**NASA DEVELOP National Program**

**2020 Summer Project Proposal**

**Virginia – Langley**

**Riley County Water Resources**

*Relating Land Cover Change to Infiltration and Runoff Distribution in Riley County, Kansas to Inform Local Resiliency Initiatives*

**Project Overview**

***Project Synopsis*:** In recent years, Riley County, Kansas has experienced unprecedented flooding that may be the result of long-term changes in land use. Using inputs from various datasets, this project will create synthetic land use/land cover (LULC) maps for the study area. These maps will be analyzed with precipitation data from GPM IMERG, elevation and slope information from LiDAR scans, soil moisture estimates from SMAP, and other factors to calculate more precise runoff curve numbers for each land cover type. These factors will also be evaluated as inputs to SWAT+ to assess runoff in Riley County watersheds. Outputs from SWAT+ will illustrate how changes in land use may have influenced runoff in recent decades. A tutorial of methods will allow end users in the City of Manhattan, Riley County Department of Planning and Development, Riley County Conservation District, the Kansas Forest Service, and the Kansas Department of Health and Environment to continue these analyses. These results will enable community development officials to understand the evolution of watersheds in Riley County and to make scientifically-informed decisions on resiliency actions.

***Community Concern:*** Repeated recent flooding of Wildcat Creek, such as the headline-making Labor Day flood of 2018, has caused extensive damage to businesses and residents of Manhattan, Kansas and their rural surroundings. There are concerns that land cover change in the Wildcat Creek watershed has led to increased runoff and may be one of several factors in consequent flooding. It is hypothesized that changes in farming practices, abandonment of infrastructure, loss of native grasslands, and alterations to the grading and elevation of the land may be contributing to these shifting hydrological patterns. Additionally, about 10-15% of the watershed is forested land. The Kansas Forest Service has observed a decline in forest quality across the state, and they hope to identify hydrologic parameters that may be affecting these forests. Further investigation of these factors will help partners prioritize resiliency efforts that will ensure the sustained health of Riley County watersheds.

***Source of Project Idea:*** Dr. Aida Farough at Kansas State University, a DEVELOP alumna, submitted a project request form to the National Program Office. The project emerged from subsequent conversations with the LaRC Fellow, Dr. Farough, and representatives from the City of Manhattan and Riley County.

***National Application Areas Addressed:*** Water Resources, Food Security & Agriculture

***Study Location:*** Riley County, KS

***Study Period:*** May2006 – May 2020

***Advisors:*** Dr. Kenton Ross (NASA Langley Research Center), Dr. Venkataraman Lakshmi (University of Virginia)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **City of Manhattan** | Dr. Bill Heatherman, Stormwater Compliance Engineer; Samantha Estabrook, Resiliency Planner; Chad Bunger, Assistant Director of Community Development | End User | Yes |
| **Riley County Department of Planning and Development** | Steve Higgins, Zoning Enforcement Officer | End User | No |
| **Kansas Department of Health and Environment, Bureau of Environmental Field Services, Watershed Management Section** | Andrew Lyon, Watershed Restoration and Protection Strategy (WRAPS) Programmatic Unit Manager; Angela Unrein, WRAPS Project Officer; Scott Satterthwaite, WRAPS Project Officer | End User | No |
| **Kansas Forest Service** | Andrew Klein, Water Quality Forester | End User | Yes |
| **Riley County Conservation District** | Aubrey Evans, District Manager | End User | No |
| **Kansas State University** | Dr. Aida Farough, Teaching Assistant Professor; Dr. Trisha Moore, Assistant Professor | Collaborator | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***The City of Manhattan and Riley County are working to determine the best course of action to prevent future flooding in the watershed, including options such as upstream dam construction, downstream channel improvements and bridge replacements, targeted buyouts of homes and businesses, and non-structural measures such as improved flood prediction and emergency management tools. Kansas Forest Service provides technical assistance to landowners and natural resource agencies regarding watershed restoration and protection strategies. The Kansas Department of Health and Environment (KDHE) develops statewide water quality standards, which includes identifying and prioritizing waterbodies and watersheds that may be impaired. Additionally, the Watershed Management Section provides expertise, assistance, and assessments of watershed restoration and protection strategies across the state to ensure groups are able to achieve water quality goals. The Riley County Conservation District works with Riley County landowners and residents to use natural resources responsibly by providing conservation planning, financial assistance, education, and representation in conservation policies and programs.

