**Title:**

**List of Authors:**

1. **Abstract** (Typically, this should be the last section written. It’s easier to summarize after you write a manuscript, rather than before.)
   1. General background statement (1-2 sentences)
      1. Ecological damage around Butte and downstream to Missoula (see Danella’s thesis)
      2. Responsibility to monitor reclaimed and restored sites long term
   2. Knowledge gap or problem to solve (1 sentence)
      1. Problem: current monitoring methods are slow, laborious, and outdated
   3. Hypothesis (1 sentence)
      1. The use of electronic sensors to automate both the collection and analysis of ecological data (environmental conditions such as weather, audio recordings, and digital images) can enhance or replace current restoration-monitoring efforts.
   4. Approach to fill knowledge gap or solve the problem (1 sentence)
      1. We focused on automating the analysis of images collected in both laboratory and field settings.
   5. List major results (2-4 sentences depending on the size of study)
      1. Result 1: Plant images in lab setting (plant leaves and stems on gray background) provides data related to plant growth and plant health/chlorophyll content
      2. Result 2:
   6. Conclusion
      1. Workflows that use vegetative indices were useful for 1) plant specimens on gray backgrounds and 2) top-down photos of quadrats from ecological fieldwork, analysis of previous and future image datasets is possible.
   7. “Parting shot”
      1. Recommend that biologist embrace computer-based automation for tasks that are too time-consuming and expensive to achieve desired levels of understanding.
2. **Introduction**
   1. Topic 1 paragraph
      1. Introduce the main topic for this paragraph (1 sentence)

* Butte mining history and current reclamation efforts
  + 1. Talking point 1
       - The years that underground vs pit mining took place, the number of miles of tunnels under Butte (20,000+), and the Berkley Pit (formed when water removal was discontinued)
    2. Talking point 2
       - Mining waste piled around Butte and flooded downstream in 1908 ([reference](https://cfwep.org/1908-flood-influenced-what-we-are-now/))
    3. Talking point 3
       - Superfund site, multi-agency effort with lots of regulations
    4. Transition from this topic to the next topic
       - Need to monitor reclaimed and restored areas long-term is necessary but overwhelming to the point that monitoring occurs infrequently
  1. Topic 2 paragraph
     1. Introduce the main topic for this paragraph (1 sentence)
        + Goal of creating functioning ecosystem to maintain “caps” where contaminated soil is covered with a layer of lime and 1-3 feet of non-contaminated soil
     2. Talking point 1
        + Regulations related to the Superfund site stipulate that native ecosystems should be restored and functional
     3. Talking point 2
        + The native plants would likely do better if the soil in the cap was populated with microbial populations that are found in natural/native
     4. Talking point 3
        + Here, our study uses digital images of willow branches and leaves from willow cuttings grown in soil from different restoration sites, which were completed in different years, along the Clark Fork River
     5. Transition from this topic to the next topic
        + In addition to monitoring restoration sites in the floodplains downstream from Butte, we also considered the possibility of using image analysis as a means of automating portions of the Butte Reclamation Evaluation System (BRES) ([reference](https://www.researchgate.net/publication/322969755_Butte_Reclamation_Evaluation_SystemBRES)).
  2. Topic 3 paragraph
     1. Introduce the main topic for this paragraph (1 sentence)
        + EPA Superfund Site (1983) 🡪 Butte Priority Soils Operational Unit (1988) 🡪 BRES as tool to monitor (reference paper again)
     2. Talking point 1
        + BRES started out as a standardized form and has since transitioned to an electronic format using iPads with imaging and GPS functionality in the field
     3. Talking point 2
        + 3rd party workers currently visit sites once every 4 years and many of the data fields require estimates following an “eye calibration” training
     4. Talking point 3
        + Many of the data fields in the BRES survey could be supplemented with, or replaced by, calculations resulting from image analysis
  3. Transition paragraph…very similar to the abstract opening sentences, but reworded enough so that it won’t feel redundant to the reader
     1. Use the three main points from the previous three paragraphs to provide an opening to introduce your study rational and purpose
     2. Remind the reader about the
        + Knowledge gap or problem (1 sentence)
          1. Current problems: too much land to monitor using standard approach, too expensive, too slow, too underpowered (statistical power), etc.
        + The hypothesis or goal (1 sentence)
          1. We propose automating the task of monitoring ecological restoration and reclamation sites via image analysis techniques to reduce costs, speed up data acquisition/analysis, and cover a larger percentage of the sites to produce more powerful and consistent analysis.
        + Approach taken to fill knowledge gap or problem (1 sentence)
          1. Photos collected from Danella’s study and photos collected to be representative of the BRES-related sites were the basis of this study.

1. **Materials and methods**
   1. Image collections
      1. Danella collected the willow branch and leaves images
         * reference Danella’s thesis <https://digitalcommons.mtech.edu/grad_rsch/297/>
         * link to the directory of your GitHub repo that contains the subset of images you analyzed
         * describe the camera (Canon Eos Rebel T6i), use of tripod, [Spyder ColorCHECKR 24](https://www.amazon.com/Datacolor-SCK200-SpyderCHECKR-24/dp/B00LPS46TW/ref=sr_1_1?crid=2N5W4ESL2O8KU&dib=eyJ2IjoiMSJ9.u2naqnnG_6pfWCC7WbUThKCsjbzeYBrNJquNfZRegnTNOiyt5parBK4qXbJPS4OLIcOOmAgH3za0CN5pCHtC39Ns0JBHZsdaTau589OHRr4KI-OCg5zYY3ZN1xW6TPOIGbXkfIH_NeVzpA3fYqjMmmwzl7bYO7wU-xyBPFhlQiCKqsgAn5oJtUIU0ipuWw6GpDXvCGUjXE0EPWkL8Xp7Np0ush4fwHOi3320kK1ZI2w.dPNWy1u7MwvJYHLY_SRoxeahiq_2Zlyz-BDpv9ct5Nk&dib_tag=se&keywords=spyder%2Bcolorchecker&qid=1721753636&sprefix=spyder%2Bcolorchecker%2Caps%2C174&sr=8-1&th=1), image format (jpeg?) and resolution
      2. You collected the quadrat images in the field
         * General location and dates of image collection
         * Reference the directory of your GitHub repo where the images are located
         * Describe your camera, the quadrat, your imaging “technique”,
   2. Coding environment and reference to your GitHub repo for this project
      1. IDE
      2. Python version
      3. Include Python libraries (with version numbers) you used and links to their pages on [pypi.org](https://pypi.org/)
2. **Results**
   1. Greenhouse image dataset description and image analysis workflow
      1. Background: skim Danella’s [thesis](https://digitalcommons.mtech.edu/grad_rsch/297/) and summarize both the general idea of the project and the
3. **Discussion**
   1. Refer back to the hypothesis
   2. Review the benefit of using vegetation indices on plant specimens laid out on gray backgrounds
4. **References**
   1. Danella’s thesis