NEW YORK STATE WATER RESOURCES INSTITUTE
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Cary Institute of Ecosystem Studies

Mid-Hudson Young Environmental Scientist (MH-YES) 2020 Program in Home Ecosystem and Watershed Ecology

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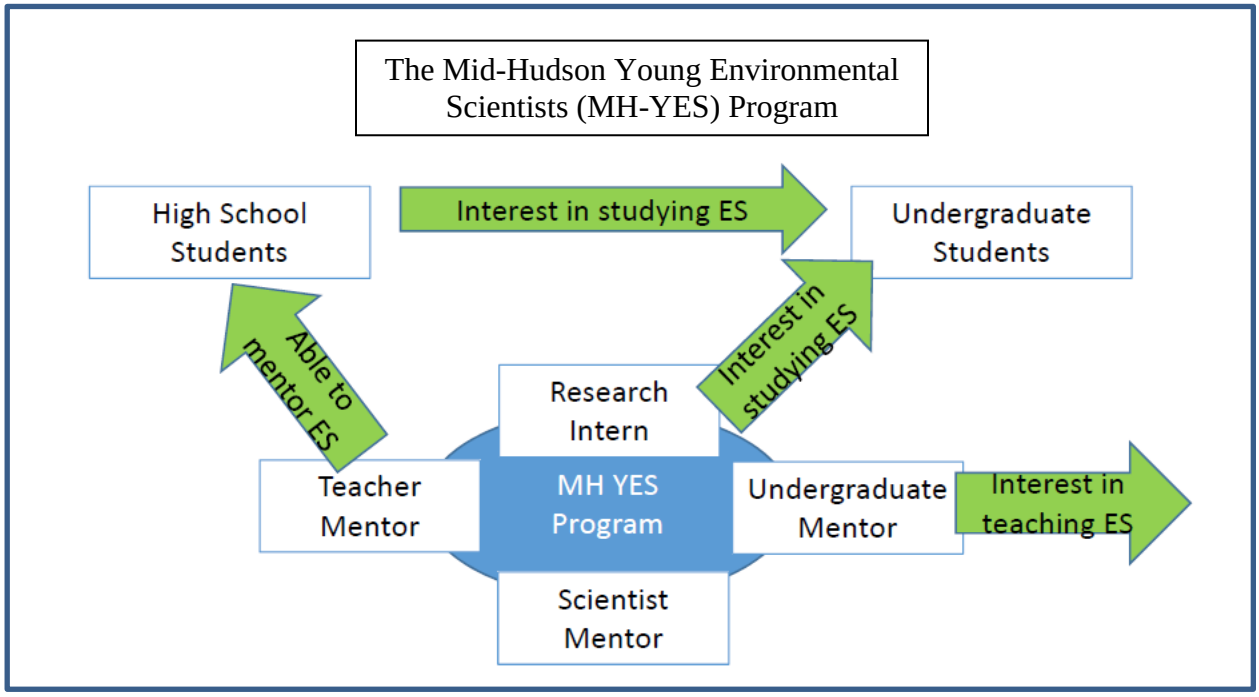

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Abstract

The 2020 Mid-Hudson Young Environmental Scientist (MH-YES) Program took place remotely from July 7 through August 14. Eight Dutchess County high school students, working in two groups, convened daily on Zoom with their mentors - research scientists, undergraduate students, and local high school science teachers – and with program leaders to develop original scientific investigations pertaining to their home ecosystems in the context of regional watershed ecology. Students performed fieldwork independently in their backyards and neighborhoods and synthesized results during virtual discussions with their team members. One research team created water budgets for members' "home ecosystems," representing inputs and outputs in schematic diagrams. The other team investigated the differences in soil water quality between deciduous and coniferous environments following a major storm event. At the end of the six-week program, students presented their findings at a virtual symposium. Students also participated in several virtual enrichment activities offered by MH-YES program leaders, the regional network of high school research programs and Cary Institute's REU program. MH-YES participants - both students and mentors - reported a positive summer experience despite significant challenges with virtual programming. High school students in particular reported social, emotional, and intellectual gains as a result of program participation.

