Combiner la protection contre l'érosion et la conservation de la biodiversité riveraine par des techniques de génie végétal

Colloque Eau & Municipalités
28 septembre 2022

Maxime Tisserant, biol., Ph. D.
Écologiste végétal

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Colloque Eau & Municipalités
1er juin 2022

Maxime Tisserant, biol., Ph. D.
Écologiste végétal

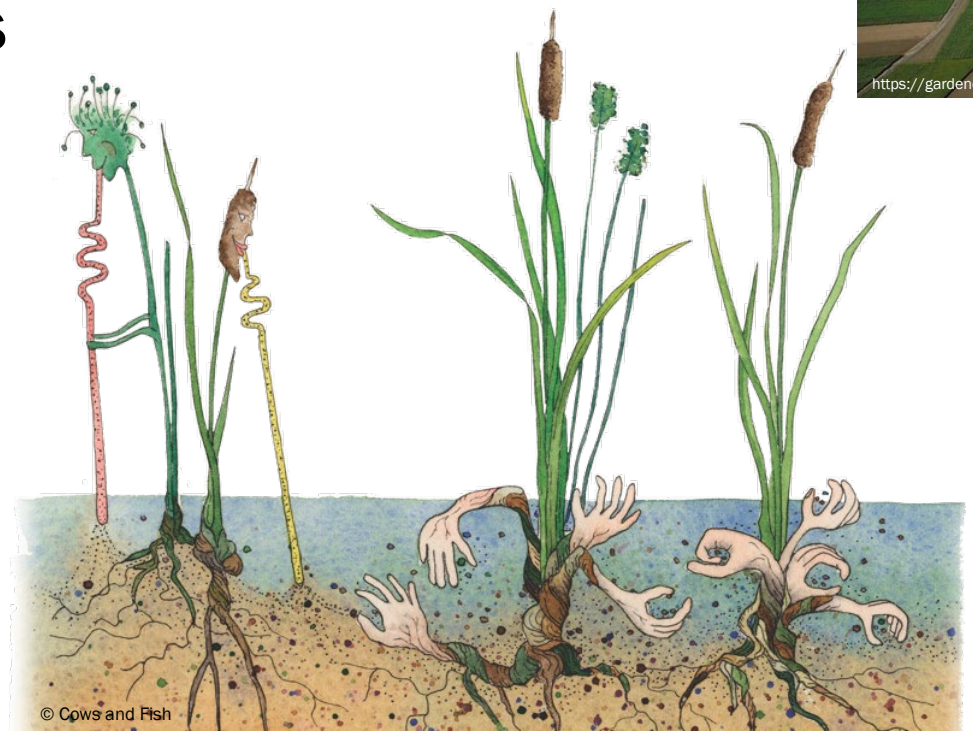
temporal
lateral
longitudinal
vertical
aquifer
temporal

Contexte

Fonctions écologiques des milieux riverains

- Filtration de l’eau
- Trappage des sédiments
- Circulation d’espèces
- Captage des intrants
- Ancrage des racines

https://gardenerscoach.wordpress.com/2013/03/17/habitat-fragmentation/



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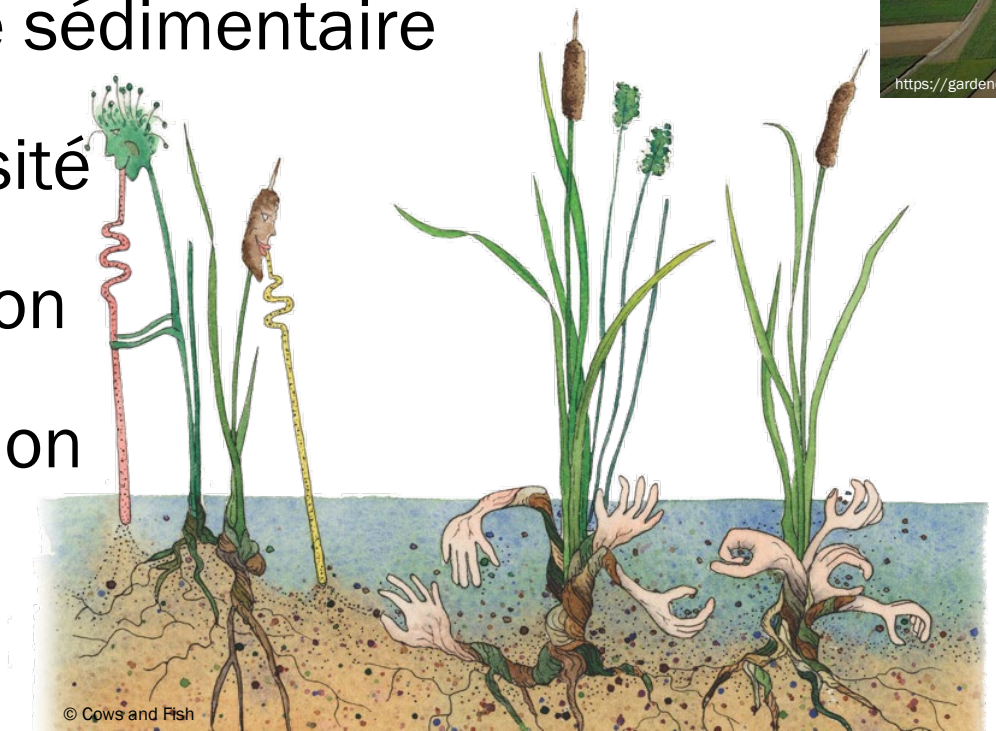
Contexte

Services écologiques des milieux riverains

- Régulation des crues
- Régulation de la charge sédimentaire
- Maintien de la biodiversité
- Diminution de la pollution
- Protection contre l'érosion

https://gardenerscoach.wordpress.com/2013/03/17/habitat-fragmentation/



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Contexte

Statistiques Canada, 2018; Pellerin & Poulin, 2013, ECC & MELCC, 2018

Contexte

Les écosystèmes riverains sont des milieux fragiles, contraints et fragmentés

Rapport de R. Beaulieu (2001):
30 000 kms linéaires de cours d'eau aménagés depuis 1950

D'après le MTQ:
Entre 2011 et 2016, 1100 projets routiers en périphérie d'écosystèmes aquatiques

Beaulieu, 2001

Contexte

Historiquement, population installée à proximité des cours d'eau

Dans les milieu fortement anthropisés, ce sont les derniers milieux naturels

Contexte

Peu ou pas de marge de manoeuvre
Habituellement en situation d’urgence
Obligation de résultat le plus rapide possible
Sécurité du public en jeu
Contraintes budgétaires

Contexte

Historiquement, population installée à proximité des cours d'eau

Dans les milieu fortement anthropisés, ce sont les derniers milieux naturels

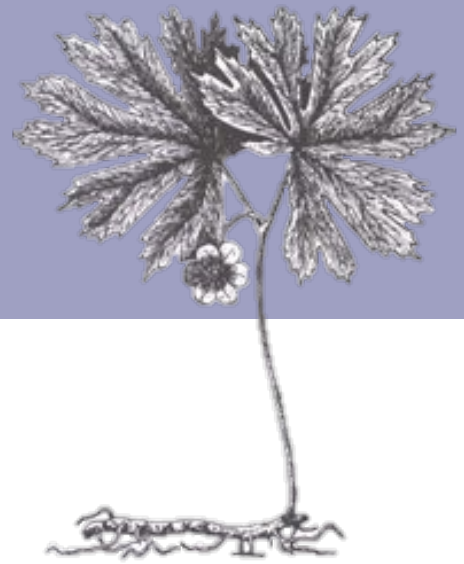
Contexte

Principes & objectifs

- **Historiquement**, techniques de construction fondées sur l'imitation des modèles naturels pour lutter contre l'érosion

- **Aujourd'hui**, assurer un compromis entre:
  - Fonctions de protection contre l'érosion
  - Fonctions écologiques
  - Fonctions récréatives

Principes & objectifs



Intervention en milieu riverain

- Faut-il réellement intervenir ?
  - Dynamique naturelle du cours d'eau
  - Évaluation des conséquences d'une non-intervention (coûts, enjeux)
- Évaluer si une gestion ciblée de la végétation existante peut suffire
- Évaluer les potentialités du génie végétal pour régler le problème
- Évaluer si des techniques combinées peuvent pallier aux derniers problèmes
- Appliquer une technique de génie civil **raisonnable et proportionnée**

