Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-366

Proposal Title: Drone-Based Multispectral Forecasting of Cyanobacterial Harmful Algal Blooms

Project Manager Information

Name: Tyler Nelson

Organization: Real Vision Drones

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Project Basic Information

Project Summary: This project uses drone-based multispectral imaging and AI to monitor and predict Cyanobacteria harmful algal blooms and toxin risks in Minnesota lakes, providing early warnings to protect lake health/communities.

ENRTF Funds Requested: $750,000

Proposed Project Completion: June 30, 2028

LCCMR Funding Category: Water (B)

Project Location

What is the best scale for describing where your work will take place?

Statewide

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project and In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Minnesota's lakes face growing threats from cyanobacterial harmful algal blooms (cHABs), driven by excess nutrients and warming. About 50% of the state's lakes are highly polluted with nutrients, making them prone to algal blooms. cHABs, especially in lakes for drinking water and recreation, pose significant public health risks, with reports linking toxic blooms to human and animal illnesses, especially in dogs. However, not all blooms produce harmful toxins, and there is currently no reliable real-time method to distinguish between toxic and non-toxic blooms, track rapidly changing bloom dynamics, or monitor the spread of toxins within the lake.

This project aims to address this gap by deploying drone-based multispectral imaging and AI-driven models to monitor selected Minnesota lakes from May to October. By combining frequent (a few times a week during peak bloom activities) aerial imaging with water sampling data on nutrients (phosphorus, nitrogen), toxins (microcystins, anatoxin-a, saxitoxin), water chemistry, and temperature, the project will develop models to predict bloom formation and toxin risk. The primary goal is to develop spectral signatures for cHABs from drone imagery to track toxic conditions and issue advisories. This will provide early warnings, helping communities and lake/beach managers protect Minnesota's

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

Our project will use drones equipped with multispectral cameras to monitor 3 Minnesota lakes with high bloom activity for one season from May to October, scanning weekly and 2-3 times per week during peak blooms. By starting before blooms appear, we will build a detailed history while collecting water samples to test for cyanotoxins and nutrients, calibrating our multispectral technology.

Combining aerial drone imaging with AI models, we will predict and detect blooms and toxin risks before they become threats. We will also track lake conditions like nutrient levels, wind mixing, and water chemistry to understand why some lakes are more prone to blooms. Since toxin production does not always correlate with bloom presence, we aim to understand how toxins move in lakes — whether they follow blooms, stay in place, or change after blooms disappear. If one side of the lake has toxic beach closures, should the other side be considered unsafe?

Our goal is to link bloom presence with toxin levels and refine our multispectral camera to detect toxins in lakes with varying water clarity. By analyzing multispectral data with AI, we aim to uncover patterns signaling toxin risks, enabling early warnings/advisories to protect health and water quality.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

Minnesota's over 11,000 lakes, 104,000 miles of rivers, and 13 million acres of surface water are ecologically and culturally vital. These water bodies support livelihoods and offer recreational opportunities like fishing and swimming. However, harmful algal blooms and the cyanotoxins they produce are increasingly threatening ecosystems and promoting invasive species, especially with warming temperatures. Our project offers a practical solution: using aerial drone-based multispectral imaging for year-round monitoring and prediction of algal blooms and cyanotoxin risks. This tool will help protect and manage these essential water resources, providing an informative, user-friendly approach to address this challenge.

Activities and Milestones

Activity 1: Development, instrumentation, and integration of drone-mounted multispectral camera system

Activity Budget: $180,000

Activity Description:
We will acquire, test, and prepare various equipment for field testing, including multispectral cameras, drones, backup batteries, and remote sensors. We currently have one DJI Mavic 3 Multispectral drone and camera system, which will be used for initial testing. This system is equipped with the four essential bands for detecting elements of a harmful algal bloom. Two additional DJI M300 drones, each fitted with MicaSense RedEdge-P sensors, will be acquired. These drones will allow multiple teams to operate simultaneously, visiting different lakes on the same day under optimal flight conditions.

The M3M camera features four 5MP multispectral band sensors and a 20MP RGB sensor for high-precision monitoring. It provides a ground sampling distance of approximately 5.4 cm/pixel at an altitude of 400 ft. The M300 and MicaSense RedEdge-P setup delivers similar image quality but adds a Blue wavelength band, enhancing the detection of sediment and turbidity in the water. Algal bloom spread and composition will be assessed from the multispectral images, processed into a single orthophoto—a corrected, true-to-scale aerial image. Machine learning algorithms will correlate Chlorophyll-a and phycocyanin levels to distinguish harmful from non-harmful algal blooms, using data from the Blue, Green, Red, Red Edge, and Near-Infrared.

