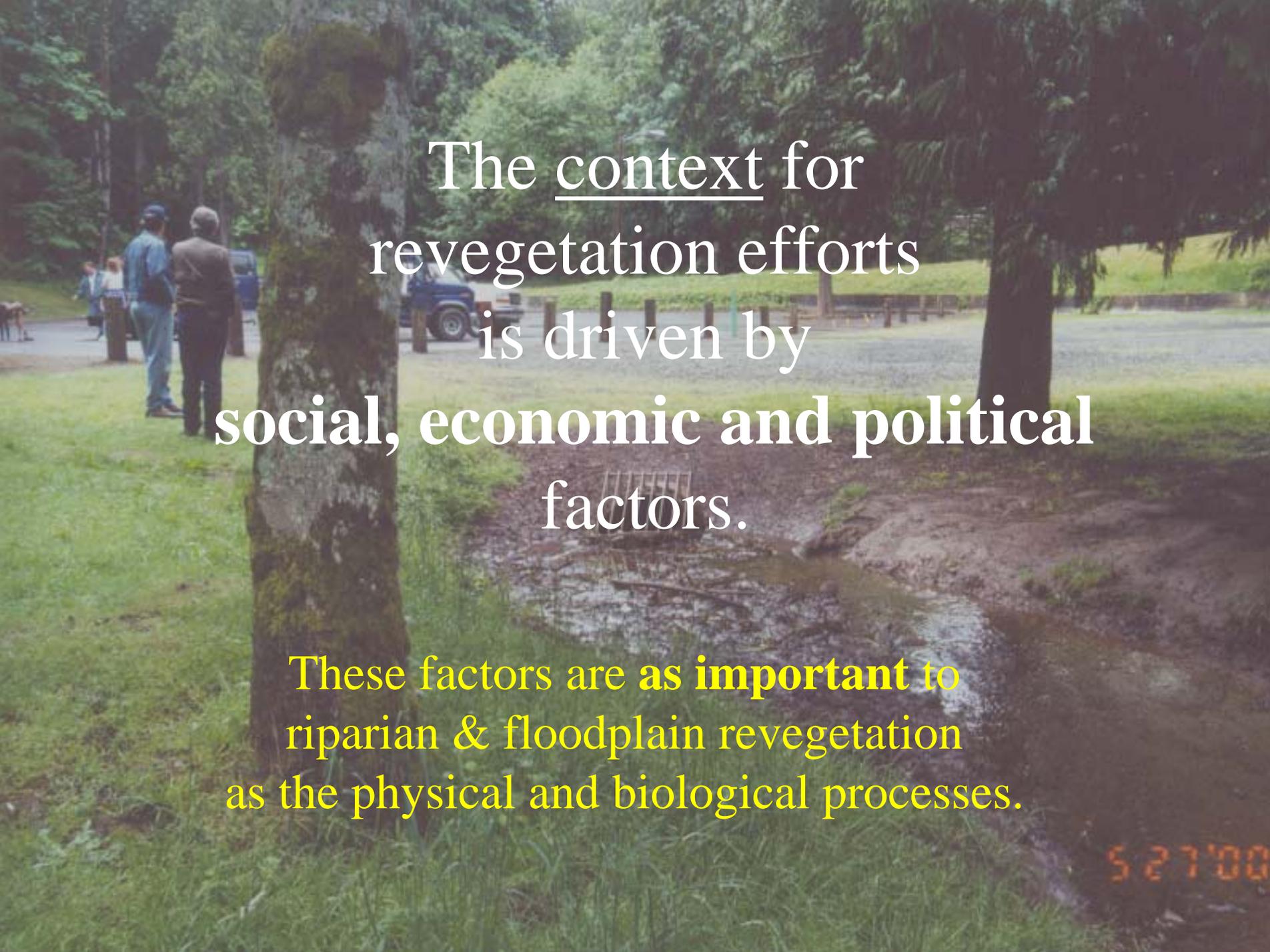


Physical considerations for revegetation strategies of streambank and floodplain

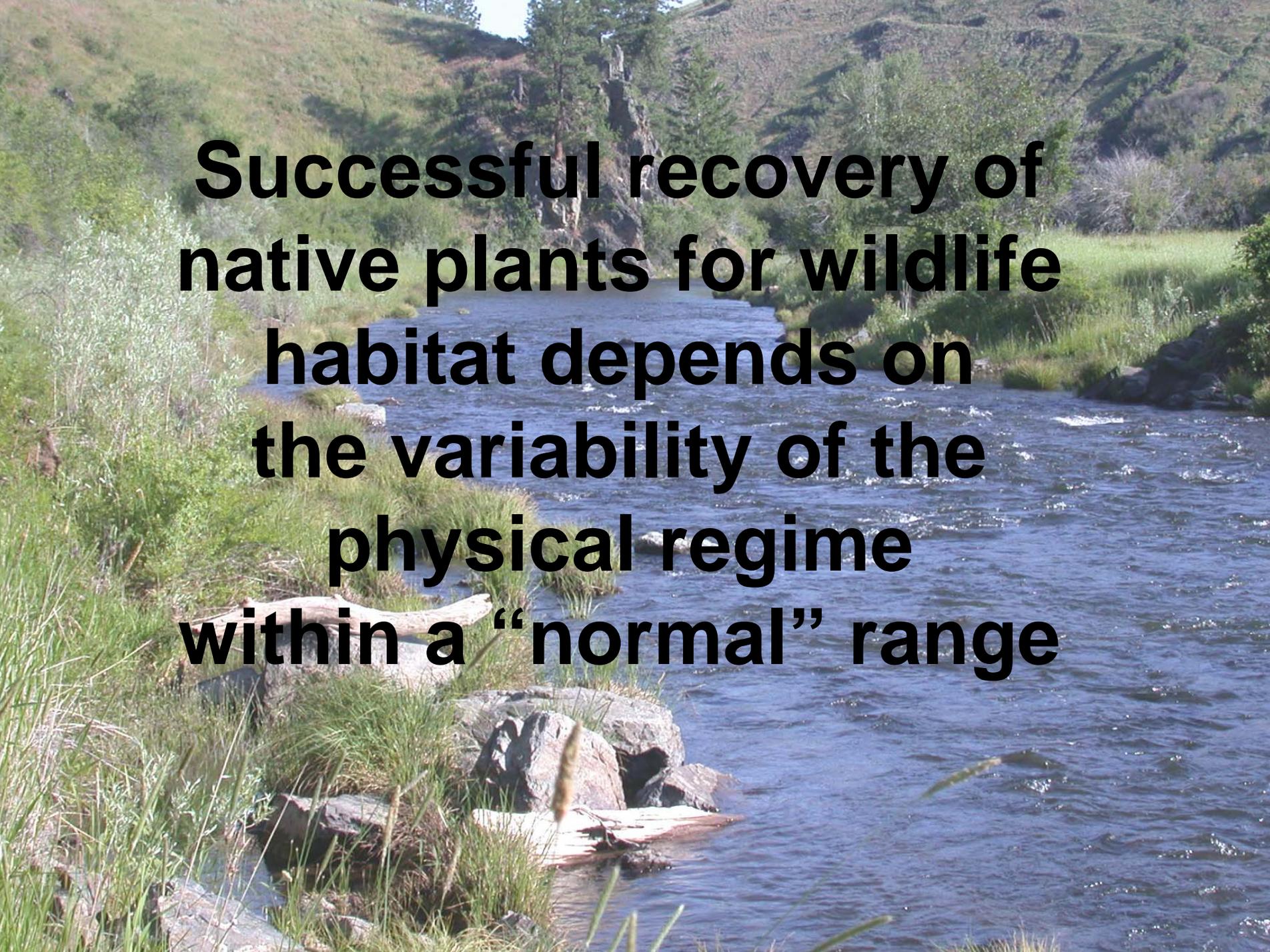
**Watershed Renaturalization
For Portland State University
Dr. Christine Perala
WaterCycle Inc, Sandy Oregon**

