BEAVER (*CASTOR CANADENSIS*) IMPACT ON WATER RESOURCES IN THE JEMEZ MOUNTAINS, NEW MEXICO

WORK PLAN

Group Members

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EXECUTIVE SUMMARY

Background and Significance. This project will model the effects of beaver (*Castor canadensis*) on stream discharge in the Jemez River. The re-establishment of this once widespread species may have significant effects on the availability of water in the arid southwest. One possible mechanism is that water trapped behind beaver dams will increase groundwater recharge and, therefore, baseflow, which will in turn retard the flow of water extending it later into the dry season. A warmer climate could cause the local snowpack to melt earlier in the spring, so increased water storage created by beaver could be a potential adaptation strategy to climate change.

Objectives. The group will address three objectives in this project: 1) Model the effect of beaver re-establishment on the stream discharge of the Jemez River; 2) Evaluate ecosystem services provided by beaver re-establishment in the Jemez River watershed; and 3) Conduct a stakeholder assessment to determine the stakeholder interests and positions regarding beaver re-establishment in the Jemez River watershed.

Literature Review. The group conducted a review of available literature regarding beaver habitat, impacts of beaver dams on watershed hydrology, relevant hydrologic models, availability of data, ecosystem services, and stakeholders. The client, WildEarth Guardians, supplied the group with a number of scholarly articles and agency documents on watershed assessments, the ecological role of beavers, and stakeholder interests. Additional research produced scholarly articles regarding past studies of the hydrological impacts of beaver impoundments, methods for approximating subsurface flow and storage, and a system for estimating beaver dam density on stream reaches. The group also reviewed several hydrologic models to determine suitability and applicability to the project's needs.

Technical Approach. The group will construct a basic conceptual model for increased subsurface water storage due to beaver impoundments in the Jemez watershed. Building on this basic conceptual model, the group will add complexity to the analysis by investigating the following model parameters: beaver dam density, evapotranspiration and climate scenarios. After determining the magnitude of impact of beaver dams on several theoretical reaches of the Jemez River, the group will use the model currently being developed by Dr. Wheaton as well as the model produced by WildEarth Guardians to determine potential dam location and density in the Jemez River watershed. The group's ultimate goal will be to use the outputs from all models above to stitch together the hydrological impacts of beaver in the Jemez watershed.

The group will evaluate how beaver re-establishment may affect ecosystem functions within the Jemez River watershed. The group will then extrapolate how those effects may lead to changes in ecosystem services that impact human well-being. These predictions will be considered alongside other concerns in the group's stakeholder analysis to evaluate the feasibility of beaver re-establishment.

1.0 OBJECTIVES

The group will focus the project on three objectives:

1. Model the effect of beaver (*Castor canadensis*) re-establishment on the stream discharge in the Jemez River.
2. Evaluate ecosystem services provided by beaver re-establishment in the Jemez River watershed.
3. Conduct a stakeholder assessment to determine the stakeholder interests and positions regarding beaver re-establishment in the Jemez River watershed.

2.0 SIGNIFICANCE OF THE PROJECT

In the arid American Southwest, access to water resources is increasingly becoming a concern. Droughts and the threat of climate change are compounding a problem caused by large populations in water poor areas. Mountain snowpack is an important part of the water supply system, as it stores water that falls in winter until it is released when it melts. Drought and climate change may cause the snow to melt earlier, changing the availability of water to farmers, ranchers, and urban users.

It is hypothesized that beaver may be able to help mitigate the problem of water storage. By building dams on lower order streams, beaver have the potential to retard the flow of water from early snowmelt and help extend streamflow to later in the year. Beaver do this both by physically preventing water from flowing with their dams and by groundwater recharge. The group will explore the effect beaver have on the seasonal timing of stream discharge. If beaver significantly extend streamflow into the summer, it would be evidence that beaver could help alleviate summer water shortages.

WildEarth Guardians (WEG), the client for this group project, is interested in this project for several reasons. As a conservation non-profit organization, WildEarth Guardians is interested in returning beaver to the ecosystem to restore a native species to the environment. Beaver were historically widespread throughout North America before they were trapped for their pelts. Furthermore, farmers and ranchers often consider beaver as pests and actively sought to remove them. Should beaver re-establishment prove to both extend streamflow later in the season and help increase mountain water storage, it would provide WildEarth Guardians with a convincing argument to present to stakeholders to support beaver re-establishment. Reframing the beaver's image from pests to providers of important ecosystem services may convince local landowners to support beaver re-establishment.

