A Bioblitz of Mt. Pleasant Creek, Belize, 2024

Connecting local communities with the biodiversity of their backyards

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Abstract

Respecting, understanding, and appreciating the biodiversity around us is a key step towards environmental stewardship. Communities may not always be connected to their local biodiversity. This is why it is important to increase their knowledge regarding the plants, animals, and fungi of their backyards and the world around them. A Bioblitz - an organized, widespread effort to collect and share biodiversity data - is one tool which can help achieve this goal. Here, we present results and reflections of conducting a 2-day Bioblitz at Mt. Pleasant Creek in Belmopan, Belize, in August 2024, involving local communities and students. With over 1000 observations of 376 taxonomic species on iNaturalist, 76 participants in the field, 12 taxa-specific experts, support from 9 local organizations, and 4 media appearances, this Bioblitz created learning and engagement opportunities, and promoted environmental stewardship for participants and the surrounding community.

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Introduction

A meaningful understanding of biodiversity fosters a sense of environmental stewardship, as knowledge of the natural world encourages individuals to protect and sustain it. Environmental stewardship may be defined as the actions taken to care for, conserve, or sustainably use the environment in pursuit of specific outcomes, such as for improved water quality in a community, or reduced deforestation in a park, or removal of an invasive species from a defined area (Bennett *et al.*, 2018). There are many motivations that make an actor - such as individual, organization, or community - more likely to engage in environmental stewardship. These may include feeling like they have personal ability/control to make a difference, increased convenience of environmental actions, intrinsic determination, self identity relating to nature, and a goal-setting mindset (Harvey *et al.*, 2014; Pidgeon & Fischhoff, 2011). The ability of actors to be stewards may be further affected by whether or not they have the appropriate infrastructure, technology, funding, quality of life, knowledge/skills, and leadership to act upon their motivations (Chapin *et al.*, 2010).

A Bioblitz is a concentrated effort over a defined area and period of time, typically involving a large group of people, to collect biodiversity data. Bioblitz events are often citizen science projects, in which the general public and/or local communities are involved in some capacity, especially in data collection. Apps such as iNaturalist (www.inaturalist.org), iSpot (www.ispotnature.org), and eBird (https://ebird.org) are popular tools for facilitating these efforts. Motivations for citizens to participate in a Bioblitz may include the desire to involve oneself in something meaningful, enjoy the wonders of nature, play a role in conservation efforts, make life better for the coming generation, learn about flora and fauna, or try something new (Leong & Kyle, 2014). Thus, for participants, there is a balance of science, education, and conservation motivations.

The primary goals of leading a Bioblitz for an organization/group are most often to create a species inventory, find new species, and engage the public (Meeus *et al.*, 2023). Bioblitz events are well-suited towards building a species inventory for an area, as they involve effort from multiple people across a defined area. The species list may be limited temporally (e.g., seasonality, time of day, year), however, resulting lists are often robust. New species or taxa in an area may be found during a Bioblitz, even in an area well-sampled (Nicolai *et al.*, 2020). Participation in a Bioblitz can cause positive social outcomes, including an increase in recording biological data (such as through iNaturalist) up to 50 weeks after the event, as well as an increase in feelings of environmental stewardship (Gass *et al.*, 2021).

Data collection is a key component of a successful Bioblitz. Typical data include geotagged and time-specific occurrence records, number of participants, and in some cases, survey responses from participants on the experience. The occurrence data can be used to create a list of species present in the area, identify common species in an area, discover new species in an area, and see the spatial and temporal distribution of taxa in an area. The number of participants and survey responses can demonstrate social outcomes of the event.

Mt. Pleasant Creek is a creek which flows from the karst hills southeast of Belmopan through University of Belize (UB) property, past the Belmopan communities of Maya Mopan, San Martin, Salvopan, Piccinni, and east of Piccinni, through forest adjacent to an area with some industrial enterprises, before passing beneath the George Price Highway. From there, the creek ultimately discharges into the Belize River. In the upstream reach within the city, the riparian edge has been considerably deforested, and edges are urbanized with houses and small-scale farming activity, with the creek being contaminated through stormwater, road runoff, household wastewater, and directly via littering. Previous research has shown the creek to have excessive nutrients and an overgrowth of floating mats in some areas, which create breeding sites for disease-carrying mosquitoes (Boles *et al.*, 2005; Boles & Ack, 2017).

Conducting a Bioblitz at Mt. Pleasant Creek is an opportunity to learn about the biodiversity in a heavily used, urban creek. As Bioblitz events are associated with positive social outcomes and an increase in environmental stewardship and knowledge in participants (Leong & Kyle, 2014), the intention of a Bioblitz at Mt. Pleasant Creek is that participation in the event would help promote care and responsibility regarding the creek itself, as well as generate a species list. Furthermore, the biodiversity data collected could be used to directly communicate with locals, showcasing the juxtaposition between the wildlife at the creek, and the trash and pollution accumulated, and paving the way for future outreach activities.

