**Riley County Water Resources**

*Comparing Runoff Curve Calculation Methods to Inform Local Resiliency Initiatives in Riley County, Kansas*

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**Project Overview**

***Project Synopsis:***

In recent years, Riley County, Kansas, has observed increased levels of flooding that may be the result of long-term changes in land use/land cover (LULC). This project partnered with Riley County, the City of Manhattan, and Kansas State University, along with several secondary partners. The team tracked changes in LULC using Landsat 5 TM, Landsat 7 ETM+, and Landsat 8 OLI to synthesize more precise maps and to analyze runoff curve numbers for each land cover type with various inputs, including elevation, soil moisture, phenology, and slope. These results will provide local stakeholders and decision makers with more detailed runoff and LULC tools to understand the evolution of watersheds in Riley County and to make scientifically-informed decisions on resiliency actions.

***Abstract:***

Riley County, Kansas, has observed increased levels of flooding, potentially due to changes in land use/land cover (LULC) and seasonal vegetation variation. This study contrasts two methods of generating runoff curve numbers (CN) from 2006-2020. (1) The traditional Soil Conservation Service CN calculation method uses a look-up table and tracked LULC to determine runoff changes. These tables allow for land cover-specific CN and account for various farming techniques but lack flexibility in calculations for various seasons or plant health. (2) A dynamic method employs normalized difference vegetation index (NDVI) compiled over the rainy season each year to calculate CN using seasonal vegetation. This method allows for a more precise analysis of runoff variability within and between rainy seasons because it can be updated with greater temporal detail and captures higher spatial resolutions by using NDVI as a proxy for LULC. This study further uses inputs from the United States Geological Survey (USGS) National Land Cover Database (NLCD), the United States Department of Agriculture (USDA) Cropland Data Layer, and Landsat imagery to create more precise LULC raster datasets including both urban cover and crop-specific land use and curve number maps of the area. Results can guide decision makers 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 toward informed decisions on resiliency strategies to address future flooding.

***Key Terms:***

remote sensing, curve number, land cover change, land use change, runoff, flooding, resiliency planning

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

***Study Location:*** Riley County, Kansas

***Study Period:*** May 2006 to May 2020

***Community Concerns:***

* The repeated recent flooding of Wildcat Creek, like the headline-making Labor Day flood of 2018, has caused extensive damage to businesses and residents of Manhattan, Kansas, as well as its rural surroundings.
* It is hypothesized that changes in urbanization, forest cover, 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.
* Local officials are looking for more insight and tools to address the lack of clarity in flood causes.

***Project Objectives:***

* Create synthetic LULC maps for the Riley County area to better demonstrate land change throughout the area to associate with potential runoff change
* Create an alternative dynamic curve number data layer using NDVI to show seasonal changes of curve numbers to highlight the variability of runoff risk within the region
* Provide partners with a tutorial on how to create a curve number data layer using a look up table or, alternately, with NDVI measurements. Each independent method of curve number estimation can inform their flood resiliency research in the future
* Create a tutorial on how to produce LULC maps using multiple sources, allowing partners to update LULC maps with new data as they are available

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **City of Manhattan** | Dr. Bill Heatherman, Stormwater Compliance Engineer; Samantha Eastbrook, 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 and Undergraduate Advisor; Dr. Trisha Moore, Assistant Professor | Collaborator | No |

***Decision-Making Practices & Policies:***

The City of Manhattan and Riley County are working to determine the best course of action to prevent future flooding in the Wildcat Creek 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. The Kansas Forest Service provides technical assistance to landowners and natural resource agencies regarding watershed restoration and protection strategies. Kansas Department of Health and Environment 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 can 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.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Landsat 5 TM** | NDVI | NDVI calculated from Landsat 5 TM from 2006-2012 was 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 ETM+ for March 2013 was 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 OLI from 2013-2019 was used to tabulate the dynamic hydrologic curve number for correlations with land use, land use change, and soil type throughout the study area. |

***Ancillary Datasets:***

* 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
* Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) – soil type and drainage class

***Software & Scripting:***

* Google Earth Engine – temporal aggregates of NDVI for seasonal variation
* ArcGIS Pro, version 2.5.1 – raster and data processing

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Dynamic NDVI-Based Curve Number Maps** | Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI | These maps will help end users gain a more comprehensive understanding of runoff risk throughout the study area. | N/A |
| **Conventional Curve Number Maps and Tables** | N/A | 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. | N/A |
| **LULC Maps** | N/A | Detailed LULC for the county over the study period using inputs from the CDL and the NLCD to create crop specific land cover maps. | N/A |
| **Story Map** | N/A | Creation of an ESRI Story Map to present findings to end users and community members to help inform resiliency strategies and distribute information. | N/A |
| **Tutorial of Methods** | N/A | A tutorial of methods for dynamic curve number calculations will allow partners to improve upon the current model as they obtain new data. It will also allow partners to define different parameters or study areas. | N/A |

***Product Benefit to End User:***

The results from these analyses will 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 land use and land cover changes that impact 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. Further investigation of these factors will help partners prioritize resiliency efforts to reduce flood risks for residents, businesses, and the agricultural community, ensuring the sustained health of Riley County watersheds.

**References**

Muche, M. E., Hutchinson, S. L., Hutchinson, J. S., & Johnston, J. M. (2019). Phenology-adjusted dynamic curve number for improved hydrologic modeling. *Journal of Environmental Management,* *235*, 403-413. doi:10.1016/j.jenvman.2018.12.115