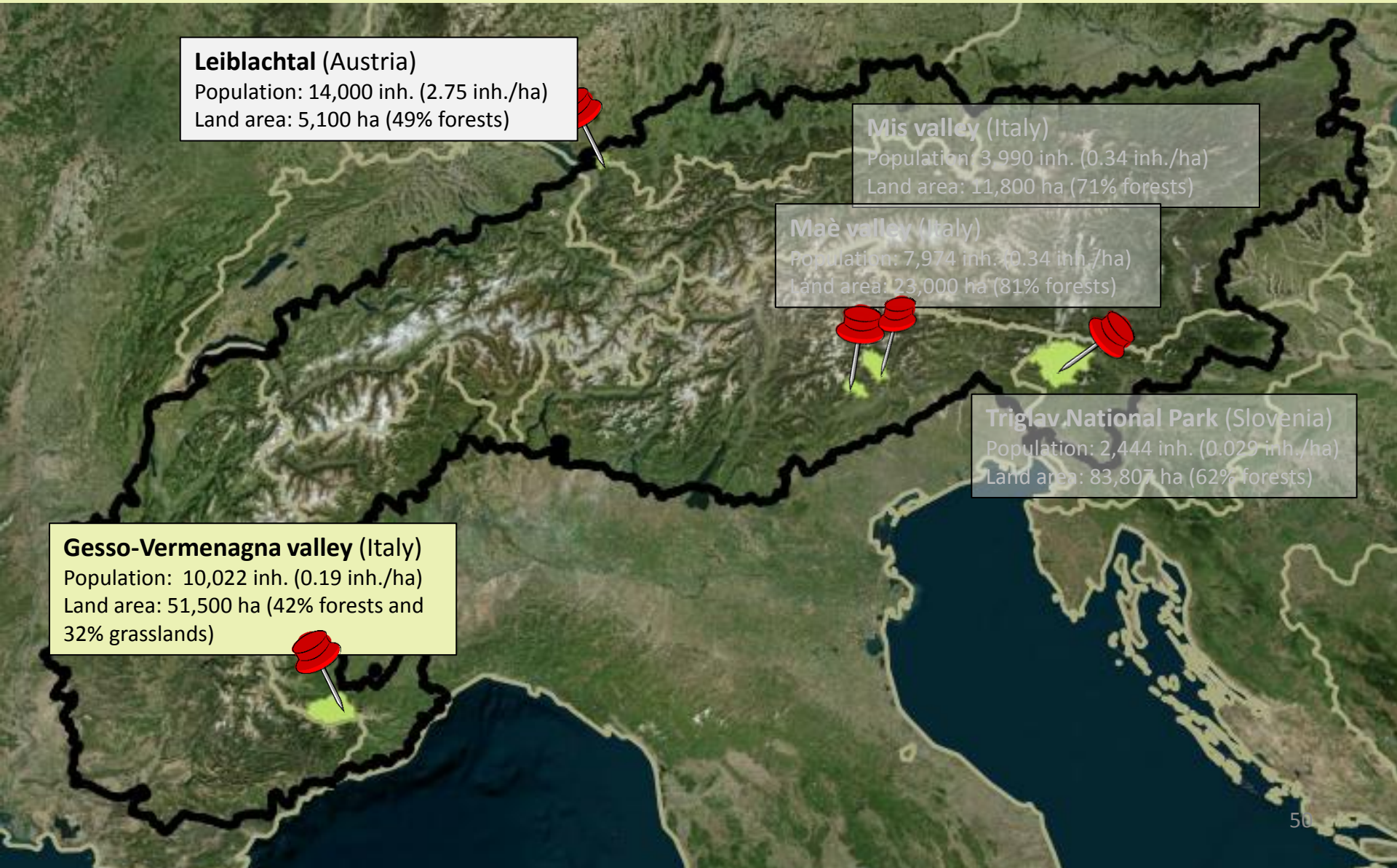
