Wisconsin Lakeshore **Restoration Project**

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Preliminary Findings

In 2007, the first-ever Environmental Protection Agency's National Lakes Assessment (NLA) confirmed the significance of lakeshore habitat to lake biological health. Nationally, the most widespread stressors measured as part of the NLA were those that affected the shoreline and shallow water areas, which in turn can affect biological condition. Results from the NLA showed that the most widespread of these is the alteration of lakeshore habitat (EPA 2007). That same year, the Wisconsin Department of Natural Resources (WDNR) initiated a long-term study to quantify the ecological benefits of lakeshore restoration on lakes with shoreland significantly altered by development for housing and recreation in Vilas County, Wisconsin, USA (see the spring 2009 *LakeLine*).

Vilas County, which is within the Northern Highland Ecological Landscape, encompasses a 2,636-km^2 area along Wisconsin's northern border with the Upper Peninsula of Michigan. This is an area of Wisconsin that is home to the third-largest concentration of freshwater glacial lakes on the planet. Approximately 53 percent of the county is privately owned; the remainder is in county, state, and federal forests, or in tribal jurisdiction. Though the population is <20,000, Vilas County has undergone relatively high residential development recently with 61 percent occurring within 100 meters of lakes. WDNR partnered with local conservation departments, contractors and nurseries, landscapers and designers, and others on rehabilitating lakeshore habitat by planting native trees, shrubs, and groundcover, and installing shore and toe erosion management systems within a ten-meter buffer (35') of the ordinary high water mark (OHWM). The Wisconsin Lakeshore Restoration Project investigates whether these endeavors led to enhanced wildlife habitat and upgraded water quality. Simply put: Are the efforts of these shoreland property owners making a difference?

The goal of the long-term inventory and monitoring project is to assess whether wildlife populations and native plant diversity increases on restored lakeshores and whether the restored habitat approximates that found on paired, reference lakes. Each paired "Reference Lake" was chosen to have similar morphometry, chemistry, and land cover to the "Developed Lakes." Habitat and wildlife measures are made at "Control" and "Restored" lakeshores on the Developed Lakes and compared to the Reference Lakes having similar aspect, slope, and fetch. The following are highlights of preliminary findings from this work to date, which is now in year seven of the ten-year study.

Carnivore distribution on high-developed vs. low-developed lakes

Earlier studies comparing low- and high-development lakes in Vilas County documented declines in the flora and fauna on the high-developed lakeshores (Elias and Meyer 2003; Lindsay et al. 2003; Woodford and Meyer 2003). However, very little was known about the effect of residential development on the mammalian carnivore community in this region, especially along lakeshores. We paired ten low-development lakes (< 10 houses/km, mean = 2.10 ± SE 0.64) with ten high-development lakes (≥ 10 houses/km, mean = 23.45 ± SE 2.69) and conducted winter track surveys between January-February 2008. Track surveys were conducted along the lakeshore 48 hours after snowfall. We recorded all fresh carnivore tracks encountered ten meters on each side of the survey transect. In addition, we tallied encounters with white-tailed deer (*Odocoileus virginianus*).

We calculated Shannon's index of species diversity for each lake. We documented 83 encounters of tracks of nine carnivore species across all lakes sampled. Five of the nine species were detected exclusively on low-development lakes (see Figure 1). Coyotes (*Canis latrans*) were the most encountered species (n = 34) across all lakes. Red foxes (*Vulpes vulpes*) and raccoons (*Procyon lotor*) had the highest encounters on high-development lakes (Figure 1). Shannon's index of species diversity was significantly higher (t = 3.547, df = 9, P = 0.006) on low-development (mean = 1.974 ± 0.438 SE) than on high-development lakes (mean = 0.277 ± 0.113 SE). Overall, there were twice as many carnivore species on low-development lakes (n = 8) than on high-development lakes (n = 4). For non-carnivore species, white-tailed deer were abundant on all high-development lakes, but were detected on only 50 percent of low-development lakes. Our results suggest that high-development lakes are having a negative effect on the carnivore community in this region. The absence of apex carnivores in an ecosystem can have a significant effect on the relative abundance of herbivores and small carnivores. This trend can lead to further reductions in biodiversity because of overgrazed native vegetation and reduced nesting bird abundance (Haskell et al. 2013).