Activity Milestones:

Description	Approximate Completion Date
Test and calibrate drones and multispectral cameras for field deployment to detect harmful algal blooms	December 31, 2026
Complete testing of the camera system in a laboratory environment	January 31, 2027
Aerial scans of a selected lake will be conducted once the ice melts and the	April 30, 2027
Activity 1 summary report	May 31, 2027

Activity 2: Identifying and analyzing three target lakes for algal bloom monitoring

Activity Budget: $20,000

Activity Description:
We will hold stakeholder meetings and discussions with our partners, the MN Pollution Control Agency; and various lake managers, to identify three target lakes and develop a comprehensive plan for extensive aerial imaging. The goal is to gather detailed data on bloom dynamics and toxin levels in lakes with significant algal activity. Below are three lakes we propose to study, though this may change based on stakeholder input. These lakes were chosen for their specific characteristics, which make them ideal for developing accurate models that link algal blooms to water contamination.

Lake Peltier, Anoka County: High-traffic area, impaired for nutrients, persistent and heterogeneous blooms that shift from Aphanizomenon blooms in spring to Microcystis bloom in summer, does not meet water clarity goals
Medicine Lake, Hennepin County: Impaired for nutrients, frequent blooms, does not meet water clarity goals, urban runoff, eutrophication risk
Pine Lake, Pine County: Impaired for nutrients, frequent blooms, does not meet water clarity goals

By focusing on these three lakes, we aim to develop well-calibrated models that link the observed blooms to toxin levels,

enabling more accurate predictions and enhanced understanding of the environmental factors contributing to HABs. This will ultimately help guide future water quality management strategies.

Activity Milestones:

Description	Approximate Completion Date
Hold stakeholder meetings with MN Pollution Control Agency and lake managers to identify three target	December 31, 2026
Develop and finalize a comprehensive aerial imaging plan for the selected lakes, incorporating stakeholder input	February 28, 2027
Activity 2 summary report	May 31, 2027

Activity 3: Comprehensive field testing of CyanoHABs measurement in 3 Minnesota lakes using multispectral imaging

Activity Budget: $200,000

Activity Description:
From May to October, during Minnesota's peak algal bloom and recreational season, our field testing will focus on three lakes. Each lake will be imaged 2-3 times per week, resulting in around 100 total measurements. Imaging a 1-mile diameter lake (~1000 acres) takes approximately 2 hours per drone flight, ensuring a high-resolution orthophoto map with a ground sampling distance of about 7 cm per pixel. This will provide detailed data on water quality and bloom dynamics. The campaign will involve two drones and dedicated teams for comprehensive coverage, with water samples from HAB-affected areas to enrich the dataset.

These efforts will generate 2D orthophoto maps of each lake, tracking seasonal variations in water contaminants. To strengthen the analysis, the collected data will be correlated with environmental factors like rainfall, temperature, humidity, and nutrient concentrations to understand bloom growth drivers. By using high-resolution multispectral imaging and AI-powered data analysis, we aim to estimate water contamination levels and predict bloom occurrences. This comprehensive approach, combining remote sensing and AI, will set a new standard for lake monitoring and management in Minnesota, the first of its kind in the state.

Activity Milestones:

Description	Approximate Completion Date
Deploy multispectral imaging system for field testing	April 30, 2027
Complete the first field testing campaign	October 31, 2027
Calibrate and optimize the multispectral imaging results with lab-scale water sample tests	November 30, 2027
Complete analysis of water contaminant data from eight lakes over a period of six months	December 31, 2027
Activity 3 summary report	December 31, 2027

Activity 4: Detailed lab analyses of water samples for nutrients and toxins from the Minnesota lakes selected in Activity 2

Activity Budget: $230,000

Activity Description:
We will conduct an extensive field campaign to test water samples for cyanobacteria toxins, nutrients, and water chemistry collected from the lakes when drone flights are occurring. We plan to collect water samples from five locations within three lakes weekly during the open-water season (approximately 20 events per lake). Surface water

samples will be collected for cyanobacteria toxins (microcystins, anatoxin-a, saxitoxin), nutrients (total nitrogen, total phosphorus, nitrate+nitrite, ammonium, soluble reactive phosphorus), algal biomass (chlorophyll a), and water chemistry (dissolved organic carbon, turbidity), while depth profiles will be recorded for physical parameters (temperature, dissolved oxygen, pH, conductivity). Cyanobacteria toxins will be measured using Enzyme-Linked Immunosorbent Assay (ELISA) kits on a semi-automated Gold Standard Diagnostics CAAS Cube, the most advanced cyanobacteria toxin instrument in Minnesota. Water chemistry samples will be analyzed following standard wet chemistry methods by NRRI's Central Analytical Laboratory, a state-certified water chemistry laboratory under the direction of co-PI Filstrup.

