Physical considerations for revegetation strategies of streambank and floodplain

Watershed Renaturalization

For Portland State University

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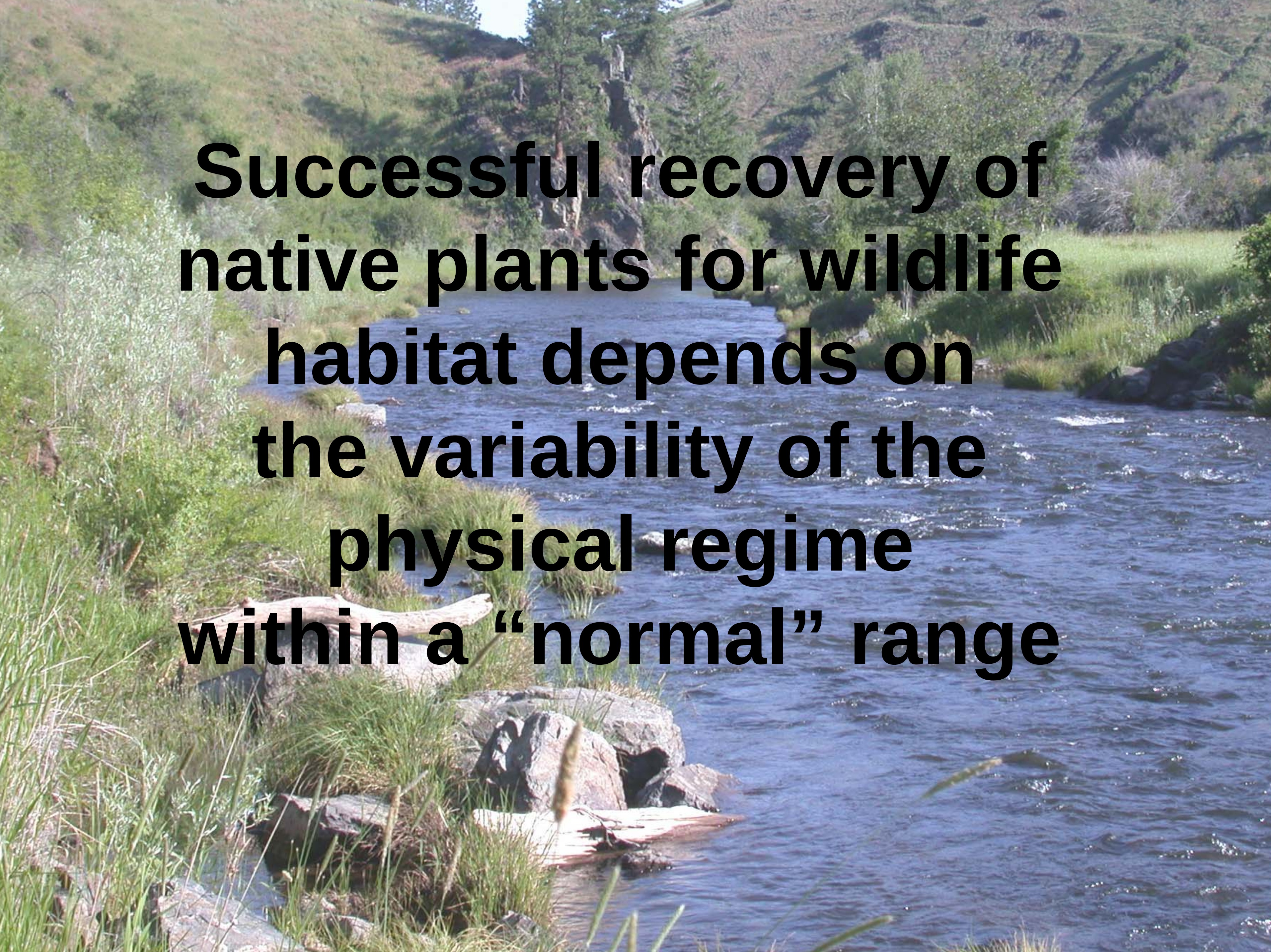
