

## Sunlight-driven transformation of contaminants of emerging concern in stormwater

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### Why are we studying this?

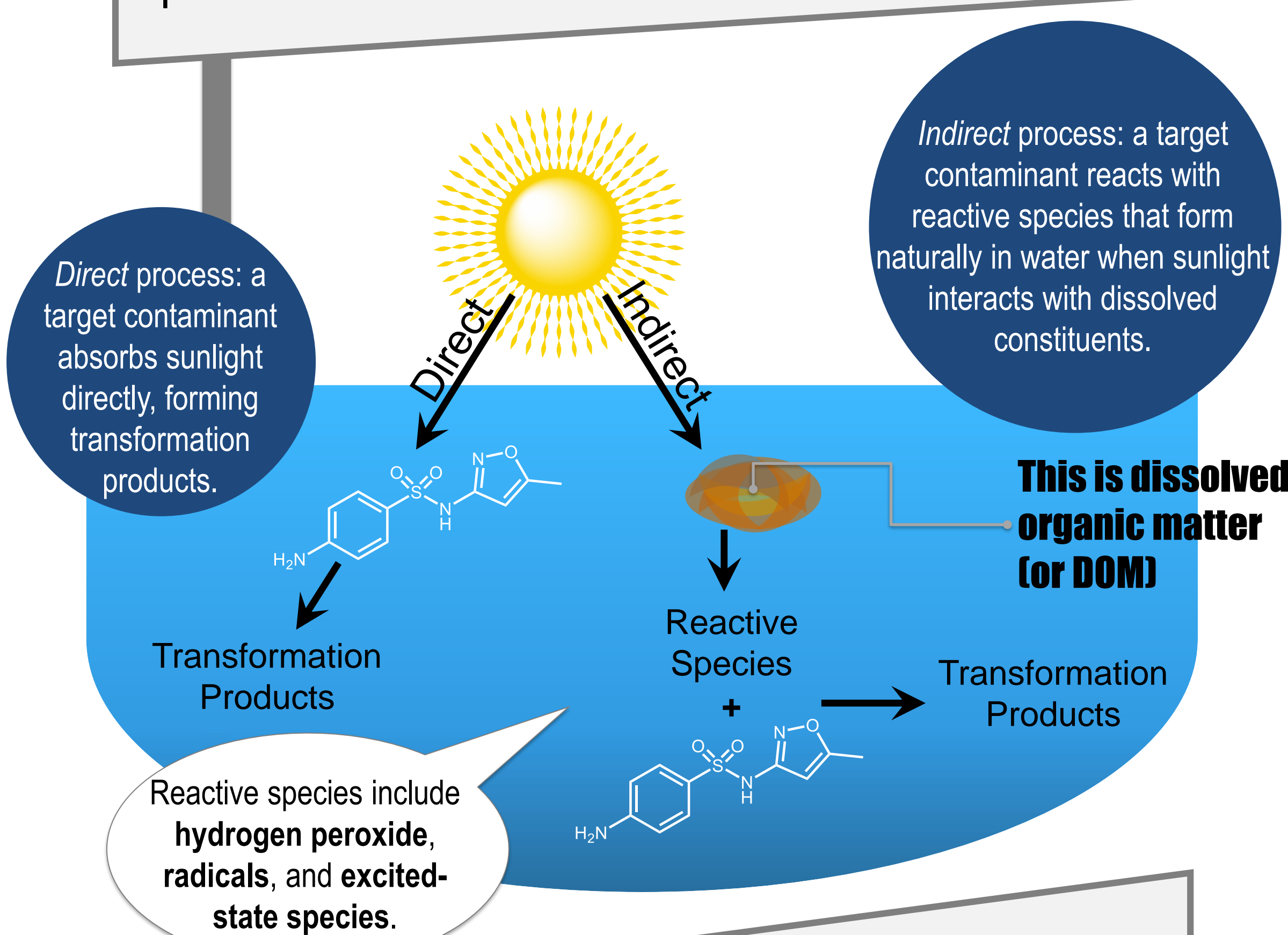
- (1) Stormwater **transports** contaminants of emerging concern (CECs) to surface water bodies.
- (2) Many contaminants that do not sorb to particles can be transported **long distances**.
- (3) Sunlight-driven transformation processes are important in **controlling CEC fate**.