***End User’s Capacity to Use NASA Earth Observations:***

*City of Manhattan* – The City of Manhattan does not currently use NASA Earth observations in its decision-making, although they are familiar with the potential uses of remote sensing and with GIS principles. This project would allow the city to use a broad range of Earth observation products in conjunction with other data sources to enrich their understanding of watershed health.

*Riley County Department of Planning and Development* – Officials at Riley County have used NOAA products, such as the National Weather Service Advanced Hydrologic Prediction Service, to report flood occurrence. This project will increase their capacity to use remotely-sensed data and indices to understand the complex relationships between land cover, precipitation, soil type, vegetation health, and runoff, so the county can produce effective policies to preserve the watershed.

*Kansas Department of Health and Environment* – In the past, the Watershed Management Section (WSM) at KDHE has used SWAT to help develop EPA 9-Element Watershed Plans and to designate project target areas, but then changed modeling tactics to account for riparian areas and close delivery of runoff to streams. With the use of SWAT+, this project would allow for a comparison of current WSM methodologies for target area designations throughout stream corridors to the new SWAT model. The use of NASA Earth observations will also increase KDHE’s capacity for WSM agricultural project implementation within the Tuttle Creek Watershed.

*Kansas Forest Service* – The Kansas Forest Service has used geospatial data in previous work and is familiar with NASA Earth observations. They hope to use updated curve numbers to identify parameters that may be affecting the health of Kansas forests.

*Riley County Conservation District* – The Riley County Conservation District does not currently use any remote sensing data in their education or conservation planning efforts.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*Kansas State University* – Collaborators at Kansas State University will provide expert knowledge of the area and locally-informed advising about hydrology and urban development within the city and county.

***Dissemination by Boundary Organizations*:**

*City of Manhattan* – In addition to sharing the results of this project with the city’s partner organizations, the team will share the results of this project with the Citizen Advisory Team.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will have biweekly teleconferences with end users to provide updates on project methodologies and analyses throughout the term, and will communicate with collaborators through phone calls and emails on an as-needed basis. The project team will take the lead on in-term communication with the partners following an introduction by the Fellow during the first week of the term.

***Transition Plan*:** All maps, data files, descriptions of project methodology, and written reports will be transferred to each of the project end users and collaborators using NASA Large File Transfer. The team will organize an end-of-term handoff presentation via WebEx to relay all information directly to all partners and answer any questions. The partner organizations will also be invited to attend the Virtual Applied Sciences Week in August.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Landsat 5 TM** | Normalized Difference Vegetation Index (NDVI) | NDVI calculated from Landsat 5 will be used to tabulate the dynamic hydrologic curve number for correlations with land use, land use change, and soil type throughout the study area. |
| **Landsat 7 ETM+** | NDVI | NDVI calculated from Landsat 7 will be used to tabulate the dynamic hydrologic curve number for correlations with land use, land use change, and soil type throughout the study area. |
| **Landsat 8 OLI** | NDVI | NDVI calculated from Landsat 8 will be used to tabulate the dynamic hydrologic curve number for correlations with land use, land use change, and soil type throughout the study area. |
| **SMAP L-band Radiometer** | Soil moisture | Gridded soil moisture, downscaled using MODIS, will be used to display trends in soil moisture over time to help understand watershed hydrological responses to various storm events. |
| **GPM IMERG** | Precipitation | Precipitation data from GPM IMERG will be used as an input to SWAT+. |

***Ancillary Datasets:***

* Riley County LiDAR scan (2015) – high-resolution source of elevation, slope, and other variables for use in SWAT+
* USGS National Land Cover Database (NLCD) (2006, 2008, 2011, 2013, 2016) – land cover and percent impervious surface cover for use in synthetic LULC raster datasets
* USDA National Agricultural Statistics Service Cropland Data Layer (CDL) (2006-2019) – crop type for use in synthetic LULC raster datasets
* USDA Natural Resources Conservation Service Gridded Soil Survey Geographic Database (gSSURGO) – soil type information for analysis of land use changes and potential impacts on runoff

***Modeling:***

* Soil & Water Assessment Tool (SWAT+) (POC: Dr. Venkataraman Lakshmi, University of Virginia) – quantify environmental impact of changes in land use, land management practices, and local climate on the watershed scale from 2006-2020 in Riley County and model the hydrologic impacts of future changes

***Software & Scripting:***

* ArcGIS Pro – implementation of SWAT+ model and map creation
* ENVI – raster imagery processing and analysis
* Python – batch processing of raster imagery

