Appendix F: Conceptual Models Developed by the WEP

A series of conceptual models were developed by the Panel throughout the Panel process, to explore, communicate and develop hypotheses that might explain the wide range of water quality benefits reported in the wetlands' literature. This approach was intended to capture expert insights as to the controlling factors that primarily influence wetland function, to provide a relative understanding of the different wetland BMP water quality performance, and to provide guidance on how best to expand and interpret the literature database.

The first set of conceptual models, Figures F-1 to F-4, are based on work by Lake et al (2007) and presented in Kreiling et al (2018). Kreling et al (2018) presented a conceptual model illustrating the potential condition of a stream and associated wetlands in a natural and restored stated based on the amount of disturbance in the watershed. The conceptual model suggests that a restored stream does not regain functions of an undisturbed natural system.

Figure F-1: This model was expanded to highlight loss of nutrient and sediment retention capacity in degraded wetlands, and expected recovery of water quality benefits associated with re-established, rehabilitated, created, or enhanced wetlands (depending on how well natural conditions have been restored or disturbance has been counteracted). The different colors and sizes of the circles highlight variable response based on BMP type (and/or time since installation). It is expected that a wetland BMP moves along a trajectory of improved or increasing function, but does not fully attain the capacity of natural wetlands. "Sub" hypotheses to describe the relative success of different wetland BMP types are also inferred.

Figure F-2: Similar to Figure F-1 but expanded to highlight the expectation that restored and rehabilitated wetland water quality benefits are similar to natural wetlands. The bullseye symbols used to plot natural wetland function highlight the panel's intent to describe observed variation in wetland retention capacity.

Figure F-3: This conceptual model continues to illustrate the relative water quality benefits of wetland BMPs but differentiated by the potential effects of physiographic setting and/or watershed position (consistent with WEP2016 panel recommendations). The condition of the wetland, while a function of watershed disturbance, is also influenced by the physical location of the wetland. The WEP2016 evaluated the effect of landscape position using physiographic province as a proxy to differentiate the potential for contaminated source waters (surface and, or groundwater) to intersect organic-rich, anoxic wetland soils.

Figure F-4: The two-dimensional model was expanded to illustrate how water quality benefits of natural and wetland BMPs depend upon existing site conditions *and* watershed conditions. That is, the potential improvement or 'lift' expected from a management action would depend in part on the conditions prior to treatment. The expected decrease in nutrient and sediment loadings would be greater the more degraded a site relative to a site that is slightly degraded, yet functioning.

Figure F-5: An alternative to the Kreiling-based model was provided to capture more detailed characterization of the watershed/landscape setting and wetland conditions. This is referenced as the "Capacity-Opportunity" conceptual model. A common thread throughout these discussions focused on the combined effects of a wetland's *capacity* and *opportunity* that drive the functional potential of a wetlands' water quality benefit. *Capacity* refers to the condition of the wetland (characteristics and size), whereas *opportunity* acknowledges the importance of location including existing/surrounding site conditions (e.g. presence/absence of a wetland, existing land use/loadings). Both of these overarching components influence a wetland's hydrology, soil, and vegetation characteristics indicative of biogeochemical functioning.

The conceptual models presented in Figures F-6 and F-7 focus on the effect of wetland specific factors and processes on nutrient and sediment retention capacity. These two models acknowledge the influence and interaction of wetland hydrology, vegetation and soils and their influence on water quality benefits provided by wetlands.

Figure F-6: The purpose of this conceptual model focused on the wetland itself and the identification of the key physical attributes, conditions and processes that influence the nutrient and sediment retention functions of a wetland. These components were identified based on available research and the ability to measure or observe them in the field.

Figure F-7: A similar approach was taken in this conceptual model that recognized the importance of wetland hydrology, vegetation and soils and their effect on wetland nutrient and sediment retention. The model illustrates how the linkages or interactions between the key drivers (factors and processes) may affect loadings to and within a wetland. The model attempts to illustrate how much load is getting to the wetland and what happens once the load gets into the wetland.

The final set of conceptual models are presented in Figures F-8 to F-11. These series of models combine the importance of landscape position and condition of the wetland, while reinforcing the integrated effects of wetland hydrology, vegetation and soil.

Figure F-8: Illustrates a conceptual diagram of regional watershed characteristics that effect wetland hydrology, water chemistry and vegetation. Combined, these influence nutrient availability and subsequently vegetation.

Figure F-9: Graphical representation of the conceptual diagram in Figure F-7 is used to illustrate the complexity of how landscape setting and local conditions affect the nutrient and sediment retention benefits of a wetland. The top left figure is from the Canadian Wetland Classification System as described by Zoltai and Vitt (1995). The classification of wetland is based on hydrology, surface morphology, and vegetation. This is presented as an over-arching model to illustrate that the condition/state of a wetland is the result of multiple components and their interactions. Secondarily, the figure in the upper right and blue arrows illustrate the influence of hydrological connectivity and wetland water chemistry. The water chemistry will affect the release and production of various anions and cations.

