2019 MCM
Problem A: Game of Ecology

In the fictional television series *Game of Thrones*, based on the series of epic fantasy novels *A Song of Ice and Fire*[1], three dragons are raised by Daenerys Targaryen, the "Mother of Dragons." When hatched, the dragons are small, roughly 10 kg, and after a year grow to roughly 30-40 kg. They continue to grow throughout their life depending on the conditions and amount of food available to them.

For the purposes of this problem, consider these three fictional dragons are living today. Assume that the basic biology of dragons described above is accurate. You will need to make some additional assumptions about dragons that might include, for example, that dragons are able to fly great distances, breath fire, and resist tremendous trauma. As you address the problem requirements, it should be clear how your assumptions are related to the physical constraints of the functions, size, diet, changes, or other characteristics associated with the animals.

Your team is assigned to analyze dragon characteristics, behavior, habits, diet, and interaction with their environment. To do so, you will have to consider many questions. At a minimum, address the following: What is the ecological impact and requirements of the dragons? What are the energy expenditures of the dragons, and what are their caloric intake requirements? How much area is required to support the three dragons? How large a community is necessary to support a dragon for varying levels of assistance that can be provided to the dragons? Be clear about what factors you are considering when addressing these questions.

As with other animals that migrate, dragons might travel to different regions of the world with very different climates. How important are the climate conditions to your analysis? For example, would moving a dragon between an arid region, a warm temperate region, and an arctic region make a big difference in the resources required to maintain and grow a dragon?

Once your dragon analysis is complete, draft a two-page letter to the author of *A Song of Ice and Fire*, George R.R. Martin, to provide guidance about how to maintain the realistic ecological underpinning of the story, especially with respect to the movement of dragons from arid regions to temperate regions and to arctic regions.

While your dragon analysis does not directly apply to a real physical situation, the mathematical modeling itself makes use of many realistic features used in modeling a situation. Aside from the modeling activities themselves, describe and discuss a situation outside of the realm of fictional dragons that your modeling efforts might help inform and provide insight?

Your submission should consist of:

- One-page Summary Sheet,
- Two-page letter,
- Your solution of no more than 20 pages, for a maximum of 23 pages with your summary and letter.
- Note: Reference list and any appendices do not count toward the 23-page limit and should appear after your completed solution.

NOTE: You should not make use of unauthorized images and materials whose use is restricted by copyright laws. Please be careful in how you use and cite the sources for your ideas and the materials used in your report.

Reference

1. Penguin Random House (2018). *A Song of Ice and Fire Series*. Retrieved from https://www.penguinrandomhouse.com/series/SOO/a-song-of-ice-and-fire/.

2019 MCM
Problem B: Send in the Drones: Developing an Aerial Disaster Relief Response System

Background: In 2017, the worst hurricane to ever hit the United States territory of Puerto Rico (see Attachment 1) left the island with severe damage and caused over 2900 fatalities. The combined destructive power of the hurricane's storm surge and wave action produced extensive damage to buildings, homes, and roads, particularly along the east and southeast coast of Puerto Rico. The storm, with its fierce winds and heavy rain, knocked down 80 percent of Puerto Rico's utility poles and all transmission lines, resulting in loss of power to essentially all of the island's 3.4 million residents. In addition, the storm damaged or destroyed the majority of the island's cellular communication networks. The electrical power and cell service outages lasted for months across much of the island, and longer in some locations. Widespread flooding blocked and damaged many highways and roads across the island, making it nearly impossible for emergency services ground vehicles to plan and navigate their routes. The full extent of the damage in Puerto Rico remained unclear for some time; dozens of areas were isolated and without communication. Demands for medical supplies, lifesaving equipment, and treatment strained health-care clinics, hospital emergency rooms, and *non-governmental organizations' (NGOs)* relief operations. Demand for medical care continued to surge for some time as the chronically ill turned to hospitals and temporary shelters for care.

Problem: Non-governmental organizations (NGOs) are often challenged to provide adequate and timely response during or after natural disasters, such as the hurricane that struck the United States territory of Puerto Rico in 2017. One NGO in particular – HELP, Inc. - is attempting to improve its response capabilities by designing a transportable disaster response system called "DroneGo." DroneGo will use rotor wing *drones* to deliver pre-packaged medical supplies and provide high-resolution aerial video reconnaissance. Selected drones should be able to perform these two missions – medical supply delivery and video reconnaissance – simultaneously or separately, depending on relief conditions and scheduling. HELP, Inc. has identified various candidate rotor wing drones that it would like your team to consider for possible use in designing its *DroneGo fleet* (see Attachments 2, 3).

