



PROJECT
REPORT

Urban Ecologists: A New After-School Program Teaching Inner-City Children about Urban Ecology

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Abstract

Children in urban environments tend to have limited exposure to environmental education programs for many reasons. This paper describes the development of a short-session after-school program, created to introduce children in an inner-city school to the concept of urban ecology. In this program, we met with a class of 20 fifth graders once a week for four weeks and evaluated students' perceptions of nature with a pre-post-intervention activity that asked students to draw a picture describing "nature." Researchers evaluated the drawings together. The results indicated an increase in the instances of animals and insects in drawings with fewer anthropic influences,

such as people, buildings, and vehicles. Overall, the program achieved its goal of exposing urban children to the ecology all around them.

Introduction

Connecting students with nature offers many benefits, including positive effects to physical, mental, and emotional well-being (Frumkin, 2001; Nisbet & Sleep, 2001; Seymour, 2016; Ulrich, 1984). Studies also suggest that the student-nature connection results in advances in learning, such as increases in creativity, problem-solving

abilities, and higher test scores (Camasso & Jagannathan, 2018; Kirnan, Ventresco, & Gardner 2018; Rowland, 2017; Swall, Ebbeskog, Hagelin, and Fagerberg, 2017). With increasing urbanization, educators should consider ways to connect students, particularly those in urban areas, with nature so that they can experience the myriad benefits nature provides.

Around the world, urban populations are increasing. UNICEF predicts that at least two thirds of all people will reside in urban environments by 2050, with over a billion of the world's children living in urban areas as of 2012 (UNICEF, 2012). Increasing urban sprawl means decreasing large-scale natural areas. This might create a disconnect between some urban dwellers and nature;

TABLE 1. Alignment Table Comparing NGSS Standards and Expectations with Components of the UE Program

Grade Level	Educational Standard	Performance Expectation	Urban Ecologists Application
3-5	LS4.D Biodiversity and Humans: 3-LS4-4: Biological Evolution and Diversity (NGSS)	<p>Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change. (LS4.D)</p> <p>Populations live in a variety of habitats and change in those habitats affects the organisms living there. (3-LS4-4)</p>	<p>The program introduces students to nature that exists in urban areas, not just in nature preserves or rural areas. Students learned that some plants tolerate toxins in the environment and remove toxins from the soil, demonstrating the resilience of nature.</p> <p>Students used this information to critically evaluate different ways insects might respond to different arrangements of plants in the student-developed mazes before and during maze development.</p> <p>During insect collection, students had opportunities to discuss the different types of shelter used by different organisms, given the wet, snowy, and freezing temperatures of the day.</p>
5	LS2.A Interdependent Relationships in Ecosystems: 5-LS2-1 Ecosystems: Interactions, Energy, and Dynamics (NGSS)	<p>The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. (LS2.A)</p> <p>Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. (5-LS2-1)</p>	<p>The program introduces students to ecosystem interactions by demonstrating the importance of plants as food and shelter for a variety of species, including many insects. We discussed the abilities of plants to decontaminate soil and water, as well as sequestering carbon dioxide from the air to provide breathable oxygen for humans.</p> <p>Maze development aided in students' understanding as the planted seeds took up water and nutrients from the soil to develop, providing shelter and food sources for insects on the final day of the program.</p>
3	CCSI.ELA-Literacy. RI.3.3. (Common Core State Standards Initiative)	Describe the relationship between... scientific ideas or concepts... using language that pertains to time, sequence, and cause/effect.	Using information provided by the program facilitators, students created a maze and discussed different ways to test insect intelligence using student-developed mazes. Students tested these hypotheses on the final day after insect collection by placing insects in the student-developed mazes.

they might fail to recognize that nature exists all around them—even in urban environments (Ardoin, Gould, Lukacs, Sponarski, & Schuh, 2019; Dillon et al., 2006). Educators, spending 6-8 hours per day with students, might offer students experiential, nature-based learning opportunities to connect with nature. Exposing urban students to science-based educational opportunities might also allow students to make deeper connections to scientific content and recognize the scientist within—connections sometimes missed in marginalized populations (Harnik & Ross, 2004; Hurtado, Cabrera, Lin, Arellano, & Espinosa, 2009). We believe our program provides one type of opportunity to get students exposed to and excited about nature, while still meeting Next Generation Science Standards.