Three Summary Points of Interest

- Working in a 100% virtual program in 2020, eight high school students (the majority of whom are from groups underrepresented in STEM fields) were able to complete original, field-based ecological investigations in their back yards and nearby neighbors that linked their local ecosystems to the larger watersheds they live in.
- Undergraduate students and high school teachers were critical mentors for the high school students, while also gaining confidence, motivation and skills in supporting student inquiry and learning in their work as educators.
- The opportunity for MH-YES students to participate in events with students from a regional network of summer high school research programs in southeastern New York State (including a Diversity in STEM panel discussion and presentations from research scientists) was invaluable.

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

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). Less common, however, are highly refined studies of the impacts of individual neighborhoods or residences on watershed ecology. Groffman et al. (2017) point to the importance of transdisciplinary, multi-scale studies to understand and predict the impact of human-dominated landscapes on ecosystem structure and function. A 2007 study by Rudd et al. (2002) also highlights the importance of backyard ecosystems in habitat connectivity. Fortunately, many backyard or neighborhood ecological protocols, such as vegetation surveys and precipitation measurements, can be implemented in a citizen science-type framework. Thus, many avenues exist for pursuing multi-scale ecological investigations.

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 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. 2020 MH-YES Program Participants

Eight local high school students (see Table 1) comprised the 2020 MH-YES cohort. All were female, with two rising juniors and six rising seniors. Students conducted original ecological research in two teams of four, with each team under the mentorship of one undergraduate student, one local high school science teacher, and one research ecologist. The MH-YES Leadership Team consisted of all six mentors (two undergraduates, two high school teachers, and two research scientists), as well as Program Director Dr. Alan Berkowitz and Program Coordinator India Futterman.

High school students were recruited for the program using a number of methods. The Program Coordinator contacted local high school science teachers throughout Dutchess County directly, sending out program information and flyers to distribute to students and display in classrooms and throughout schools. The Program Coordinator also reached out to local youth empowerment groups, such as the Northeast Community Center's Teen Team Coordinator (Millerton, NY) with program information. The Program Coordinator also visited one high school classroom in Pine Plains, NY in person to present program details. Additionally, informational flyers were distributed at a NYS DEC conference "Research in the Reserve".

Table 1. Profile of the 8 high school students who participated in the 2020 MH-YES Program.

Year in School	School	Home Town	Race/Ethnicity
Rising Junior	John Jay Senior High School	Hopewell Junction	White
Rising Junior	Arlington High School	Hopewell Junction	White
Rising Senior	Arlington High School	Hopewell Junction	African American
Rising Junior	FDR High School	Poughkeepsie	African American/White
Rising Senior	Millbrook High School	Millbrook	African American/White
Rising Senior	Arlington High School	Poughkeepsie	Hispanic
Rising Senior	Our Lady of Lourdes High School	Wappingers Falls	Hispanic
Rising Senior	Webutuck High School	Wassaic	Hispanic

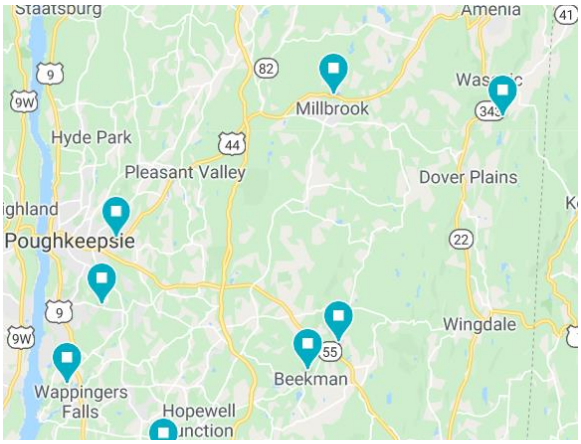

Figure 1. Geographic location of the homes of the 8 high school students who participated in the 2020 MH-YES program.

