WSF 2022 Annual Report #5192

Quantifying the Impact of Eastern Redcedar Encroachment on Recharge in the Nebraska Sandhills

We are finishing up this project and will have it completed by December 2022. We will have four journal articles published or submitted by December. The funding from the Water Sustainability helped fund the two PhD students that have worked on developing Eastern Redcedar encroachment scenarios and to determine their impact on the water resources in the Nebraska Sandhills. We also added an extra component to this research that wasn't in the proposal. We evaluated the impact of climate change, independently and with ERC encroachment, to determine their impact on discharge in the Middle Loup River watershed (Figure 1) and groundwater levels in the Nebraska Sandhills.

Our fist paper has been submitted to the journal *Science of the Total Environment*. In this study we evaluated the impact of Redcedar encroachment for multiple scenarios. Using a moving window (3x3 m to 7x7 m) with a dilate morphological filter, encroachment scenarios of 11.9%, 16.1%, 28.0%, 40.6%, 57.5%, 72.5% and 100% were developed and simulated by the calibrated SWAT model. With the reduction in streamflow to the Middle Loup River, we also evaluated the impact that this reduction would have on atrazine concentrations in the Platte River.

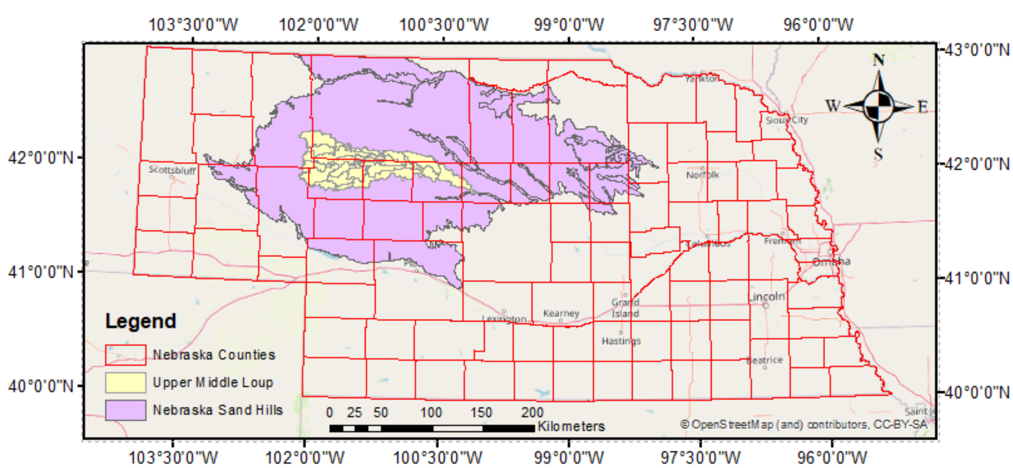

Figure 1: Location of the Upper Middle Loup watershed compared with Nebraska Sandhills and Nebraska state map.

Our second paper has been submitted to the journal *Remote Sensing of Environment*. In this paper we integrated object-based image analysis of high-resolution National Agricultural Imagery Program (NAIP) images and deep neural network (DNN) to calculate the current and past Redcedar cover using Landsat images (Figure 2). We trained, tested, and validated the DNN classifier on Landsat operational land imager (OLI-DNN) and thematic mapper (TM-DNN) satellite images. The TM-DNN model was then transferred to extract the Redcedar area from 1990 and 2000 Landsat TM images. The training and validation samples were generated using object-based classification of NAIP images. The overall accuracy greater than 90% and Kappa statistics greater than 83% show that the Redcedar area is accurately delineated and mapped. The results show the spatial and temporal pattern in Redcedar encroachment. The Redcedar annually increased by 9.8% from 1990-2000, 4.9% from 2000-2010, 7.5% in 2010-2020, and 13.8% from 1990-2020 at regional scale. High encroachment rates in counties with Redcedar cover less than 1% of the area such as Dawson (194%), Loup (95%), Arthur (65%), and Perkins (62%) reveal establishment in newer areas. The distribution in Lincoln and Key Paha Counties, with a high proportion of Loess canyons and hills, shows consistent presence and substantial increase in Redcedar area. The study shows DNN and transfer learning provide an accurate representation of Redcedar encroachment even when ground truth data are limited or unavailable using Landsat data. This study demonstrates the potential to extrapolate regional assessments of woody species invasions in the Great Plains in North America.

