Hydrology - Part 1

Hydrology

"Hydrology is probably the most important determinant of the establishment and maintenance of specific types of wetlands and wetland processes." *(M&G)*

Hydrologic Cycle

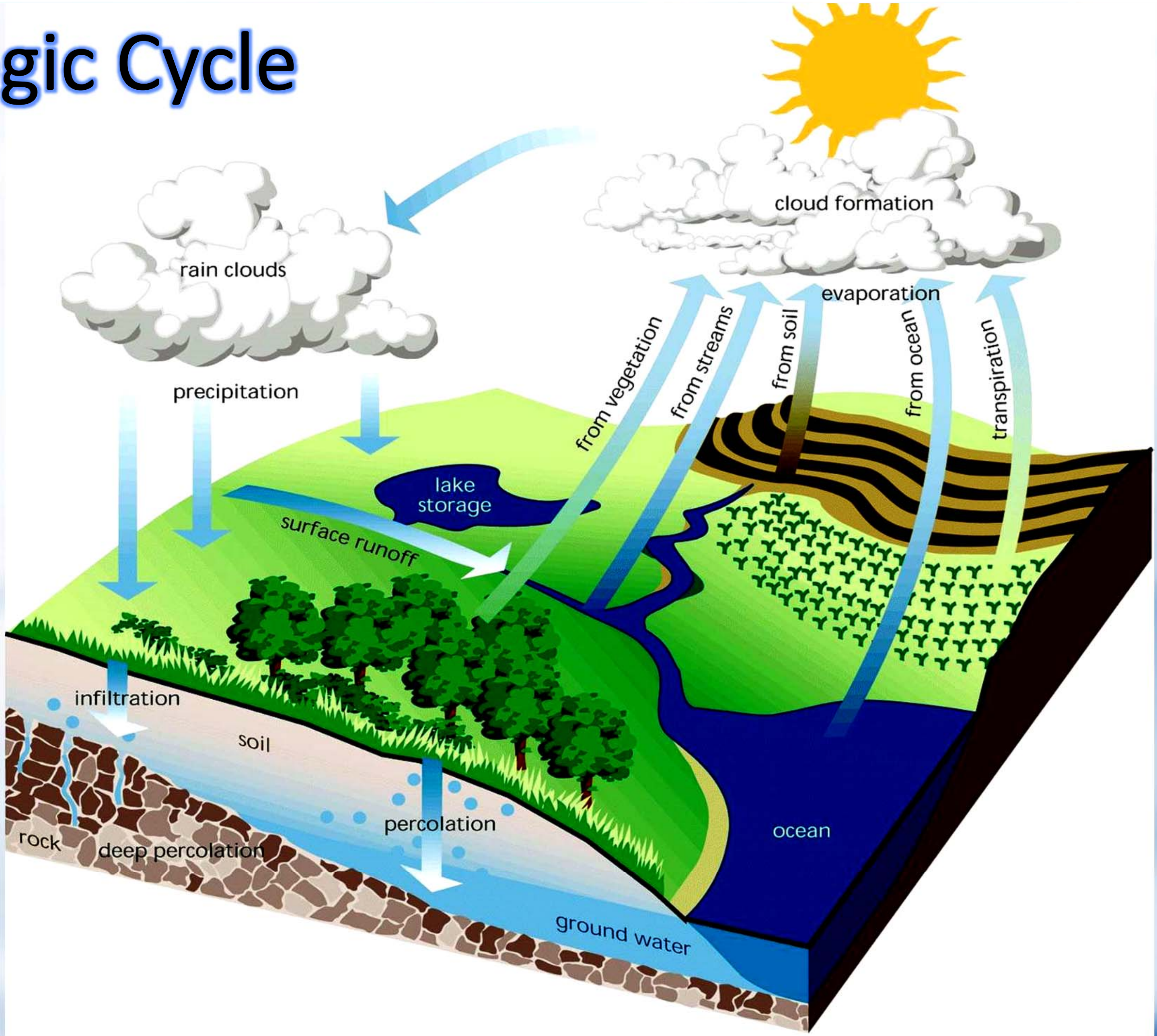


Fig. 2.2 -- The hydrologic cycle. The transfer of water from precipitation to surface water and ground water, to storage and runoff, and eventually back to the atmosphere is an ongoing cycle.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
Interagency Stream Restoration Working Group (15 federal agencies)(FISRWG).

Water Cycle

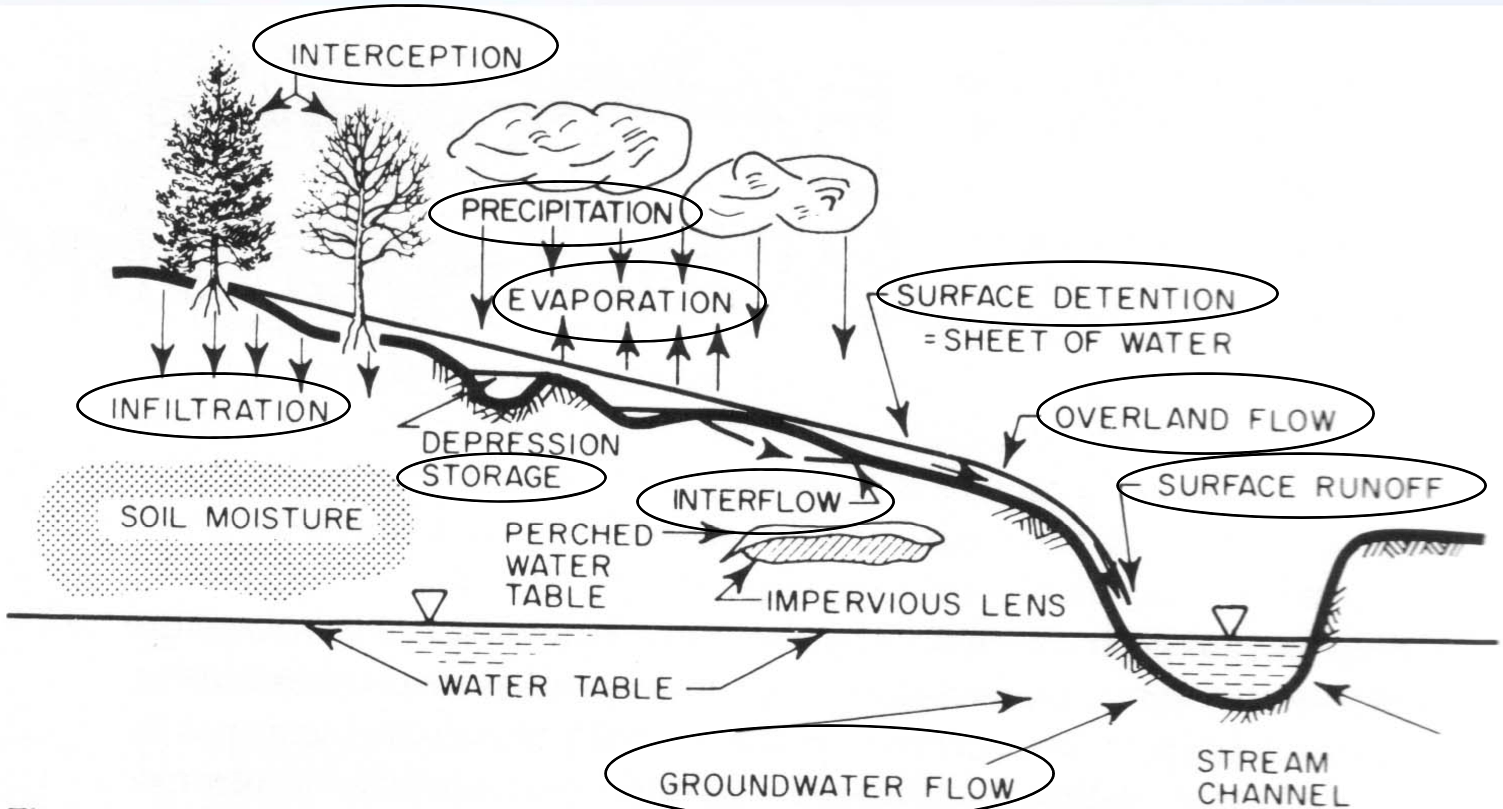


Figure 4-1 Simplified representation of the major pathways of the runoff phase of the hydrological cycle. (From Grey, D. M., ed.: Handbook on the Principles of Hydrology. Ottawa, National Research Council of Canada, 1970. Reprinted by permission of Water Information Center, Inc., Manhasset Isle, Port Washington, New York, after Davis and DeWeist, 1966.)