A photograph of a park-like setting. In the foreground, a stream flows through a grassy area. A large tree trunk is visible on the left side. In the background, several people are standing near a blue car parked on a paved area. The scene is surrounded by lush green trees and foliage.

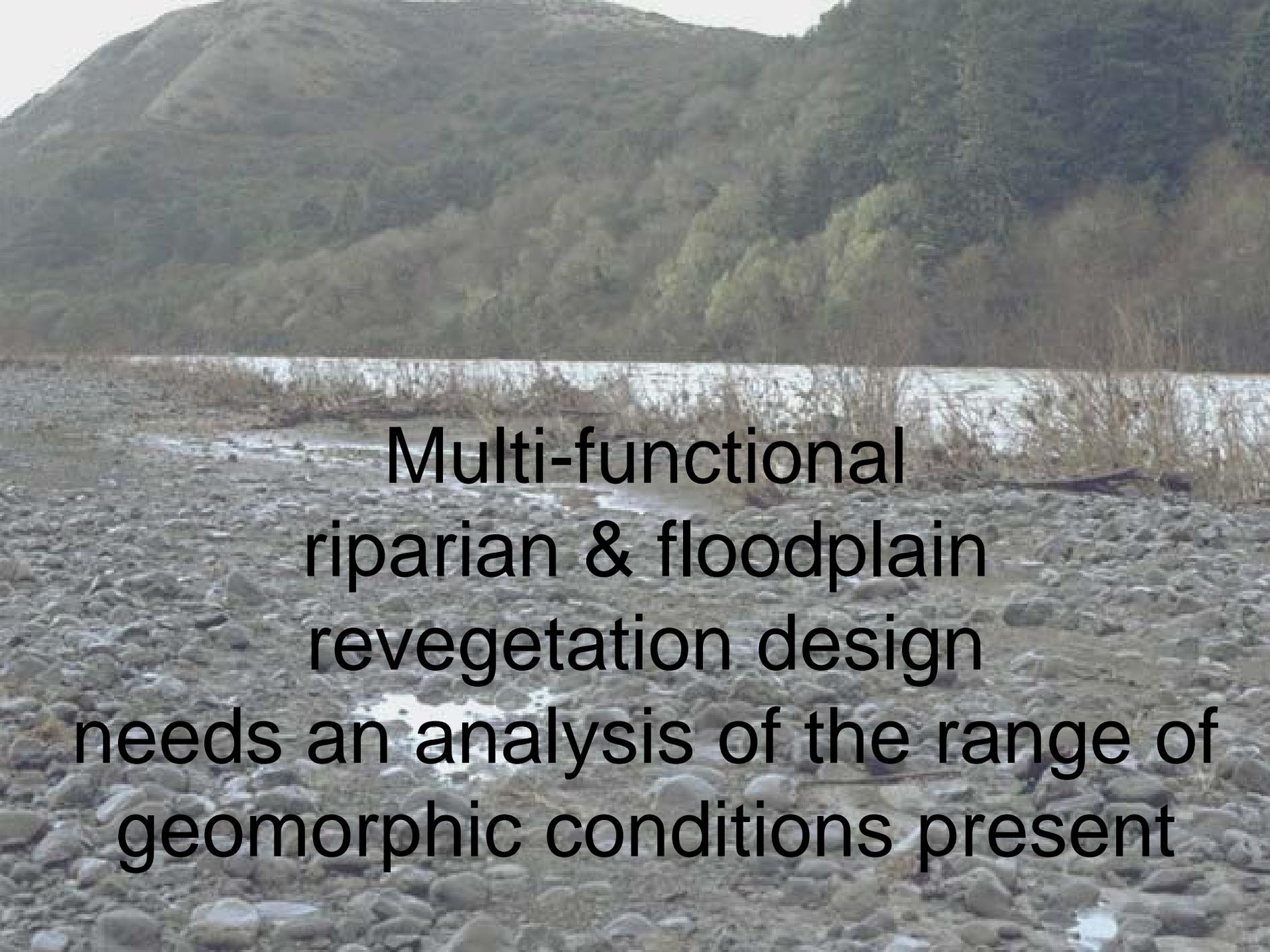
The context for
revegetation efforts
is driven by
social, economic and political
factors.

