Les Conservatoires d'Espaces Naturels
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Great European Dynamic Rivers and the «Free Space for Rivers » concept
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CONSIDERATION OF LATERAL MOBILITY FOR RIVER MANAGEMENT IN ITALY

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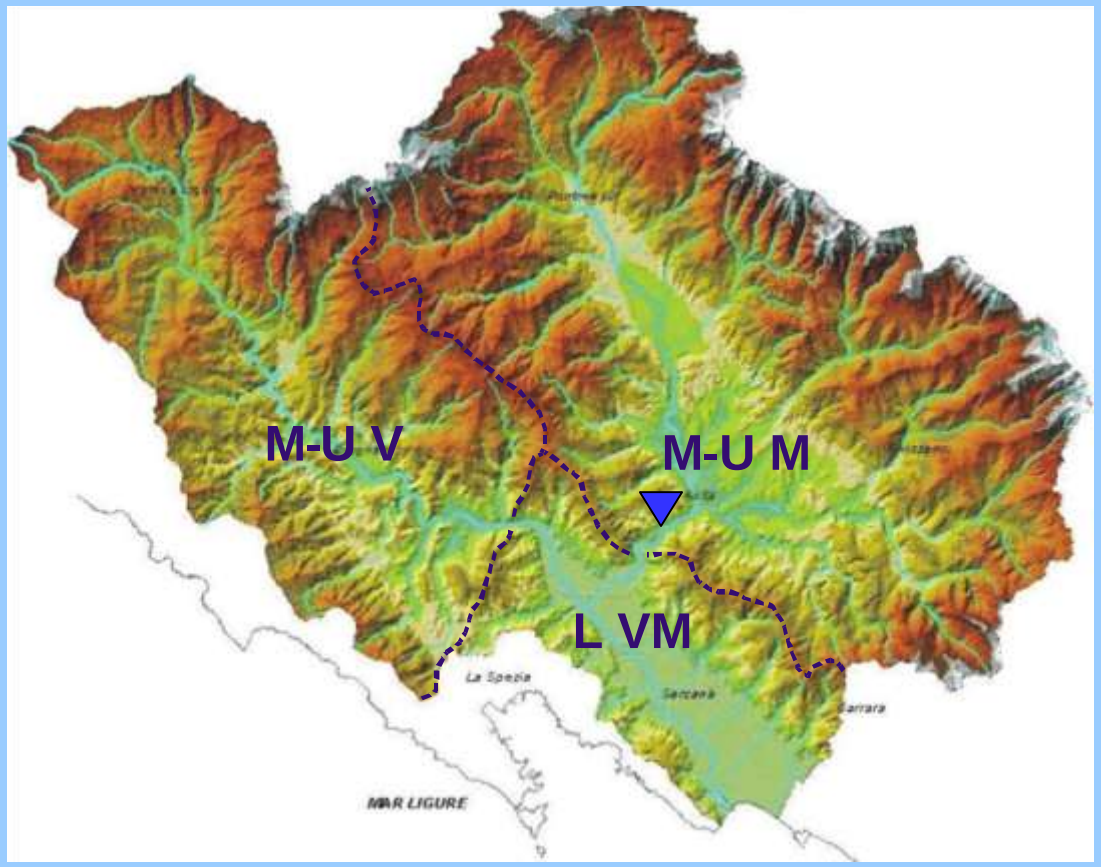
DICeA

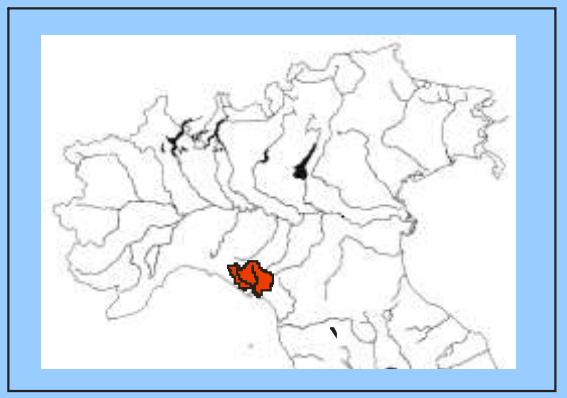
PRESENTATION OUTLINE

1. The **Magra River project**

2. Lateral mobility and Water Framework Directive: a **new methodology for hydromorphological assessment and classification** of Italian rivers

MAGRA RIVER: GENERAL SETTING





M-U V: middle – upper Vara
M-U M: middle – upper Magra
L VM: lower Vara - Magra
▼ : gauging station

Total catchment area: 1698.5 km^2
Vara catchment area: 572 km^2
Basin relief: 1639 m
Mean annual precipitation: 1707 mm
Magra R. length: 69.5 km
Vara R. length: 65 km
q_{med}: 40.8 m^3/s **Q_2:** 622.7 m^3/s

THE MAGRA RIVER PROJECT

PROBLEMS: severe incision, bedload deficit and associated environmental problems

AIMS: to define a scientific strategy design for promoting sustainable management of sediment and channel mobility

RINALDI M., SIMONCINI C., PIEGAY H. (2009) - *Scientific strategy design for promoting a sustainable sediment management: the case of the Magra River (Central – Northern Italy).* River Research and Applications, 25, 607-625.

