Lesson 2: Wetlands Habitat monitoring

Objectives:
Students will:

- Learn about different approaches to monitor Wetlands Habitats including GPS mapping for keystone species (Beavers), riparian survey, water chemistry analysis, Flow Monitoring, and Benthic Macro-invertebrate analysis.
- Quantify data collected at monitoring sites looking at physical, chemical, and biological parameters to gain an understanding of impacts from wetland habitats.

Recommended duration: 1-2 Field Days

Proposed method:
Students will experience wetlands in the field and learn and utilize methods for monitoring wetland habitats. The various monitoring methods include:

- **Mapping -** Global Position System (GPS) data collection to map wetlands areas and signs of past and present beaver activity. Usually two teams will walk on opposite sides of the bank identifying beaver sign and creating a map using GPS units. Photos are taken at dams lodges and important features encountered along the bank. Waders are required as you may have to cross water or explore the wetlands and find hidden beaver sign.
- **Water Chemistry/Streamflow** – Using New Mexico Watershed Watch methods, data is collected above and below areas of wetland interest to determine the effects wetlands have on basic water quality parameters. Please refer to Water Quality Monitoring Methods Handouts and data sheets.
- **Riparian habitat survey** – Six different measurements of riparian area health help identify the health of riverine wetlands. This method is a variation of the twelve-step method for riverine monitoring of riparian areas.
- **Benthic macroinvertebrate** - Collecting and sorting aquatic insects to major groups in the wetlands helps gain an understanding of the impacts wetlands have on biological communities.

You may not have enough time in the field to collect all of the data described in this activity during your field trip. We suggest you collect as a minimum water quality, wetlands map and the riparian survey.

Materials:

1. GPS units including training on mapping using GPS units and a computer with Google Earth or geographic information systems maps. Students must also be trained to identify wetland and beaver signs, Field Data collection form , and waders
2. Water Chemistry kit (Temperature, PH, TDS, dissolved oxygen, and colorimeter for nutrient analysis and streamflow equipment including 100-foot measuring tape, yard stick, streamflow and water chemistry form and waders
3. Riparian survey for wetlands/beaver sites form and 100-foot measuring tape
4. Benthic-Macro-invertebrate collection net, waders, sieve or sorting bucket with 500um screen for sampling, plastic sorting trays, forceps and tweezers, magnifying glasses and microscope for identification, benthic invertebrate identification sheets and field sheet

Field Mapping Method description

Preparation Steps

1. **Select Study Area** – Study areas can be selected for a variety of reasons, for example: to check if historic beaver areas are active, an area is planned for development, an area is planned for habitat restoration. After the study area has been selected, choose a study area name, map and describe the geographic location, and develop a general description with known information (e.g. ecoregion, general vegetation, land use, etc.).
2. **Permission to Survey** - Obtain landowner/manager permission to conduct the survey in the area, inform them of the survey timing and address any other logistics (e.g. locked gates, livestock, dogs).
3. **Pre-Survey Training** - Conduct training on general beaver ecology, sign identification and the use of GPS.
4. **Gather Equipment -** data sheets with clipboard, digital camera, GPS, waders or water shoes, full length pants, first aid kit, pin flags and permanent markers, binoculars,
5. **Develop Transects** - Divide the study area into transects (a stretch of waterway) that can be surveyed in one field trip. Develop a label for each transect; the label should be short so it can be used as the label in the GPS (e.g. T1, T2). Mark the boundaries of the transect on both sides of the stream with pin flags that are labeled.