DroneGo's pre-packaged medical supplies, called *medical packages*, are meant to augment, not replace, the supplies provided by local medical assistance organizations on-site within the country affected by the disaster. HELP, Inc. is planning on three different medical packages referred to as MED1, MED2, and MED3. Drones will carry these medical packages within *drone cargo bays* for delivery to selected locations (see Attachments 4, 5). Depending on the specific drone being used to transport medical supplies, it may be possible that multiple medical packages can be transported in a single drone cargo bay. Note that drones must land on the ground to offload medical supplies from the drone cargo bays. The video capability of the drones will provide high-resolution video of damaged and serviceable transportation road networks to HELP, Inc.'s command and control center for ground-based route planning.

HELP, Inc. will use International Standards Organization (ISO) standard dry *cargo containers* to quickly transport a complete DroneGo disaster response system to a particular disaster area. The individual shipping containers for all drones in the DroneGo fleet, along with all required medical packages, must fit within a maximum of three of the ISO cargo containers to be delivered to a single location, or up to three different locations if three cargo containers are used in the disaster area. Each shipping container's contents should be packed in order to minimize any need for buffer materials for unused space. Table 1 shows the dimensions of an ISO standard dry cargo container.

Table 1. Standard ISO Container Dimensions

	Exterior			Interior			Door Opening	
	Length	Width	Height	Length	Width	Height	Width	Height
20' Standard Dry Container	20'	8'	8'6"	19'3"	7'8"	7' 10"	7'8"	7'5"

HELP, Inc. is asking your team to use the 2017 situation in Puerto Rico to design a DroneGo disaster response system that will fit within the containers noted while meeting the anticipated medical supply demands during a potential similar future disaster scenario. It is possible that the demand requirements of this scenario may exceed the capabilities of the drone fleet your team identifies. If this occurs, HELP, Inc. wants to clearly understand any tradeoffs that it must make for implementing solutions to address these shortcomings.

Part 1. Develop a DroneGo disaster response system to support the Puerto Rico hurricane disaster scenario.

Consider the background information, the requirements identified in the problem statement, and the information provided in the problem attachments to address the following.

- **A.** Recommend a drone fleet and set of medical packages for the HELP, Inc. DroneGo disaster response system that will meet the requirements of the Puerto Rico hurricane scenario. Design the associated packing configuration for each of up to three ISO cargo containers to transport the system to Puerto Rico.
- **B.** Identify the best location or locations on Puerto Rico to position one, two, or three cargo containers of the DroneGo disaster response system to be able to conduct both medical supply delivery and video reconnaissance of road networks.
- **C.** For each type of drone included in the DroneGo fleet:

  a. Provide the *drone payload packing configurations* (i.e. the medical packages packed into the drone cargo bay), delivery routes and schedule to meet the identified emergency medical package requirements of the Puerto Rico hurricane scenario.

  b. Provide a drone flight plan that will enable the DroneGo fleet to use onboard video cameras to assess the major highways and roads in support of the Help, Inc. mission.

Part 2. Memo

Write a 1–2 page memo to the Chief Operating Officer (CEO) of HELP, Inc. summarizing your modeling results, conclusions, and recommendations so that she can share with her Board of Directors.

Your MCM team submission should consist of:

- One-page Summary Sheet,
- One- to Two-page memo to the HELP, Inc. CEO
- Your solution of no more than 20 pages, for a maximum of 23 pages with your summary and memo.
- Note: <u>Reference list and any appendices do not count toward the 23-page limit and should appear after your completed solution.</u>

Attachments:

1. Map of Puerto Rico
2. Potential Candidate Drones for DroneGo Fleet Consideration (with Drone payload capability)
3. Drone Cargo Bay Packing Configuration/Dimensions by Type
4. Anticipated Medical Package Demand
5. Emergency Medical Package Configuration/Dimensions

Attachment 1: Map of Puerto Rico

Attachment 2: Potential Candidate Drones for DroneGo Fleet Consideration (with Drone *Payload Capability)*

