Riparian vegetation planting can be guided by machine learning model

Gregory Pasternack[1], Romina Diaz-Gomez[1], and Hervé Guillon[1]

[1]University of California Davis

November 23, 2022

Abstract

Designing where to plant riparian vegetation is a component of many river projects. Several mechanistic models have been developed considering biological, soil, hydrological, and hydraulic requirements that influence riparian vegetation growth. However, many models are not spatial explicit and there remains high uncertainty as to where plantings will survive or die. This study sought to determine if a machine learning (ML) algorithm could be trained to accurately characterize the complex set of site attributes that promote survival, and do so exclusively using metrics derived from airborne LiDAR. Results could then be used to guide planting strategies. The selected testbed river was 34 km of alluvial, regulated, gravel/cobble river where planting projects are common and have high mortality. The lower Yuba River, California, USA was mapped at sub-meter resolution in 2017. Our approach has four steps. First, a set of 32,000 vegetation presence/absence observations were randomly selected from LiDAR-derived polygons of naturally occurring established vegetation. Second, the river was split into 75 training, validation and test areas. Third, a set of 17 LiDAR-derived topographic potential predictors were computed at 0.91-m (3-ft) resolution. Finally, a Random Forest machine learning model was trained to best predict vegetation presence. The model results in a riparian vegetation presence probability map and has a "Area Under the Curve" (AUC) of 0.77. As probability values are difficult to interpret, a forage ratio electivity index analysis was performed with statistical bootstrapping. Results show that points with probability values > 0.8 had ˜ 8.5 times more riparian vegetation present than would be likely from random chance at the 95% confidence level. Microtopographic 'vector ruggedness' was identified as the main driver for vegetation presence, followed by Terrain Ruggedness Index and Roughness. In conclusion, a ML model can identify where riparian vegetation planting are most likely to succeed and guide design. Our results also suggest that more attention should be paid to creating rugged microtopography under plantings to help cuttings and seedlings establish deposition critical for nutrition.

Riparian vegetation planting can be guided by machine learning model

Romina Díaz Gómez [1*], Gregory B. Pasternack[1], Hervé Guillon[1]

[1]Department of Land, Air, and Water Resources, University of California at Davis, Davis, CA

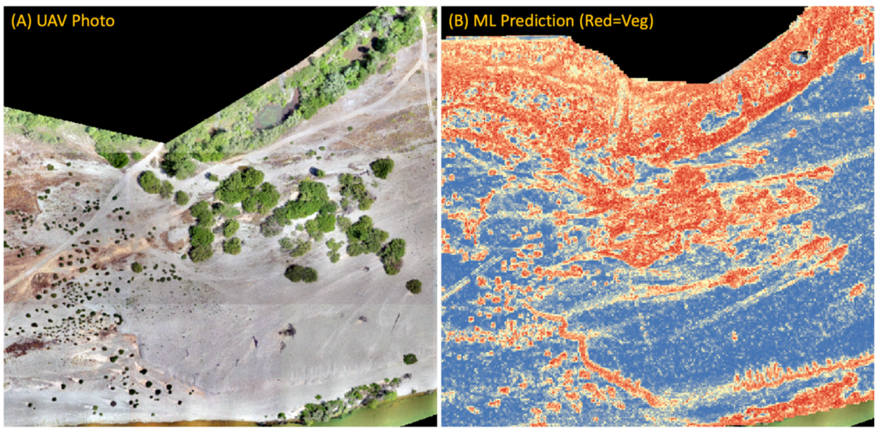
* Corresponding author: Romina Diaz-Gomez, rdiazgomez@ucdavis.edu

Abstract

Designing where to plant riparian vegetation is a component of many river projects. Several mechanistic models have been developed considering biological, soil, hydrological, and hydraulic requirements that influence riparian vegetation growth. However, many models are not spatial explicit and there remains high uncertainty as to where plantings will survive or die. This study sought to determine if a machine learning (ML) algorithm could be trained to accurately characterize the complex set of site attributes that promote survival, and do so exclusively using metrics derived from airborne LiDAR. Results could then be used to guide planting strategies. The selected testbed river was 34 km of alluvial, regulated, gravel/cobble river where planting projects are common and have high mortality. The lower Yuba River, California, USA was