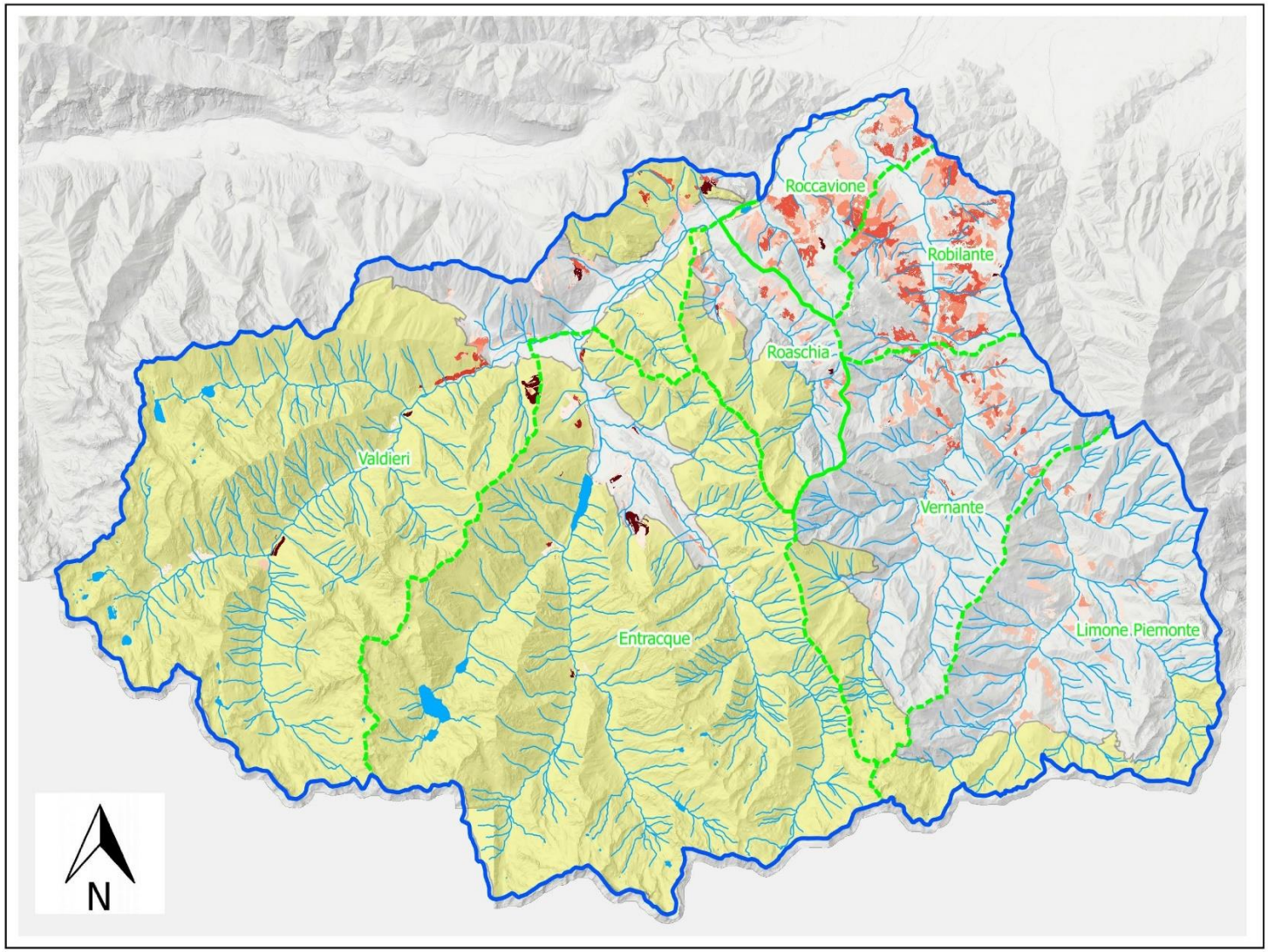