	Shipping Container Dimensions			Performance Characteristics/Capabilities			Configurations Capabilities		
Drone	**Length (in.)**	**Width (in.)**	**Height (in.)**	**Max Payload Capability (lbs.)**	**Speed (km/h)**	**Flight Time No Cargo (min)**	**Video Capable**	**Medical Package Capable**	**Drone Cargo Bay Type***
A	45	45	25	3.5	40	35	Y	Y	1
B	30	30	22	8	79	40	Y	Y	1
C	60	50	30	14	64	35	Y	Y	2
D	25	20	25	11	60	18	Y	Y	1
E	25	20	27	15	60	15	Y	Y	2
F	40	40	25	22	79	24	N	Y	2
G	32	32	17	20	64	16	Y	Y	2
H Tethered	65	75	41	N/A	N/A	Indefinite	N	N	N/A

*Note that cargo bays are affixed to the drone and that drone must be on the ground to offload cargo. See Attachment 3 for Drone Cargo Bay Type Configuration/Dimensions.

Attachment 3: Drone Cargo Bay Packing Configuration/Dimensions by Type

Drone Cargo Bay Type	Length (in)	Width (in)	Height (in)	
1	8	10	14	Top Loaded
2	24	20	20	Top Loaded

Attachment 4: Anticipated Medical Package Demand

Delivery Location			Emergency Medical Packages **		
Location Name	**Latitude**	**Longitude**	**Requirement**	**Quantity**	**Frequency**
Caribbean Medical Center Jajardo	18.33	-65.65	MED 1 MED 3	1 1	Daily Daily
Hospital HIMA San Pablo	18.22	-66.03	MED 1 MED 3	2 1	Daily Daily
Hospital Pavia Santurce San Juan	18.44	-66.07	MED 1 MED 2	1 1	Daily Daily
Puerto Rico Children's Hospital Bayamon	18.40	-66.16	MED 1 MED 2 MED 3	2 1 2	Daily Daily Daily
Hospital Pavia Arecibo Arecibo	18.47	-66.73	MED 1	1	Daily

**See Attachment 5 for Emergency Medical Packages 1, 2, and 3 Configurations/Dimensions.

Attachment 5: Emergency Medical Package Configuration/Dimensions

Emergency Medical Package Configuration		
Package ID	Weight (lbs.)	Package Dimensions (in.) (L × W × H)
MED 1	2	14 × 7 × 5
MED 2	2	5 × 8 × 5
MED 3	3	12 × 7 × 4

Glossary:

Cargo Container (Shipping Container): a large rectangular container with doors on the ends for loading and packing, and made of material suitable for shipping, storing, and handling in many weather and climate conditions.

Drone (Unmanned Aerial Vehicle, UAV): a flying robot that can be remotely controlled or fly autonomously through software-controlled flight plans in their embedded systems that work in conjunction with onboard sensors and GPS.

Drone Cargo Bay: For rotor wing drones, this is an externally carried “box” used to transport materials. For this problem, the drones under consideration have one of two types (sizes) of cargo bays. Note that each drone must land for the medical packages to be unloaded from the bay at its destination.

Drone Fleet: a set of drones for a particular mission or purpose. For this problem, the total set of drones by type (A to H) and Payload Capability (Visual and Medical) needed to meet the requirements of HELP, Inc.

Drone Payload Packing Configuration: how the drone payload bays are packed. For this problem, how the medical packages being transported by a drone are packed inside the drone cargo bay.

Medical Package: a predetermined set of medical supplies packed in a single container. For this problem, there are three Medical Package Configurations (MED1, MED2, MED3) available for transport by a drone from a deployed cargo container location to the demand location.

Non-governmental Organization (NGO): Usually non-profit and sometimes international organization independent of government and governmental organizations that is active in humanitarian, educational, healthcare, social, public policy, human rights, environmental and other areas in attempts to affect change.

Payload Capability: the carrying capacity of an aircraft or launch vehicle, usually measured in terms of weight. For this problem, the capability/capacity of the drone to carry medical packages.

2019 MCM
Problem C: The Opioid Crisis

Background: The United States is experiencing a national crisis regarding the use of *synthetic* and *non-synthetic opioids,* either for the treatment and management of pain (legal, prescription use) or for recreational purposes (illegal, non-prescription use). Federal organizations such as the Centers for Disease Control (CDC) are struggling to "save lives and prevent negative health effects of this epidemic, such as opioid use disorder, hepatitis, and HIV infections, and neonatal abstinence syndrome."[1] Simply enforcing existing laws is a complex challenge for the Federal Bureau of Investigation (FBI), and the U.S. Drug Enforcement Administration (DEA), among others.