Generalized Wetland Water Budget

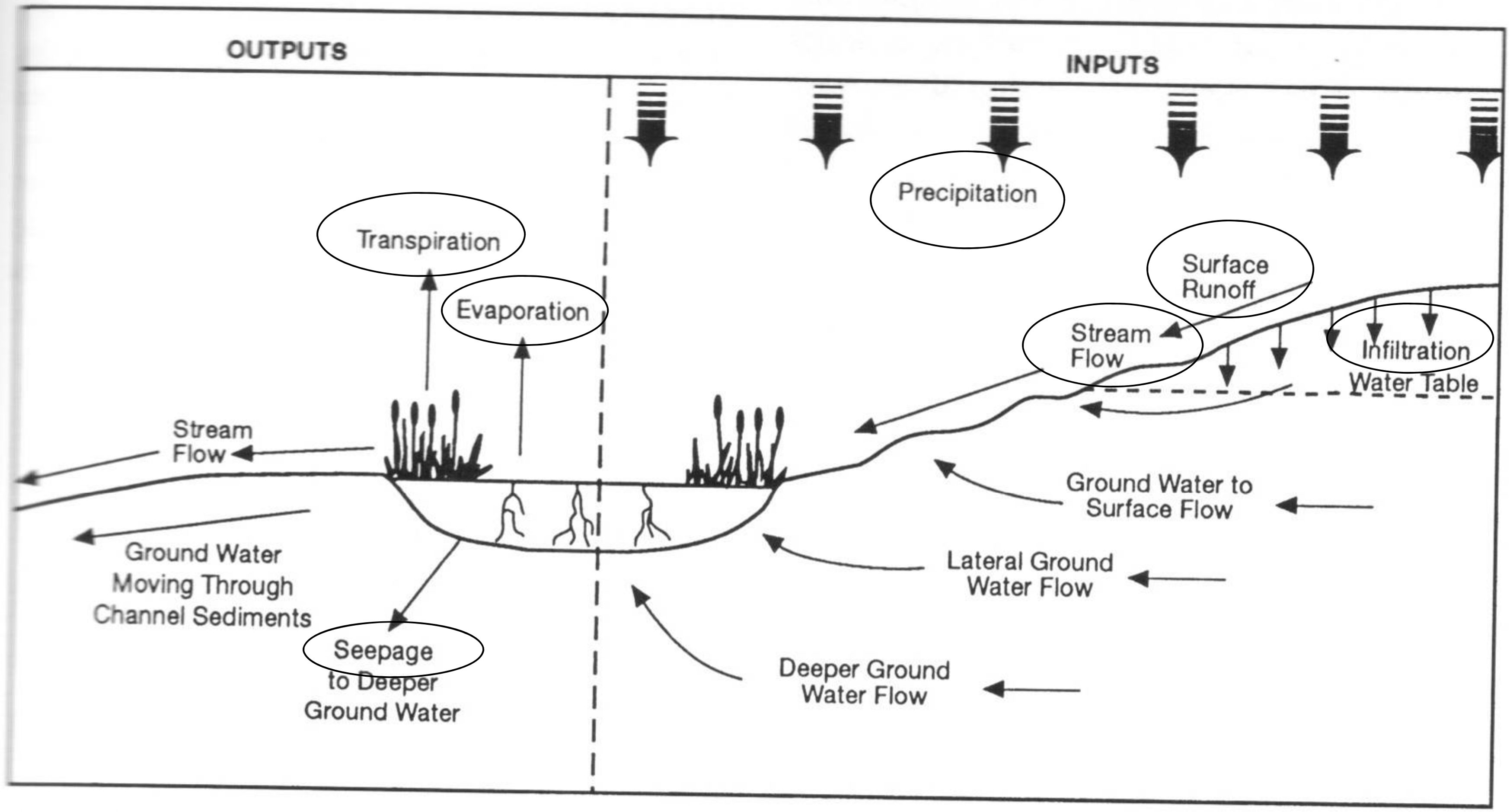


Figure 2.2. Water inputs and outputs for a nontidal wetland. Not all wetlands receive water from all sources; some wetlands are strictly surface-water driven. The water budget for an individual wetland is not easily determined since it is difficult to measure some of the inputs and outputs. (Source: Stone and Stone 1994; copyright 1994 the American Ground Water Trust. Reprinted with permission.)

From: Tiner, 1998

Wetlands exhibit differences in the extent of control by surface water or groundwater.

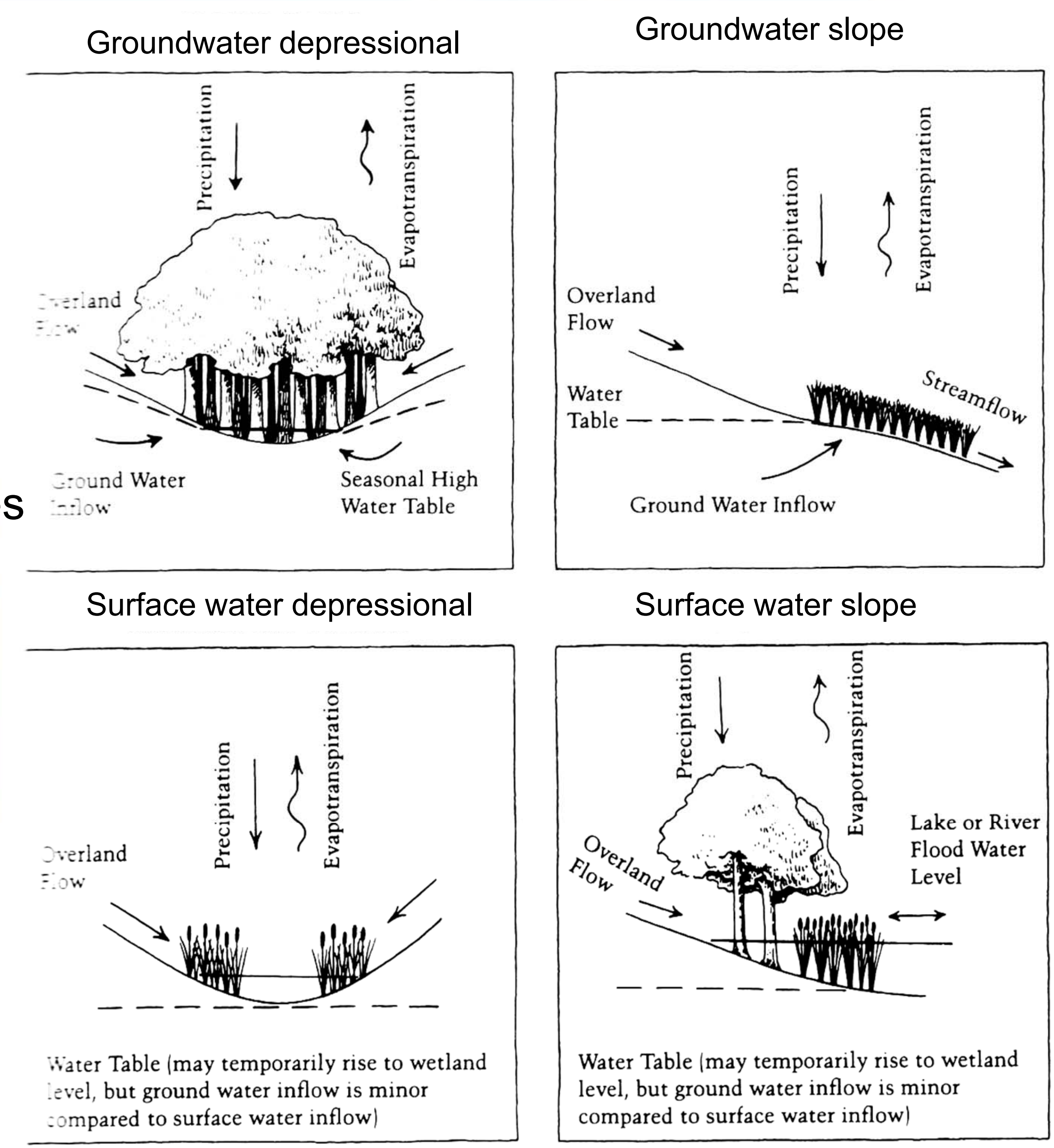
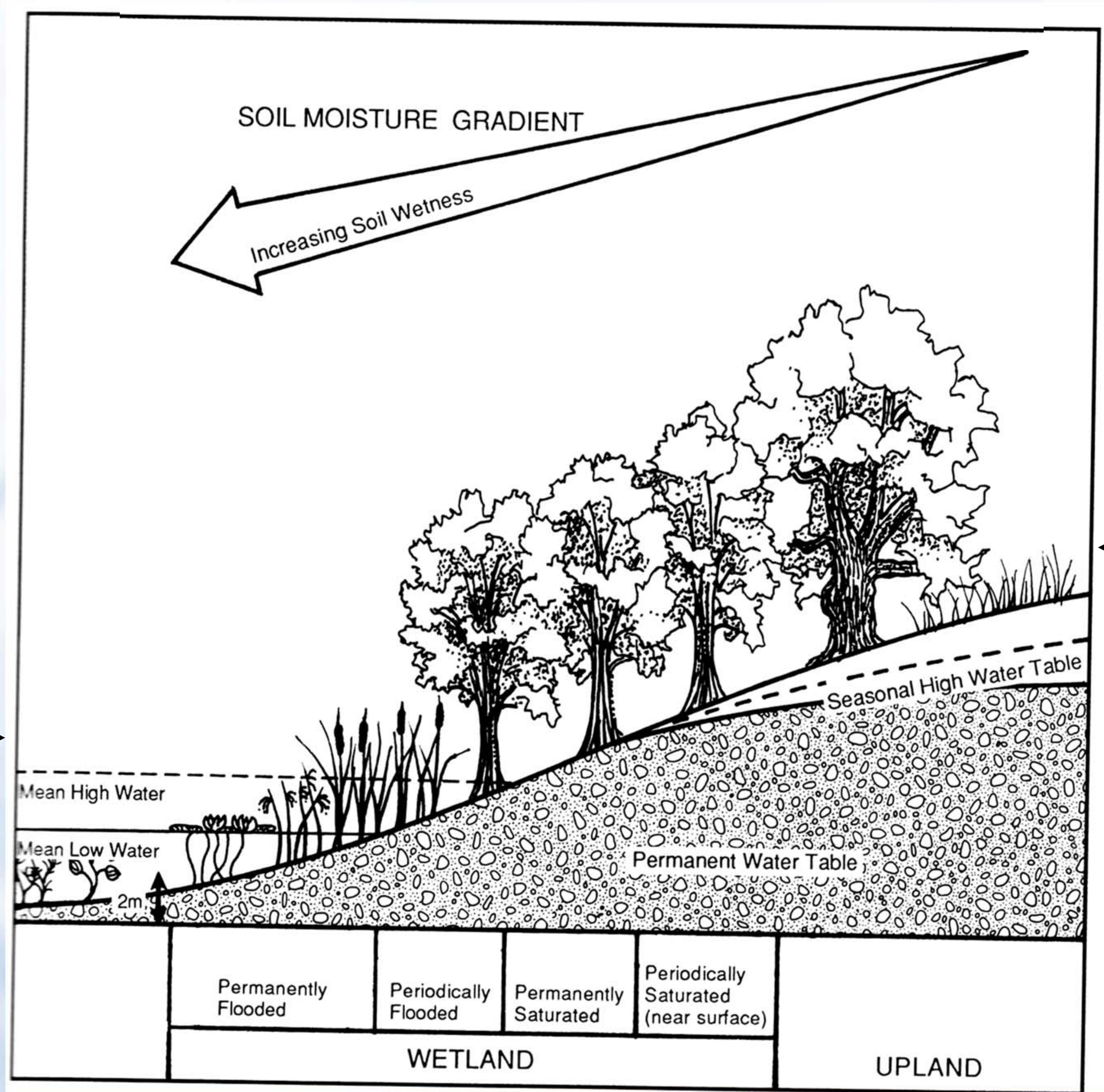