In 2023, the first University of Belize Environmental Research Institute (UB-ERI) Bioblitz took place. It was a smaller-scale event, with 70 observations by 6 observers, and a focus on the University of Belize Campus in Belmopan, Belize, using an iNaturalist project (https://www.inaturalist.org/projects/belmopan-bioblitz-2023). In 2024, we aimed to do a larger-scale Bioblitz with more participants and taxa, across a more focused area during a 24-hour window. The UB-ERI and University of Belize Environmental Club (UB EClub) banded together for this purpose (Table 1), to get a species list of Mt. Pleasant Creek, and as a preliminary step in increasing awareness of biodiversity in the area, and increasing environmental stewardship in participants and the surrounding community.

Table 1. Primary organizers for the 2024 Bioblitz, along with their affiliations and contributions as per Consortia Advancing Standards in Research Administration Information (CRediT) standards (NISO CRediT Working Group, 2022). Sorted alphabetically by first name.

Organizer Name	Affiliation	Contributions
Abidas Ash	UBERI	Conceptualization, Administration, Data curation, Investigation, Writing - original draft
Ashira Rancharan	UB EClub	Administration, Investigation
Elsy Perez	UBERI	Investigation, Data curation, Writing - original draft
Dwayne Rodriguez	UBERI	Visualization
Gabriel Lanza	UB EClub	Investigation
Ivis Chan	UBERI	Funding Acquisition ¹
Jake Snaddon	UBERI	Conceptualization, Data curation, Methodology, Supervision, Investigation, Writing – review & editing
Jaylani Cawich	UB EClub	Investigation
Jessica Boles	UBERI	Administration, Investigation, Writing - original draft, Data curation, Visualization
Jocelyn Zavala	UBERI & UB EClub	Administration, Investigation, Writing - original draft
Pio Saqui	UB EClub	Funding Acquisition ² , Supervision
Samih Young	UB EClub	Conceptualization, Administration, Investigation
Samuel Esperanza	UB EClub	Administration, Investigation

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Methods

Location

The study area for the Bioblitz comprised a 7.5 km stretch of the Mt. Pleasant Creek, between UB-owned land in the south (upstream) to the edge of the George Price Highway in the north (downstream), including a 100m band on each side of the creek as well as the creek itself. This study area was divided into seven sections, approximately equal in size, though divided to accommodate logistics regarding accessing and taking groups to the creek for each section (Figure 1).

Section descriptions:

- Section 1 extends from UB property into the beginning of the Maya Mopan community of Belmopan. The upstream part of Section 1 is forested, whereas the downstream part is more urban, with residential buildings close to the river.
- Section 2 continues through Maya Mopan from the edge of Section 1 until the San Martin Avenue bridge. This section is mostly residential, with some inaccessible stretches, and some residences reaching inside the study area, close to the creek edge. Occasional residences block off creek access directly, through fences or open drainage systems creating swampy terrain.
- Section 3 stretches between the San Martin Avenue bridge and Cemetery Road Bridge, into the San Martin Community. This section has clear trails and is heavily residential.
- Section 4 is very similar in nature to Section 3, however it continues further downstream from the Cemetery Road Bridge until Pine Street in the Salvapan community.
- Section 5 is less accessible, as there are uncleared sections without trails. However, occasional creek access and clearing provides spots within the study area to collect data for Section 5, from Pine Street to Salt Lake Street and beside the Piccinni community.
- Section 6 extends from Salt Lake Street to Treasure Road. As most of this section is not cleared and inaccessible by foot, Section 6 also includes a tributary of the creek from Treasure Road to the creek crossing at Frosty Lake Street. Unfortunately, this crossing specifically was cleared during the week before the Bioblitz, leading to much of Section 6 being devoid of plants.
- Section 7 includes the main creek from Treasure Road downstream to the George Price Highway at Belmopan city limits. Section 7 is mostly forested and uncleared. Thus, it may be accessed only at Treasure Road. and through private property with permission from the George Price Highway.



Figure 1. Map of study area, Mt. Pleasant Creek and riparian edge in Belmopan, Belize. Sections are outlined in black bold, and red diamonds indicate access points for each section. Grid cells are 100 m² and cut to fit within the study area. The yellow star indicates Saint Martin's Government School. Created in QGIS by Dwayne Rodriguez and Elsy Perez, UBERI, using a Google Terrain Hybrid Map.

Saint Martin's Government Primary School (St Martin's) was used with permission of the principal as a base of operations for field efforts. St. Martin's is situated by the Cemetery Road Bridge, providing walking access to sections 2-5. Observations made at St. Martin's were also included in the study.