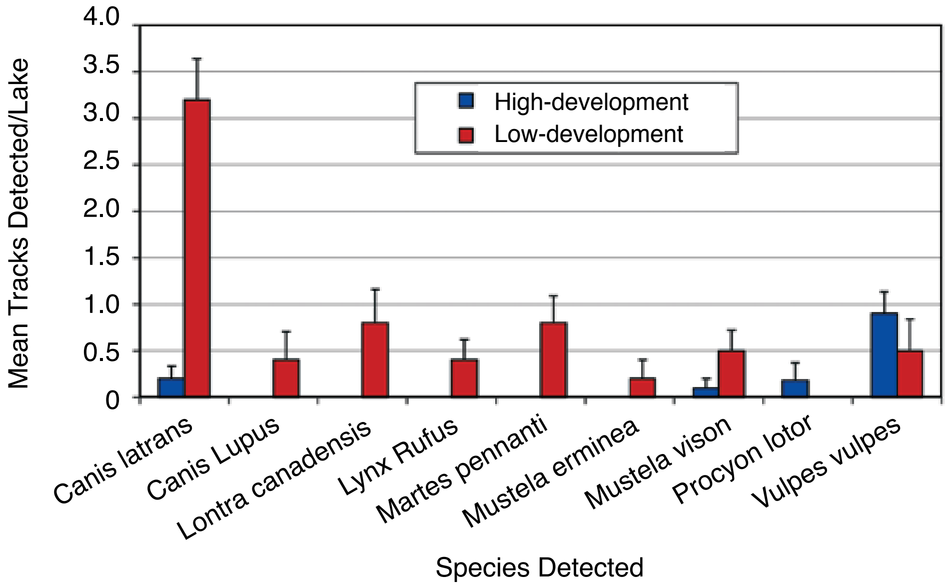

Figure 1. The mean and standard error of individual species detected by snow track surveys within pairs of ten lakes each pair containing a low- and high-development lake, in Vilas County, Wisconsin, USA. Data was collected in January and February of 2008 (Haskell et al. 2013).

Native plant communities prior to lakeshore restoration

Previous research in the Northern Highlands documented significant effects of housing development on lakeshore habitat, including a reduction in near-shore tree and shrub canopy, floating aquatic macrophytes, tree and sapling canopy in the uplands, and coarse wood in the littoral zone, near-shore zone, and uplands within the terrestrial buffer (Elias and Meyer 2003). In this project, we quantified and compared the abundance and diversity of trees, saplings, and shrubs measured at 50 ten-meter x ten-meter vegetation plots on Reference Lakes (Jag, White Sand, Starrett, Star, and Escanaba Lakes) to that measured at 49 vegetation plots on Developed Lakes (Moon, Lost, Crystal, Little St. Germain, and Found Lakes-both lake sets are in Vilas County, WI, USA). Vegetation plots on Developed Lakes occurred systematically (one plot every 50 meters) along lakeshores slated for restoration activities, with measurements made the year prior to restoration activities (see Figure 2). Vegetation plots on Reference Lakes also occurred every 50 meters along a lakeshore selected to provide similar physical characteristics (fetch, slope, and aspect) as the lakeshore to be restored at the paired Developed Lakes. Measurements were made concurrently with those at the Developed Lakes (see Figure 3). We also compared canopy openness using digital photography and WinSCANOPY software and counted and measured the amount of coarse wood (logs, snags, stumps) present (see Figure 4). Measures made at Reference Lakes were compared to those made at Developed Lakes using nonparametric techniques (Kruskal Wallis nonparametric analysis).

We found the total number of trees per plot and the tree species diversity index (SDI) were significantly greater at vegetation plots on Reference Lakes, however trees were larger (as indexed by average basal area measured at breast height) on Developed Lakes. The total number of small tree saplings (dbh <5cm at 1.37m height) per plot and SDI were significantly lower on Developed Lakes, however similar numbers of large tree saplings (dbh > 5cm at 1.37m height) and sapling SDI were measured on Reference vs. Developed Lakes. Similarly, the total number of small shrubs (<1.37m) per plot and SDI were greater at Reference vs. Developed sites, however the number and SDI of large shrubs (>1.37m) were similar. There was a greater number and larger diameter of downed woody material (DWM) present at plots on Reference Lakes vs. Developed Lakes, however there was no difference in the number of snags or stumps present in the two lake categories. Analysis of canopy openness indicated canopy openness was greater

Figure 2. Project botanists record vegetation data at a lakeshore site in June 2007.