There are implications for important sectors of the U.S. economy as well. For example, if the opioid crisis spreads to all cross-sections of the U.S. population (including the college-educated and those with advanced degrees), businesses requiring precision labor skills, high technology component assembly, and sensitive trust or security relationships with clients and customers might have difficulty filling these positions. Further, if the percentage of people with opioid addiction increases within the elderly, health care costs and assisted living facility staffing will also be affected.

The DEA/National Forensic Laboratory Information System (NFLIS), as part of the Drug Enforcement Administration's (DEA) Office of Diversion Control, publishes a data-heavy annual report addressing "drug identification results and associated information from drug cases analyzed by federal, state, and local forensic laboratories." The database within NFLIS includes data from crime laboratories that handle over 88% of the nation's estimated 1.2 million annual state and local drug cases. For this problem, we focus on the individual counties located in five (5) U.S. states: Ohio, Kentucky, West Virginia, Virginia, and Tennessee. In the U.S., a *county* is the next lower level of government below each state that has taxation authority.

Supplied with this problem description are several data sets for your use. The first file (MCM_NFLIS_Data.xlsx) contains drug identification counts in years 2010-2017 for narcotic analgesics (synthetic opioids) and *heroin* in each of the counties from these five states as reported to the DEA by crime laboratories throughout each state. A drug identification occurs when evidence is submitted to crime laboratories by law enforcement agencies as part of a criminal investigation and the laboratory's forensic scientists test the evidence. Typically, when law enforcement organizations submit these samples, they provide location data (county) with their incident reports. When evidence is submitted to a crime laboratory and this location data is not provided, the crime laboratory uses the location of the city/county/state investigating law enforcement organization that submitted the case. For the purposes of this problem, you may assume that the county location data are correct as provided.

The additional seven (7) files are zipped folders containing extracts from the U.S. Census Bureau that represent a common set of *socio-economic factors* collected for the counties of these five states during each of the years 2010-2016 (ACS_xx_5YR_DP02.zip). (Note: The same data were not available for 2017.)

A code sheet is present with each data set that defines each of the variables noted. While you may use other resources for research and background information, THE DATA SETS PROVIDED CONTAIN THE ONLY DATA YOU SHOULD USE FOR THIS PROBLEM.

[1] Centers for Disease Control website, (https://www.cdc.gov/features/confronting-opioids/index.html), accessed 4 September 2018.

Problem:

Part 1. Using the NFLIS data provided, build a mathematical model to describe the spread and characteristics of the reported synthetic opioid and heroin incidents (cases) in and between the five states and their counties over time. Using your model, identify any possible locations where specific opioid use might have started in each of the five states.

If the patterns and characteristics your team identified continue, are there any specific concerns the U.S. government should have? At what drug identification threshold levels do these occur? Where and when does your model predict they will occur in the future?

Part 2. Using the U.S. Census socio-economic data provided, address the following questions:

There are a good number of competing hypotheses that have been offered as explanations as to how opioid use got to its current level, who is using/abusing it, what contributes to the growth in opioid use and addiction, and why opioid use persists despite its known dangers. Is use or trends-in-use somehow associated with any of the U.S. Census socio-economic data provided? If so, modify your model from **Part 1** to include any important factors from this data set.

Part 3. Finally, using a combination of your **Part 1** and **Part 2** results, identify a possible strategy for countering the opioid crisis. Use your model(s) to test the effectiveness of this strategy; identifying any significant parameter bounds that success (or failure) is dependent upon.

In addition to your main report, include a 1-2 page memo to the Chief Administrator, DEA/NFLIS Database summarizing any significant insights or results you identified during this modeling effort.

Your submission should consist of:

- One-page Summary Sheet,
- One- to Two-page memo,
- Your solution of no more than 20 pages, for a maximum of 23 pages with your summary and memo.
- Note: Reference list and any appendices do not count toward the 23-page limit and should appear after your completed solution.

Attachments:

2019_MCMProblemC_DATA.zip **-** Includes seven zip folders and the NFLIS_Data file.

