Mid-Hudson Young Environmental Scientists (MH-YES) 2021 Program in Watershed Ecology

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Abstract
The 2021 Mid-Hudson Young Environmental Scientists (MH-YES) Program took place in-person this year from July 26 to August 13 at sites in both Millbrook, NY at Cary Institute and in Poughkeepsie, NY along the Fall Kill Creek and at a Marist College laboratory. The 2021 MH-YES program team included four scientists, two high school science teachers, two undergraduate student mentors, and eight high school students. All students, scientists, and one high school teacher hailed from Dutchess County, and one high school teacher was from neighboring Ulster County. Over the course of the three-week program, students learn to develop and complete scientific research projects related to watershed ecology. The entire group collaboratively collected data on water and soil ecology, then they divided into two groups to plan and carry out studies with these data. The two studies were: *Effects of Japanese knotweed on the riparian zone of the Fall Kill and Wappinger Creek* and *How stream proximity and urbanization affect soil nutrients*. In addition to field and lab studies, the MH-YES participants engaged in several enrichment activities, including field trips to Norrie Point Environmental Center and Innisfree Garden. The students gave two final presentations: a virtual presentation to the Fall Kill Watershed Coalition and an outdoor in-person presentation to family and friends at the Mid-Hudson Children’s Museum.

Three Summary Points of Interest:

- A deeper partnership was cultivated between the MH-YES and TIDES programs as a way to strengthen promotion and recruitment efforts for these ‘sister’ programs. This also included a field trip to Norrie Point so that students could learn more about the Hudson River estuary and spark students’ interest in applying for the TIDES program in the future.
- The 2021 program was 3 weeks long, rather than 6 weeks, as a way to provide a more exploratory environmental science experience as well as to fit better into students’ and teachers’ summer scheduling. There were also four scientist mentors who exposed students to many different kinds of research topics and field methods.
- Participants gained essential competencies such as collaboration and scientific communication. Students left the program with more advanced knowledge in watershed ecology, statistics, and public speaking. Results among the program participants have been outstanding with 100% showing measurable gains in their confidence and ability in several scientific research skills, such as formulating hypotheses, performing field research, and analyzing data.

*Keywords: student-driven research, high school students, water quality, Hudson River, Fall Kill, tiered mentorship*

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I. INTRODUCTION
Dutchess County, NY straddles two major watersheds, the Lower Hudson River and the Housatonic. Many streams and other water bodies nested within these drainage basins are high on the NYS DEC Waterbody Inventory/Priority Waterbodies List (WI/PWL), listed as “impaired” or “stressed.” The Fall Kill that runs from Staatsburg to Poughkeepsie, where it empties into the Hudson River is a notable example. Dutchess County is a tapestry of very low to very high density residential areas, planned developments, business districts, land conservation areas, agricultural swaths, and light to heavy industry (dutchessny.gov: Municipal Zoning Maps). Such anthropogenic alterations of the land surface introduce pollutants, alter permeability and runoff patterns, influence vegetation diversity and landscape structure, and produce heat islands, all impacting the overall health of the watershed.

Both the Lower Hudson and Housatonic watersheds have been the subject of ecological studies on the effects of urbanization (Limburg et al 2005), the influence of land use on estuarine sediment and carbon inputs (Howarth et al, 1991), anthropogenic impacts on eel populations (Machut et al 2007), sewage and antibiotic-resistant bacteria (Young et al 2013), and PCB contamination (Donigian, Jr. and Love, 2007). There is a national and regional push to engage more communities in science in general, and in water resources in particular. Recently, there have been citizen science initiatives in partnership with secondary school and college students to investigate bacterial species in a local watershed (Agate et al. 2016). Yet, more research is needed on effective strategies for engaging these communities (de Lacalle and Petruso 2012). We address both the critical need for better understanding of urban streams and the need for effective community engagement strategies through the MH-YES project. The section of Wappinger Creek that flows through Cary Institute provides a useful point of comparison to the Fall Kill.

The impact of involving students in challenging research experiences is well known (Thiry et al. 2016), though the impact on high school students is not as well documented. Zhe et al. (2010) describe a high school STEM bridge program incorporating approaches from the literature for increasing interest and self-confidence in STEM that “was one that relied upon inclusive, inquiry-based science, emphasized problem-based learning, and incorporated visual demonstration.” The program was very successful at encouraging students to attend college, with 86% of those intending to continue to college choosing STEM majors. The near-peer mentoring approach describes a situation in which an undergraduate student involved in a research project mentors a middle or high school student. Tenenbaum et al. (2014) studied this approach for a science education summer research internship program. They found advantages for both groups. High school students had an increased interest and engagement in the STEM disciplines, and undergraduate mentors experienced personal, professional, and educational growth.