Adam et al., 2008; diapo d'André Evette

Techniques de stabilisation de berge

Matériaux vivants

Boutures

© André Evette

Pieux

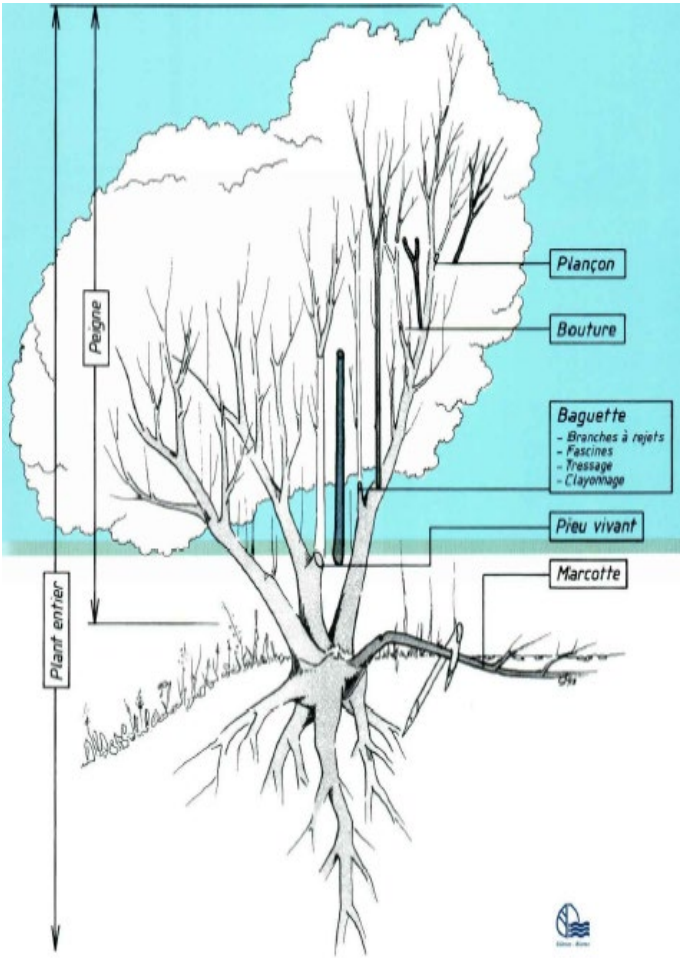
© Aqua Terra Solutions

Plants

© Pépinière Rustique

Semences

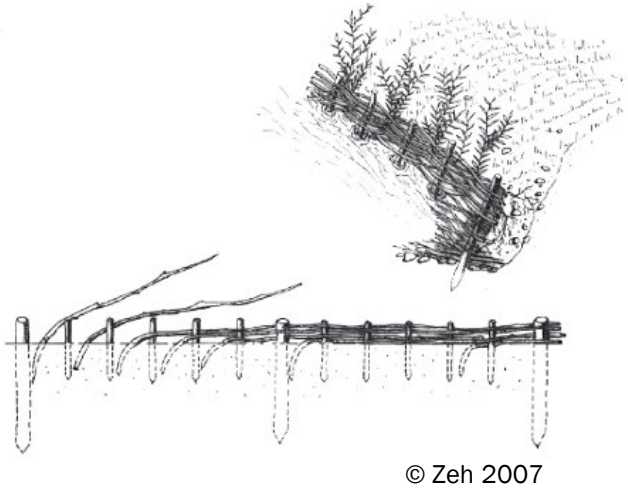
© André Evette



© Biotec

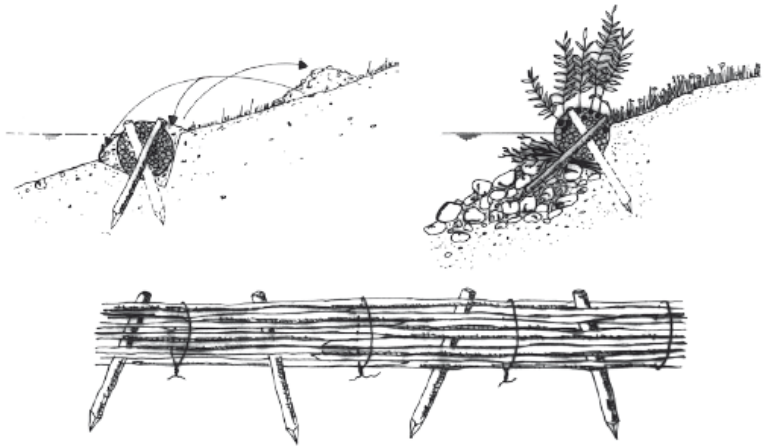
Techniques de stabilisation de berge

- Tressage



Techniques de stabilisation de berge

- Fascine

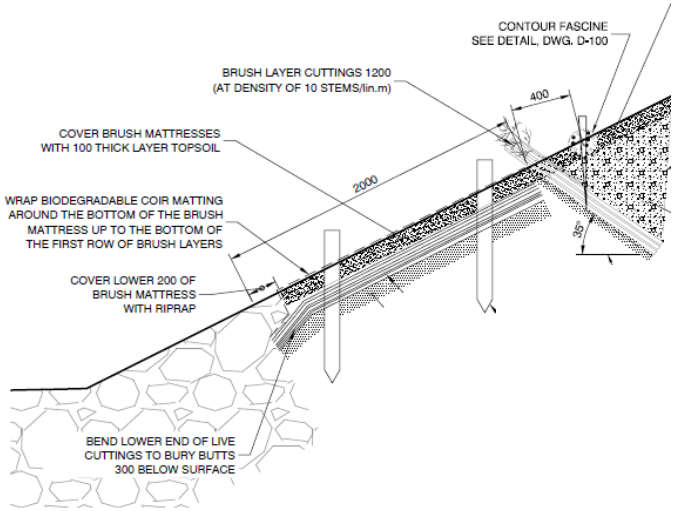


© Zeh 2007

Techniques de stabilisation de berge

- Couches de branches à rejet

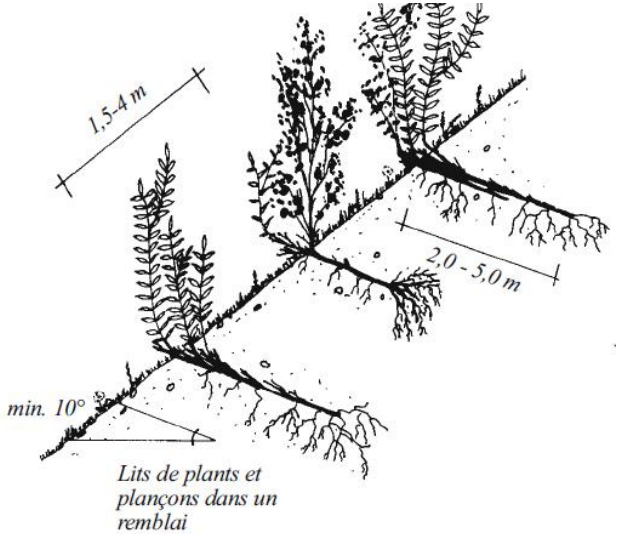
© Ville de Calgary



© Terra Erosion Control

Techniques de stabilisation de berge

- Lits de plants et plançons

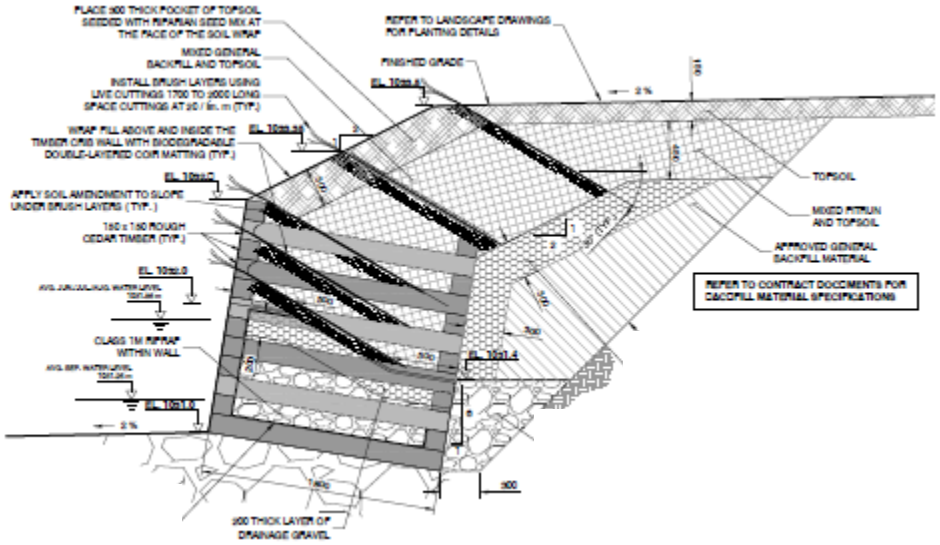


Lits de plants et plançons dans un remblai

© Aqua Terra Solutions

Techniques de stabilisation de berge

- Caissons végétalisés



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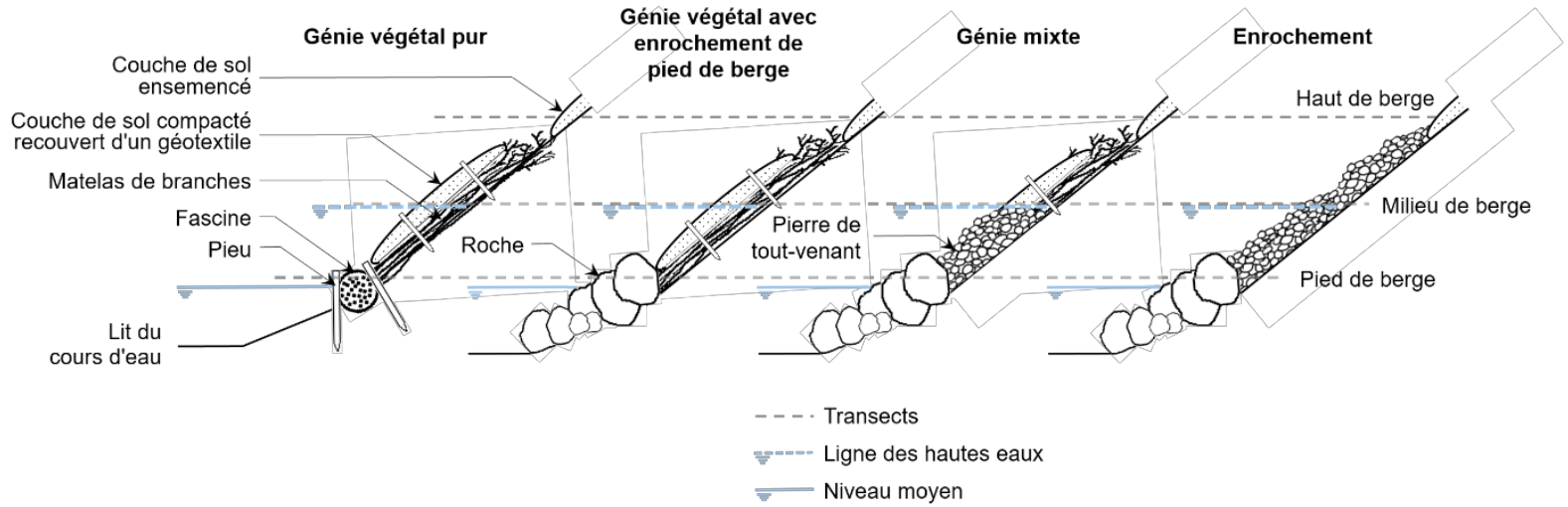
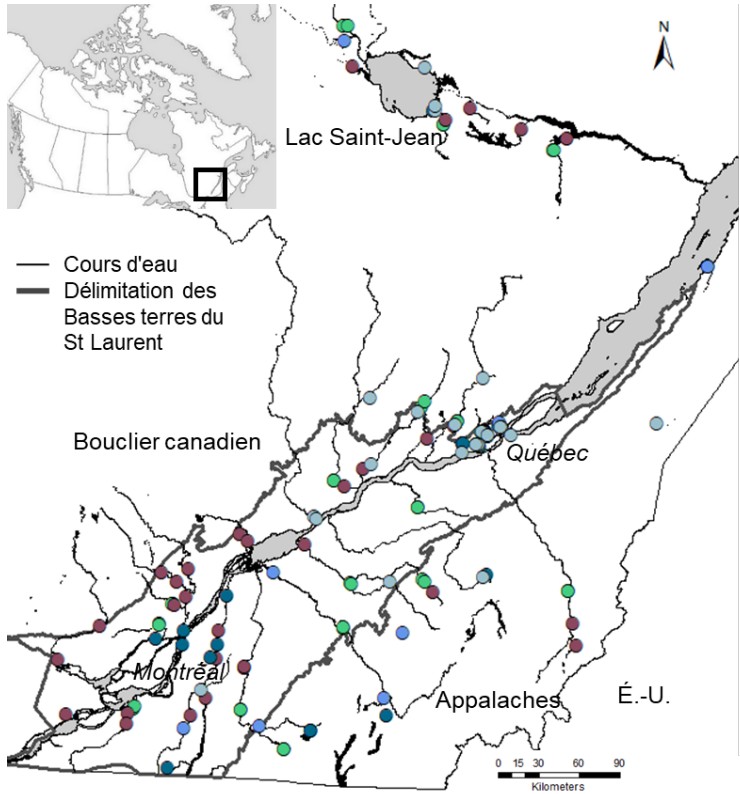
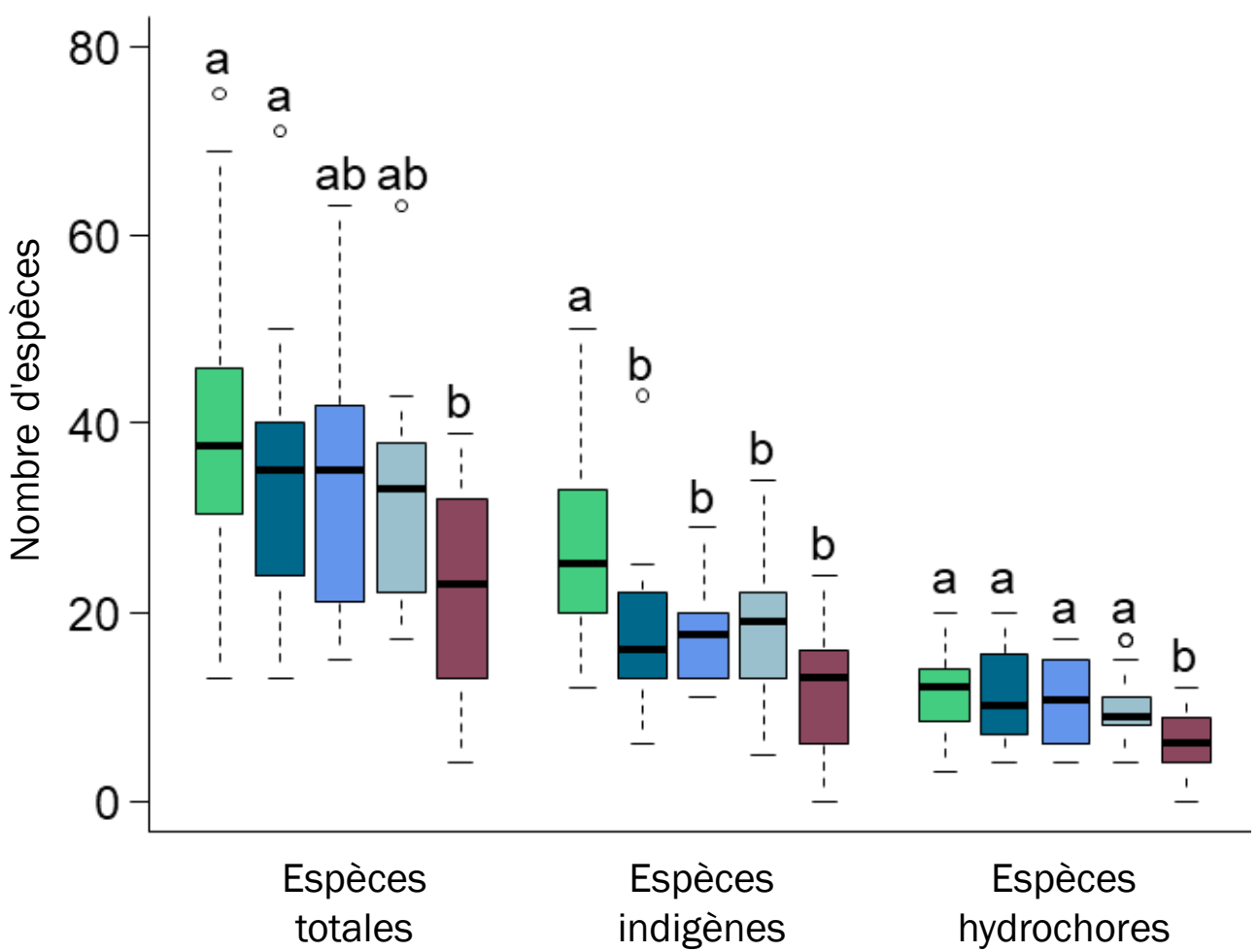
Stabilisation et biodiversité