ACS_10_5YR_DP02.zip	ACS_11_5YR_DP02.zip
ACS_12_5YR_DP02.zip	ACS_13_5YR_DP02.zip
ACS_14_5YR_DP02.zip	ACS_15_5YR_DP02.zip
ACS_16_5YR_DP02.zip	MCM_NFLIS_Data.xlsx

Glossary:

analgesic – pain relieving medication

county – (in the U.S.) an administrative or political subdivision of a state; a region having specific boundaries and some level of governmental authority.

heroin – an illegal, euphoria producing, highly addictive analgesic drug processed from morphine (a naturally occurring substance extracted from the seed pods of certain varieties of poppy plants).

non-synthetic opioids – a class of drugs made from extracting chemicals in opium leaves, e.g. morphine, codeine, heroin.

opioids – pain relieving drugs that are often highly addictive

socio-economic factors – factors within a society that describe the relationship between social and economic status and class such as education, income, occupation, and employment.

synthetic opioid – man-made opioids

2019 ICM
Problem D: Time to leave the Louvre

The increasing number of terror attacks in France[1] requires a review of the emergency evacuation plans at many popular destinations. Your ICM team is helping to design evacuation plans at the Louvre in Paris, France. In general, the goal of evacuation is to have all occupants leave the building as quickly and safely as possible. Upon notification of a required evacuation, individuals egress to and through an optimal exit in order to empty the building as quickly as possible.

The Louvre is one of the world's largest and most visited art museum, receiving more than 8.1 million visitors in 2017[2]. The number of guests in the museum varies throughout the day and year, which provides challenges in planning for regular movement within the museum. The diversity of visitors -- speaking a variety of languages, groups traveling together, and disabled visitors -- makes evacuation in an emergency even more challenging.

The Louvre has five floors, two of which are underground.

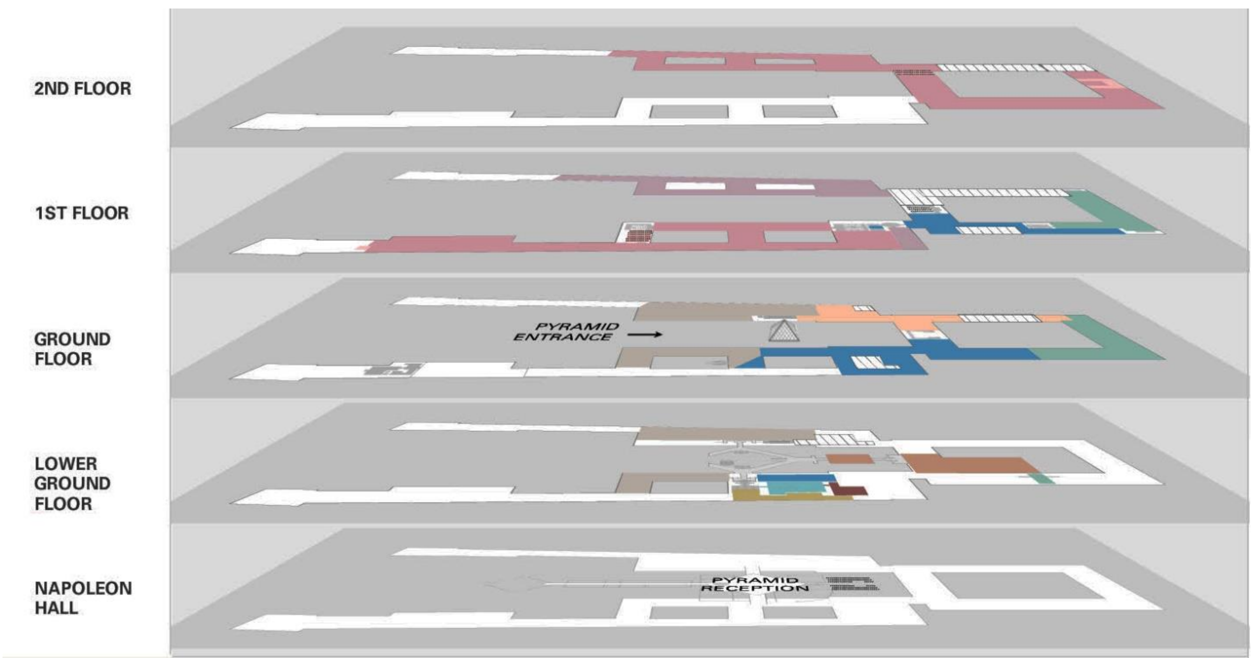

Figure 1: Floor plan of Louvre[3]