1. Channel changes and trends of adjustment

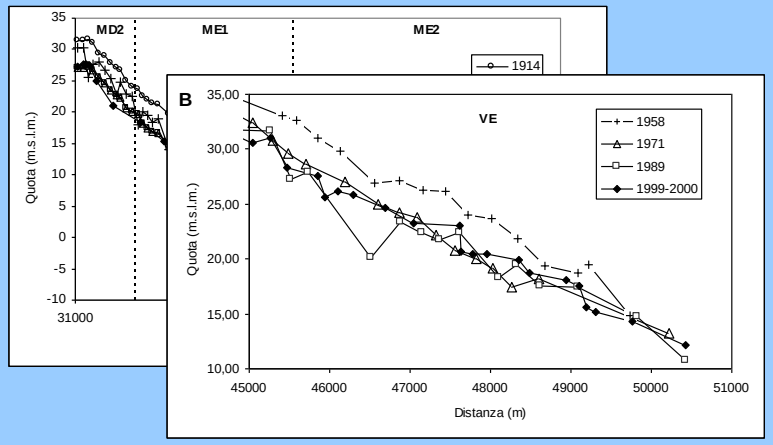
Historical maps

Old postcards

Multi-temporal series of aerial photos

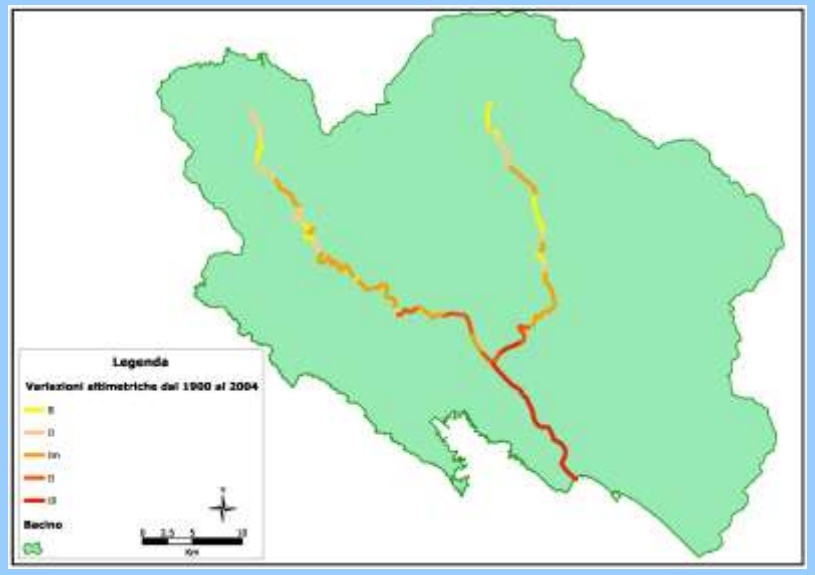
1. Channel changes and trends of adjustment

Longitudinal profiles

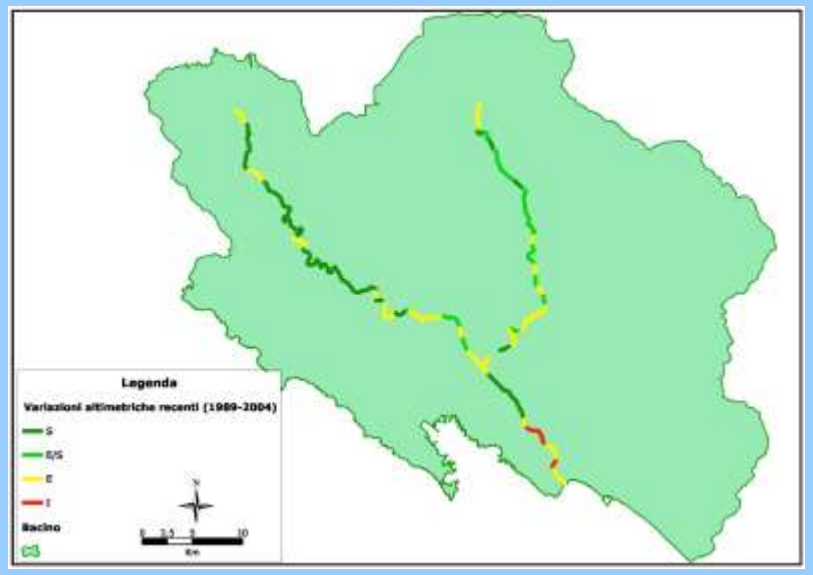


Field surveys

Bed-level changes over the last 100 years

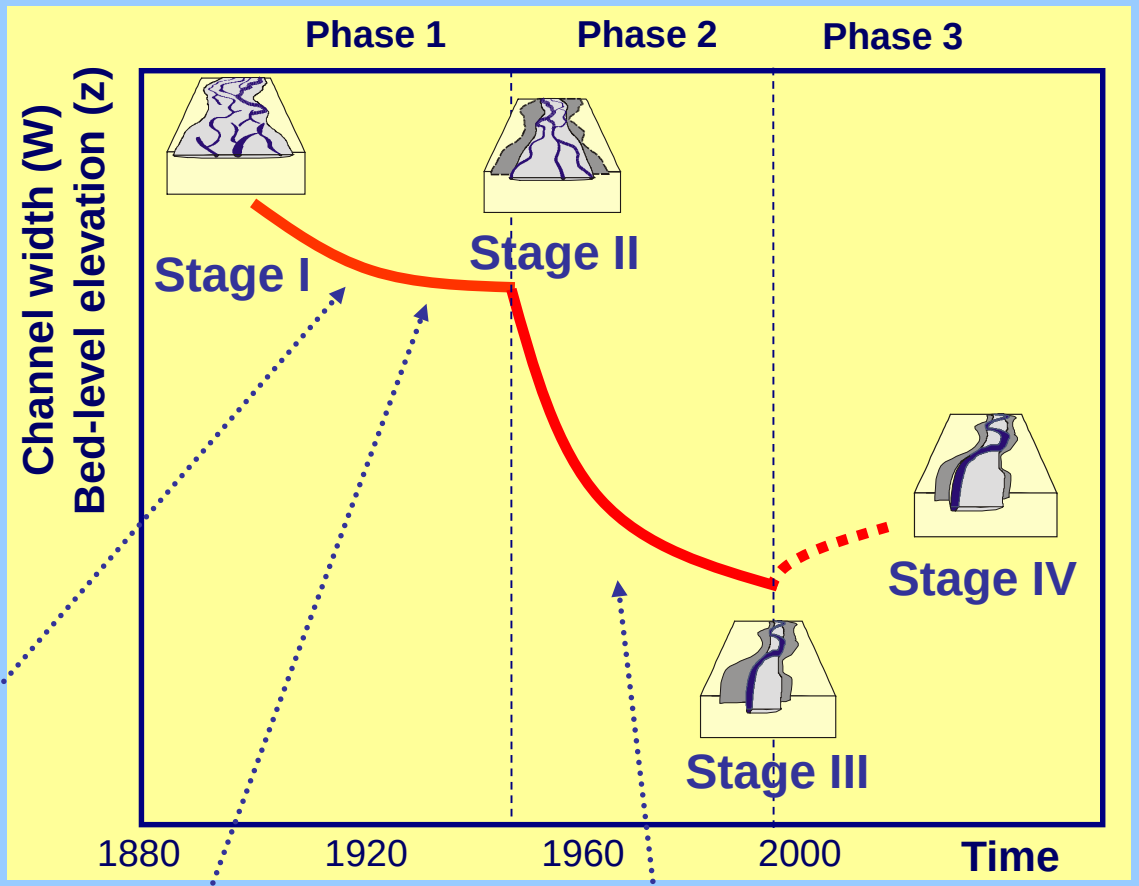


Present trends of bed-level changes (last 10 – 15 years)



1. Channel changes and trends of adjustment

Reforestation (end 1800 – beginning 1900)



Groynes (1920/30)

Sediment mining (1950/80)