Figures F-10 and F-11: A set of key factors/process emerging from this conceptual model are presented.

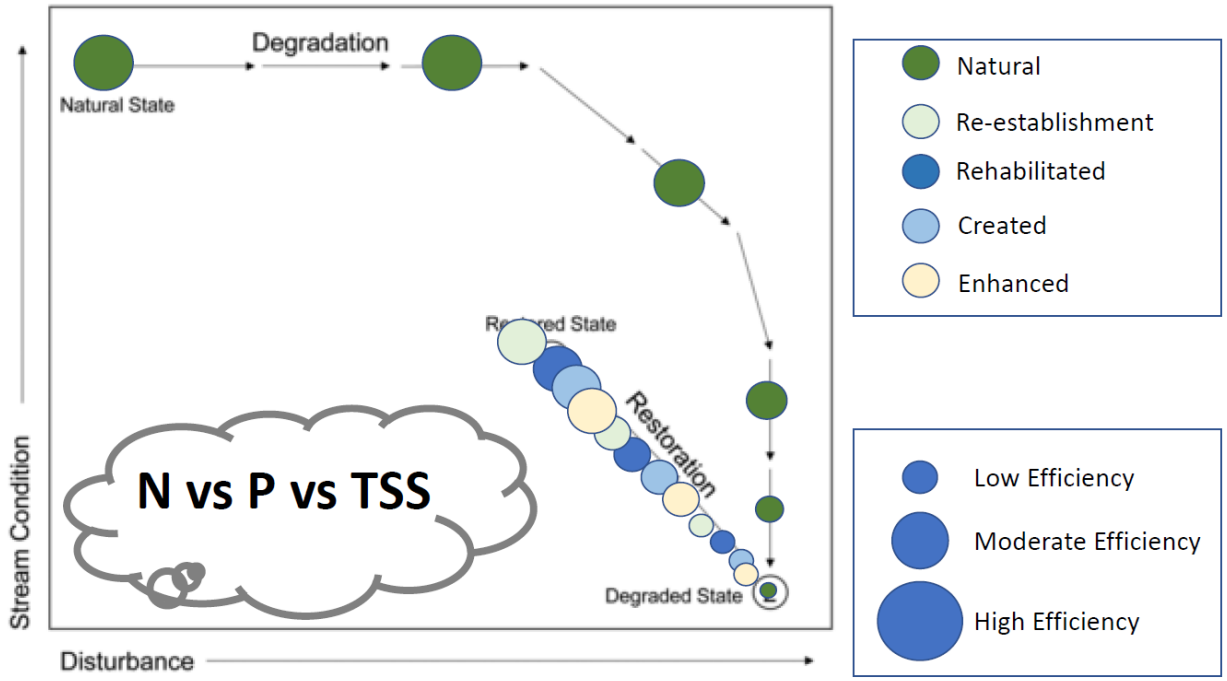


Figure F-1.