We developed Urban Ecologists as a way to connect elementary-aged students in urban school districts to nature through experiential, nature-based learning. In our program we wanted students to explore urban ecology through an inquiry-based program to increase understanding of the world around them (Berkowitz & Hollweg, 1999). To determine whether our program was effective for helping students recognize nature all around the urban environment, we focused on the following research question: would participants' perspectives of nature change after exposure to nature in an urban environment?

Further, to make this program relevant to classroom science standards, we aligned the content with Next Generation Science Standards (NGSS) LS4.D: Biodiversity and Humans, LS2.A: Interdependent Relationships in Ecosystems, and Common Core State Standards Initiative CCSI.ELA-Literacy.RI.3.3: "Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect" (Table 1; NGSS Lead States, 2013; National Governors Association Center for Best Practices, Council of Chief of State School Officers, 2010).

Methods

We created a program to introduce the concept of urban ecology to a classroom of 20 fifth-grade students at a school in northeast Ohio that serves children who live

in an urban environment. Our program, called Urban Ecologists (UE), was built to increase the students' understanding of nature found in their urban environment, specifically around the school. The program consisted of 45-minute meetings, occurring once a week for four consecutive weeks during the last hour of school, in October and November of 2019. Program lessons were conducted in the students' regular classroom each of the four days except on the final day, when we took them outside to collect insects on school property.

The education group included two graduate and four undergraduate students. The undergraduate students worked in rotating groups of two to develop each day's activities using general outlines provided by the graduate student leaders. Each weekly meeting consisted of a short presentation to cover background material, followed by activities. If time permitted, the education group led the students in a discussion of information related to the day's activities. As an incentive for participating in the program, we gave students program t-shirts and art supplies.

Program Description

The schedule consisted of four separate but related days of activities. Day One started with a brief introduction of the program and researchers; the students were then asked to draw what they thought of when they heard the word "nature." We provided students with approximately fifteen minutes to complete the drawing exercise. Several students chose to share their drawings with the class before the research group collected the drawings. After the drawing exercise, the research group asked the students to sit in a circle and participate in a game toss. Students tossed a stuffed toy plant around in the group, and each student who caught the toy called out a word they associated with nature. After the game (~five minutes), the research group asked the students to create a picture of themselves as scientists using construction paper and drawing instruments provided by the research group (Figure 1a). These activities acquainted us with the students' understanding of nature before learning new facts and concepts from the UE program.

Beginning with the second week, we used an inquiry-learning model to encourage personal connections with nature among the students. Day Two focused on plants

native to northeast Ohio, especially those found in urban environments. In the presentation, we shared with students several images of plants that they might see near their homes. We also shared with students some ways plants can remove harmful toxins from the soil. Following the presentation, we provided students with trays, soil, and seeds of plants native to Northeast Ohio: switchgrass (*Panicum virgatum*), goldenrod (*Solidago canadensis*), chicory (*Cichorium intybus*), and upland cress (*Barbarea verna*). We asked each student to fill one tray with soil and encouraged the students to sow the seeds in a maze shape. We explained to the students that we would share a fun activity related to the maze the following week (Figure 1b). Students tended to the seeds and plants for two weeks in their classroom.

On Day Three, we discussed the differences between human and insect brains and why learning would be important to navigating an insect's natural environment. We then asked the students to consider how to test insect learning ability within an experiment—in a maze, for example. We discussed the types of tests that would be appropriate in a maze, such as recording the amount of time it would take an insect to complete a maze with a food reward at the end, and then directed the students to draw a maze for an insect of their choice.

The final day of the program brought all the lessons together. The research group provided students with replacement plant mazes, as needed. Prior to heading outdoors, the research group gave each student a net and a small plastic container to hold insects. The group went to a grassy slope on school grounds where the research group demonstrated proper net sweeping techniques for insect collection. After fifteen minutes of searching for insects, the students placed insects in the plant mazes and observed the insects for one minute (Figure 1d). For students unable to catch insects, we provided lady beetles (*Hippodamia convergens*) for the plant mazes. After this exercise, we released collected insects back into the same natural area and collected all lady beetles from the students. Finally, we asked the students to repeat the nature drawing exercise from Day One. This day ran longer than expected, and students had only about five minutes to complete the drawing prior to school dismissal. We collected the drawings at the end of the day.