Bioblitz Design

The Bioblitz was open for a 24 hour period, from 1 pm Aug 23rd - 1 pm Aug 24th, local time. iNaturalist was used as the primary data collection tool and repository for recording observations, which were integrated into the project '2024 Belize Bioblitz' (https://www.inaturalist.org/projects/2024-belize-bioblitz). The project included any grade observations from any taxa and any iNaturalist members, as long as they were made within the study area during the open period.

Four main data collection events occurred within the Bioblitz open period. From 1:30-4:30 pm, Aug 23rd, seven groups of data collectors sampled opportunistically, one of each of the seven sections, ensuring all sections were covered. Equipment including sweep nets, dippers, and gloves were provided to assist groups with catching and handling wildlife. Living samples were collected and later identified and released back into the creek or riparian edge. Two fruit-feeding butterfly traps (variation of the Van Someren-Rydon butterfly trap) (Mullany *et al.* 2018) traps were set up in each section, baited with overripe bananas, to attract butterflies and moths. They were left up overnight and taken down the following day. Orchid bee traps, baited with eucalyptus oil, were set up in sections 5 and 7, and taken down the following day. Participants took photographs and recordings, or wrote handwritten observations of all biodiversity observed. Observations were uploaded onto iNaturalist.

From 6-8:30 pm, Aug 23rd, data collectors met at St. Martin's, where a mothlight was set up to attract insects, comprising a mercury-vapor lamp and large white sheet (Figure S.1). The data collectors then split into two groups which explored either Section 4 or Section 5 of the creek. Each group took flashlights and photographed any animals found in their sections. Observations were uploaded onto iNaturalist. To detect the presence of bat species, three AudioMoth acoustic devices (Hill et al. 2018) were

placed to record audio from bats overnight. One was placed at St. Martin's and one in section 4 and 5, next to the river. The AudioMoth units were set to record 5-minute recordings, at a sample rate of 250 kHz, with sleep periods of 30-seconds between recordings, from 7 pm till 6 am, resulting in a total of 120 recordings per device. These data were later imported into Kaleidoscope Pro (www.wildlifeacoustics.com),the Bat Auto-ID classifier for Neotropical bats was used to identify recordings with bat calls and to determine the most likely bat species in the area. Then, the bat species identified were added into iNaturalist with clips of the audio waves as evidence.

From 6-8 am, Aug 24th, seven groups, each led by expert birders conducted bird surveys at Mt. Pleasant Creek. Each group sampled one of the seven sections by using the transect protocol which consists of counting and recording birds seen or heard while walking from the start of their assigned section (point A) to the end of the section (point B). Two apps, eBird and Merlin Bird ID, facilitated the surveys. The eBird app was used as the main recording tool for bird sightings and count, whereas the Merlin Bird ID app was used by some participants to record audio of birds and assist in the identification of birds heard along their assigned transect. At point A of the transect, an eBird checklist was started by the group leader or the person assigned to track observations. As the group walked down the transect, each bird species seen or heard was identified and recorded in the checklist. Binoculars were used to observe birds carefully to make an accurate identification to species level. In the case of not getting a good look at a bird, it was only identified to genus level. In addition to bird species, the number of individuals observed was also recorded. At the end of the transect (point B), the eBird checklist was stopped and shared with Abidas Ash (UBERI Avian Biologist), for transfer to iNaturalist via a csv appropriately formatted for import.

From 9-11:30 am, Aug 24th, four groups of data collectors sampled one of either Section 2, Section 3, Section 4, and Section 5. Participants photographed, took recordings, or wrote handwritten observations of all biodiversity observed. Observations were uploaded onto iNaturalist.

The iNaturalist project remained open for observations to be uploaded after the event, as many participants were not able to upload during the event itself. Organizers reached out to individuals to encourage them to upload observations for a duration of two weeks after the event.

Environmental Fair

An Environmental Fair was held at St. Martin's from 9 am-12 pm on Aug 24th, to draw more attention to the Bioblitz, and provide additional educational opportunities for

participants. Fifteen organizations were contacted via email with invitations to participate in the Environmental Fair. Of those invited, eight organizations attended. Each organization set up educational booths, covering various environmental topics (Table 2). The planning process for the event involved the use of the RACI matrix to ensure clear communication and smooth workflows (Miranda & Watts, 2024).

Organization Name	Торіс
Belize Karst Habitat Conservation	Biodiversity, Protected Areas, Water Quality Testing
Belmopan City Council	General Environmental Information
Full Circle Belize	Plastic Pollution, Plastic Solutions
The Belize Zoo	Biodiversity Education
The National Biodiversity Office	Biodiversity, Protected Areas
UB E-Club	Conservation, Environmental Awareness
UBERI	Environmental Research Initiatives
Wildlife Conservation Society	Wildlife Conservation
Friends for Conservation Development	Wildlife and Watershed Conservation, Protected Areas Management

 Table 2. Local organizations that participated in the Bioblitz Environmental Fair

 2024, along with their topic of focus. Sorted alphabetically by first name.