Interested high school students filled out an online application with several multiple choice and long-answer questions, and submitted a short essay on what environmental science means to them. All applicants that met basic program requirements (age) were interviewed virtually by the Program Coordinator and were required to submit teacher recommendation letters. The Program Coordinator selected a group of "finalists" from the original pool of 14 applicants based on expressed interest in the program (in both written applications and interviews), teacher recommendation letters, and anticipated program benefits to the student. Finalists' materials were reviewed by both the Program Director and both participating high school teachers to select the final group of 8 students. Students were notified of their acceptance in early May of 2020.

Two local high school science teachers served in the 2020 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 2020/Spring 2021 following completion of the summer program. The 2020 RET Fellows were the same as those in the 2019 MH-YES program: Ms. Kaila Hastings, a biology and marine biology instructor at Arlington High School; and Dr. Deborah Kravchuk, an instructor of earth science, biology, and paleontology at FDR High School. Following the 2019 MH-YES program, both teachers expressed a strong interest in participating in future programs. Being familiar with the unique structure of the MH-YES program and having developed personal strategies for mentoring success, both teachers were natural choices for the 2020 program.

Undergraduate students served as near-peer mentors for the MH-YES students, assisting with protocol instruction, data analysis, research proposals and presentations, and scientific journal article reading skills. One undergraduate mentor, Kathryn Samarro, is a current fourth-year environmental science and policy student at Marist College, Poughkeepsie, NY and served as a summer research assistant to scientist mentor Dr. Zion Klos. Annabelle McCarthy, currently a third-year biology student at California State University, Monterey Bay, participated in Cary Institute's Translational Ecology Research Experience for Undergraduates (TE REU) program, and worked with scientist mentor Dr. Stuart Findlay.
Dr. Zion Klos, Associate Professor of Environmental Science at Marist College, and Dr. Stuart Findlay, Senior Scientist at Cary Institute of Ecosystem Studies, served as scientist mentors for the 2020 program. Drs. Klos and Findlay also served as scientist mentors in the 2019 program.

Program evaluation support comprising pre- and post-program individual interviews and a mid-program focus group interview, was provided by Cary Institute's Education Program Leader Ashley Alred and 2020 Cary TE REU participant Elizabeth Jurado, currently a fourth-year ecology student the University of Georgia. Joint activities with the southeast New York regional high school research program network were led by Margie Turrin and Laurel Zaima of Lamont-Doherty Earth Observatory's Secondary School Field Research Program (SSFRP).

II.B. 2020 MH-YES Program Activities

The COVID-19 pandemic necessitated the restructuring of field-based science education initiatives to conform to CDC safety guidelines. Cary Institute of Ecosystem Studies' third annual Mid-Hudson Young Environmental Scientists (MH-YES) program, which ran from July 6th through August 14th, was no exception. Activities in the program were organized in three strands, all of which took place virtually or individually at students' homes: 1) Team Research Projects, 2) Science Skill Development, and 3) Enrichment, with assessment activities interwoven throughout. Table 2 is a summary of activities in each of these categories.

While initial plans for the all-virtual 2020 program emphasized work students could do using existing data, GIS and other map-based information and other on-line sources, surveys and conversations with the

high school students ahead of time revealed a very strong interest in doing field work. In order to accomplish this in a 100% remote framework, participants studied their home and neighborhood

Table 2. 2020 MH-YES activities in three program strands, plus assessment activities.