Additional stakeholders within New Mexico are state and federal wildlife agencies, including the New Mexico Department of Game and Fish, the Surface Water Quality Bureau at the New Mexico Environmental Department, US Fish and Wildlife Service, and USFS; and academic researchers at local New Mexico universities, including the Department of Fish, Wildlife, and Conservation Ecology at New Mexico State University. Additional stakeholders include landowners and groups such as Animal Protection of New Mexico who serve to determine safe ways for beaver re-establishment and

landowner interaction; farmers; ranchers; anglers; conservation groups; native Americans; and downstream water users (New Mexico Environment Department 2013).

Furthermore, beaver re-establishment has been investigated throughout the Cascade and Rocky Mountain ranges in Washington, Oregon, Utah, and Colorado. State and federal agencies and academic researchers in Utah and Colorado are particularly interested in this project for incorporation into their beaver management plans (Utah DWR 2010) as an adaptation to climate change, specifically, the Utah Department of Wildlife and the Department of Watershed Science at Utah State University.

3.0 BACKGROUND AND LITERATURE REVIEW

3.1 Objective 1: Stream Discharge

The literature review focused primarily on three areas for this objective: 1) the known impacts of beaver dams on the hydrologic properties of a watershed; 2) the types of models that would be relevant to the project; and 3) the existing and available data. The findings demonstrate that sufficient data exists regarding the ecological roles of beavers, the hydrologic impacts of beaver dams, and relevant climate, precipitation, flow, and soil data necessary for modeling the Jemez River watershed.

WildEarth Guardians was consulted to obtain relevant information and develop a conceptual model of how the project will be conducted. Of principal interest are a series of watershed assessments conducted by the USFS on the Jemez River watershed (USFS 2001-05). These assessments include information on land use, the various jurisdictional agencies in the region, and suitable beaver habitat. Furthermore, the assessments include maps and watershed delineations of all sub-basins within the Jemez River watershed. Other articles relevant to the project include literature on the ecological role of beavers. Another report investigated the hydrological impacts of beaver ponds on stream flows on a river in Alaska and provided methods for calculating flood attenuation based on parameters like beaver dam density and average dam height which could be useful to the project (Beedle 1991).

The group considered several models to assess their relevance to the project, including the Regional Hydro-Ecologic Simulation System (Tague and Grant 2004), the Water Evaluation and Planning system (WEAP; SEI 2013), and the Army Corps of Engineers Hydrologic Engineering Centers River Analysis System (HEC-RAS; HEC 1995). The group determined that WEAP may be best suited to model the project's findings regarding hydrologic, ecological, and stakeholder interests. The model utilizes an integrated approach to water balance accounting, taking into account parameters such as regional water use, infiltration rates, evapotranspiration, and issues pertaining to water rights stakeholders.

Accurate data regarding sources, sinks, and fluxes of water within the Jemez River watershed are all necessary input parameters for WEAP, and different methods for

approximating parameter values representative of watershed characteristics will be assessed for precision, accuracy, and complexity. Potential methods for determining hydrologic parameters that were investigated include estimating water storage for a range of drainage areas and parameter values at the sub-basin scale (Dr. Thomas Dunne, personal communication, May 28, 2013); the Thornthwaite water balance model (McCabe and Markstrom 2010); the Priestly-Taylor evapotranspiration equation (Priestley and Taylor 1972); and the Tague and Grant (2009) method for calculating streamflow recession and timing. The sub-basin approach can be used to approximate increased storage due to beaver impoundments for a range of drainage areas within the watershed based on channel depth, drainage area, water input, and the hydraulic conductivity of the underlying geology. The Thornthwaite water balance model can be used to approximate monthly water storage using a variety of parameters including: precipitation, infiltration, snowmelt, soil moisture, and evapotranspiration. The Priestley-Taylor equation relies on solar radiation, temperature and vapor pressure to calculate local evapotranspiration rates. The Tague and Grant method is a conceptual model that predicts the sensitivity of a downstream flow to time of recharge and geology. Any combination of these approaches may be employed to ascertain hydrologic parameter values for WEAP.

Knowledge of suitable beaver habitat will be used to predict potential beaver populations, which will in turn be used to predict beaver dam density. A model produced by Wildearth Guardians that ranks area within the watershed as suitable beaver habitat can be used to assess likely beaver densities within regions of the watershed (Mr. Bryan Bird, personal communication, 9 May 2013). A separate model provided by external advisor Dr. Joe Wheaton can be used to predict beaver dam density based on beaver population, vegetation and stream order (Dr. Joe Wheaton, personal communication, 9 May 2013).