Water chemistry data will be used to (1) validate multispectral images to accurately estimate key parameters, (2) better predict how cyanobacteria blooms develop and move through different parts of the lake, and (3) develop predictive relationships among cyanobacteria toxins, water chemistry, and environmental conditions within study lakes.

Activity Milestones:

Description	Approximate Completion Date
Collect weekly water samples from five locations in each of the three lakes for cyanobacteria	December 31, 2027
Analyze cyanobacteria toxins using ELISA kits and water chemistry samples using standard wet chemistry methods	February 28, 2028
Use water chemistry data to validate multispectral images, predict cyanobacteria bloom movement, and develop predictive	March 31, 2028
Activity 4 summary report	May 31, 2028

Activity 5: Validation of multispectral imaging data with sampled water tests, data analysis, and hypotheses testing

Activity Budget: $60,000

Activity Description:
In this activity, the multispectral imaging data will undergo validation against laboratory-based testing of water samples. Once the reliability of the imaging data is confirmed, it will undergo thorough analysis to elucidate the presence and impact of water contaminants on water management practices. Leveraging high-precision multispectral data will aid in investigating the hypotheses outlined below.

Hypothesis 1: Cyanobacteria blooms in Minnesota lakes are linked to water chemistry and physical conditions, with higher nutrients (nitrogen, phosphorus), higher ammonium, reduced water transparency (dissolved organic carbon, turbidity), and warmer stratified waters increasing bloom risk.

Hypothesis 2: AI-driven models based on multispectral drone imagery can accurately predict HABs, enabling early toxin risk detection before exceeding public health thresholds.

Hypothesis 3: Cyanobacterial blooms show spatial variability within lakes, with toxin concentrations potentially elevated in areas without visible blooms.

Hypothesis 4: Real-time monitoring using multispectral imaging and AI analysis will offer a more reliable and timely method for detecting and forecasting toxic algal blooms compared to traditional sampling, covering the entire lake rather than just select regions. One drone pilot can cover a 1000-acre lake in an 8-hour workday.

Activity Milestones:

Description	Approximate Completion Date
Complete multispectral image processing and data analysis	March 31, 2028
Multispectral imaging data validation and aerial sensor package development	April 30, 2028
Analyze validated imaging data to assess the impact of water contaminants on management practices and	May 31, 2028
Activity 5 summary report	May 31, 2028

Activity 6: Additional field testing to fine-tune aerial multispectral monitoring package, if necessary

Activity Budget: $30,000

Activity Description:
If our team identifies the need for additional field test data concerning a specific scenario or lake water contaminant, either due to inconclusive results from initial field testing or the discovery of intriguing contaminant behavior necessitating further investigation, we will revisit the same lakes identified in activity 1. Additional field data will be collected over several weeks during the subsequent season of Y2028, spanning from March to May, encompassing spring and summer contaminant dynamics. In the event that an insufficient amount of contaminants is found at these eight lakes, alternative lakes or water bodies in southwest Minnesota will serve as backup options to validate and refine the aerial sensor package.

Activity Milestones:

Description	Approximate Completion Date
Complete additional field testing to recalibrate and fine-tune the multispectral sensor system, if necessary	May 31, 2028

Activity 7: Reporting, IP and patent filing, results dissemination, and journal paper writing

Activity Budget: $30,000

Activity Description:
This phase of the project will focus on final data analysis and report writing. We aim to refine our multispectral image analysis algorithm and AI-driven toolbox, integrating hardware-specific insights gained from this study. Our goal is to package this technology and file a patent to secure intellectual property rights.

Building on this foundation, we plan to develop a drone-based multispectral remote sensing system for monitoring lakes and water bodies, with the long-term vision of launching a startup.