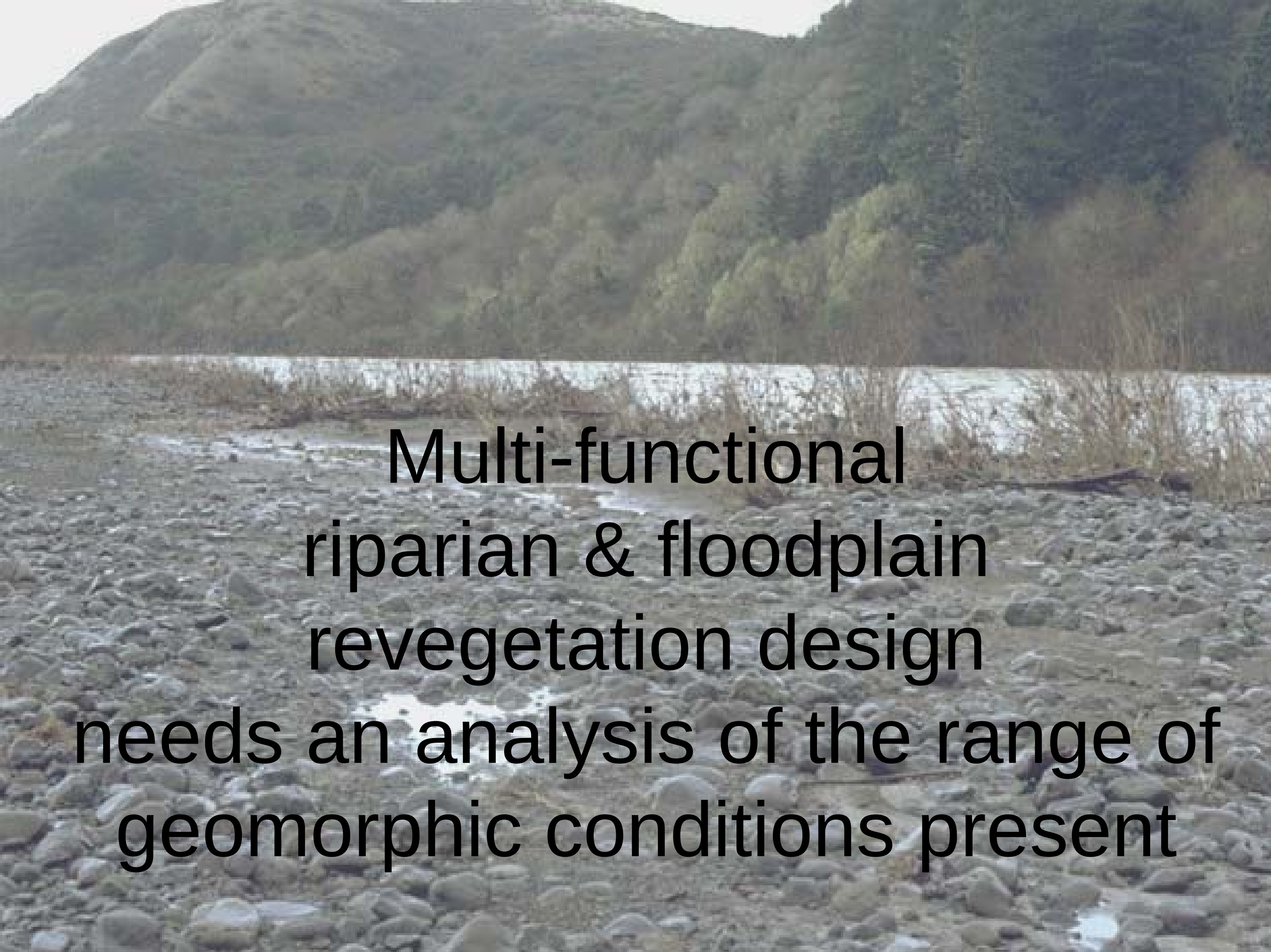
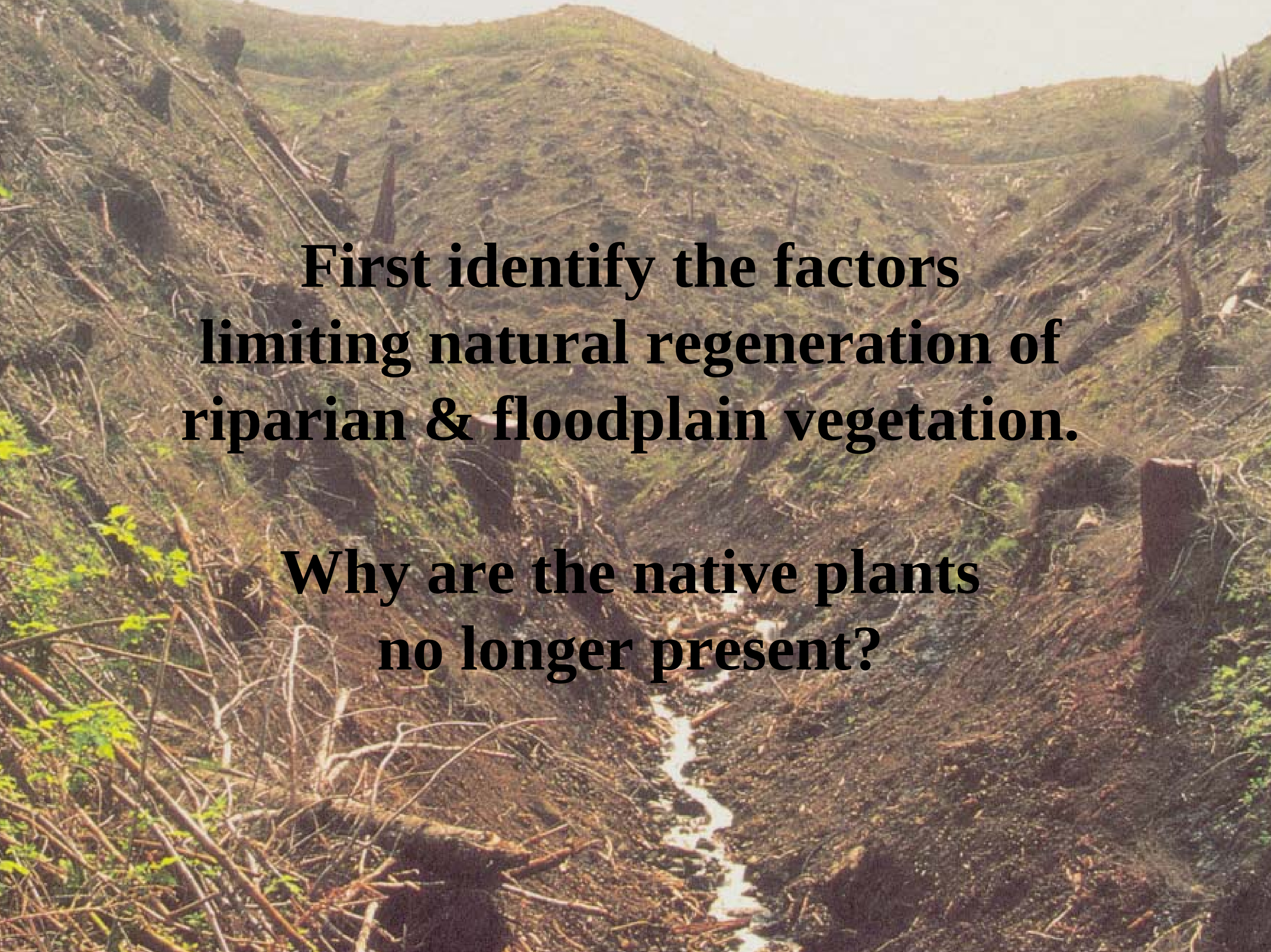
The <u>context</u> for
revegetation efforts
is driven by
social, economic and political
factors.