Figure 2.10. Hydrologic inputs and outputs for surface-water and groundwater wetlands. (Source: Tiner 1988; redrawn from Novitski 1982)

Wetland Formation



Topography

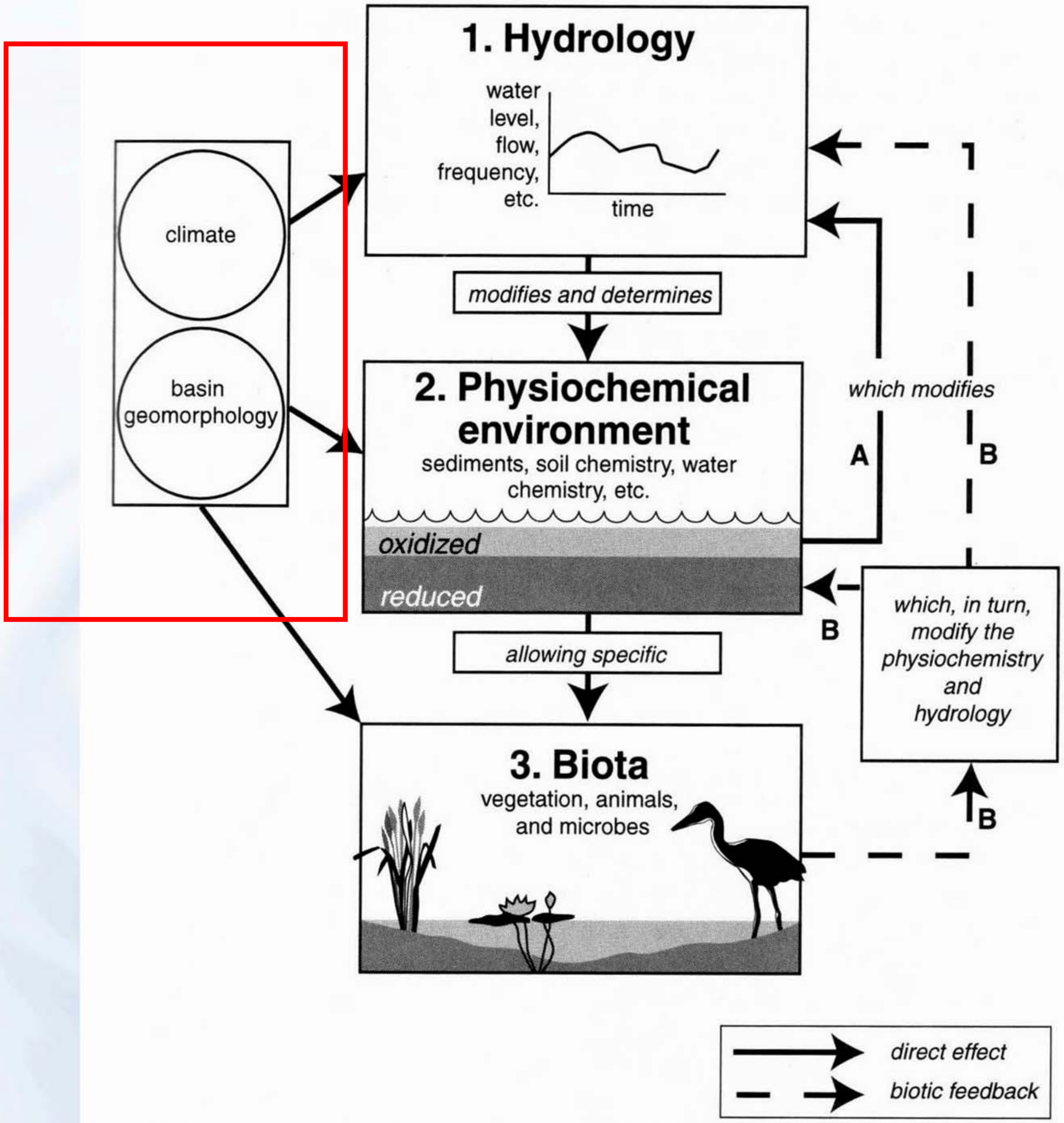
Water Source

Ground water: Usually mid-winter to mid-spring

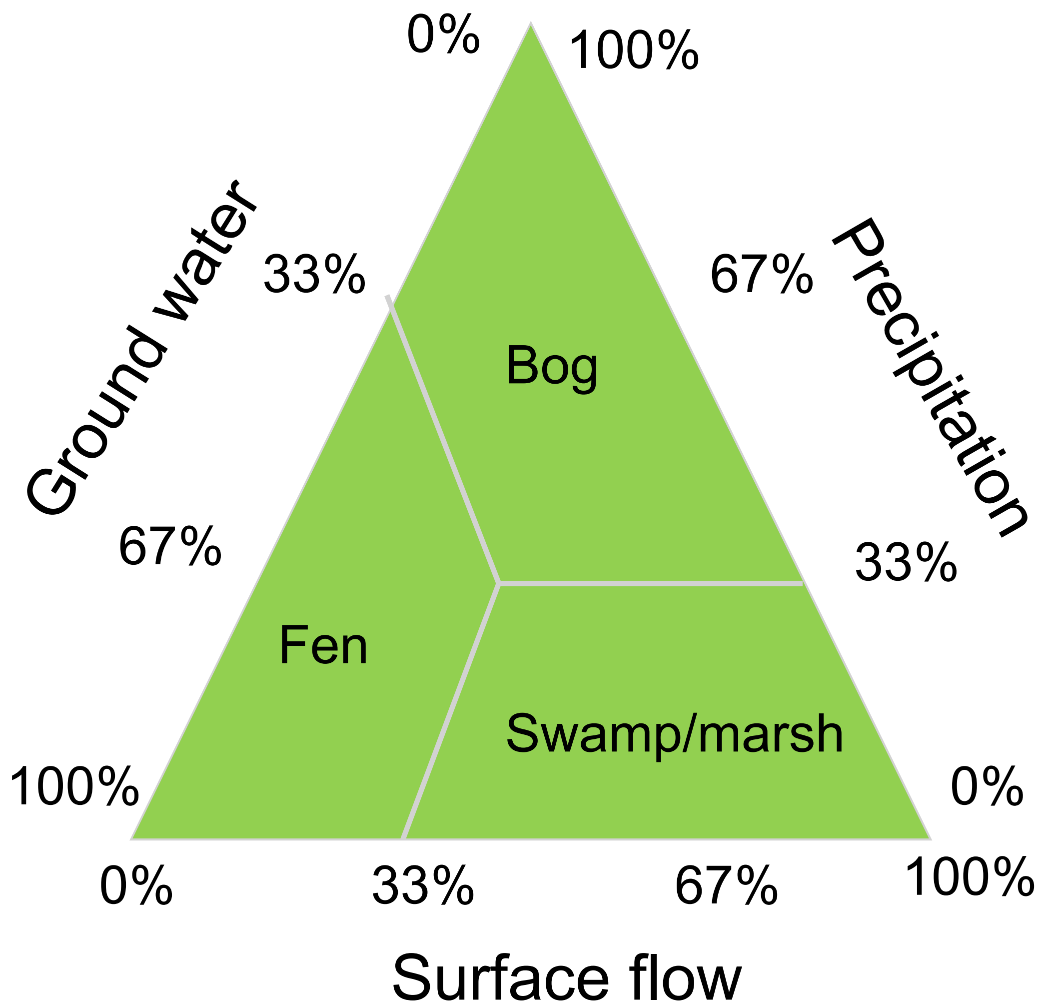
Surface water: Usually late summer to fall