The MH-YES project idea was developed as a direct result of discussions of best practices supported by an NSF INCLUDES design and implementation grant awarded to Columbia University. The Secondary School Field Research Program (SSFRP) run by the Lamont Doherty Earth Observatory, in which high school students spend a summer working on research projects with Lamont scientists, highlights the value of near-peer mentoring and involving high school students in real scientific research experiences and has documented success in attracting underrepresented groups to STEM fields (Margie Turrin, pers. comm.). The MH-YES project incorporates these best practices while involving students in research experiences that increase understanding of aquatic ecology and chemistry in the mid-Hudson region.
II. METHODS

II.A. 2021 MH-YES Program Participants

Eight local high school students (see Table 1) comprised the 2021 MH-YES cohort. Seven students live in Dutchess County and one lives in Ulster County (Highland). The MH-YES leadership team consisted of six primary mentors (two undergraduate students, two high school teachers, and two scientists), as well two secondary mentor scientists. Dr. Alan Berkowitz served as Program Director and Ashley Alred as Program Coordinator. Participants spent the majority of the program working together as one whole team for field data collection during weeks one and two; during week three, the students split into two groups for their investigative projects.

<table>
<thead>
<tr>
<th>Year in School</th>
<th>School</th>
<th>Home Town</th>
<th>Race/Ethnicity</th>
<th>Previous environmental science experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rising Senior</td>
<td>Arlington HS</td>
<td>Hopewell Junct.</td>
<td>White</td>
<td>MH-YES 2020</td>
</tr>
<tr>
<td>Rising Senior</td>
<td>Arlington HS</td>
<td>Poughkeepsie</td>
<td>South Asian</td>
<td>TIDES 2021</td>
</tr>
<tr>
<td>Rising Senior</td>
<td>Our Lady of Lourdes HS</td>
<td>Poughkeepsie</td>
<td>East Asian</td>
<td>None</td>
</tr>
<tr>
<td>Rising Junior</td>
<td>Poughkeepsie HS</td>
<td>Poughkeepsie</td>
<td>Black or African American</td>
<td>TIDES 2021</td>
</tr>
<tr>
<td>Rising Junior</td>
<td>Millbrook HS</td>
<td>Millbrook</td>
<td>Black or African American; White</td>
<td>None</td>
</tr>
<tr>
<td>Rising Junior</td>
<td>Millbrook HS</td>
<td>Millbrook</td>
<td>White</td>
<td>None</td>
</tr>
<tr>
<td>Rising Junior</td>
<td>John Jay Senior HS</td>
<td>Hopewell Junct.</td>
<td>Black or African American</td>
<td>None</td>
</tr>
<tr>
<td>Rising Junior</td>
<td>Highland HS</td>
<td>Highland</td>
<td>South Asian</td>
<td>TIDES 2020</td>
</tr>
</tbody>
</table>

Figure 1. Geographic location of the homes of the 8 high school students who participated in the 2021 MH-YES program, denoted by yellow star symbol.
Two local high school science teachers served in the 2021 MH-YES program both as mentors to the high school students and Research Experiences for Teachers (RET) Fellows, developing curricula to bring to their classrooms in Fall 2021/Spring 2022 following completion of the summer program. The 2021 RET Fellows were the same as those in the 2019 and 2020 MH-YES programs: Ms. Kaila Hastings, a biology and marine biology instructor at Arlington High School; and Dr. Deborah Kravchuk, an earth science, biology, and paleontology instructor at FDR High School. Following the 2020 MH-YES program, both teachers expressed a strong interest in participating in again in the future. Being familiar with the unique mentoring structure of the MH-YES program and having insight into how a six-week program functioned and could compare to the new, three-week structure, both teachers were natural choices for the 2021 program.

Undergraduate students served as near-peer mentors for the MH-YES students, assisting with protocol instruction, data analysis, and the research posters and presentations. One undergraduate mentor, Emma Butzler, is a current fourth-year environmental science and policy student at Marist College, Poughkeepsie, NY and serves as a research and teaching assistant to scientist mentor Dr. Zion Klos. Joelle Weir, currently a third-year environmental chemistry and journalism student at the University of Toronto, Toronto, Ontario-Canada, participated the 2018 MH-YES program as a high school student and returned to serve as a mentor in 2021.

Dr. Zion Klos (Associate Professor of Environmental Science) at Marist College and Dr. Jane Lucas (Community Ecologist) at Cary Institute served as primary mentors. Dr. Ilya Fischhoff (Disease Ecologist) and Dr. Emma Rosi (Aquatic Ecologist) at Cary Institute of Ecosystem Studies served as secondary scientist mentors for the 2021 program. Dr. Klos also served as a scientist mentor in the 2019 and 2020 programs. Drs. Lucas and Klos were available in person during the program, while Drs. Fischhoff and Rosi provided guidance virtually via Zoom.

Joint activities with the sister TIDES program at DEC’s Norrie Point were led by Program Coordinator Maija Niemisto and Student Conservation Association member Trevorneize Green. The MH-YES team also attended an ecological tour of Innisfree Garden, facilitated by landscape curator Kate Kerin.

11.B. Recruitment & Interview Process

This year, the Program Coordinator (Ashley Alred) and the coordinator of DEC’s The Institute Discovering Environmental Scientists (Maija Niemisto), or TIDES program, decided to take a new, collaborative approach to recruiting, developing an application, interviewing, and selecting students. They first planned their programs for completely separate dates in the summer (TIDES: early July; MH-YES: late July-early August) so that there was no overlap between programs. To simplify the application process, make it more accessible, and attract a greater array of students, they created a common application form using Google Forms. Google Forms was specifically chosen so that students could easily fill out the application no matter the device they were using (laptop, Chromebook, smart phone, etc.). To contribute to accessibility, there was no requirement to attach a resume, cover letter, or teacher recommendation. The application allowed students to apply for MH-YES only, TIDES only, or both MH-YES and TIDES. This way, some students could potentially participate in a full summer of field research between the two programs, or students might be accepted to one program and encouraged to apply to the other the following year.