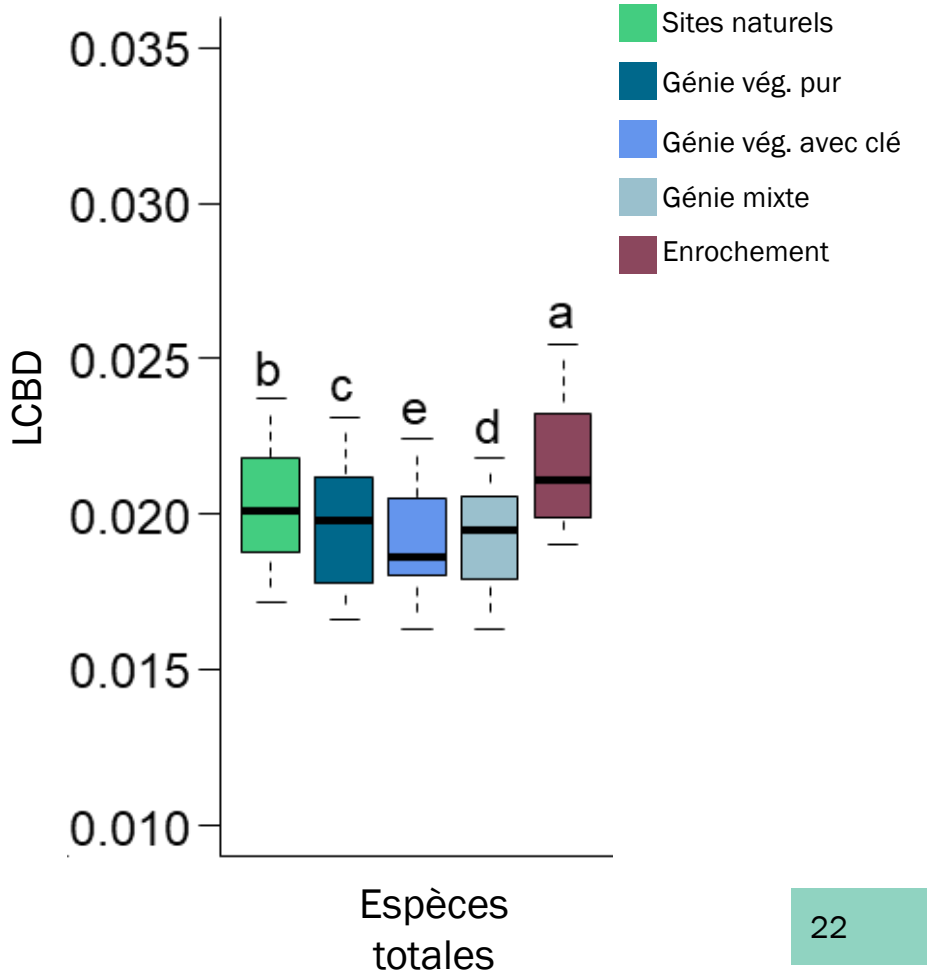
Quelle biodiversité pour quel type d'ouvrage ?