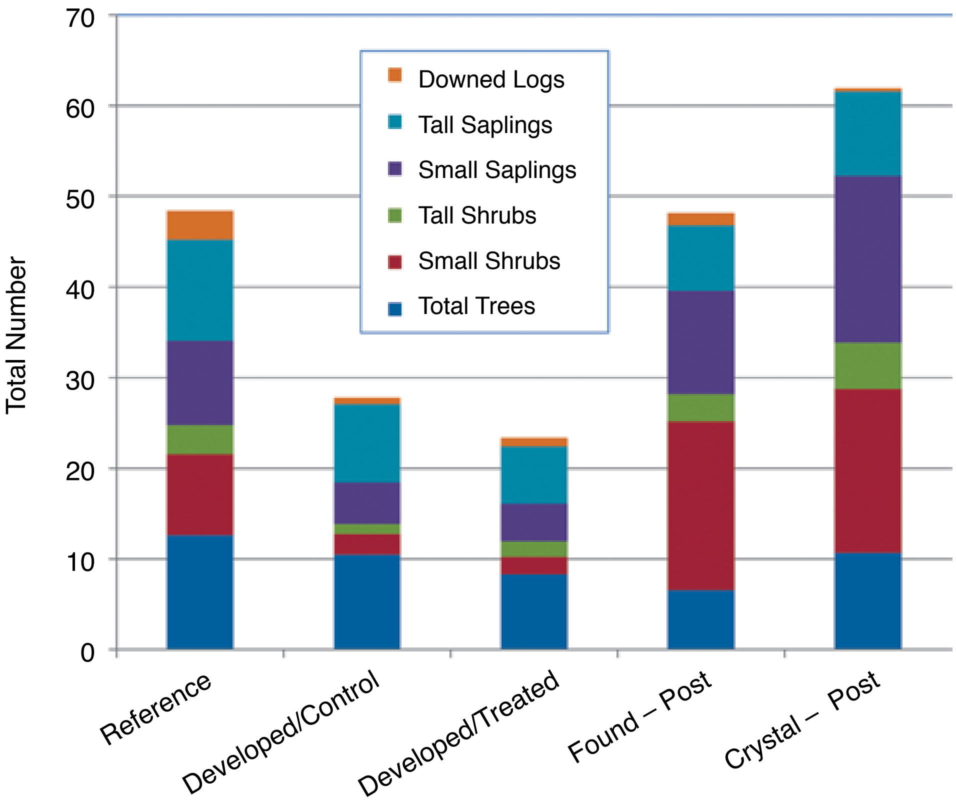

Figure 3. Initial habitat structure at vegetation plots along reference shorelines on undeveloped lakes (n=5) as compared to vegetation plots at control shorelines on developed lakes (n=5) and treated shorelines (shorelines selected for habitat restoration) on developed lakes (n=5). Also, conditions at 2 "treated" lakeshores, two to three years after planting (Found and Crystal).