Assesment of available biomass in Piedmont Region
Economical potential



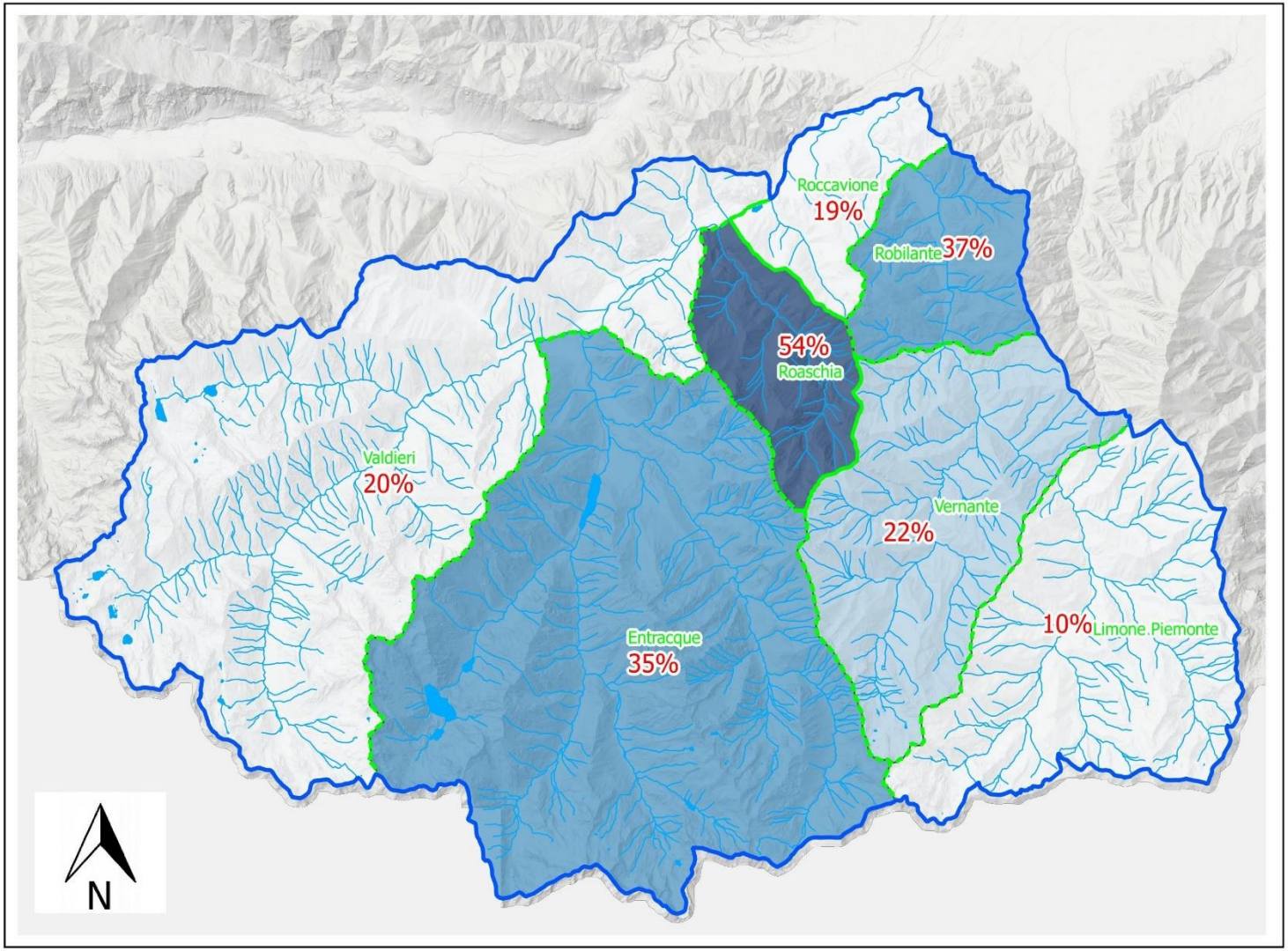
Data sources:

PIEDMONT REGION
for raster background, for streams and lakes datasets and for administrative boundaries
EURAC
for interruptions and fish passages positions

Resolution: 2.11m/px

Author(s): G. Curetti G. Garegnani
using GRASS Gis and Qgis, may 2015

Assesment of available biomass in Piedmont Region
Coverage percentage of heat consumption