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

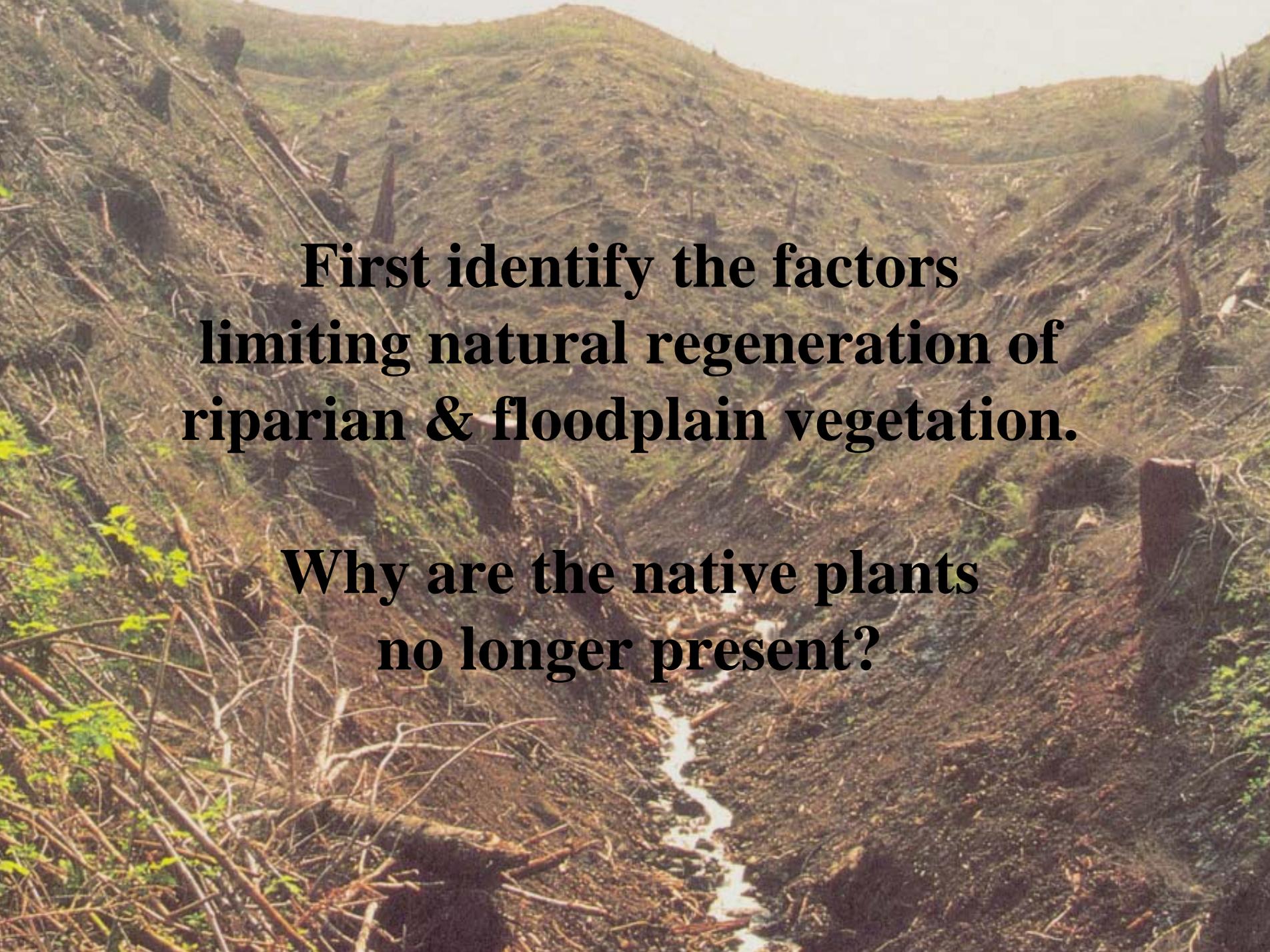
5:27'00

A scenic view of a river flowing through a lush, green landscape. The river is the central focus, with water that is a deep blue-grey color, showing some white rapids and ripples. The banks are covered in tall green grasses and reeds. In the background, there are rolling hills and mountains, some with rocky outcrops. The sky is not clearly visible, but the overall scene is bright and sunny. The text is overlaid on the image in a large, bold, black font.

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

A landscape photograph showing a wide, rocky riverbed in the foreground. The riverbed is composed of numerous smooth, grey and brown stones of various sizes. In the middle ground, there is a line of tall, dry grasses and reeds. Behind this, a dense forest of green trees covers a hillside. The sky is overcast and grey. The text is overlaid on the lower half of the image.