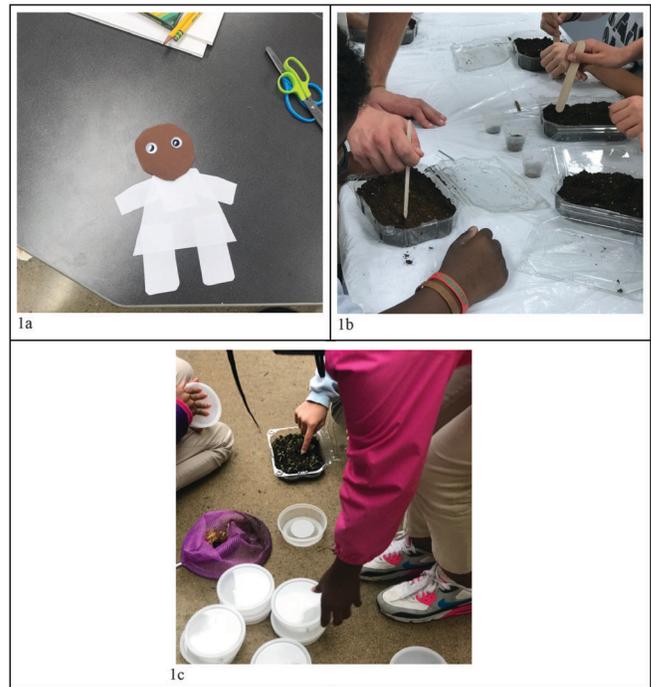


FIGURE 1. Photographs of activities students participated in during the Urban Ecologists program **1a)** A student's representation of himself as a scientist **1b)** Students planting seeds to create mazes for insects **1c)** Students placing insects in plant mazes on the final day of the program

Analysis

To evaluate the UE program, we employed a simple pre-post-intervention task. As previously stated, on the first day of the program we asked each student to draw a picture that reflected what they thought about when hearing the term "nature." We created inventories according to items represented (Sanford, Staples, & Snowman, 2017; Flowers, Carroll, Green, & Larson, 2015). We repeated this task on the last day of the program before the students were dismissed. Because of unforeseen time constraints (see Limitations, below), we provided students with just five minutes to complete the post-program drawings. We chose to employ this evaluation method after speaking with a school liaison, who expressed concern about the ability of these children to express their opinions in written form. This type of evaluation has been successfully employed with children through eighth grade (Sanford et al., 2017).

Using an emergent thematic coding analysis, researchers analyzed each drawing and developed codes to compare pre-program drawings to post-program drawings in order to determine whether the intervention changed

perceptions of what "nature" means to the students. Because of the small sample size ($n = 20$), each researcher coded all drawings, and the group worked together to reach full agreement. To determine statistical significance, we used a chi-square analysis.

Results

Through our program, we planned to explore any influence that urban nature-based inquiry could have on student perspectives of urban nature. To determine any influence, we started by asking students to verbally state things that reminded them of nature. Waterfalls, trees, and animals ranked at the top of the list (17% each). For the complete list, see Table 2.

Next, we asked students to draw nature. Implementing our iterative, thematic coding analysis, we identified a variety of codes which we narrowed down into categories. (See Table 3 for a complete list of categories and codes.) Prior to being exposed to urban nature by our program, students more commonly described nature using images of Plants (37%), Celestial sphere (18%), Geology (12%), Animals (10%), Anthropogenic influences (8%), and/or Water (5%). Comparatively, after our program exposed students to urban nature, students most commonly described nature using images of Plants (34%) Animals (17%), Celestial sphere (14%), Geology (11%), Water (7%), Insects (6%), and/or Weather (6%). For brevity, we include only categorical themes with $\geq 5\%$ frequency. See Figures 2 and 3 for categorical comparisons, with frequencies.