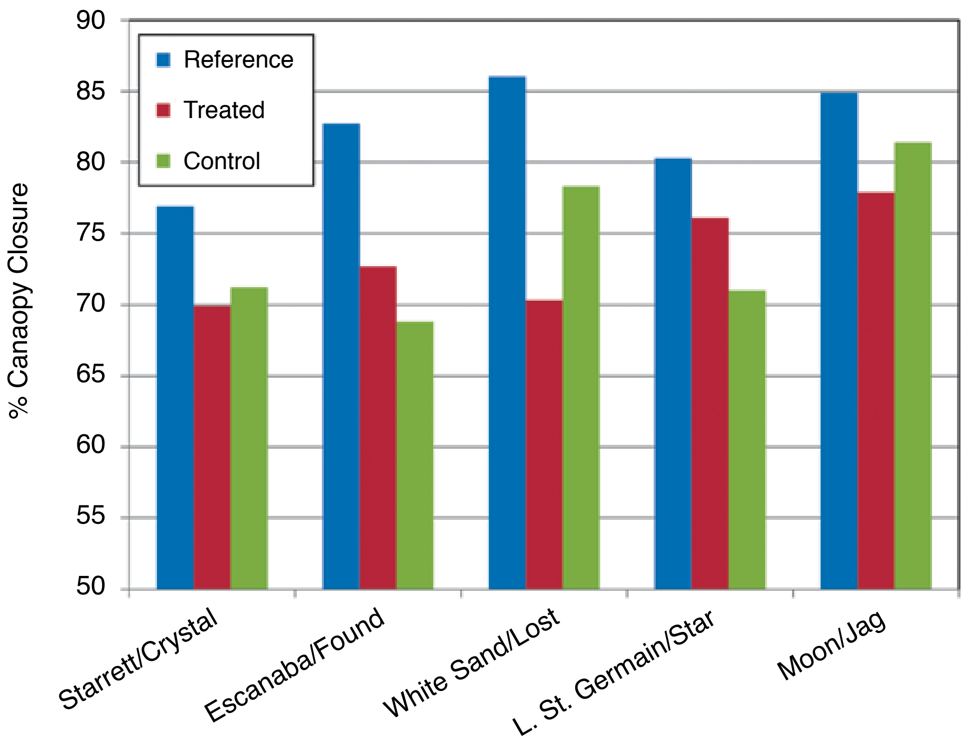

Figure 4. Initial forest canopy closure at vegetation plots along reference shorelines on undeveloped lakes (n=5) as compared to canopy closure at vegetation plots at control shorelines on developed lakes (n=5) and treated shorelines (shorelines selected for habitat restoration) on developed lakes (n=5).

at Developed vs. Reference Lakes. These results support the overarching goals for restoration efforts – to increase the density and diversity of small saplings and shrubs, to augment DWM when needed, and to work towards a plant community with greater canopy closure once mature.

Native plant communities at Developed Lakes two-three years post-restoration

To date, we have re-measured vegetation plots at two Developed Lakes where restoration plantings have occurred (Found and Crystal Lakes). These measures were made two-three years following the plantings, and results are compared to: (1) measures made at the same plots prior to restoration; and (2) to vegetation plots at the paired Reference Lakes. Total trees per plot did not differ at vegetation plots pre- and post-restoration at both Found and Crystal Lakes as no tree-sized individuals were planted, only saplings. The total tree count at Crystal was similar to the Reference Lake (Starrett) following planting; however, total trees per plot were significantly lower at Found Lake as compared to the Reference Lake (Escanaba) following planting. This is likely due to a wind event which toppled many of the mature trees at the Found Lake sites in the 1990s – saplings will need to mature to replace the tree canopy on this lakeshore.

As intended, small saplings and total sampling count were significantly greater at the Found Lake plots post-planting. Additionally, the number of saplings also increased at Crystal Lake plots post-planting; however, the difference was not statistically significant. Following planting, there was no difference in sapling numbers or sapling species diversity at the Developed/Treated Lakes when compared to the Reference Lakes indicating similar sapling numbers and diversity were achieved by the restoration plantings.

Shrubs were significantly more abundant at the Found Lake plots post-planting, and significantly exceed the number at the Reference Lake (Escanaba). This reflects the fact that succession will need to occur at Found Lake, trending towards a closed tree canopy in the future. Shrubs are less abundant on the Reference Lake as trees there are mature and the canopy is mostly closed. Small stature shrubs were more abundant at Crystal Lake following planting, and total shrubs were similar in number to the Reference Lake (Starrett) post-planting. Downed woody material (DWM) was more abundant at Found Lake, but not Crystal Lake following plantings. DWM study plots were included in the Found Lake restoration design, providing the increased numbers. DWM at both Crystal and Found Lakes were still significantly less than at the Reference Lakes post-planting, indicating additional DWM augmentation will be required at all restoration sites.

Measuring the value of wildlife habitat restoration on lakeshores

Previous research has shown that lakeshore housing development is associated with changes in breeding bird guild structure and green frog (*Rana clamitans*) abundance and habitat suitability on Developed Lakes in the Northern Highlands (Lindsay and Meyer 2003; Woodford and Meyer 2003). In this project, wildlife surveys (avian, frog calling, and small mammal) were conducted on targeted lakes since 2007 by staff members from Michigan Technological University, North Lakeland Discovery Center, and Moon Beach United Church of Christ.