The group also searched the US Geological Survey (USGS), University of New Mexico, and Jemez River Critical Zone Observatory (CZO) websites for data that would be pertinent to the group's hydrologic model. The group gathered an abundance of streamflow, climate, soil type, snowpack, and topographical information that will assist in calibrating the group's hydrologic model. However, stream gauge data for the Jemez River was limited to a site that was near the Jemez Canyon Dam, which may make it hard to model the impacts of beaver dams on lower order streams that are higher up in the watershed.

3.2 Objective 2: Ecosystem Services

For this objective, the literature review focused on the definition of ecosystem services, ecosystem services that may be provided by beaver re-establishment, how those services may affect human welfare, and the likelihood of long-term ecosystem change due to beaver impacts. The findings indicate that there are several publications on the benefits humans obtain from ecosystems, the methodology to assess which services an ecosystem provides, and how beaver play a role in the provision of such services.

These publications will be utilized in the review of potential ecosystem services that beaver could provide for the Jemez River watershed.

WildEarth Guardians published a preliminary study on ecosystem services provided by beaver introduction. This paper highlighted several potential impacts on the ecosystem functions. These impacts included the creation of ponds in the river system through dam-building, regularly feeding on a variety of plant species, and interacting with other organisms within the ecosystem. The paper also suggested that such impacts may lead to additional changes in the ecosystem that would lead to benefits for human well-being. These anticipated effects would be resultant to beaver's dam-building abilities which would create ponds in the river system (Bird 2011).

The group will refer to the Millennium Ecosystem Assessment report, "Ecosystems and Human Well-being: A Framework for Assessment" in its evaluation of potential ecosystem services that can be provided by the Jemez River watershed (MA 2005). Any ecosystem provides services which can be classified along functional lines into four categories through this framework: supporting services, provisioning services, regulating services, and cultural services.

The group will also refer to the Millennium Ecosystem Assessment report to determine other potential drivers of ecosystem change on the Jemez River watershed. The ecological role of beaver will be examined in relation to these drivers. That way, the group will be able to discern potential effects on those drivers through beaver re-establishment.

3.3 Objective 3: Stakeholder Analysis

Beaver re-establishment in the Jemez River watershed would require the interaction of a variety of project stakeholders. Project stakeholders are individuals, groups of people, agencies, and organizations that are actively involved in the project or whose interests may be affected as a result of the project. Stakeholders interests, ideas, and goals related to the proposed project need to be considered in order to achieve the project's goals and support for the project.

A preliminary list of stakeholders within New Mexico include state and federal wildlife agencies, such as the New Mexico Department of Game and Fish, the Surface Water Quality Bureau at the New Mexico Environmental Department, US Fish and Wildlife Service, and USFS; and academic researchers at local New Mexico universities, including the Department of Fish, Wildlife, and Conservation Ecology at New Mexico State University. Additional stakeholders include landowners and groups such as Animal Protection of New Mexico who serve to determine safe ways for beaver re-establishment and landowner interaction; farmers; ranchers; anglers; conservation groups; native Americans; and downstream water users (New Mexico Environment Department 2013).

Furthermore, beaver re-establishment has been investigated throughout the Cascade and Rocky Mountain ranges in Washington, Oregon, Utah, and Colorado. State and federal agencies and academic researchers in Utah and Colorado are particularly interested in this project for incorporation into their beaver management plans (Utah DWR 2010) as an adaptation to climate change, specifically, the Utah Department of Wildlife and the Department of Watershed Science at Utah State University.

Several approaches to conducting a stakeholder analysis were evaluated, including classifying stakeholders based on power to influence other stakeholders and the project (Mitchell 1997), value hierarchies and key performance areas (Fletcher 2003), or the needs and importance of stakeholders in relation to other stakeholders (Cameron 2010).

4.0 TECHNICAL APPROACH

4.1 Objective 1: Stream Discharge

4.1.1 *Conceptual Hydrological Modeling*

The group will construct a basic conceptual model for increased subsurface water storage due to beaver impoundments using four basic parameters: drainage area, average stream depth, water input, and the hydraulic conductivity of the underlying geology. The group will model a few different sizes of theoretical basins based on drainage area. Sizes for these theoretical basins will be chosen so that they represent the distribution of actual sub-basin drainage areas within the Jemez River watershed. The purpose of this model will ultimately be to interpolate the data to estimate storage for actual sub-basins within the watershed.

Building on this basic model, the group will add complexity by investigating more precise methods for estimating the following model parameters: beaver dam density, evapotranspiration and climate scenarios.