TABLE 2. List of Words Students Use to Describe Nature

Words	Frequency (%)
Waterfall	17
Trees	17
Animals	17
Flowers	6
Plants	6
Rainbows	6
Leaves	6
Nets	6
Squirrels	6
Nature, "That's All"	6
People sit in sun	6
River	6

Comparing the results of the pre-program drawing to the post-program drawing, we observed an increase in a few categories: Animals, Insects, Water, Weather, and Animal Structures. Categories that decreased in frequency after the urban nature intervention included Anthropogenic influences ($\downarrow 5\%$), Celestial sphere ($\downarrow 4\%$), Plants ($\downarrow 3\%$), and Geology ($\downarrow 1\%$). See Figure 4 for pre- and post-program comparisons.

The most common biotic categories emerging from the drawings include Plants > Animals > Insects, regardless of proximity to the urban nature intervention (see Figure 5).

We compared the frequencies of image categories from pre-program to post-program drawings using the $p \leq 0.05$ threshold. We found no significant differences between the frequencies of image categories in the pre- and post-program drawings (chi-square $p \geq 0.176$).

FIGURE 2. Frequencies of most common nature images produced by students before the urban ecology program.

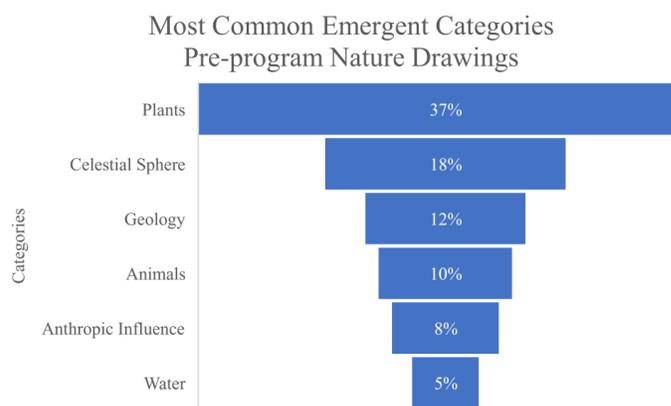


FIGURE 3. Frequencies of most common nature images produced by students after the urban ecology program.

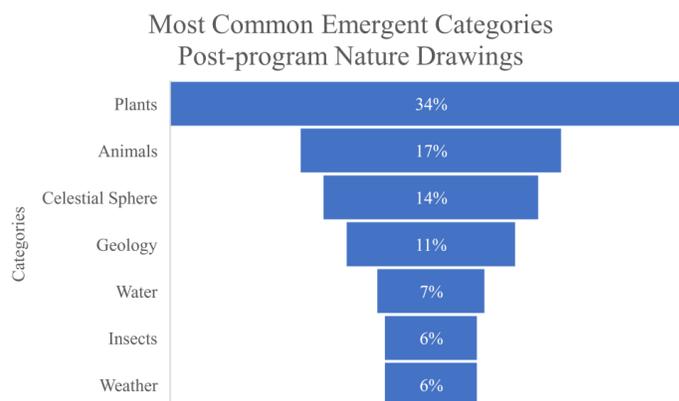


TABLE 3. List of Categories with Associated Codes

Categories	Codes
Plants	Plants
	Trees
	Fruits
	Bushes
	Flowers
	Grass
	Moss
Animals	Birds
	Amphibians
	Worms
	Reptiles
	Mammals
	Fish
Insects	Insects
	Arthropods
Celestial Sphere	Sun
	Moon
	Stars
	Rainbows
	Blue Sky
Geology	Soil
	Rocks
	Mountains
Water	Pond
	Waterfall
	River
Anthropic Influence	Buildings
	Stores
	Humans
	Trails and Parks
	Insect Nets
	Vehicles
Spiritual/Religious	Verbal explanation
Weather	Clouds
	Rain
Animal Structures	Nests
	Ant Hill

FIGURE 4. Comparison of the frequencies of nature images in the students' drawing, pre-program versus post-program. Stars indicate an increase in frequency of this category after students participated in the urban ecology program