Week	Team Research Projects	Skill Development	Enrichment	Assessment
Pre-program	● **Leadership Team planning**		● **Pre-Program Zoom Hangout** (all participants)	● **Survey -** Safety, Technology, Workplace
1	● **Research Introductions** (Klos, Findlay) ● **Home Water Systems** (Berkowitz)	● **50 Questions** (Berkowitz) – observe-ask-hypothesize-test ● **Safety Training** ● **GIS Workshop** (Futterman) – Google Earth ● **Field Protocol Workshop** (Berkowitz) - Infiltration	● **Group Discussion** – teams ● **Translational Ecology Panel** (REU Program) – Applied Ecology ● **My Place and Water Pathways**	● **Survey -** Pre-Program ● **Interviews** – Pre-Program ● **Reflective journaling**
2	● **Teams** – develop research questions ● **Presentations** (2 teams) – Research plans ● **Proposals** - preparation	● **GIS Workshop** (Futterman) – Ground Truthing ● **Journal Club** (McCarthy, Samarro) – reading research articles	● **Translational Ecology Panel** (REU Program) - Activism ● **Seminar** (Phipps, James Scenic Hudson) – Community Engagement ● **Data Nugget Review**	● **Reflective journaling**
3	● **Teams –** scouting field study locations ● **Proposals** – review and revision	● **Journal Club** (McCarthy, Samarro) – reviewing proposals ● **Workshop** (Kravchuk, Hastings, Futterman) – proposal writing	**Translational Ecology Panel** (REU Program) – SciComm ● **Workshop** (Turrin, Zaima) – SciComm ● **Discussion** (Roble) – Ask a Scientist	● **Reflective journaling**
4	● **Teams** – final research plans, materials and methods preparation	● **Workshop** – Data Analysis (Hastings)	● **Going to College Discussion** (Cary REU students)	● **Mid-Program Focus Group** ● **Reflective journaling**
5	● **Data collection**		● **REU Symposium**	● **Reflective journaling**
6	● **Data collection & analysis** ● **Final MH-YES Symposium**	● **Workshop** (Futterman) – Effective Presentations	● **Diversity & Inclusion in STEM Panel** (Turrin)	● **Surveys –** Students and Mentors Post-Program ● **Interviews** – Post-Program ● **Personal Statement** – Environmental Scientist

environments individually, convening on Zoom to synthesize results, and using GIS techniques to extrapolate their hyper-localized observations to the scale of the watershed(s). The remote nature of the 2020 program made safety planning a challenge: how were program leaders to ensure the safety of students embarking on individual field excursions, many of which were in neighborhood parks? In response, the Program Coordinator contacted each student's parent(s) individually by phone to discuss safety concerns and create a safety document that reflected these specific concerns), as well as assessing internet access and other technological needs.

Whole group team building started with a virtual meet-and-greet a week before the program began, and was supported by daily check-in and wrap-up sessions with the teacher and undergraduate mentors and, quite frequently, the Coordinator, Program Director and mentor scientists. The first week engaged students in a number of activities that guided them in looking at their home parcel as an ecosystem worthy of investigation and important for its role in influencing the quality and quantity of water reaching nearby streams. They generated questions and considered how to shape testable hypotheses based on these, and diagrams of water in their home ecosystem. These provided a starting point for their research projects, and also allowed MH-YES scientists to build student understanding of the pools and pathways of water in local systems. Student skills and knowledge were enhanced with workshops, presentations, literature reading assignments and preliminary fieldwork.

Two research teams were formed based on the common interests of the high school students from a longer list of project ideas the whole group developed over the first two weeks. By the end of the second week, preliminary research topics were identified for each team, and work on research proposals underway. Teams delivered oral presentations of research proposals, received feedback from the MH-YES scientists and then worked on refining their proposals and plans in Week 3. Students spent the vast majority of Weeks 4 through 6 performing extensive field data collection and synthesizing results in daily group Zoom discussions. One team's project was titled, "Impacts of Hydrological Infrastructure on Water". Team members created "water budgets" for their homes, quantified inputs and outputs and identified hydrological pathways to understand how their individual properties contribute to the profile of the watershed. They discovered that water quality changed as it flowed over/through both natural and human infrastructures, including house roofs. The other team's project was titled, "War Between Coniferous and Deciduous Soil: Pre and Post Storm Water Quality." They found that the type of trees affects soil water quality differently and were surprised by the differences between their homes. At the end of the program, the students presented their research at the virtual Symposium on August 14, 2020.