4.1.2 *Beaver Dam Density: Wheaton Model and WildEarth Guardians Model*

After determining the magnitude of impact of beaver dams on several theoretical reaches of the Jemez River, the group will use the model currently being developed by Dr. Wheaton at Utah State University as well as the geographic information system (GIS) model produced by WildEarth Guardians to determine potential dam location and density in the Jemez River watershed (also see section 4.1.3). The Wheaton Model uses stream characteristics (order, slope, vegetation profile) to predict the density of beaver dam along specific reaches of a river. WildEarth Guardians' GIS model, developed by Bird's Eye View GIS, aims to predict suitable beaver habitat in New Mexico using land cover, canopy cover, stream gradient, stream order, and distance to roads. The group will then match Jemez River reaches to the theoretical reaches (determined above, 4.1.1) and combine this with the dam density information to model the effects beaver dam on the entire Jemez River. This will be done as a first order

approximation, estimating the true distribution of reaches in the watershed and replicating it using the group's pre-determined theoretical reaches.

4.1.3 *Further Analysis*

Once subsurface water storage is estimated for each sub-basin within the watershed, the group will create a water balance budget to account for changes in flow timing resulting from subsurface storage due to beaver impoundments in the watershed using a water balance model (to be determined). This basic accounting method will be a gross approximation of the impact that beaver impoundments have on the hydrology of the watershed. The ultimate goal of the simplistic model will be to determine the magnitude of the change in flow and timing due to beaver impoundments, so that it can be compared to the average baseline flow.

Complexity can then be added to the model in terms of beaver dam density, spatial variation in precipitation across different sub-basins, evapotranspiration rates, and varying climatic conditions to name a few. The group has determined that a likely approach to estimating the impacts of these parameters will involve the use of a radiative water balance model as well as modifications on Darcy's Law (Tague and Grant 2009) to best capture the specific environmental conditions related to water storage behind a beaver dam.

The group's ultimate goal will be to use the outputs above to stitch together the hydrological impacts of beaver in the Jemez watershed. If possible, this will be accomplished in a simple, conceptual way in order to produce a first-order product that would be useful for further analysis, particularly for determination of impacts on ecosystem services.

4.2 Objective 2: Ecosystem Services

4.2.1 *Conceptual ecosystem service evaluation*

The group will define "ecosystem service" and what the scope of the ecosystem service evaluation will be for this project. This will be done by collecting physical data of the region to better determine the bounds of the target ecosystem and its characteristics. Any services that can be quantifiably measured will be the focus of the group's analysis. The group will work alongside WildEarth Guardians to obtain the necessary local ecological data. Such data will include, but will not be limited to, climate, hydrology, soil type, and vegetation cover (see Section 5.0).

By referring to the Millennium Ecosystem Assessment report, "Ecosystems and Human Well-being: A Framework for Assessment" (MA 2005) the group will be able to separate the various biotic and abiotic factors incorporated to make up the ecosystem into the four classifications of ecosystem services. This categorization of services will enable the group to focus on those services which can quantifiably measured for analysis.

4.2.2 *Determine ecosystem services that are affected by beaver*

In conjunction with WildEarth Guardians, the group will determine which service(s) among those provided by the Jemez River ecosystem are affected by beaver and the potential beaver re-establishment. This will be done by examining how beaver behavior affects abiotic ecological factors. These effects will then be evaluated by the group to determine potential impacts on ecosystem functions and the subsequent services provided by those functions.

After determining what possible ecosystem services may be available from the Jemez River watershed, the group will conduct literature review on the specific effect beaver have on riverine ecosystems and then assess how those impacts affect services provided by such ecosystems (Bird 2011).

Potential ecosystem services that the group anticipates evaluating include water storage, sediment retention, and riparian habitat creation. Beaver dams block water flow and pool water. These ponds can create habitats suitable for organisms that better survive in lentic environments. Sediment trapped by the dam may also decrease turbidity of the water. Water quality may also be improved as a result of dam-building and habitat creation (Bird 2011).

4.2.3 *Evaluate ecosystem services and potential effects on human well-being*

The group will evaluate which ecosystem services provided by the Jemez River watershed affect human well-being. Then, by applying the information obtained during 4.2.1 and 4.2.2, the group will extrapolate how beaver re-establishment will affect human well-being. The results from this analysis will play an interconnected role with the interests and positions of stakeholders, as investigated in Objective 3.