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

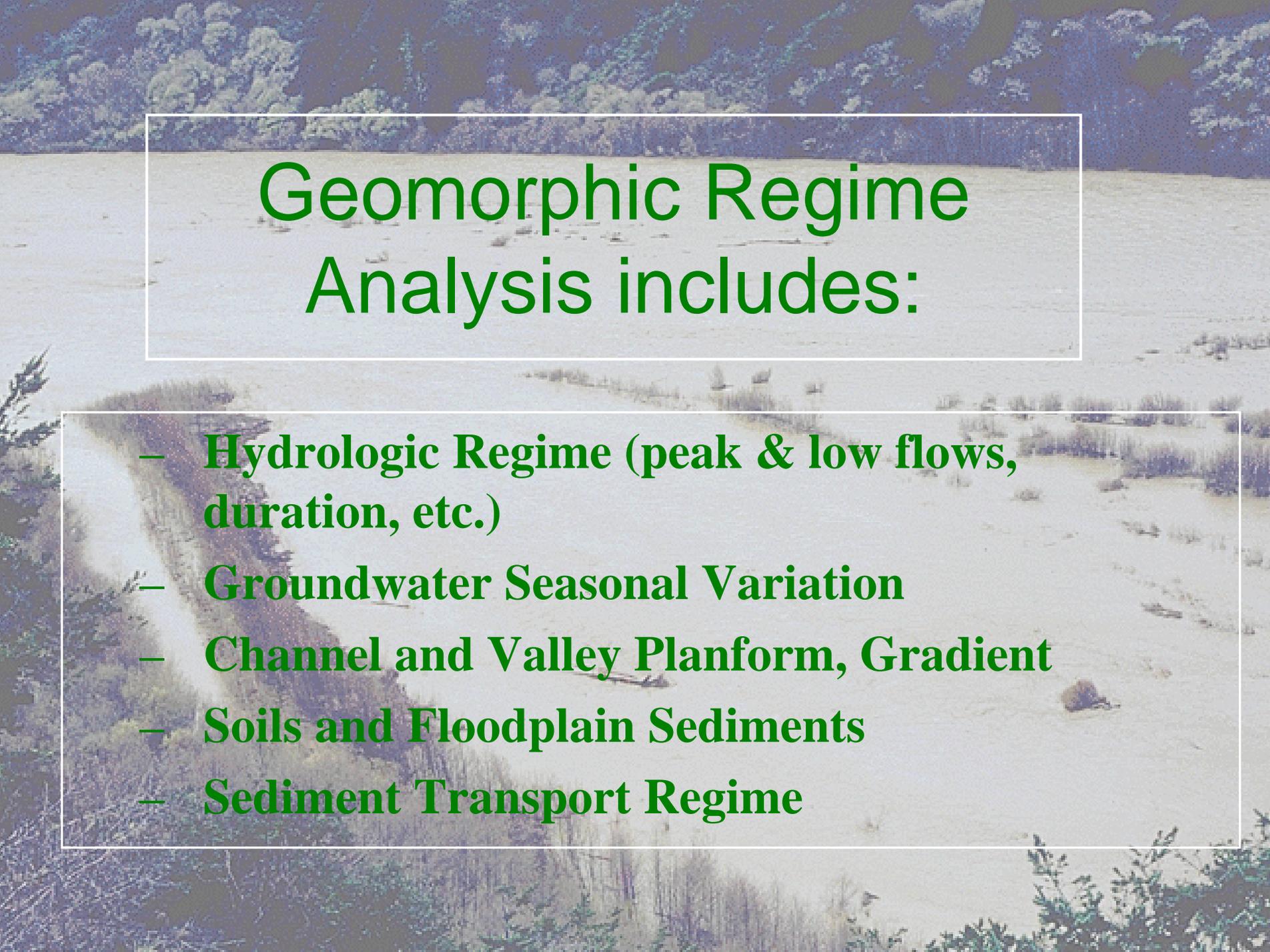


**First identify the factors
limiting natural regeneration of
riparian & floodplain vegetation.**

**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!

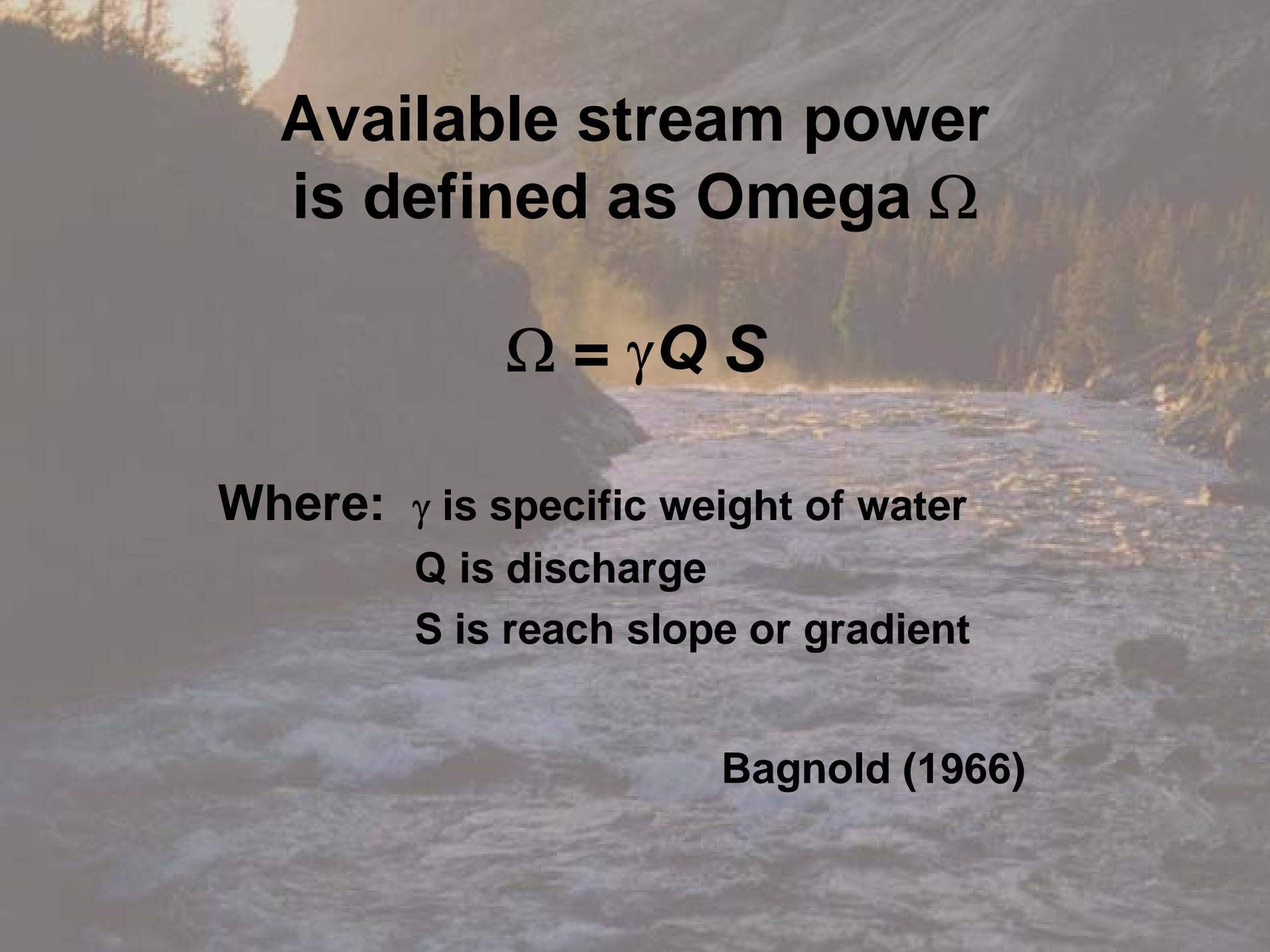
No consistent, quantitative method is available for measurement of the erosional resistance of stream banks & floodplains for the full range of discharge, geomorphic and vegetative conditions.

(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

$$\phi = \Omega / W$$

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**

A photograph of a river or stream flowing through a lush, green forest. The water is dark and reflects the surrounding trees. The banks are covered in tall grasses and shrubs. The sky is overcast.