2. Identification of areas for potential sediment recharge

Semi-quantitative approach

Two types of **sediment sources** were considered:

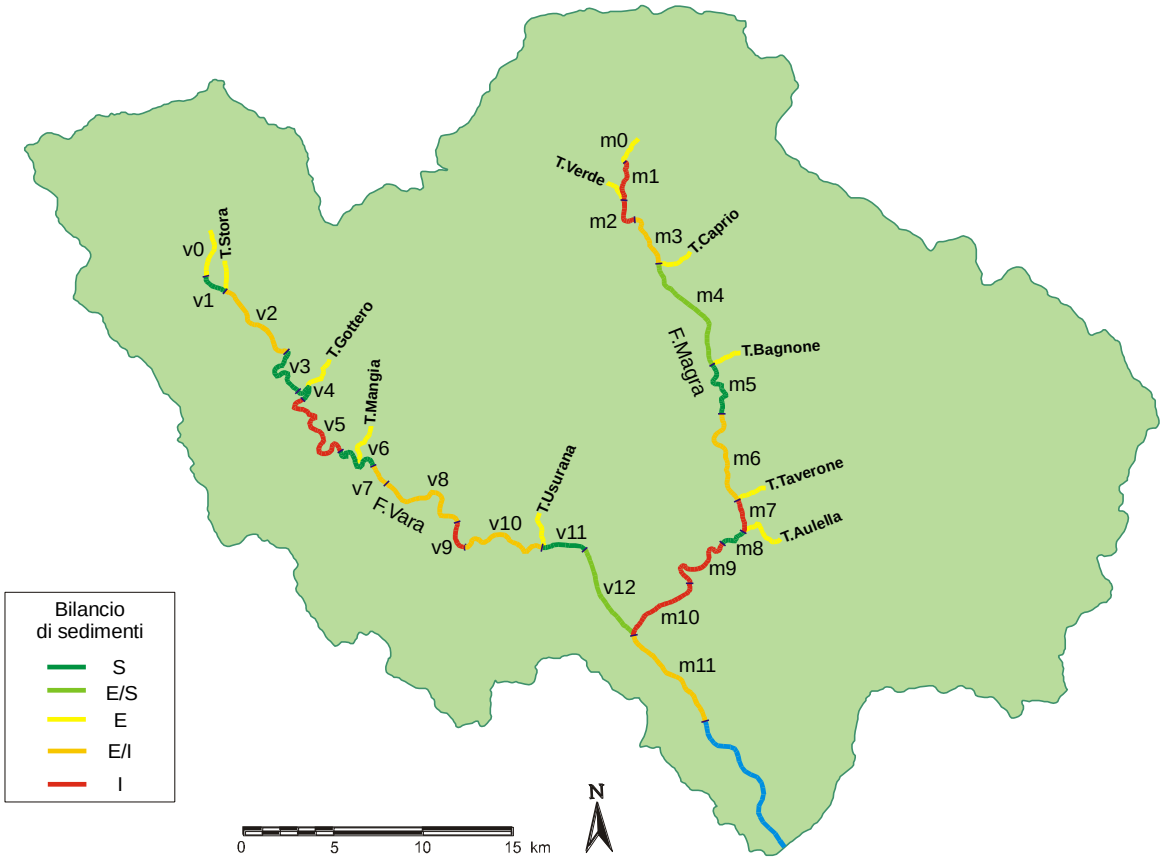
(A) **sediment recharge by landslides**

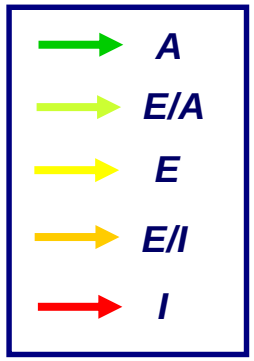
(B) **direct sediment recharge in the hydrographic network**