Prior to the fair, a clean up with volunteers was conducted at St. Martin's to tidy the area and remove any trash. Booth setup began at 8 a.m. for attending organizations and volunteers, and the event officially commenced at 9 a.m. with an opening ceremony featuring key speakers: (1) Dr. Jake Snaddon, Director of UBERI, who discussed the background and importance of the Bioblitz, (2) Samuel Esperanza, Vice President of the UB E-Club, provided insights into the "Sowing Seeds of Change" project, (3) Kiria Chan, Communication Assistant at the National Biodiversity Office, spoke about their partnership with the UB E-Club. At 12 p.m., four school bags containing school supplies, sponsored by Hon. Oscar Mira, were raffled. Additionally, five tote bags with the "Sowing Seeds of Change" logo, sponsored by the UB Environmental Club, were also raffled. The purpose of the raffle was to attract additional community members to the fair.

Certificates of appreciation for participation and expert contribution were given to the invited experts who participated in the 2024 Belize BioBlitz. After the event, additional certificates were digitally distributed to all participants as a show of appreciation for their support, and to establish post-event communication for later follow-up. The closing ceremony was delivered by Dr. Pio Saqui, the advisor to the UB E-Club, followed by lunch and refreshments provided to all participants.

Participation and Advertising

To engage students and the community, participation in the Bioblitz was open to anyone who wished to join us. A Google sign-up sheet was created and shared in two UB student group chats: The UB EClub chat, consisting of approximately 100 members, and the Jaguars group chat, which has 43 Natural Resources Management students. Two posters were designed—one focused on the BioBlitz and the other on the Environmental Fair. These were promoted on the UB E-Club and UBERI social media accounts, including Facebook and Instagram. Several organizers also shared the posters on their personal social media platforms. Additionally, 10 printed copies of each flyer were distributed to nearby stores, and 10 flyers advertising the BioBlitz were placed around the UB's Belmopan Campus.

After the event, all participants were provided with a link to a Google Sheets feedback form, to allow us to hear their experiences and critiques for the event.

Four media appearances, made between Channel 7 and PlusTV, were made by Bioblitz event organizers to promote the event prior to the field dates, and disseminate findings/results after the event.

<u>Analysis</u>

Data of the surveys and iNaturalist observations were exported from their respective platforms and analyzed in R using the tidyverse and iNEXT packages. A rarefaction and extrapolation analysis was done on the observations data to visualize species richness over the number of observed individuals. To give time for identifiers to process the observations, a period of 2 weeks was given before the data were extracted from

iNaturalist. Bat audio recordings were analyzed using Kaleidoscope Pro 5.6.8 with the Bats of the Neotropics 5.4.0.

Results

<u>Summary</u>

Participation for the event was high, especially for the main (general) Bioblitz activities on Aug 23rd and 24th, which had 52 and 33 participants respectively. In total, 76 participants joined us for the Bioblitz (Table 3).

The weather was mostly sunny and cloudy on August 23rd, for the duration of the first Bioblitz session and the night Bioblitz session. Overnight, it rained hard, raining lightly through the start of the birding Bioblitz on August 24th. By the late morning the weather was sunny again.

Table 3. Participation summary of the 2024 Belize Bioblitz, by activity, number of groups, and number of participants. At the bottom is a count of all unique participants across all events.

Activity	Date	Num. of Groups	Num. of Participants
Cleanup of St. Martin's	Aug 23	1	12
General Bioblitz 1	Aug 23	7	52
Night Bioblitz	Aug 23	2	21
Birding Bioblitz	Aug 24	7	27
General Bioblitz 2	Aug 24	4	33
TOTAL	Aug 23-24		76

In total, there were 41 observers and 120 identifiers involved in the iNaturalist project (to date 2024-09-11). 115 of the 120 of the identifiers were external to the project, meaning that there was excellent involvement from the wider iNaturalist community on securing IDs for our observations (Table 4).

A wide variety of plants and animals were found during the Bioblitz, as well as trash and signs of extensive damage to the riparian edge (Figure 2). In particular, participants observed the accumulation of garbage more in the urban sections of the creek, from Sections 1, 2, 3, 4, and 6. Garbage observed included plastic and glass containers, broken appliances such as a fridge, disposable diapers, batteries, and tires.

