Poster Abstracts & Bios

Presenters are listed alphabetically

Analyzing aquatic insect body size variation in river networks
Gretel Baur, Virginia Tech.

Gretel Baur is pursuing a master's degree in biological sciences at Virginia Tech. Her research interests include stream insect ecology, environmental education, and all things freshwater.

Body size is one of the most important aspects of an organism's biology and determines metabolism, a vital life function. Analyzing organism mass with respect to abundance at a given scale is known as a size spectra analysis. Steeper size spectra slopes indicate less efficient energy transfer between food web levels. Aquatic systems are a particularly useful place to study size spectra because predator mouth size limits predation. Some research has been done to show how size spectra vary spatially over large landscapes, but variation within a singular river network is an understudied angle. I sampled aquatic insects at eight sites within Little Stoney Creek in Giles County, a third order stream that feeds into the New River. I then made size spectra graphs to compare headwater sites to mainstem sites. This work has broader implications for ecological monitoring, as size spectra are an emerging method for non-taxonomic analysis of ecosystem response to disturbance or restoration.

Cross-dating Death: Applications of Dendrochronology for Early Detection of Emerald Ash Borer Invasion and Tree Mortality

Lucas Biscan-White, Radford University

The spread of non-native invasive insects in North American forests has resulted in significant losses of native foundation tree species, which are crucial for ecosystem stability. In particular, invasive insects such as the emerald ash borer (EAB) have devastated ash tree populations since its introduction in the late 20th century, leading to extensive mortality and economic losses. Traditional monitoring methods, relying on visible signs of infection, have limitations in detecting early-stage infestations. Dendrochronology, the study of tree rings, offers a promising approach for early detection and precise measurement of tree decline. By examining growth rings of dead ash trees, researchers can identify early signs of EAB infection and assess the rate of decline more accurately. This approach can aid in implementing timely treatment and control measures to mitigate the impact of EAB on forest ecosystems. This project sampled 40 ash trees from study sites in southwest Virginia and conducted detailed dendrochronological analyses to determine the death date of sampled infected ash trees, many dying some seven to eight years before visual observations. By utilizing dendrochronology to analyze growth rings of dead ash trees, new insights into early infection indicators, the rate of decline, and dying behaviors of ash trees in advanced decline have been identified. By correlating these findings with existing monitoring data, this project seeks to enhance early detection and inform effective management practices. This comprehensive approach, spanning from data collection to statistical analysis, holds promise for mitigating the impact of EAB on forest ecosystems and guiding conservation efforts.

Quantifying spatiotemporal metacommunity variability using benthic and drift sampling of stream macroinvertebrates

Brian Bush, Virginia Tech

Brian is a 2nd year graduate student in the Virginia Tech Department of Biological Sciences. He received his undergraduate education at The Ohio State University and has performed extensive field research across the country. He is interested in aquatic macroinvertebrate community ecology, with particular emphasis on how dispersal affects these communities.

Metacommunity theory has received considerable attention in freshwater macroinvertebrate ecological research due to its utility in informing the mechanisms underlying community assembly. However, spatiotemporal variation in macroinvertebrate metacommunity dynamics is still relatively poorly understood, despite seasonal variation in macroinvertebrate dispersal being a well-documented phenomenon. Here, we present research aimed at quantifying spatiotemporal metacommunity variability through the combination of benthic and drift surveys in a single river network. We hypothesized that headwater and mainstem sites would exhibit distinct communities, with headwater sites exhibiting stronger temporal variation in community dissimilarity in line with a species sorting perspective (as opposed to mass effects in mainstems). We also hypothesized that concurrent drift surveys would be more similar to benthic surveys in headwaters compared to mainstems, also in line with current understanding of metacommunity dynamics in dendritic stream networks. For our survey design, 8 sites were sampled monthly along Little Stony Creek, a 3rd order stream network in Giles County, VA.

Collection sSites were established along a drainage area gradient in the network (1st - 3rd order), allowing for a distinction between headwaters and mainstem sites. Environmental parameters and channel dimensions were collected concurrently with biological data as covariates. While sample identification is ongoing, we predict ordination of the community data using Nonmetric multi-dimensional scaling (NMDS) will show distinct spatially structured communities that vary temporally in accordance with the degree of dissimilarity of drift samples. Considering the many anthropogenic factors altering freshwater metacommunities, incorporation of temporal, instead of simply spatial, variability can better inform management of these impressively complex systems.