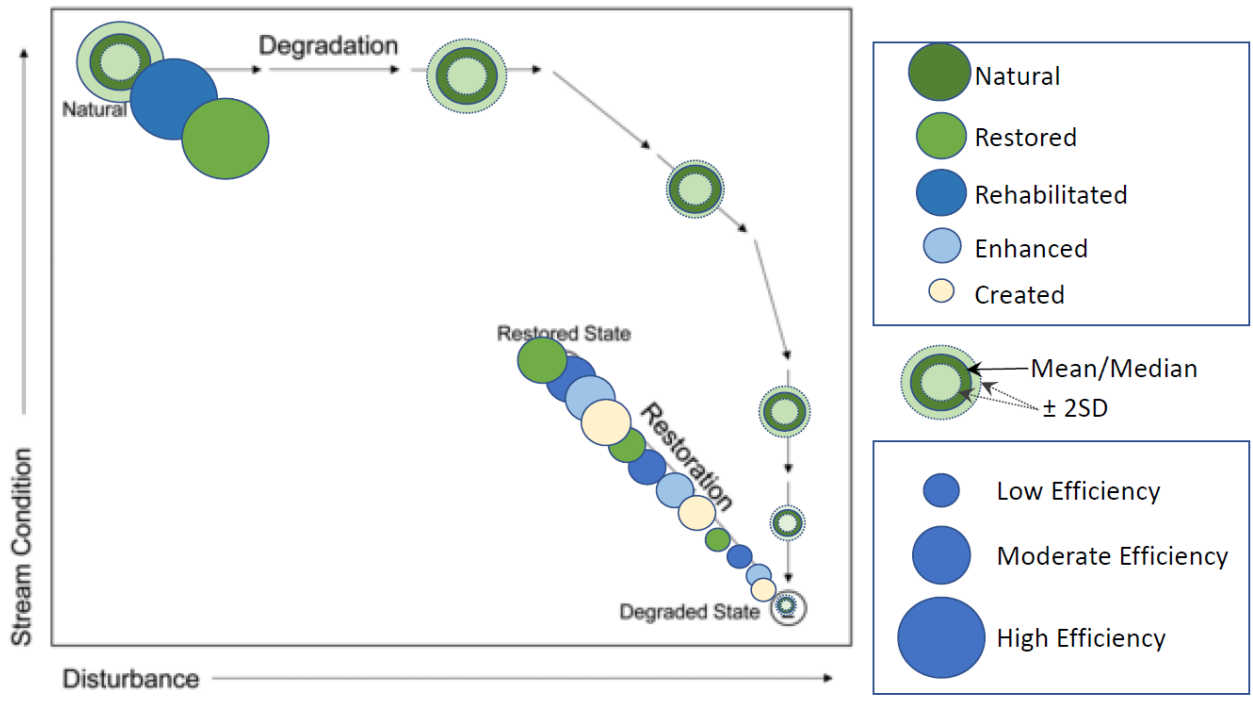
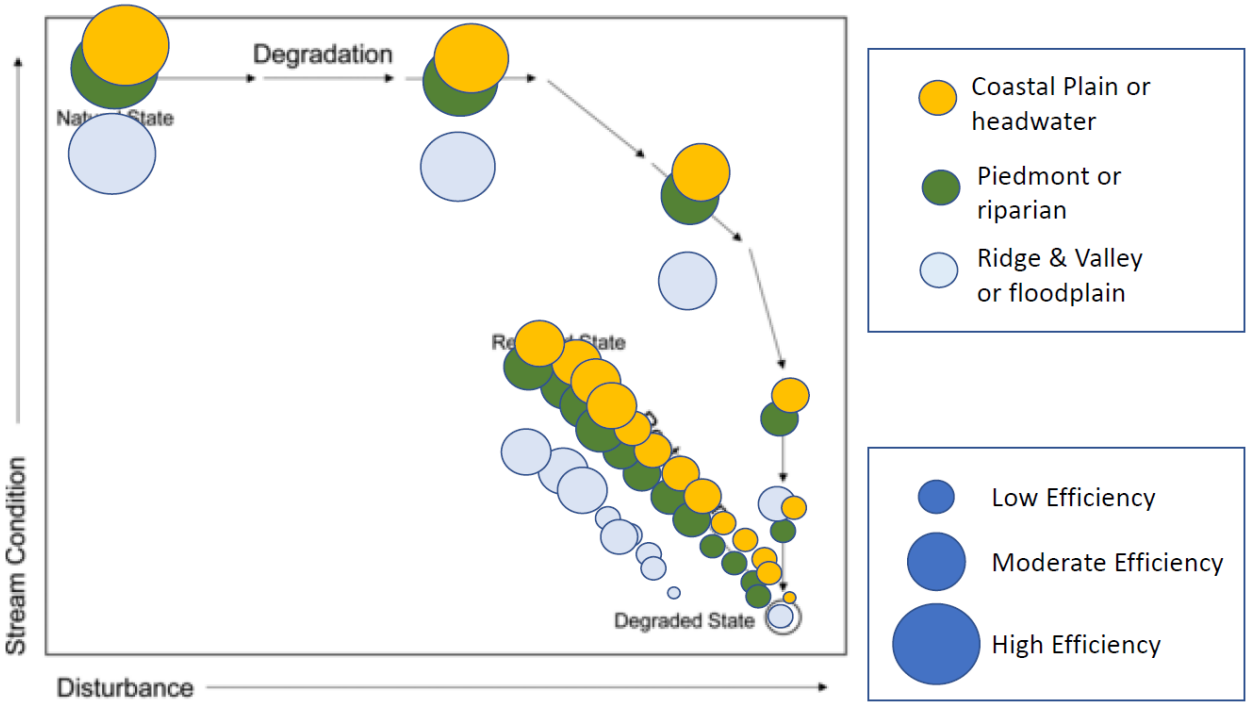