Tiner 1998

Hydrology, the driving factor in wetlands

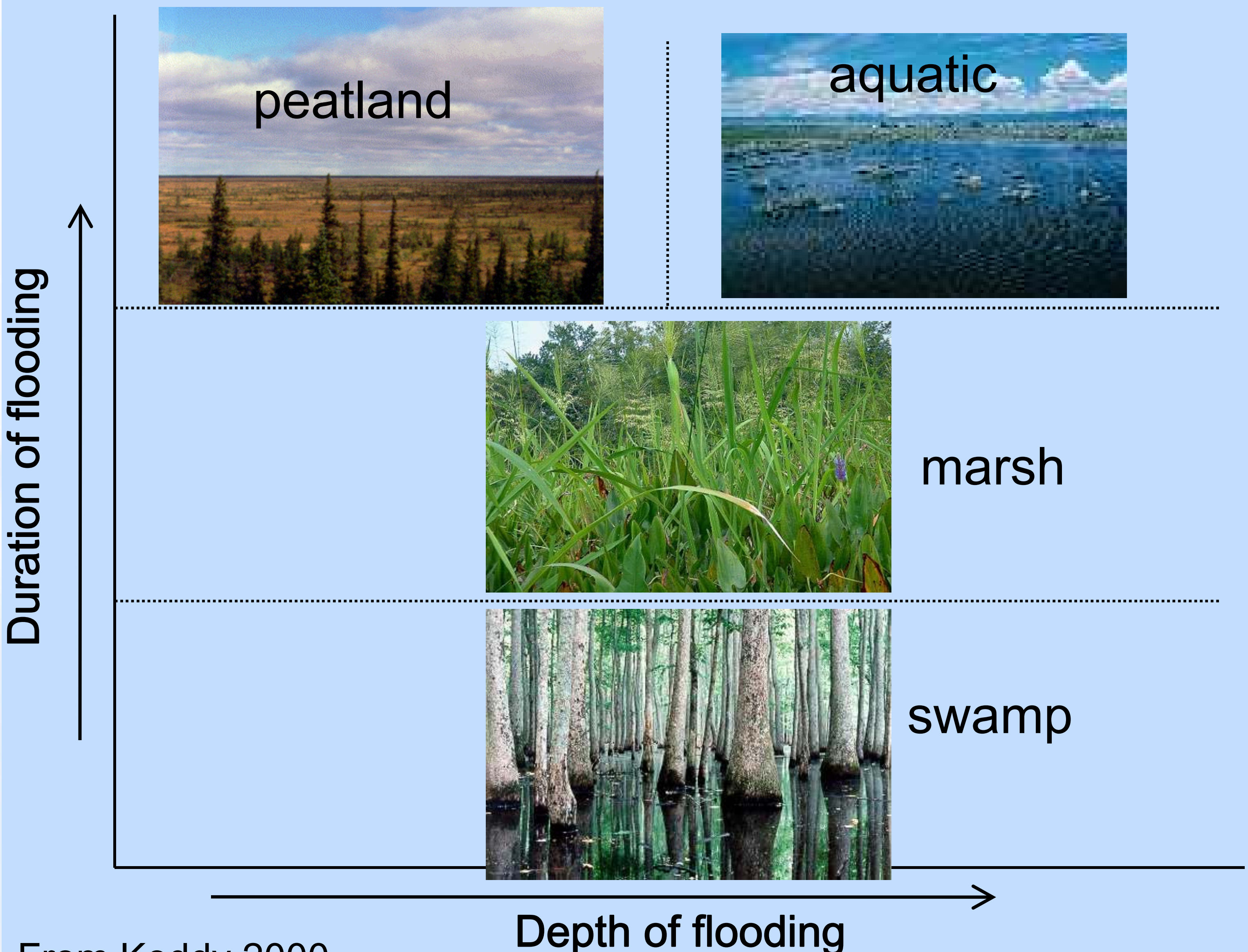


Water source and wetland type



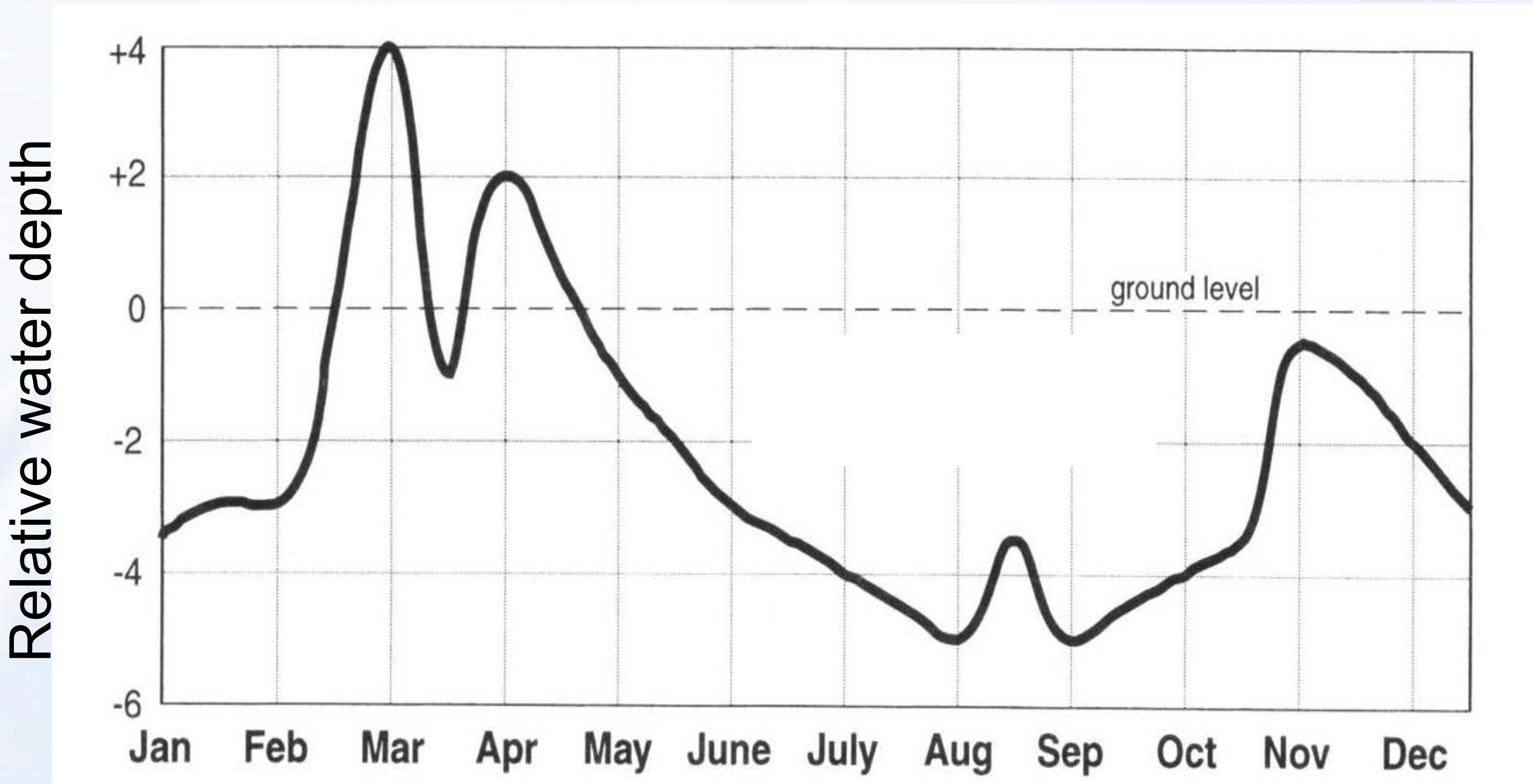
From Brinson 1992, Keddy 2000

Hydrology and wetland type



From Keddy 2000

Idealized wetland hydroperiod



Tiner 1998

Wetland Hydroperiods

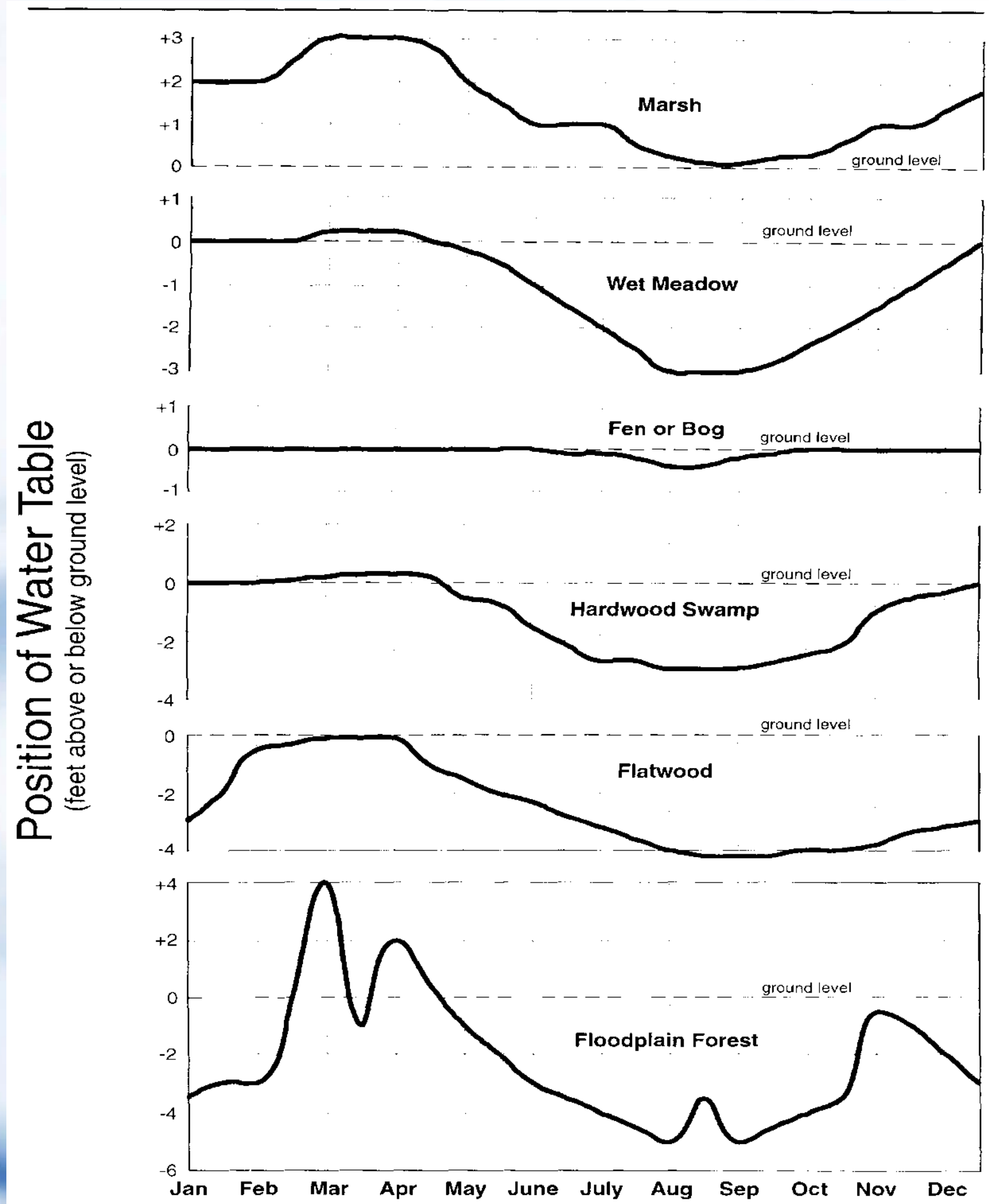
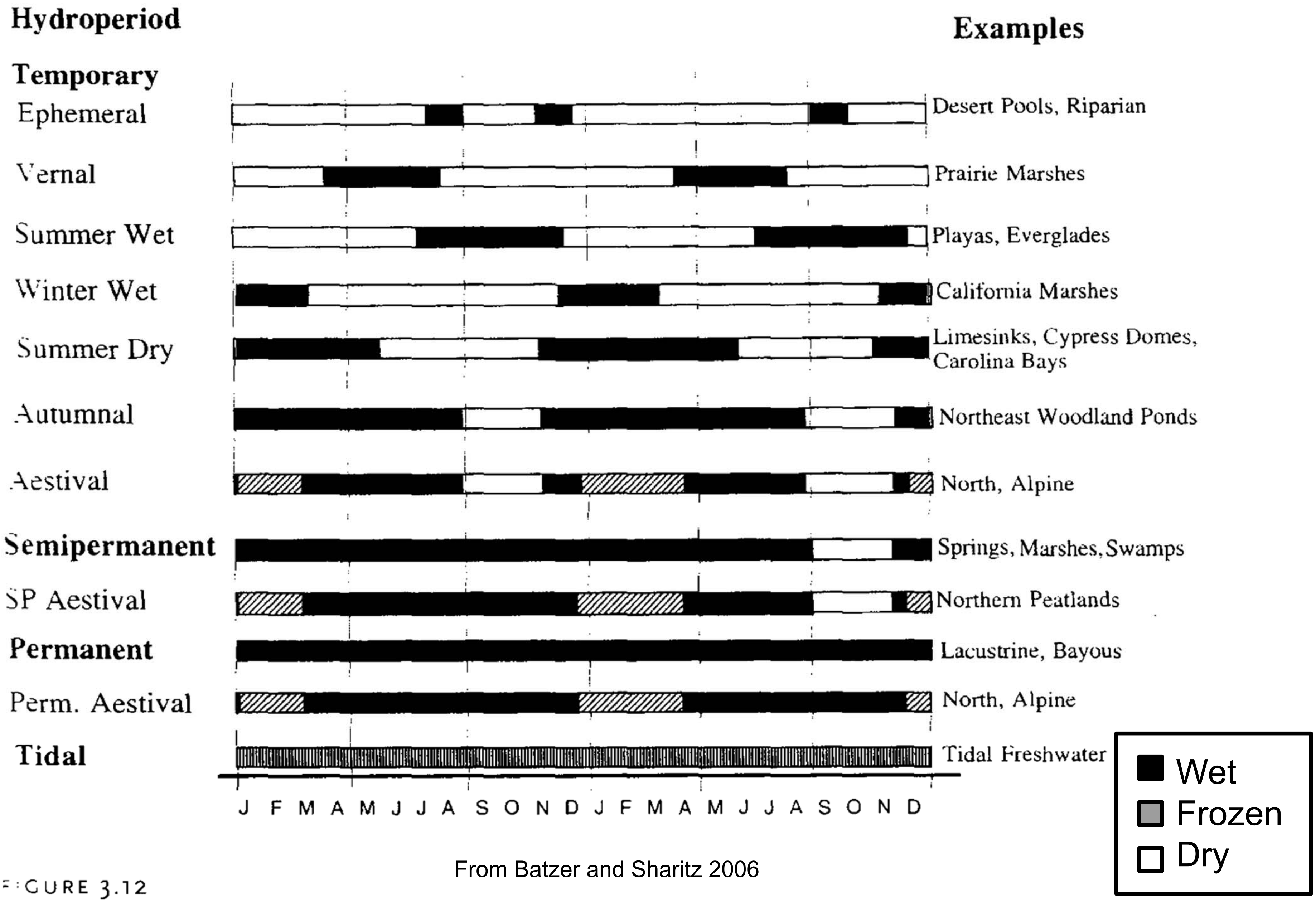


Figure 2.5. Examples of hydroperiods for nontidal wetlands. (Note: These are examples for the referenced type; there is variability in water table fluctuations within types also.)

From: Tiner, 1999.



From Batzer and Sharitz 2006

FIGURE 3.12

Summary of hydropatterns observed in North America. Dark blocks represent inundation, hatched blocks represent iced conditions, and white areas represent dry periods. Reprinted from Wissinger

Factors influencing hydrology

- Abiotic
  - Geomorphology
  - Climate
  - Geology
  - Soils
  - Land use / human activities
- Biotic
  - Vegetation type/cover
  - Animal activity