The 380,000 exhibits located on these five floors cover approximately 72,735 square meters, with building wings as long as 480 meters or 5 city blocks[3]. The pyramid entrance is the main and most used public entrance to the museum. However, there are also three other entrances usually reserved for groups and individuals with museum memberships: the Passage Richelieu entrance, the Carrousel du Louvre entrance, and the Portes Des Lions entrance. The Louvre has an online application, "Affluences" (https://www.affluences.com/louvre.php), that provides real-time updates on the estimated waiting time at each of these entrances to help facilitate entry to the museum. Your team might consider how technology, to include apps such as Affluences, or others could be used to facilitate your evacuation plan.

Only *emergency personnel* and museum officials know the actual number of total available exit points (service doors, employee entrances, VIP entrances, emergency exits, and old secret entrances built by the monarchy, etc.). While public awareness of these exit points could provide additional strength to an evacuation plan, their use would simultaneously cause security concerns due to the lower or limited security postures at these exits compared with level of security at the four main entrances. Thus, when creating your model, your team should consider carefully when and how any additional exits might be utilized.

Your supervisor wants your ICM team to develop an emergency evacuation model that allows the museum leaders to explore a range of options to evacuate visitors from the museum, while also allowing emergency personnel to enter the building as quickly as possible. It is important to identify potential *bottlenecks* that may limit movement towards the exits. The museum emergency planners are especially interested in an adaptable model that can be designed to address a broad set of considerations and various types of potential threats. Each threat has the potential to alter or remove segments of possible routes to safety that may be essential in a single optimized route. Once developed, validate your model(s) and discuss how the Louvre would implement it.

Based on the results of your work, propose policy and procedural recommendations for emergency management of the Louvre. Include any applicable crowd management and control procedures that your team believes are necessary for the safety of the visitors. Additionally, discuss how you could adapt and implement your model(s) for other large, crowded structures.

Your submission should consist of:

- One-page Summary Sheet,
- Your solution of no more than 20 pages, for a maximum of 21 pages with your summary.
- Judges expect a complete list of references with in-text citations, but may not consider appendices in the judging process.
- Note: <u>Reference list and any appendices do not count toward the 21-page limit and should appear after your completed solution.</u>

References:

[1] Reporters, Telegraph. "Terror Attacks in France: From Toulouse to the Louvre." *The Telegraph, Telegraph Media Group*, 24 June 2018, www.telegraph.co.uk/news/0/terror-attacks-france-toulouse-louvre/.

[2] "8.1 Million Visitors to the Louvre in 2017." *Louvre Press Release*, 25 Jan. 2018, presse.louvre.fr/8-1-million-visitors-to-the-louvre-in-2017/.

[3] "Interactive Floor Plans." *Louvre - Interactive Floor Plans | Louvre Museum | Paris*, 30 June 2016, www.louvre.fr/en/plan.

[4] "Pyramid" Project Launch – The Musée du Louvre is improving visitor reception (2014-2016)." *Louvre Press Kit*, 18 Sept. 2014, www.louvre.fr/sites/default/files/dp_pyramide%2028102014_en.pdf.

[5] "The 'Pyramid' Project - Improving Visitor Reception (2014-2016)." *Louvre Press Release,* 6 July 2016, presse.louvre.fr/the-pyramid-project/.

Glossary:

Bottlenecks – places where movement is dramatically slowed or even stopped.

Emergency personnel – people who help in an emergency, such as guards, fire fighters, medics, ambulance crews, doctors, and police.

2019 ICM
Problem E: What is the Cost of Environmental Degradation?

Economic theory often disregards the impact of its decisions on the *biosphere* or assumes unlimited resources or capacity for its needs. There is a flaw in this viewpoint, and the environment is now facing the consequences. The biosphere provides many natural processes to maintain a healthy and sustainable environment for human life, which are known as *ecosystem services*. Examples include turning waste into food, water filtration, growing food, pollinating plants, and converting carbon dioxide into oxygen. However, whenever humans alter the ecosystem, we potentially limit or remove ecosystem services. The impact of local small-scale changes in land use, such as building a few roads, sewers, bridges, houses, or factories may seem negligible. Add to these small projects, large-scale projects such as building or relocating a large corporate headquarters, building a pipeline across the country, or expanding or altering waterways for extended commercial use. Now think about the impact of many of these projects across a region, country, and the world. While individually these activities may seem inconsequential to the total ability of the biosphere's functioning potential, cumulatively they are directly impacting the *biodiversity* and causing *environmental degradation*.