4.3 Objective 3: Stakeholder Analysis

4.3.1 *Stakeholder list*

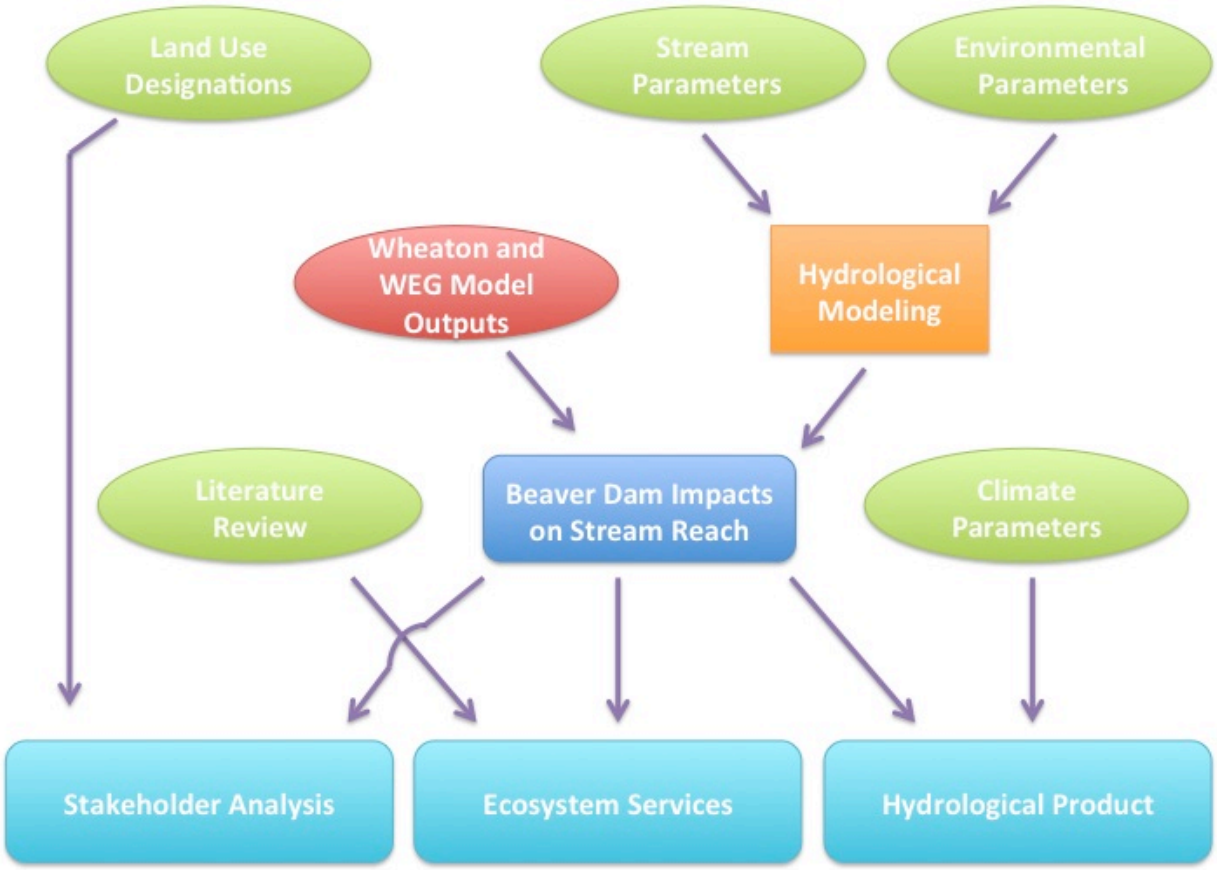
The group will develop a list of all stakeholders relevant to beaver re-establishment in the Jemez River watershed by consulting with WildEarth Guardians and other known stakeholders. The group will use land use designation maps to determine land ownership that may dictate stakeholder involvement. The stakeholders are anticipated to include federal and state agencies, non-governmental organizations (NGOs), not-for-profit organizations, native American tribes, academic researchers, fishermen, ranchers, private landowners, and specifically those already identified during the literature review process (Section 3.3).

4.3.2 *Stakeholder analysis*

After developing a list of stakeholders for beaver re-establishment, the group will conduct a preliminary stakeholder analysis to determine the interests, goals, and

positions of the stakeholders. This will be completed by reviewing publications from each stakeholder, mission statements of organizations, and, when necessary, informal interviews with stakeholders. Further analysis of stakeholders based on importance, priority, alliances, etc of stakeholders for beaver re-establishment will not be undertaken as part of this preliminary research. If deemed necessary as a result of Objectives 1 and 2 of the project, further stakeholder analysis may be undertaken.

4.4 Flowchart of Project Technical Approach



5.0 DATA CATALOG

Data critical to the technical approach covered in Sections 4.1 and 4.2 are included below in Table 5.1, *Data*, along with the likely source for these data.