These factors are **as important** to
riparian & floodplain revegetation
as the physical and biological processes.


Successful recovery of
native plants for wildlife
habitat depends on
the variability of the
physical regime
within a “normal” range


Multi-functional
riparian & floodplain
revegetation design
needs an analysis of the range of
geomorphic conditions present



First identify the factors limiting natural regeneration of riparian & floodplain vegetation.

Why are the native plants no longer present?

Next, characterize the geomorphic context for channel- floodplain & vegetation-fluvial interactions

Geomorphic Regime Analysis includes:

– **Hydrologic Regime (peak & low flows, duration, etc.)**
– **Groundwater Seasonal Variation**
– **Channel and Valley Planform, Gradient**
– **Soils and Floodplain Sediments**
– **Sediment Transport Regime**

Floodplain Energy Regime Classification

- **The Genetic Evolution of Floodplains concept is based on the product of stream power and sediment character**
- **The Energy Regime provides a context for floodplain revegetation strategies**

Nanson & Croke (1992)

A Caveat!

No consistent, quantitative method is available for measurement of the erosional resistance of stream banks & floodplains for the full range of discharge, geomorphic and vegetative conditions.

(Nanson & Croke, 1992)

Threshold Definitions

Stream power (W/m^2) is the ability of flowing water to do work, estimated from Q discharge

Erosional resistance of the floodplain can be estimated from the median sediment particle size

Available stream power is defined as Omega Ω

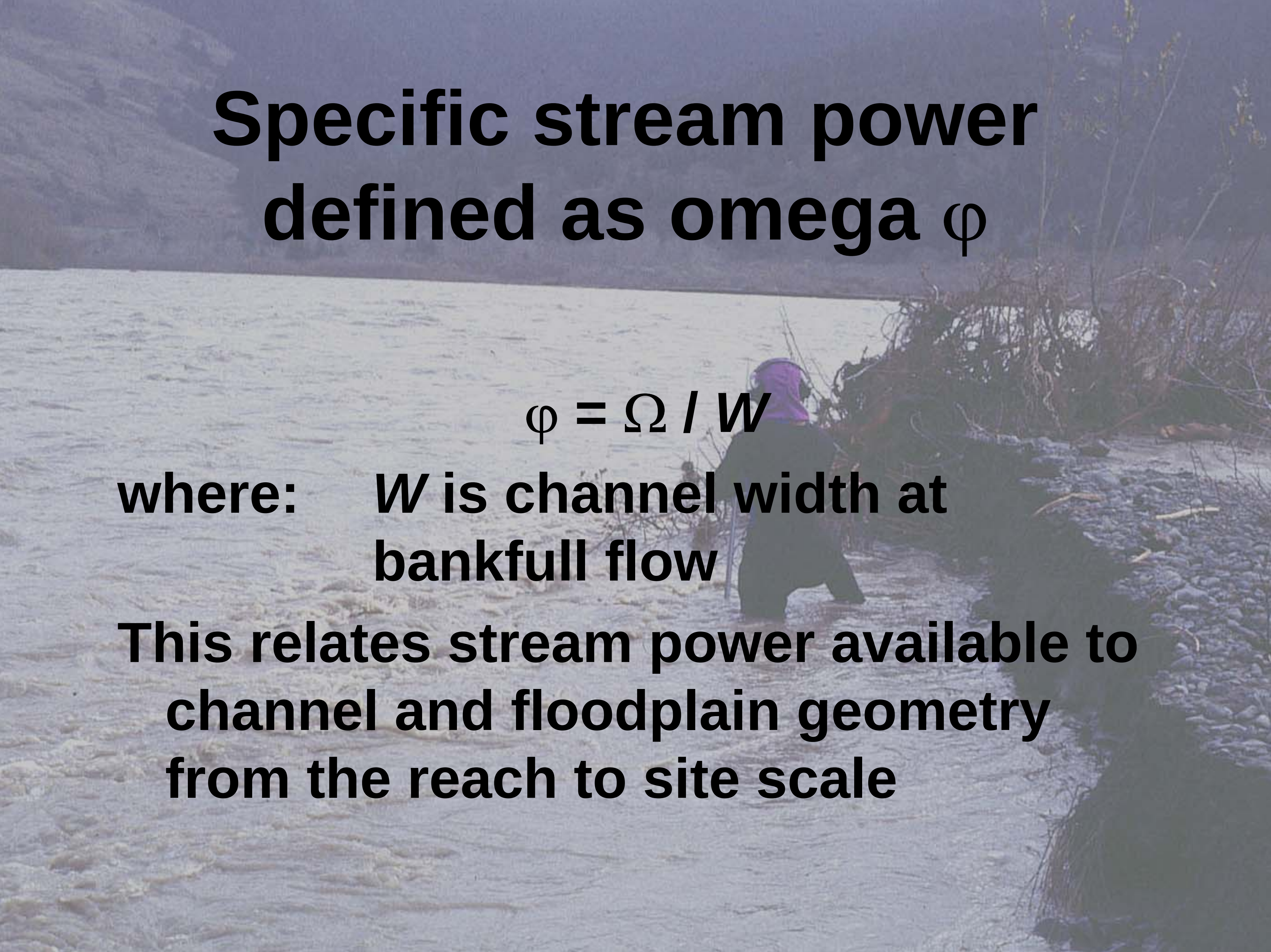
$$\Omega = \gamma Q\,S$$

Where: γ is specific weight of water

Q is discharge

S is reach slope or gradient

Bagnold (1966)



Specific stream power defined as omega φ

$$\varphi = \Omega / W$$

where: *W* **is channel width at bankfull flow**

This relates stream power available to channel and floodplain geometry from the reach to site scale

Genetic Classes of Floodplains

Class A: High-energy Non-Cohesive

Class B: Medium energy Non-Cohesive

Class C: Low- energy Cohesive

Distinguish between confined (presence of bedrock) and unconfined floodplains

Within the floodplain context, we can evaluate potential stream bank failure mechanisms based on two regimes