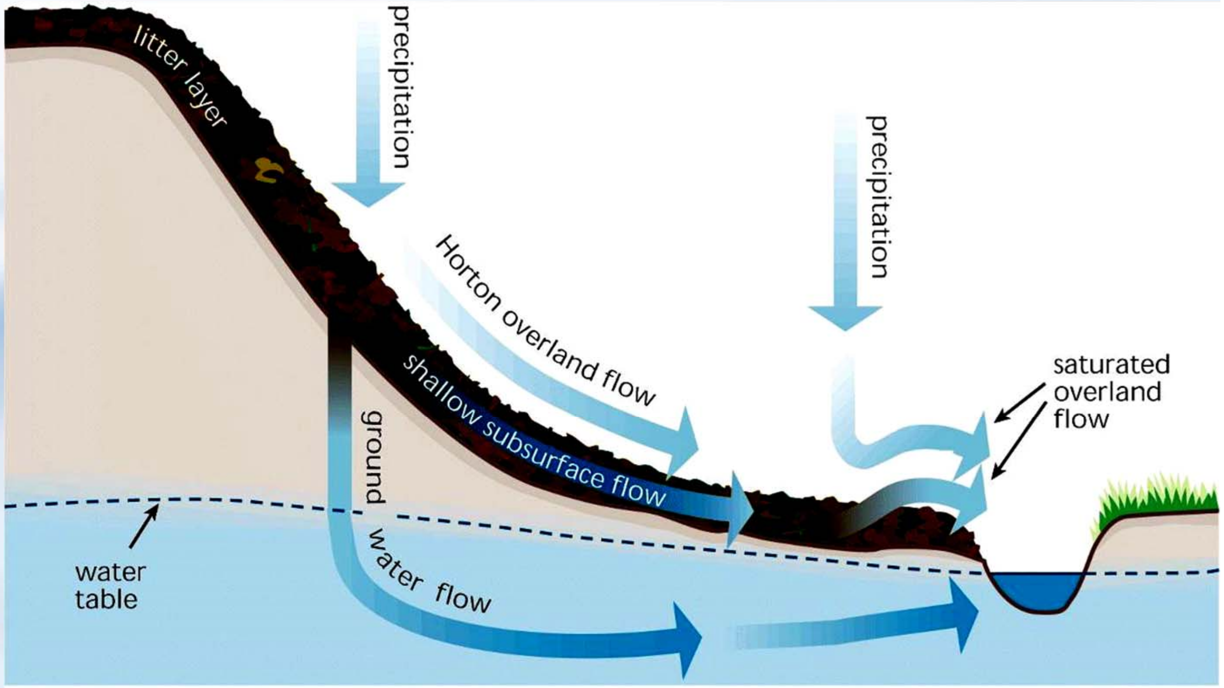


Fig. 2.10 -- Flow paths of water over a surface. The portion of precipitation that runs off or infiltrates to the ground water table depends on the soil's permeability rate; surface roughness, and intensity of precipitation. In Stream Corridor Restoration: Principles, Processes, and Practices (10/98). Interagency Stream Restoration Working Group (15 federal agencies)(FISRWG).

Effects of Hydrology on Wetlands

- Plant community composition and diversity
- Primary productivity
- Organic matter accumulation
- Nutrient cycling and nutrient availability

Biotic factors influencing hydrology & physiochemistry:

- Plants influence hydrology by:
  - Trapping and binding sediments
  - Transpiring moisture
  - Interrupting water flow
- Plants influence physical environment by:
  - Shading
  - Trapping sediment
  - Retaining nutrients
  - Building peat
- Microbes control nutrient availability and influence most chemical processes in wetland soils and the water column.