TABLE 5.1, Data

Data Type	Data Source
Average SWE	USDA NRCS SNOTEL sites
SWE Trends	USDA NRCS SNOTEL sites
Non-snow Precipitation	USDA NRCS SNOTEL sites, University of New Mexico
Temperature	USDA NRCS SNOTEL sites, NOAA Climate Prediction Center
Soil Moisture	USDA NRCS Geospatial Database
Field Capacity	USDA NRCS Geospatial Database
Vegetation Type and Cover	USGS LandFIRE Database
Stream Gauge Data	USGS, University of New Mexico
Climate Data	NOAA Climate Prediction Center, National Climatic Data Center, TNC Report
Digital Elevation (DEM) Data	USGS
Geological Data	USGS, CZO
Hydrological Data	National Hydrological Database for New Mexico
Land Use Designations	State of New Mexico

6.0 DELIVERABLES

6.1 Client deliverables

- Work Plan
- Model for stream discharge
- Final report

6.2 Academic deliverables

- Work plan
- Group Project Website
- Academic Defense Presentation
- Final Report
- Project Brief
- Project Poster
- Final Public Presentation

7.0 MILESTONES

7.1 Spring Quarter: April - June, 2013

Weekly	Hold weekly meetings on Tuesdays with faculty advisor and Fridays for group work sessions.
May 9	Group representative to attend Beaver Conference in New Mexico.
May 21	Submit draft Work Plan to faculty advisor for review and comment.
May 28	Faculty advisor to provide feedback on draft Work Plan to group. Group to address faculty advisor's comments and revise accordingly.
May 30	Submit the revised Work Plan to external advisors and client for review and comment.
June 4	Hold Spring Review Meeting with faculty advisor, external advisors, and client to review work plan.
June 7	Provide link to website to Bren Group Project Coordinator.
June 12	Group to review all gathered data and determine what needs to be collected over the summer in New Mexico.
June 14	Complete conceptual model and preliminary data gathering.
June 14	Submit a 1-page summary of Spring Review Meeting to faculty advisor.

June 14	Submit final Work Plan to faculty advisor, external advisors, and client.
June 14	Submit Self and Peer Evaluations to faculty advisor and Bren Group Project Coordinator.

7.2 Fall Quarter: October - December, 2013

Weekly	Hold weekly meetings with faculty advisor and group work sessions.
Oct 1	Group to review data gathered in New Mexico, set specific milestones for fall quarter.
By Nov 15	Host fall review meeting with faculty advisor, client, and external advisors.
By Nov 20	Submit 1-page summary of fall review meeting to faculty advisor.
Dec 13	Complete models and data analysis.
Dec 13	Submit Progress Report to faculty advisor.
Dec 13	Submit Self and Peer Evaluations to faculty advisor and Bren Group Project Coordinator.

7.3 Winter Quarter: January - March, 2014

Weekly	Hold weekly meetings with faculty advisor and group work sessions.
Feb 21	Submit draft Final Report to faculty advisor.
Feb 21/28	Group Project Defenses.
March 7	Submit final Presentation Program Abstract to Bren Group Project Coordinator. (Template sent out by Group Project Coordinator 2 weeks prior.)
March 7	Submit draft Project Brief to faculty advisor.
March 7	Submit draft Project Poster to faculty advisor.
March 21	Submit Final Report (.pdf version) to faculty advisor and Bren Group Project.
March 21	Submit Self and Peer Evaluations to faculty advisor and Bren Group Project.
March 21	Submit Faculty Advisor Evaluation to Bren Group Project.

7.4 Spring Quarter: April - May, 2014

April 4	Submit final Project Brief and Project Poster (.pdf version) to faculty advisor and Bren Group Project Coordinator; post on Group Project website.
By April 4	Print Final Poster and Project Briefs.
By April 4	Take group photo with faculty advisor to use as the first slide in the Final Presentation.
By April 4	Submit draft Final Presentation to faculty advisor for review.
April 7-10	Practice and videotape Final Presentation.
April 11	Master's Project Final Presentations .

8.0 MANAGEMENT PLAN

The Management Plan outlines a group's management structure and general plan for the form and function of the group.

8.1 Group structure and management

8.1.1 *Project Manager*

The project manager, Ms. Shelby Petro, is in charge of coordinating meetings, agendas, and meeting minutes; tracking milestones; and organizing group activities.

8.1.2 *Data/Computing Manager*

The data/computing manager, Mr. Alex Caillat, is in charge of organizing and maintaining the data for the group project.

8.1.3 *Financial Manager*

The financial manager, Mr. Bret Callaway, is in charge of tracking and maintaining the budget for the group project.

8.1.4 *Web Manager*

The web manager, Mr. Drake Hebert, is in charge of creating, organizing, and updating the website for the group project.

8.1.5 *Internship Coordinator*

The internship coordinator, Mr. Andrew Nguyen, is in charge of coordinating with WildEarth Guardians (Mr. Bryan Bird) about the summer internships for two group members (Mr. Drake Hebert and Mr. Andrew Nguyen).