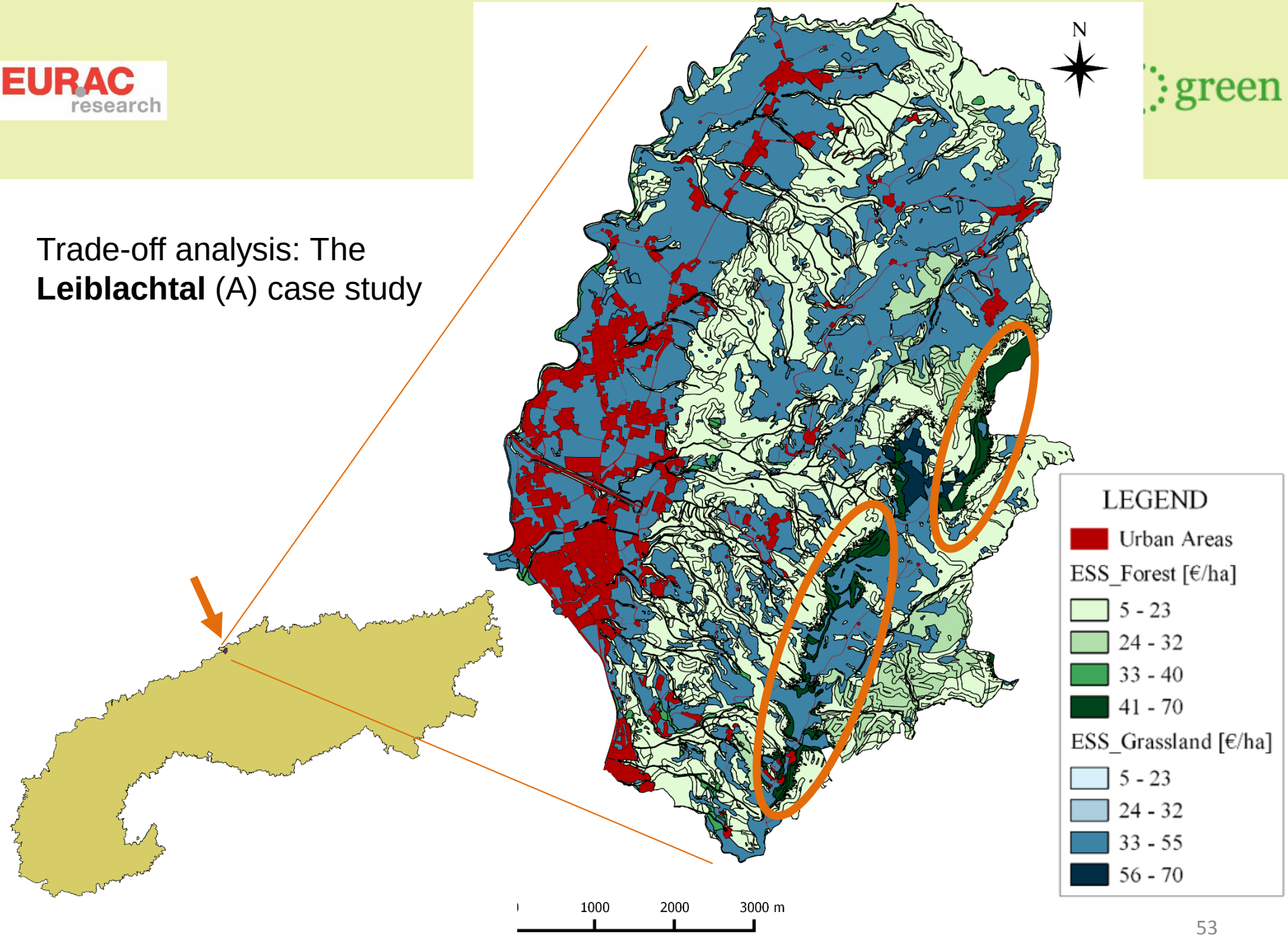
Data sources:

PIEDMONT REGION
for raster background, for streams and lakes datasets and for administrative boundaries
EURAC
for interruptions and fish passages positions
ISTAT
Heat consumption data

Resolution: 2.11m/px

Author(s): G. Curetti G. Garegnani
using GRASS Gis and Qgis, may 2015

Trade-off analysis: The
Leiblachtal (A) case study



Thank for your attention

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