An Assessment of Aquatic Invertebrates at an Ecosystem Restoration and Reference Site in the New River Gorge National Park and Preserve, WV

Cole Cline, WVU Institute of Technology, Jay Raymond, WVUIT

Aquatic invertebrates were sampled at two human created ponds, Pike and Grandview Pond, in the New River Gorge National Park and Preserve, WV, during the spring of 2024. Pike Pond is a 0.5-hectare impounded wetland that will have an earthen dam removed in the summer of 2024 due to a reduced functioning outlet. Grandview Pond is also a human created pond but serves as a reference site because it has many characteristics of a natural water body. Sampling methods in spring 2024 were the use of submerged litter bags with three different substrates (eastern white pine foliage, rhododendron foliage, leaf litter) and sediment cores. Samples were collected in February, March, and April. In addition, kick net sampling was conducted by students in the ecology classes at West Virginia University Institute of Technology (WVUIT) in the fall of 2022 and 2023. The sampling from 2022-2024 provides a baseline dataset to assess changes in aquatic invertebrate assemblages prior to the ecosystem restoration project at Pike Pond. This project will be monitored by undergraduate student researchers and students of the fall ecology classes at WVUIT after to assess the efficacy of the ecosystem restoration project.

The New Scenic River in Virginia

Lynn Crump, Tricia Pearsall, Historic Falls of James Scenic River Advisory Committee
Dylan Stephens, VCU

Lynn Crump, PLA, retired from the Virginia Department of Conservation and Recreation where she worked on scenic resources with the Virginia Outdoors Plan, Byways Program, and Scenic Rivers Program. With Scenic Virginia she manages the statewide scenic recognition program which helps Virginia's communities identify their scenic viewsheds.

Dylan Stephens is a Master of Environmental Studies Student with Virginia Commonwealth University, who leverages GIS and data analysis to explore environmental issues. His recent work focuses on scenic viewshed analysis and public outreach using ArcGIS dashboards, he has long been inspired by a passion for the incredible diversity and beauty of the Mid-Atlantic forests.

Abstract: This session intends to inspire Virginia Communities to designate sections of the New River under Virginia's Scenic Rivers Program. The history of the New River in Virginia is long and has many twists. The history of its scenic designation is only a little less entwined. Several times during the last 50 years there has been great interest in designating sections of the New River as part of the Virginia Scenic River program. In the early 2000s, there was also a movement to get a portion of the New River in VA and WVA designated as a National Wild and Scenic River. Even though those attempts were unsuccessful, there are still local citizens who believe that the river should be recognized for its outstanding scenic, historic, and natural characteristics, as well as its recreational value.
The Virginia Scenic Rivers Program recognizes rivers for all of these qualities, and Virginia's designation process brings a broad spectrum of community participants together to consider all benefits for the river and regional communities. This presentation will examine the history of the Virginia Scenic River program, its successes, and its challenges, then completely review the process of getting a river nominated and designated. We will discuss previous Scenic River work that has already been completed on the New River in Virginia.

Virginia Scenic Rivers
Lynn Crump, Scenic Virginia,
Map of the designated Scenic Rivers in southwestern Virginia. Hands-on map gathering Public Opinion on Scenic designation possibilities and qualities.

Preliminary Analysis of Water Quality in the Greenbrier River of West Virginia
Haidyn DePinho, WV DEP, Matthew Williams, WVSOM.
Haidyn DePinho graduated from Concord University with an Environmental Geoscience Degree and started her full time Americorp VISTA position with the WV Department of Environmental Protection in the fall of 2023. She is working full time to help build capacity with the Greenbrier River Watershed Association and Friends of the Second Creek until August of 2023.

Dr. Matthew Williams is an Associate Professor at West Virginia School of Osteopathic Medicine where he teaches medical microbiology. He has a variety of scientific interests including probiotics development, public health, and clean water access, but is most passionate about providing experiences to students that will facilitate the next stages of their careers.