8.1.6 *Faculty Advisor*

The faculty advisor, Prof. John Melack, will meet weekly with students; participate in spring and fall review meetings; review and provide feedback on the work plan, defense presentation, final report, project brief, poster and final presentation; and assign grades to students for ESM 401A, B and C.

8.1.7 *External Advisors*

The external advisors, Dr. Naomi Tague and Dr. Joe Wheaton, will participate in spring and fall review meetings and may review and provide feedback on a portion or all of the final report and/or other deliverables, as the group determines appropriate. The group will assess how much involvement is desired and appropriate for clients and external advisors and will provide them opportunities for their engagement by inviting them to meetings, providing agendas and draft/final work products, and sufficient time to review and comment on materials.

8.2 Meeting structure

All students in the group will meet weekly to discuss and advance their progress toward project objectives. In addition, all students in the group will meet weekly with the faculty advisor to discuss progress and potential strategies to resolve any obstacles. If the faculty advisor is not available for one of the weekly meetings, then the group may use email, phone or Skype to engage the faculty member. Students are expected to meet with the faculty advisor, client and external advisory committee once in spring quarter and once in fall quarter to evaluate progress and provide feedback. The project manager will schedule the meetings and meeting rooms and notify participants with an agenda. The project manager will also take and distribute meeting minutes to all group members following the meeting. The project manager will take responsibility to schedule meetings with the faculty advisor, client, and external advisors and notify all attendees with sufficient time so they can join the meetings and review background materials.

8.3 Guidelines for interacting with faculty advisors, clients, and external advisors

Interactions with the faculty advisor, client, and external advisors will be conducted by all group project members; however the main points of contact are outlined in Table 8.3-1, *Main Points of Contact*. After contact with an advisor or the client, the group project member contact will complete either a contact report form, saved on Dropbox in the “Contact Report Form” folder, or will draft an email that will be sent to the five group

members. All coordination with clients, faculty advisor, and external advisors will be conducted with the highest professional standards.

TABLE 8.3-1, Main Points of Contact

Position	Contact	Student Contact
Faculty Advisor	Dr. John Melack	Ms. Shelby Petro
Client	Mr. Bryan Bird	Ms. Shelby Petro
External Advisors	Dr. Joe Wheaton	Mr. Alexandre Caillat
	Dr. Naomi Tague	Mr. Andrew Nguyen

The group project members will keep the client informed of project progress at the spring and fall review meetings, as a minimum, and up to monthly coordination as project coordination is deemed necessary by the group project members and/or advisors.

8.4 Systems to ensure that critical tasks are completed on time

The project manager will track the group's progress in completing milestones on time by utilizing Gantter project management application and Google Calendar, which is shared with all group members. Additionally, the project manager will create action items following each meeting and will revisit the status of each action item to ensure that the group member assigned to the item completed the item, or assign another group member to assist in completing the task.

8.5 Procedures for documenting, cataloging, and archiving information

Meeting agendas and minutes, calendar, contact information, messages, documents, website, budget projections and expenditures, and data will be gathered and organized so that it is accessible to all group project members. The group project members will create, gather, and organize group project materials as follows:

8.5.1 *Meeting agendas and minutes*

The project manager will create meeting agendas using Google Docs and share with all group project members so that each member can add talking points to the agenda for each meeting. During the meeting, the project manager will take meeting minutes in the same Google Doc as the agenda so that the notes are available for each group member. Following each meeting, the project manager will save the meeting agenda and minutes as a PDF on Dropbox in the "Meeting Minutes" folder.

8.5.2 *Calendar*

The project manager will create a Google Calendar and will share with all group project members. The project manager will schedule meetings, milestones, workshops, and other group project related events in the calendar.

8.5.3 *Contact Information*

The project manager will create a spreadsheet using Google Docs and share with all group project members. As new contacts are discovered and connections made, the group project member who made the contact shall enter this person's name, organization, and contact information into the "Contacts" spreadsheet. After contacting an outside source, the group project member who made the contact will complete either a contact report form, saved on Dropbox in the "Contact Report Form" folder, or will draft an email that will be sent to the five group members. All coordination will be conducted with the highest professional standards.

8.5.4 *Messages*

All group project members will use email as a primary form of messaging other group project members, faculty advisor, client, and external advisors. Text messaging will also be used as a form of communication between group project members for quick responses.

8.5.5 *Work Plan*

The project manager will create a Google Doc for the draft Work Plan and share with all group project members. The draft Work Plan will be edited by all group project members until it is finalized. Once finalized, the project manager will create a MS Word document for final formatting, and will save both a Word document and portable document format (PDF) of the Work Plan on Dropbox in the "Work Plan" folder.