Landslides selected as suitable for potential sediment recharge

Sub-catchment selected as suitable for potential direct sediment recharge

3. Sediment transport and sediment budget

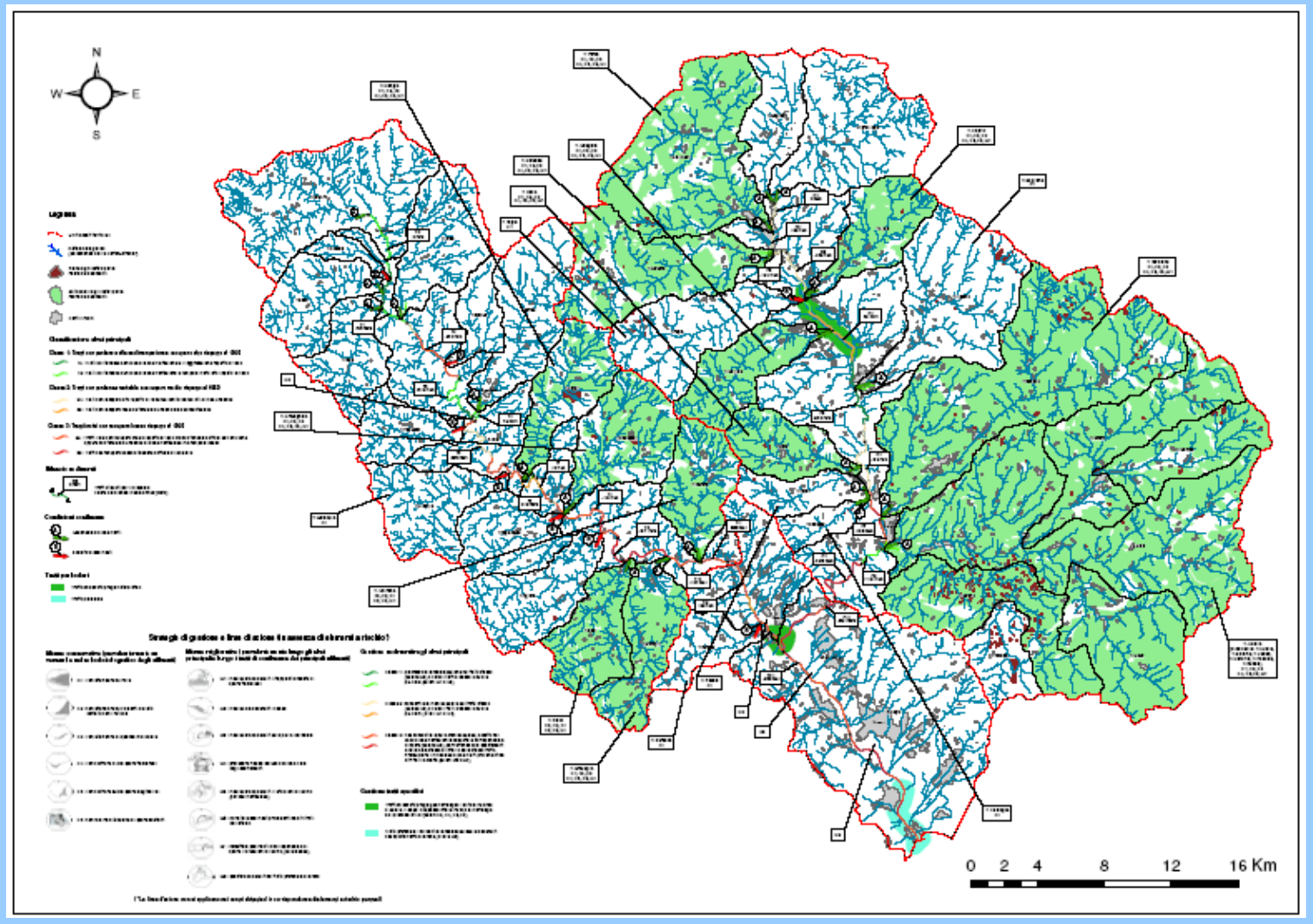




A) aggrading;
E/A) equilibrium/aggrading;
E) equilibrium;
E/I) equilibrium/incising;
I) incising

Map of strategies for sediment management

All the aspects previously analysed have been synthesised in a ‘map of strategies for sediment management’ (scale 1:60.000)



Map of strategies for sediment management

Actions and/or measures at catchment and river scale

Actions to preserve natural sediment supply (mainly hillslopes and tributaries)

C1: **do not stabilise landslides**

C2: **do not stabilise hillslopes in direct connection with the hydrographic network**

C3: **do not stabilise eroding streambanks**

C4: **do not build new transversal hydraulic structures**

C5: **do not build new longitudinal hydraulic structures**

C6: **avoid maintenance of existing hydraulic structures**

Actions to promote sediment budget recovery (main alluvial channels)

M1: **mobilise sediments trapped upstream of weirs**

M2: **mobilise instream sediments**

M3: **move sediments accumulated on the floodplain into the channel**

M4: **carry out a bedload release downstream of dams**

M5: **mobilise sediments in situations of hydraulic risk (for aggradation)**

M6: **introduce sediments deriving from other reaches**

M7: **introduce sediments in situations of risk (for local scour)**

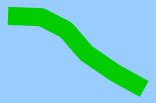
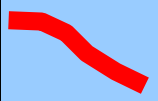
River classification and management actions

(a) bed-level changes at the scale of 100 years (from 1900 to 2004) (stable, limited incision, moderate incision, intense incision, very intense incision)

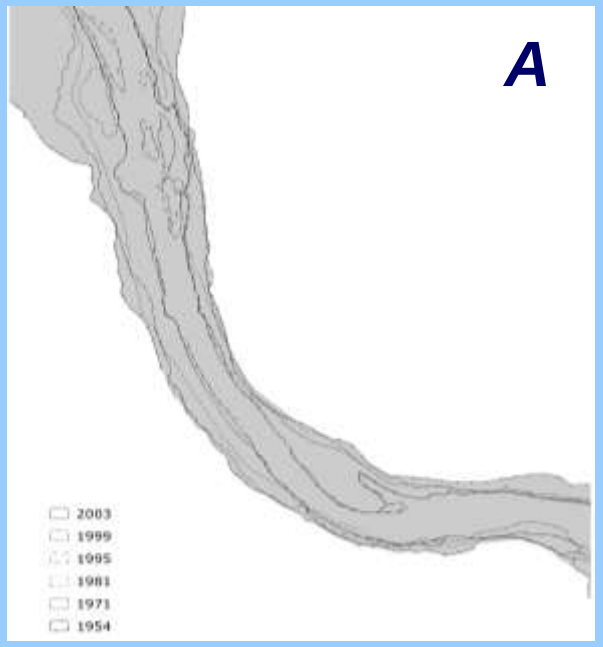
(b) Present trend of bed-level adjustments *(*aggrading, equilibrium/aggrading, equilibrium, incising)

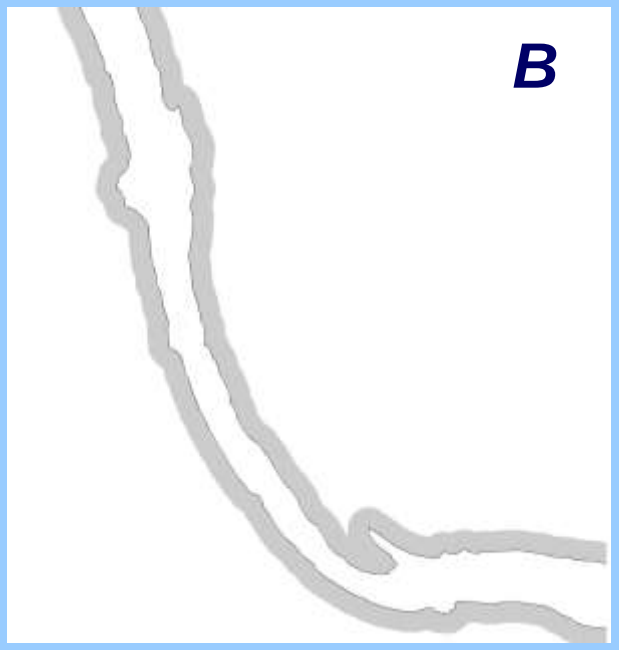
(c) Bed-level recovery compared to the situation of 1950 (recovery > 100 %, from 80 to 100 %, from 50 to 80 %, from 0 to 50 %, < 0 %)

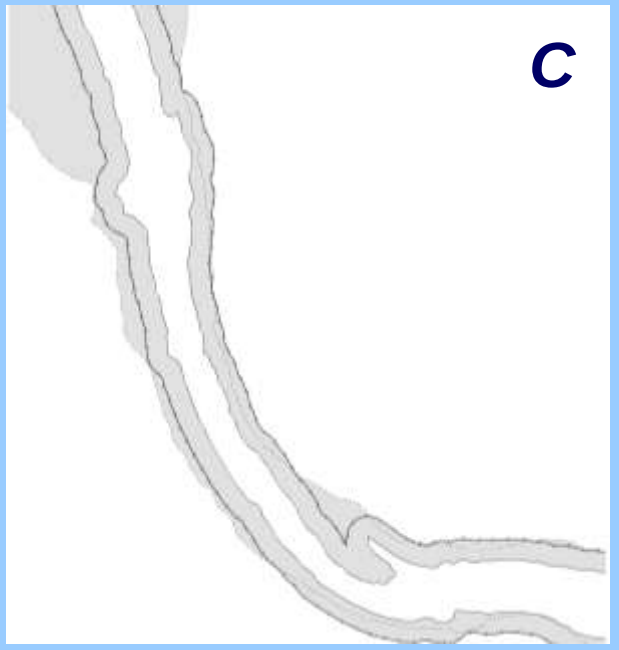
(d) Hydraulic sediment budget (aggrading, equilibrium/aggrading, equilibrium, equilibrium/incising, incising)