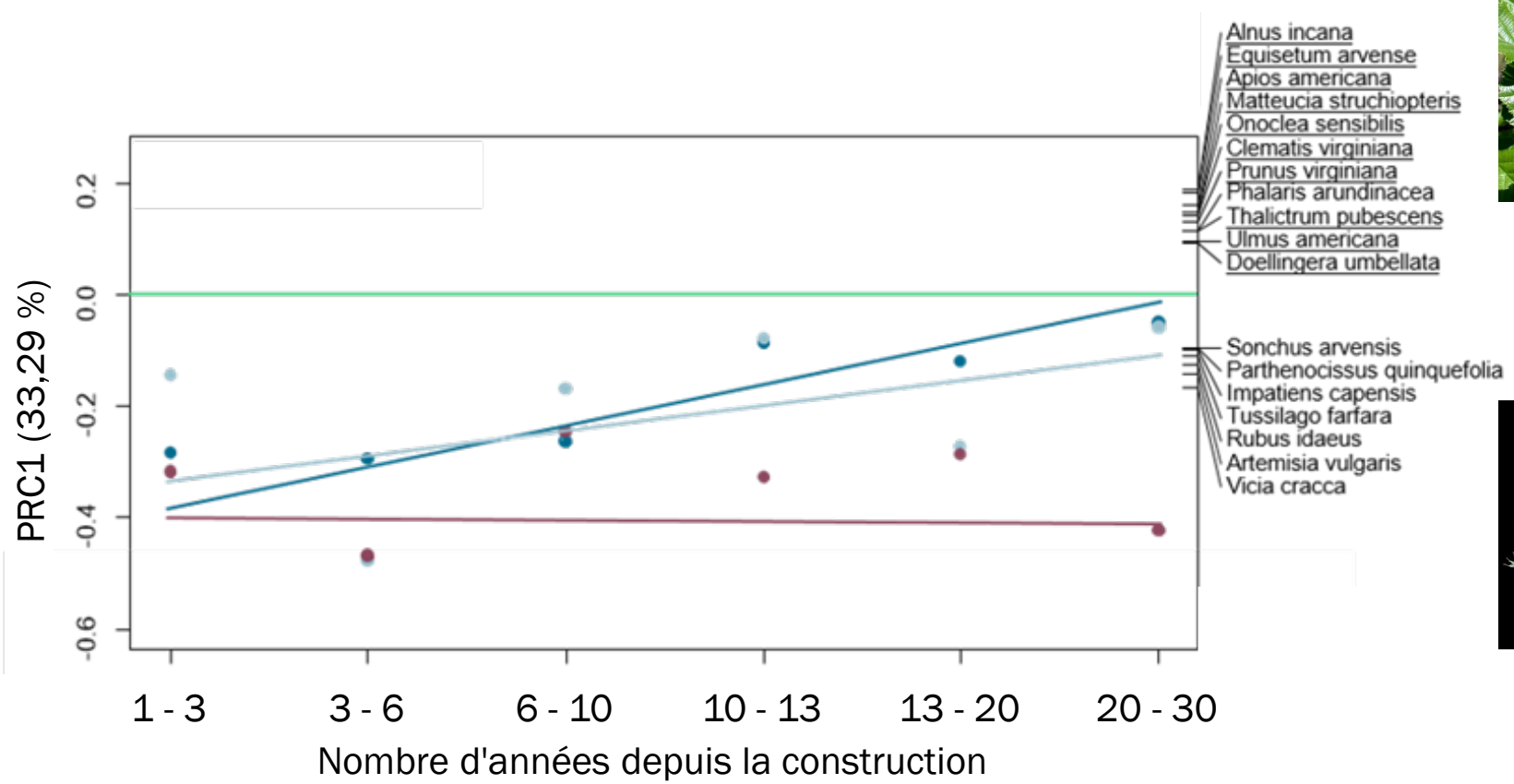
Stabilisation et biodiversité





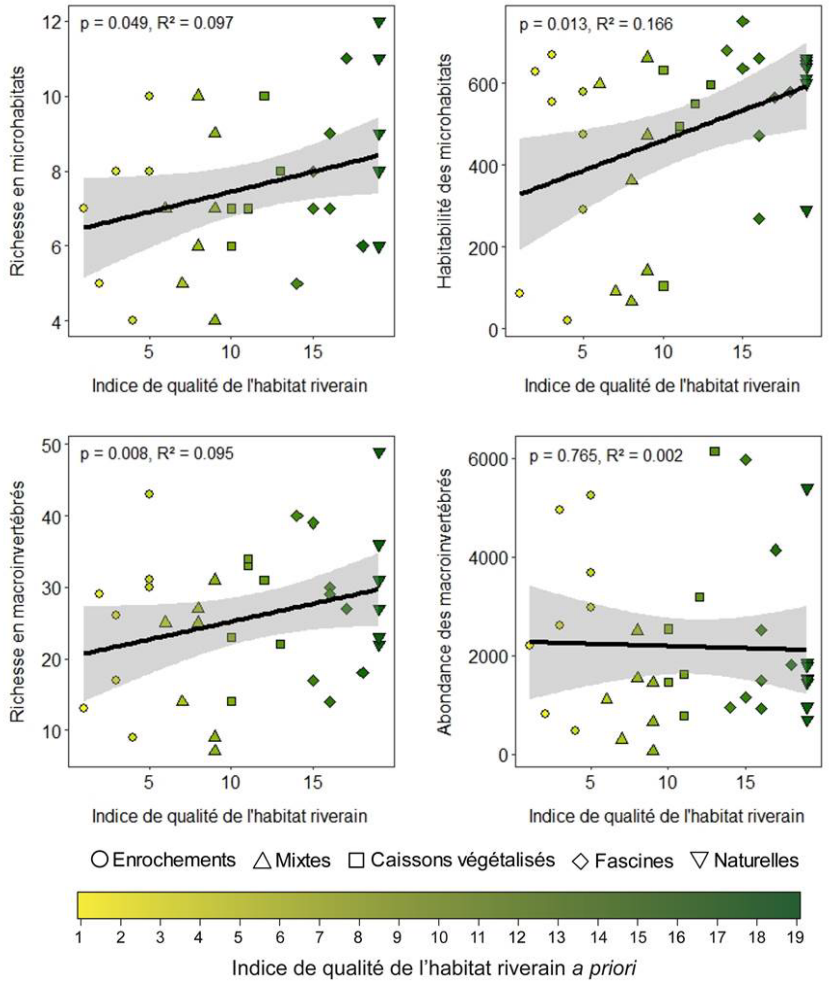
Tisserant et al., 2020

Stabilisation et biodiversité



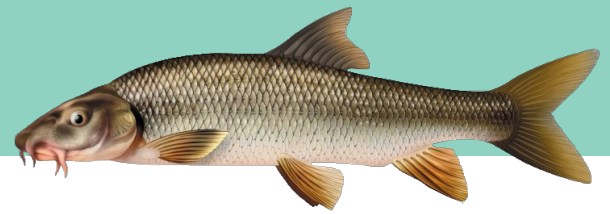
Tisserant et al., 2020

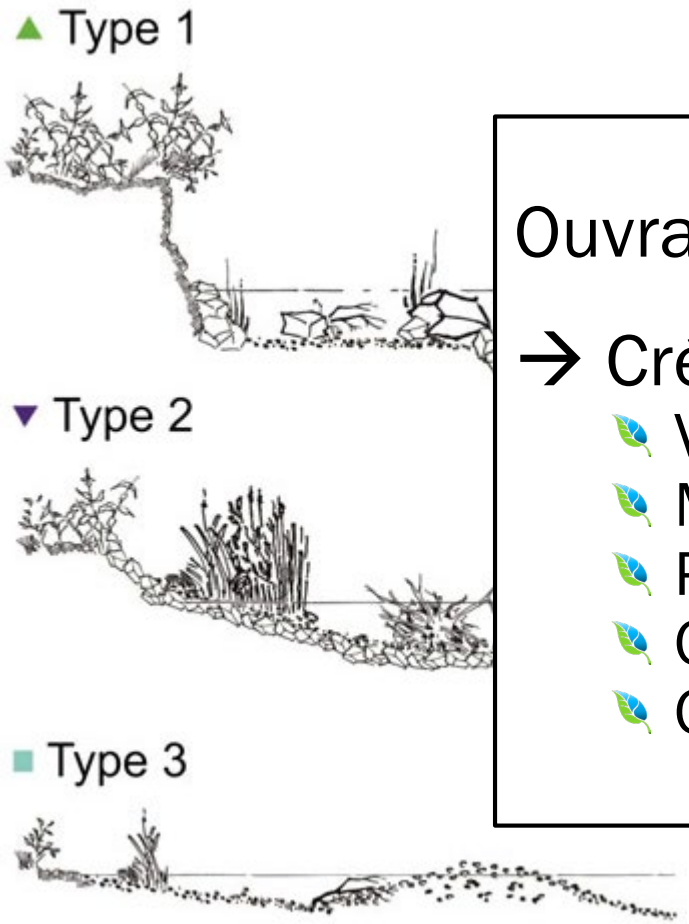
Stabilisation et biodiversité



Cavaillé et al., 2018; Janssen et al., 2019

Stabilisation et biodiversité

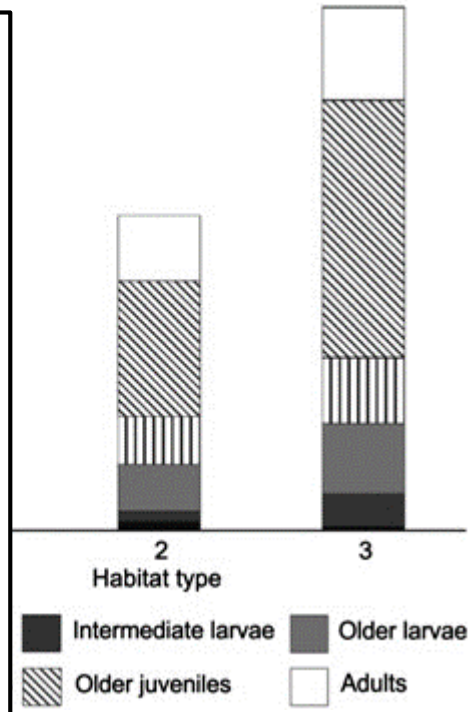




Ouvrages de génie végétal

→ Création de microhabitats biogènes

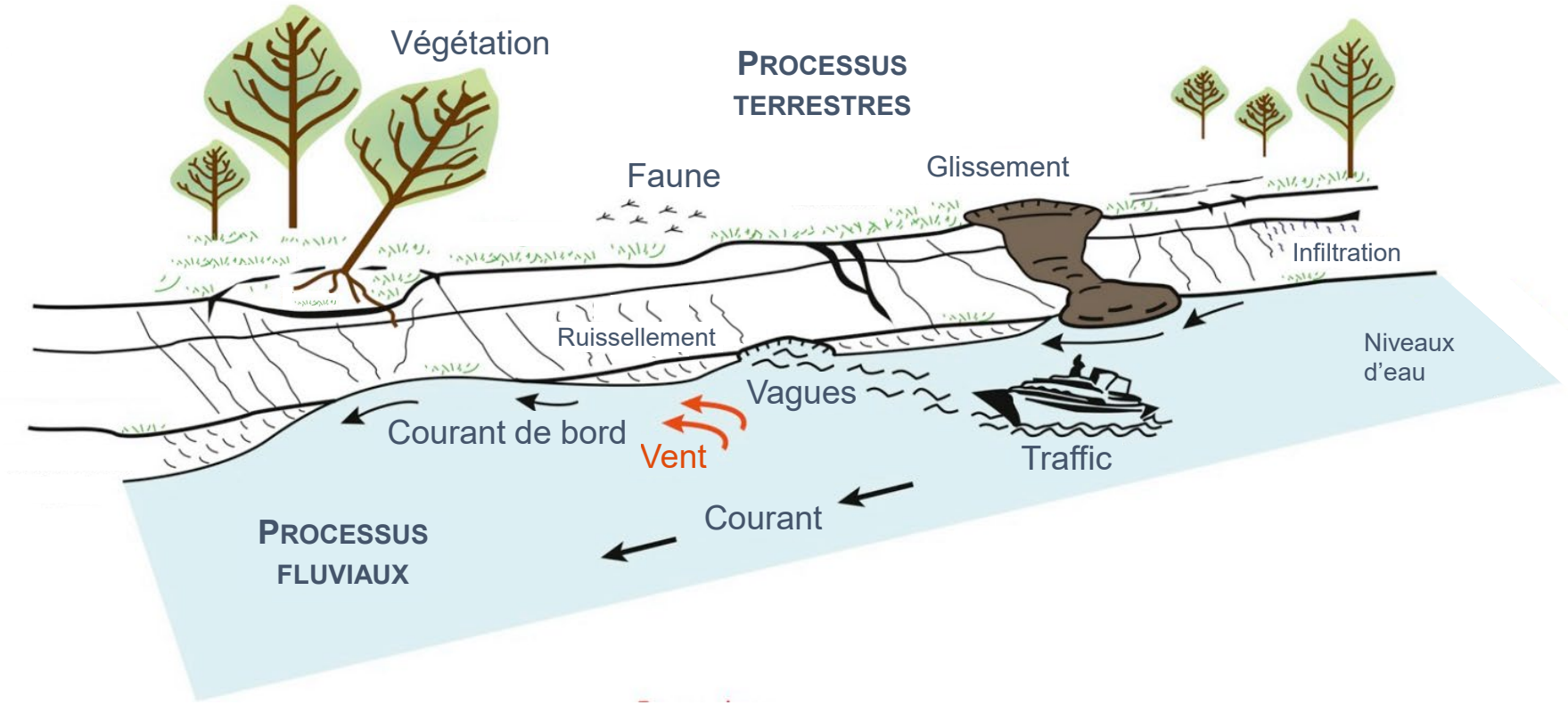
- Végétaux
- Macroinvertébrés benthiques
- Poissons
- Oiseau
- Qualité de l'habitat riverain



Pander et al., 2017

Développement et obstacles

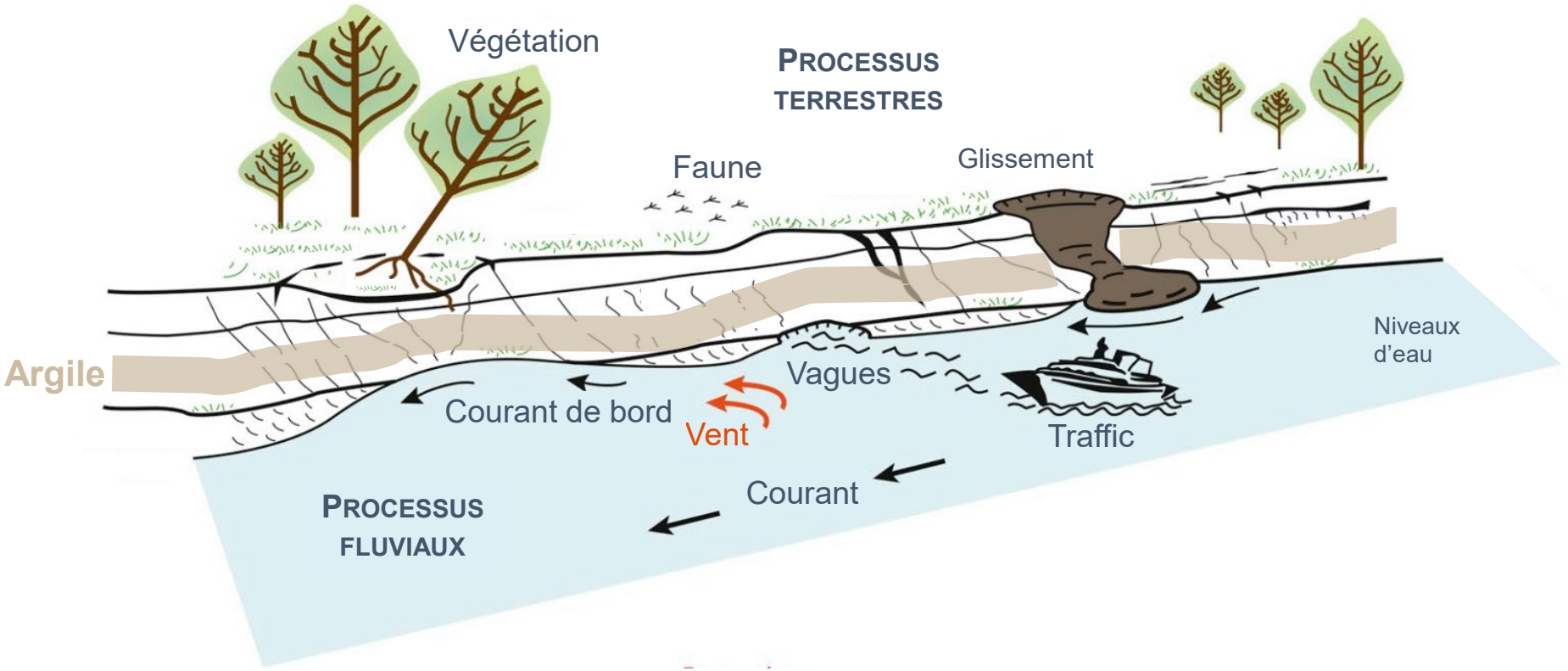
Des inconnues dans l'équation québécoise



