Key Findings for Impacts of Urbanization on Wetlands

Urbanization contributes to direct habitat loss, modifies hydrological and sedimentation regimes, and alters the dynamics of nutrients and chemical pollutants (Lee, et al., 2006). This leads to a shift in species dominance and ecosystem productivity. When wetland ecosystem services are degraded, they must often be replaced by more costly water treatment and flood control practices (Wright, Tomlinson, Schueler, Cappiella, Kitchell, & Hirschman, 2006). For understanding how wetlands will respond to changes, it is important to consider the combination of multiple stressors (Mantyka-Pringle, Martin, Moffatt, Linke, & Rhodes, Understanding and predicting the combined effects of climate change and land-use change on freshwater macroinvertebrates and fish, 2014).

Hydrological changes and water level fluctuations influence biological communities

- Watershed imperviousness and forested area and the wetland's degree of outlet constriction were significant factors affecting the wetland's hydroperiod (REINELT, HORNER, & AZOUS, 1998).
    - Wetlands with water level fluctuations of 20 cm resulted in lower plant richness and fluctuations above 20 cm were more likely to result in low amphibian richness.
- Flooded conditions reduced plant species richness, especially for annuals (Baldwin, Egnotovich, & Clarke, 2001).
- Shallow flooding (submerged by 10 cm) early in the growing season is a more important determinant of vegetation community composition than flooding later in the season (Baldwin, Egnotovich, & Clarke, 2001).
    - Early season floods can have a large impact on species diversity by significantly reducing seedling recruitment and growth (Baldwin, Egnotovich, & Clarke, 2001; REINELT, HORNER, & AZOUS, 1998).
- Small increases in frequency and duration of inundation reduced diversity of plant communities (Baldwin, Egnotovich, & Clarke, 2001).
- Changes to the hydrological regime results in reduced species richness and loss of sensitive species (Elton, Del Giudice, Montgomery, & Roberti, 2011; REINELT, HORNER, & AZOUS, 1998).
    - Change in open water conditions shifts dominant vegetation and ecology of system (Elton, Del Giudice, Montgomery, & Roberti, 2011).
    - Plant community shifts toward composition of invasive and tolerant plants (Wright, Tomlinson, Schueler, Cappiella, Kitchell, & Hirschman, 2006).
- Prolonged flooding, and sediment and nutrient additions accelerates growth of tolerant, fast growing plants, such as reed canary grass (*Pharalis arundinacea*), which are then able to invade easily (Kercher, Herr-Turoff, & Zedler, 2007).
    - Prolonged flooding and sediment additions resulted in a decline of resident native species. Since native species were unable to utilize supplementary resources, invasive species could proliferate.

Watershed's land cover influences waterbody's biodiversity

- Percent land cover within watershed was negatively correlated with zooplankton richness, macrophyte abundance, molluscan presence, and amphibian presence (Dodson, 2008).
  - Herbicide application likely reduced primary production by macrophytes decreasing subsequent resources available for herbivores and predators.
  - If a watershed is more than 30% covered in lawn, a pond will have a few zooplankton, no macrophytes, no snails, and no amphibians.
- Impervious cover was a strong predictor of chloride trends within lakes (Dugan, et al., 2017).
  - Lakes surrounded by more than 1% impervious land cover showed increasing chloride trends.
  - Impervious surfaces and road density within at least 500 m of a lake were associated with increased chloride.
- Taxonomic groups became more homogenous in direct or indirect response to aquatic ecosystem degradation in wetlands of developed landscapes (LOUGHEED, MCINTOSH, PARKER, & STEVENSON, 2008).
  - Wetlands in undeveloped areas had species-rich heterogeneous communities dominated by floating-leaved plants whereas nutrient rich wetlands in developed areas were dominated by duckweed, suggesting a shift to an alternative stable state.
  - Duckweed dominance was associated with a change in community of macrophytes, diatoms, zooplankton and macroinvertebrates.
- Invertebrate community indices decline with increasing imperviousness (Wright, Tomlinson, Schueler, Cappiella, Kitchell, & Hirschman, 2006).
- Amphibians and reptiles are susceptible to decline because they depend on buffer habitats around wetland (Wright, Tomlinson, Schueler, Cappiella, Kitchell, & Hirschman, 2006). Amphibian richness and abundance decline with impervious cover and water level fluctuation increase.

Climate Change

- Models showing the combined impacts of urbanization and climate change demonstrate that these influences can be the leading drivers for declines in macroinvertebrates and fish populations (Mantyka-Pringle, Martin, Moffatt, Linke, & Rhodes, Understanding and predicting the combined effects of climate change and land-use change on freshwater macroinvertebrates and fish, 2014).
  - Urbanization results in higher nutrients and runoff, while climate change will also contribute to higher nutrients and warmer water temperatures.

Prioritization for wetland conservation

- When the combined threats of climate change and land-cover change were taken into account, riparian restoration was the most effective adaptation strategy (Mantyka-Pringle, et al., Prioritizing management actions for the conservation of freshwaterbiodiversity under changing climate and land-cover, 2016).

  - When costs were considered, farm and land management and stream riparian restoration were the most cost effective options for preserving freshwater macroinvertebrates and fish richness.

Recommendations:

Landuse within Watershed:

- Lawn area should be limited within a watershed; suburban developments should have more meadow or woodland habitat as opposed to lawns (Dodson, 2008).
- Best management practices for road salt application should be applied to roads in close proximity to waterbodies (Dugan, et al., 2017).
- Minimize impervious surfaces and maximize forest retention (REINELT, HORNER, & AZOUS, 1998).

Hydrologic Regime:

- It is important to maintain water quality and hydrological regime throughout urbanization because timing of inundation and duration impacts flora and fauna diversity (Elton, Del Giudice, Montgomery, & Roberti, 2011).
  - Both surface water and groundwater hydrology need to be preserved.
  - Low impact development techniques need to be implemented in development because they represent the best available technology.
- Since the combined effects of prolonged flooding, sedimentation, and excess nutrients, favor invasive reed canary grass, efforts should be taken to infiltrate water in uplands so that periods of wetland flooding are reduced (Kercher, Herr-Turoff, & Zedler, 2007).

Wetland conservation:

- Protection should be focused on the wetlands that are most sensitive (Elton, Del Giudice, Montgomery, & Roberti, 2011).
- When federal and state regulations are insufficient to protect wetlands, gaps can be closed through local regulations (Wright, Tomlinson, Schueler, Cappiella, Kitchell, & Hirschman, 2006).
- Land-use controls can be implemented in watershed's of sensitive wetlands. These controls should focus on minimizing water level fluctuations and impervious surfaces, clustering growth away from hydrological source areas, reducing construction during the wet season, and retaining forests (REINELT, HORNER, & AZOUS, 1998).
- To cost effectively conserve wetlands, prioritize stream riparian restoration and farm and land management (Mantyka-Pringle, et al., Prioritizing management actions for the conservation of freshwaterbiodiversity under changing climate and land-cover, 2016).

- Riparian restoration is the most effective tool for buffering the impacts of climate change and urban growth (Mantyka-Pringle, Martin, Moffatt, Linke, & Rhodes, Understanding and predicting the combined effects of climate change and land-use change on freshwater macroinvertebrates and fish, 2014)

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