Figure F-2



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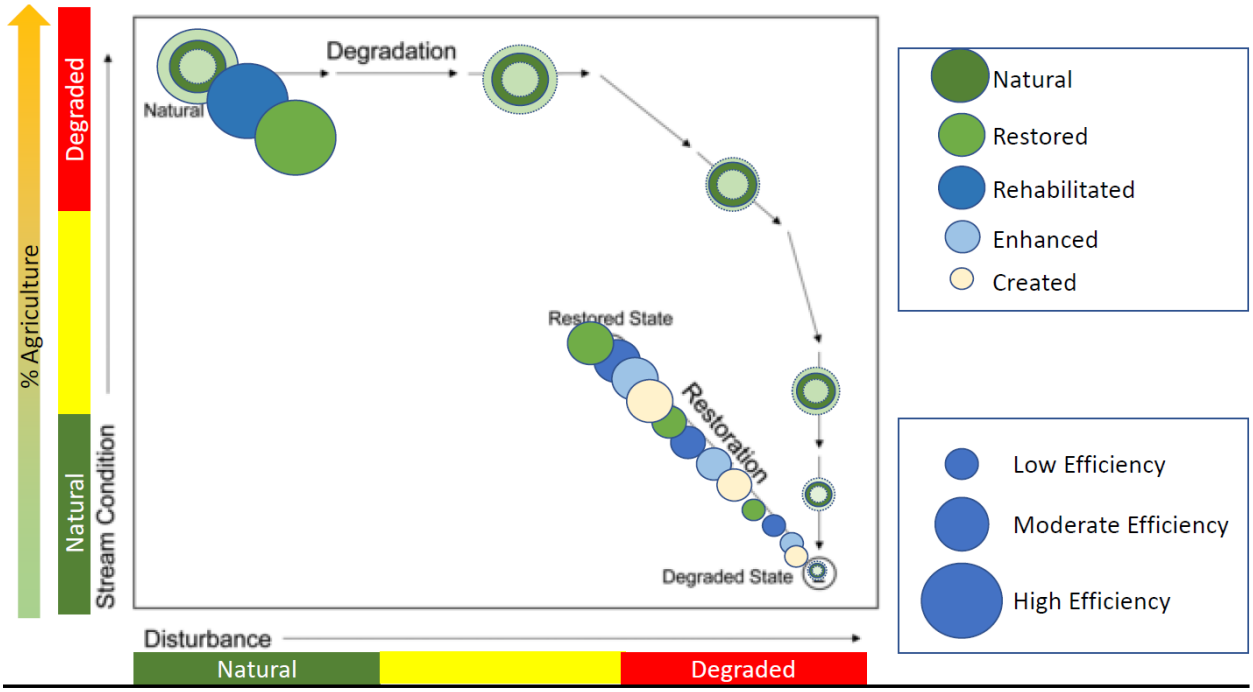

Figure F-4.