During the recruitment process, the Program Coordinator contacted local high school science teachers throughout Dutchess County directly via email, sending out program information and flyers to distribute to students and display on platforms like Google Classroom. She contacted...
teachers in Northeast Dutchess County (Stissing Mountain High School, Webutuck High School, Millbrook High School, and Dover Plains High School) as well as Poughkeepsie High School in Poughkeepsie. She held a Zoom call with students from the environmental club at Arlington High School to share about Cary Institute programming, including MH-YES, in January 2021. The Program Coordinator also reached out to local libraries, Dutchess BOCES, and the Fall Kill Watershed Coalition in Poughkeepsie as a way to share the MH-YES-TIDES program flier. Cary Institute social media sites (i.e., Instagram, Facebook, and Twitter) were utilized for promotion. Since the TIDES Program Coordinator was leading in-person programming for the EELs project during the Spring, she was able to recruit students via the relationships she built with participating students; Cary hopes to utilize in-person programming in much the same way during future in-person programming.

The MH-YES and TIDES Program Coordinators determined that when evaluating high school students who naturally have limited experience applying to jobs and internships, that the interviews would be the key to reviewing and selecting applicants, rather than place an emphasis on the quality of the initial application. They took the time to interview all 54 applicants who applied before the deadline either together or separately, depending on the student's program interest. Of these, 23 applicants were interested in both programs, 15 in MH-YES only, and 16 in TIDES only. In total, 38 students applied to be in MH-YES this year. This was a remarkable turnout for the first time implementing this collaborative recruitment and interview process. During and after interviewing the students, the Program Coordinators held discussions with each other to assess the students and took detailed notes. They determined which students would be finalists to be awarded the opportunity to attend both programs or one of the programs.

For MH-YES specifically, the Program Coordinator selected a group of eight “finalists,” and also created a ranked list of other students to offer the position to if any of the eight declined. The Program Coordinator gathered feedback and advice for determining these finalists from the Program Director and the two high school teacher participants. The Program Coordinator considered a holistic set of factors to determine the 2021 MH-YES group composition including but not limited to the following: interest in environmental science, experience with environmental science within and outside of classroom experience, participation in past MH-YES or TIDES programs, their personality traits (e.g., did their teachers recommending them mention that the student was particularly inclusive or kind toward others, were they a leader, were they quiet yet a strong team member, etc.), their grade level, their personal background, and the school they attend. For these eight students, the Program Coordinator requested a teacher contact who could provide a recommendation; the teachers were contacted via email and all provided high accolades for each student. Once this recommendation was received, the students and their parents were notified of their acceptance in early June. All eight accepted. There were two students who also accepted a position with the TIDES program, so they participated in five full weeks of summer field research.

II.C. 2021 MH-YES Program Restructuring

The Program Coordinator and Director decided to restructure the 2021 program in two primary ways. The first was designing a three-week, as opposed to six-week, program as a way to shift and improve student outcomes, as well as increase accessibility during the summer for both students and mentors. The second positive change was to broaden the types of students selected for the program to allow students to participate for a second summer and to welcome students earlier in their high school years.
Informed by feedback from past MH-YES programs, planning meetings with scientist and teacher mentors, and discussions with the Program Coordinator of the TIDES program, it was determined that a 3-week program was worth considering for many reasons. A shorter program would fit into student and mentor schedules more easily during a busy summer. The new design would also place less of an emphasis on a long-term, in-depth field research project and more so on broader, more explorative research opportunities during a shorter program. Since the MH-YES program seeks to involve students with little to no environmental science experience, it makes sense to expose students to many different kinds of research and career opportunities as a way to get them excited about the field of environmental science and all that it has to offer. In light of this goal, there were four, rather than two, research protocols for students to explore. Instead of developing their own research question and study design at the beginning of the program, scientists demonstrated field protocols for the topics of water quality, soil health, animal behavior, and microplastics, and students collected data for these during the first two weeks. By the end of the second week, students developed a sense for the data they were especially interested in exploring more deeply. They then developed a question and selected datasets to analyze and use for their final presentations during the third and final week. There were also a variety of guest speakers, including the program’s own mentors, who shared the richness of the available careers within the environmental science field.

In the spirit of broadening the scope of the program, there were two field site locations representing both a rural site (in Millbrook) and an urban site (in Poughkeepsie). During the three weeks, students collected water and soil data from both the Wappinger Creek on Cary's campus in Millbrook and the Fall Kill Creek in Poughkeepsie. Students could then compare and contrast rural and urban watersheds through both visual assessments and data analyses.

We also made some important changes to who could apply to the program. In previous years, students who had already participated in the program could not reapply. The program was also restricted to rising juniors and seniors. This year, however, we opened the program to MH-YES alumni as well as rising sophomores, as the TIDES program also does. Both of these changes were made in the spirit of providing repeat opportunities for environmental science research as a student progresses through high school. For example, a returning MH-YES student learns new field protocols, increases their research skill proficiency, and also is able to serve as a mentor to peers who may not have had any field experience prior to the program.