**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

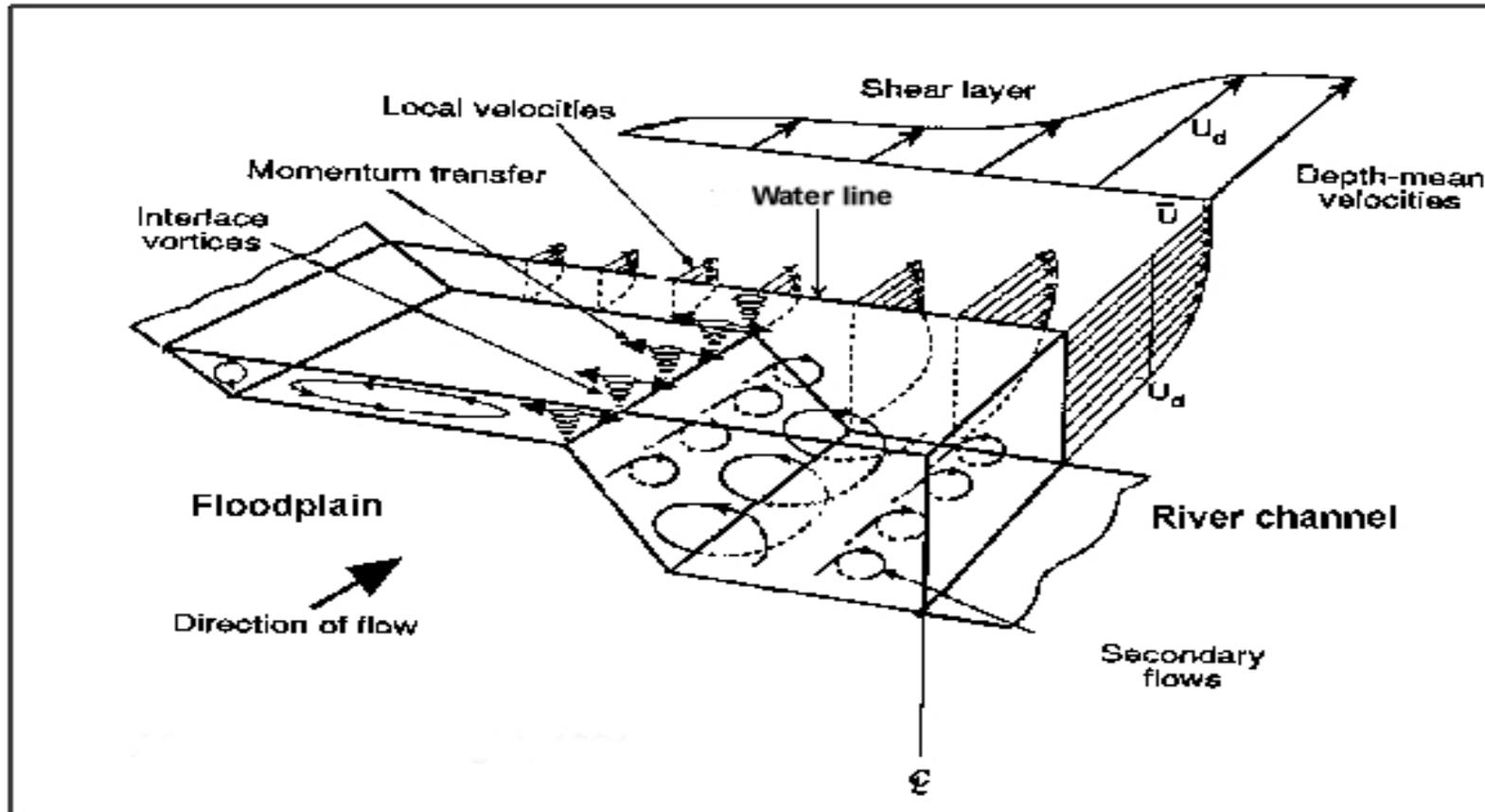
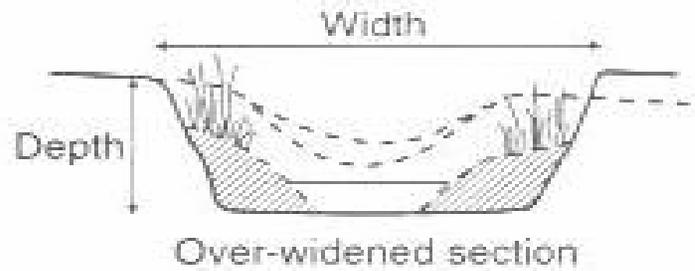
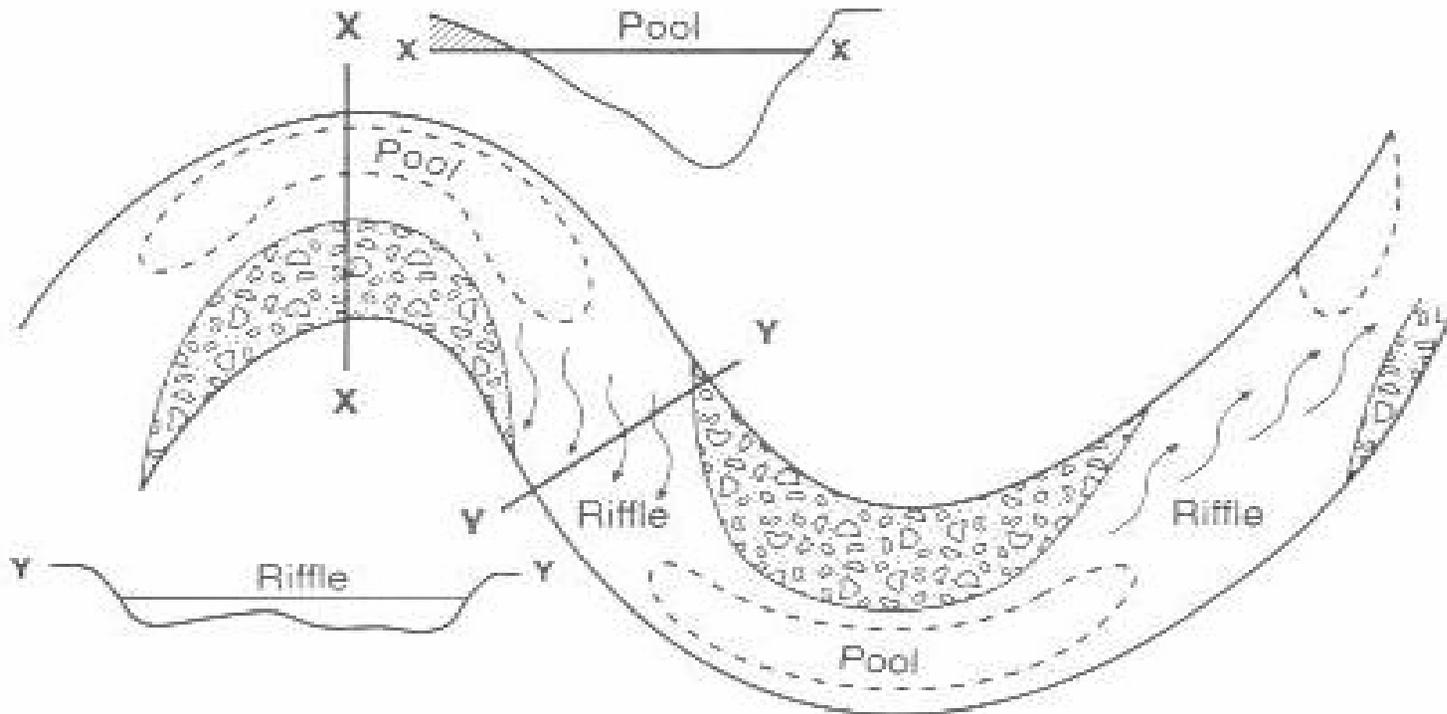
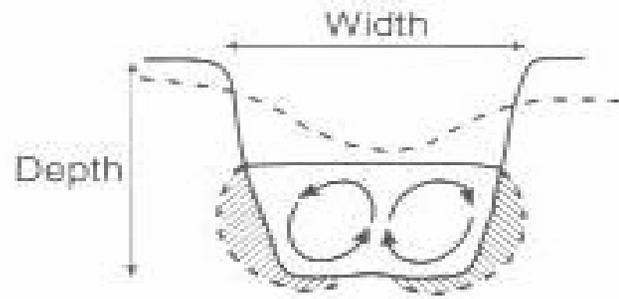


Figure 1. Idealised river orthogonal view, showing distribution of hydraulic shear stresses in channel, at bank and on floodplain, from Shiono and Knight (1990).