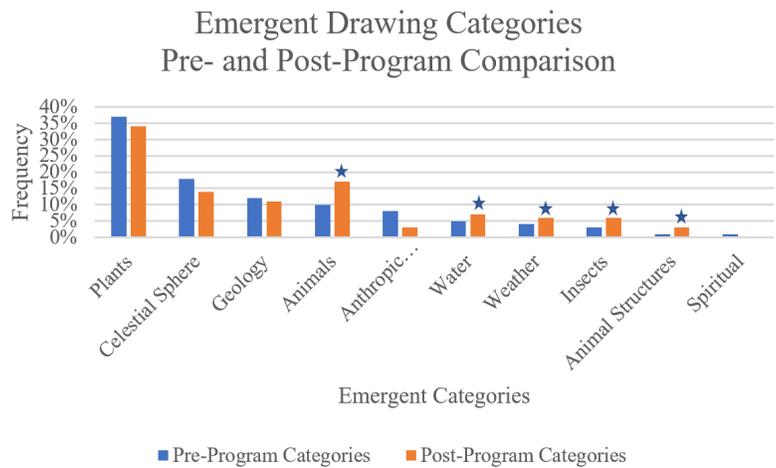
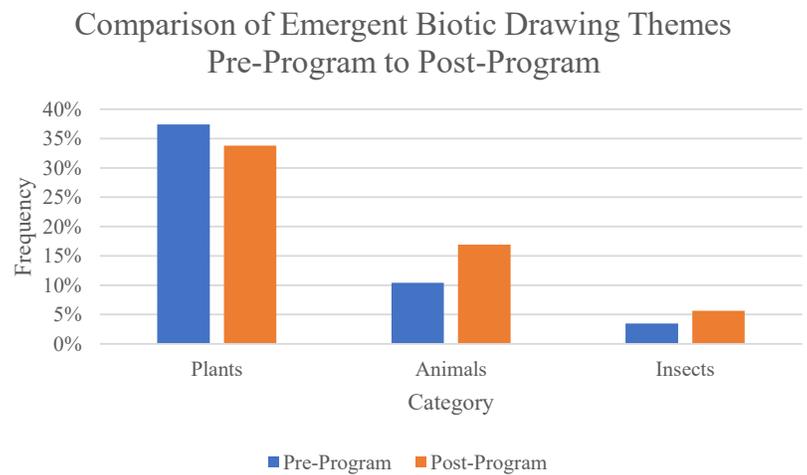


FIGURE 5. Comparison of the frequencies of biotic images in the student drawing, pre-program to post-program.



Discussion

The results of our study provide some indication that an urban nature-based intervention could influence the nature perspectives of young urban public-school students. Before experiencing urban nature, students most often associated nature with plants, the celestial sphere, geology, animals, anthropic influences, and water, based on student drawings. Following the urban nature experience, the most commonly drawn images included plants, animals, the celestial sphere, geology, water, insects, and weather. (Note: in the post-program drawings, insects and weather images both occurred with 6 % frequency.) After the intervention, the frequency of animals and insects increased.

The category Animals included birds, amphibians, worms, reptiles, mammals, and fish. During our time outdoors, students visually observed or physically interacted with several species of animals.

For example, students saw birds, such as robins, on the ground. As we turned over rocks, we found amphibians, such as salamanders. Many students became very excited to observe, study, and touch the salamander. Many, if not all, had never seen a salamander in real life prior to this experience. Now students understand that finding salamanders in nature is as easy as turning over a rock or a log.

The category Insects included all insects and other arthropods, such as spiders, lady beetles, ants, and butterflies. During our time indoors, we taught students about plants and insects, encouraging students to build plant mazes for insects to traverse. During our time outdoors, we taught students proper insect collection techniques (net sweeping and hand collection) and provided lady beetles for students to introduce into plant mazes on the last day of the program. Students had opportunities to visually observe or physically interact with several species of insects and arthropods. In addition to the lady beetles supplied by us, students observed ants, spiders, and more. Many students appeared to enjoy working with these organisms, and some even changed perspectives once given the opportunity to touch an insect.