Conduct your mapping survey

1. **Fill out general information at the top of the data form**. Record the GPS coordinates at the start point and at the end of the transect, record the end point. The GPS unit can be used to determine the transect length. Record the date, weather, and surveyor names.
2. **Walk along the transect mapping wetland & beaver sign** (both active and historical). Team members should split up on either side of the stream if possible. It may be necessary to get into the stream to examine all areas. Bank dens can be hard to see from the bank. Walking should be at the water's edge if at all possible. Team members may need to walk away from the stream to be able to see this area. Binoculars can be used to scan areas that are not easily accessible. For determining the extent of wet areas, team members need to create a line feature by walking the edge of the stream or pond for the full length of the transect area on both sides of the stream. Beaver signs are typically mapped as point features. Use the codes shown on the field form to record the types of sign.
3. **Estimate if the wetland or beaver sign is recent beaver activity or historical activity.** The team needs to make a determination as to whether or not there is an active resident beaver family. Finding three or more different active beaver signs (e.g. lodge, dam, cuttings, scat, scent mound) is a good indicator of an active beaver family. Active sites have cuttings that are brightly colored, well-maintained dams and lodges, fresh material on dams or lodges, food caches, fresh trails, etc. Inactive sites have cuttings that have a weathered, gray look, no fresh mud or cut material on dams or lodges or dams or lodges may be caved in or broken. If the wetland or beaver sign is "Active, assign the "A" to the type of sign code. Give the code "I" for inactive features. Record GPS coordinates of the point features on the field sheet. Observe and record the dominant vegetation form and dominant species in the field notes.
4. **Record beaver dam, lodge and trail features with a camera.** Take photos of any significant sign such as beaver lodges. You might also collect samples of active beaver sign such as recent cuttings.

Beaver Sign Survey

by River Source for

Project Name: River/Stream Name:

Date: Name of Surveyors:

Transect GPS Coord. Beginning*: ________________/________________ End: ________________/_________________ * in Decimal Degrees with 6 decimals

GPS Unit Name:

Conditions	Time	Clouds	Wind	Precip
Start				
End				

Beaver Area ID	Activity Status	Upstream Extent GPS Coordinates		Downstream Extent GPS Coordinates	Description/Comments (e.g. vegetation type, condition)
Beaver Area ID	**Sign Type**	**Activity Status**	**# of Sign (estimate)**	**GPS Coordinates**	**Description/Comments**

Examples of Codes: A = Active, I = Inactive, BD = Beaver Dam, CU = Cutting, FC = Food cache, TR = Trail, CA = Canal, SL = Slide, TR = Track, SM = Scent Mound SC = Scat , LO = Above water or ground lodge, BL= Bank Lodge or Den. GET GPS coordinates only on beaver dams, food caches and lodges

Note = Establish willow cuttings by estimating the number of willow patches/shrubs that have been cut in a ten foot square area, not each individual stem

Beaver Area ID	Sign Type	Activity Status	# of Sign (estimate)	GPS Coordinates	Description/Comments

Field notes on dominant types of riparian plants:

Water Quality Monitoring Methods
New Mexico Watershed Watch

How to test 6 water measurements for Healthy Watersheds, Fisheries & Resilient Communities.

1. Streamflow
2. Temperature
3. pH
4. Total Dissolved Solids
5. Turbidity
6. Dissolved oxygen

For more information visit www.RiverSource.net
and
http://www.wildlife.state.nm.us/education

The following 13 pages are designed to be laminated into cards for field work

Streamflow or Discharge

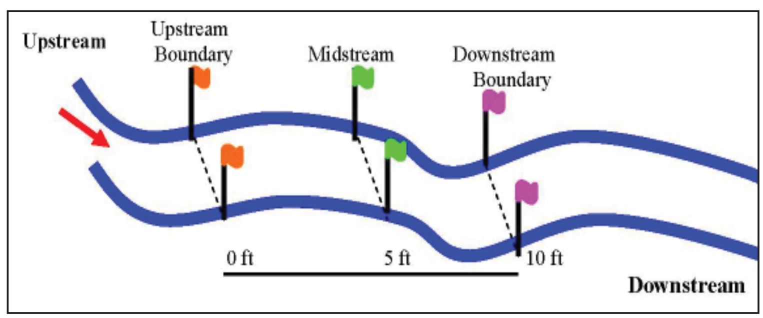
Streamflow is a measure of how much volume of water is passing by a point every second. Your results are recorded in cubic feet per second (CFS).

