Phenotypic plasticity of Populus nigra to hydrogeomorphological constraints: A trait-based approach

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Background

- Black poplar (*Populus nigra* L.) pioneer trees are **riparian ecosystem engineers** which modify their fluvial habitat, e.g. by enhancing sediment accumulation.
- **Plant functional traits** related to morphology, wood anatomy and biomechanics are fundamental in controlling plant resistance to **hydrogeomorphological constraints**, such as drag force and sediment burial.
- Response traits to these constraints possibly express a **trade-off** between the functions of resisting uprooting and acquiring resources in the sediments that are trapped.
- The engineer effect implies that young individuals are successful in establishment. However, the **specific above and below-ground responses** of young poplars to hydrogeomorphological constraints that lead to establishment remain poorly understood.

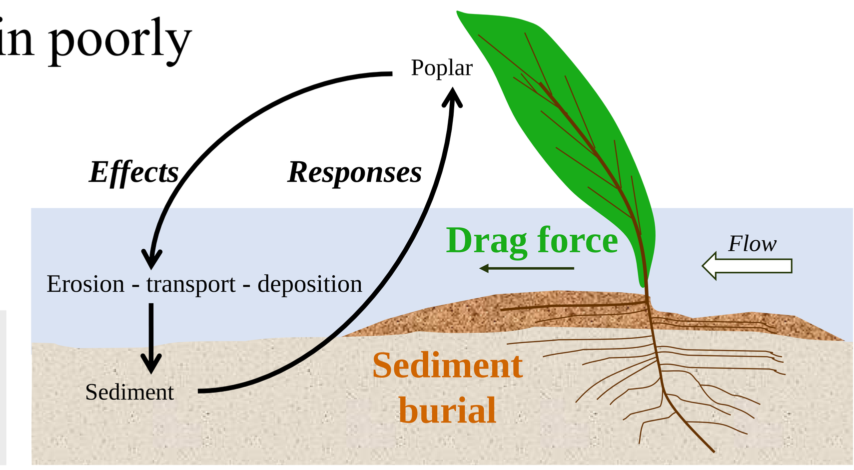

Figure 1. Reciprocal interaction between vegetation and water and sediment dynamics.

Goal

Based on the hypothesis of an **eco-evolutionary feedback** between woody riparian species and fluvial geomorphology, we performed a **semi-controlled *ex situ* experiment** to exhaustively quantify **response traits** of poplar cuttings to simulated **hydrogeomorphological constraints** (i.e. drag force and sediment burial) during their early development and to discriminate specific responses to each type of constraint.

Experimental treatments

- A **completely randomized experimental design** was employed with cuttings (n=128) and treatments, i.e. sediment burial (SB), drag force exerted by floods (DF), their combination (DFSB), and control (C).
- The treatments were applied according to the seasonal occurrence and average duration of floods in the region where the genotype came from (*P. nigra* var. *J. Pourtet*).

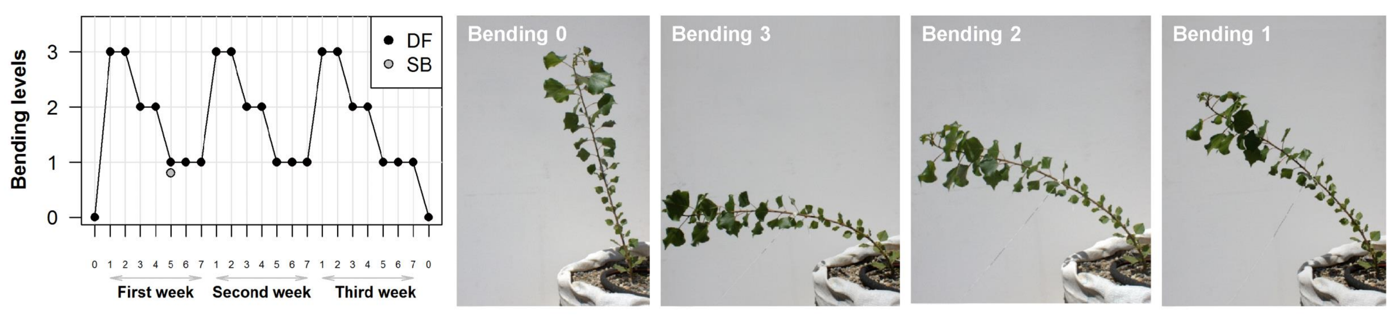

Figure 2. Modulation of the **drag force treatment (DF)** to reproduce the hydrograph of a typical spring flood. The modulation starts from relax position (bending level 0 = no bending), passing then to the maximum level of bending (level 3), followed by intermediate (level 2) and finally low bending (level 1). The entire pulse is modulated for one week. Three consecutive events of one week each were simulated.

- The **sediment burial treatment (SB)** consisted in the application of a 15 cm-layer of sandy sediment around the main stem during the recession limb of the first bending curve to simulate the deposited sediment after a flood event.

Figure 3. Example of the four treatments within a pallet.

Response trait measurements

- Growth and plant status were monitored during all the experiment (May-Sep.). Two **partial harvests** were performed to assess plant development (especially, belowground) and to test the methodology of extraction and sub-sampling.

Figure 4. From left to right, examples of plants harvested in the 1st (6A, 14C) and 2nd harvest (31C-DFSB, 1B-SB).