The 2020 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, staff from Scenic Hudson, colleagues from the regional network coordinated by Margie Turrin, and undergraduate students from Cary's TE-REU program (see Table 2). Though everyone would have preferred to present and participate in these sessions 'in real life,' students still benefited tremendously despite the virtual nature of the program. As much as possible, the training and enrichment sessions involved active engagement of everyone involved. Students were often given assignments to work on individually which they posted on a shared drive and then discussed when back with the whole group. One such assignment entailed providing feedback to the Cary TE-REU undergraduate students about a data-based lesson (Data Nugget) they were developing for K-12 students.

Complementing these activities were periodic assessments for helping guide program implementation, weekly reflective writing assignments and a mid-program focus group meeting where students shared their feelings about the program. Pre- and post-program surveys (Cary and NYNJ Regional Network versions) and interviews provided invaluable information about student interests and outcomes, as did a final reflective writing prompt where they crafted a Personal Environmental Scientist Statement. MH-YES teachers, undergraduates and mentors also complete end-of-program surveys.

III. RESULTS AND DISCUSSION

III.A. Scientific Outcomes

MH-YES research projects helped students learn about the eco-hydrology of their home parcels and nearby neighborhoods. By acting on the commitment of the Leadership Team to giving students agency in defining their research questions and associated methods, all in the absence of in-person fieldwork or training, time became a limiting factor to the ultimate implementation of the research projects. Unavoidable delays in acquisition and safe distribution of materials and supplies meant that data collection didn't start in earnest until week 5. Furthermore, the at-home nature of the research meant that each student was working on her own to contribute her data to the pool of results for the team. Despite these constraints, students were able to collect several types of data and arrive at tentative answers to their research questions. The Cary Team that worked with Drs. Findlay and Kravchuk and Ms. McCarthy measured precipitation, evaporation, transpiration and infiltration to estimate the importance of each pathway of water input and output in their home ecosystem. They also measured water quality of roof runoff. The Marist Team that worked with Dr. Klos, Ms. Hastings and Ms. Samarro compared water quality (pH, conductivity and Total Dissolved Solids (TDS)) in soils under coniferous versus deciduous trees in each of their four backyards. They also described soil texture and type, and the size of the trees to see if these helped explain differences in soil water quality. While their results were equivocal, they did discover interesting differences in soil water quality between tree types and across their four properties. The students' final presentations will be posted on the Cary MH-YES website, and are available upon request.

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. Once again in 2020, a majority of the cohort of high school students were from groups traditionally underrepresented in STEM, with three Hispanic, three African American and two white students. One of the two college students is Hispanic, and both high school instructors teach at schools with significant minority populations. Thus, we achieved our goal of reaching a diverse pool of students in environmental science. Outcomes for the four groups of program participants – high school students, undergraduates, teachers, and scientists – are described briefly in the following sections. Reports from interviews of MH-YES high school students and the TIDES program are attached.

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

We used the post-program surveys to help gauge the value of different facets of the 2020 MH-YES program for student learning. Students were almost universally happy with all aspects of the program in helping them learn about science research, with only one student rating one elements as less than "somewhat valuable" or greater (Table 3). Students found the daily meetings, their research projects and the field investigations most valuable, along with several of the enrichment activities (community engagement discussion, data analysis workshop and the Diversity in STEM and Going to College panel, Table 3). When asked which aspects of the program should be increased, kept the same or decreased, student again indicated a high level of satisfaction (most responded "keep the same", see Table 4). Four wanted more whole-group time, and two wanted more time for conducting research both in the field and on-line (Table 4). Students were able to benefit from the program despite working entirely from home and via zoom. In response to a question about challenges they faced, two mentioned technical difficulties (slow, unreliable internet, power outages), two struggled with family and work balance, two with 2 distractions in the home setting,.one with setbacks during her fieldwork and one found that working alone was challenging.

Table 3. Frequency of high school student responses in the post-program survey (n=8) to the question, How valuable for your learning about science research did you find each of the following activities of the MH-YES 2020 program? Activities are sorted from highest to lowest mean score.