Symbol	Classes and associated channel bed conditions	Management actions
	***Class 1*****:** Reaches with tendency to aggradation and high bed recovery compared to 1950	**Promoting sediment mobilization** within the same reach (action ***M2***) or to the closest downstream reach in class 3 (actions ***M1*** or ***M5***)
	***Class 2*****:** Reaches with variable tendencies and medium recovery	**Allowing sediment mobilization** within the same reach (action ***M2***) or to the closest downstream reach in class 3 (actions ***M1*** or ***M5***)
	***Class 3*****:** Incised reaches with low bed recovery compared to 1950	**Not allowing any sediment mobilization**, except in case of local aggradation upstream of weirs (action ***M5***), and **promoting introduction of sediments** deriving from upstream reaches in class 1 or 2 (actions ***M6*** or ***M7***)

The Functional Mobility Corridor







A) Corridor of historical channel mobility, corresponding to the extent of the channel mobility during the last 50 years; B) Erodible corridor in the next 50 years, based on present mean rates of bank erosion; C) Erodible corridor or ‘functional mobility corridor’: external limit of the two previous areas.

The Functional Mobility Corridor

Restriction to the **previous 50 years** and **next 50 years** for the following reasons:

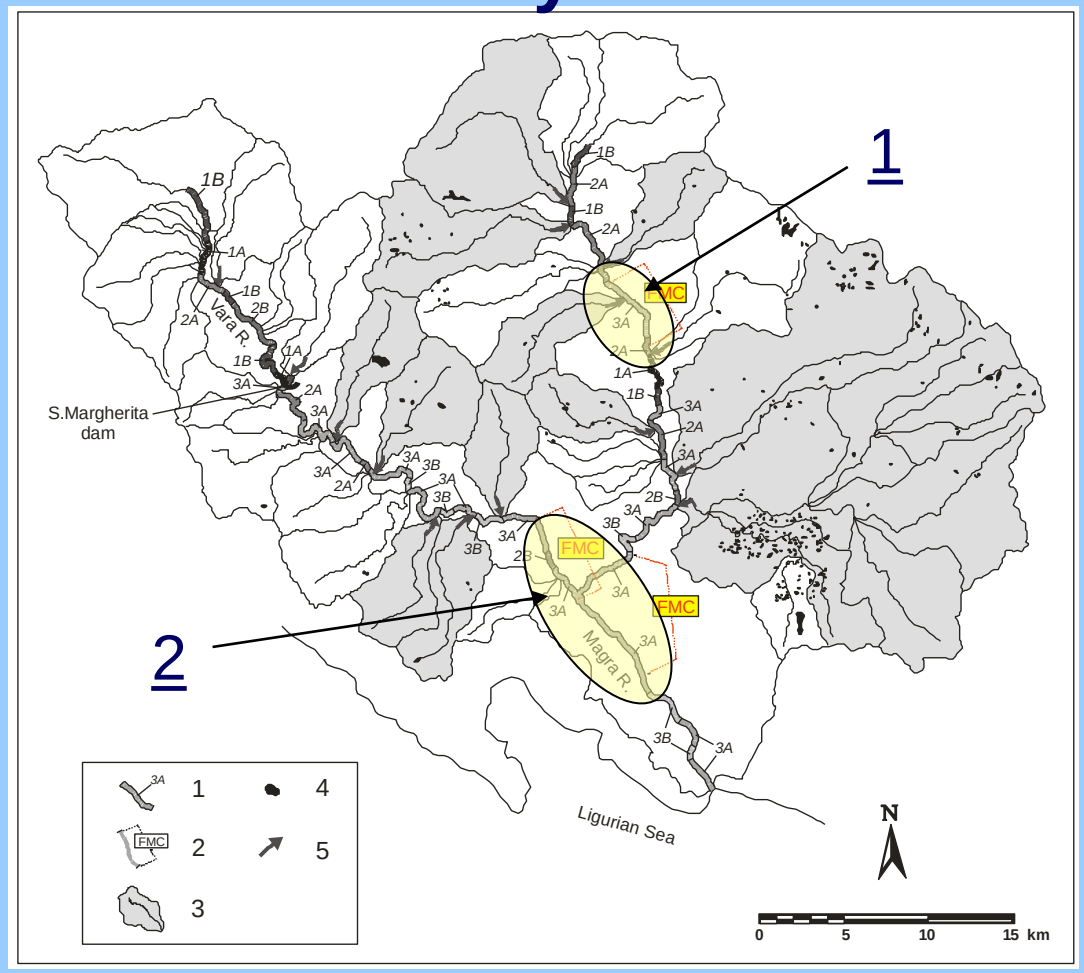
(a) beginning of the 1900: different channel patterns and watershed conditions;

(b) such a wide streamway would have **doubtful practical application**, given that part of the alluvial plain is today urbanised

(c) **future 50 years** has been selected because they correspond with the life span of the management project