- At the end of the first growing season, a **final harvest** was performed in which plants were divided into two groups of equal number (n=48 each): "**whole-plant extraction**" and "**uprooting test**". Above- and below-ground **morphological traits** were measured manually and from image analysis for both groups.

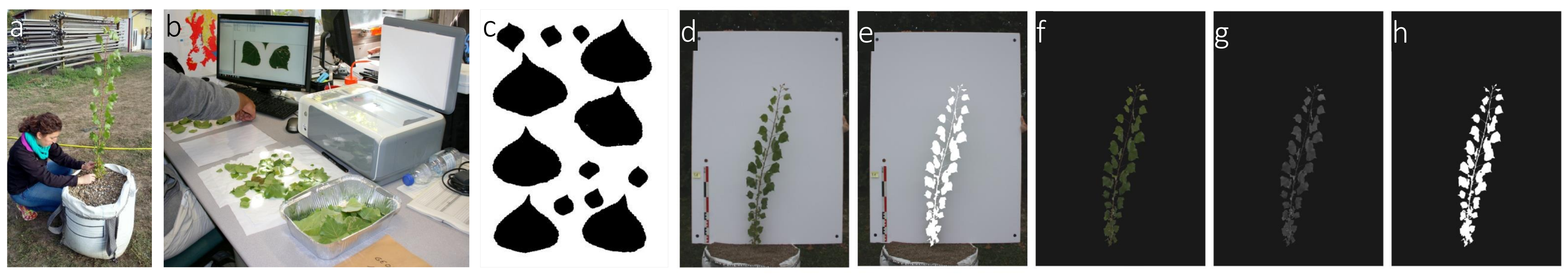

Figure 5. Above-ground trait measurements by hand (a) and from image analysis of leaves (b, c) and the plant (d-h).

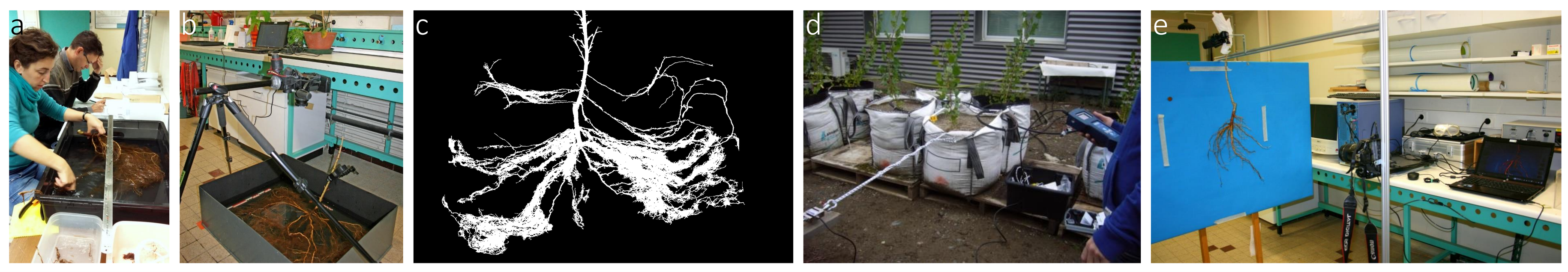

Figure 6. Below-ground trait measurements by hand (a) and from image analysis after the whole-plant extraction (b, c) and after the plant uprooting with a winching device (d, e).

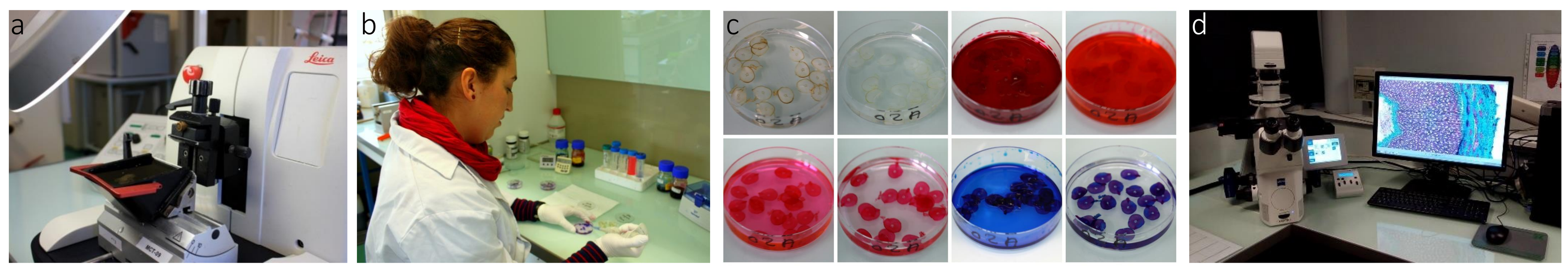

Figure 7. Preparation of anatomy sections (a-c) and image processing (d) for anatomical trait measurements.

Perspectives

- More than **one-hundred traits** were recorded. Approximately, half of those initially quantified showed **significant differences** between treatments.
- Preliminary results suggest that **sediment burial** may have a larger impact than drag force on the total phenotypic variation among individuals in the early stages of poplar growth. Therefore, improving acquisition of resources may be a priority for the plant, rather than reinforcing anchoring when exposed to those constraints.
- Further multicollinearity analyses will be performed in order to define the main **trait response syndromes**.
- This multi-trait approach is likely to improve our understanding of how **intraspecific phenotypic plasticity** of this foundation woody pioneer species, when exposed to hydrogeomorphological constraints, has important ecological effects on riparian ecosystem structure and functioning.

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