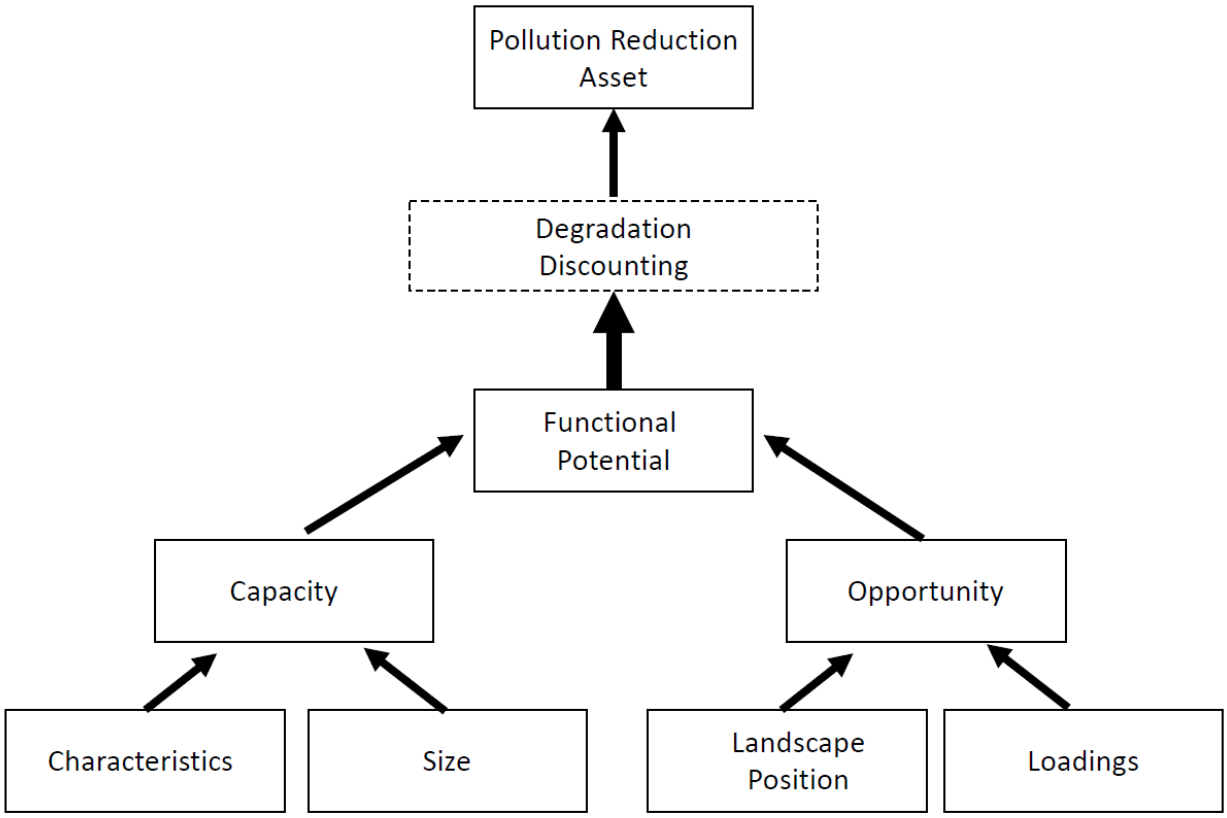

Figure F-5

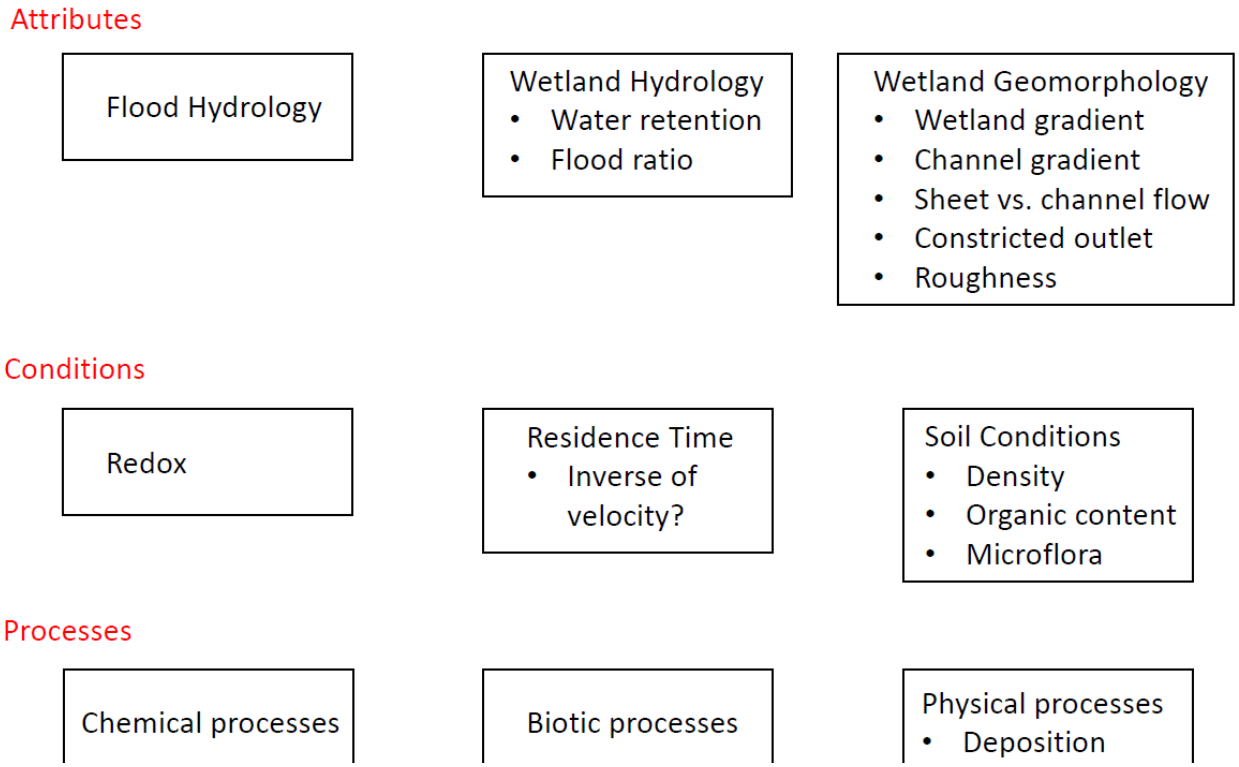

Figure F-6.