When comparing pre-program drawings to post-program drawings, we identified a shift from an idealized view of nature (Figures 6a and 6b) to one that included items observed by students during the outside portion of the program (Figures 6c and 6d). The increase in the frequency of animals and insects on the post-program drawings, compared to the pre-program drawings, suggests the success of our program in influencing student perspectives of nature. Prior to our program, students less frequently included animals and insects in drawings of nature. After students had directly experienced urban nature via our program, the frequency of animals and insects included in drawings increased.

The categories that decreased in frequency between pre- and post-program include Anthropogenic influences ($\downarrow 5\%$), Celestial sphere ($\downarrow 4\%$), Plants ($\downarrow 3\%$), and Geology ($\downarrow 1\%$). Anthropogenic influence saw the greatest decrease (approaching significance at the $p \leq 0.10$ threshold with $p = 0.176$). Contrastingly, the p -values for the other decreasing categories calculate well above the 0.1 threshold with p -values ≥ 0.5). While we cannot boast any significant difference between the frequency of these changes between pre- and post-program drawings, the decrease



FIGURE 6. Examples of pre- and post-program drawings by students. 6a and 6b were drawn on the first day before the program began and show a more idealized version of nature with exotic animals (giraffe) and uncommon weather (rainbow). 6c and 6d were completed at the end of the program and show examples of creatures encountered by the students during the outdoors part of the program (worm, ants, ladybug).

in frequency might be enough to suggest perspective changes among the students. This could be important if we consider that the students might less frequently associate anthropogenic influences, such as buildings and vehicles, with the natural world in urban environments. This is an important outcome for our program.

It is worth noting that our results failed to determine any statistically significant differences between the pre-program and post-program drawing renditions. We suspect two factors contributed to this result. First, we had a relatively small sample size. This is typical of classroom-based interventions. To obtain statistical significance, we would increase our sample size by offering this program in other urban fifth-grade classrooms. Second, the time allotted to students for the post-program drawing activity differed from the pre-program drawing activity. For the post-program drawing, students received approximately five minutes to complete the activity, compared to fifteen minutes for the pre-program drawing. We discuss this in greater detail in Limitations, below. However, even without obtaining statistical significance, we find our results to be thought-provoking; we believe they indicate that nature-based interventions influence student perspectives of nature.

Limitations

We experienced a few limitations to our study methods and analysis. When we designed the program, we planned to use our final day with the students to take them outdoors to interact with nature. We also planned to use this day to implement the post-program drawing exercise. However, we failed to realize the length of time each of these activities would take, including preparing students for outdoor time by putting coats on and navigating students to and from the outdoor area. As well, the children needed time to prepare for end-of-day dismissal. Having facilitated the learning activity, we ran short of time for the drawing exercise. This resulted in significantly less time for students to provide detailed drawings (down from 15 minutes to five minutes), compared to the pre-program drawings (down from 115 items to 71 items). One student failed to complete the drawing given the rush at the end of the day. For future studies, we discussed different possibilities, including adding a day to the program strictly for evaluation and unpacking the experience. Another possibility would be asking the teacher to provide students with time to complete the drawing on a subsequent day.

Another limitation we experienced was some difficulty interpreting the drawings without the students present. During the drawing exercises, our staff interacted with students to gather more information on some of the drawings. These staff members made notes on these drawings to help guide our coding methods. However, we were not able to talk directly with each student during both pre- and post-exercises given our short time with them. This led to a bit of uncertainty as we attempted to analyze the drawings. For future studies, we believe it could be helpful to invite each student to explain drawings verbally or by writing on the drawing itself. Researchers and educators would need to assess age-related and cognitive abilities when deciding on the best strategy for each group of students.

Future Directions

We believe this is a program that can continue to develop and expand to additional classrooms, with some improvements. As stated above, we would add a fifth day to the experience as a final wrap-up session with the students. This would allow us to capture more detail in

the final assessment and would also include discussion time in the classroom to tie all of the program days together. We could also expand the amount of planning by the undergraduates for each day's activities, to give them more experience in creating informal education programs. Finally, we would move the program earlier in the school year when the insects are naturally more plentiful. Overall, this is a promising pilot that has the ability to grow into a larger, recurring outreach program.

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