Traditionally, most land use projects do not consider the impact of, or account for changes to, ecosystem services. The economic costs to *mitigate* negative results of land use changes: polluted rivers, poor air quality, hazardous waste sites, poorly treated waste water, climate changes, etc., are often not included in the plan. Is it possible to put a value on the environmental cost of land use development projects? How would environmental degradation be accounted for in these project costs? Once ecosystem services are accounted for in the cost-benefit ratio of a project, then the true and comprehensive *valuation* of the project can be determined and assessed.

Your ICM team has been hired to create an ecological services valuation model to understand the true economic costs of land use projects when ecosystem services are considered. Use your model to perform a cost benefit analysis of land use development projects of varying sizes, from small community-based projects to large national projects. Evaluate the effectiveness of your model based on your analyses and model design. What are the implications of your modeling on land use project planners and managers? How might your model need to change over time?

Your submission should consist of:

- One-page Summary Sheet,
- Your solution of no more than 20 pages, for a maximum of 21 pages with your summary.
- Judges expect a complete list of references with in-text citations, but may not consider appendices in the judging process.
- Note: <u>Reference list and any appendices do not count toward the 21-page limit and should appear after your completed solution.</u>

References:

Chee, Y., 2004. An ecological perspective on the valuation of ecosystem services. Biological Conservation 120, 549-565.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van den Belt, M., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253– 260.

Gómez-Baggethuna, E., de Groot, R., Lomas, P., Montesa, C., 1 April 2010. The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. Ecological Economics 69 (6), 1209-1218.

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Richmond, A., Kaufmann R., Myneni, R., 2007, Valuing ecosystem services: A shadow price for net primary production. Ecological Economics 64, 454-462.

Yang, Q., Liu, G., Casazza, M., Campbell, E., Giannettia, B., Brown, M., December 2018. Development of a new framework for non-monetary accounting on ecosystem services valuation. Ecosystem Services 34A, 37-54.

Data sources:

US based data: https://www.data.gov/ecosystems/

Satellite data: https://www.ncdc.noaa.gov/data-access/satellite-data/satellite-data-access-datasets

Glossary:

Biodiversity - refers to the variety of life in an ecosystem; all of the living organisms within a given area.

Biosphere - the part of the Earth that is occupied by living organisms and generally includes the interaction between these organisms and their physical environment.

Ecosystem - a subset of the biosphere that primarily focuses on the interaction between living things and their physical environment.

Ecosystem Services – the many benefits and assets that humans receive freely from our natural environment and a fully functioning ecosystem.

Environmental Degradation – the deterioration or compromise of the natural environment through consumption of assets either by natural processes or human activities.

Mitigate – to make less severe, painful, or impactful.

Valuation - refers to the estimating or determining the current worth of something.

2019 ICM
Problem F: Universal, Decentralized, Digital Currency: Is it possible?

Digital currency can be used like traditional currencies to buy and sell goods, except that it is digital and has no physical representation. Digital currency enables its users to make transactions instantaneously and without any concern for national borders. *Cryptocurrency* is a subset of digital currency with unique features of privacy, decentralization, security and encryption. Cryptocurrencies have exploded in popularity in various parts of the world; moving from an *underground cult* interest to a globally accepted phenomenon. Bitcoin and Ethereum, both cryptocurrencies, have grown in value, while investors are projecting rapid growth for other cryptocurrencies such as Dogecoin or Ripple. In addition to digital and cryptocurrencies, there are also new digital methods for financial transactions that enable users to instantaneously exchange money with nothing more than an email address or a thumbprint. Peer-to-peer payment systems offered by companies like PayPal, Stripe, Venmo, Zelle, Apple Pay, Square Cash, and Google Pay offer virtual movement of money across the globe in seconds without ever having to verify the transaction through a bank or currency exchange. Digital transactions outpace cash and check transactions because they are not delayed by banking policies, national borders, citizenship, debts, or other social-economic factors. These new currency systems decentralize financial transactions, leaving many to consider a world where traditional banking may become obsolete.