CECs are defined here as trace organic contaminants, such as pesticides, pharmaceuticals, and endocrine disruptors.

Can we design a treatment pond that takes advantage of sunlight-driven transformation processes to lower downstream loads of CECs?

### What are *sunlight-driven transformation processes*?

Physical and chemical processes that occur when sunlight interacts with dissolved constituents in natural and engineered water bodies. They are broadly classified as *direct* and *indirect* processes.



Dissolved organic matter (or DOM) is a major water constituent that controls the rate and efficiencies of *direct* and *indirect* processes:

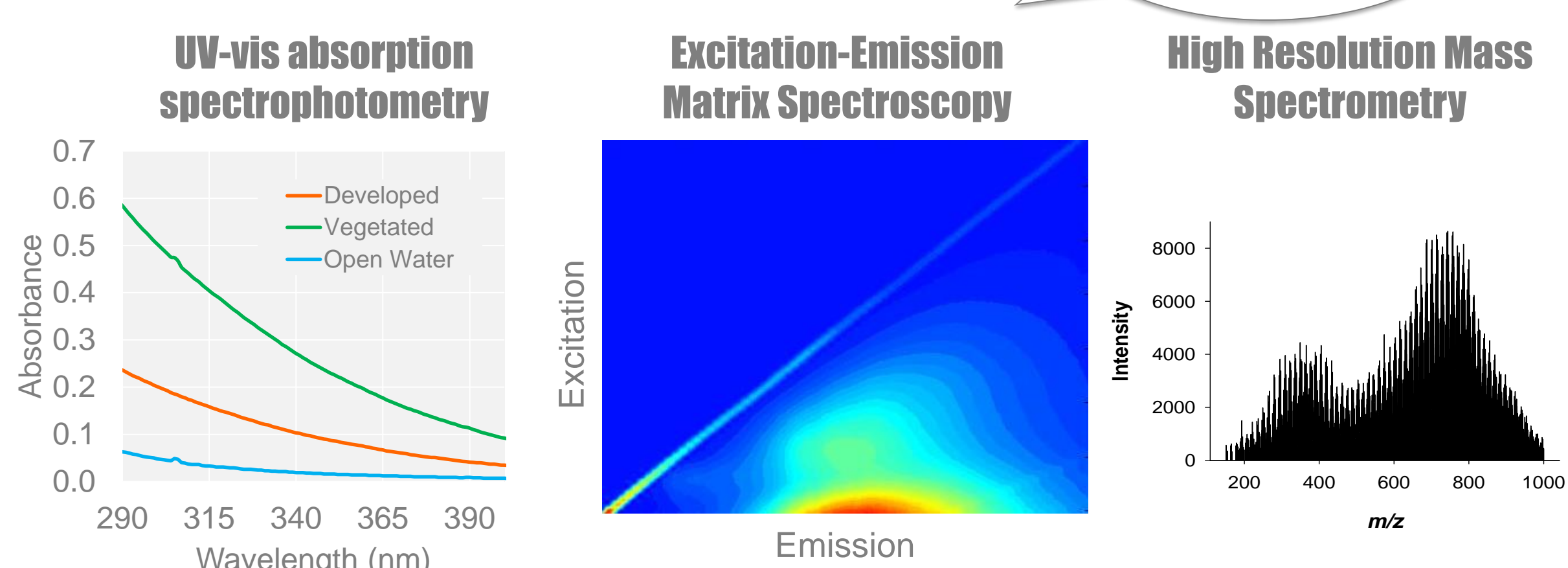
- (1) In direct processes, DOM acts as a screen, blocking light from reaching CECs;
- (2) In indirect processes, DOM acts as a sensitizer, forming reactive species that can transform CECs.