Hydraulic forces through a meandering channel



Over-widened section
Width : Depth ratio increased



Over-deepened section
Width : Depth ratio

Bank erosion during flooding: thalweg lateral migration

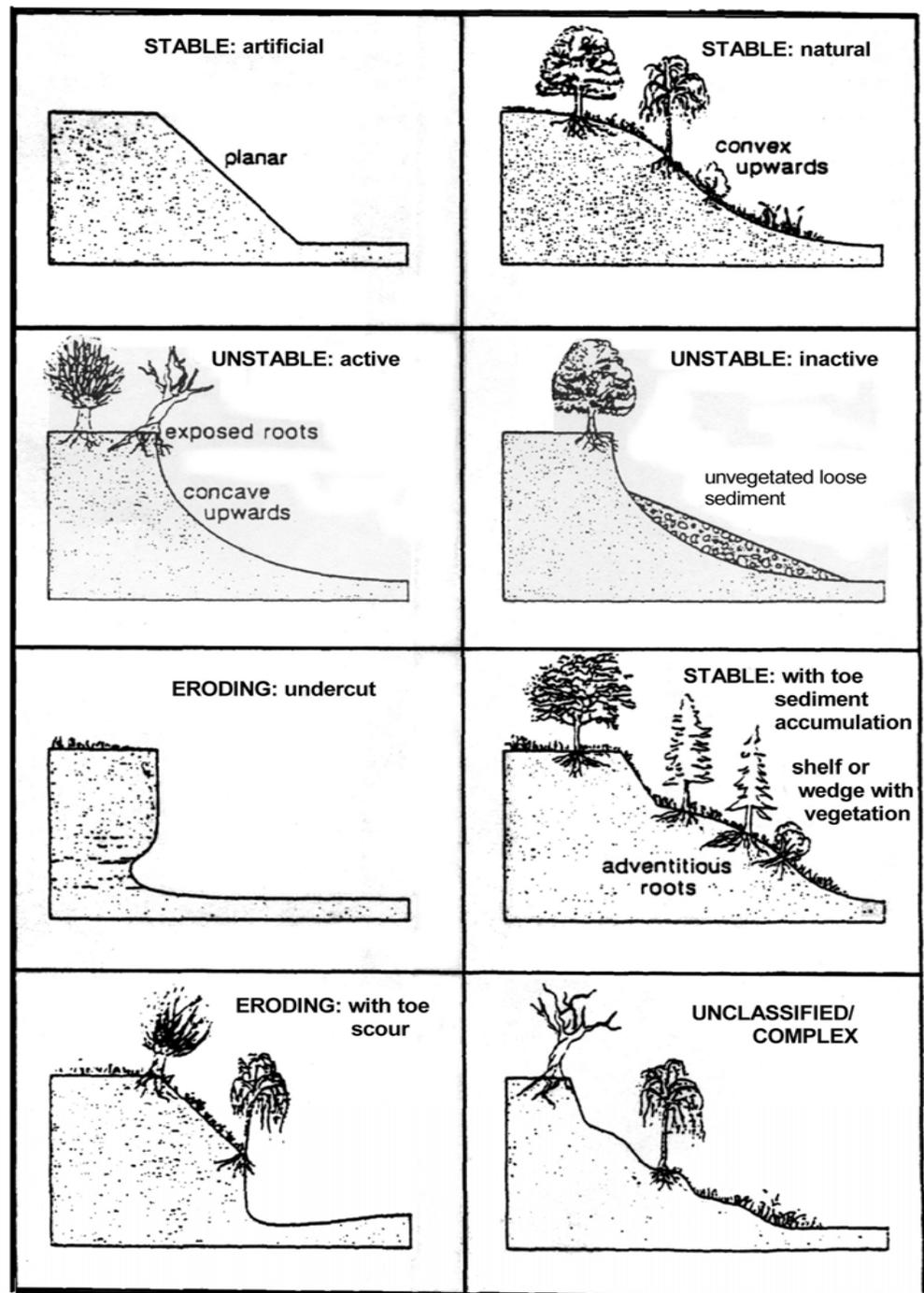
**Anticipate geomorphic channel migration
from historic map & air photo analysis**

**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 reconnaissance 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

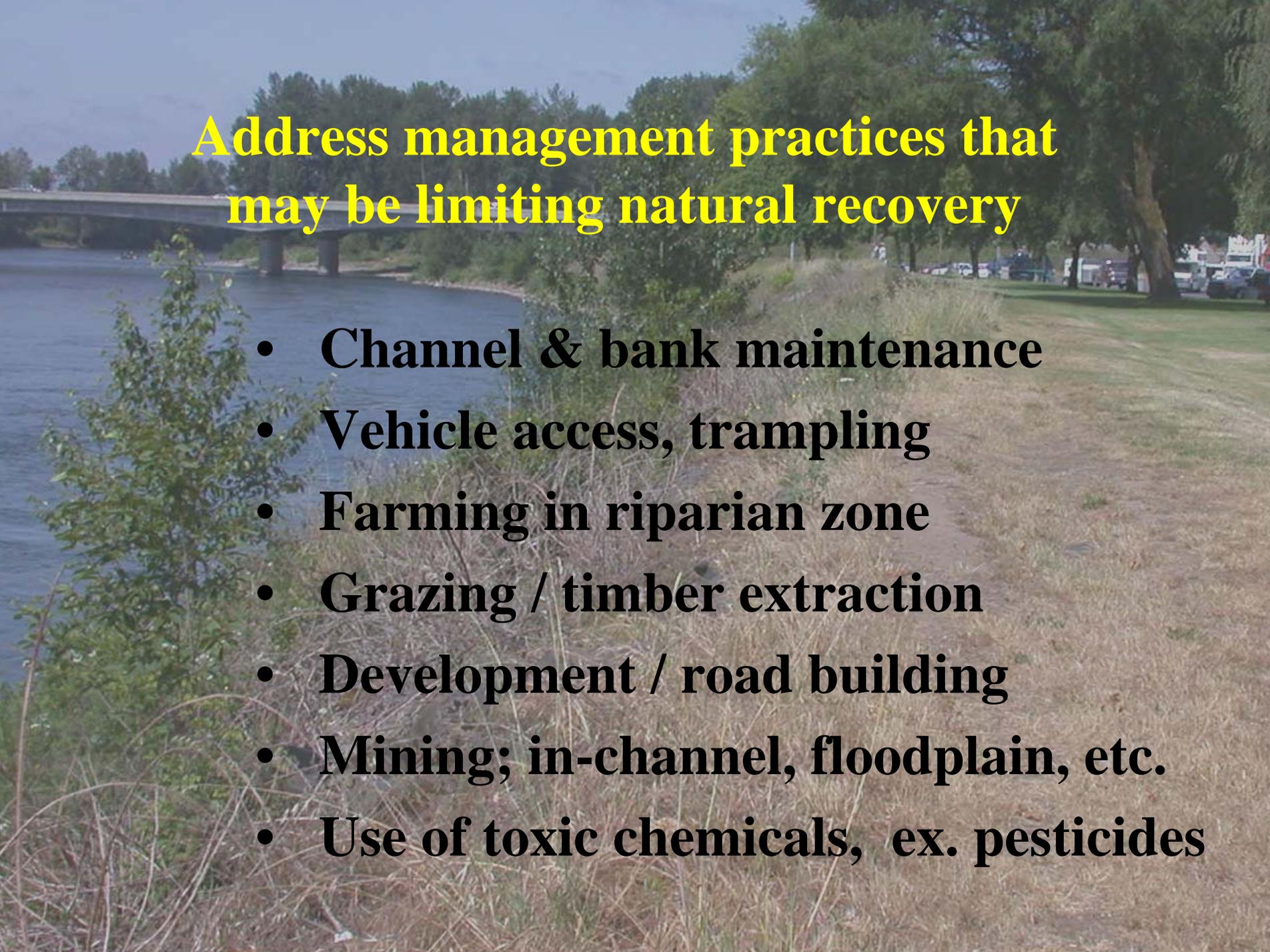
Cowan (1959) method for computing floodplain roughness