At the end of the program, the students presented their research twice, which was also a change from previous years of the program. This provided feedback and practice in science communication. On Thursday, August 12th, students gave virtual presentations to members of the Fall Kill Watershed Coalition, a community-based volunteer group that performs research and promotes stewardship of the Fall Kill Creek in Poughkeepsie. The Fall Kill Watershed Coalition had previously met virtually with students on the first day of the program to share information about the Fall Kill Creek and their personal career paths, so this was a wonderful way for the students to reciprocate and share their research findings back with the Coalition.

On Friday, August 13th, students gave in-person presentations and shared formal scientific posters at their MH-YES Program Celebration at the outdoor pavilion of the Mid-Hudson Children’s Museum in Poughkeepsie. The students were able to present, share their posters, then demonstrate field techniques for their families at the same place along the Fall Kill Creek where they had collected their data. It was a very special event that we hope to replicate in the future, hopefully collaborating with the museum by incorporating public demonstrations for a museum family audience when COVID is no longer a threat to public health.

This report was prepared for the New York State Water Resources Institute (NYSWRI) and the Hudson River Estuary Program of the New York State Department of Environmental Conservation with support from the NYS Environmental Protection Fund.
As with last year, COVID-19 continued to impact society in summer 2021. MH-YES was able to operate in-person this year, but a safety protocol was created informed with CDC safety guidelines and with careful consultation with Cary Institute's safety officer, leadership team, Program Director, program mentors, as well as conversations with all participants' parents.

II.D. 2021 MH-YES Program Activities

Activities in the program were organized in three strands: 1) Team Research Projects, 2) Science Skill Development, and 3) Enrichment, with assessment activities interwoven throughout.

During the week prior to the program, a virtual orientation was held on Zoom as way for all participants (i.e., mentors, students, coordinator, and director) to meet and receive an overview of what to expect for the program. There was ample communication with parents as well, including plans for those who needed transportation to the field sites, which we provided with Cary Institute vans. On day one of the program, the Program Coordinator led the high school students, undergraduate mentors, and teacher mentors in team building activities outdoors, which included fun games and ice breakers to build rapport and get to know the team members. For each day of the program, there was a morning check-in meeting and a wrap-up session at the end of the day, which often included time for journaling and reflection.

The first two weeks of the program were primarily focused on data collection in the field. Day one kicked off the program with introductions to soil ecology, research pedagogy, watershed ecology, and asking scientific questions. From there, Dr. Jane Lucas guided students in soil data collection at both Cary Institute and Poughkeepsie. Also in week one students implemented the groundhog animal behavior protocol designed by Dr. Ilya Fischhoff in Poughkeepsie. The week was wrapped up with students being introduced to water quality field methods by Dr. Zion Klos to prepare them for the second week of aquatic-based data collection. In this final field activity, students also learned how to sample for macroinvertebrates in the Wappinger Creek at Cary, and they preserved their specimens to prepare for dissecting the following week when implementing the microplastics protocol developed by Dr. Emma Rosi.

During the second week, field investigations continued with water-based data collection along Wappinger Creek and Fall Kill Creek. They also sampled for macroinvertebrates in the Fall Kill and completed the microplastics protocol. Students collected additional groundhog animal behavior data and applied these skills by creating their own behavioral ethograms for a new species. By the end of the second week, all data was officially collected, and students were ready to choose which topic and data they wanted to explore more deeply. They formed two groups, one of which wanted to focus possible interactions between the invasive plant species Japanese knotweed and water quality, while the other group decided to investigate how soil health parameters may change near and far from the creeks in both a rural and urban setting.

Week three was all about data exploration and analysis, with students synthesizing their new understanding of their watershed in a scientific poster and a slideshow presentation. Students learned the basics of data analysis and how to create graphs, trend lines, and how to communicate complicated statistics for a public audience. They took on the admirable challenge of putting together a scientific poster, most of them doing so for the very first time, and creating a briefer version of their findings for their virtual presentation to the Fall Kill Watershed Coalition in Poughkeepsie and for their final, in-person presentation to their families.

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The 2021 MH-YES high school students benefited from training and enrichment activities provided by a wide range of individuals and programs, including the undergraduate and high school teacher mentors, Cary scientists, members of Poughkeepsie’s Fall Kill Watershed Coalition, colleagues from Norrie Point Environmental Center, a representative from the Kingston Land Trust, and landscape curators at Millbrook’s Innisfree Garden.

Pre- and post-program surveys and informal interviews provided invaluable information about student interests and outcomes. MH-YES teachers and undergraduates also completed end-of-program surveys, and the two primary mentor scientists participated in a focus group meeting to gather their feedback about the program and its outcomes for them and the other participants.

III. RESULTS AND DISCUSSION

III.A. Scientific Outcomes

One team’s project, guided by Dr. Zion Klos and undergraduate mentor Emma Butzler, was titled, “Effects of Japanese knotweed on the riparian zone of the Fall Kill and Wappinger Creek.” Japanese knotweed is an invasive plant species that forms dense thickets that reduce species diversity along waterways, so the students were curious what kind of impact the presence of this plant might have on water quality indicators like nitrate and chloride. They discovered that Japanese knotweed could possibly have a positive impact on lowering the amounts of nitrite and chloride in creeks, which was a surprising finding for the students since positive outcomes are generally not associated with invasive species.