Vegetation can alter hydrology

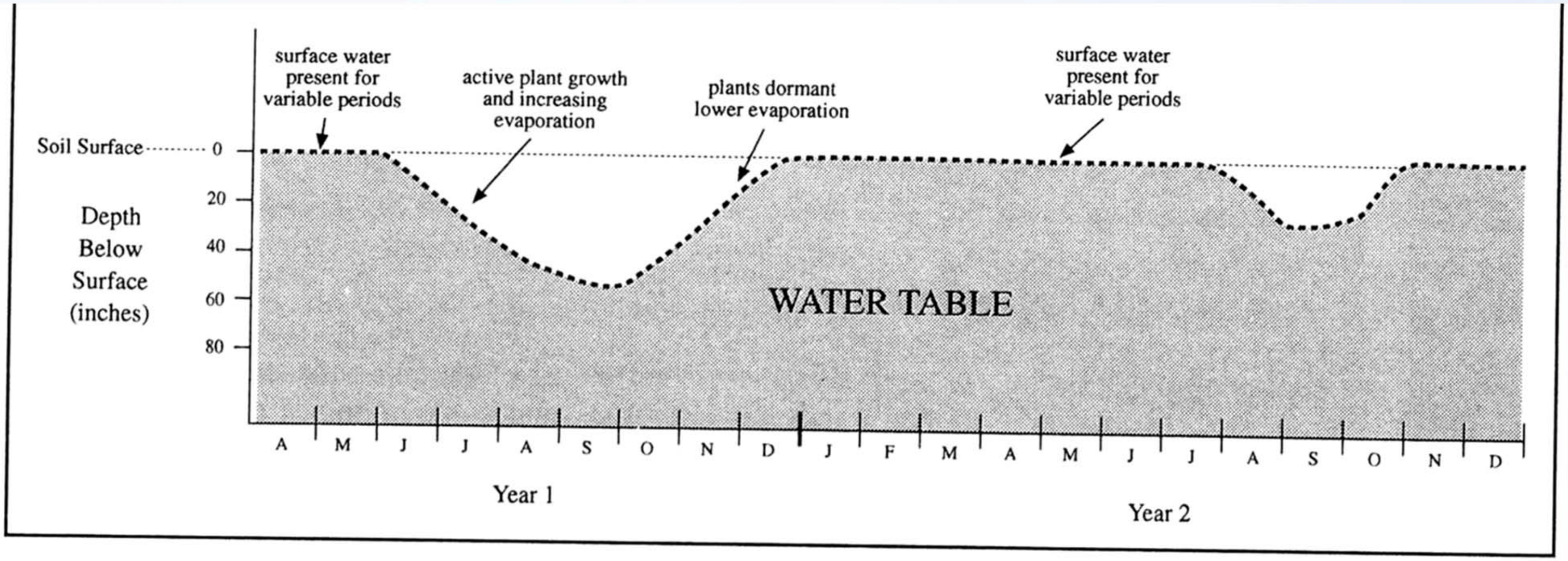


Figure 2.9. Water-table fluctuations in a typical nontidal forested wetland. In general, the water table is at or near the surface through winter and spring, then drops markedly in summer, and rises in the fall. Both seasonal and annual variations are due to changes in precipitation and other factors. (Source: Data from Lyford 1964)

From Tiner 1998

Species Composition and Richness

- Hydrology selects water-tolerant vegetation and excludes flood-intolerant species;
- In general, the longer (and more frequent) the flood period, the lower the species richness due to changes in oxygen concentrations and soil chemistry.
- Vegetation species richness, in general, increases as water flow-through increases.
- Spatial heterogeneity (associated with tidal or riparian areas esp.) increases species richness.

Midwestern plant behavioral groups

Group	Waterlog tolerance (summer, no damage)	Drought tolerance	Example species
Upland trees	~ 1 day	Mod – high	White oak, sugar maple
Floodplain flora	~ 6 days	Mod – high	Swamp oak, willow
Swamp shrubs & trees	6 weeks+	Low – high	Dogwood, pussywillow, tamarack, black spruce
Bog and fen herbs	6 weeks (longer if float)	Low	*Carex, Calamagrostis*
Emergent macrophytes	Permanent	None-low	*Scirpus, Typha*
Submergent macrophytes	Permanent	None-low	*Potamogeton, Elodea*
Duckweeds	Permanent	None	*Lemna, Wolffia*

adapted from Zimmerman 1987

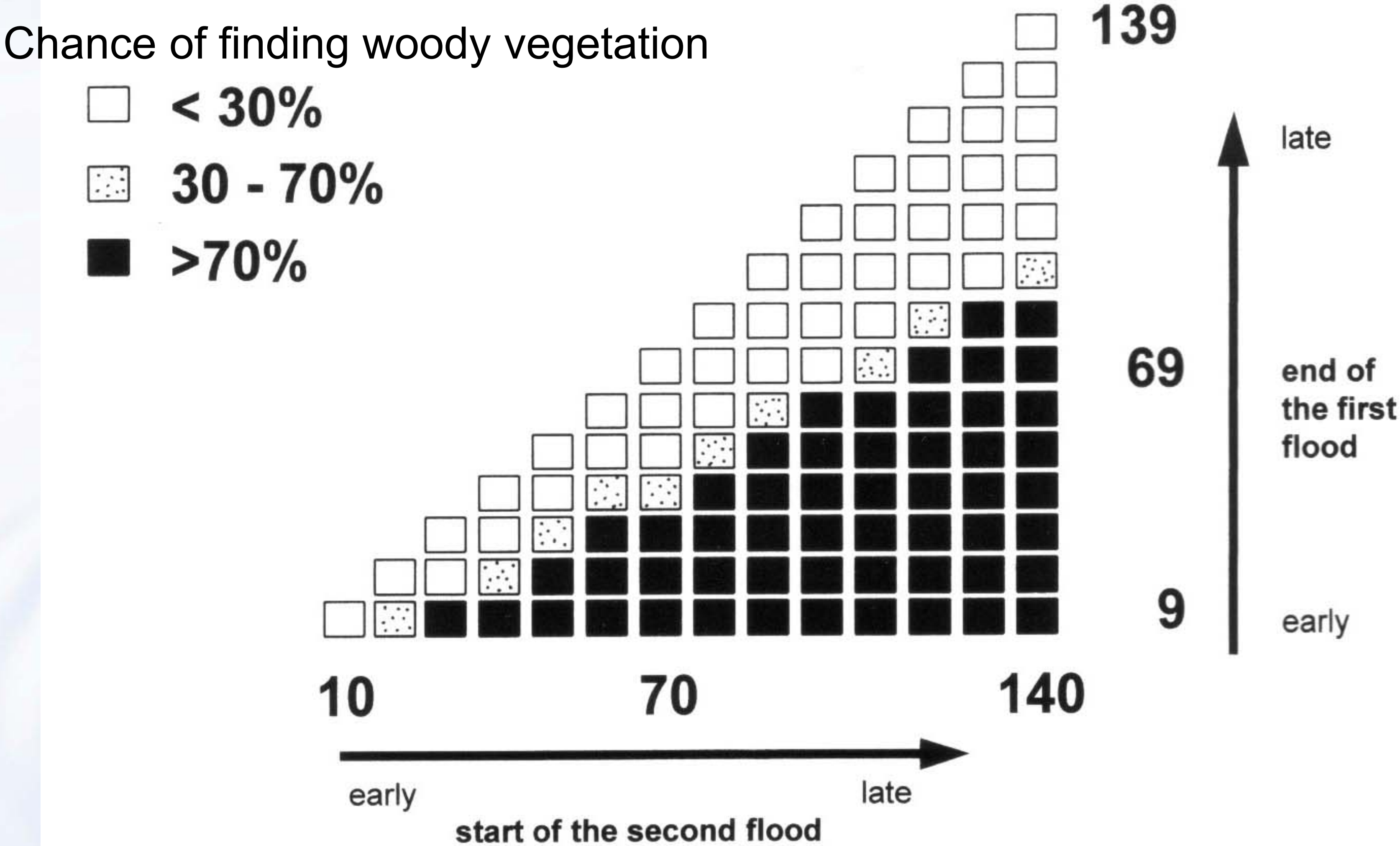


Figure 4.14 The probability of finding woody as opposed to herbaceous plants in a wetland can be predicted by knowing when the first flood ends and when the second flood (if any) begins (from Toner and Keddy 1997).

Survival time of flood-tolerant trees during inundation

Common Name	Species	Survival time (yrs)
Black oak	*Quercus nigra*	2
Burr oak	*Quercus macrocarpa*	2
Silver maple	*Acer saccharinum*	2
Red Maple	*Acer rubrum*	2
Green Ash	*Fraxinus pennsylvanica*	2
Cottonwood	*Populus deltoides*	2
Willow	*Salix interior*	2
Southern red oak	*Quercus falcata*	1
Box Elder	*Acer negundo*	0.5
Sycamore	*Platanus occidentalis*	0.5
Lodgepole pine	*Pinus contorta*	0.3