Streamflow or discharge of a river can fluctuate depending on:

- Season ~ extra runoff with snowmelt during the spring, less during the summer with increased evaporation and plant use
- Weather ~ streamflow increases during rainstorms, decreases during drought
- Irrigation ~ less streamflow during irrigation season for crops or fields
- Disturbances to the landscape ~ parking lots, roads, and other impervious surfaces create more peak runoff

Materials needed to measure streamflow include:

1. Tape measure
2. Yard stick
3. Stopwatch
4. Orange or piece of citrus (preferred) or a small but easy to identify floating object
5. 6 flags or sticks to mark channel banks
6. Calculator



To estimate streamflow (make sure to use a Watershed Watch field form):

1. Measure a 10ft straight section of stream with flags placed at the upstream (0ft), middle (5ft), and downstream end (10ft). The length can be adjusted for smaller or larger streams.
2. Measure the stream width (W) perpendicular the flags (upstream, middle, and bottom) and average your 3 measurements.
3. Measure the depth (D) at equal intervals across the channel along the width transects that appears the most typical of the 10 foot length of stream. Take a minimum of 9 measurements of depth and then average your results.
4. Multiply average stream width (W) times the average stream depth (D) to get a cross-sectional area in ft^2 (A=WxD).
5. Measure velocity by droppng your floating object upstream of the top flag and timing how long it takes to float 10 feet (or the distance from upstream to the downstream boundaries). Take the measurement a minimum of 3 times in the middle and on the sides of the stream. Average your results. Divide 10 feet (or the distance from upstream to the downstream boundaries) by your average time in seconds to get a measurement of velocity (V in feet per second).
6. Multiply your cross-sectional area (A) times your average velocity (V) to get streamflow in CFS

If the stream channel bottom is rough (e.g. lots of cobble or gravel) multiply your answer by 0.8. If the channel bottom is smooth (e.g. sandy or bedrock), multiply your answer by 0.9. These factors reduce your initial streamflow measurement to compensate for the velocity of the stream running slower than on the top of the stream where you took your veleocity measurements.

Standards and Methods for Interpreting Streamflow:

For mountain streams Barbour and Stribling (1991) consider that 2 cfs are necessary to support a high-quality, coldwater fishery.

Temperature

Temperature is a measure of water warmth or coldness. We record our results in degrees Celsius. Fish and other aquatic organisms have trouble getting enough oxygen at very warm temperatures.

Causes of increased temperature in water:

- Removal of riparian shade provided by trees, shrubs and grasses (such a willow canopy)
- Urban runoff from hot streets and sidewalks
- Increased turbidity (particles in water absorb sunlight and heats water)
- Warmer seasons (summer vs. winter) or lower elevations where it tends to be warmer
- Increased water surface area (e.g. wide and flat stream channel)
- Industries discharging warm water used to cool machinery

Why do we care about water temperature of our streams?

- Amount of dissolved oxygen in water (warm water holds less oxygen than cold water)
- The amount of energy used by (metabolism) of aquatic organisms
- Vulnerability of organisms to pollution, parasites, or disease
- The ability of fish and aquatic organisms to survive. Most fish, frogs, and macroinvertebrates are cold blooded. If the temperature changes rapidly their metabolism does not work well.

Measurement Method

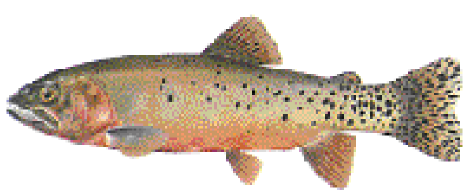
1. Ensure thermometer is functional (i.e. no bubbles separating the color indicator)
2. Find a shady spot to measure (use your own shadow if there isn't any shade)
3. Place thermometer completely in the running water and wait for the temperature to stop changing (at least 1 minute)
4. Read temperature while thermometer is underwater or immediately after taking it out of the water and record on the data sheet. Record temperature in degrees Celsius.