Activity	Not at all	Minimally	Some-what	Very	Extremely
Daily check-in and wrap up meetings	0	0	0	2	6
Community Engagement Discussion (Kate, Preyah from Scenic Hudson)	0	0	0	3	5
Your research project	0	0	1	3	4
Field investigations	0	0	1	3	4
Data Analysis Workshops (Kaila)	0	0	1	3	4
Diversity in STEM Panel	0	0	1	3	4
Going to College Panel (REU students)	0	0	1	3	4
Mid-program focus group session (Ashley)	0	0	2	1	5
Final presentation and symposium	0	0	0	6	2
Home Water Pathways activity (Alan)	0	0	1	4	3
My Place Profile assignment (Alan)	0	0	2	3	3
Science Communication Workshop (Erin)	0	0	2	3	3
REU Symposium	0	0	3	1	4
GIS Workshops (India)	0	0	3	2	3
Journal Clubs (Annabel and Katey)	0	0	4	1	3
Reflective writing assignments	0	0	3	3	2
50 Questions activity (Alan)	0	0	3	4	1
Data Nuggets "pilot testing"	0	1	4	1	2

Table 4. Frequency of high school student responses in the post-program survey (n=8) to the question, Now tell us which type of activity should be increased, which kept the same, and which decreased to make the program better in the future.

Activity	Decrease	Keep the same	Increase
Meetings with the whole MH-YES group for planning research, workshops, seminars, journal clubs, check-ins and wrap-ups	0	4	4
Conducting investigations both outside (collecting data) and inside (measuring, etc.)	0	6	2
Conducting research on-line using maps, other data	0	6	2
Meetings with your research team, mentors	1	6	1
Working on your own doing calculations, reading and writing for your research project	1	7	0
Working on your own on assignments other than your research project (reflective writing, My Place Profile, etc.)	1	7	0

Table 5. Frequency of high school student responses in the post-program survey (n=8) to the question, Please rate the amount you learned or gained in each of the following outcomes targeted by the 2020 MHY Program. Outcomes are sorted from the highest to the lowest average gain.

Outcomes	None	Only a little	A fair amount	A moderate amount	A great deal
Carrying out field investigations.	0	0	0	2	6
Working with data, making calculations and analyzing results.	0	0	0	3	5
Virtual learning and networking.	0	0	0	4	4
Designing effective research methods and approaches.	0	0	1	3	4
Collaborating as part of a team.	0	0	1	4	3
Understanding what good science entails.	0	0	1	5	2
Understanding water in home and neighborhood systems.	0	0	3	2	3
Building lasting relationships with peers, mentors.	0	1	1	3	3
Contributing to final products (research presentation, report).	0	0	2	4	2
Understanding options for pursuing academic study and work in environmental science.	0	0	2	5	1
Completing all assignments.	0	1	3	2	2
Working independently.	1	1	3	1	2

MH-YES high school students reported at least a fair amount of learning or gain for virtually all intended outcomes for the 2020 program (Table 5). Not surprisingly, they gained the most in learning about how to carry out field investigations, working with data and designing research methods; somewhat less expected was the high gain reported for virtual learning and networking (Table 5). Since the research focused on students' homes and neighborhoods, we were particularly interested in whether their understanding or feelings about these spaces changed as a result of their participation. All of the students indicated that their knowledge about their home property changed as a result of their participation (Table 6), while

Table 6. Number of students (n=8) scoring the following statements in the Post-Program Survey item: As an MH-YES student this summer, you studied your home and neighborhood or surrounding area. Please indicate your level of agreement or disagreement with the following statements about those spaces. SD=strongly disagree, D=disagree, N=neither agree nor disagree, A=agree, SA=strongly agree.