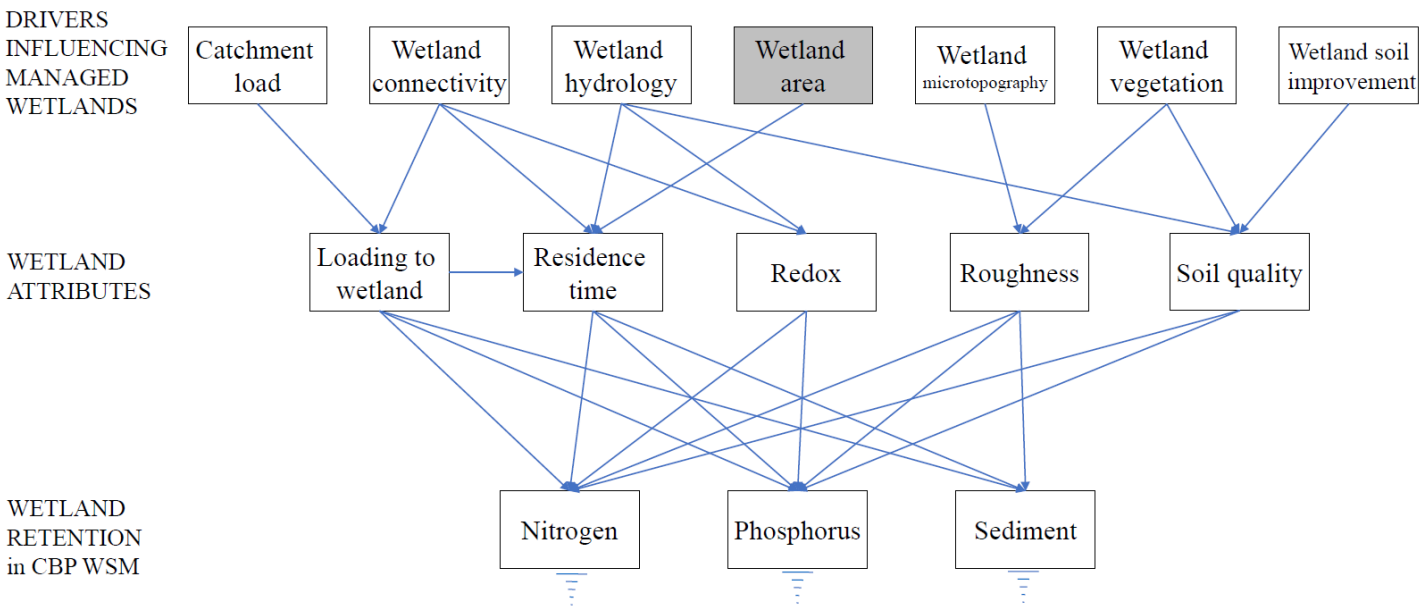

Figure F-7.

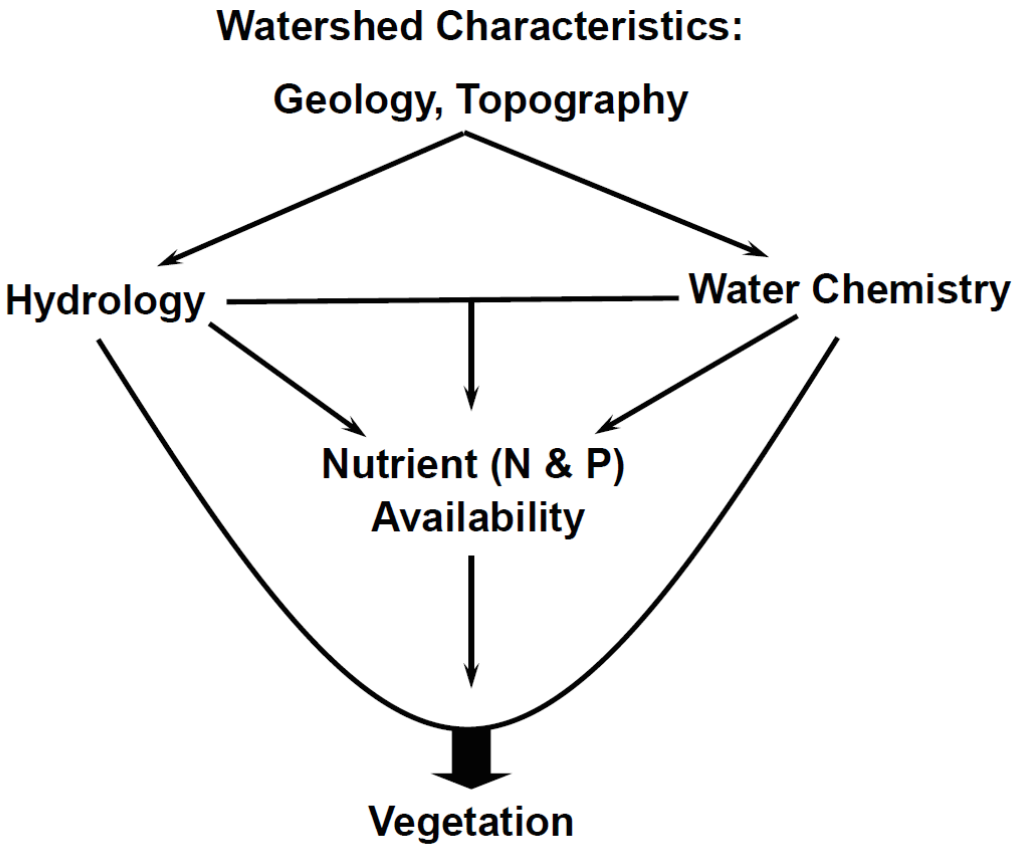

Figure F-8.