Breeding bird surveys

Lindsay and Meyer (2002) showed no significant differences between Developed and Undeveloped Lakes in bird abundance, richness or species diversity in the Northern Highlands. However, several species and some resource-guilds were commonly associated with one lake-type or the other. A significantly higher diversity of diet guilds was found on Developed Lakes, though significant declines in the prevalence of insectivorous and ground-nesting birds were documented on these lakes. In contrast, higher prevalence of seed-eating and deciduous-tree nesting birds was recorded on Developed Lakes. Levels of development on lakeshores in northern Wisconsin appear to affect the composition of avian communities, which is of concern for the health of these forested lacustrine habitats.

To test whether lakeshore restoration can mitigate these effects, a 250-meter line transect method was used to characterize breeding bird communities along targeted lakeshores. Transects were placed in our three lakeshore treatments: (1) control, (2) restored, and (3) paired reference. All birds detected by sight or sound were recorded (see Figure 5); however, we selected 24 species as indicators that have specific habitat requirements. In this study, there is no indication to date that any of the indicator species are responding consistently to restoration. This lack of response may reflect: (a) the need for maturation of the restoration sites; (b) the restorations are of insufficient scale to promote avian colonization; or(c) the landscape within which the restorations occur may more strongly influence guild and species composition then the lakeshore restorations themselves. Further investigation is needed to fully understand if the amount of restoration is adequate for breeding birds.

Calling frog surveys

Woodford and Meyer (2003) found lower green frog (*Rana clamitans*) abundance on Developed Lakes in the Northern Highlands, an association with habitat suitability, not necessarily housing density. It was found that habitat features associated with green frog presence included adjacent wetlands, shoreline shrubs, and emergent and floating vegetation, which were frequently less on Developed Lakes. In this study, green frog abundance was quantified by conducting nocturnal calling surveys by canoe along 250-meter transects adjacent to our treatment lakeshores. To date, we found no increase in frog abundance at the restored lakeshores. To enhance restoration benefits, we may want to initiate aquatic macrophyte restoration in the near-shore littoral zone along these lakeshores. Pending receipt of additional funding and permit approval, we will develop tree drop zones (downed whole trees, with root mass anchored to shore, branches extending lakeward) to develop quiet-water areas for macrophyte restoration and to assess green frog response to the practice. Placement of tree drops is currently practiced by WDNR

Figure 5. Volunteers from the North Lakeland Discovery Center's Bird Club (in nearby Manitowish Waters, Vilas County, Wisconsin, USA) perform a bird survey at a lakeshore site in June 2007.

fisheries biologists to augment fish habitat on Developed Lakes in the Northern Highlands. Of note, we had a precipitous decline in calling green frogs at one Reference Lake (Escanaba) 2008-2010, followed by a rebound 2011-present. Ranavirus was diagnosed in a sample of dead frogs found on this lake during that period, when several thousand frogs died.

Small mammal surveys

No previous work was conducted in the Northern Highlands to evaluate the effects of lakeshore housing development on small mammal abundance and distribution. To measure possible effects, Sherman live traps were placed along 250-meter transects on our treatment lakeshores. We captured 2,402 individuals representing 14 species along the small mammal transects (2007-2012). *Peromyscus* spp. and the eastern chipmunk (*Tamias striatus*) were the most common, representing 42 percent and 28 percent of the individuals trapped, respectively.

To date, there is no clear pattern of association with small mammal abundance, diversity, or species occurrence between lake development types. Of interest, however, was the finding that nearly all *Peromyscus* spp. trapped along Developed Lakes were the white-footed mouse *(P. leucopus),* a species previously distributed in central and southern Wisconsin. The northern deer mouse *(P. maniculatus)* was previously common in the Northern Highlands but trapped only at a few sites, mostly on one Reference Lake (Escanaba Lake), which is several miles from any permanent human settlement.

In 2011 and 2012, staff from Marshfield Clinic Research Foundation collaborated with us to investigate how lakeshore development in Vilas County alters the risks for tick-borne infectious diseases (TBIDs) and whether these risks may be reduced by restoration of native vegetation. Tick-borne diseases (Lyme disease) dramatically increased in Wisconsin over the last decade. Because small mammals are also the primary reservoirs for TBIDs, changes in their communities in response to development and restoration may have important implications for the risks of TBIDs to humans and their pets in these areas. For instance, changes in small mammal communities and specifically the dominance of communities by the white-footed mouse are associated with habitat fragmentation in the eastern United States and are hypothesized to be important ecological drivers of human TBID risks (Ostfeld 2011). Our results indicate the probability of a small mammal harboring at least one tick at the Developed, Control sites was significantly higher than that found at the Reference Lake sites. Moreover, small mammals captured at the Restored sites had a significantly lower risk of harboring ticks compared to the developed sites and overall were infested with lower abundances of ticks (see Figures 6 and 7). These observations suggest there may be higher risks of TBIDs at the Developed Lake sites and that lakeshore restoration may somehow mitigate these risks. Efforts are underway to investigate these possibilities further.