Statement	SD	D	N	A	SA
My feelings about my home property changed.	0	1	1	4	2
My knowledge about my home property changed.	0	0	0	2	6
My feelings about my neighborhood changed.	0	1	4	2	1
My knowledge about my neighborhood changed.	0	0	2	3	3

participation affected the feelings about their homes for a smaller number of students. Student comments in this part of the survey were illuminating and included:

- *I learned a great deal about the way water moves through it and how it interacts on a larger scale.*
- *I definitely got more of the feel that what I have and do on my property really can make a difference and can affect my watershed*
- *I have discovered a whole array of natural findings, and I feel that ecology is closer to home*
- *I have a much better understanding of the hydrological infrastructure of my neighborhood.*
- *I had never realized how much water flowed through my neighborhood*

We were pleasantly surprised that students were able to connect with each other and the mentors and program leaders despite the virtual nature of the 2020 program. In response to the post-program survey item about their favorite aspect of the program, six students mentioned that they bonded with at least peers and 4 included mentors in this list; two mentioned the fieldwork, and one each mentioned data analysis, feedback, and the program panels. Similarly, when asked about the most valuable aspect of the program, six mentioned the teamwork, feedback, mentors, three mentioned the workshops and two mentioned learning new methods and using new tools. Finally, in response to the survey item asking what advice they would give to a fellow high school student considering the MH-YES program for next year, the eight responses were all very encouraging:

- *Go for it if you are willing to make friends and spend a lot of time there.*
- *Yes! Do it if you are interested in science but mostly if you feel strongly in ecosystems and ecology, as well as with working with people!*
- *Don't be so nervous*
- *Be ready for a lot of work, but a lot of fun*
- *I would advise them to do it because it is incredibly fun and helpful.*
- *If by next year it is not online anymore I would tell them to go for it*
- *Ask questions if you are confused with something, don't feel embarrassed asking questions because the mentors are really understanding*
- *Anticipate fun, learning, and stay safe outdoors at all times.*

III.B.2. Participant Outcomes – Undergraduate Students

The two undergraduate students in the 2020 MH-YES program reported many significant benefit from their participation. When asked, How confident do you feel that you were a successful mentor?, one answered *somewhat* and one *extremely*. And when asked, How likely are you to pursue professional activities involving research mentoring in the future?, one responded *moderately* and the other, *extremely*. In response to the post-program survey question, How has this experience changed your approach to practicing and/or teaching science?, they responded:

- *I have never considered teaching science very strongly before this experience, and I really enjoyed working with science educators to understand their experience first hand. I felt a strong connection with the students I was working with as well as the teachers and I feel I am more open to considering science education. In addition, I am much more understanding of my previous science educators!*
- *I think that science teachers have to be patient and remember that all the little things aren't always intuitive to high school students, because they don't have all the background knowledge to fill in the gaps.*

- In reflecting on the importance of different activities, they rated all items *extremely important*, including Increasing inclusivity in the sciences

- Engaging the local community in protecting the ecosystem
- Engaging high school students in doing their own hands-on research
- Having students organize, analyze and make sense from data
- Helping students develop effective activities to engage/communicate to the public about the science research they are doing for the summer
- Working with high school students

Finally, the undergraduates indicated a mix of insights into the impact of the remote nature of the program on program outcomes and on their own success as mentors (Table 7).

Table 7. Number of undergraduate student responses to the question in the post-program survey, Given the remote nature of this summer's program, please rate your agreement with the following statements?

Statements	SD	D	Neither	A	SA
The students worked effectively on the projects even though they worked remotely.				2	
Our program participants developed a strong sense of team.				1	1
It seemed the students had a hard time concentrating on the project work because of at home distractions.		1	1		
Although we were unable to work in the field together I feel the students learned a lot through their work on this summer's research project.					2
I felt I was effective in my mentoring role even though I was working remotely with the students.		1			1

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

Teachers in the 2020 MH-YES program found virtually all aspects of the program at least somewhat useful for their teaching and learning (Table 7). Interestingly, their responses were similar to those of the high school students (see Table 3).

Table 7. Number of teacher responses to the question on the post-program survey, How valuable for your teaching and learning were the following activities? Items are sorted from most to least valuable on average.