The **excited state of DOM (T\*)** is an especially important reactive species because it reacts with CECs and forms other reactive species.

### What is Dissolved Organic Matter?

It is a heterogeneous mixture of organic material that originates from living cells (e.g., exudates) or the degradation of plant and microbial cells. Its composition can change depending on *land cover* and other environmental parameters.

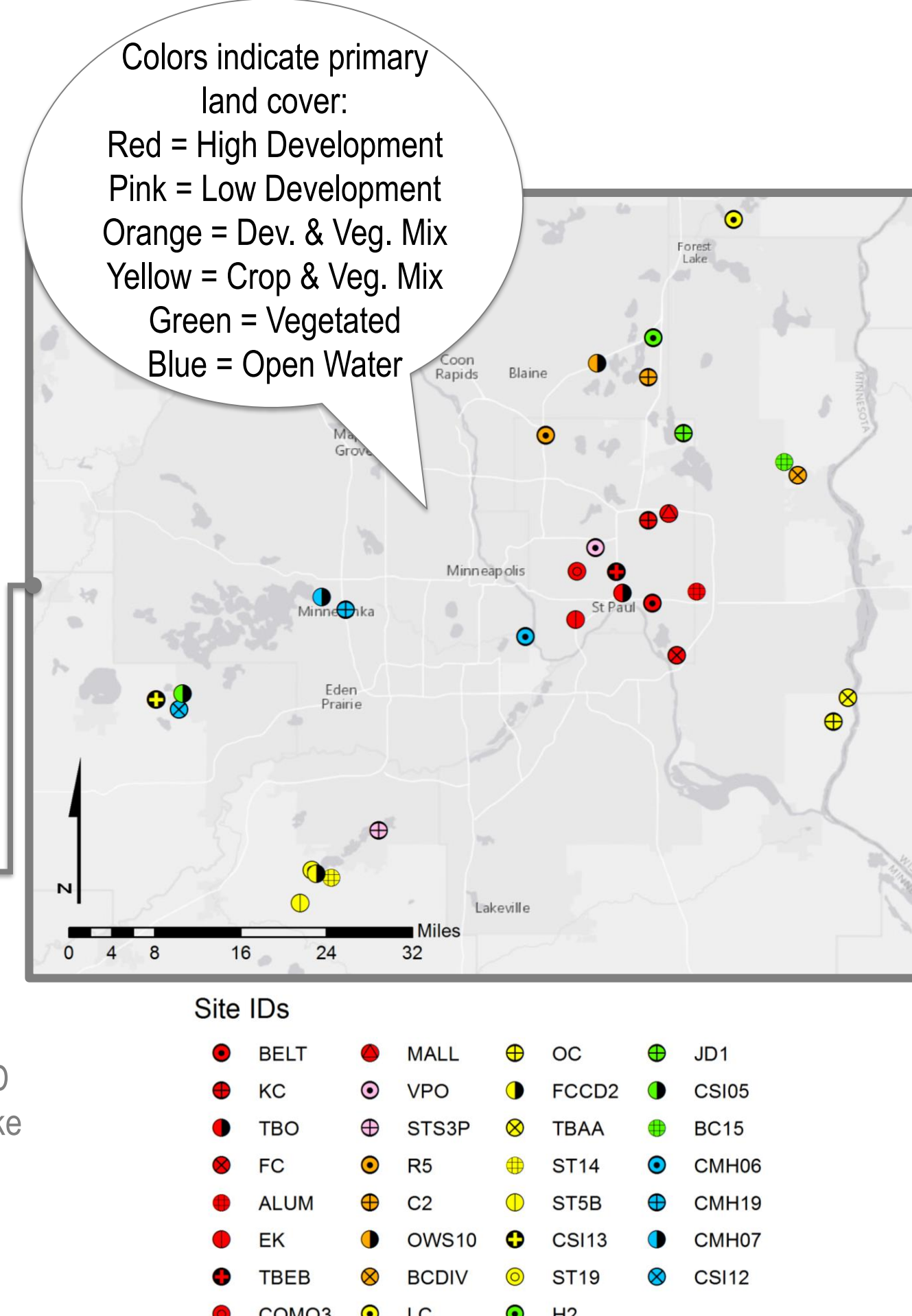
There are several ways to characterize DOM. Each method gives different information.