Adapté de Chassiot et al., 2021

Développement et obstacles

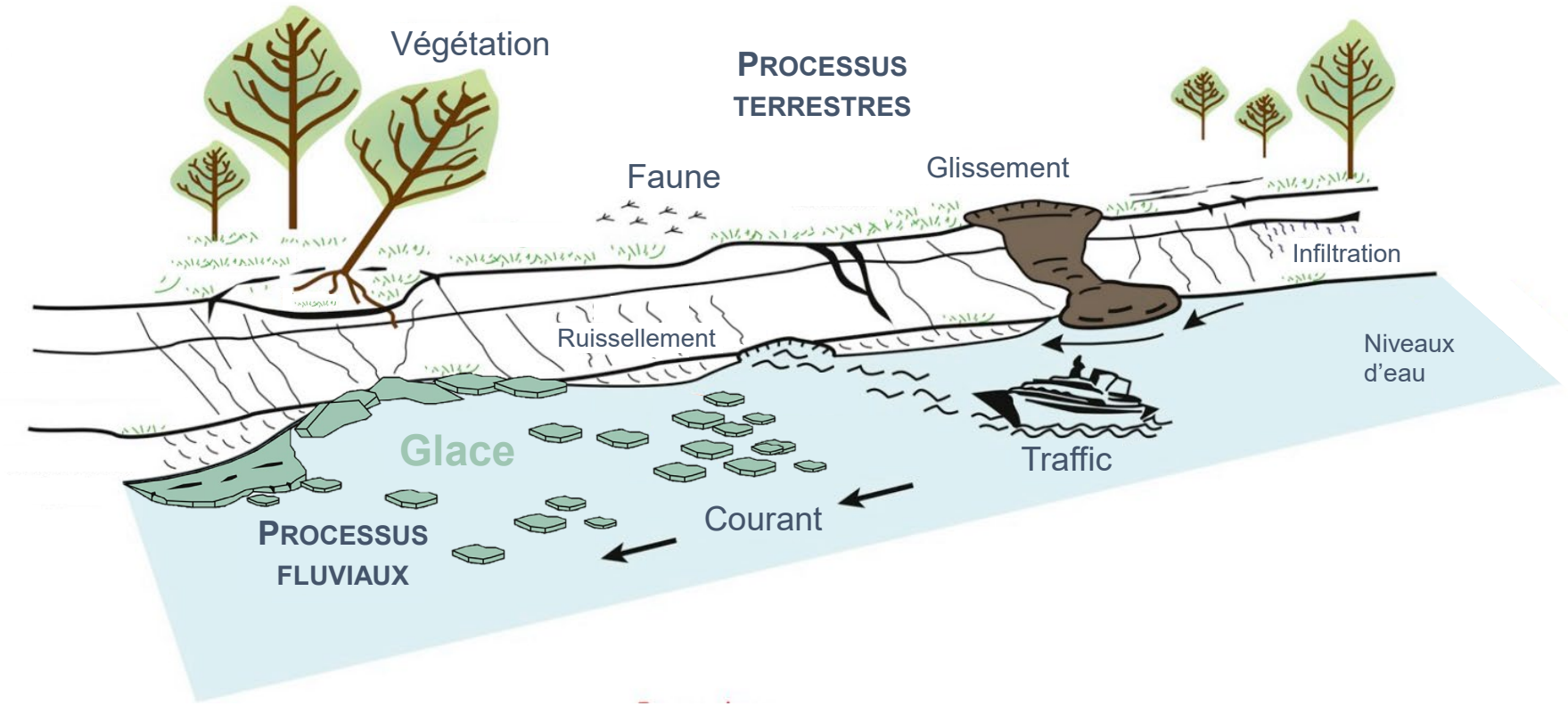
Des inconnues dans l'équation québécoise



Adapté de Chassiot et al., 2021

Développement et obstacles

Des inconnues dans l'équation québécoise



Adapté de Chassiot et al., 2021

Développement et obstacles

PORTFOLIO DE SOLUTIONS RÉSILIENTES ET ÉCORESPONSABLES DE STABILISATION DES RIVES SUR LE TERRITOIRE DE LA MRC DE PORTNEUF

Problématiques liées à la stabilisation des rives

Pression immobilière sur les rives

Phénomènes d'érosion de rive de plus en plus fréquents et importants (CC)

Caractérisation des berges de la partie fluviale du Saint-Laurent (U Laval – mars 2020) : 19% des rives en érosion active sur le territoire de la TCREF

Municipalités et citoyens démunis face à la situation

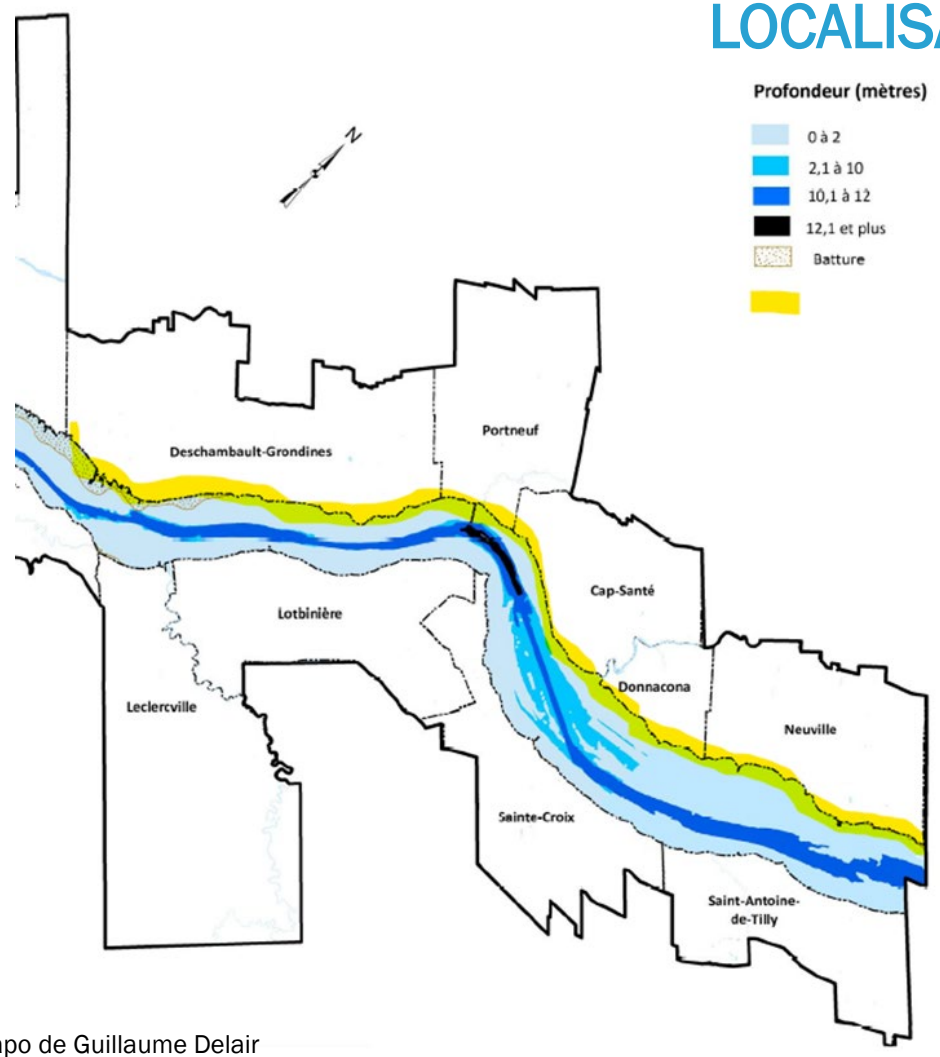
Municipalités : complexité d'application de la réglementation en ce qui a trait aux rives

Milieu particulier avec de grosses contraintes (fortes marées, dynamique des glaces, etc…)

Diapo de Guillaume Delair

Développement et obstacles

LOCALISATION



ÉTAPES

2021

Formation d'un Comité expert

Identification des sites retenus (cas typiques d'érosion avec enjeux)

Amorce des plans types de stabilisation adaptés à chaque cas de figure

Mars 2022 – mars 2023

Finalisation des plans types de stabilisation et réalisation du portfolio

Présentation du portfolio aux municipalités de la MRC de Portneuf

Formation des entrepreneurs de la région

Mars 2023 – mars 2024

Rédaction d'un guide pour les propriétaires riverains

Tenue d'assemblées d'information publique destinés aux riverains du fleuve

Diapo de Guillaume Delair

Développement et obstacles

Érosion en rive naturelle – pente douce

Érosion en rive naturelle – pente forte

Muret de béton désuet

Enrochement désuet

Falaises : meuble et en shiste

Diapo de Guillaume Delair

Développement et obstacles

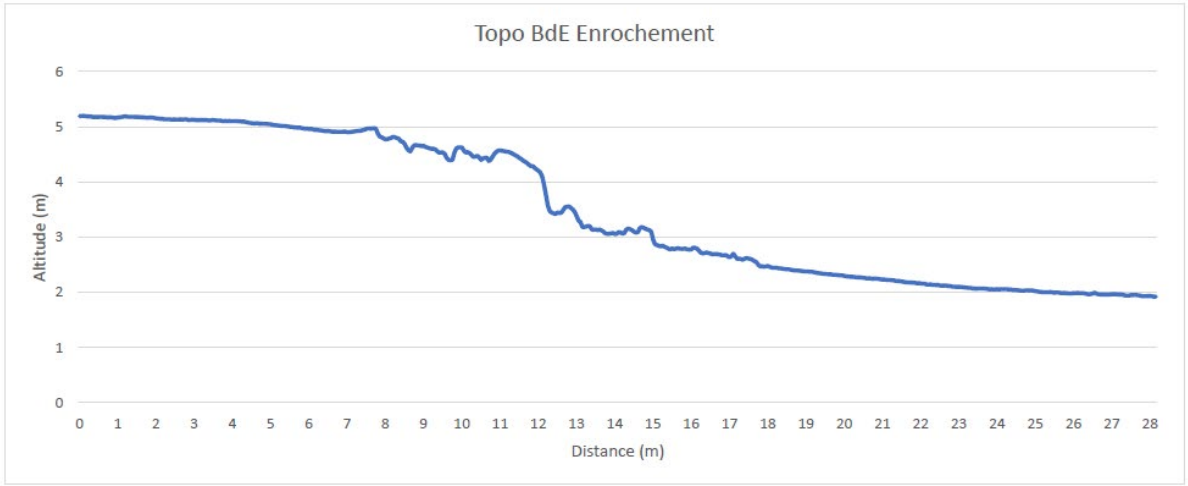
FORMATION D'UN COMITÉ D'EXPERTS

Chercheurs : U Laval / UQAR
Représentants des Ministères : MELCC, MFFP, MTQ
OBV (CAPSA, CBJC)
Québec Vert (anciennement FIHOQ)
MRC de Portneuf