The Functional Mobility Corridor

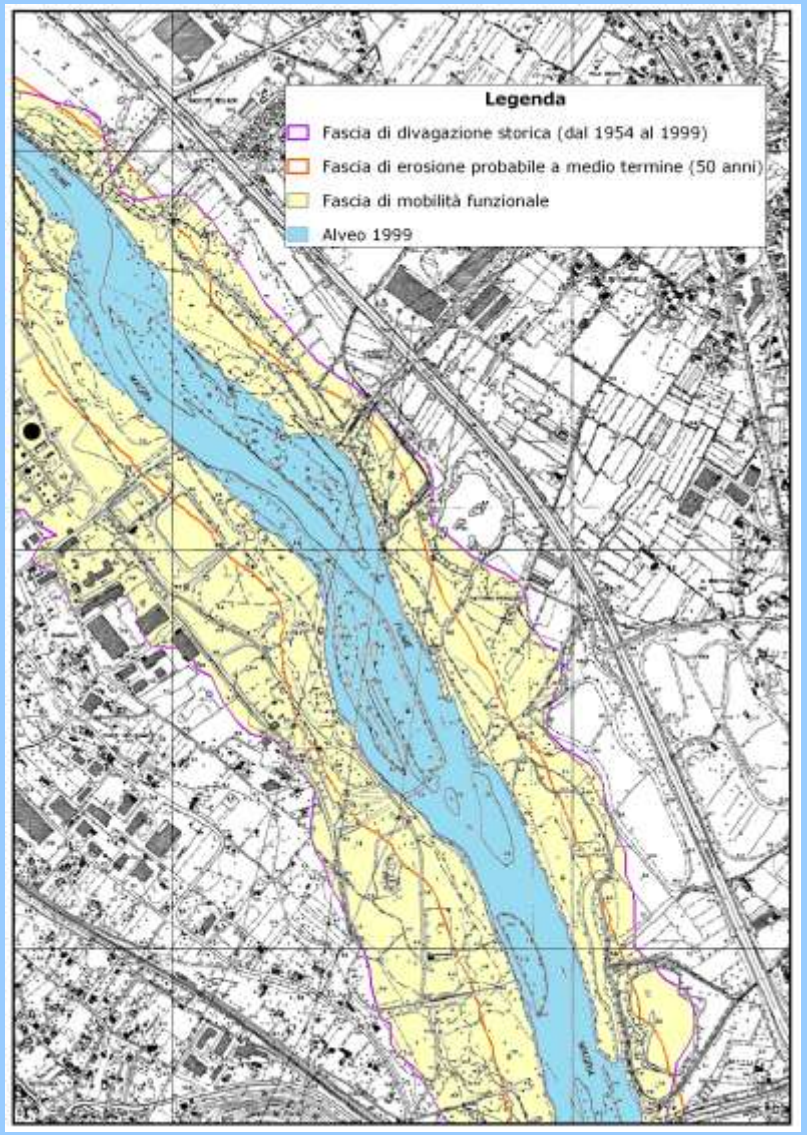
Reaches where to **encourage the application of the functional mobility corridor (FMC)** were identified as reaches with **wider valley floor and natural tendency to lateral mobility**, in order **to promote additional sediment supply by eroding banks**.



The Functional Mobility Corridor

GIS analysis and mapping

'**Actual functional mobility corridor**' : on-going process of **participatory management** led by the Basin Authority of Magra River, taking into account justified **local constraints** (e.g. main infrastructures, protection of drinking water wells, etc.) and then developing specific **land-use policies to permit erosion** to occur



A new methodology for hydromorphological assessment and classification of Italian rivers

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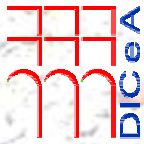
Dipartimento di Ingegneria Civile e Ambientale, Università di Firenze



"Free space for rivers" and WFD

CEN (Guidance standard for assessing the hydromorphological features of rivers): introduces "**the freedom for a river channel to migrate across a floodplain**"

This requires a **consideration for the processes of lateral mobility** (i.e. bank erosion and potential lateral movements as positive attributes* of rivers)

* Florsheim J.L., Mount J.F. & Chin A. (2008) – *Bank erosion as a desirable attribute of rivers*. BioScience, 58 (6), 519-529.

Existing hydromorphological methods

Existing methods of habitat survey (AusRivAS, US EPA, RHS, Caravaggio, etc.) not designed for the WFD aims. Main limits:

1) **form-based approach** (no considerations on geomorphic processes and trends of adjustment);

2) **"reference conditions" in terms of forms** (presence and number) of **reaches in present conditions** (although already altered);

3) not suitable for **analysis of pressures and impacts** and for the design of restoration actions

etc.

Panaro River (Northern Italy)

Objective

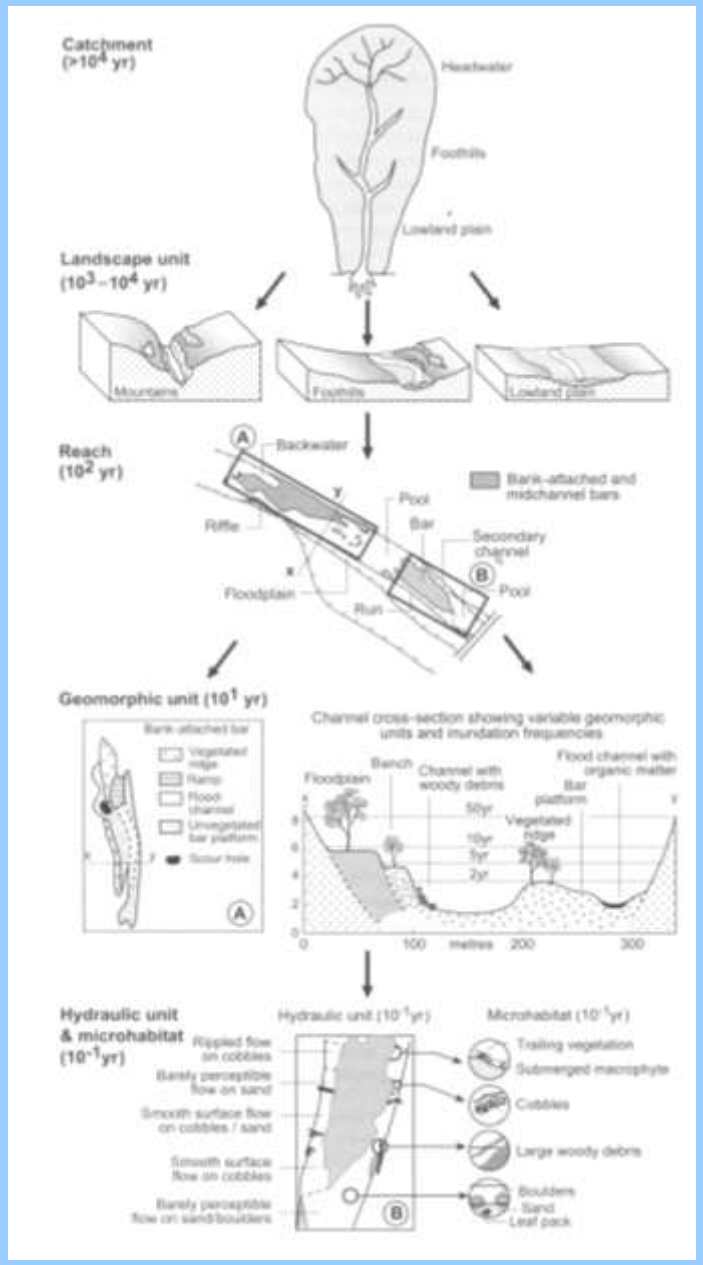
To develop a 'process-oriented' system for hydromorphological assessment and classification

Approaches and methods

(1) **Remote sensing and GIS analysis**

(2) **Stream reconnaissance field survey**

Spatial scales



Hierarchical nested approach:

(1) **Watershed**

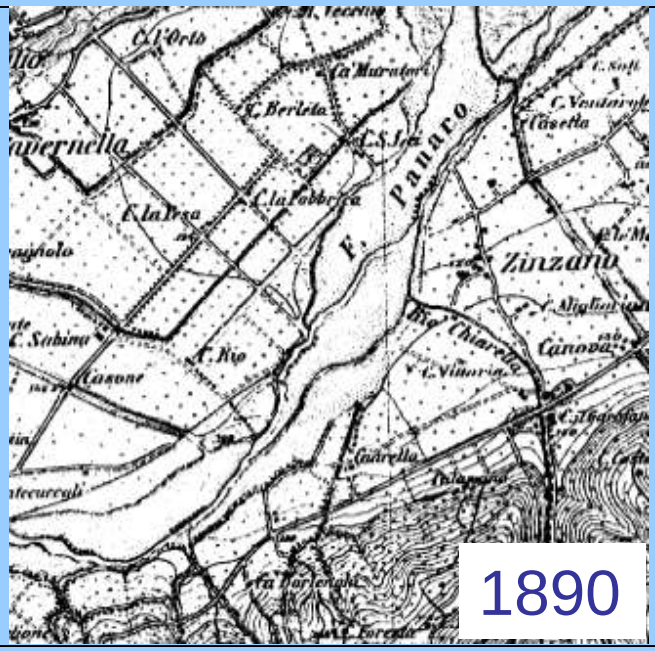
(2) **Landscape (physiographic) unit**

(3) **Reach**: basic unit for remote sensing

(4) **Site**: basic unit for field survey

(5) **Sedimentary unit**

Temporal scales



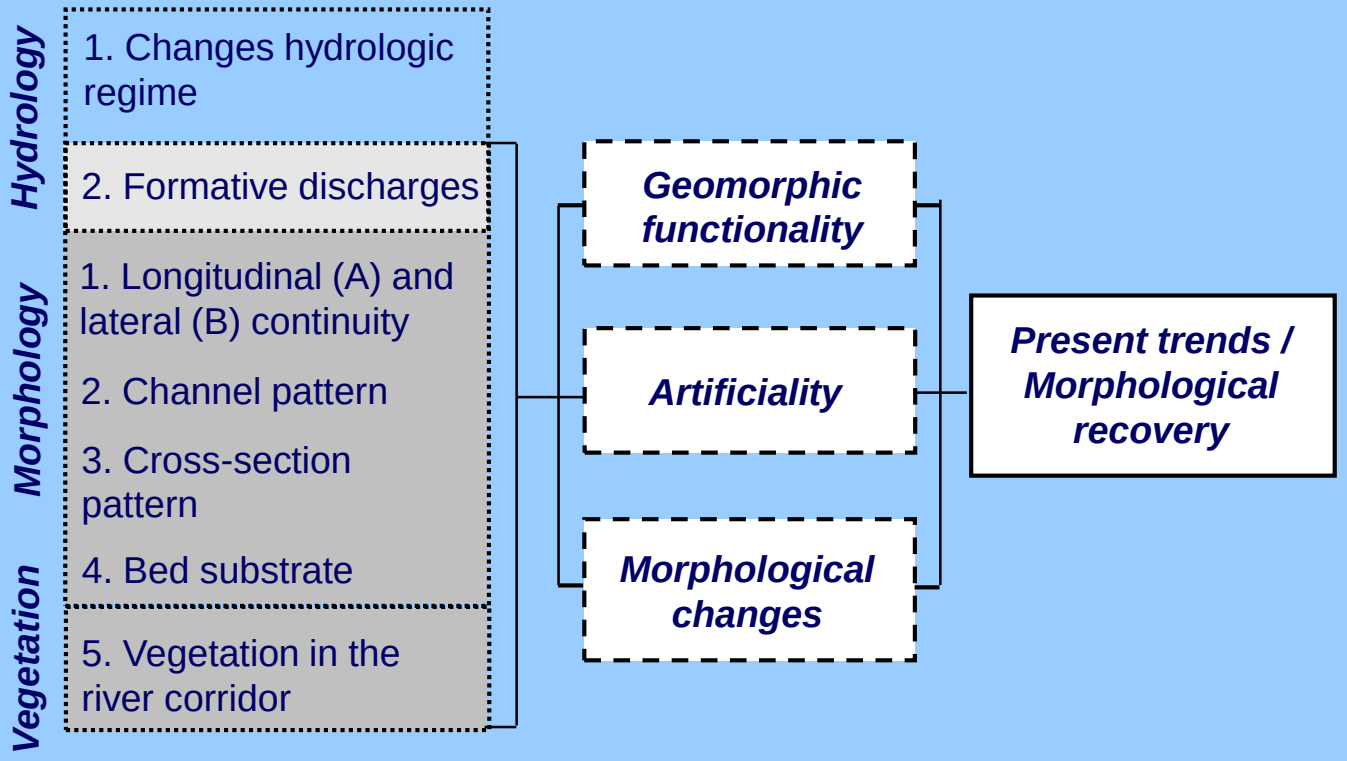
1954-55 (IGM GAI air flight): not a “reference state” but as a **measure of recent morphological alterations** (only for “large” rivers: channel width > 30 m)