Above-ground Hydraulic Processes

Below-ground Geotechnical Processes

Hydraulic forces on a straight reach: channel bank & floodplain

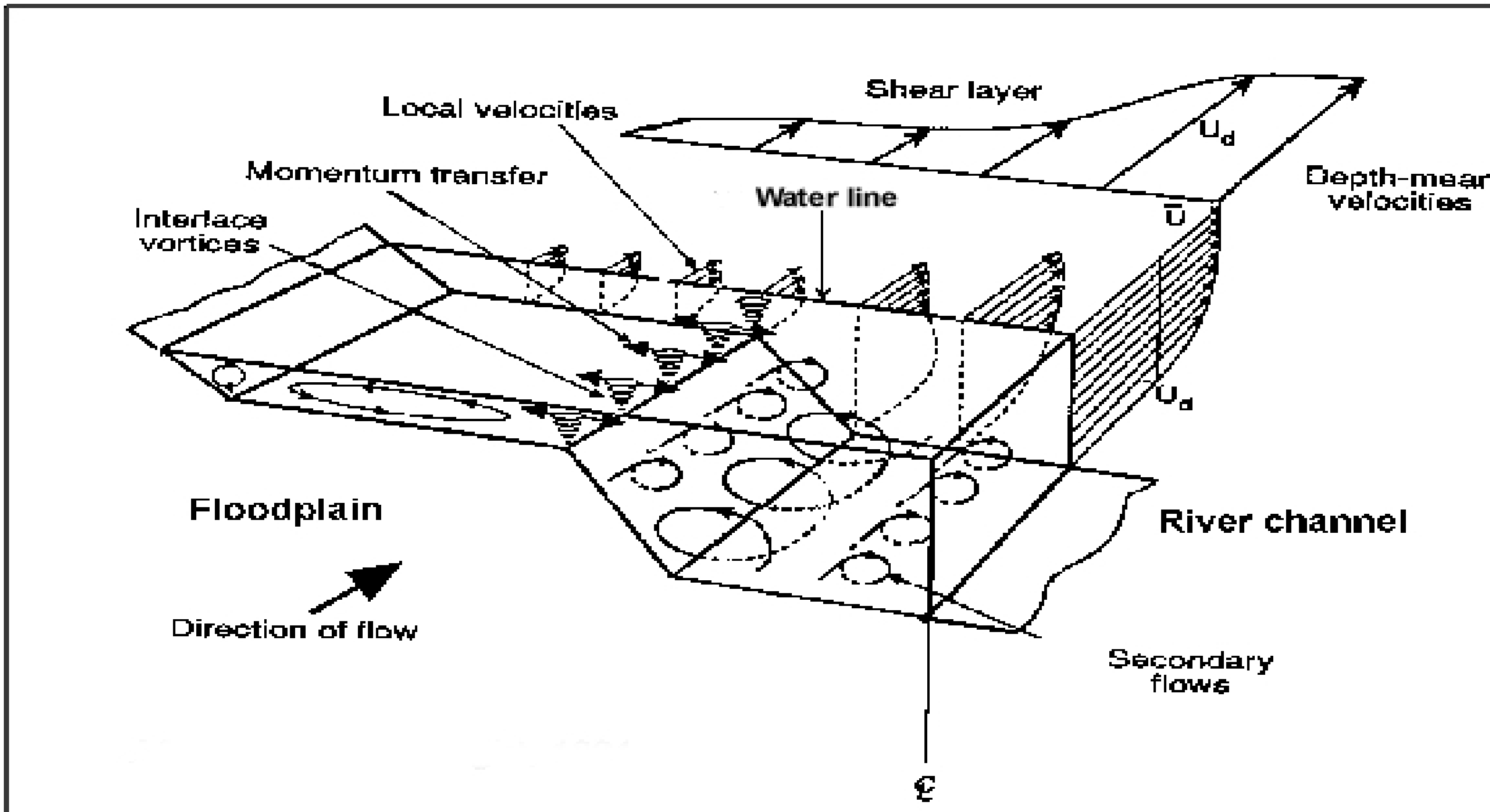
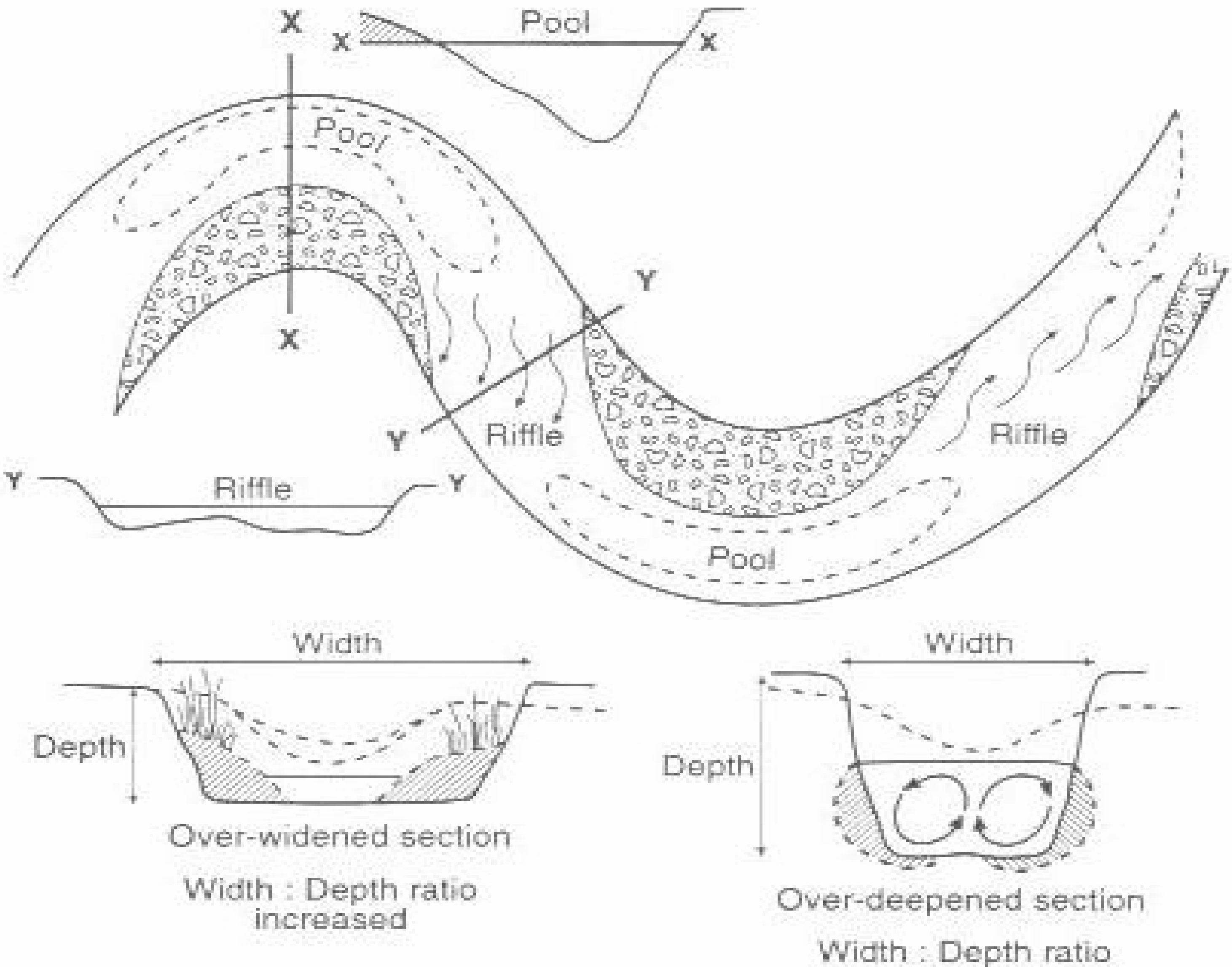