The Greenbrier River flows for 173 miles before emptying into the New River making up 30% of its volume and impacting millions of people each year through tourism and drinking water sources. The Greenbrier River is generally known to have moderate to good water quality based on previous studies, but an extensive analysis has not been performed in nearly thirty years. Coliform bacteria have been recognized as one of the leading impairments to this watershed. The Greenbrier River Watershed Association and West Virginia School of Osteopathic Medicine partnered to create a water monitoring program to sample at 18 public access points along the river, once a month starting in August of 2023. The project consists of five groups divided along the river to analyze several parameters including coliform bacteria, suspended solids, pH, dissolved oxygen, conductivity, and several physical

characteristics. This current report is an overview on project setup and analyzes seven months of preliminary data to assess Greenbrier River's general water quality. Overall, the project has created strong partnerships that aims to guide remediation efforts and promises to be a valuable resource for community water monitoring into the future.

The Pulse of Species: Introducing the Interactive River Project
Benjamin Erlandson, The Upper New, Inc.
Dr. Benjamin Erlandson spends as much time as possible outside, exploring the New River Basin, switching gears between fiction, nonfiction, and visual arts. As a reader, a writer, a photographer, a filmmaker, and an independent scholar, Ben constantly explores intersections of narrative, knowledge, belief, learning, assessment, and behavior change.

We begin with an overview of the Interactive Basin Project (IBP), a multi-layered interactive map and data visualizations, interconnected, with initial visual and spatial focus of the IBP upon the Upper New River Basin (05050001), including equipment "in the wild" in each of the eighteen 10-digit watersheds within the UNR Basin (camera traps, geocached kiosks, programmable geolocated drones, etc.). We'll discuss how we intend for people to interact with the IBP across hybrid experiences, using The Pulse Of The Species (TPOTS) project as our primary pedagogical example, including maps, guidebooks, and other curricula designed and delivered by The Upper New (eliciting eco-reflective narratives). We'll discuss how and why we intend to hybridize experiences - using near field communication (NFC) tags loaded with custom learning data - for longitudinal collections of incidental local-global learning journeys for a variety of stakeholders, resulting in the foundation and growth of interspecific ecological communities of practice for identity formation through three modes of belonging (to the biosphere): engagement, alignment, and imagination. We'll describe a curricular example: an in situ exploration of "what might have been" if the Blue Ridge Project hydroelectric dams were built in 1976 (flooding thousands of acres along the VA/NC border, to be decommissioned in 2026, a permanent net energy loss) specifically to expose the "generational forgetting" that often plagues our environmental psychology. We'll connect these curricular concepts to current learning projects, including research narratives, eco-critical reviews, Eco Challenges, an annotated eco-bibliography, seminar workshops, and our multimodal readers theater series.

Is "Half-Earth" enough? What does ecological justice look like, and how will we know it if we think we see it?
Benjamin Erlandson, The Upper New, Inc.
We introduce the pragmatics of ecological justice with a review of the Half-Earth (Wilson, 2016) concept, coupled with basic concepts of Continental Conservation (Soulé, et al, 1999): the core areas, connectivity, and buffer zones, focused on our continent: Rewilding North America (Foreman, 2004), aligned locally with the contiguous wilderness of federal and state park lands and wildlife sanctuaries crossing the cusp of the Upper New River basin, along the escarpment in Alleghany and Wilkes counties of North Carolina. We'll explore specific ways the Upper New River basin fits into the continental conservation puzzle, and how to use Half-Earth as a starting point for achieving ecological justice for all inhabitants of the biosphere. We'll describe the pragmatics of intuitive justice, compare environmental and

ecological perspectives, and rationalize ecological justice as the “achievement” of an ecoliterate human species: using pragmatic examples of mindset shifts, systems wisdom, and leverage points for nonlinear systems intervention. We’ll then explore ecological justice as a culmination of lifelong learning and practice concerning The Commons and collective human behavior change in service of a truly sustainable global society housing nine billion humans (0.01% of total biomass) in the biosphere. We’ll consider the intuitive justice served up by “smart cities” and a “deceptively simple” solution such as driverless cars. We’ll hypothesize future networked transit networks and urban core districts for a justified distribution of humans, where we sleep, eat, work, learn, heal, and believe, as loving resistance fighters. Can we have ecological justice? Can we DO ecological justice?

Giles ReNew After '22

Ann Goette, Paul Moody, Ralph Robertson. ReNew the New River--Giles.

The presenters are all longtime river advocates in Giles County.