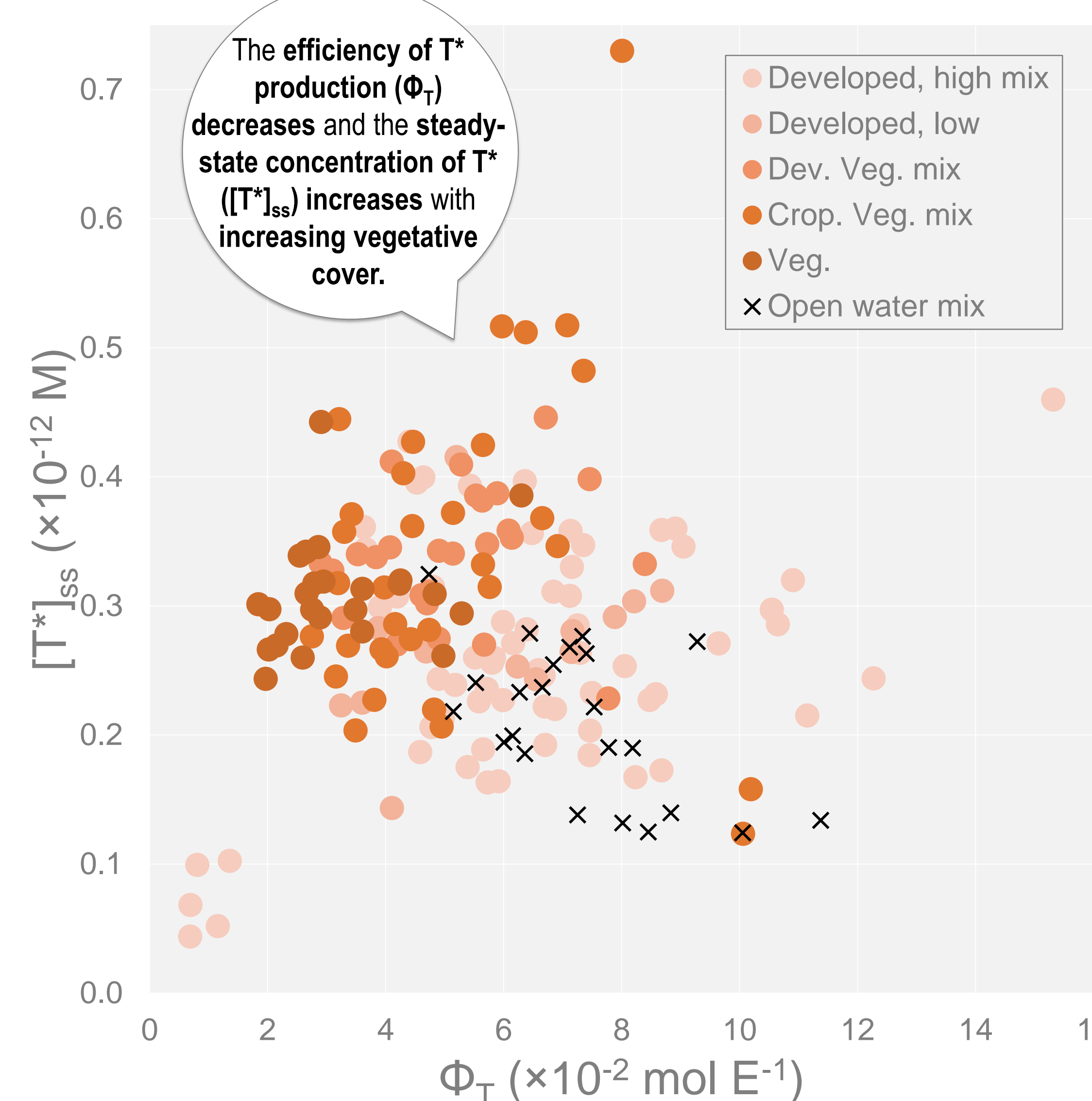
### Study design:

We **partnered** with CRWD, MCWD, RWMWD, RCWD, PLSLWD, and WCD to collect **185 stormwater samples**.

Abbreviations:  
CRWD = Capital Region Watershed District; MCWD = Minnehaha Creek Watershed District; RWMWD = Ramsey Washington Metro Watershed District; RCWD = Rice Creek Watershed District; PLSLWD = Prior Lake Spring Lake Watershed District; WCD = Washington Conservation District



### What we have found:

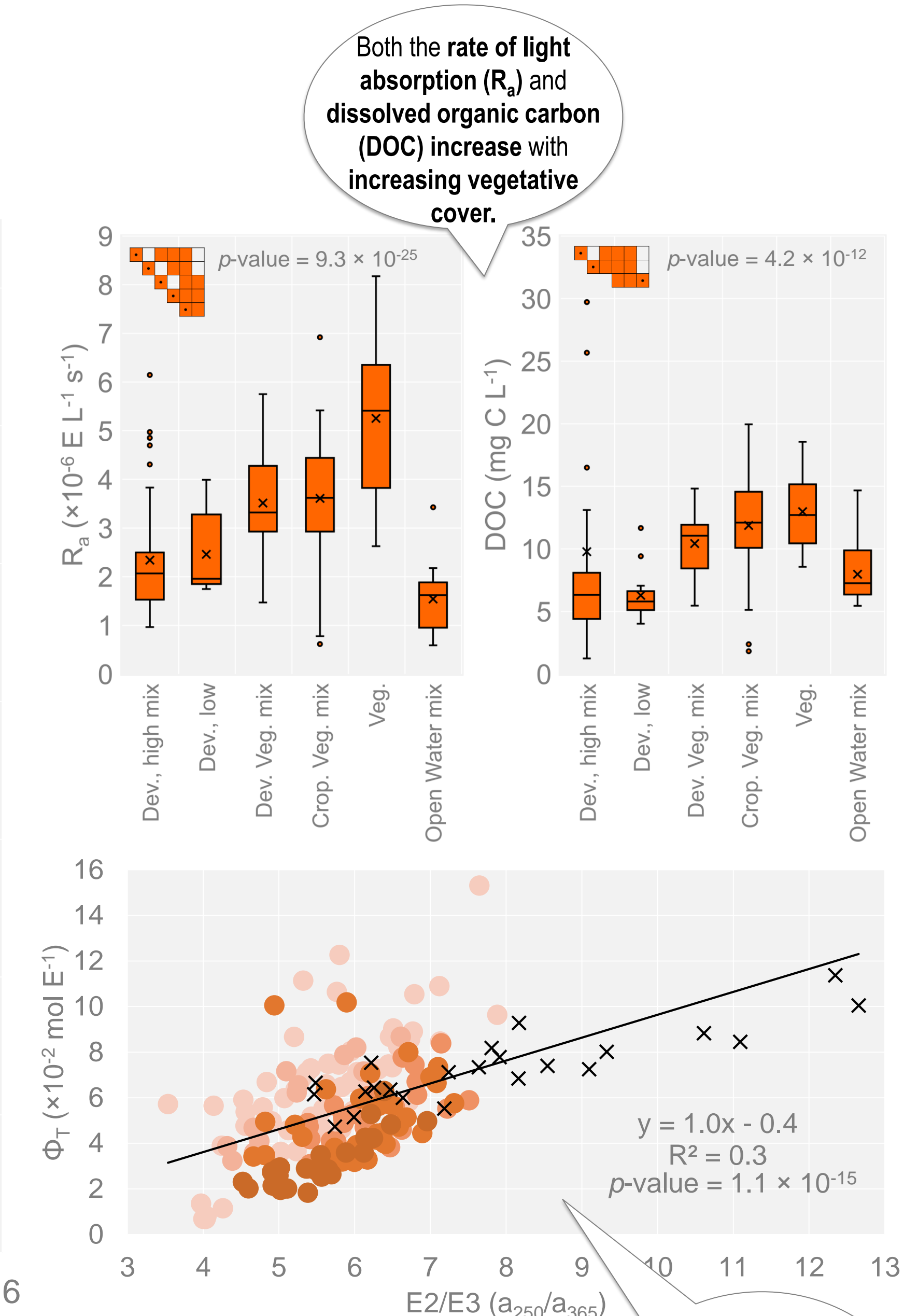


### What we measured:

- (1)  $R_a$  = the rate at which DOM absorbs sunlight.