Beyond fulfilling the LCCMR Fund's deliverable requirements, the team will prepare manuscripts for peer-reviewed journals and actively share findings with key stakeholders. This includes lake managers, personnel from Minnesota watershed districts, the Minnesota Pollution Control Agency (MPCA), the Minnesota Department of Health (MDH), and water resource management companies. By engaging these groups, we aim to ensure the practical implementation of our research in real-world water quality monitoring and management.

Activity Milestones:

Description	Approximate Completion Date
File IP and patents before any public disclosure of research results	September 30, 2027
Finished writing the first draft of the journal/conference article	March 31, 2028
Activity 7 summary report	May 31, 2028

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Dr. Sayan Biswas	TerraCare Energy LLC	Dr. Sayan Biswas specializes in optical sensing, imaging, and laser-based diagnostics. He co-founded TerraCare Energy to address critical challenges in air, land, and water resources. With expertise in leading large grants and commercialization strategies, he advances technologies from concept to reality, bridging research innovation with practical applications.	Yes
Dr. Chris Filstrup	Natural Resources Research Institute, University of Minnesota Duluth	Dr. Chris Filstrup is a lake scientist specializing in harmful algal blooms, nutrient cycling, and freshwater-management. He leads the Central Analytical Lab, a state-certified water chemistry lab, and analyzes large datasets to assess climate and land use impacts on water quality. His research spans from farm ponds to Lake Superior.	Yes
Kimberly Laing	Minnesota Pollution Control Agency	Kimberly Laing, Manager of the Surface Water Monitoring Section at the MN Pollution Control Agency, will serve as an external advisor. We plan to meet her team during the bloom season to discuss field tests, review results, refine our approach, and explore the end-use and dissemination of our findings.	No

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?

Our project seeks to create an advanced yet cost-effective aerial monitoring system for Minnesota's water bodies, combining multispectral imaging and AI to detect, monitor, and predict harmful cyanobacterial blooms and toxin risks. By enhancing detection and monitoring methods, we aim to better protect the state's water resources. Findings will be shared with key stakeholders, including the Minnesota Pollution Control Agency (MPCA), the Minnesota Department of Health (MDH), and the Department of Natural Resources (DNR). Additionally, we will work with the UMN Office of Technology Commercialization to patent and license our integrated multispectral sensor and AI technology for commercialization.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Catch and Reveal: Discovering Unknown Fish Contamination Threats	M.L. 2022, , Chp. 94, Art. , Sec. 2, Subd. 04g	$246,000
Wildfire Impacts on Mercury Cycling in Wilderness Lakes	M.L. 2024, , Chp. 83, Art. , Sec. 2, Subd. 04i	$297,000
LiDAR Technology to Help Prevent Wildlife Fatalities from Wind Turbines	M.L. 2024, , Chp. 83, Art. , Sec. 2, Subd. 08m	$525,000

Project Manager and Organization Qualifications

Project Manager Name: Tyler Nelson

Job Title: Remote Pilot In Command

Provide description of the project manager's qualifications to manage the proposed project.

With over 4 years and 1000 hours of drone flight data collection, processing and expertise, Tyler has come to a vast understanding of the latest drone and software technology. Tyler has worked tirelessly as a solo-entrepreneur along side

some fairly large companies and counties in MN to deliver high quality and timely crucial drone data for their on-going projects. Before owning and operating this drone business, Tyler was (and still is) a Master Class A registered Electrician in the state of MN and has lead jobsites with 10 people at his command. Leadership and a passion for nature rehabilitation will ensure Tyler's prompt ability to solve the challenging and rewarding issue of water quality control!

Organization: Real Vision Drones

Organization Description:
Real Vision Drones is a drone data acquisition and processing business led by its founder and CEO, Tyler Nelson. We use drones to tackle some of the biggest environmental, surveying and solar energy projects we can get our hands on. With expertise in electrical systems, drone operations, computer systems, machine learning development and GNSS processes, Real Vision Drones aims solely to make the world a better place through the implementation of these individual skill sets.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Tyler Nelson		Principal Investigator			25%	1.1		$140,000
Christopher Filstrup		Co-principal Investigator			27.06%	0.2		$25,689
Sayan Biswas		Co-principal Investigator			28%	0.8		$180,000
Research Technician		Field Testing Engineer			25%	2		$100,000
Elena Ceballos		Lab Researcher			27.06%	0.34		$25,923
Eva Hendrickson		Lab Researcher			27.06%	0.54		$35,309
Jerry Henneck		Lab Researcher			27.06%	0.2		$20,387
UG Lab Assistant		Undergraduate Project Assistant			27.06%	0.36		$12,701
							Sub Total	**$540,009**
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Equipment	Data Processing Computer	This computer will be specifically used to process the large data sets that are produced from the multispectral camera. It will also be used to build and implement the AI learning models.					$8,000
	Tools and Supplies	Batteries, controllers, charging stations, generators, emergency supplies, Drone operation permits.	These equipment and supplies are necessary for efficient and compliant operations.					$18,891
	Tools and Supplies	Laboratory supplies to measure cyanobacteria toxins (microcystins, anatoxin-a, saxitoxin) in water samples. Also, includes bottles needed to collect and store water samples.	Lab supplies to measure cyanotoxins, nutrients, etc.					$41,793