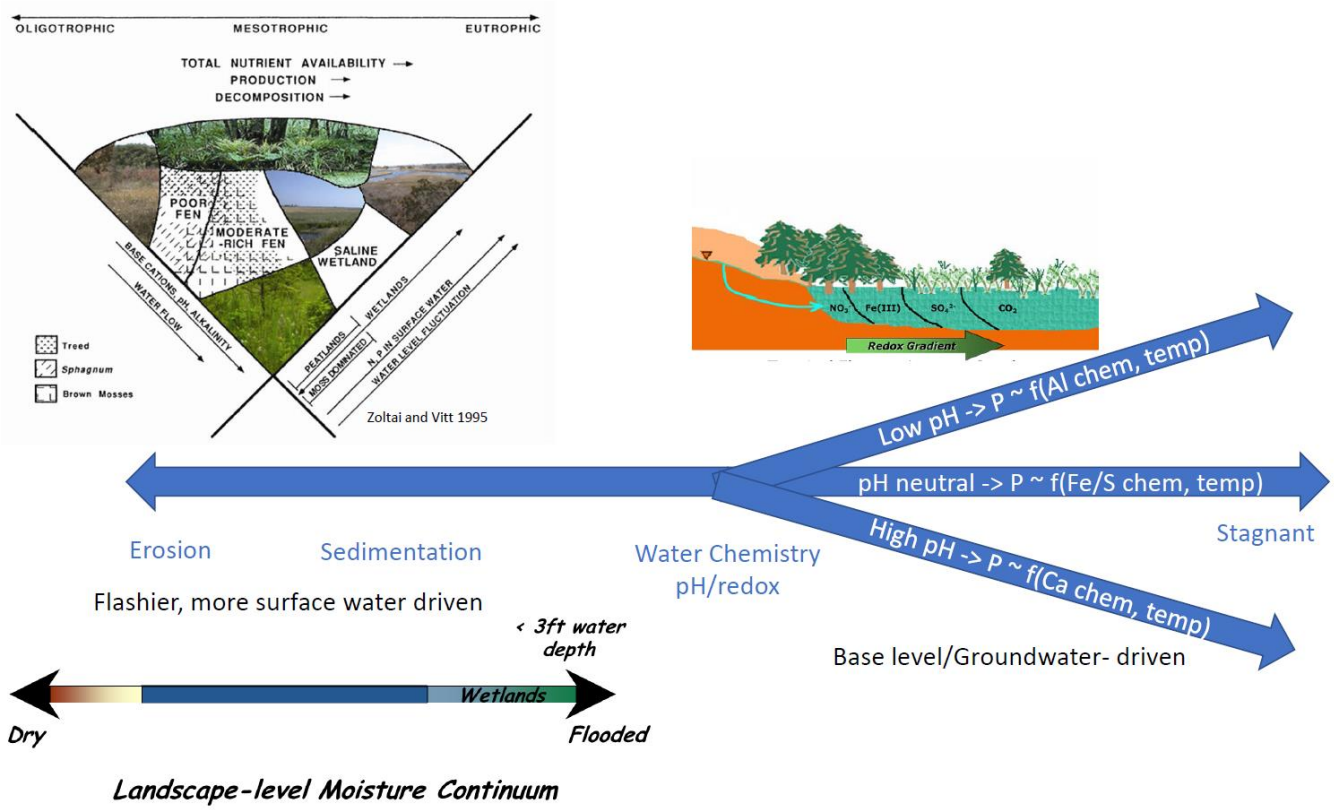
OLIGOTROPHIC
MESOTROPHIC
EUTROPHIC
TOTAL NUTRIENT AVAILABILITY
PRODUCTION
DECOMPOSITION
POOR FEN
MODERATE -RICH FEN
SALINE WETLAND
BASE CATIONS, pH, ALKALINITY
WATER FLOW
PEATLANDS
MOSS DOMINATED
WETLANDS
N, P IN SURFACE WATER
WATER LEVEL FLUCTUATION
Treed
Sphagnum
Brown Mosses
Zoltai and Vitt 1995
Redox Gradient
Low pH -> P ~ f(Al chem, temp)
pH neutral -> P ~ f(Fe/S chem, temp)
High pH -> P ~ f(Ca chem, temp)
Erosion
Sedimentation
Water Chemistry
pH/redox
Stagnant
Flashier, more surface water driven
Base level/Groundwater- driven
< 3ft water depth
Wetlands
Dry
Flooded
Landscape-level Moisture Continuum

Figure F-9.