8.5.6 *Final Report*

The project manager will create a Google Doc for the draft Final Report and share with all group project members. The draft Final Report will be edited by all group project members until it is finalized. Once finalized, the project manager will create a MS Word document for final formatting, and will save both a Word document and PDF of the Final Report on Dropbox in the "Final Report" folder.

8.5.7 *Website*

The web manager will create the group project website. The web manager will seek input from all group project members for biography and photograph, in addition to any other information that may be necessary for completing the website requirements. The web manager will publish the website after approval from all group project members.

The web manager will be responsible for updating the group project website as necessary during the course of the group project.

8.5.8 *Budget Projections and Expenditures*

The financial manager will create an Excel Spreadsheet and store it on Dropbox in the "Budget" folder. The financial manager will update the spreadsheet to reflect expenditures made by group members. Individual group members will be responsible for informing the financial manager of necessary changes to the spreadsheet and keeping expense receipts to facilitate record-keeping. Copies of all financial expenditures and disbursement requests to Bren shall be kept on Dropbox in the "Budget" folder.

8.5.9 *Data*

All group project members will collect data for the project. Data will be stored on the Bren network in the group project's (G:) drive, as the data will likely be large files. Data should be extracted from sources and processed into Excel Documents and also stored on the (G:) drive. All ArcGIS files and documents should also be stored on the (G:) drive. The data manager will backup all data on a weekly basis to the local (C:) drive of the group project computer.

8.5.10 *Literature Review Results*

All group project members will collect relevant articles to be used as research and literature review for the group project. The relevant articles should be saved on Dropbox in the "Research Articles" folder. Within this folder, each article shall be organized into a relevant topic folder. After reading the article, the group project member shall fill out the Annotated Bibliography document in the "Research Articles" folder for easy access later on.

8.6 Overall expectations of group members and faculty advisors

8.6.1 *Group members*

It is expected that all group project members contribute to the overall success of the group project. To achieve this success, group project members should operate with open communication of expectations, needs, concerns, and any problems that may arise during the course of the project. Additionally, it is expected that each group project member check and respond to emails related to the group project. It is expected that all group project members attend the weekly meetings with the faculty advisor, the weekly working meetings, and the spring and fall review meetings, barring any previously scheduled commitments that prohibit them from attending.

8.6.2 *Faculty advisor*

It is expected that the faculty advisor attend the weekly group meeting, barring any previously scheduled commitments that prohibit them from attending. It is also expected that the faculty advisor operates with open communication with the group project members and provides input to the approach, progress, and plan for the project without taking over the project as their own. It is expected that the faculty advisor provide timely feedback on each step of the project so that the group project members can react to the feedback in a timely manner and the project schedule is not compromised.

8.7 Conflict resolution process

Some of the tasks undertaken by the group may turn out to be unexpectedly difficult, and even impossible. It is important that any group member who encounters such challenges communicates the problem to other members promptly by email, or adding the issue to the weekly meeting agenda. The group will address the issue together and then share ideas and/or seek guidance from the faculty advisor to determine what actions should be taken to resolve the issue. If needed, the group may decide to re-focus the project if the task is beyond the capacities of the group. Prompt and continuous communication will assist the group in overcoming such difficulties and avoid late surprises or disappointment. Other difficulties may arise because of uneven contributions among the members. This dynamic can lead to feelings of exclusion or that one or more members are not pulling their weight.

The starting point for managing conflict is for the group to assume all or some of the responsibility for the problem. The group shall first focus on assisting or motivating a group member experiencing difficulty, realizing that the problem might arise for anybody. The group will deal with the problem by first initiating peer review and, if necessary, division or re-negotiation of responsibilities. If a resolution cannot be reached using these tools, then the group shall engage the faculty advisor and/or Bren School administration.

9.0 BUDGET AND JUSTIFICATION

Several expenses are anticipated in the group project. The projected expenses are outlined in Table 9-1, *Projected Expenses*.

TABLE 9-1, Projected Expenses

Reason for Expense	Expense	Remaining Budget
Beginning Budget	---	$1,300.00
Group member to attend Beaver Conference in NM (gas/mileage/parking reimbursement)	$155.00	$1,145.00
Group member's WEAP presentation in Ventura (gas/mileage reimbursement)*	$100.00	$1,045.00
WEAP model licence*	$250.00	$795.00
Printing costs for poster	$300.00	$495.00
Conference Calls with WildEarth Guardians*	$100.00	$395.00

** Subject to change; pending purchase receipt collection*

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