Effects of Flooding on Survival and Performance of Potential Replacement Species in Black Ash Swamp Hardwood Forests

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Overview:

- Flood Duration Experiment
  - In 2020, 18 species of tree seedlings were exposed to water tables at the soil surface for 3, 6, 9, 12, and 15 weeks. Basal diameter growth, height growth, and survival were assessed to determine suitability to flooded conditions.
  - American elm (*Ulmus americana*), river birch (*Betula nigra*), and bald cypress (*Taxodium distichum*) had the highest and most consistent height and basal diameter growth across flooding duration treatments.
- Water Table Depth/Shade Experiment
  - In 2021, 23 species of tree seedlings were exposed to three water table depths (0, 14, 27 cm below soil surface) and three light reduction levels (0%, 40%, 70% reduced) assigned in a 3 x 3 factorial design. Basal diameter growth, height growth, gas exchange rates, and survival were assessed to determine suitability to flooded conditions.
  - Depth of water table below soil surface during the growing season has a greater effect on seedling growth and gas exchange rates than light reduction.
- In the water table depth/shade experiment, bald cypress had the highest and most consistent height growth and photosynthetic rates across water table depth and light reduction treatments.

Summary:

Black ash (*Fraxinus nigra*) swamps represent 4.5% of the forested area in the western Great Lakes region (Michigan, Minnesota, Wisconsin). Within the swamp hardwood cover type, black ash comprises 40% to almost 100% of the canopy cover and acts as a foundational species, impacting hydrologic regime, nutrient cycling, and wildlife habitat. The dominance of

black ash in these stands makes them particularly vulnerable to the invasive emerald ash borer (EAB) (*Agrilus planipennis* Fairmaire) (Coleoptera: Buprestidae). EAB infestation can result in a mortality rate of up to 99% for ash species within 5 to 7 years. Due to the threat EAB invasion poses to the structure and function of black ash forests, research is being conducted to determine adaptation strategies for managers. One such strategy is to increase tree species diversity through artificial regeneration (from planting). However, there is limited information available on how potential replacement tree species respond to flooding and available light (shade).

Silvicultural Concepts:

- Flood Duration Experiment
    - Silver maple (*Acer saccharinum*), river birch, American elm, sycamore (*Platanus occidentalis*), and bald cypress showed the highest and most consistent height and basal diameter growth rates across flood duration treatments.
    - Red maple (*Acer rubrum*), yellow birch (*Beluta alleghaniensis*), swamp white oak (*Quercus bicolor*), and tamarack (*Larix laricina*) exhibited high and consistent height and basal diameter growth rates after having been flooded for 3 to 9 weeks.
- Water Table Depth/Shade Experiment
    - Bald cypress had the highest and most consistent height growth and photosynthetic rates across water table depth and light reduction treatments.
    - Black spruce (*Picea mariana*), white spruce (*Picea glauca*), tamarack, trembling aspen (*Populus tremuloides*), northern white cedar (*Thuja occidentalis*), red maple, American basswood (*Tilia americana*), American elm, yellow birch, silver maple, hackberry (*Celtis occidentalis*), river birch, swamp white oak, and sycamore exhibited high and consistent growth and gas exchange rates after having been exposed to water table depths 14 cm below soil surface for 15 weeks.
- In the water table depth/shade experiment, bald cypress, tamarack, trembling aspen, river birch, and sycamore exhibited the highest transpiration rates.

Management Applications:

- Managers can use the results of this study to choose a suite of species that will establish successfully under the local conditions in their black ash wetlands threatened by emerald ash borer.

Figure 1—During the flooding duration experiment, flooding was simulated by filling stock tanks with tap water up to the soil surface.

Figure 2—For the water table depth/shade experiment, water table depth treatments (simulated in stock tanks) were nested within light reduction treatments. Gas exchange measurements were taken with both the Licor 6400 and 6800.

Table 1—Survival percentage for each species in the flood duration experiment.

	Treatment				
Species	**3-week flood**	**6-week flood**	**9-week flood**	**12-week flood**	**15-week flood**
Red maple	100	100	100	88	50
Sugar maple	25	0	13	25	13
Silver maple	100	100	100	100	100
Yellow birch	88	100	75	75	38
Bitternut hickory	75	63	100	100	100
River birch	88	100	100	100	100
Black walnut	0	13	0	0	13
White oak	88	88	63	63	63
Swamp white oak	100	100	88	88	100
American elm	100	100	100	100	100
Tamarack	63	100	38	100	38
White spruce	63	38	50	50	38
Black spruce	75	50	0	50	38
Red pine	100	88	38	75	50
White pine	100	88	63	63	88
Northern white cedar	75	50	75	88	100
Sycamore	100	100	100	100	100
Bald cypress	100	100	100	100	100