Figure 1. Idealised river orthogonal view, showing distribution of hydraulic shear stresses in channel, at bank and on floodplain, from Shiono and Knight (1990).

Hydraulic forces through a meandering channel

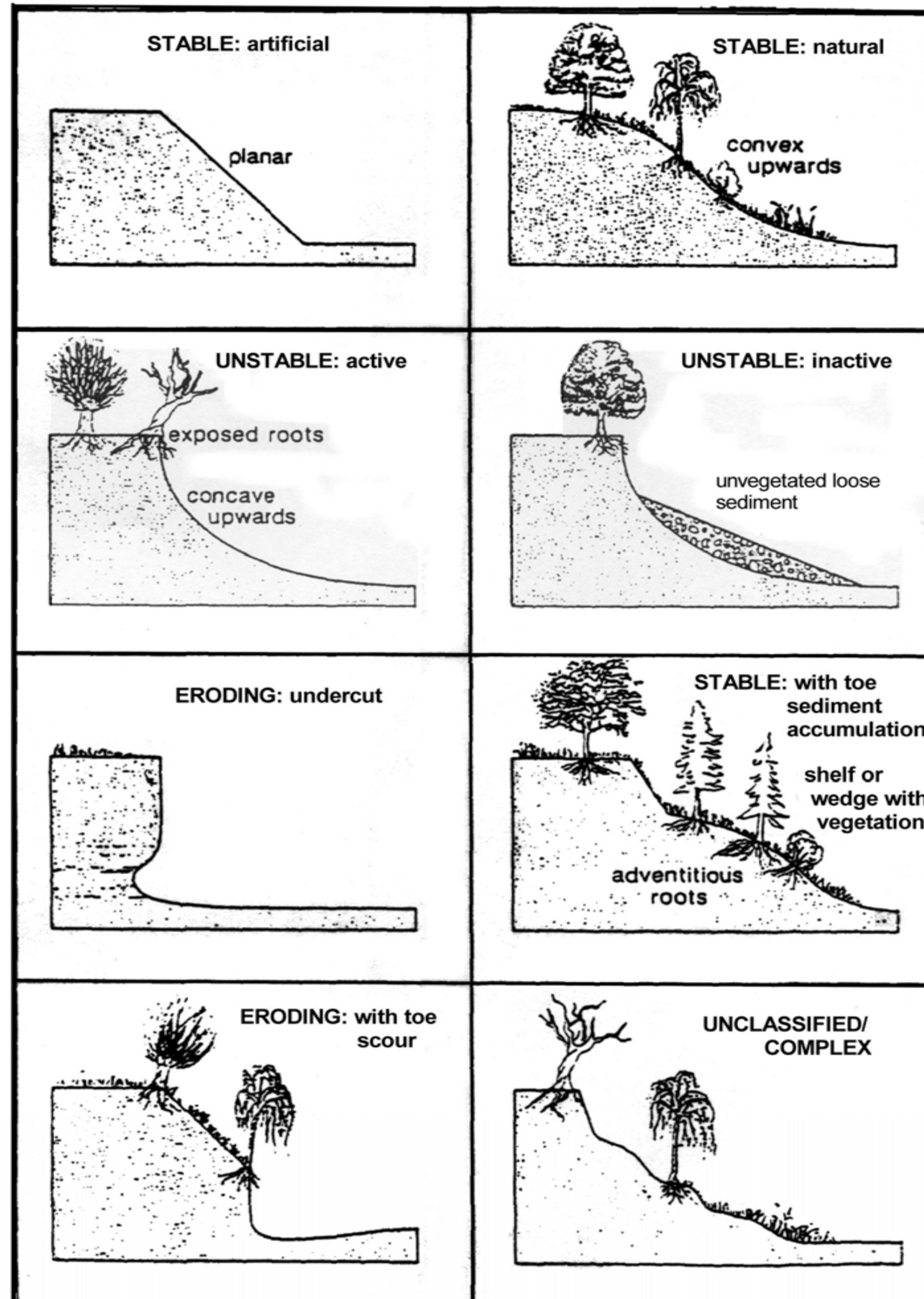


Bank erosion during flooding: thalweg lateral migration

- **Anticipate geomorphic channel migration from historic map & air photo analysis**
- **Design for catastrophic failure during flooding, esp. during hydrograph decline**
- **How can a bank revegetation scheme fail during the flood? Either by overtopping scour or undercutting below the root zone**

Geotechnical issues: Modes of Bank Failure

Diagram from C.R. Thorne, 1998. Stream reconnaisance manual.