Table 4. iNaturalist results summary of the 2024 Belize Bioblitz by contributor type, and whether they are a member of the project

Contributor Type	Project Member	Number of Contributors
Identifier	Yes	5
	No	115
	Total	120
Observers	Total	41





В



С



D



Figure 2. Photo plate of cropped images showcasing the contrast between environmental damage and biodiversity observed during the 2024 Belize Bioblitz. A and B (Jocelyn Zavala) demonstrate examples of littering at Mt. Pleasant Creek. C (Wilson Arevalo, https://www.inaturalist.org/observations/237675929) is a Complex Phallus Indusiatus stinkhorn. D (Jess Boles,

https://www.inaturalist.org/observations/237729862) is a Leucauge argyra spider. E (Miguel Sho, https://www.inaturalist.org/observations/237760246) is an Auriferous Green Sweat Bee (Augochlora aurifera). F (Jake Snaddon,

https://www.inaturalist.org/observations/237723470) is a bullhorn acacia (Vachellia cornigera).

Species Richness

Results for the Bioblitz may be found on the iNaturalist project (https://www.inaturalist.org/projects/2024-belize-bioblitz). At this current point, (2024-09-11), when organized by iNaturalist category, the most popular groups were insects with 485 observations and 114 unique species, plants with 382 observations and 125 unique species, and birds with 179 observations and 73 unique species, with 1294 observations and 373 unique species overall (Table 5).

Category	Observations	Таха	Observations at Species Level	Unique Species
Birds	179	75	176	73
Amphibians	18	3	14	3
Reptiles	12	5	9	5
Mammals	22	13	20	11
Ray-finned Fishes	5	4	3	3
Molluscs	30	15	13	6
Arachnids	64	29	23	13
Insects	485	201	220	114

Table 5. iNaturalist results summary of the 2024 Belize Bioblitz by iNaturalist category, including number of observations, unique taxa, unique species, and unique species that are threatened

Plants	382	148	265	125
Fungi and Lichens	31	21	16	14
Protozoans	1	1	0	0
TOTAL	1294	527	769	374

A rarefaction and extrapolation curve shows us that we only sampled a small amount of the expected biodiversity of Mt. Pleasant Creek (Figure 3). Insects, plants, and birds have more than 200 species-level observations each. However, most groups do not have enough species-level observations to create robust curves.



Figure 3. Rarefaction and extrapolation curve of species richness (q = 0) of primary groups of biodiversity, including amphibians (Amphibia), birds (Aves), fungi (Fungi), Mammals (Mammalia), plants (Plantae), arachnids (Arachnida), fish (Actinopterygii), insects (Insecta), molluscs (Mollusca), and reptiles (Reptilia). Black stars represent individual and richness counts from the 2024 Belize Bioblitz. To the right of the black stars are predicted data based on an iNEXT species accumulation curve. Data used are filtered to solely include observations at species level.

Feedback Survey Results

77% of respondents rated the event 5/5 for enjoyment. However, only 44% rated the event 5/5 for safety, with 4/5 being the most common choice. 67% of respondents rated the event as 5/5 for it being educational, and 72% said they would be very likely (5/5) to participate in the event again next year (Figure 4, Panels C-G).



Figure 4. Google Forms survey results of 18 participants of the 2024 Belize Bioblitz, including which activities they participated in (A), whether they took photographs (B), whether they uploaded their photographs to iNaturalist (C), how much from 1-5 they

enjoyed the event (D), how safe from 1-5 they felt (E), how educational the event was from 1-5 (F), and how likely they would be to participate next year from 1-5 (G). In each scale, 1 represented the most negative response, and 5 represented the most positive response.

Media Involvement

The event was promoted on four media appearances. The first, with Sunup (7News Belize) on Aug 20th, 2024, gained 1.7k views on YouTube (https://www.youtube.com/live/ooYDV0vH_x0?si=4Ztq02K5Z__SEsXO&t=6715). The second, with PlusTV on Aug 21st, 2024, gained 48 views on YouTube (https://youtu.be/8NvupNYpyI0?t=2751). The third, with Sunup on Sept 18, 2024, gained 1.3k views on YouTube (https://www.youtube.com/live/tJiS88ByUok?si=tjFQig4qXjmzRGC3&t=4833). The fourth, with PlusTV on Sept 19th, 2024, gained 75 views on Youtube (https://www.youtube.com/live/3Xy6RmwlNeg?si=TGhqKkzMXSdazOK_&t=2687) and was with City Council representatives and scientists involved in past research at Mt. Pleasant Creek. All four media appearances were also aired live on their respective television channels, to an unknown number of at-home or radio viewers.

Discussion

Overall, the 2024 Belize Bioblitz fulfilled its primary objectives of collecting biodiversity data at Mt. Pleasant Creek and engaging the surrounding community. A significant range of flora and fauna was recorded (Figure S.2), with the most abundant observations occurring in the insect, plant, and bird categories. The event yielded 1294 observations and 374 unique species (Table 5), with 120 identifiers on iNaturalist from across the world (Table 4). The recorded biodiversity likely represents only a fraction of the total diversity at the creek, emphasizing the potential for further exploration and study within the area (Figure 3).