Standards and Methods for Interpreting

The New Mexico Water Quality Standards says " the introduction of heat by other than natural causes shall not increase the temperature, as measured from above the point of introduction, by more than 2.7˚C (5˚F) in a stream, or more than 1.7˚C (3˚F) in a lake or reservoir."

Does the water temperature protect desirable fish? New Mexico Water Quality Standards for Fisheries say that the temperature needs to be lower than:

≤20˚C (68˚ F), max temp 23˚C	High Quality Cold Water Fishery
≤25˚C (77˚ F)	Marginal Cold Water Fishery
≤32.2˚C (90˚ F)	Warm Water Fishery



Rio Grande Cutthroat Trout

pH

pH is a measure of how **acidic** or **basic** the water is. pH is measured on a scale of 0 to 14. Distilled water which has no impurities is **neutral** with a pH of 7. Numbers less than 7 are acidic and above are basic.

Causes of altered pH values in water:

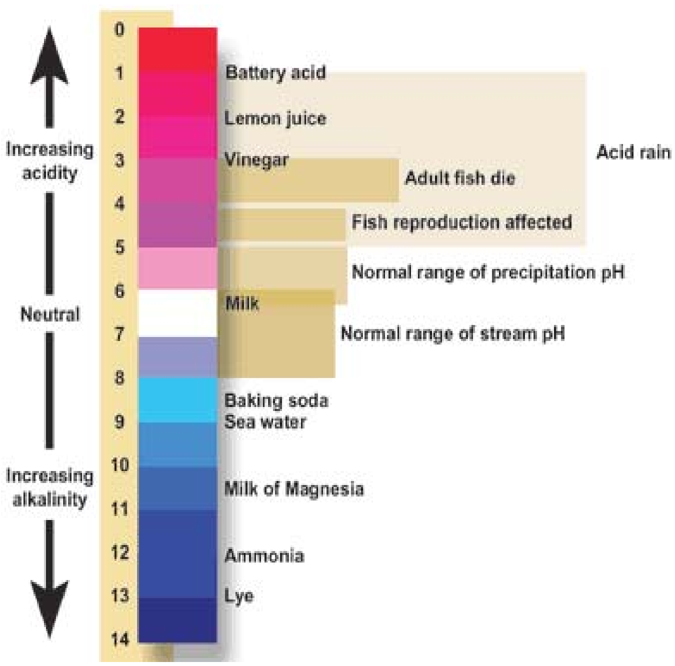
- Rainfall has pH value of around 5 to 6 due to carbonic acid picked up in the air.
- The pH of water in springs, streams, and lakes are influenced by the geology. In New Mexico limestone soils raise pH values of water - many New Mexico streams have basic pH (7 to 8.8).
- Plant photosynthesis removes carbon dioxide from water, raising pH of your stream. Expect the highest pH to occur in the early afternoon when the sun is highest.
- Mining exposes rocks to rain and produce a change in pH, often making the water more acidic.
- Dumping pollutants directly into streams can have intense and immediate changes in pH.
- "Acid rain" comes from sulfuric acid produced by coal burning. The basic soils of New Mexico help to decrease the effects of acid rain.

Why do we care about pH of our streams?

- Water with extremely high or low pH is deadly. A pH below 4 will kill most fish and very few animals can tolerate waters below pH of 3.
- Even moderately acidic waters (low pH) reduces the hatching success of fish eggs, irritate fish and aquatic insect gills and damage membranes.
- Amphibians are particularly vulnerable because their skin is so sensitive to pollution.