Factors affecting vegetation hydraulic resistance

In channel	Off main channel
Emergent to flow	Submerged
Depth of root zone	Flow directed below roots/ not
Stems Herbaceous	Stems Woody
Stems Flexible	Stems Rigid
Stems Sparse	Stems Dense

Cowan (1959) method for computing floodplain roughness

$$n = (n_0 + n_1 + n_2 + n_3 + n_4) * m$$ where:

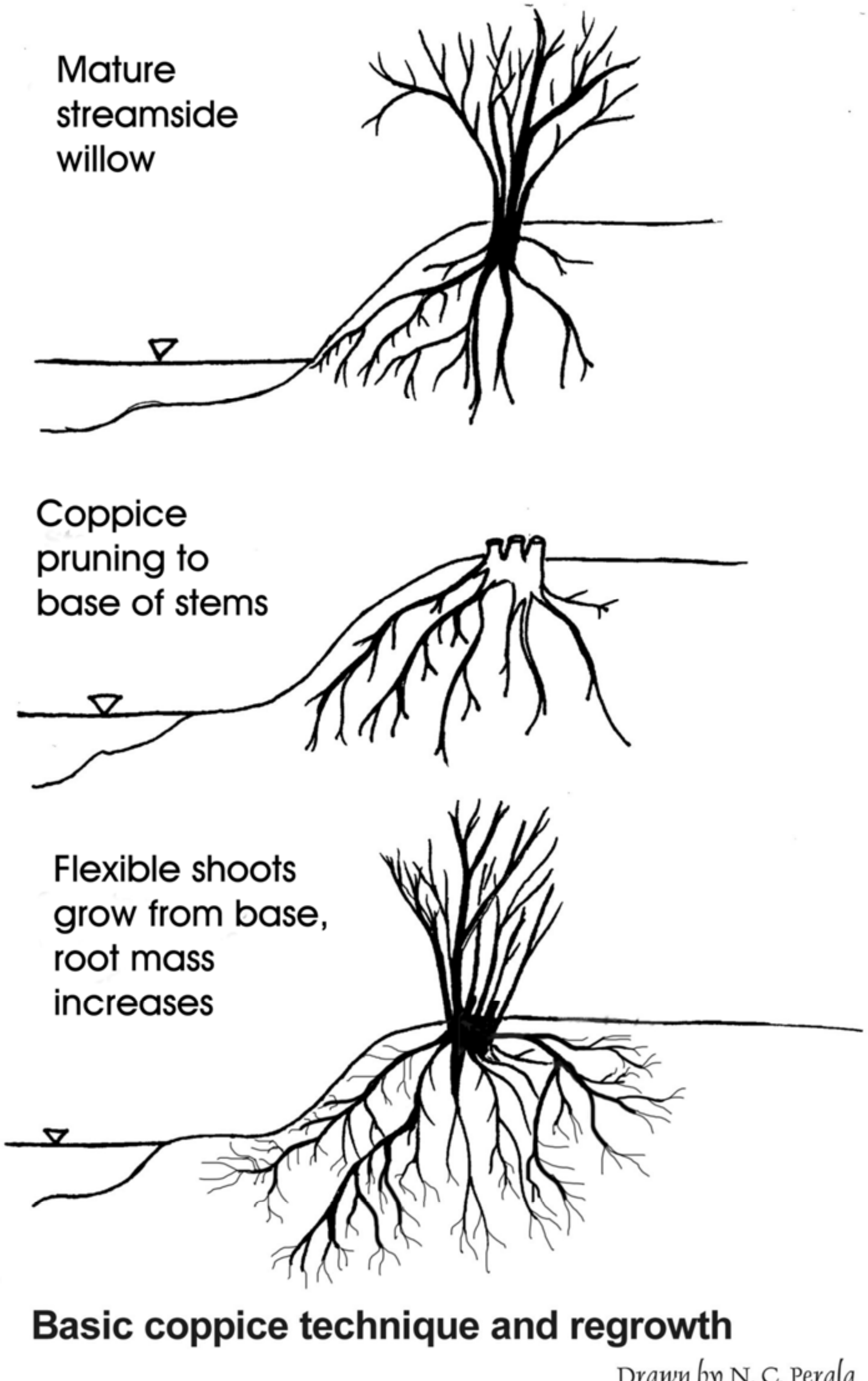
- n_0 = channel material, 0.020 soil - 0.028 coarse gravel
- n_1 = degree of irregularity:
  0.000 smooth - 0.020 severe irregularity
- n_2 = channel cross-section variation:
  0.000 gradual - 0.015 alternating
- n_3 = effect of obstructions: 0.000 negligible - 0.050 severe
- n_4 = vegetation: 0.000 low - 0.05-0.100 very high, dense
- m = meandering: 1.000 minor - 1.300 severe

An approach to Riparian Revegetation: from less to more intervention

1. Natural re-colonization or recruitment.
2. Address exotic plant/ animal species invasion.
3. Modify river maintenance/ management program.
4. Parkland container planting for aesthetics or wildlife habitat considerations.
5. Geotextile treatments with woody or herbaceous vegetation (including seeding).
6. Structural engineering integrating woody plants.