After Crawford 1982

Hydrology and Primary Productivity

Nutrients, oxygen, toxins

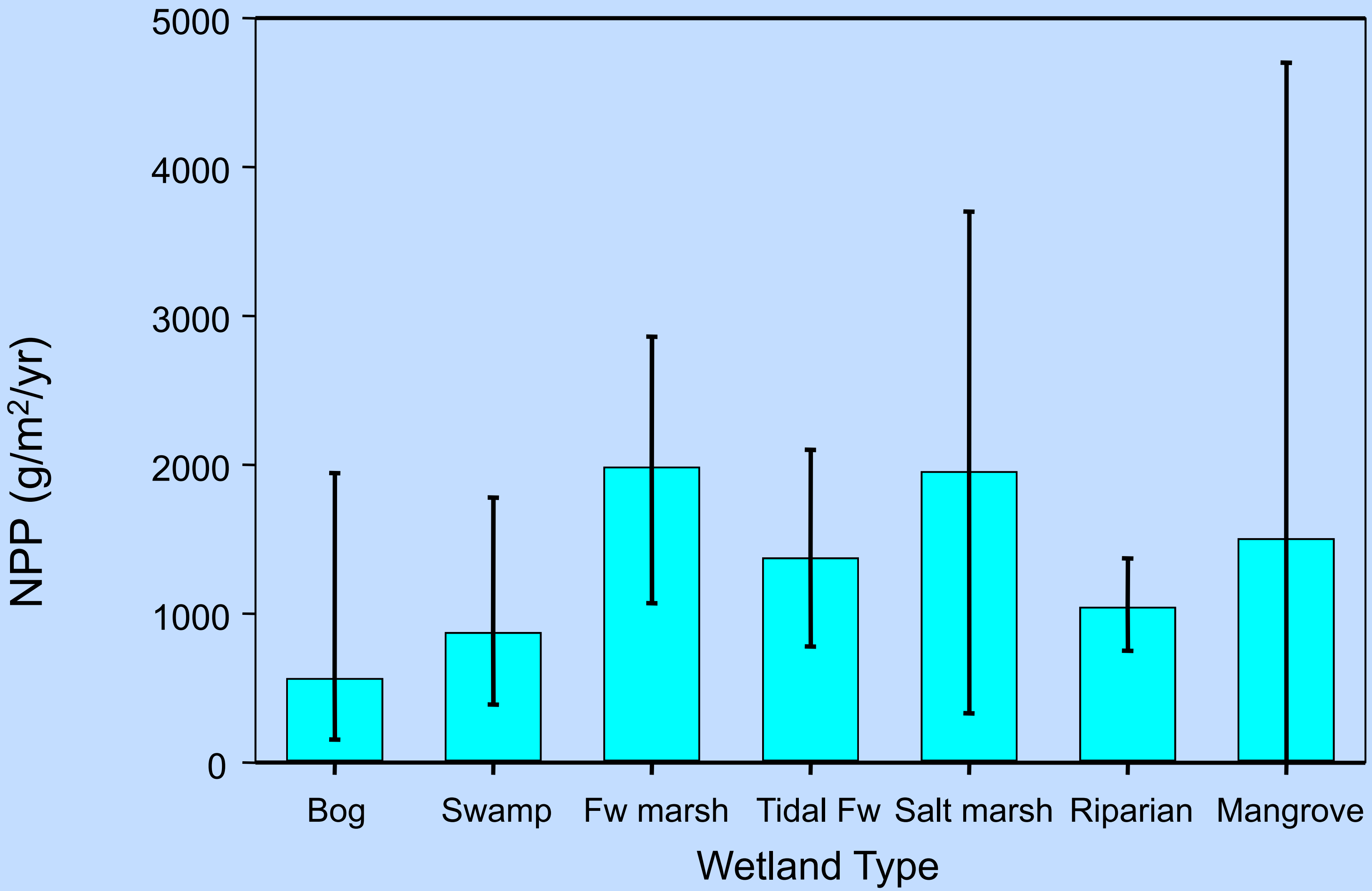
Primary Production

- Openness to hydrologic fluxes can be correlated with potential primary production.
  - Stagnant (non-flowing) or continuously deep water wetlands generally have lower primary production than wetlands in slowly flowing areas or those subject to periodic flooding.
  - Productivity is generally low under continuously flooded or drained conditions, and is explained by nutrient inputs.
  - Productivity is lowest in precipitation-dominated systems (bogs), and highest in flood-prone riparian systems.
- Responses of individual species to water fluctuations varies, so the relationship between production and hydrology is not definitive.

Hydrology and Primary Productivity

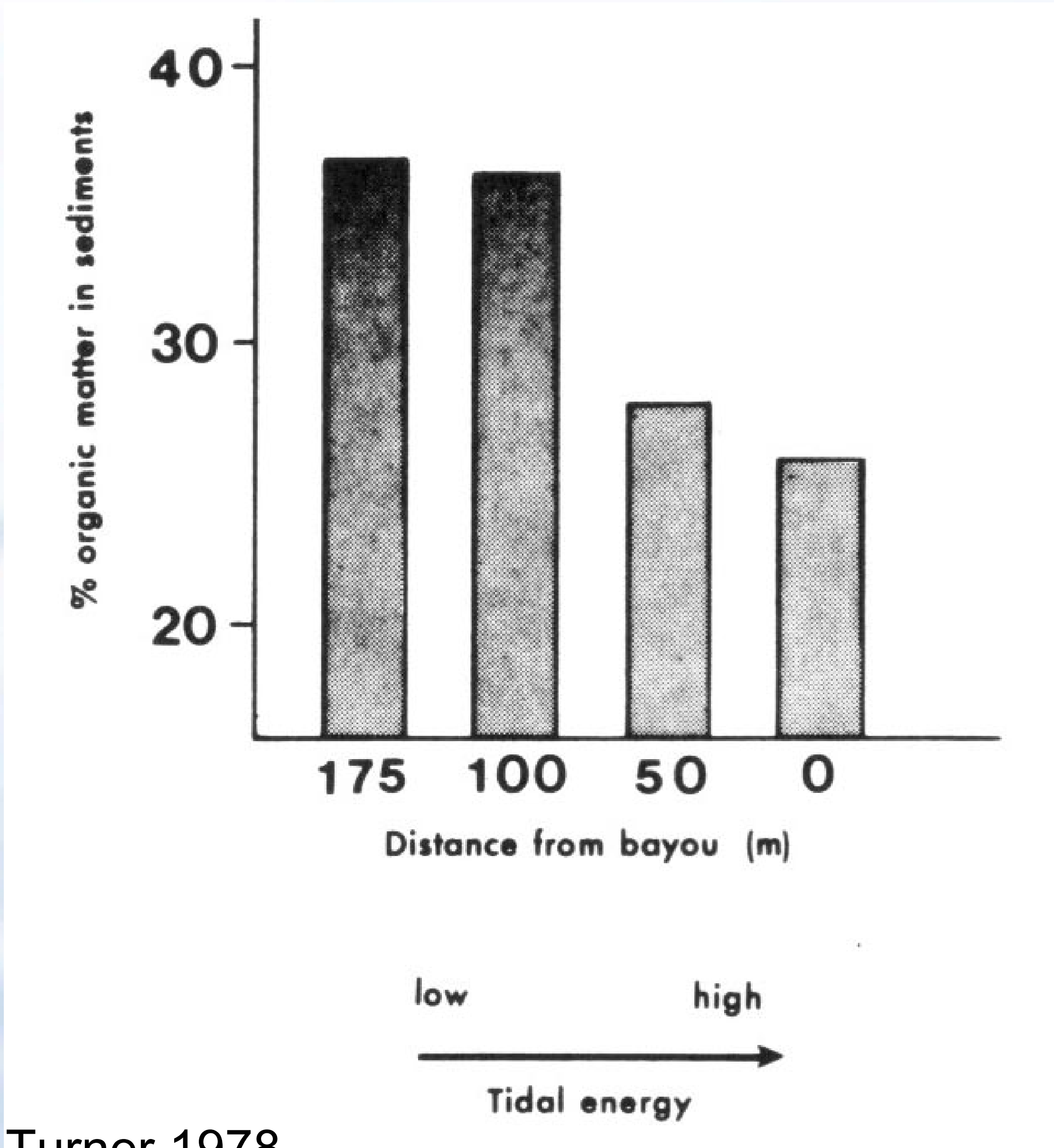
Cypress swamp flow exposure	NPP ($g/m^2/yr$)
Stagnant (cypress domes in Florida)	192
Cypress domes in a riverine system (Florida)	600
Very slowly flowing water (Okefenokee Swamp, Georgia)	692
Riverine edge strand (Big Cypress Swamp, Florida)	1170
Semi-riverine with seasonal flooding (des Allemands Swamp, Louisiana)	1140

From Conner & Day, 1976; Gosselink & Turner, 1978



Mitsch & Gosselink 2000

Evidence of productivity export



Gosselink & Turner 1978

Evidence of productivity export

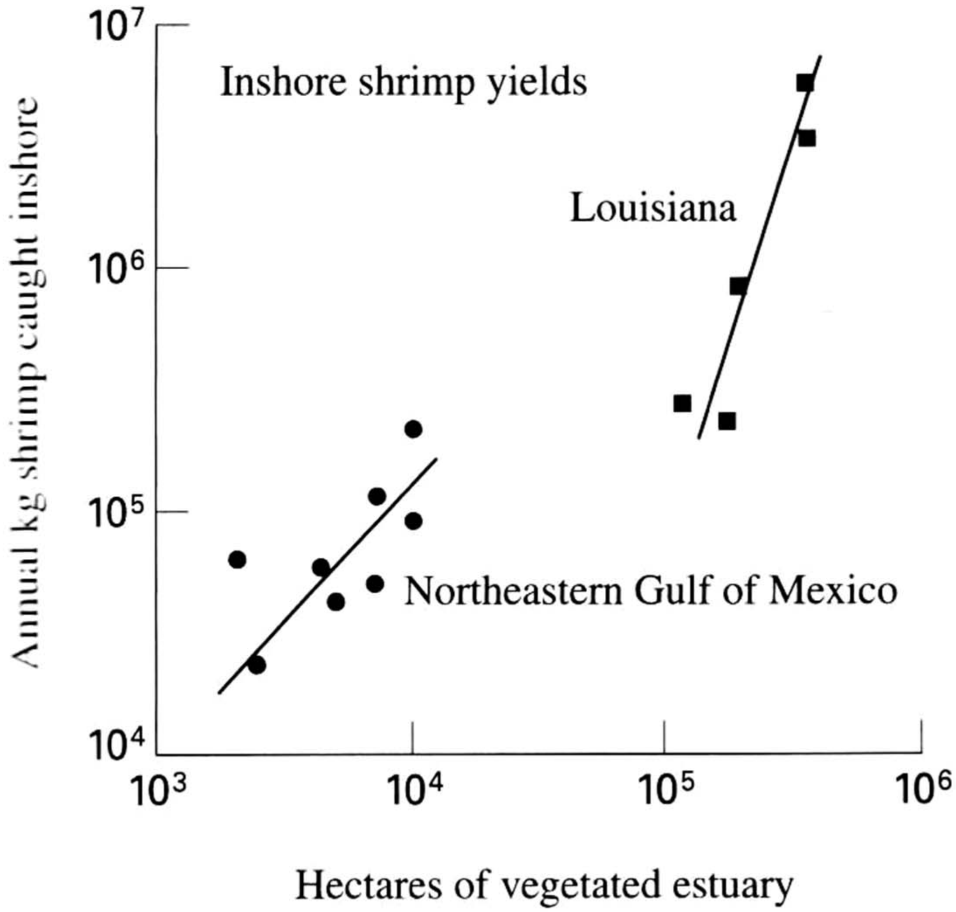


Figure 1.19 The relationship between the mean annual yield of shrimp caught inshore and the area of vegetated estuary (from Turner 1977).