Measurement Method

- Make sure the pH meter been rinsed with distilled/demineralized water
- Uncap and turn on pH meter and dip meter in moving water
- Wait for reading to stabilize (wait at least one minute)
- Read and record pH measurement while meter is held in water
- Rinse the pH meter in distilled/demineralized water before capping



Standards and Methods for Interpreting

- The allowable range of pH is 6.6 to 8.8 in most streams in New Mexico. Some streams are allowed to range as high as 9.0.

- Water becomes unsuitable for most organisms at extremes less than 4.1 or greater than 9.5

Total Dissolved Solids (TDS)

TDS is a measure of dissolved (molecular, ionized, or micro-granular) inorganic and organic substances contained in a liquid. We use conductivity to estimate TDS, using an electrical current since the higher the concentration of dissolved ionized solids, the more electricity is conducted.

Causes of altered TDS values in water:

- Naturally occurring minerals such as calcium, magnesium, sodium, and other salts,
- Higher concentrations of TDS may come from runoff from agriculture or residential areas. Flood irrigation can flush salts from farm fields. Stormwater from city roads can wash salts into rivers.
- Nutrients from fertilizers can add excessive nitrate and phosphates to streams from runoff.

Why do we care about TDS in our streams?

- Rapid increases in TDS levels can be toxic for some aquatic organisms.
- Spawning fishes and juveniles appear to be more sensitive to high TDS levels.
- People prefer to drink and bathe in water with TDS levels lower than 500 mg/L.

Measurement Methods

- Ensure the TDS meter is calibrated and has been rinsed with distilled/ demineralized water.
- Uncap and turn on the TDS meter.
- Dip the meter in moving or non-stagnant water.
- Wait for reading to stabilize (wait at least one minute).
- Read the TDS measurement while meter is held in water and record the result in mg/L.
- Rinse the conductivity meter in distilled/demineralized water before capping and storing in it's box.

Standards and Methods for Interpreting

- The standard for human drinking water is 500 mg/l which is an aesthetic standard (based on how salty the water tastes).
- There are standards for specific river segments in New Mexico based on the state water quality standards.
- Some species of fish have been shown to have impaired spawning at levels as low as 350 mg/L.

Turbidity

Turbidity is a measure of water transparency (i.e. water clarity or cloudiness).

Causes of Turbidity:

- Sediment from soil erosion that enters the stream and creates suspended particles.
- Algae growth, particularly in larger rivers that are wider, slower and more exposed to the sun.
- Forest fires, roads, or anything that removes plants that can help keep soil out of the stream.
- Good vegetation cover in the riparian areas near streams generally decreases turbidity.
- Pollutants from urban runoff such as oil and grease or nutrients (plant food) that increase algae.

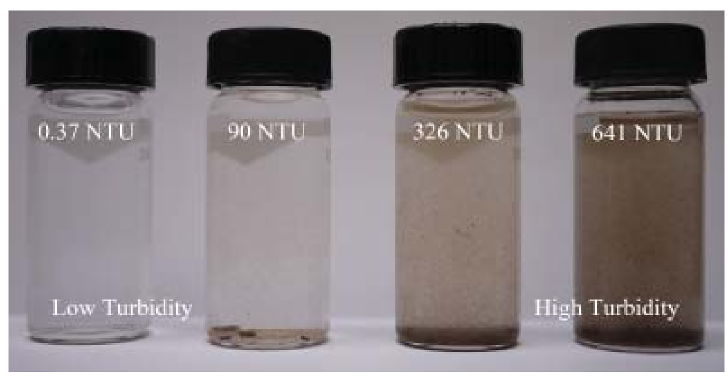
Why do we care about turbidity in our streams?

- Turbidity can raise the water temperature because suspended sediment absorbs heat.
- Suspended particles absorb sunlight which prevents aquatic plants from growing on the stream bottom.
- Sediments can clog fish gills and reduce visibility for fish to see prey and predators.
- Settling of sediment can bury organisms and spawning beds (areas where fish lay eggs).