Lessons learned in the art and science of intelligent tinkering on lakeshores

- Landowners are essential to any restoration strategy; without willing lakeshore property owners, opportunities for rehabilitating lakeshore habitat are minimal. Within the Northern Highlands, we found interest low among lake property owners. Finding local, on-lake champions of lakeshore rehabilitation work like lake association officers or master gardeners can make for effective peer-to-peer learning and

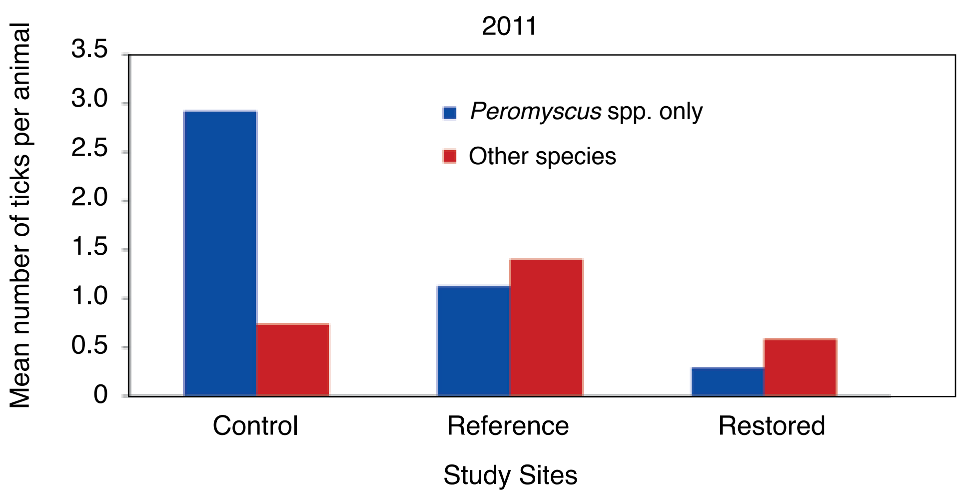

Figure 6. The mean number of ticks infesting Peromyscus *spp. (white-footed and deer mice) and all other small mammal species captured at the lakeshore treatment sites during 2011.*

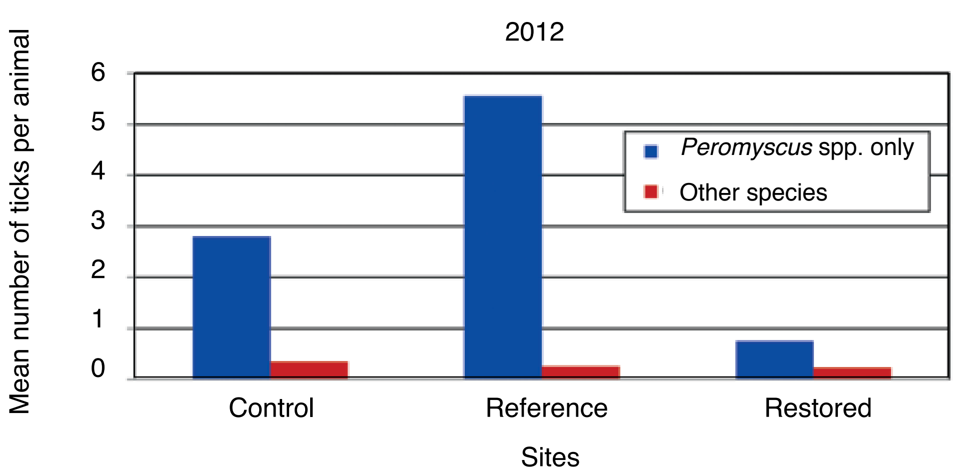

Figure 7. The mean number of ticks infesting Peromyscus *spp. (white-footed and deer mice) and all other small mammal species captured at the lakeshore treatment sites during 2012.*

project buy-in. Two lakes involved with this project had less success with securing landowners because no effective local lake champion could be found to make the case for recruiting suitable lakeshore property owners.