This poster will offer a general history of Giles ReNew, some photos and graphics. This will include additional accomplishments since our 2022 presentation at the Symposium. We would have--the very well-versed in all New River lore--Ralph Robertson standing by during the poster session.

Prehistoric Lithic Resource Sites along the Roanoke: New evidence of prehistoric Migration Pathways to the Southern Appalachians.

William S. Henika, Appalachian Geology Research Associate, Virginia Tech and Virginia Museum of Natural History

Henika’s interest in lithic artifacts began with the discovery of a soapstone bowl on a UVa mineralogy fieldtrip in 1965. In the 57 years since his graduate work at the Lewis Brooks Museum he has published detailed geologic and geophysical surveys of more than 50 quadrangles in SW VA.

Recent archeological and geological evidence indicates ice age hunters had traversed rivers from both coasts deep into North American before a land route had opened across Beringia. Archaic and Paleo Indian tools and spear points found in state geological surveys along the Roanoke from North Carolina across the Continental Divide into Southwestern Virginia were crafted from localized materials exposed during late Pleistocene uplift and erosion along major fracture systems related to the Mesozoic opening of the Atlantic Ocean basin. A most probable portage site from the Roanoke to the New River Basin is found near the head of navigation on the North Fork of the Roanoke. The pathway over the divide leads westward from the Shannon site, a late woodland village built upon earlier Archaic period campsites delineated by hearth stones and artifacts excavated beneath the Souxian (Saponi –Tutelo) village site.

Using GIS to Identify Stream Restoration Sites for Water Quality Improvement
Jason Hightower, Water and Land Solutions
Jason Hightower is a graduate of Appalachian State University. His studies of geography and geology tie into the current work he does as a GIS analyst for Water & Land Solutions.
GIS can be a useful tool for site suitability analysis. Publicly available data, combined with basic GIS processing can yield numerous prospective sites per county. This example looks at the intersection of property, natural resource and land cover datasets. Filtering these outputs can provide sites with high environmental uplift potential. These are the ideal locations for restoration and revegetation in order to improve stream function and water quality.

Exploring Phosphorus Flux Dynamics in the Headwaters of the South Fork New River
George Hotelling, Appalachian State University, CHE and GES department
In the headwaters of the South Fork New River, members of the AppAqua research cluster at App State are conducting a study to quantify the flux of total phosphorus (TP) using advanced monitoring techniques. Our primary objective is to address the question: How much phosphorus is present in the high country waterways, and can this value be predicted without resorting to intensive monitoring efforts? Methods include data and sample collection by in situ data sondes, ISCO stormwater autosamplers, grab samples, and analysis for TP by laboratory digests, and ICP-OES. By examining TP flux trends in conjunction with high water events, we have identified distinct relationships that potentially enable interpolations based on known P concentrations and hydrographs. This work is important because P sustainability is emerging as a critical topic, given its extensive use, nonrenewable nature, and potential to pollute waterways when present in excess. Work to better understand P transports can aid understanding the causes of eutrophication events and harmful algal blooms (HABs), two potential results of nutrient pollution, and it can help identify where best management practices (BMPs) should be discussed. The Science and Technology for Phosphorus Sustainability Center (STEPS), a convergence science center funded by the National Science Foundation, has spearheaded this initiative. By engaging in interdisciplinary and stakeholder collaboration, we, within STEPS, strive to contribute valuable insights to inform strategies for sustainable phosphorus management, addressing concerns related to improving use efficiency and promoting the overall health of aquatic ecosystems in the New River.

Introducing the Virginia Institute for Invertebrates
Benjamin Jantzen, Virginia Institute for Invertebrates
Ben Jantzen writes about the philosophy of biology and builds computer programs for scientific discovery at Virginia Tech. He previously studied insect flight and metabolism. Jantzen is the current President of the Virginia Institute for Invertebrates, an enthusiastic Virginia Master Naturalist, and a Councilor for the Virginia Natural History Society.
The changing landscape in western Virginia offers both challenges and opportunities for learning about and conserving invertebrate biodiversity – the rich abundance of tiny but amazing forms of life that dwell on our hillsides and in our streams, rivers, and caves. The Virginia Institute for Invertebrates (VII) is a new nonprofit forming in the New River Valley with a mission to monitor, witness, and conserve invertebrate life in the state. This is vital but often