	Not at all	Minimally	Somewhat	Very	Extremely
Daily check-in and wrap-up meetings					2
The team research project				1	1
One-on-one meetings with scientist mentors				1	1
Field investigations				1	1
Diversity in STEM Panel				1	1
One-on-one meetings with India				1	1

Designing and implementing workshops and lesson plans				1	1
Leadership Team Meetings				2	
Community Engagement Discussion (Scenic Hudson)				2	
Final research presentations and symposium			1	1	
Workshops (GIS, Data Analysis, Communication)			1	1	
REU Symposium			1	1	
Student assignments (50 Questions, Home Water System, My Place Profile)			1	1	
Journal Clubs			2		
RET Network Meetings			2		
Going to College Panel			2		
Data Nugget project		1		1	

Teachers reported either some or a lot of learning in all aspects of ecohydrology targeted in the 2020 MH-YES program (Table 8). We are particularly happy that teachers learned about using protocols and equipment despite the fact that no in-person instruction took place. Between the results for both students and teachers, this suggests that field instruction can be effective even if done entirely through remote programming.

Finally, teachers reported that they will regularly use most of the teaching techniques that were modeled in the 2020 MH-YES program. In this way, the program will reach hundreds of high school students in addition to the 8 that participated intensively in the summer program.

Table 8. Frequency of teachers' responses on the post-program survey to the question, How much did you learn about the following aspects of ecohydrology from participation in the MH-YES program? Items scored highest on average are listed first.

Topics	No learning	Some learning	A lot of learning
Water pathways in neighborhoods and residential watersheds			2
Factors affecting water quality in neighborhoods and residential watersheds			2
Protocols for measuring water quality in home ecosystems			2
Designing ecology field studies (sampling design, etc.)			2
Working with data about water in home ecosystems			2
Water pathways in and out of home ecosystems		1	1
Factors affecting water quality in home ecosystems		1	1
Protocols for measuring water pathways in home ecosystems		1	1
Using scientific equipment		1	1

Table 9. Number of teacher responses to the question on the post-program survey, How much do you intend to use the following activities in your classroom in the future?

	Regularly	Occasionally	Rarely	Never
Engaging students in inquiry-based learning, where students uncover their own questions	2			
Helping students organize, analyze and make sense from data	2			
Helping students develop effective activities to engage the public in ecology	2			
Designing effective ecology research projects with students	1	1		

III.B.4. Participant Outcomes – Mentor Scientists

Two mentor scientists participated in the 2020 MYES program, on for his third summer and the other his second summer. Both were excited and prepared to build on past work in local watersheds and streams, but were happy to pivot to guiding students in studying water in their very local environments. This shift meant that the topics of study in the 2020 program would not be as closely aligned with the scientists' research areas, and therefore the prospect of the students making meaningful contributions the mentors' research was diminished. However, both were quite satisfied with the program and found it beneficial in many ways. One of the two scientists completed the post-program survey. He commented that the three aspects of mentoring the students he found most rewarding were *seeing growth, seeing joy for science, and seeing excitement for fieldwork*. Most challenge were [the fact that it was] *easy to disconnect virtually, time limitations on my end, and last-minute program organization*. In response to the question about how the experience changes his approach to teaching science he commented, *helps me realize more about what high school students come to college prepared to do*. Finally, we asked about the impact of the remote learning situation on the 2020 program. The mentor agreed with the statement, Although we were unable to work in the field together I feel the students learned a lot through their work on this summer's research project, which is very encouraging. He neither agreed nor disagreed with the statements, The students worked effectively on the projects even though we were working remotely and I felt that my work on the program was a good investment of my time, but did disagree with the statement, I felt I was effective in my work with the students even though I was working remotely with them. From our conversations with colleagues around the country, the MH-YES program evinced a similar mix of surprisingly positive outcomes despite virtual program along with the recognition of many limitations we faced both individually and collectively.

IV. Outreach Comments

Given the on-line nature of the program, we were not able to engage the MH-YES participants in community outreach events in 2020.

V. Summary of Training

High school students trained: 8
Undergraduates trained: 2
Teachers trained: 2
Students reached through teachers: ~250

VI. Publications/Presentations

This project resulted in 2 presentations of the two student research projects at the MHYES Symposium on August 14, 2020. Copies are available upon request.

VII. References

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