mapped at sub-meter resolution in 2017. Our approach has four steps. First, a set of 32,000 vegetation presence/absence observations were randomly selected from LiDAR-derived polygons of naturally occurring established vegetation. Second, the river was split into 75 training, validation and test areas. Third, a set of 17 LiDAR-derived topographic potential predictors were computed at 0.91-m (3-ft) resolution. Finally, a Random Forest machine learning model was trained to best predict vegetation presence. The model results in a riparian vegetation presence probability map and has a "Area Under the Curve" (AUC) of 0.77. As probability values are difficult to interpret, a forage ratio electivity index analysis was performed with statistical bootstrapping. Results show that points with probability values > 0.8 had ~ 8.5 times more riparian vegetation present than would be likely from random chance at the 95% confidence level. Microtopographic 'vector ruggedness' was identified as the main driver for vegetation presence, followed by Terrain Ruggedness Index and Roughness. In conclusion, a ML model can identify where riparian vegetation planting are most likely to succeed and guide design. Our results also suggest that more attention should be paid to creating rugged microtopography under plantings to help cuttings and seedlings establish deposition critical for nutrition.

Keywords: riparian vegetation, Lidar, roughness, planting, machine learning, remote sensing,



Plain-Language Summary:

Designing where to plant riparian vegetation is a component of many river projects. We propose that artificial intelligence can be used to aid the design of riparian plantings, hopefully improving project outcomes. In this study we show that machine learning can accurately predict where vegetation is found on a gravel/cobble river and that machine learning identifies important variables critical to planting success but which are not typically used in planting design.

Session Title:

EP002. Applications of Ecosystem Restoration and Natural or Nature-based Features as Green Infrastructure for Vulnerable Aquatic Systems

Session Description:

Aquatic systems, including wetlands, estuaries, rivers, and lakes, provide ecologically and economically important services for the communities that surround them. These human and natural systems are tightly coupled, and development pressures have led to significant degradation in aquatic ecosystems over the last century. Opportunities are increasingly sought to recover lost ecosystem services through restoration and to harness ecosystem benefits by implementing green infrastructure designs inspired by natural and nature-based features (NNBF). This multidisciplinary session welcomes studies related to aquatic restoration or design of NNBF, including (1) development of novel strategies and best practices for "successful" restoration and/or green infrastructure design (e.g. design of reef restoration, living shoreline or bank protection, floodplain storage), (2) biogeochemical or hydrodynamic impacts of implementation (e.g. flow alteration, wave buffering, carbon sequestration), and (3) scientific advances leading to high-fidelity predictions of outcomes related to these investments (e.g. ecosystem modelling, site or species selection, benefit valuation).

Conveners:

David Cannon (University of Central Florida)

Kelly Kibler (University of Central Florida)

–

Riparian vegetation planting can be guided by machine learning model

Romina Díaz Gómez [1*], Gregory B. Pasternack[1], Hervé Guillon[1]

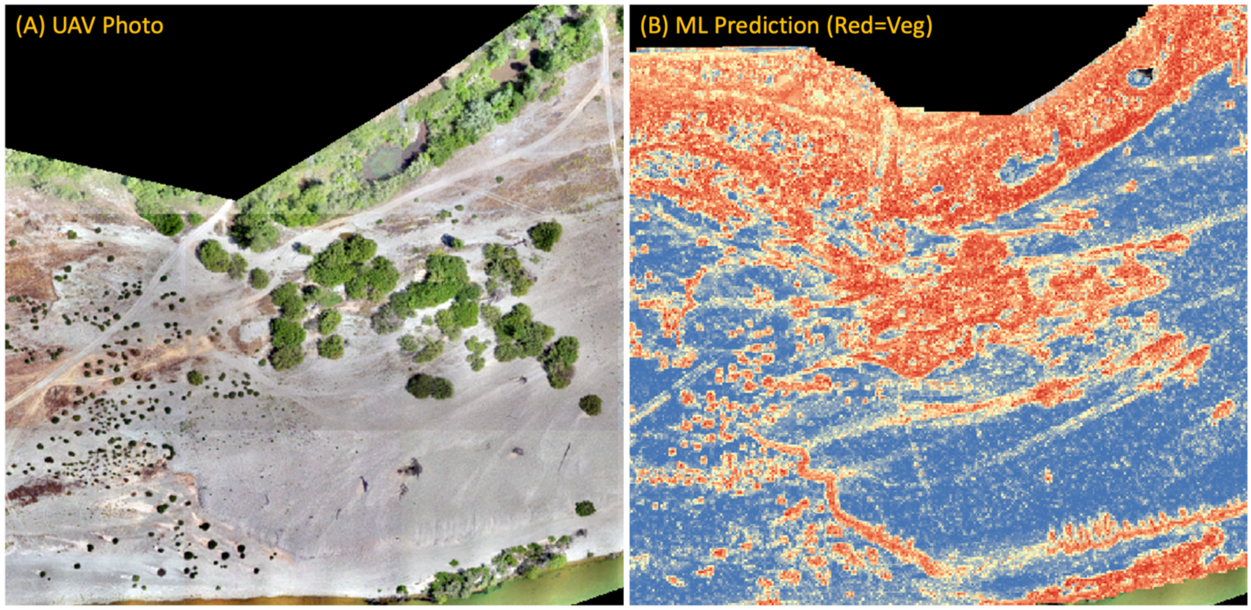
[1]Department of Land, Air, and Water Resources, University of California at Davis, Davis, CA