The Bioblitz activities attracted 76 participants (Table 3), showcasing high engagement, with positive feedback from attendees (Figure 4) and engagement in the field (Figure S.1). By participating, they were able to gain knowledge about the biodiversity of Mt. Pleasant Creek and witness firsthand the littering and pollution in the area. However,

the participants seemed to primarily be students and representatives from organizations, not those that live directly near the creek. This study demonstrates the biodiversity richness of Mt. Pleasant Creek, but also the importance of continuing to monitor and engage the community, to counteract concerning environmental practices and raise awareness.

Insects

Out of 220 species-level observations, we found 114 unique species of insects. This relatively steep species accumulation suggests that there are many more insect species unrecorded, and additional sampling effort would yield a much higher species richness (Figure 3). The Aztec Spur-throated Grasshopper (*Aidemona azteca*), Zebra Longwing (*Heliconius charithonia*), Queen (*Danaus gilippus*), and *Romalea obscura* were the most frequently recorded insect species identified during the Bioblitz. 11 insects orders were represented, including Odonata (dragonflies, damselflies), Lepidoptera (moths, butterflies), Hymentoptera (bees, ants, wasps), Coleoptera (beetles), Hemiptera (bugs, cicadas, hoppers), Orthoptera (grasshoppers, crickets), Diptera (flies), Blattodea (roaches), Mantodea (mantises), Neuroptera (lacewings, antlions, owlflies), and Trichoptera (caddisflies), which represents a fair amount of taxonomic diversity.

Insects were mostly collected through random encounters along the creek or at lures (orchid bee lures, butterfly traps, or the mothlight), or by actively moving rocks, logs, or trash, or using the sweep nets. Due to the diversity of insect microhabitats and life histories, it is likely that many insect types were underrepresented in our sampling. For example, ground-dwelling arthropods, such as springtails, isopods, termites, centipedes, and millipedes could have been found with more active searching.

While rocks were overturned in the creek, and creek sediment was collected for processing, aquatic macroinvertebrates such as larval dragonflies, caddisflies, or mayflies were not found, nor adult aquatic insects like backswimmers, giant water bugs, or skaters. This may be a result of low sampling effort in the water and lack of proper equipment, or represent low numbers of aquatic macroinvertebrates, an indication of the water quality of the creek. In 2015, with focused sampling, 35 taxa of aquatic macroinvertebrates were found during a rapid ecological assessment, very few of which were observed during our Bioblitz (Boles & Ack, 2017). For future surveys, having a specific team working on aquatic macroinvertebrates could help fill this gap, and provide information about biodiversity within the creek itself.

Out of 485 observations, 265 insects are currently not identified to species level - which is more than half of the sample. 113 were not identified to genus level, and 40 were not

even to family level. Despite being the most species rich class of the Bioblitz, insects can be difficult to identify to species level from photographs. Providing participants with equipment such as clip-on phone macro lenses, magnifying glasses, or jeweler's loupes could help magnify photos and increase the ease of identification.

<u>Plants</u>

Out of 265 species-level observations, we found 125 unique species of plants (Table 5). This rate of species accumulation is not as steep as that for insects; however, it is steep enough to suggest a large amount of unrecorded biodiversity at the site (Figure 3). As plants are stationary (and often attractive in appearance), they were well-sampled. For example, the most observed species across all groups was a plant - the Star of Bethlehem (*Hippobroma longiflora*). 117 plant observations are currently not identified to the species level. In upcoming years, it may serve us well to be more clear to participants on the diagnostic plant characteristics that need to be photographed to identify the more challenging plants.

<u>Birds</u>

Out of 176 species-level observations, we found 73 unique species of birds (Table 5), suggesting that further sampling could slightly increase the species richness, up to around 80-90 bird species (Figure 3). A previous study of bird diversity in Belmopan recorded 104 species from 1964 individuals observed over a four month period (Perez 2024). Impressively, almost every bird observed was identified to the species level. This is likely due to the nature of the sampling, as it was done with multiple expert birders leading data collection in the field and with reference to birdsong using the Merlin App. On eBird, typically only observations with a high level of confidence in the species identification are recorded by the observers.

A total of nine common species were identified as they were recorded at each of the sections. These include: Blue-black Grassquit (*Volatinia jacarina*), Clay-colored Thrush (*Turdus grayi*), Golden-fronted Woodpecker (*Melanerpes aurifrons*), Great Kiskadee (*Pitangus sulphuratus*), Great-tailed Grackle (*Quiscalus mexicanus*), Melodious Blackbird (*Dives dives*), Morelet's Seedeater (*Sporophila morelleti*), Social Flycatcher (*Myiozetetes similis*), and Spot-breasted Wren (*Pheugopedius maculipectus*). These species have been known to inhabit forest edges to disturbed secondary growth vegetation which makes it fitting to have these species as common as that is the

vegetation type that is along the Mt. Pleasant Creek. In addition, these species are mostly granivores and insectivores.