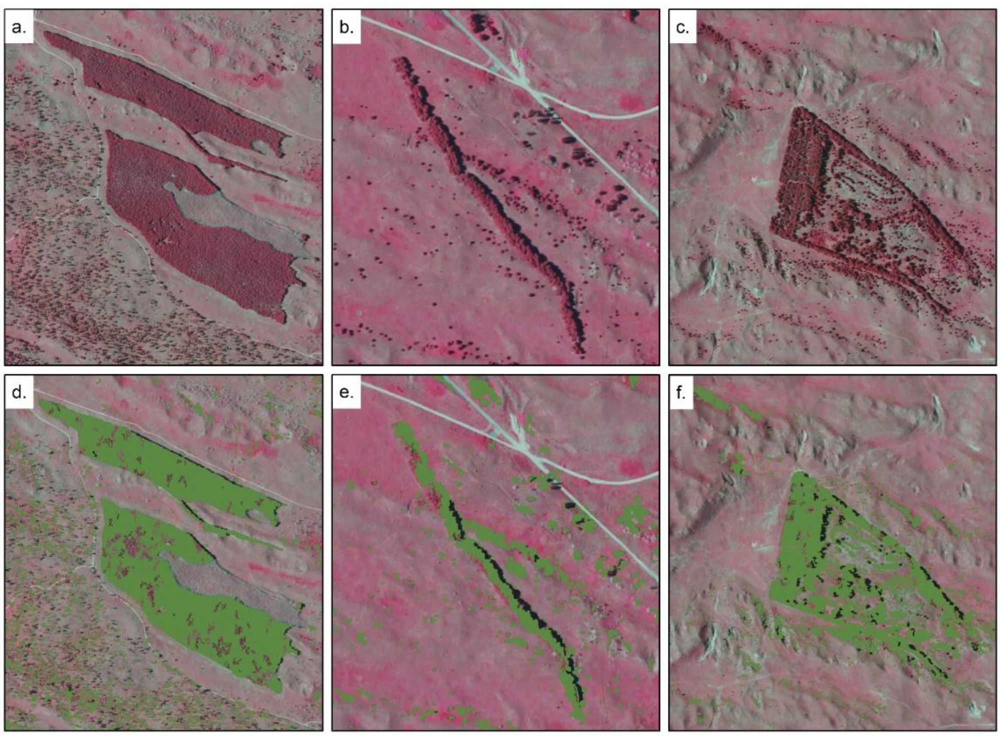

Figure 2. Redcedar identification using object-based image classification of National Aerial Imagery Program (NAIP) images (e.g., 2020). The upper row (a, b, c) shows the false-color composite of NAIP images while the bottom row (d, e, f) shows the extracted Redcedar overlaid on the corresponding NAIP images.

For our third paper we evaluated the impact of both climate change and Redcedar on water resources in the Nebraska Sandhills. We ranked the CMIP5 222 climate models based on the aridity index and identified three models representing wet, median, and dry conditions.

Additionally, the levels of CO_2 emissions under each one of the selected climate models were also simulated over the period from 2000 to 2099 segmented into three periods (2000-2030, 2030-2060, 2060-2099). Hypothetical Redcedar encroachment scenarios of 11.6% and 72.9% were simulated as well as a likely encroachment scenario that was determined based on a combination of neural network and Markov-chain cellular automata model. This paper is in preparation and will be submitted in the next few months.

The simulations completed in our previous papers on used the surface water model SWAT. We could simulate recharge, evapotranspiration and streamflow, but not groundwater levels. In this final chapter, we coupled the SWAT model with MODFLOW, a groundwater model. We then simulated three climate change scenarios to determine their impact on groundwater and lake levels in the Nebraska Sandhills.