The second team’s project, guided by Dr. Jane Lucas and undergraduate mentor Joelle Weir, was titled, “How does stream proximity and urbanization affect soil nutrients?” They found that the urban soil samples had higher nitrogen levels, which they hypothesize could be influenced by increased amounts of fertilizers and auto emissions than in rural locations. They also discovered that the soil they sampled at the urban field site was more alkaline, which could be due to limestone or concrete building materials.

III.B. Program Outcomes

One of the main goals of the MH-YES program is to engage a diverse group of students in exciting and authentic research in environmental science, with an emphasis on students from groups traditionally underrepresented in STEM. This year students self-described as being the following: three as black or African American, two as South Asian, one as East Asian, and three as white. Two of the eight students were first generation American citizens, one of whom moved to the United States as a teenager. Several students will be first generation college students as well. One college student self-described as black or African American, and one college student was white. Both high school instructors self-described as white. Although we had record numbers of program applicants, thanks to the new collaborative recruitment and application process with the TIDES program, we acknowledge that we did not have the high turnout in applicants we were hoping from groups underrepresented in STEM. We attribute this recruitment challenge to limitations for direct recruiting due to the ongoing pandemic and the inevitable time required for a new Program Coordinator to build personal connections with teachers, Dutchess BOCES, local libraries, and other community organizations.
Ultimately, the student group was diverse and well-balanced in many ways. This year’s group bonded especially well, with members comfortable and supportive of one another within just a few days of the program. The joy they took in their final presentations and the bittersweet departures afterward were clear evidence of the meaningful relationships that were cultivated during the program.

We also found positive outcomes in the knowledge, skills, and confidence that participants gained and took away from the program. Outcomes for the four groups of program participants – high school students, undergraduates, teachers, and scientists – are described briefly in the following sections.

III.B.1. Participant Outcomes – High School Students

Through both quantitative summaries and qualitative coding of open-ended responses, we found that two main themes emerged from the pre- and post-survey data to describe the primary ways in which MH-YES impacted high school participants: 1) Students reported increased confidence in their ability to perform environmental science skills and 2) The program facilitated relationship-building and teamwork. We have also disseminated MH-YES program participant findings (2020-2021) with a broader audience via a research poster created for the National Association for Environmental Education 2021 Conference (see Appendix A). The following are summary tables of student responses to 2021 post-survey questions.

<table>
<thead>
<tr>
<th>Environmental science research skill</th>
<th>Decreased</th>
<th>Stayed same</th>
<th>Increased</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduct a scientific research project.</td>
<td>0</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Perform fieldwork in my local environment.</td>
<td>0</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Ask research questions and formulate hypotheses.</td>
<td>0</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Use theory to frame research questions and methods.</td>
<td>0</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Design effective research methods and approaches.</td>
<td>0</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Analyze scientific data.</td>
<td>0</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Present publicly.</td>
<td>0</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Read and understand scientific journals articles.</td>
<td>0</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Work as a part of a team.</td>
<td>1</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Openly express my thoughts and ideas to my peers.</td>
<td>1</td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>

As can be seen in Table 2, for most of the environmental science research skills listed in the post-survey, a majority high school students reported that their abilities increased through the MH-YES program. Most notably, seven of eight students rated their ability as increasing for conducting a scientific research project and performing fieldwork in their local environment, which is an outcome we would certainly hope for given the goals of the MH-YES program. It’s encouraging to see that students overwhelmingly rated their scientific skills as either improving, with some noting that their skills remained the same. Having the students rate their abilities for these skills also highlighted areas where participants may need more support in future programs, namely with reading and understanding scientific journal articles, and the social aspects of working as a team and openly expressing thoughts and ideas to peers. As can be seen in Table 2, one student indicated...
a decreased ability to work as part of a team and to express themselves to their peers. This likely stems from some moments of conflict that arose during the third week when students analyzed their data and created the presentations. The students ultimately resolved their differences and worked together to create a successful presentation. These moments highlighted the importance of incorporating a few more times for team building and reflection in future programs. We strive to create an MH-YES team that represents diverse perspectives, which naturally requires support to not only navigate interpersonal differences that may arise, but to develop appreciation and valuation of these differences.

Table 3. Frequency of high school student responses (n=8) in the post-program survey to a self-assessment prompt on how participating in MH-YES made them feel about personal strengths, weaknesses, motivations, and scientific skills.