* Corresponding author: Romina Diaz-Gomez, rdiazgomez@ucdavis.edu

Abstract

Designing where to plant riparian vegetation is a component of many river projects. Several mechanistic models have been developed considering biological, soil, hydrological, and hydraulic requirements that influence riparian vegetation growth. However, many models are not spatial explicit and there remains high uncertainty as to where plantings will survive or die. This study sought to determine if a machine learning (ML) algorithm could be trained to accurately characterize the complex set of site attributes that promote survival, and do so exclusively using metrics derived from airborne LiDAR. Results could then be used to guide planting strategies. The selected testbed river was 34 km of alluvial, regulated, gravel/cobble river where planting projects are common and have high mortality. The lower Yuba River, California, USA was mapped at sub-meter resolution in 2017. Our approach has four steps. First, a set of 32,000 vegetation presence/absence observations were randomly selected from LiDAR-derived polygons of naturally occurring established vegetation. Second, the river was split into 75 training, validation and test areas. Third, a set of 17 LiDAR-derived topographic potential predictors were computed at 0.91-m (3-ft) resolution. Finally, a Random Forest machine learning model was trained to best predict vegetation presence. The model results in a riparian vegetation presence probability map and has a "Area Under the Curve" (AUC) of 0.77. As probability values are difficult to interpret, a forage ratio electivity index analysis was performed with statistical bootstrapping. Results show that points with probability values > 0.8 had ~ 8.5 times more riparian vegetation present than would be likely from random chance at the 95% confidence level. Microtopographic 'vector ruggedness' was identified as the main driver for vegetation presence, followed by Terrain Ruggedness Index and Roughness. In conclusion, a ML model can identify where riparian vegetation planting are most likely to succeed and guide design. Our results also suggest that more attention should be paid to creating rugged microtopography under plantings to help cuttings and seedlings establish deposition critical for nutrition.

Keywords: riparian vegetation, Lidar, roughness, planting, machine learning, remote sensing,



Plain-Language Summary:

Designing where to plant riparian vegetation is a component of many river projects. We propose that artificial intelligence can be used to aid the design of riparian plantings, hopefully improving project outcomes. In this study we show that machine learning can accurately predict where vegetation is found on a gravel/cobble river and that machine learning identifies important variables critical to planting success but which are not typically used in planting design.

Session Title:

EP002. Applications of Ecosystem Restoration and Natural or Nature-based Features as Green Infrastructure for Vulnerable Aquatic Systems

Session Description:

Aquatic systems, including wetlands, estuaries, rivers, and lakes, provide ecologically and economically important services for the communities that surround them. These human and natural systems are tightly coupled, and development pressures have led to significant degradation in aquatic ecosystems over the last century. Opportunities are increasingly sought to recover lost ecosystem services through restoration and to harness ecosystem benefits by implementing green infrastructure designs inspired by natural and nature-based features (NNBF). This multidisciplinary session welcomes studies related to aquatic restoration or design of NNBF, including (1) development of novel strategies and best practices for "successful" restoration and/or green infrastructure design (e.g. design of reef restoration, living shoreline or bank protection, floodplain storage), (2) biogeochemical or hydrodynamic impacts of implementation (e.g. flow alteration, wave buffering, carbon sequestration), and (3) scientific advances leading to high-fidelity predictions of outcomes related to these investments (e.g. ecosystem modelling, site or species selection, benefit valuation).

Conveners:

David Cannon (University of Central Florida)

Kelly Kibler (University of Central Florida)

--