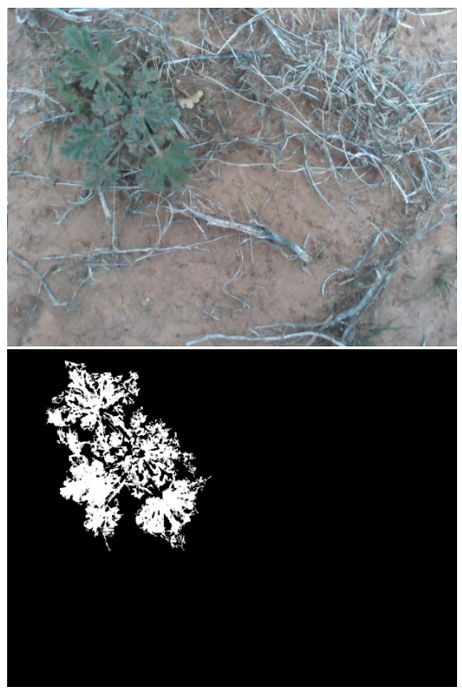
NRI: INT: Autonomous Restoration and Revegetation of Degraded Ecosystems

Heckman, Correll, Barger (University of Colorado, Boulder)

Summary: We will develop robotic multi-agent motion planning, joint visual-tactile perception, and multimodal 3D map construction techniques to support targeted seed planting in degraded rangelands, beginning with experiments in the Canyonlands region of Utah.

What makes a successful ecological intervention?

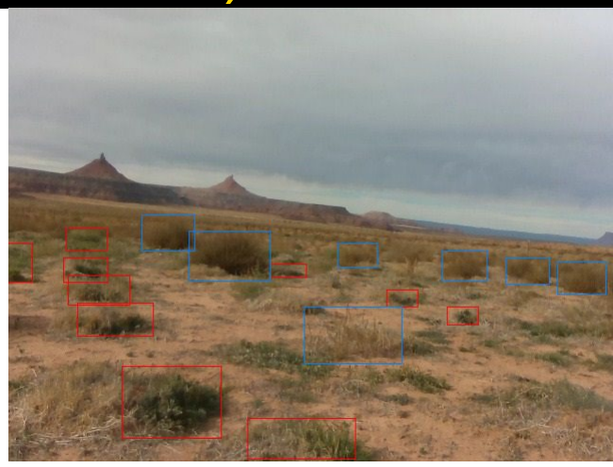
We abstract germination factors into a joint feature space over which we can find the optimum plane which describes the ideal combination of factors for revegetation.



Example of a plant mask for monitoring revegetation results

Goals for Autonomous Ecological Intervention

1. Identify factors which contribute to plant growth in real time
2. Take appropriate action to promote revegetation
3. Monitor vegetation growth to augment revegetation dataset features over time
4. Correctly associate measurements to individual objects for accurate data correlation and feature mapping over time
5. Optimize terrain exploration and intervention to maximize revegetation



Example of a real-time labelled image. The red boxes indicate ConMods and the blue boxes indicate shrubs.

ID	Description
T1	**Initial Field Deployment (Fall 2021)**: Deployed with manual cart, collected onboard localization and visual data
T1.1	Seedling monitoring: Observe grass seedlings in the fall, collect data, and make continuous maps of relevant data such as the presence of existing vegetation and terrain features
T1.2	Use feature selection techniques for topography, lidar, and visual sensors.
T1.3	Train joint feature spaces to determine the relevant factors to seed germination
T2	**Field Deployment 2 (Spring 2022)**: Deploy with tele-operation, supervised navigation, collect GPS, onboard localization and visual data
T2.1	Plant maturation monitoring: Similarly, to T1.1 we can use data collected in the spring to correlate what factors contribute to maturation of seedlings as well as the efficacy of interventions
T3	**Autonomous Planting and ConMod Application:** Using visual-tactile sensing, take the appropriate interventions
T3.1	Merge visual-tactile sensing into platform for terrain manipulation and ConMod Deployment
T3.2	Using the information gathered from T1.1 and T2.1 we can make decisions about when and where it is beneficial to take certain interventions for revegetation
T4	**Evaluation and Continuous Deployment**
T4.1	Address the challenges with communication, navigation, and power electronics associated with continuous, long-term deployment. Implement LLMs for constraining landmarks.
T4.2	Gather further information about what contributes to successful environmental intervention in degraded rangelands and autonomously plant, monitor, and place ConMods to assist these efforts.