$$n = (n_0 + n_1 + n_2 + n_3 + n_4) * m \quad \text{where:}$$

- 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

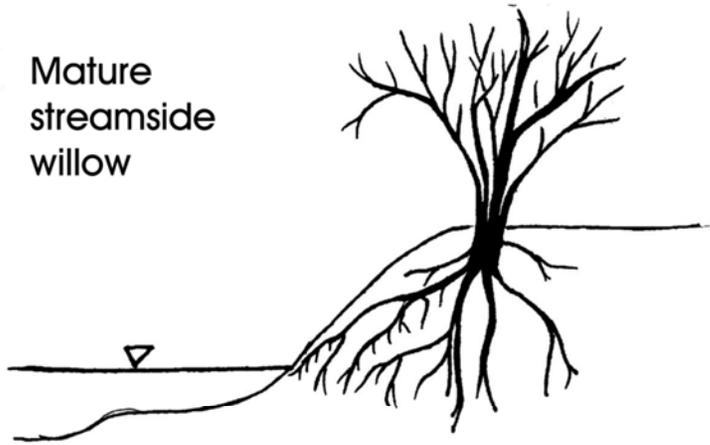
1. Natural re-colonization or recruitment.
2. Address exotic plant/ animal species invasion.
3. Modify river maintenance/ management program.
4. Parkland container planting for aesthetics or wildlife habitat considerations.
5. Geotextile treatments with woody or herbaceous vegetation (including seeding).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

A scenic view of a river with a bridge in the background and a grassy bank in the foreground. The text is overlaid on the image.

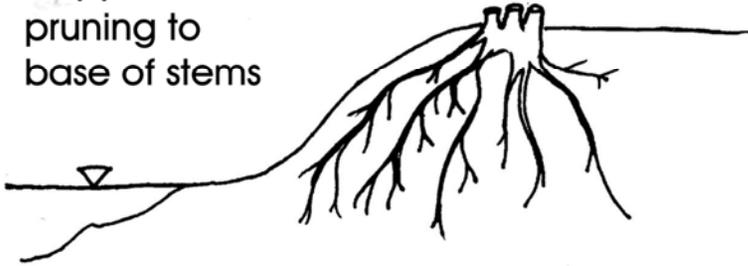
Address management practices that may be limiting natural recovery

- **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**

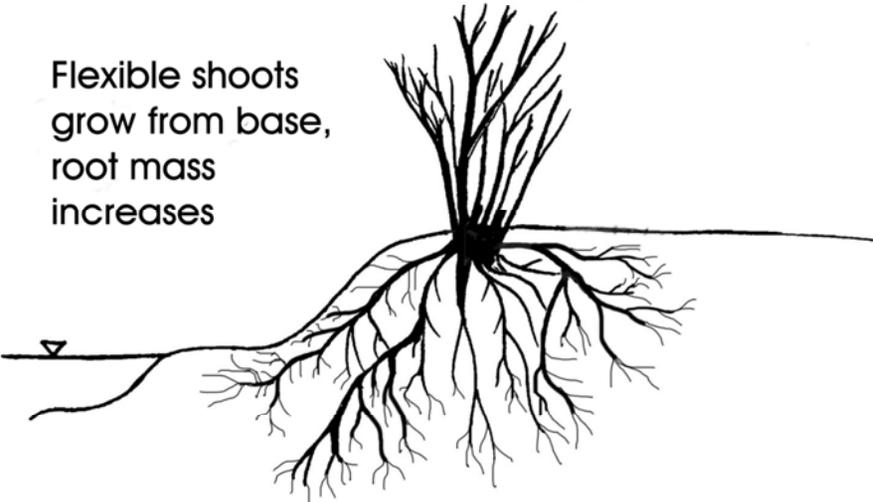
Mature
streamside
willow



Coppice
pruning to
base of stems



Flexible shoots
grow from base,
root mass
increases



Basic coppice technique and regrowth

Drawn by N. C. Perala

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.**

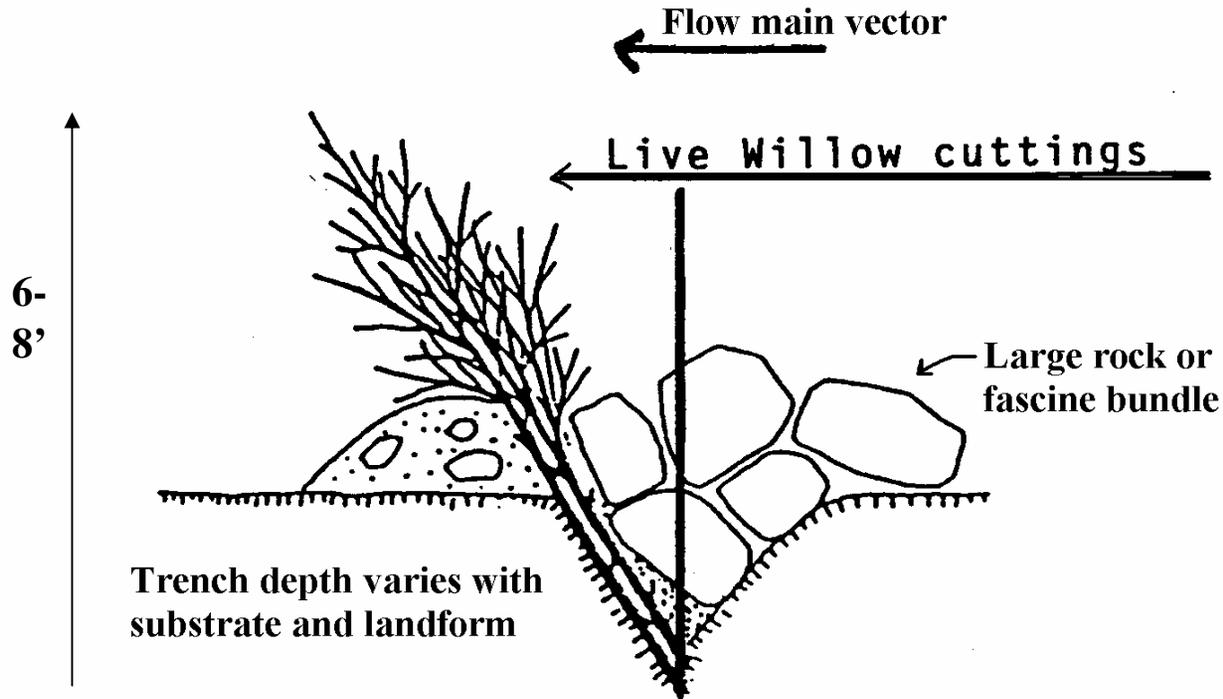
Structural revegetation working with river engineering in a geomorphic context