Turbidity from a storm event

Measurement Methods

- Ensure turbidimeter is turned on and reads “0.00 NTU” (Nephelometric Turbidity Units)
- Take a clean vial and submerge in the water in a location that is near the middle of the stream 2 times and empty the bottle. On the third time take the sample that you'll measure.
- Make sure you collect your sample upstream of where people are walking in the stream and do not disturb site around sample site as this leads to higher measurement than actually exists.
- Seal sample, hold it by the lid, and gently wipe off glass with a soft cloth (remove water, fingerprints, oils, dirt)
- Open turbidimeter lid and place vial in carriage with diamond on vial facing towards turbidimeter buttons
- Close lid, press “Read,” and wait until turbidimeter provides a response
- Record number of NTUs, remove vial, pour out the sample, and repeat process 2 more times to get an average
- Rinse out the vial with distilled/demineralized water to remove sediment particles and make the vial ready for the next time it gets used



Standards and Methods for Interpreting

- Drinking water 0.5 NTU
- Activities shall not cause turbidity to increase more than 10 NTU over background turbidity (measured at a point immediately upstream of the activity) when the turbidity is 50 NTU or less.

Dissolved Oxygen

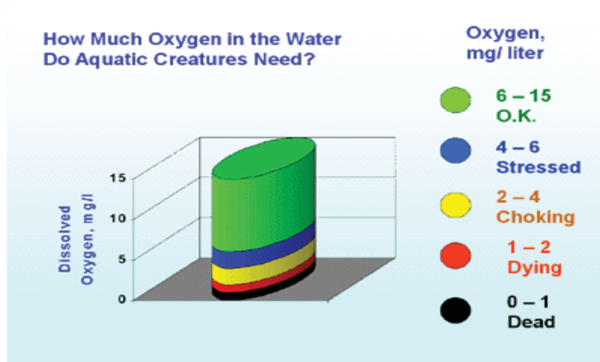
Dissolved Oxygen is a measure of gaseous oxygen in water that helps aquatic organisms survive.

Importance of Dissolved Oxygen (DO):

- Temperature Aquatic organisms require oxygen for survival. Changes in DO can impact organisms ability to grow and develop.

Factors Influencing Dissolved Oxygen

- Temperature--As temperature increases, the ability of water to hold oxygen is diminished (e.g. imagine a pot of boiling water, just before it starts to boil the tiny bubbles which form are oxygen coming out of solution). Vegetation shading a stream will help maintain healthly oxygen levels.
- Pressure--As air pressure increases the pressure of oxygen increases so water exposed to that air can absorb more oxygen. Thus water at high altitude can hold less oxygen than water of a similar temperature at sea level



Measurement Methods

- Fill water sampling bottle to allow no air bubbles as they will give incorrect results.
- Add eight drops each of Manganous Sulfate Solution and Alkaline Potassium Iodide Azide to sample bottle, cap and gently mix.
- Allow precipitate to settle then add eight drops of Sulfuric Acid or one level 1g spoonfull of Sulfamic Acid Powder depending on which kit type you have. At this point the sample has been fixed and exposure to air will not affect the results.
- Cap and mix until reagent and precipitate dissolve.
- Fill test tube with 20mL of sample.
- Add eight drops of Starch Indicator.
- Fill Titrator with Sodium Thiosulfate.
- Slowly add Sodium Thiosulfate to test tube one drop at a time while gently swirling until blue color just disappears (Care should be taken to prevent adding to much Sodium Thiosulfate)
- Read result on titrator as ppm of Dissolved Oxygen.
- Dispose of the water with reagents in a well-capped bottle labeled "waste water".