<table>
<thead>
<tr>
<th>Participating in MH-YES has helped me feel...</th>
<th>Not at all</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>A lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confident to try new things</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>More sure of what my strengths and weaknesses are</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Able to accept responsibility</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Willing to take on a leadership role</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>A desire to help take care of the environment</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>I have a good future ahead of me</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>I am a part of nature</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>I have better science skills</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>I have better research skills</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

While MH-YES is primarily a scientific endeavor, it’s also an opportunity for holistic growth in a number of ways such as increasing personal confidence, self-awareness of strengths and weaknesses, ability to accept responsibility, and becoming more of a leader. Seven of eight high school student participants self-reported that MH-YES positively influenced these feelings (Table 3), but it is worth noting that at least one student felt that MH-YES had a more limited influence on their personal confidence to try new things, being sure of their strengths and weaknesses, ability to take on a leadership role, and that they had a good future ahead of them. As with the Table 2 summary, this highlights the importance of consistent positive guidance and check-ins from the mentors throughout the program to make sure students are feeling supported and uplifted. This survey question also demonstrated that through the program, students had strong feelings of wanting to care for the environment and that they were part of nature, which is a positive outcome given that one of the goals of MH-YES is to help participants better understand and connect to their local ecosystem.

Table 4. Frequency of high school student responses (n=8) in the post-program survey to a self-assessment prompt on how MH-YES impacted select collaborative and scientific abilities.

<table>
<thead>
<tr>
<th>Participating in MH-YES has improved my ability to...</th>
<th>Not at all</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>A lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interact with adults</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Think about how my actions affect others</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Tell other people about what I’ve learned</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Work as part of a team or group</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Share my thoughts and ideas with others</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Be patient</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

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Think critically as I make decisions or try to solve a problem

<table>
<thead>
<tr>
<th></th>
<th>None</th>
<th>Min.</th>
<th>Some</th>
<th>Very</th>
<th>Extr.</th>
<th>Less</th>
<th>Same</th>
<th>More</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field investigations during Weeks 1 &amp; 2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Data analysis during Week 3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Preparing scientific posters and presentations during Week 3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Seminars by mentors and guest speakers</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Field trips (Norrie Point &amp; Innisfree Garden)</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Community engagement (with the Fall Kill Watershed Coalition)</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

When asked to self-assess how MH-YES impacted select collaborative and scientific abilities, all high school students rated a positive impact for working as part of a team or group, sharing thoughts and ideas with others, and being patient (Table 4). For some abilities, though, there was more variation in how students felt MH-YES impacted them. For example, four of eight students indicated a “medium” impact on their ability to interact with adults. This may be a natural response from teenagers, but it’s also important to note for training our mentors to be approachable and approachable to the students. It is encouraging to see that most students felt that MH-YES positively impacted their ability to work as a team and to be patient, two essential skills for collaborative scientific work.

Table 5. Frequency of high school student responses (n=8) in the post-program survey to the question, “How valuable (see corresponding abbreviations for None, Minimally, Somewhat, Very, or Extremely Valuable) for your learning about science research did you find each of the following activities of the MH-YES 2021 program?” and secondly to the question, “Now tell us which type of activity should be increased (i.e., More), which kept the same, and which decreased (i.e., Less) to make the program better in the future.” Frequencies in bold were particularly noteworthy.

By and large, the high school students found the field investigations and data analysis to be either “Very valuable” or “Extremely valuable,” which is encouraging feedback since these are the two activities students in which they spend time over the three weeks. Six of the eight students felt like the time spent was “just right” and two wanted even more time with these activities. Four of the eight students also thought that preparing the final presentations and the field trips were “Extremely valuable.” Interestingly, all eight students recommend maintaining the same amount of time for the presentation preparation, and three of eight students would like to see the field trips increase. The rating of value of the seminars by mentors and guest speakers resulted in the most variation among the students, and two wanted to see fewer seminars in the future; this may indicate that we decrease the number of seminars, or change how interactive these are, for future programs. Finally, community engagement was found to be “Very valuable” or “Extremely valuable” by a majority of students, and three wanted to see this aspect increase in future programs. Overall, this feedback tells us that most of the program hits a “sweet spot” for students in terms of the amount of time and effort they spend on the different kinds of scientific activities.
Open-Ended Responses

When asked what they felt were the three most important things they gained from the program, responses illuminated the multifaceted nature of this program, how it not only increases their ecological knowledge and understanding of environmental science careers, but how to think more critically and what it means to be part of a collaborative group:

- How to look for opportunities in this field of science
- Expanded more on thinking what actions and what organisms affect/impact the environment
- Accept that I make mistakes
- Creating a real deal research science project and poster
- Investigating the environment
- I learned to be more open
- Getting the hands-on experience on the science research field
- Being able to learn more about our local environment
- Resources/people to reach out to if I have any questions/need (scientific) help
- Joy

In response to the post-program survey item about their favorite aspect of the program, there were some commonalities in that three students really enjoyed the field data collection, three students appreciated getting to analyze the data they collected, and two students liked the enrichment field trips. However, this particular survey question really stands out at getting a wide variety of responses, which lends support to the positive outcomes associated with how many different kinds of opportunities MH-YES offered this summer. All eight student responses below illustrate this:

1. My favorite part was getting the data samples. Being able to have fun while enjoying science. Also the field trips were very fun and informational.
2. Working with my team members and doing the project with them. My members made me feel loved and cared for, but also gave me positive criticism (vice versa) which made me feel comfortable.
3. The soil ecology research we did. I really enjoyed collecting and analyzing the samples. I definitely want to learn more about this field in the future.
4. My favorite part was being picked up and dropped off by my favorite personal Uber driver (one of the teacher mentors) and also just being a part of this program.
5. Using waders to go in the water to catch macroinvertebrates.
6. The trip to Norrie Point, the canoes were quite fun!
7. Oh goodness, so many!! For the most part I enjoyed the field collecting data in the streams and then the analysis of that data. Looking at all the different factors playing a role on water quality was just so cool to see at the sites and then when typed up to compare the two water sources we chose against one another. Also just getting my hands wet and going in these field sites is just so fun, I love the outdoors and learning more about it.
8. I felt that analyzing the data that was collected was the most interesting part because we got to see what our data showed us.