There were a few forest habitat specific species that were observed in the areas within dense secondary forest. These species included: Green-backed Sparrow (*Arremonops chloronotus*), Ivory-billed Woodcreeper (*Xiphorhynchus flavigaster*), Mayan Antthrush (*Formicarius moniliger*), Ruddy Quail-Dove (*Geotrgon montana*), Slaty-tailed Trogon (*Trogon massena*), White-breasted Wood-Wren (*Henicorhina leucosticta*) and White-collared Manakin (*Manacus candei*). The majority of the species observed were resident species and the common taxa were tanagers, seedeaters, flycatchers, parrots and doves.

Since this Bioblitz occurred in the early season of migration there were some migratory bird species that were recorded. These migratory species are early migrants which means that they are on their way to southern Central America to South America where they will be wintering. These included species in the taxa of swallows, martins, vireos, warblers and Orioles. In addition, there were two species of austral migrants that were recorded during this Bioblitz. These are species that are from South America that come to breed during the breeding season in Central America. These are Sulphur-bellied Flycatcher (*Myiodynastes luteiventris*) and Yellow-green Vireo (*Vireo flavoviridis*).

Overall, the birding community was happy to have been involved in this year's Bioblitz and it was great that these lead experts shared their knowledge with other birding enthusiasts that joined this activity.

Arachnids

Out of 23 species-level observations, we found 13 unique species of arachnids (Table 5). These were exclusively spiders, though higher-level taxonomic observation included a tailless whip scorpion and a harvestman. *Leucauge argyra*, a type of orchard spider, was the most commonly observed arachnid during the Bioblitz.

To improve the ratio of identified to non-identified observations for arachnids, photographs of the eyes and female/male genitalia specifically could be a good strategy. As in Insecta, tools to magnify in the field could help lower the scale of photographs for arachnids. To improve the number of observations of spiders, a beat sheet could be used, as well as a mist spray bottle and flashlight for noticing spiderwebs under canopy.

Other Taxa

Out of 16 species-level observations, we found 14 unique species of fungi (Table 5). These fungi were diverse, comprising both the Basidiomycota and Ascomycota phyla, including examples of shelf fungi, stinkhorns, and lichen.

Out of 13 species-level observations of molluscs, we found 6 unique species (Table 5). While the species richness identified is low, 56% of observations do not currently have a species ID. While molluscs may be identified in the field with guides such as the Land Snails of Belize (Dourson *et al.*, 2018), samples were not directly collected and brought back to be identified at base, and pictures were often insufficient for identification. In the future, specifically bringing shells back to base could assist in this process and produce more complete identifications.

Out of 14 species-level observations of amphibians , we found 3 unique species (Table 5), including the Central American Gulf Coast Toad (*Incilius valliceps*), Mexican White-lipped Frog (*Leptodactylus fragilis*), and Vaillant's Frog (*Lithobates vaillanti*). Despite hearing numerous frog and toad calls, our sample was limited to only these three species. Recording calls of frogs and toads next year could supplement our species list.

Out of 9 species-level observations, we found 5 unique species of reptiles (Table 5), including basilisks, anoles, a Black-striped Snake (*Coniophanes imperialis*), and an Asian House Gecko (*Hemidactylus frenatus*). A Morelet's crocodile (*Crocodylus moreletii*) is known to be in the area, but was not found during the Bioblitz.

Out of 20 species-level observations, we found 11 unique species of mammals (Table 5). These included 7 species of bats, 2 domestic species, and 2 squirrel species. Mammals such as the Yucatán Black Howler Monkey (*Alouatta pigra*) and agoutis/paca are known to be in the area, but were not found during the Bioblitz. The 7 species of bats were identified using Kaleidoscope Pro, and such auto identification can have high levels of inaccuracy. This list should be considered a preliminary species list. The recordings have been sent to Bruce Miller (Belize Bat Expert) for species verification.

Out of 3 species-level observations, we found 3 unique species of ray-finned fish (Table 5), including the Pike Topminnow (*Belonesox belizanus*), Two-spot Live Bearer (*Poecilia parae*), and the threatened Peten Cichlid (*Chuco intermedium*). A fourth taxa recorded was *Astyanax sp.* with two observations. This is likely to be the Central Tetra (*Astyanax aeneus*) which was historically recorded as abundant (Boles & Ack, 2017). We also did not observe any Gambusia, like the Stippled Gambusia (*Gambusia sexradiata*) or Sleek Mosquitofish (*Gambuia luma*), which were previously recorded by Boles & Ack (2017).

In future surveys, more focus on the aquatic sampling would provide better coverage for species within the creek itself.

