Engineering: Building with Nature MOOC

Ecological Design Principles

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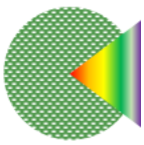
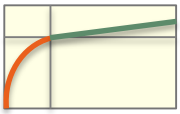
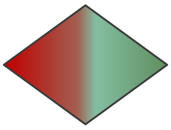
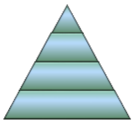
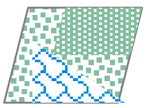
- *What does nature-friendly design mean?*
- *What are the principles upon which it is based?*
- *How do you include ecosystem-based thinking in your hydraulic engineering design practice?*

Answering these questions enables a multi-disciplinary negotiation space to emerge between ecology, environmental science and engineering design. This document attempts to answer the questions by expounding a set of eleven Ecological Design Principles.

Remember, we are not discussing the potential impacts of the infrastructure on the environment, nor are we evaluating the goods and services deriving to humans from an ecosystem. Instead, we are learning how to make design choices that accord more fully with the character and functional integrity of the ecosystem.

By applying the Ecological Design Principles fully across multiple time and scales, you can ensure that the inherent character and functional integrity of the ecosystem is maintained. Moreover, if you apply them along with the Engineering Design Principles, you connect your hydraulic engineering design choices with choices to conserve, restore or provide opportunities for the ecosystem. That is, you practice Building with Nature!

1. Continuity 	Continuity of water and sediment flows and land-water interfaces in the ecosystem. An ecosystem could be well connected or very fragmented. For instance, dams can interrupt the continuum of a river, and alter the quantity of water and sediments available in the downstream river. In another example, coastal defences such as closed groynes can interrupt the longshore transport of sediments, whereas an open groyne system continues to allow some sediment transport.
2. No direct human disturbance 	This aims to minimize or prevent direct human disturbance on the ecosystem. Where direct disturbance occurs, the health of the ecosystem may be affected.
3. Endogeneity 	Level of invasion of an ecosystem by exotic species. A high level of indigenous species is preferred above invasive colonisation. Invasive species can limit the survival opportunities of native species. Therefore, a hydraulic structure or its associated activities should not advantage invasive species above indigenous species. For example, the Zebra mussel is an invasive species in European and north-American waters.

4. Population viability 	A species is viable when it has the ability to persist. That is, its size exceeds a critical threshold. When its size is below the threshold, the population may face extinction. An infrastructure should not threaten the ability of populations to persist, but instead should provide opportunities for endangered populations.
5. Opportunity for threatened species 	Because the ability of threatened species to thrive is compromised, particular attention can be paid to creating opportunities for their survival and restoration. Hydraulic infrastructures can help by offering, rather than denying, new habitats, restoring connectivity and improving circulation, for instance. This criterion focuses on particular species - the species level - rather than the population level of criterion nr. 4.
6. Trophic web integrity 	Ecosystems are complex networks in which matter, energy and living beings interact. A fully representative trophic web has all levels and all species interacting in a healthy way. When critical species, also known as keystone species, are missing the integrity of the trophic web is harmed and the ecosystem is no longer healthy. For example, when urchins are missing from a coral reef environment, algae take over and smother the coral.
7. Opportunities for ecological succession 	Ecological succession is the natural change in the species present in an ecosystem over time. For instance, pioneer plant species that grow on a newly forming dune are later replaced by secondary vegetation as the dune becomes more stable. Finally, the ecosystem achieves its climax state when tertiary vegetation such as woodland is fully established. According to this principle, opportunities for the process of dynamic change should be ongoing and need to be offered for each and every stage from pioneer to climax.
8. Zone integrity 	Zone integrity aims to ensure that the natural mosaic of the ecosystem is fully represented. The presence of the full range of zonal diversity is a condition for ecosystem health. When one or more zones are missing, the integrity of the ecosystem is compromised. For instance, an estuarine saltmarsh is characterized by a continuum from submerged mud flat to the upland zone that is only occasionally inundated. A missing or underrepresented zone would signal an imbalance in the ecosystem, possibly in response to atypical abiotic forcing or habitat disturbance.

9. Characteristic (in)organic cycles 	This principle relates to the integrity of the throughputs of carbon, nitrogen, phosphorous and silicon in an ecosystem. Inorganic and organic cycles that are fully representative and that function at all levels within their natural ranges, act to support and enable ecosystem character and functioning. When the throughputs are disrupted or pushed outside their natural ranges, the character and functioning of the ecosystem can alter. For instance, when dunes receive an excessive supply of nitrogen via air pollution, tertiary dune vegetation growth is over-stimulated and the natural dynamic movement of sand is limited.
10. Characteristic physical-chemical water quality 	This principle aims to ensure that the natural distribution of water quality states is maintained over time and space. When water quality parameters are within their dynamic natural ranges, ecosystem functions are supported. Otherwise, atypical events can be triggered. For example, when oxygen levels become depleted, algal blooms and even fish kills can occur.
11. Resilience 	Resilience is the capacity of the ecosystem to maintain its integrity following consecutive disturbances. Therefore, an ecosystem is resilient when it is able to withstand and even benefit from reasonable, foreseeable disturbances. An ecosystem is vulnerable when its character and functional integrity will alter after single disturbances.

References and Further Reading

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