Shrimp harvest in the Gulf of Mexico is correlated with area of salt marsh.

Keddy 2000

Animal influences on wetlands

- Beaver:
  - Known as "ecosystem engineers" creating and destroying wetland habitats
  - Alter geochemical processes on a global scale.
  - The majority of the water flowing across the Kabetogama Peninsula in N. Minnesota flows through at least one beaver pond, altering water chemistry as it flows through the pond (Johnston & Naiman 1990, Naiman et al. 1988).
- Muskrat
  - Change flow patterns,
  - Harvest emergent vegetation
- Geese
  - Remove vegetation
- Alligator
  - Construct "gator holes"

Vegetative change effected by beaver, 1940-1986

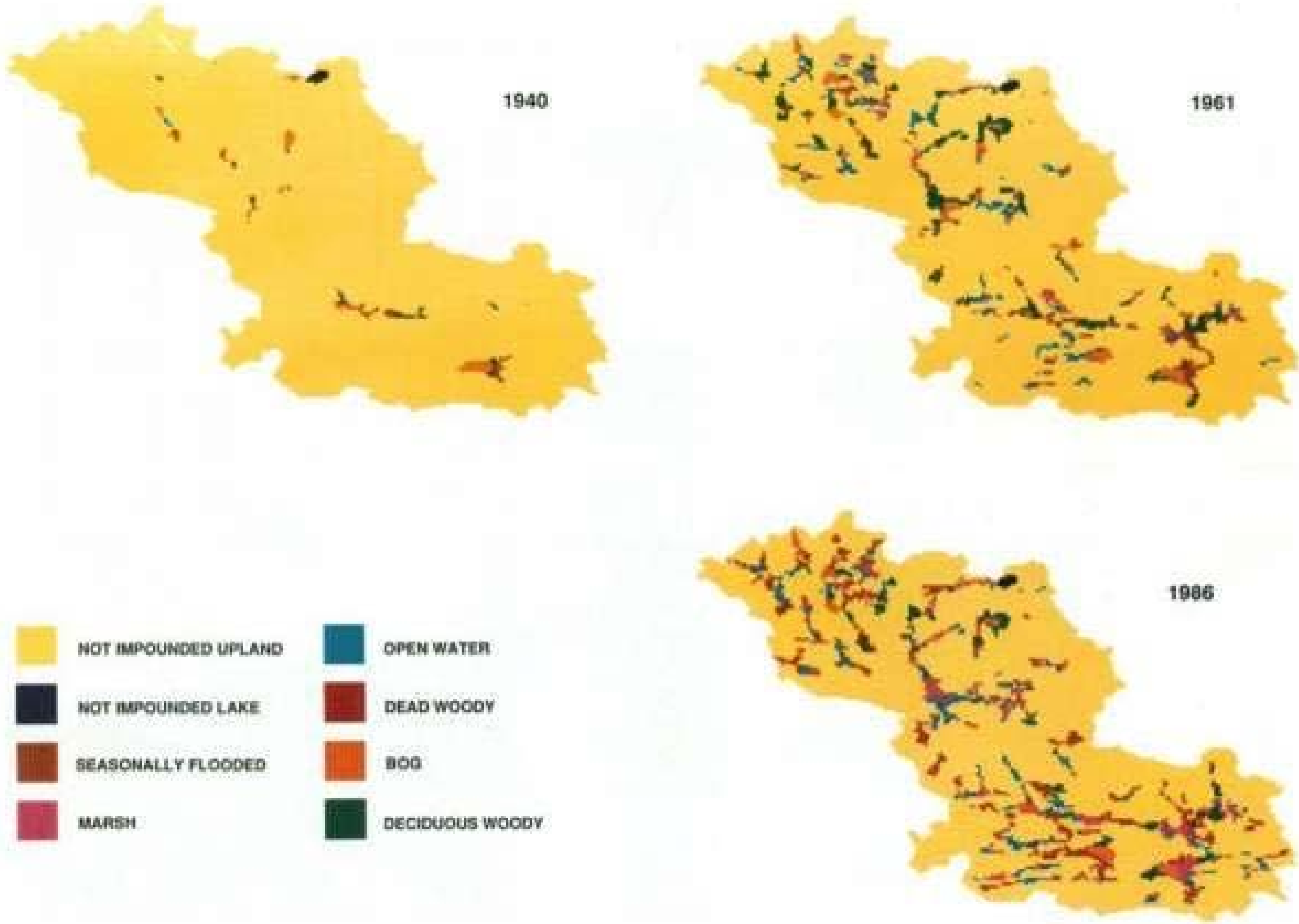


Figure 5. Vegetative change effected by beaver on a 45-square-kilometer watershed on the Kabetogama Peninsula. Colors of individual pixels represent different vegetative community types. Note the increase in dam density between 1940 and 1986, and the shift in vegetative community types over the same period.

From: Naiman, et al.. 1988. Bioscience 38(11).

A wetland classification scheme based on hydrology and nutrients

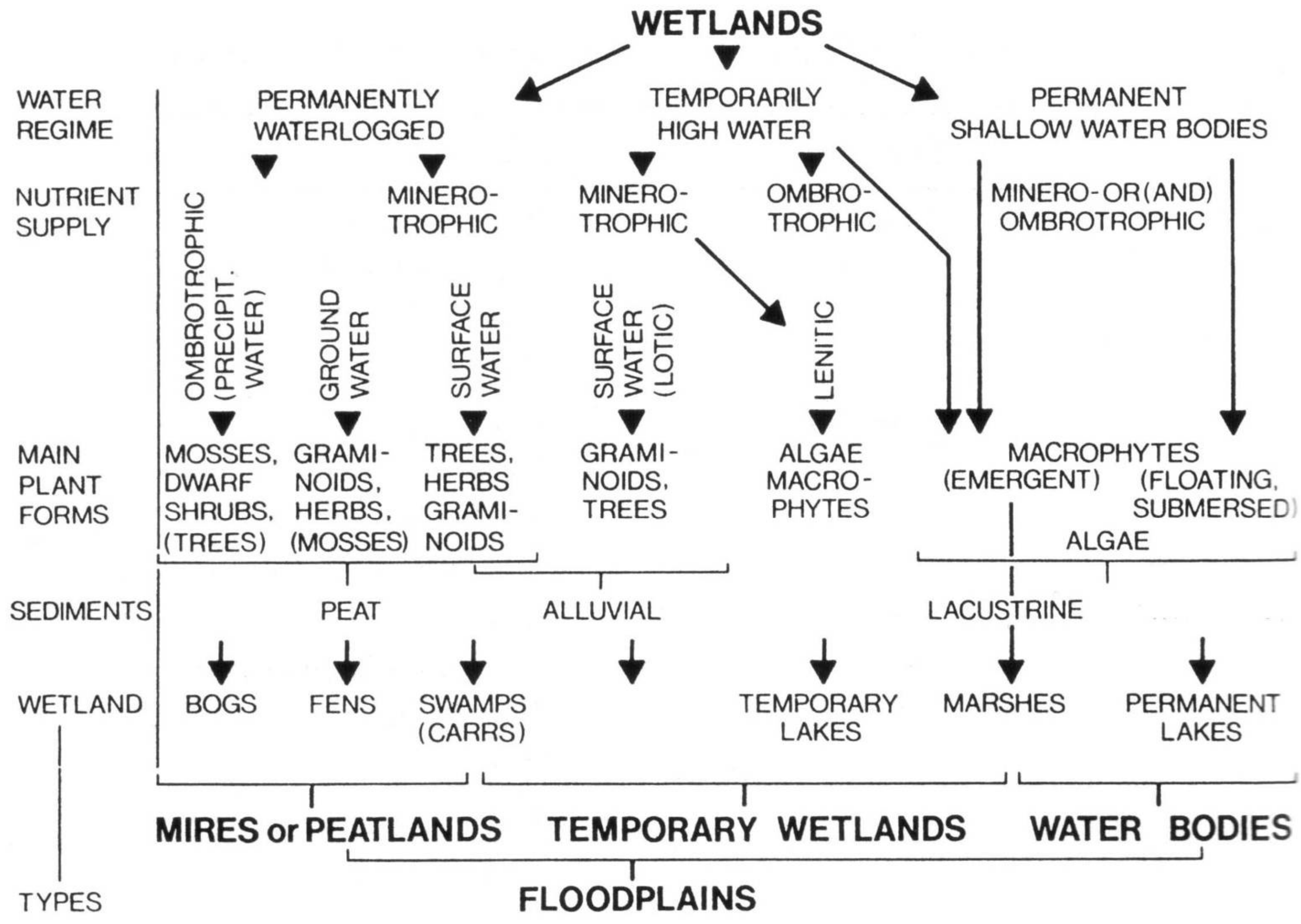


Figure 1.9 Wetland type is related to environmental factors such as water regime and nutrient supply (from Gopal *et al.* 1990).