Participant Feedback

Participants rated the event relatively high in enjoyment and educational content, indicating that participation was enjoyable and effective. However, the sample size for the survey was low. While there were 76 participants in the Bioblitz, we only received 18 responses on the feedback survey, meaning we had a response rate of only 24% (Figure 4).

We also allowed participants to relay to us what they liked about the Bioblitz, what they did not like about the Bioblitz, and what the organizers could improve on for next year. Participants liked getting to be in nature and seeing plants/animals, learning about different species and science, photographing nature, and the community feel and enthusiasm of the event. Participants did not like the garbage at the creek, feeling like we were passing through people's yards, and the overall urban setting of the mid-range sections. Participant advice for next year is to have longer activities, collect specimens in the field to look at later, better safety considerations, more time with experts and larger groups to learn about what we are finding, more focus on aquatic flora and fauna, and easier signup process.

Final Thoughts

There were several challenges we faced, in planning and executing the 2024 Bioblitz. Firstly, was handling the logistics around the event, especially the Environmental Fair. As there was only a small budget for this project, keeping participants fed and hydrated, as well providing space and resources for invited organizations, required additional logistics. Creative solutions, as well as donations from individuals and Bowen and Bowen, ensured the planning was a success.

Secondly, was engaging the community itself in the project. While there was good turnout for the Bioblitz activities, participants tended to be students or organization representatives, not people that live along Mt. Pleasant Creek. In addition, participants already had a strong sense of environmental stewardship or love for nature - they were not the same people throwing trash in the creek. The Environmental Fair was one strategy we hoped would attract more community members. However, value from the fair was more for participants and family of participants than locals along the creek. Next

year, instead of an Environmental Fair, we can explore other avenues for engaging the community. Holding the main base from the Bioblitz in a location where there is a high level of public foot traffic can increase engagement. Additionally, this year, we can explore strategies like sharing Bioblitz results to community members, and engaging in 1-on-1 conversations to spark discussion around helping the creek. One positive is the decent amount of view for our media appearances, which hopefully assisted with spreading awareness beyond direct participants.

Thirdly, was acquiring observations from all participants. Only 54% of participants uploaded observations directly to iNaturalist under their own account name (Tables 3 & 5). It is unclear whether the remaining 46% of participants did not take photos or simply did not upload their photos.

Fourthly, was ensuring good sampling across all taxa. While insects, birds, and plants were well-represented, taxa such as fungi, fish, and mammals were lacking in observations. In the future, refining sampling methods and creating activities that target specific taxa could be of value.

The 2024 Belize Bioblitz was a coordinated effort to investigate the Biodiversity of Mt. Pleasant Creek, and promote understanding and a sense of environmental stewardship in the community and participants. Through this event, we created a large species list for the area, and a model for each major taxa on expected species richness with larger sampling effort. We interacted with participants and community members, and encouraged care and appreciation of the natural world. While it had its challenges and limitations, the event was a success, and we look forward to doing a refined followup Bioblitz in 2025.

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Supplemental Materials



Figure S.1. Photo plate of images of participant experiences during the 2024 Belize Bioblitz. A (Jake Snaddon) shows participants at the night activity, beside the UV moth light. B (Ian Guerra) shows community engagement at the ERI booth of the Environmental Fair. C (Jess Boles) shows participants watching a demonstration by the ERI director on using sweep nets in the field. D (Jaylani Cawich) shows participants at Section 4. E (Reeve Boles) shows participants at Section 1. F (Latha Thomas) shows participants at Section 3. All photographs of minors are included with the express written consent of a parent or guardian, obtained either directly or through a prior disclosure agreement.



Figure S.2. Photo plate of cropped images of biodiversity observed during the 2024 Belize Bioblitz. A (Elsy Perez, https://www.inaturalist.org/observations/237510083) is a Jungle Flame (Ixora coccinea). B (Reneisha Hamilton,

*https://www.inaturalist.org/observations/*237524244) *is a Dark Calephelis (*Calephelis velutina). C (Khloe Peyrefitte, https://www.inaturalist.org/observations/237537683) *is a Green-eyed Dancer (*Argia frequentula). D (*Reyna Choj,*

https://www.inaturalist.org/observations/237540885) is a Mexican Primrose-willow (Ludwigia octovalvis). E (Jake Snaddon,

https://www.inaturalist.org/observations/237579775) is a Slime Mold (Phylum Mycetozoa) beneath a UV light. F (Angelina Escalante,

https://www.inaturalist.org/observations/237682001) is a Paches gloriosus. G (Jake Snaddon, https://www.inaturalist.org/observations/240987832) is an audio recording of a Sinaloan Mastiff Bat (Molossus sinaloae). H (Jess Boles,

https://www.inaturalist.org/observations/237848035) is a Clathrus crispus stinkhorn. I (Miguel Sho, https://www.inaturalist.org/observations/237763192) is a Miniature Awlsnail (Subulina octona).