							Sub Total	**$68,684**
Capital Expenditures								
		2 x DJI M300 package	The two DJI M300 drones, equipped with controllers and batteries, will carry the Micasense multispectral package. These drones are ideal for the project, as they can support up to 6 lbs of camera weight and offer approximately 40 minutes of flight time. This capability will be crucial for the success of the project.	X				$28,000
		2 x Micasense Red-Edge P Multispectral camera	This will be the multispectral camera that is attached to the drone in order to capture the different electromagnetic wavelengths required to build a multispectral data set.	X				$30,000
							Sub Total	**$58,000**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Other	1-3 team members from U of MN, Duluth will travel to the lake sites, 2-3 times per week during peak bloom season. Travel to field sites to collect water samples. Based on published university rates.	Collect water sample for lab analyses					$9,591
	Other	1-2 team members from the drone multispectral team under Tyler Nelson will travel from North Branch, MN to the lakes sites, 2-3 times per week during peak bloom season (totalling 35-70 times one way for one full season), to fly drones and collect multispectral imaging data. Personal vehicle maintenance and fuel costs included.	Fly multispectral drones to collect algal bloom data for one full season					$20,000
							Sub Total	**$29,591**

Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	One trip per year for two PIs and a lab researcher to a relevant conference to dissemnate the results	Discuss research progress and take part in relevant community discussions	X				$12,000
							Sub Total	**$12,000**
Printing and Publication								
	Publication	Publication cost in open source journals	Open source journal let everyone access the research results at free of cost					$4,000
							Sub Total	**$4,000**
Other Expenses								
		Scientific services	NRRI Central Analytical Laboratory analytical fees to analyze water samples for chlorophyll a, total nitrogen, total phosphorus, nitrate+nitrite, ammonium, soluble reactive phosphorus, dissolved organic carbon, and turbidity. Also, includes fees to prepare sampling bottles.					$37,716
							Sub Total	**$37,716**
							Grand Total	**$750,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Expenditures		2 x DJI M300 package	Another crucial piece of equipment to accomplish our goals with this project. **Additional Explanation :** These drones are needed to carry the multispectral imaging camera. These drones will be exclusively used to capture data using the specific cameras over water bodies.
Capital Expenditures		2 x Micasense Red-Edge P Multispectral camera	This is the camera that is used on the drone, another crucial piece of equipment to accomplish this projects goals. **Additional Explanation :** This camera is the piece of kit that will acquire all of the areal drone imagery.
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	One trip per year for two PIs and a lab researcher to a relevant conference to dissemnate the results	Take part in national conference, meetings, etc. to discuss LCCMR project's results and find potential stakeholders interested in the technology.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**-**

Total Project Cost: $750,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 944ed7b6-959.pdf

Alternate Text for Visual Component

The image illustrates the issue of hazardous cyanobacterial blooms and the associated toxin risks to human health and animals. It also highlights the proposed solution of using drone-based multispectral imaging on Medicine Lake. The project objectives are outlined, showcasing past experience surveying land and forests in Virginia, MN....

Financial Capacity

Title	File
Financial Capacity Note	40305c27-8c8.pdf

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
Board Resolution_ Real Vision Drones, LLC	bd320401-f07.pdf
NewsArticle NH Monitoring Harmful Algal Blooms Using Drones	e20af80c-3b7.pdf
SOW UMN Filstrup	5788291a-be8.pdf
UMN Filstrup NRRI Support Letter	8fcf6623-349.pdf
MN Pollution Control Agency Support Letter	2e4d3d09-fb0.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the Commissioner's Plan applies.

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

Yes

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

Yes

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

No

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

Sayan Biswas - TerraCare Energy

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A