Finally, in response to the survey item asking what advice they would give to a high school friend considering the MH-YES program for next year, the eight responses were all very encouraging:

- Do it! It will help you think more on colleges and careers! It also has many people who care for their environment which will enact you to care (more) about the environment!
- You will enjoy and just remember be open to ideas and discussions.

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Try it out because it is a great opportunity.
Apply.
Make sure your prepared and come with an open mind and schedule so you can really enjoy it.
They should definitely apply, overall MH-YES was a great experience and allowed me to learn a lot about ecology!
Do it!
Go for it! It’s so much fun and everyone is so helpful. It would be a real loss if you didn’t even try to apply.

III.B.2. Participant Outcomes – Undergraduate Students
One undergraduate is a rising senior at Marist College in Poughkeepsie, and one undergraduate is a rising junior at the University of Ontario and is an MH-YES alum, having participated in the 2018 program. Both undergraduates brought unique skills and insights to their mentorship roles, and they both reported benefiting from their participation.

Table 6. Frequency of undergraduate mentor (n=2) responses in the post-program survey to the following question: “From your perspective, how useful do you think each of the following activities were for your learning and career development?”

<table>
<thead>
<tr>
<th>Activity</th>
<th>Limited use</th>
<th>Somewhat useful</th>
<th>Very useful</th>
<th>Extremely useful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field investigations during Weeks 1 &amp; 2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Data analysis during Week 3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Preparing scientific posters and presentations during Week 3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Seminars by mentors and guest speakers</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Field trips (Norrie Point &amp; Innisfree Garden)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Community engagement (with the Fall Kill Watershed Coalition)</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Preparing and presenting a personal career talk (UG only)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

The undergraduate mentors rated the field investigations, data analysis, presentations, and preparing their own personal career talk as being extremely useful for their learning and career development. The two mentors differed in their opinion of two activities: one thought the seminars and the field trips were “Extremely important” whereas one mentor thought they were of “Limited use.” This is interesting, and the seminar response being of perceived limited use aligns with what some of the high school students felt as well. It’s interesting that one undergraduate mentor found the field trips to be of limited use, but perhaps they saw those as simply being opportunities for extracurricular fun rather than directly applicable to their future studies and career growth. Follow-up interviews in future programs would help provide greater explanation. Overall, though, it is apparent that the MH-YES program as a whole was perceived as being useful for the undergraduate mentors’ learning and career development.

When asked, “How likely are you to pursue professional activities involving research mentoring in the future?” one responded “Moderately likely” and one responded, “Extremely likely.” Both said they would “Definitely” recommend this internship to a fellow student or friend.
Additional quotes from post-survey:

- In response to, “How valuable for your learning and career development were the following activities?”
  - I really enjoyed leading stream collection. It was the first time that I was put in the position to have the responsibilities to organize everything. I really enjoyed it.
  - I learned a lot over the past three weeks about organization and how to manage one’s time.
- In response to, “From your perspective, how valuable do you think each of the following activities were for the students?”
  - I think the investigations were very rewarding and useful but I think the data analysis put the entire program together. The students were able to work with the data and fully understand what the variables meant and the numbers meant.
- In response to, “What were the highlights of the internship for you? What worked well for you?”
  - The trip to Norrie Point was very enlightening and I loved engaging with graduate students and the students at MH-YES who previously worked at Norrie Point about their projects.
  - I really enjoyed getting to know the students in depth and sharing the advice that I have acquired since being in college. I enjoyed sharing my research with the class and actually getting into the stream and doing the research that I have done. The Fall Kill (Creek) gave the students perspective on water quality.
- In response to, “List 3 aspects of mentoring students this summer that you found to be rewarding.”
  - The relationships I built with the students
  - Sharing my passion and my projects
  - Watching the students really get into the things they were learning about

III.B.3. Participant Outcomes – High School Teachers

Both high school teacher mentors participated in previous years’ MH-YES programs. Some of the teachers’ quotes reflect this multi-year experience. They had an overall positive experience in 2021, and we also learned more about what teachers are looking for in an experience like this and what is achievable during a 3-week time frame, as well as what can reasonably be done within a busy school year. We are using their feedback to inform the shape of the 2022 teacher fellowship.

Table 8. High school teacher responses to “How valuable for learning and teaching were the following activities...?” both from their perception of the students’ experience and their own.