neglected work. Despite the public attention on an "insect apocalypse", little is actually known about long term trends in invertebrate populations of the Appalachians. To address this shortcoming, VII is thinking long-term and building a network of monitoring stations that will span from the Appalachian Plateau to the Piedmont across western Virginia. Counting insects and crayfish is one thing, but appreciating their unique contributions to the diversity of life is another. For the overwhelming majority of invertebrates, little is known about how they make their living in the economy of life. VII is establishing an annual grant program to support field work in the natural history of invertebrates. Finally, VII will capitalize on the continuing conversion of agricultural land and infrastructure development in the region to establish conservation corridors that connect increasingly fragmented patches of prime invertebrate habitat. This presentation explains each part of the VII mission and the problem it solves, and describes the many ways in which New River residents and enthusiasts can help. With small animals, small actions can have big consequences.

Pesticides and Pollinators

Elizabeth (Bepe) Kafka, Doug Cox, Miguel Tejero, Deborah Greif, Preserve Grayson

Bepe (Elizabeth) Kafka joined Preserve Grayson after being caught in drift from pesticide sprayed from a helicopter in a Christmas tree field over the ridge from her home. Although her background is in landscape painting, she has dedicated her life to protecting this little piece of paradise and its watershed.

Poster showing in very simplified terms some of the detrimental effects of pesticides on honeybees and other pollinators.

PSA: Brown-headed Nuthatches Headed Your Way!

Noah McNeill, Virginia Tech Biological Sciences

The brown-headed nuthatch (Sitta pusilla) is not a traditional bird of the New River Valley, and has experienced broad population declines over the last century. However, recent sightings demonstrate that this species is progressively expanding into the region, sometimes in surprising habitats. My work on this species occurs in North Carolina, focused on how their mixed species foraging flock behavior is impacted by the characteristics of different habitats and predator frequencies. My findings reveal that brown-headed nuthatches can be mixed flock leaders that other species follow while foraging. These flocks also seem more frequent in areas with lots of avian predators. Through awareness of this highly localized, historically absent species, I hope to introduce to the public to a fascinating new resident of the New River Valley and its behavior. Furthermore, I wish to encourage naturalists to keep their eyes and ears peeled for brown-headed nuthatches in the region, particularly where they have not yet been recorded. Additionally, I will speak to land managers on practices which may aid in further expansion of the species, including prescribed burning and forest thinning, nest box provisioning, and pine planting.

Birds of the Headwaters: A Survey of the birds of Peak Creek and their habitat.

Bill Opengari, Friends of Peak Creek

Bill Opengari is a past board member of the Virginia Society of Ornithology and Science Museum of SW VA and a current board member of the Friends of Peak Creek. Bill has participated in bird mapping studies with the US Geological Survey and is Project Leader for the Dora Bluebird Trail.

Abstract: Results of a six-year study of both nesting and migratory birds along Peak Creek and their role in healthy riparian habitat and streamside ecology will be presented. Peak Creek is a 26-mile-long headwater of the New River and a major tributary of Claytor Lake. This poster presentation looks at the role of birds as ecoservice providers. They make crucial contributions across the habitats and play a vital role in acting as pollinators, controlling pests, and maintaining healthy streamside ecology.

We will summarize the Peak Creek Watershed's bird diversity, compare observations across the area and explain why protecting bird species supports protection of the headwaters of the New River.

Urban Development and the Loading of Solid Waste into the Headwaters of the New River: Classification, Accumulation, and Potential Sources, an Assessment of Winkler Creek

Paige Patterson, NC State Cooperative Extension Service

There is a visually staggering amount of solid waste that collects around infrastructure, accumulates in eddies, and becomes hung in vegetation within the New River watershed. This presentation will summarize the findings of a graduate school research project examining a single headwater stream that is free of debris as it enters the urbanized area of Boone, North Carolina. Data was collected to assess where solid waste collects and is deposited along this stream as it flows through the urbanized area. 10 evaluation sites were set up, each with a below and above high water plot. At each site trash was collected, counted, and categorized into 10 main material types with sub categories. The process was repeated 3 times at 30 day intervals to determine the rate of deposition. A GIS map was created to analyze the proximity of risk factors such as buildings, dumpsters, and parking areas. Having data on the most common materials recovered, their spatial distribution, as well as their potential sources, will better inform policymakers on the type of mitigation that could be the most impactful. While the United Nations seeks a legally binding agreement between nations to create terms for mitigating plastic waste on an international level, we must work locally in individual watersheds to identify problem areas followed by developing actionable plans.