- Natural resource educators, contractors, planners, and other consultants to these landowners need to be hands-on with their assistance. They must openly communicate with landowners to understand their vision for their lakeshore properties on access points, view corridors, plant selection, storage needs, landscaping preferences, and other facets of the project. For example, we need to meet landowners where their landscape values are, whether they champion a "messy look" closer to a wild lakeshore or a "tidy" aesthetic that might accentuate drifts of plants, delineated edgings, and lower growing native vegetation.
- Incorporating ecological design principles of water infiltration, retention, reuse, and flow control into our strategies with landowners pays dividends. This includes low impact development (LID) approaches and practices that are targeted to reduce runoff of water and pollutants like rain gardens and barrels, permeable pavements, green roofs, living walls, infiltration planters, drain systems, water bars, brush bundles, gutters, and cisterns.
- Finding erosion control solutions for landowners to challenges from ice heave and wave action are critical to success. This fact often brings willing landowners to the table for doing shoreland rehabilitation so we need to make sure we address these concerns effectively. Innovative advances in erosion control materials that meet state standards and codes can be found by partnering with land and water conservation departments, consultants, and others.
- Shoreland zoning and other regulatory instruments alone are not enough to protect lakeshore habitat. Lakes with minimum frontage lake lots at 200 feet versus 100 feet (or less) withstand the stressors of human disturbance more positively.
- Holistic and inclusive lake community partnerships can support lakeshore restoration work of all kinds. Be open to possible project helpers like lake organizations, scouting groups, master gardeners, churches and other community organizations (see Figure 8).
- Lakeshore rehabilitation projects are good for local economies and small business owners. Expenditures from these lake projects provide income to area contractors, nurseries, landscapers, erosion control specialists, and others employed in facets of the work.
- Select native plant species that are proven work horses, namely sedges, grasses, and rushes. These soil-holding plants are important to the goal of restoring ecological functions to lakeshore areas and they can persist throughout the transition zone from upland areas to near-shore locations with wet feet.
- Upland species can be a challenge to get established without proper maintenance. The soil condition, aspect, and slopes should be considered when generating a plant list.
- Maintenance is a vital part of the process (i.e., monitoring for ample watering regimes; invasive species control needs; browse protection systems like spray deterrents, temporary fencing, or motion-sensory sprinkler plans; proper dock storage; etc.).
- Degradation of lakeshore habitat cover is the most important stressor of lakes.
- *At present,* voluntary restoration of lakeshore habitat will likely have only a modest influence on watershed health. Even mandatory mitigation requirements wrapped up in local shoreland rules may only marginally increase participation. But when politically possible, shoreland rules or zoning that require lakeshore habitat conservation and restoration can perhaps provide the greatest benefit in the long term. Understanding more deeply and clearly the barriers landowners confront in ultimately accepting the practice of lakeshore habitat restoration and devising

Figure 8. An educational sign describing the Moon Beach Camp lakeshore restoration effort.

marketing strategies that utilize this information may also pay dividends in the future.

- Few wildlife survey results illustrate clear relations to restoration activities two to five years post restoration. It could be that: (1) the scale of restoration is too small to affect change; (2) it is too early to anticipate change given the lack of development of habitat on the restored sites; (3) our survey techniques to date are not sensitive to real changes that may have occurred for birds, frogs, and small mammals; and/or (4) new surveys need to be implemented to measure change that occurs at the scale of our lakeshore restorations.
- Additional surveys need to be implemented to measure change that more likely occurs at the scale of our lakeshore restorations (e.g., pollinators; soil microbes/arthropods; soil chemistry; fine woody material; root growth and depth; etc.).

Acknowledgements

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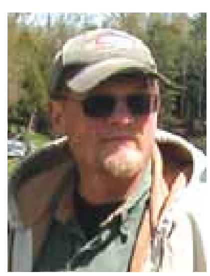

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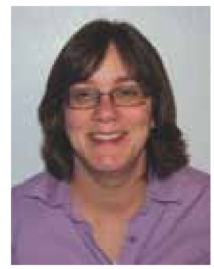

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