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



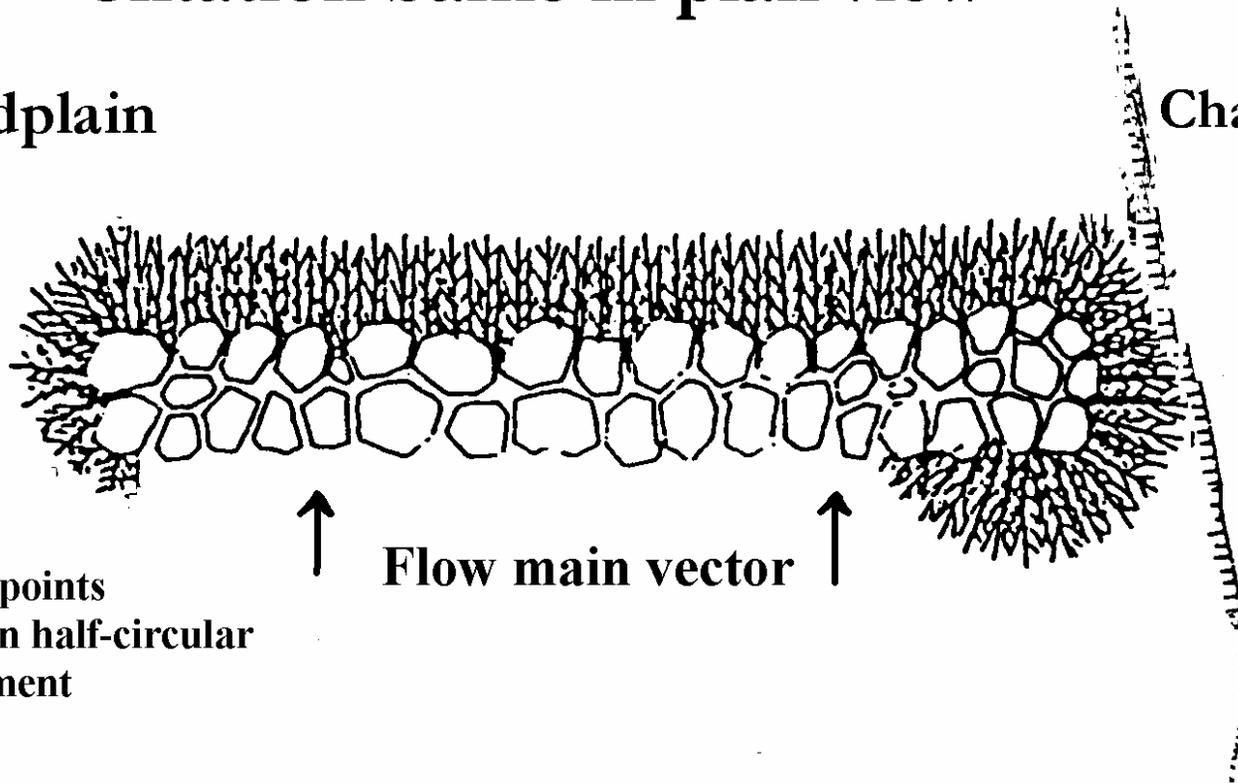
Trench Cross-section View

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

Siltation baffle in plan view

Floodplain

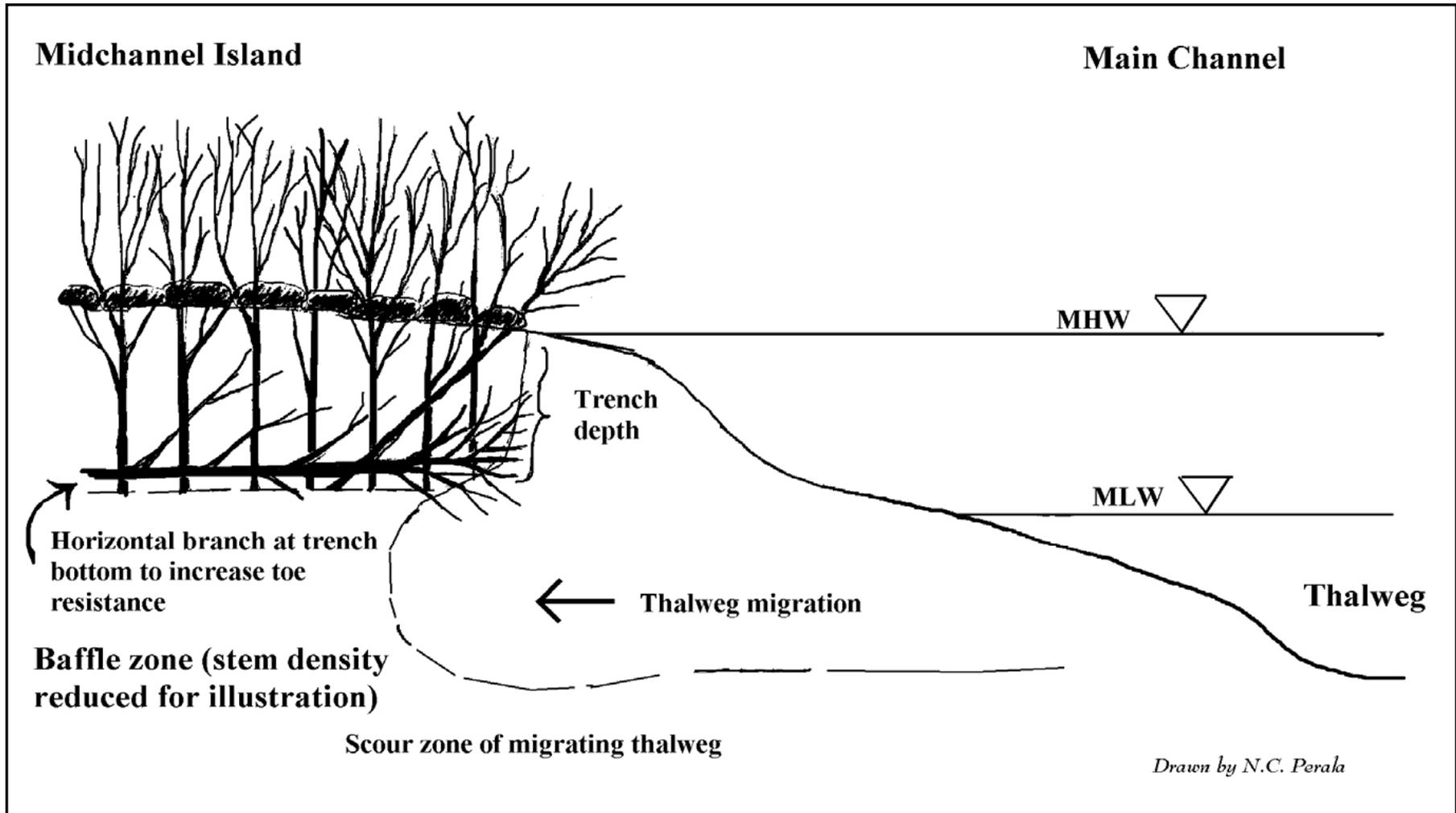
Channel



Note endpoints
planted in half-circular
arrangement

Flow main vector

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.