Diapo de Guillaume Delaï

Développement et obstacles

ACQUISITION DE DONNÉES SUR LE TERRAIN



Diapo de Guillaume Delair

Développement et obstacles

RÉDUCTION DES IMPACTS DES ALÉAS HYDROCLIMATIQUES DANS LE BASSIN VERSANT DU COURS D'EAU URBAIN

Cours d'eau problématique
Pression immobilière
Forts débits de pointe
Forte charge sédimentaire

Projet novateur
Aménagement d'infrastructures vertes dans le bassin versant
Réduction des débits
Rétention des sédiments
Restauration des milieux aquatiques et riverains

Démarche citoyenne
Implication des résidents du bassin versant
Rencontres d'information et de consultation

Développement et obstacles

Institut national de la recherche scientifique

PERFORMANCE DES SOLUTIONS BASÉES SUR LA NATURE POUR LA PROTECTION CONTRE L'ÉROSION CÔTIÈRE

Objectifs

Étudier la **capacité d'atténuation des vagues** et la **protection contre l'érosion** d'un **talus végétalisé** par rapport à un talus non végétalisé dans **différentes conditions hydrodynamiques**

Identifier l'influence des **caractéristiques spécifiques des plantes** (hauteur, rigidité, etc.) sur l'atténuation des vagues et la protection contre l'érosion

Mesurer la **force de traînée** exercée sur différentes espèces de végétation dans différentes conditions hydrodynamiques et quantifier le coefficient de traînée (Cd)

Étudie l'influence de la **saisonnalité** sur la capacité d'atténuation des vagues et l'érosion

Développement et obstacles

PROJET DE CRÉATION D'UNE BASE DE DONNÉES SUR LE GÉNIE VÉGÉTAL EN FRANCE

Objectifs

Promouvoir le développement des techniques auprès des gestionnaires

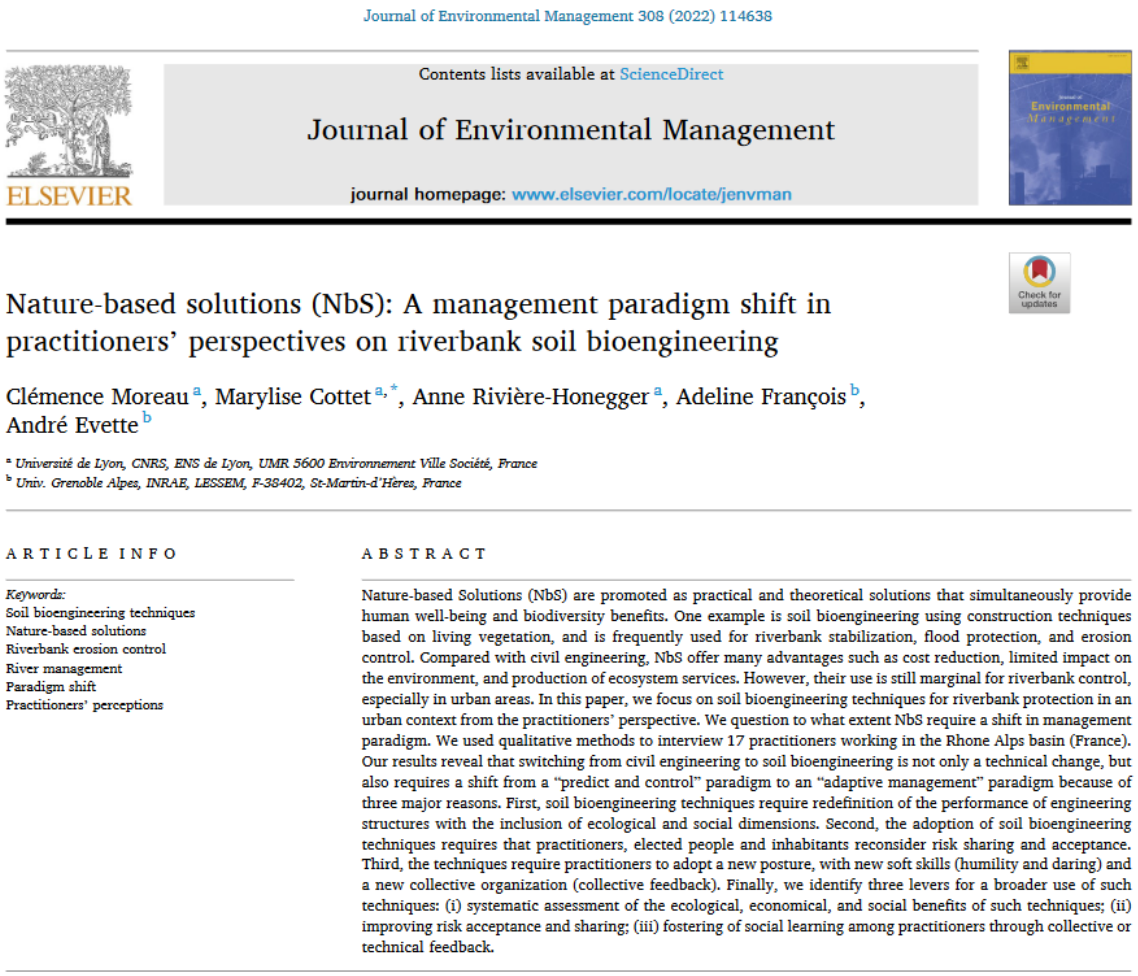
Développer des connaissances permettant d'améliorer l'utilisation des techniques

Identification des causes d'échec principales

Mauvaise reprise de la végétation

Rupture mécanique de l'ouvrage

Développement et obstacles



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Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/jenvman

Nature-based solutions (NbS): A management paradigm shift in practitioners' perspectives on riverbank soil bioengineering

Clémence Moreau [a], Marylise Cottet [a,*], Anne Rivière-Honegger [a], Adeline François [b], André Evette [b]

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[b] Univ. Grenoble Alpes, INRAE, LESSEM, F-38402, St-Martin-d'Hères, France

ARTICLE INFO

Keywords:
Soil bioengineering techniques
Nature-based solutions
Riverbank erosion control
River management
Paradigm shift
Practitioners' perceptions

ABSTRACT

Nature-based Solutions (NbS) are promoted as practical and theoretical solutions that simultaneously provide human well-being and biodiversity benefits. One example is soil bioengineering using construction techniques based on living vegetation, and is frequently used for riverbank stabilization, flood protection, and erosion control. Compared with civil engineering, NbS offer many advantages such as cost reduction, limited impact on the environment, and production of ecosystem services. However, their use is still marginal for riverbank control, especially in urban areas. In this paper, we focus on soil bioengineering techniques for riverbank protection in an urban context from the practitioners' perspective. We question to what extent NbS require a shift in management paradigm. We used qualitative methods to interview 17 practitioners working in the Rhone Alps basin (France). Our results reveal that switching from civil engineering to soil bioengineering is not only a technical change, but also requires a shift from a "predict and control" paradigm to an "adaptive management" paradigm because of three major reasons. First, soil bioengineering techniques require redefinition of the performance of engineering structures with the inclusion of ecological and social dimensions. Second, the adoption of soil bioengineering techniques requires that practitioners, elected people and inhabitants reconsider risk sharing and acceptance. Third, the techniques require practitioners to adopt a new posture, with new soft skills (humility and daring) and a new collective organization (collective feedback). Finally, we identify three levers for a broader use of such techniques: (i) systematic assessment of the ecological, economical, and social benefits of such techniques; (ii) improving risk acceptance and sharing; (iii) fostering of social learning among practitioners through collective or technical feedback.

Changement de paradigme

Dimensionnement & contrôle → Gestion adaptative

Accepter la prise de risque pour s'adapter aux changements globaux

Identification de pistes pour promouvoir le génie végétal

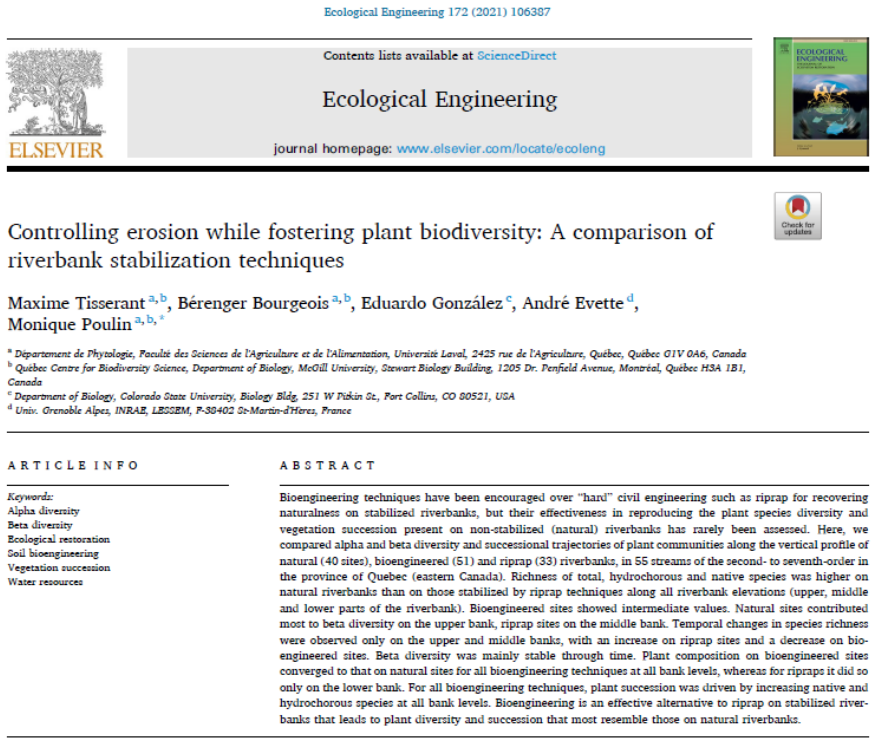
Évaluation des bénéfices écologiques, sociaux et économiques des techniques

Acceptation et partage du risque

Retour d'expérience et transfert des connaissances pour améliorer 'l'apprentissage social'