Using water quality as a proxy to estimate microplastic concentrations via Landsat and Sentinel-2 in the New River, VA

Luisana Rodriguez-Sequeira, Virginia Tech

Luisana Rodriguez-Sequeira is a master's student at VT working with Dr. George Allen's Global Rivers Group. She holds a Bachelor's degree in Earth Science and Computational Mathematics from the University of California, Santa Cruz, and is grateful to be working on a project that weaves fieldwork with satellite imagery analysis.

Microplastics (<5mm), are pervasive in Earth's environments, and rivers are a major transport pathway. Microplastic detection methods that rely on counting individual particles are time consuming and require laborious field collection, inhibiting real-time insights over large spatial extents. Satellite remote sensing of water quality can provide relatively high spatial and temporal coverage of inland water bodies, and though a handful of correlated microplastic assessments have been done, a wide-variety of study sites are needed to form a coherent model. We focused our study in the New River near Blacksburg, VA, and collected weekly water quality measurements (turbidity, dissolved oxygen, chlorophyll) and surface-water microplastic samples. We combined these in situ measurements with remotely-sensed water quality indices from cotemporal observations from Landsat and Sentinel-2 to develop a model predicting microplastic concentration from remotely-sensed water quality parameters. We validated the model using in-situ measurements. By providing more observations than what can be done with in situ sampling alone, we can improve large-scale water quality analyses and modeling leading to better assessments of mismanaged plastic waste in rivers.

Friends of the Rivers of Virginia Around the Commonwealth
Rick Roth, Friends Of the Rivers of Virginia
Annotated map of the Commonwealth with FORVA projects located and highlighted.

Firescapes of the New River Basin
Thomas Saladyga, Concord University, Stockton Maxwell, Radford University
Dr. Thomas Saladyga is professor of Geography in the Department of Physical and Environmental Sciences at Concord University in Athens, West Virginia. His research interests include Appalachian fire ecology and forest management, dendrochronology, and environmental history.
Dr. Stockton Maxwell is a professor of Geospatial Science at Radford University. His research specialties are biogeography, dendrochronology, and paleoenvironmental change.
Fire is an important biophysical process in many ecosystems, influencing nutrient cycling and the distribution of plant species and associated wildlife habitat. In the Central Appalachian Mountains, fire exclusion during the last century has resulted in significant changes in forest structure and species composition in many fire-adapted plant communities, most notably a decrease in oak regeneration and herbaceous diversity and an increase in shade-tolerant, fire-sensitive tree species. Here, we examine historical patterns of forest fire occurrence at New River Gorge National Park and Preserve. We also present some key findings from regional fire history research that place modern fire regimes into a broader historical context. Collectively, these fire datasets, as well as contemporary fire management policies and public perceptions of wildfire, provide a framework for understanding New River Basin "firescapes." Finally, we address future opportunities and potential challenges to forest fire research and management within the New River Basin and across the Central Appalachian Mountains in general.

The New River, Claytor Lake and Lakeview Neighborhood—Dynamics in Stewardship
David Stevenson, Friends of Claytor Lake
This presentation is a discussion and thought experiment regarding caring for a part of the New River known as the Lakeview Neighborhood on Claytor Lake.
There are interesting and challenging dynamics between the natural geography of the area, the fact that it has been modified by the construction of the Claytor Hydro-Power Dam in 1939, the construction of the Lakeview Neighborhood in the early 1950's and the community of neighbors in the current day.
The talk will touch briefly on how these dynamics interact and relate to each other, and discuss, as a thought experiment, ideas of continued stewardship for the area.

Botanical inventory of Piney Creek Preserve, Beckley, WV
Elijah Strickland, WVU Institute of Technology, Jay Raymond, West Virginia UIT
I am Elijah Strickland, a 19-year-old, second-year Biology student at West Virginia University Institute of Technology. I am from Oak Hill, West Virginia, minutes away from the New River Gorge Bridge. I am passionate about advancing my education while also better understanding the richness and complexity of the Appalachian ecosystems. In the future, I plan to continue my education in the biological field and hope to achieve a long career of exploration and discovery.