<table>
<thead>
<tr>
<th>Activities</th>
<th>Teachers vs. Students</th>
<th>Not at all</th>
<th>Minimally</th>
<th>Somewhat</th>
<th>Very</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field investigations during Weeks 1 &amp; 2</td>
<td>For teachers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>For students</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Data analysis during Week 3</td>
<td>For teachers</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>For students</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Preparing scientific posters and presentations during Week 3</td>
<td>For teachers</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>For students</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Seminars by mentors and guest speakers</td>
<td>For teachers</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

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The teachers felt that the most beneficial activities for learning and teaching were the field investigations and the “enrichment” activities, which included seminars, field trip, and community engagement (Table 8). It’s interesting that the teachers perceived higher value of seminars and field trips for students than did the students. On the other hand, teachers perceived lower value of data analysis and poster preparation than did the students. These results encourage us to maintain our emphasis on data and synthesis, and to reconsider the number and nature of seminars and field trips to maximize the chance of achieving the value for the students that is perceived by the teachers.

Open-Ended Responses:

“Reflecting on the program, did it meet your expectations of what you hoped to gain, and what specifically did you gain from participating in this year’s program?”

- I really enjoyed learning about the ethograms. I feel that they could be especially useful in the future. I also really liked incorporating the macroinvertebrate dissections into this year’s protocols. It was so cool to work with several scientists over the course of the 3 weeks.
- The program was the best yet. Keeping the two groups together and offering multiple learning opportunities within was amazing. Allowing the students to collect data for the sake of learning the sampling techniques and then to self-select the data they wanted to analyze, making their own connections was priceless. That made this exceed my expectations.

“What worked well for you as a teacher mentor in the program this summer?”

- I liked working as a whole group this year. I also liked learning about different protocols. It was really valuable to learn from the scientists along with the students. I really enjoyed helping the projects come together. The structure of the program was really unique and creative.
- Having by the teacher mentors work together with the students. One teacher is a life science person and the other is a physical science person. They both offer different expertise to the students.

“What advice would you give to a teacher colleague considering participation in the MH-YES program? Include your thoughts about what kind of teacher would be a best fit.”

- I feel that you have to be flexible and also love the outdoors. They have to be confident in their field work and stream ecology. They have to be hardworking and dedicated to the program. It is important to be a team player and a good communicator.
- One who is willing to go the extra mile and be a team player.
Additional quotes:

- Thank you for giving me the opportunity to work with MH-YES these past 3 years. I have learned so much and would be willing to collaborate any time in the future. This program has inspired me to do so much more in my classroom.

One of the biggest takeaways from this summer is to adjust our expectations for teacher outcomes to reflect the realities of what can be achieved in a short, intense three week program. Teachers are excited to contribute to the success of the program for all participants, to gain knowledge of ecology concepts and methodology and to build skills in mentorship. The teachers wanted to be fully involved with the students 100% of the time, rather than step away to work on lessons for school year implementation. They also communicated the constraints they face in having their students do ecological field and lab studies during the school year due to scheduling and testing constraints. We are planning for the teacher fellows in future programs to identify a modest, attainable project that builds on their MH-YES experience and bring some aspect into their classroom teaching.

III.B.4. Participant Outcomes – Mentor Scientists

We did not conduct formal surveys of the mentor scientists; rather, we documented their feedback in a program debrief meeting that included the scientists, high school teachers, and Cary educators one week after the program concluded. Two scientists participated in this meeting: Dr. Jane Lucas from Cary Institute and Dr. Zion Klos from Marist College. It was invaluable to receive their feedback, especially since this was Dr. Lucas’s first experience with MH-YES and Dr. Klos’ fourth year. These were the main takeaways:

- Both scientists felt like one of the biggest strengths to MH-YES is the great mentor to student ratio; it was really nice to have so much consistent support.
- Dr. Klos expressed that the amount of student learning that happened was higher this year in terms of the products produced. In terms of time allocation, we had a better amount of time for the final products. It was beneficial to have focused datasets. Students got a lot of positive exposure to field methods, but still had creativity into the question they would explore during the presentations.
- Dr. Lucas came away excited to increase the amount of collaborative work they do with the high school teachers in future programs. She noted that the undergraduate mentors were a great asset to the program.
- They both saw huge student outcomes, both for the high school and undergraduate students.
- They had a positive and rewarding experience this summer, and are already looking forward to being involved for the 2022 program.

IV. Outreach Comments

MH-YES students presented their findings to the Fall Kill Watershed Coalition virtually. Given the ongoing nature of the COVID-19 pandemic, we were not able to engage the MH-YES participants in other community outreach events in 2021. However, we received a request from the Mid-Hudson Children’s Museum about engaging in a partnership whereby they would host the students’ final presentations in an event open to the public, followed by the students facilitating research-related outreach for children and their families. We hope to bring this partnership to fruition in 2022.
V. Summary of Training

High school students trained: 8  
Undergraduates trained: 2  
Teachers trained: 2

VI. Publications/Presentations

This project resulted in two scientific posters and two slideshow presentations of the two student research projects at the MH-YES Presentations & Celebration on August 13, 2021 at the Mid-Hudson Children’s Museum’s outdoor pavilion overlooking the Hudson River in Poughkeepsie. Copies are available upon request.

Ashley Alred developed a research poster on 2020-2021 student outcomes for the NAAEE Research Symposium in Fall 2021 (See Appendix A).

VII. References


This report was prepared for the New York State Water Resources Institute (NYSWRI) and the Hudson River Estuary Program of the New York State Department of Environmental Conservation with support from the NYS Environmental Protection Fund.