- (2)  $[T^*]_{ss}$  = the steady-state concentration of the reactive species, T\* (just like water flowing into and out of a tank).
- (3)  $\Phi_T$  = the efficiency with which the reactive species, T\*, is formed.

$$r_{CEC} \sim \frac{\alpha}{R_a} \times k_{dir} + k_{T^*} \times [T^*]_{ss}$$

Because DOM controls sunlight-driven transformation processes of CECs, we characterized 3 important variables of the stormwater DOM.



The efficiency of T\* production ( $\Phi_T$ ) increases with E2/E3, a proxy for the degree of DOM photobleaching.

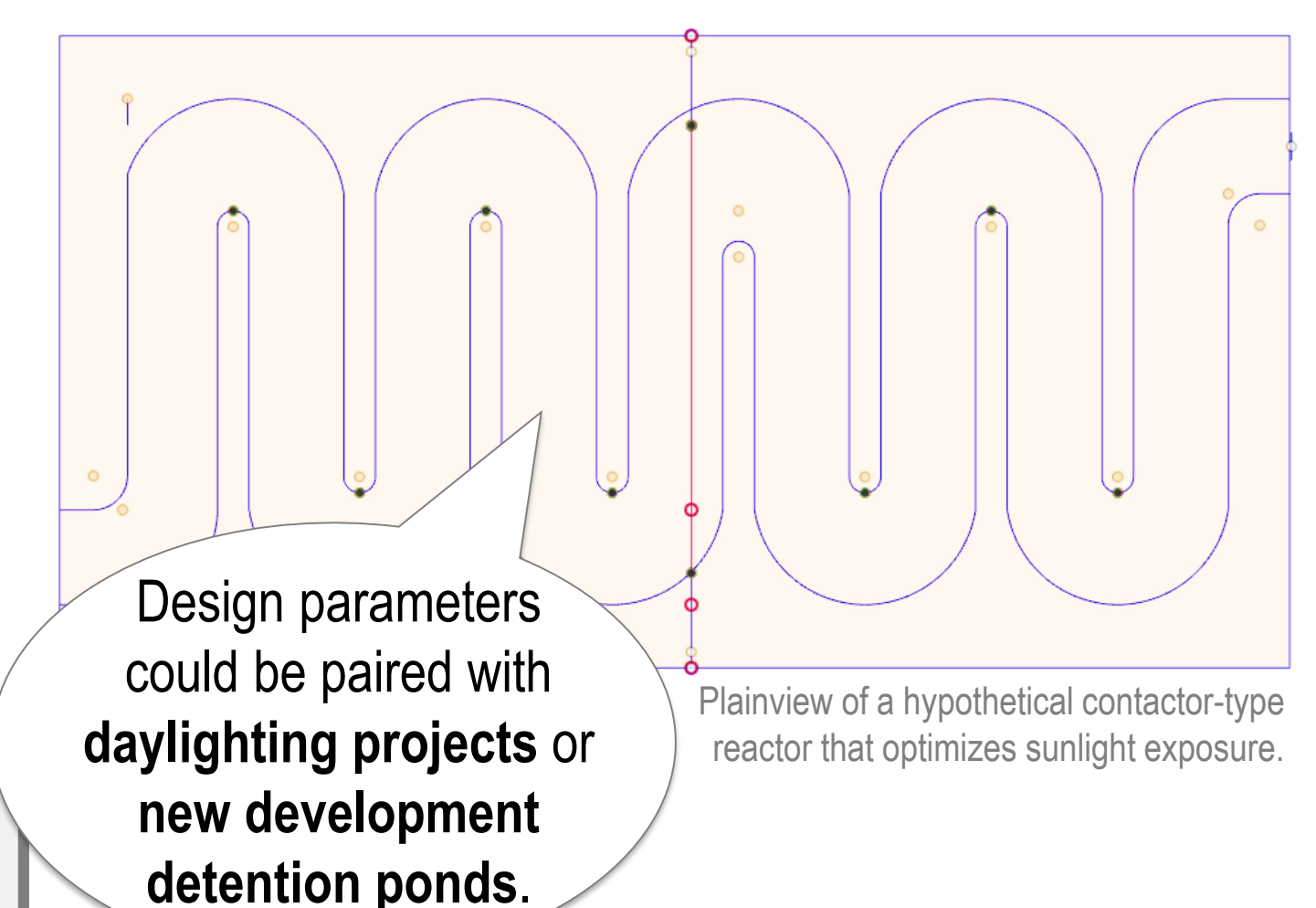
### Key findings:

- (1) Watersheds with highly vegetated land cover have high concentrations of DOC, resulting in high  $[T^*]_{ss}$ . This will increase rates of *indirect* transformation processes.
- (2) Watersheds with highly vegetated land cover will also have relatively high  $R_a$ . This will slow down rates of *direct* transformation processes.

### How this information can be used:

Given site-specific characteristics and CEC-specific transformation rates, a treatment pond that optimizes sunlight exposure can be designed.

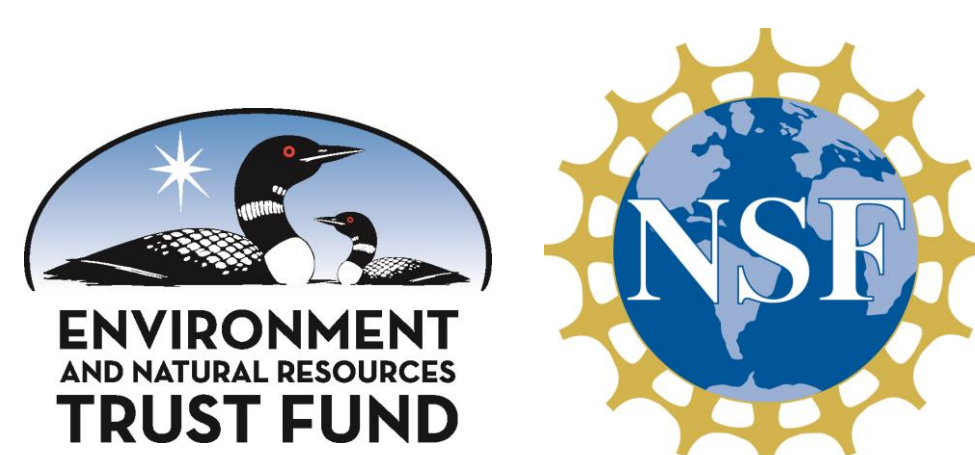
$$\tau = V/Q \quad C = C_0 e^{-k(V/Q)}$$



### Further Reading

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