Conclusion

Québec



Ecological Engineering 172 (2021) 106387

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journal homepage: www.elsevier.com/locate/ecoleng

Controlling erosion while fostering plant biodiversity: A comparison of riverbank stabilization techniques

Maxime Tisserant [a,b], Bérenger Bourgeois [a,b], Eduardo González [c], André Evette [d], Monique Poulin [a,b,*]

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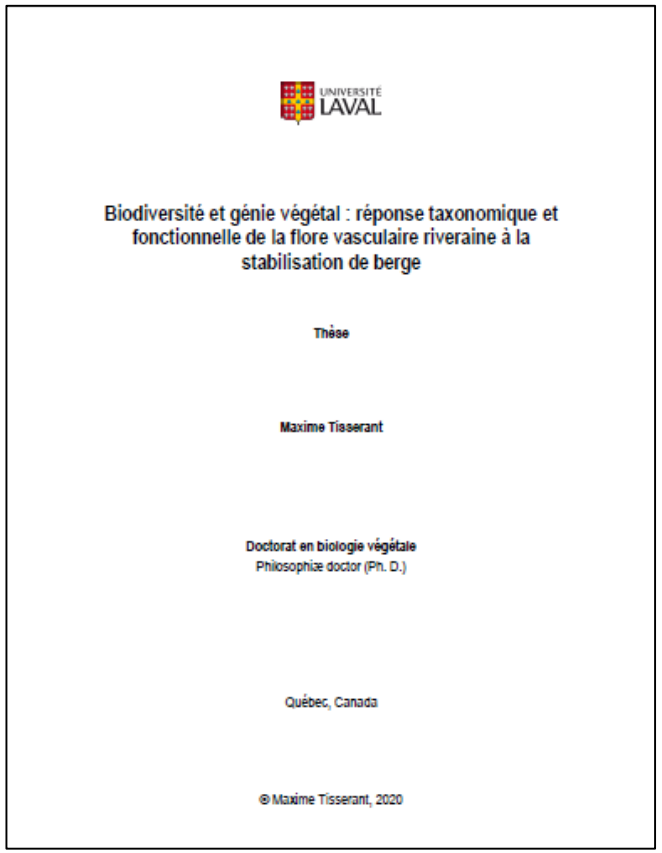
[b] Québec Centre for Biodiversity Science, Department of Biology, McGill University, Stewart Biology Building, 1205 Dr. Penfield Avenue, Montréal, Québec H3A 1B1, Canada
[c] Department of Biology, Colorado State University, Biology Bldg, 251 W Pitkin St., Fort Collins, CO 80521, USA
[d] Univ. Grenoble Alpes, INRAE, LESSEM, F-38402 St-Martin-d'Heres, France

ARTICLE INFO

Keywords:
Alpha diversity
Beta diversity
Ecological restoration
Soil bioengineering
Vegetation succession
Water resources

ABSTRACT

Bioengineering techniques have been encouraged over "hard" civil engineering such as riprap for recovering naturalness on stabilized riverbanks, but their effectiveness in reproducing the plant species diversity and vegetation succession present on non-stabilized (natural) riverbanks has rarely been assessed. Here, we compared alpha and beta diversity and successional trajectories of plant communities along the vertical profile of natural (40 sites), bioengineered (51) and riprap (33) riverbanks, in 55 streams of the second- to seventh-order in the province of Quebec (eastern Canada). Richness of total, hydrochorous and native species was higher on natural riverbanks than on those stabilized by riprap techniques along all riverbank elevations (upper, middle and lower parts of the riverbank). Bioengineered sites showed intermediate values. Natural sites contributed most to beta diversity on the upper bank, riprap sites on the middle bank. Temporal changes in species richness were observed only on the upper and middle banks, with an increase on riprap sites and a decrease on bio-engineered sites. Beta diversity was mainly stable through time. Plant composition on bioengineered sites converged to that on natural sites for all bioengineering techniques at all bank levels, whereas for ripraps it did so only on the lower bank. For all bioengineering techniques, plant succession was driven by increasing native and hydrochorous species at all bank levels. Bioengineering is an effective alternative to riprap on stabilized river-banks that leads to plant diversity and succession that most resemble those on natural riverbanks.



UNIVERSITÉ LAVAL

Biodiversité et génie végétal : réponse taxonomique et fonctionnelle de la flore vasculaire riveraine à la stabilisation de berge

Thèse

Maxime Tisserant

Doctorat en biologie végétale
Philosophiæ doctor (Ph. D.)

Québec, Canada

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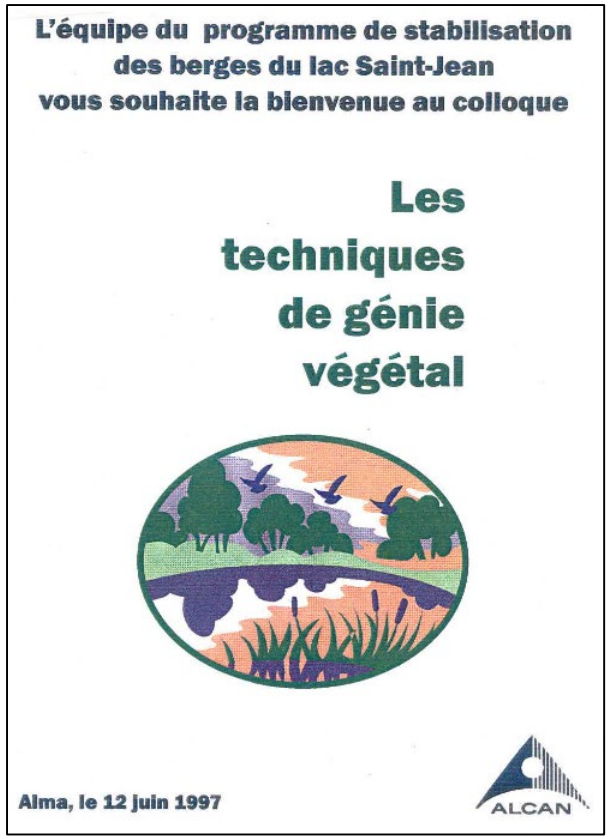
Conclusion

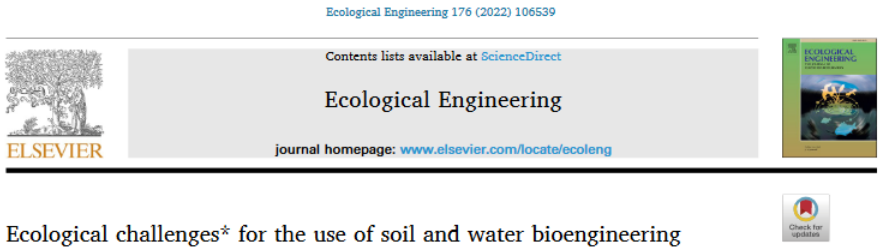
Québec & Canada


L'équipe du programme de stabilisation
des berges du lac Saint-Jean
vous souhaite la bienvenue au colloque

Les
techniques
de génie
végétal

Alma, le 12 juin 1997

ALCAN


Ecological Engineering 176 (2022) 106539

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Ecological challenges* for the use of soil and water bioengineering techniques in river and coastal engineering projects

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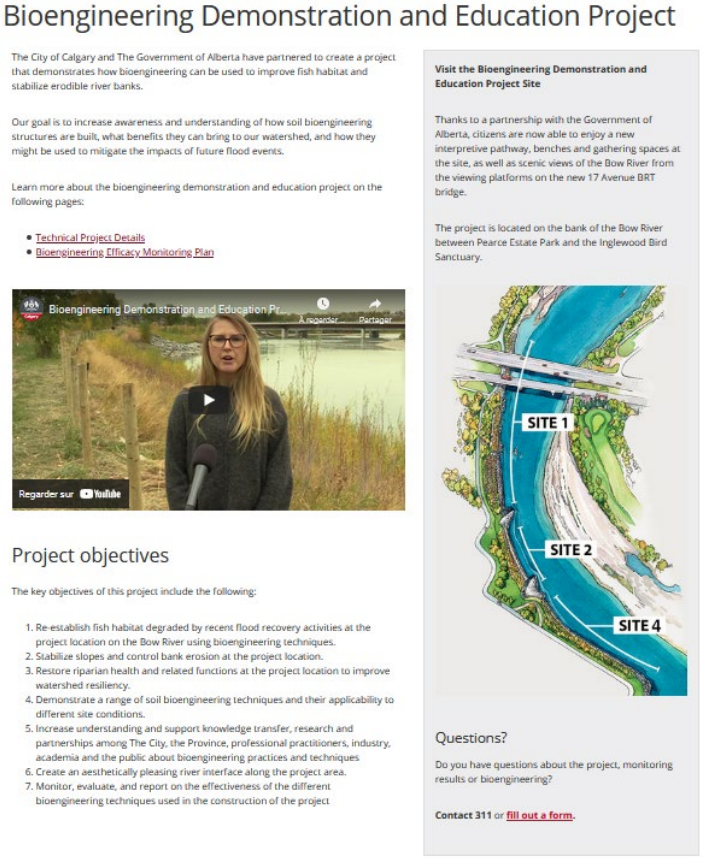
ABSTRACT

A major challenge for the modern river and coastal management is a holistic design approach in order to integrate flood and erosion protection combined with ecological restoration. Nowadays, a lot of EU regulations request nature-based engineering solutions such as soil and water bioengineering techniques (SWBE). In contrast to conventional 'hard' civil engineering structures, the idea of SWBE structures is the use of biological components in the engineering structure to not just consider a technical function, but also ecological and aesthetic values. While SWBE techniques are applied worldwide and well established as an engineering discipline, there is a high demand on the further development specifically in terms of ecology.

The use of plants in river engineering projects requires the right choice of species depending on the techniques used and the environmental conditions. Furthermore, a right harvest, storage and implementation of the plants is significant. Their use also requires the quantification of the hydraulic and sedimentological impact of riparian vegetation on the one hand and on the other hand to know the impact of SWBE structures on the aquatic and terrestrial habitats. Different ecological, vegetational and phytosociological criterias are available and discussed in terms of assessment of SWBE structures. All these criteria can be helpful to develop a framework supporting stakeholders to define objectives, design, implementation work and to assess the post-construction lifetime phase, which is most relevant for SWBE structures. From a wider point of view, when looking at the multitaxonomic diversity in both terrestrial and aquatic habitats, it has been shown that SWBE techniques could enhance global riparian habitat quality by allowing a greater richness and density of pioneer tree species. The use of phytosociology has become more important for the application of SWBE structures as nature-based vegetation composition. Specific challenges arise for river managers and practitioners with invasive alien species and climate change forcing us to redefine what is meant by 'non-native' species. Therefore, using a local and historical phytosociological typology to define the reference to be achieved could become increasingly misleading. By analyzing the ecological value of SWBE structures, another aspect must be considered from an ecological point of view. The possible negative impacts on ecosystems caused by SWBE measures, during the period of construction (e.g., emissions, energy consumption, intervention in nature) should be taken into consideration. A popular methodology to provide the possibility of achieving a better understanding of environmental burdens and to assess the potential environmental impact of products or services is environmental life cycle assessment (LCA). We are faced with the problems of climate change which means that we have to optimize our civil engineering (including SWBE) construction activities in terms of positive effects, for example urban heat islands or carbon storage and also any potential negative effects, for example emission of greenhouse gases or energy demand.