Standards and Methods for Interpreting

- DO <2 ppm is fatal to most fish
- DO <3 ppm is stressfull to most fish
- DO above 6 ppm is sufficient for most species

Based on the temperatures and barometric pressures commonly found in New Mexico streams, the saturation point of DO in the water will rarely rise above 10ppm

Beaver Habitat Survey **(6/30/09 rev.)**

Project name & River name ***Date:***

Surveyors:

Step 1: Establish the presence or absence of 3 active beaver signs or 3 historical beaver sign

Yes, *3 active or historical sign are present, go to* ***step 2*** ***No,*** *2 or less sign are present*

Step 2: Measure quality of basic indicators of beaver habitat potential

Rate each of the parameters on a scale of 0 to 4 . Assign scores based on the characteristics described in the Poor, Fair, Good, Excellent columns. Use scores in the parenthesis that are in the middle of the range if the characteristics clearly represent the descriptions. For example, a riparian area with < 3 height classes would be given a 3.5 score.

	Parameter	Excellent	Good	Fair	Poor	Score	
		3-4 (3.5)	2-3 (2.5)	1-2 (1.5)	0-1 (0.5)		Notes
1	Presence of woody obligate riparian shrubs & trees	Cottonwoods, willow and alderspecies abundant	Cottonwoods & willows present but not abundant or in limited age/height classes	Only one type of native woody riparian shrubs & trees, sparse coverage	Cottonwoods & willows not present at site		
2	Stream Flow Above 7,000 feet -> ---------------------- Below 7,000 feet ->	≥ 2 cfs ------------- ≥ 5 cfs	1-1.9 cfs ------------------ 2-4.9 cfs	0.5 - 0.9 cfs ------------------- 1.0 - 1.9	<0.5 cfs ------------------ <0.9 cfs		

Step 3: Measure Indicators 3-6 for Beaver Habitat Potential if you obtained a Excellent or Good Score on parameter #1 AND #2 above.

3	Vegetation Structural Diversity	> 3 height classes grass/shrub/tree	2 height classes mostly trees	1 height class grass/forbs	1 height class sparse vegetation		
4	Vegetation Buffer Width	≥ 60 feet	40 - 59 feet	20-39 feet	< 20 feet		
5	Vegetation Diversity	> 20 plant species including at least native willows, cottonwoonwood and alder	15-19 plant species including 2 of 3 native obligate woody species	5-14 plant species with only one native obligate woody species	0-4 plant species		
6	Vegetation Abundance/cover	Plant cover is >75%	Plant cover is 50 - 74%	Plant cover is 25 49%	Plant cover is less than 25%		

Step 4: Divide total score by number of parameters measured

Total scores between 2-4 and high scores for #1 & #2 scoring excellent or good indicates high potential for beaver persistence or re-establishment.

for NM Department of Game and Fish

Beaver Habitat Survey BACKGROUND INFORMATION

Date: ______ **Time:**________ **Elevation:** _________

Project name: _____________________________________

Stream name: _____________________________________

Surveyors: ____

Landowner/Manager name:_________________________

Weather		
Now	Past 48 Hours	
		Clear/Sunny
		Overcast
		Showers
		Rain (steady rain)
		Storrm (heavy rain)

Site & Vegetation type description: ____

____

River corridor land uses: Place "D" for dominant and "X" if present - otherwise leave blank. Use blank spaces for land uses not listed.

Roadless area		Cropland		Golf course		Urban	
Wooded area w/ roads		Grazed pasture		Recreation area		Commerical/Industrial	
Wooded Logging area		Ungrazed grassland		Scattered residential			