Address management practices that may be limiting natural recovery

- Channel & bank maintenance
- Vehicle access, trampling
- Farming in riparian zone
- Grazing / timber extraction
- Development / road building
- Mining; in-channel, floodplain, etc.
- Use of toxic chemicals, ex. pesticides



Basic coppice technique and regrowth

Consider modifying existing river maintenance for riparian recovery

As example:

Bank maintenance "coppicing" for sustainable resource extraction.

Flood defense, habitat and economic activity can co-exist.

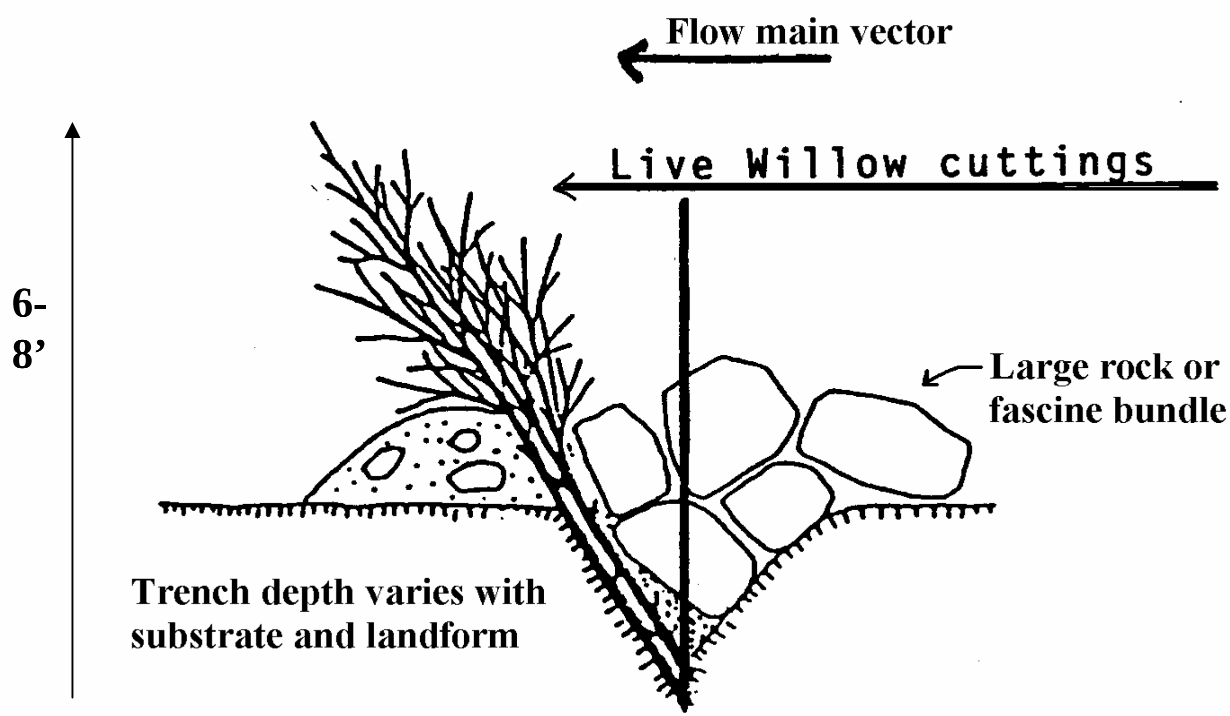
Structural revegetation working with river engineering in a geomorphic context

Relate the revegetation strategy to:

- level of constraints (ex. development)
- risk exposure (ex. value of real estate)
- thresholds of physical and anthropogenic stresses
- social and political tolerance for sustainable practice, environmental care

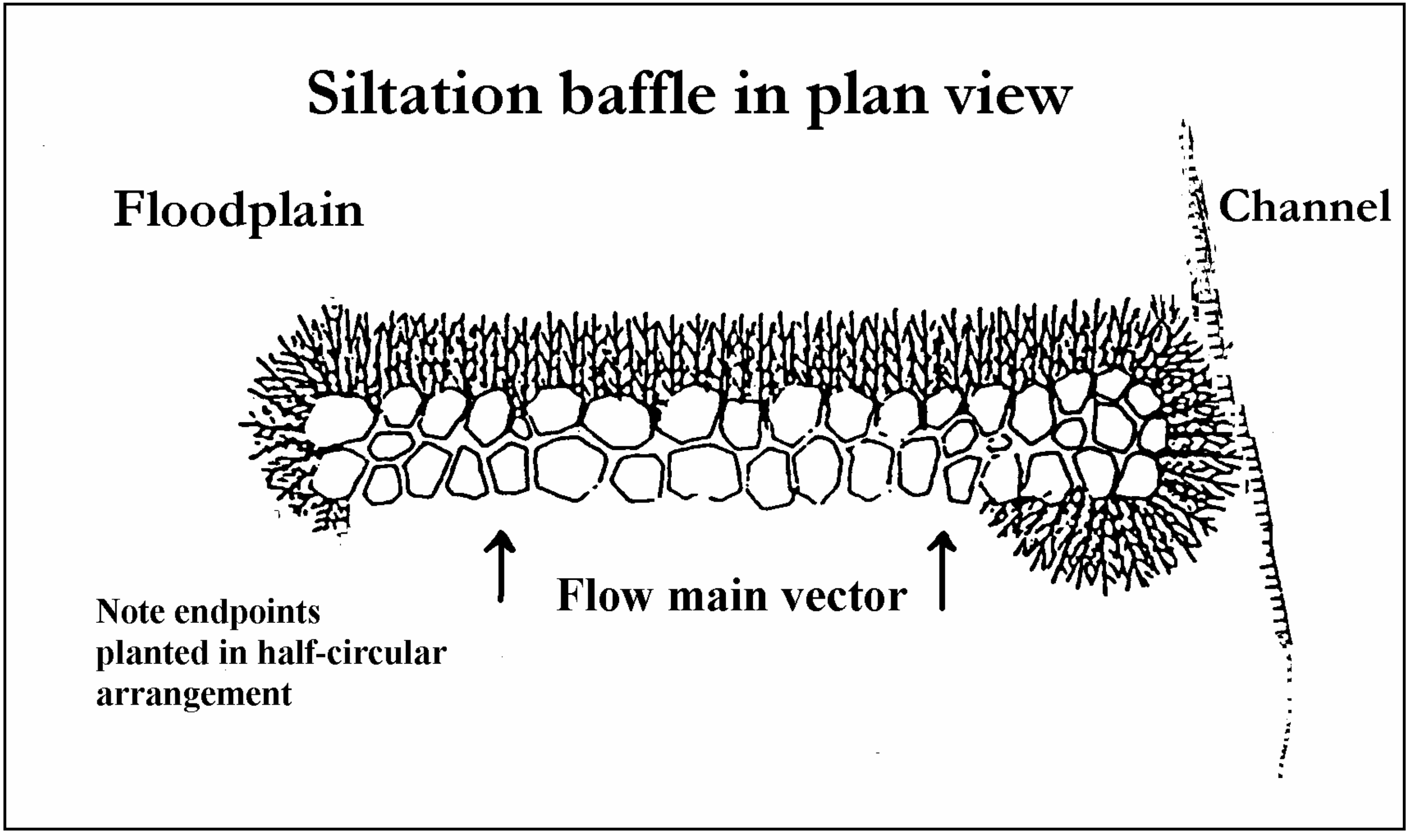
An example of structural revegetation method for a high shear stress, high sediment load environment: the Live Siltation Baffle