Concerns about security of cryptocurrencies worry both citizens and economic analysts. These concerns have constrained its growth in some communities. On the other hand, much of the popularity of cryptocurrency is due to its departure from traditional overly-restrictive security and debt measures that rely on oversight by large banks and governments. These oversight institutions are often expensive, deeply bureaucratic, and sometimes corrupt. Some experts believe that a universal, decentralized, digital currency with internal security like *blockchain* can make markets more efficient by eliminating barriers to the flow of money. This is particularly important in countries where the majority of citizens do not have bank accounts and are unable to invest in regional or global financial markets. Some governments, however, view the lack of regulation around these currencies and their *anonymity* as too risky because of how easily they can be used in *illicit* transactions, such as tax sheltering or purchasing illegal merchandise. Others feel that a secure digital currency offers a more convenient and safer form of financial exchange. For instance, a universally accepted currency would enable truly global financial markets and would protect individual assets against regional inflation *fluctuations* and artificial manipulation of currency by regional governments. If alternative digital systems become more established, there will be many questions about how digital currency will affect current banking systems and *nation-based currencies*.

Your policy modeling team has been employed by the International Currency Marketing (ICM) Alliance to help them identify the viability and effects of a global decentralized digital financial market. ICM Alliance has asked you to construct a model that adequately represents this type of financial system, being sure to identify key factors that would limit or facilitate its growth, access, security, and stability at both the individual, national, and global levels. This requires you to consider the different needs of countries and their willingness to work with this new financial marketplace and modify their current banking and *monetary* models. It may or may not require them to abandon their own currency, so that adds a level of complexity to the market model. You are not to choose an existing digital currency, but discuss the strategies for adoption, and problems in implementation of, a general digital currency. You should also include the mechanisms for oversight of such a global digital currency. The ICM Alliance has asked you to extend your analysis to consider the long-term effects of such a system on the current banking industry; the local, regional, and world economy; and international relations between countries.

ICM requests a report of your modeling and analysis, and a separate one-page policy recommendation for national leaders, who hold mixed opinions about this effort. The policy recommendation should offer rationale for the parameters and dynamics included in your model and reflect the insights you gained from your modeling. Your polices might address, for example, growth, reach, access, security, and stability of the system.

Your team's submission should consist of:

- One-page Summary Sheet,
- One-page policy recommendation for national leaders,
- Your solution of no more than 20 pages, for a maximum of 22 pages with your summary and policy recommendation.
- Judges expect a complete list of references with in-text citations, but may not consider appendices in the judging process.
- Note: Reference list and any appendices do not count toward the 22-page limit and should appear after your completed solution.

References:

Paul Krugman, "O Canada: A neglected nation gets its Nobel". *Slate*, Oct 19, 1999. https://slate.com/business/1999/10/o-canada.html

Stephanie Lo and J. Christina Wang, "Bitcoin as Money?" *Current Policy Perspectives*, Federal Reserve Bank of Boston, 2014. https://www.bostonfed.org/publications/current-policy-perspectives/2014/bitcoin-as-money.aspx or https://www.bostonfed.org/-/media/Documents/Workingpapers/PDF/cpp1404.pdf

Glossary:

Anonymity – the state of being unnamed or unidentified; the state of being anonymous.

Blockchain – the record keeping technology that can document transactions between two parties in a verifiable and permanent way; a digital database containing information that can be shared and simultaneously used across a large publicly accessible and decentralized network.

Cryptocurrency – a digital or virtual currency that uses cryptography (protecting information through the use of codes) for security.

Digital Currency – [digital money, electronic money, electronic currency] is a type of currency in digital (electronic) versus physical (coins, paper) form.

Illicit – illegal or dishonest.

Fluctuations – variations or oscillations; rises and falls. .

Monetary – relating to money or finances, or to the mechanisms by which money is supplied to and circulates in the economy.

Nation-based currencies – [national currencies] a system of money issued by a central bank and in common use within a particular nation or group of nations; examples are United States dollar (USD), Chinese renminbi (RMB or CNY), European Euro (EUR), British pound sterling (GBP), and Japanese yen (JPY).

Underground cult – hidden or mysterious group of people sharing an excessive devotion toward a particular person, belief, or thing.