General structure

Phase 1: Initial classification

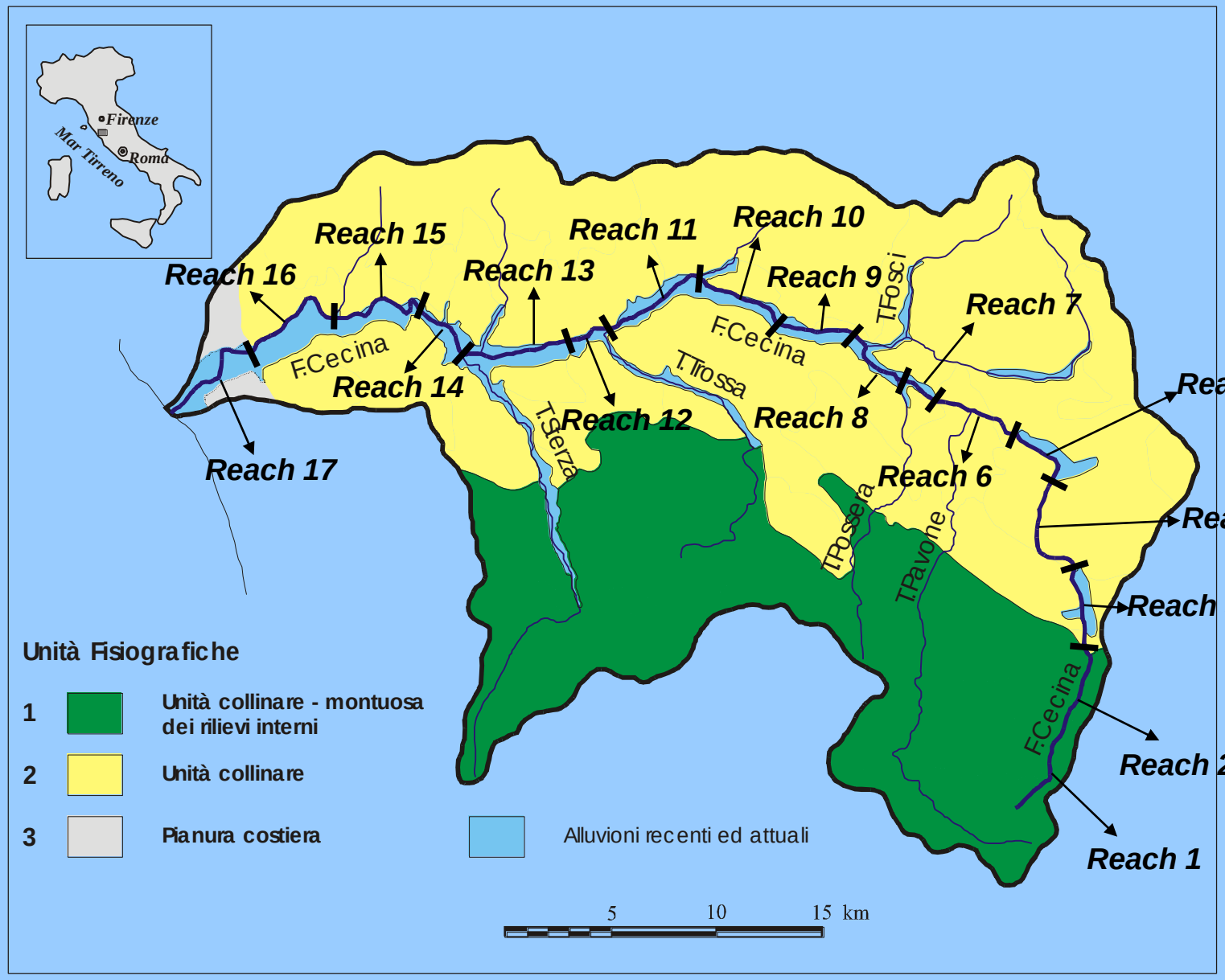
1. Physiographic units
2. Confinement
3. Channel morphology
4. Other discontinuities

Phase 2: Present morphological assessment



Phase 3: Monitoring

Phase 1: Initial classification



Phase 2: Present morphological assessment

It includes **three components**:

(1) **Geomorphological functionality**

(2) **Artificial elements** (“artificiality”)

(3) **Morphological changes**

Geomorphological functionality

CODE	INDICATOR	RANGE OF APPLICATION
Geomorphological functioning		
Continuity		
F1	*Longitudinal continuity in sediment flux and wood*	All
F2	*Presence of (modern) floodplain*	Only ***NC***
F3	*Hillslopes – stream connection*	Only ***C***
F4	*Processes of bank retreat*	Only ***NC***
F5	*Presence of a potentially erodible corridor*	Only ***NC***
Morphology		
Channel pattern		
F6	*Bed configuration – valley slope*	Only ***C***
F7	*Forms and processes typical for the channel pattern*	***NC***: all; ***C***: only ***BR/W***
F8	*Presence of typical fluvial forms in the alluvial plain*	Only lowland ***NC***
Cross-section configuration		
F9	*Variability of the cross-section*	All
Bed substrate		
F10	*Structure of the channel bed*	All
F11	*Presence of woody material*	All
Vegetation		
F12	*Type of vegetation in the fluvial corridor*	All
F13	*Width of functional formations in the fluvial corridor*	All
F14	*Linear extension of functional formations along the banks*	All

CONFINEMENT
C: confined
NC: semi- and non confined

MORPHOLOGY
ST: single-thread
BR/W: braided / wandering

SIZE
P: small/medium (<30 m)
L: large (>30 m)

Artificiality

CODE	INDICATOR	RANGE OF APPLICATION
	Artificiality	
Alteration of longitudinal continuity upstream		
A1	*Alteration of formative discharges*	All
A2	*Interception of sediment transport*	All
Alteration of longitudinal continuity in the reach		
A3	*Dams*	All
A4	*Other alterations of formative discharges*	All
A5	*Check dams*	All
A6	*Weirs*	All
A7	*Bridges, fords, culverts*	All
Alterations of lateral continuity		
A8	*Bank protections*	All
A9	*Artificial levees*	Only ***NC***
A10	*Changes of river course*	Only ***NC***
Alterations of the substrate		
A11	*Bed revetment*	All
Interventions of removal		
A12	*Sediment removal*	All
A13	*Wood removal*	All
A14	*Cut of vegetation*	All

CONFINEMENT
C: confined
NC: semi- and non confined

MORPHOLOGY
ST: single-thread
BR/W: braided / wandering

SIZE
P: small/medium (<30 m)
L: large (>30 m)

Morphological changes

CODE	INDICATOR	RANGE OF APPLICATION
Morphological changes		
V1	*Changes in channel pattern*	Only ***L***
V2	*Changes in channel width*	Only ***L***
V3	*Bed-level changes*	Only ***L***

CONFINEMENT	***MORPHOLOGY***	***SIZE***
C: confined	***ST***: single-thread	***P***: small/medium (<30 m)
NC: semi- and non confined	***BR/W***: braided / wandering	***L***: large (>30 m)

Two protocols of morphological assessment:

1. **Confined channels**
2. **Semi-confined / Non confined channels**

'Reference conditions' (max score):

- **Processes functioning** ('dynamic equilibrium')
- **No artificiality**
- **No significant changes** of channel form, size, and bed elevation during the last decades (50-60 years)

Scoring and classification system

A1	Indicator	
A	No alterations	*0*
B	Medium alteration	*2*
C	High alteration	*5*

Total deviation: *Stot = F1+…+F14+A1+…+A14+V1+…V3*

Morphological Alteration Index: ***IAM= Stot / Smax***

Morphological Quality Index*:* ***IQM=1-IAM***

Classes	*IQM*
Very good	*0.85 – 1.0*
Good	*0.7 – 0.85*
Moderate	*0.4 – 0.7*
Poor	*0.2 – 0.4*
Very poor	*0.0 – 0.2*