Design Diagram of Live Siltation Baffle Construction

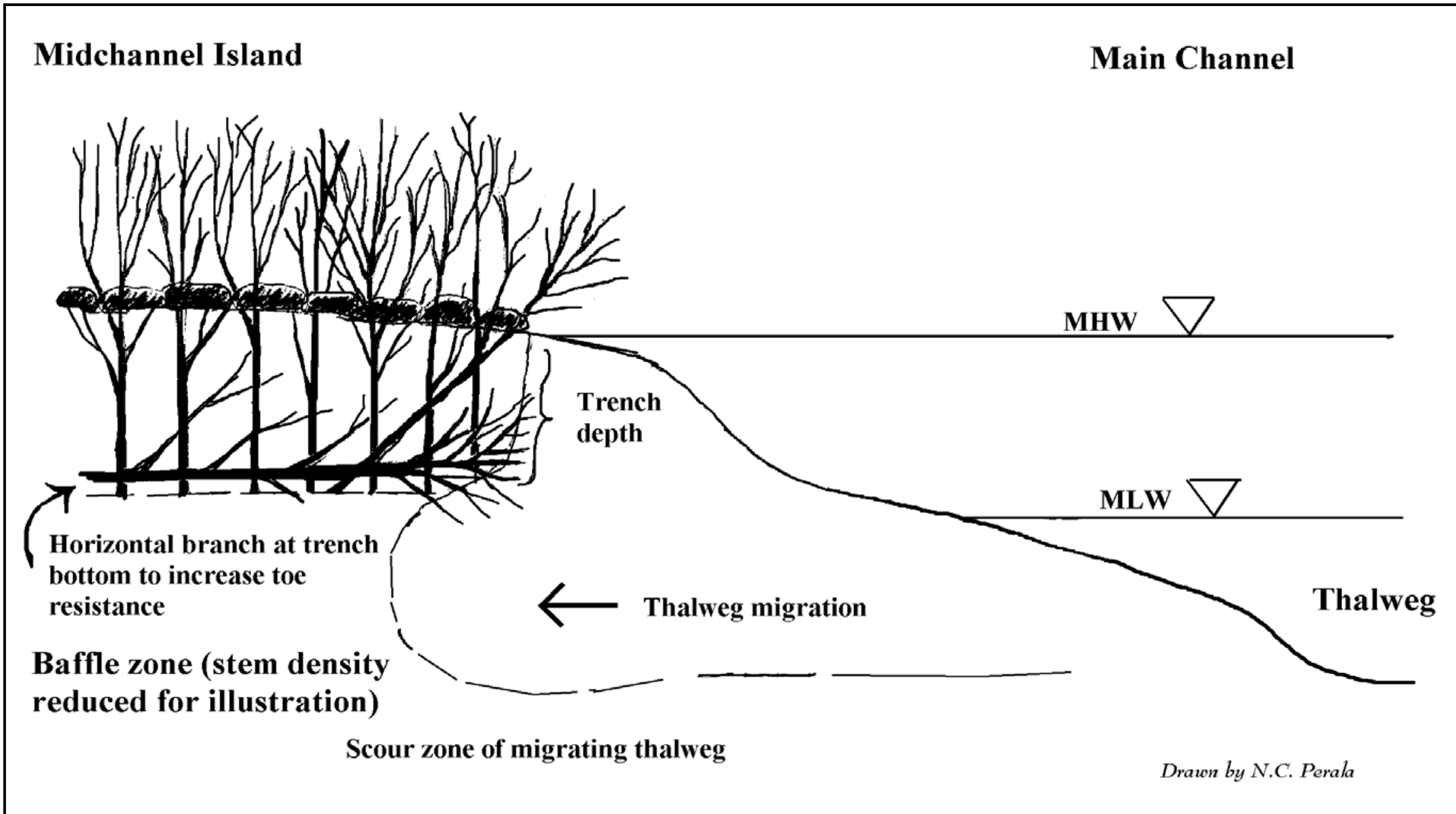


Trench Cross-section View

Floodplain Willow Baffle: large woody stems engineered with rock for bank stability, sediment retention & habitat



Modification of ‘traditional’ designs often required for field conditions, such as high potential for lateral channel migration



Conclusions

Revegetation efforts within the geomorphic context of streambank and floodplain are the most cost-effective strategies.

The work is more complex than it appears.

Cooperation among multiple disciplines is essential; engineering, geomorphology, plant & wildlife ecology, horticulture, sociology, economics, etc.

The goal is to recover complex floodplain plant communities for multiple functions that serve the needs of society, present and future.