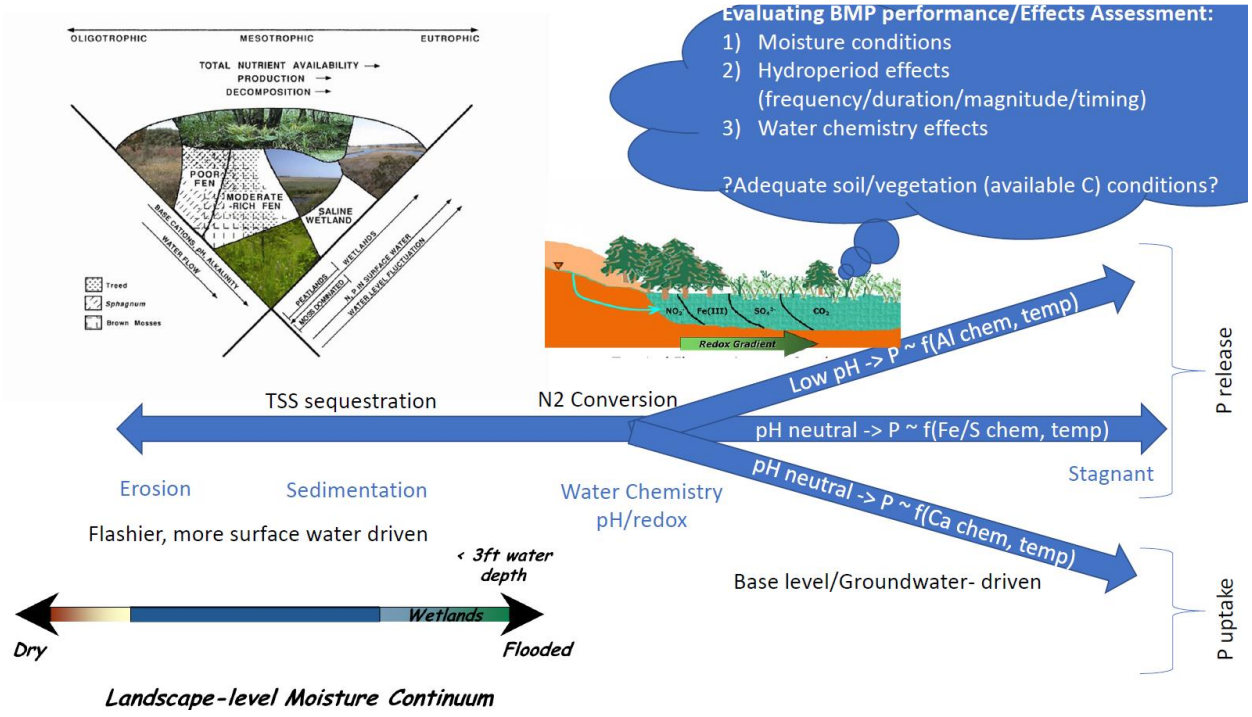

Figure F-10.

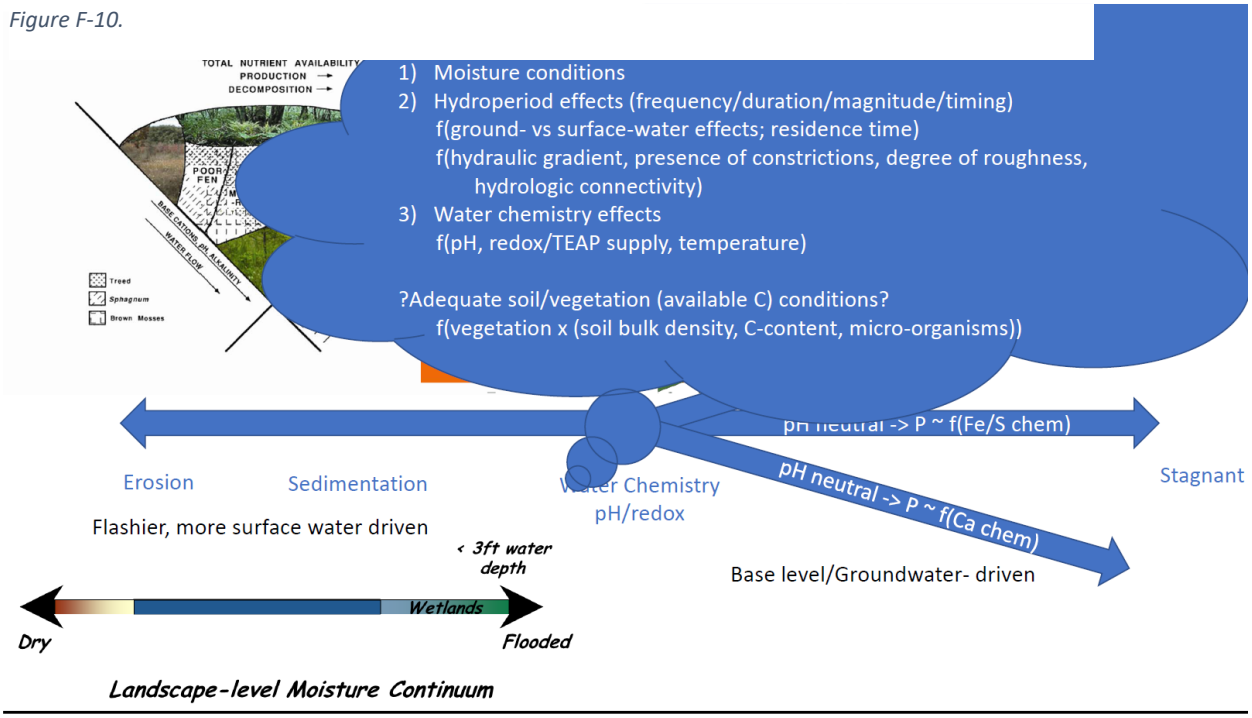

Figure F-11.