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Geodatabase of Watershed Properties**  **2006 - 2020** | Partners will use the information provided in this database to analyze changes in land use, precipitation events, and multiple hydrologic parameters to determine drivers of increased runoff. | This geodatabase will incorporate NDVI, soil moisture, precipitation, and LULC, along with any outputs of SWAT+. | N/A |
| **Synthetic LULC Maps** | These maps will help end users gain a more comprehensive understanding of specific land use throughout the study area by combining and visualizing a number of datasets. | These maps will incorporate NLCD and CDL land cover and cropland types in one synthesized raster. | N/A |
| **Dynamic Curve Number Tables** | Partners will utilize the hydrologic curve number associated with different land cover and soil types throughout the watershed to gain a more precise picture of runoff associated with different land use types present in the study area. | Dynamic curve number tables will be calculated using NDVI along with synthetic LULC map, soil moisture, and ancillary soil type data. | N/A |
| **Parameterized SWAT+ for Riley County Watersheds** | Hydrologic modeling through SWAT+ will help partners understand how changes in land use and climatological variables have influenced runoff in the county. | SWAT+ will require inputs from NLCD, CDL, LiDAR scans, and GPM IMERG, along with other climatological variables. | N/A |
| **Tutorial of Methods** | A tutorial of methods for SWAT+ and curve number calculations will allow partners to improve upon the current model as they obtain new data or refine the parameters. It will also allow them to input future scenarios to forecast potential changes in the watershed. | N/A | N/A |

***End-User Benefit*:** The partners hope that results from these analyses may help determine what resiliency actions, such as the establishment of conservation areas, could make a notable difference in decreasing runoff. These analyses will also inform future infrastructure investments, such as the creation of upstream dams, downstream channel improvements, and bridge replacements. The end users will be able to use this information to assess watershed and stream health throughout Riley County and the methods presented in this project may be applied to the rest of the state for further analysis.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2020 Summer

***Related DEVELOP Work:***

2018 Summer (ID) – Idaho Water Resources: Estimating Soil Moisture in Semiarid Sagebrush Steppe Utilizing NASA Satellite Imagery

2018 Summer (MSFC) – Chao Phraya Water Resources: Assessing Water Quality in Chao Phraya Basin, Thailand through Sedimentation Modeling and Urban Footprint Expansion

2018 Spring (LaRC) – Patuxent Water Resources: Assessing Land Cover and Land Use Change to Inform Watershed Resource Management

**Notes**

Calculations of curve numbers, synthetic LULC maps, and a geodatabase of hydrologic parameters such as soil moisture and NDVI will be the primary focus of this term, with parameterization of SWAT+ as a goal if time permits. A second term of this work may continue work with SWAT+, including forecasting of possible future changes in runoff, and may also seek to evaluate management practices such as changes in tillage over the study period. For curve number calculations, Dr. Moore shared a methodology for calculating a “dynamic curve number” using NDVI to adjust the curve number as a function of vegetation development, a methodology that was developed using the nearby Konza Prairie as a model. The partners have provided a large number of additional resources and reference layers for the team to explore, some of which are listed below. Additionally, the partners have identified two grass-type prairies nearby (the Konza Prairie LTER and the National Tall Grass Prairie) that could be used as land use reference conditions for comparison with the more dynamic landscape we are focusing on in this project. Communicative tools aimed at educating the public about development near stream banks may be a useful product of this work.

Inundation Maps of Manhattan, KS:

<https://www.rileycountyks.gov/1190/Wildcat-Creek-Flood-Prediction-Inundatio>

USGS Streamflow data:

<https://waterdata.usgs.gov/nwis/inventory/?site_no=06879810> (Can pull statistics that relate the percentage of different land covers to streamflow or runoff)

Soil health resources: <https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/health/mgnt/?cid=stelprdb1257753>

Methods for estimating annual exceedance probability streamflows: <https://pubs.usgs.gov/sir/2017/5063/sir20175063.pdf>

Riley County Social Vulnerability Index:

<https://drive.google.com/file/d/1ehmGTufyCb14MpOm7Yq4j-5bet83LvjG/view>

Wildcat Creek dam location study: <https://drive.google.com/file/d/1JwA35HtnERknEhwnBUBL_6NGOxmNFbQs/view>

Dynamic Curve Number:

<https://www.sciencedirect.com.er.lib.k-state.edu/science/article/pii/S0301479718315433>