We must critically examine our model of the SWBE approach, the application of SWBE techniques does not automatically mean an ecological improvement. SWBE systems are dynamic and always different, depending on their field of application. A harmonization of strategies and goals needs to be developed in order to support coherent measures aimed at improving the ecological status of river bodies, coastal areas and at the same time, guaranteeing hydraulic safety and adequate protection of human activities from hydromorphological hazards (flooding, floodplain erosion, failure of river and coastal-related infrastructures).


Bioengineering Demonstration and Education Project

The City of Calgary and The Government of Alberta have partnered to create a project that demonstrates how bioengineering can be used to improve fish habitat and stabilize erodible river banks.

Our goal is to increase awareness and understanding of how soil bioengineering structures are built, what benefits they can bring to our watershed, and how they might be used to mitigate the impacts of future flood events.

Learn more about the bioengineering demonstration and education project on the following pages:

- Technical Project Details
- Bioengineering Efficacy Monitoring Plan

Bioengineering Demonstration and Education Pr...

Regarder sur YouTube

Project objectives

The key objectives of this project include the following:

1. Re-establish fish habitat degraded by recent flood recovery activities at the project location on the Bow River using bioengineering techniques.
2. Stabilize slopes and control bank erosion at the project location.
3. Restore riparian health and related functions at the project location to improve watershed resiliency.
4. Demonstrate a range of soil bioengineering techniques and their applicability to different site conditions.
5. Increase understanding and support knowledge transfer, research and partnerships among The City, the Province, professional practitioners, industry, academia and the public about bioengineering practices and techniques
6. Create an aesthetically pleasing river interface along the project area.
7. Monitor, evaluate, and report on the effectiveness of the different bioengineering techniques used in the construction of the project

Visit the Bioengineering Demonstration and Education Project Site

Thanks to a partnership with the Government of Alberta, citizens are now able to enjoy a new interpretive pathway, benches and gathering spaces at the site, as well as scenic views of the Bow River from the viewing platforms on the new 17 Avenue BRT bridge.

The project is located on the bank of the Bow River between Pearce Estate Park and the Inglewood Bird Sanctuary.

SITE 1
SITE 2
SITE 4

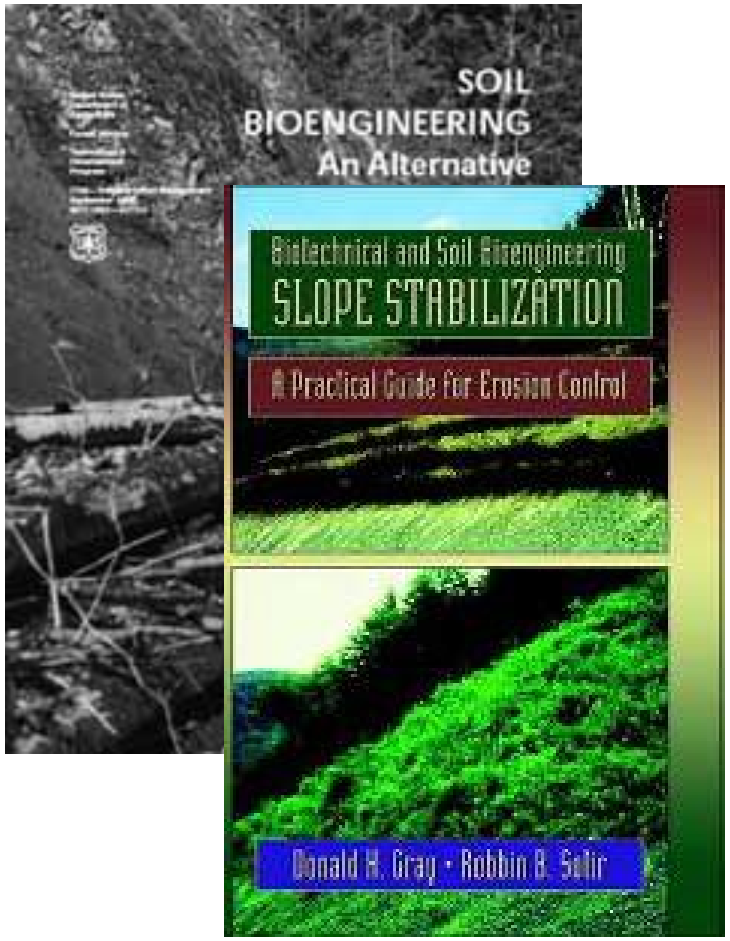
Questions?

Do you have questions about the project, monitoring results or bioengineering?

Contact 311 or **fill out a form**.

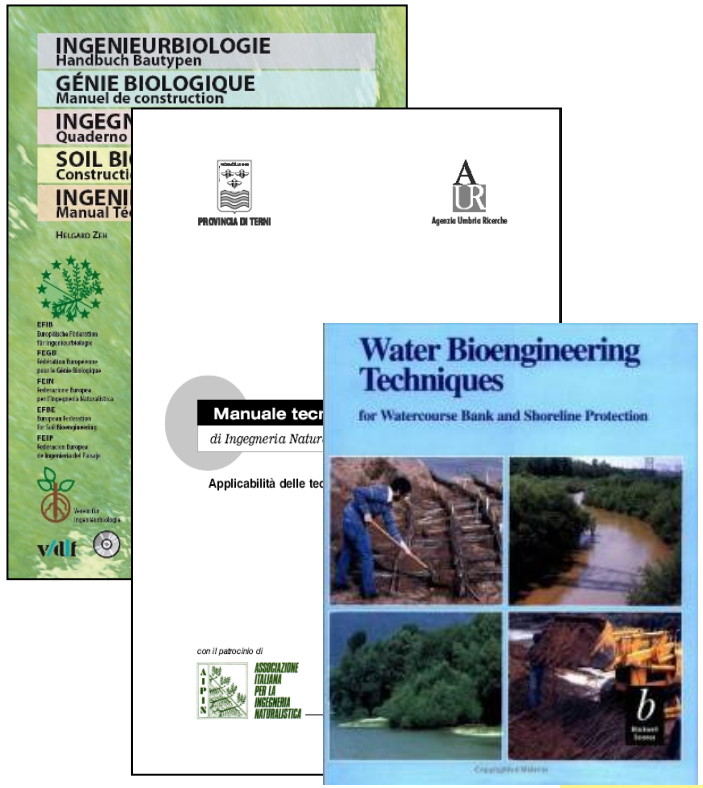
Conclusion

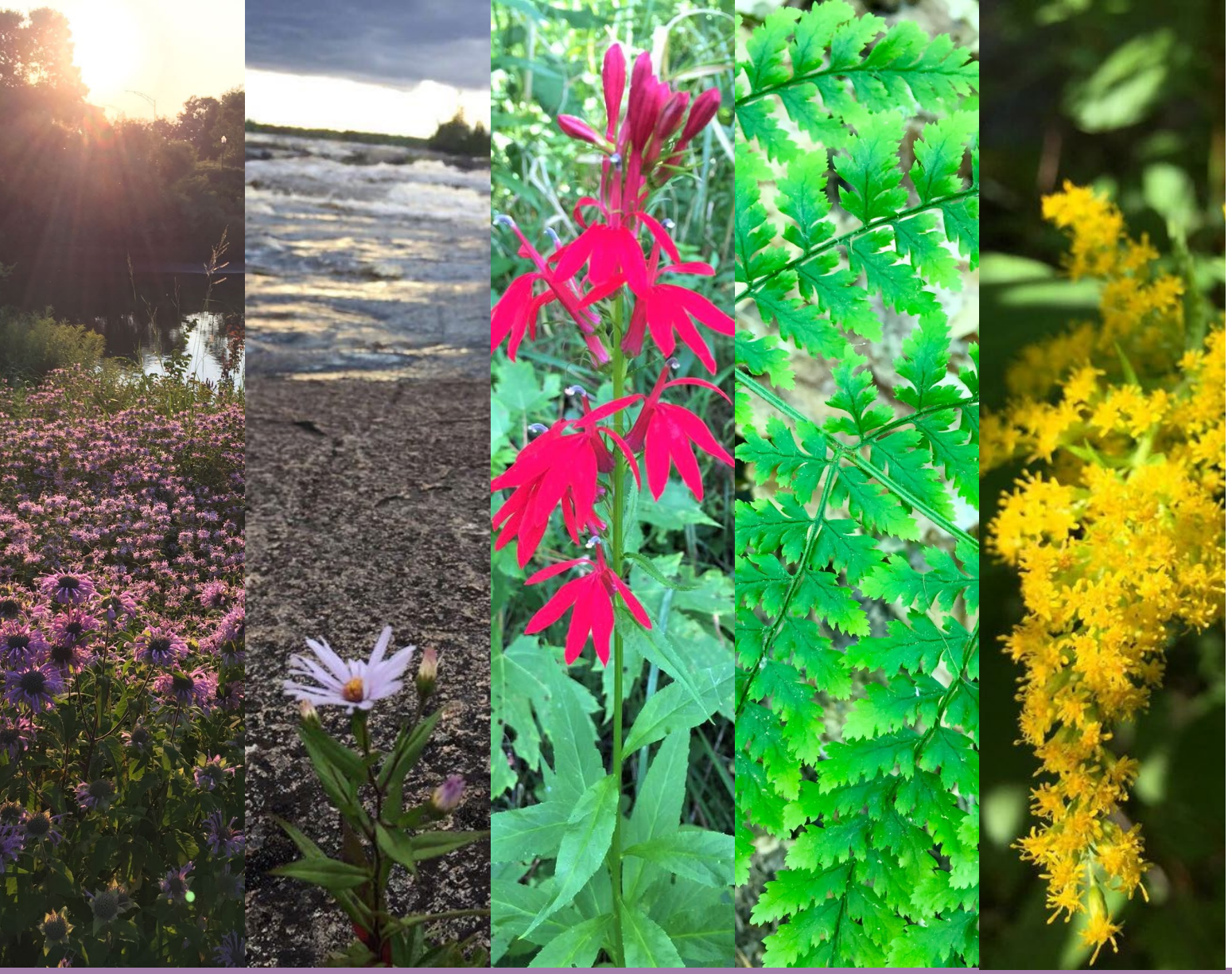
États-Unis



France

Europe





Merci !

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Annexes

Techniques de génie végétal et techniques mixtes	Unité	Prix observés (fournitures + mise en œuvre)	
		En France (en € HT)	En Suisse (en CHF HT)
ENHERBEMENT / ENSEMENCEMENT (géotextile compris)	m^2	4 à 10	8 à 9
BOUTURES	Unité	1 à 5	2,5 à 5
PLANTATIONS	Unité	2 à 10	3 à 20
FASCINES DE SAULES	ml	50 à 100	60 à 150
LITS DE PLANTS ET PLANÇONS	ml de lit	20 à 40	60 à 100
COUCHES DE BRANCHES À REJETS	m^2	30 à 80	80 à 100
CAISSONS VÉGÉTALISÉS	m^3 de bois posé	100 à 400	300 à 700
ENROCHEMENT	m^3	70 à 150	170 à 500

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