Resevoir or irrigation above? (Y/N) __________________________

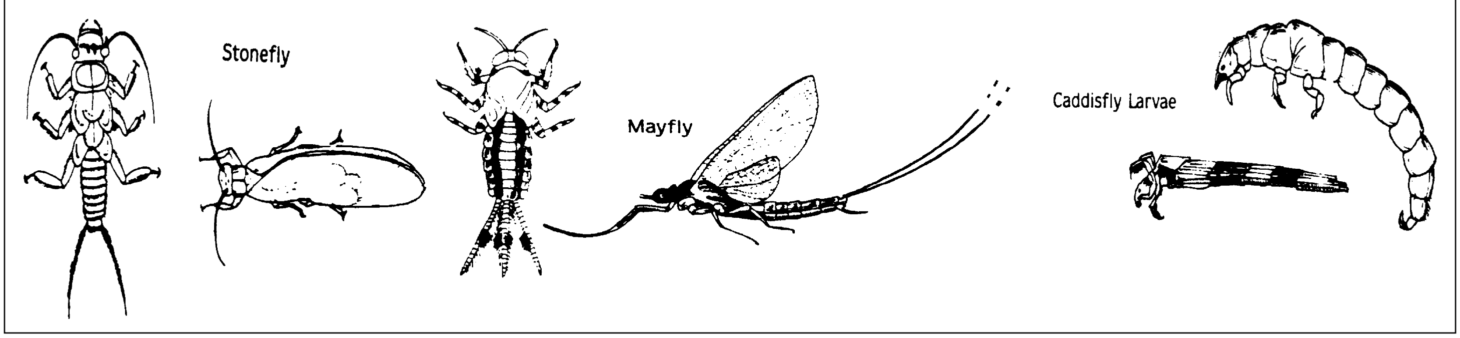
Sketch of site: Draw a "bird's eye" view of the segment of the river that includes a sketch of the site, north arrow and approximate scale for 100 -200 feet. Note the places where water flow was measured. Also note land uses features such as direction of water flow, roads, wetlands, ditches, pastures, corrals, grazed areas, trails, or homes.

Fun Hands-on Science Education Doing.....
Benthic Macroinvertebrate Studies!!!

Getting to know the local benthic macroinvertebrates in your river is fun and a great way to learn about how healthy your river is. A river is a combination of physical, chemical and biological characteristics. Many chemical characteristics change overtime, sometimes very rapidly to natural and human-caused changes and still have very little cumulative effect on living organisms in rivers. Benthic and riparian area studies help us understand how aquatic communities respond to stress integrated over time whereas to chemical monitoring focuses on the stress and exposure characteristics of pollution. The aquatic insects may tell us more about the condition of rivers and streams than conventional chemical monitoring techniques. Studying river insects and riparian habitat tells us about changes that streamflow and chemistry monitoring may miss.

The health and integrity of the ecological community of insects can occur only when chemical, physical and biological **stressors** are negligible or minor. For instance, river insects that have preferred environmental conditions, such as stoneflies (Order: Plecoptera) that like cool, clear water with lots of oxygen, often disappear from the river community when urban development increases rapid water runoff and decreases water quality. For example, watersheds with historic and current overgrazing or urban areas with over 25% of impervious surface tend to have benthic communities that are less diverse and more dominated by pollution-tolerant insects than watersheds that are less disturbed by human communities (May et.al. 2000). The focus on benthic macrointebrates helps evaluate the chemical, physical, and biological characteristics and their cumulative effects in the health of many riparian-dependent organisms that need wet areas to survive.

The word “benthic” means bottom dwelling and refers to organisms that live on the bottom (substrate) of a river, stream or lake. The term “macroinvertebrate” means the organisms without a spine (invertebrate) that can be seen without the aid of a microscope or can be seen by the unaided eye.



Since aquatic insects provide great long-term markers / **indicators** of stream and watershed health you can use these activities to do your own investigations about river health. What kinds of questions do you have about your rivers health and how can studying benthic macroinvertebrates help you read the landscape and tell a story the health of your river?

River characteristics that affect benthic macroinvertebrate communities

This section briefly presents the physical, chemical, and biological characteristics of the river ecosystem and describes how these change upstream to downstream

1. Physical Characteristics

Elevation: The height above sea level impacts how far the river drops from source to mouth. This affects a number of characteristics such as gradient, temperature, and shading.

Gradient: The slope of the river determines the current velocity and bottom composition.

Flow: The amount of water in the river determines the amount of bottom covered by water. In New Mexico, drought and irrigation diversions can severely impact the benthic community and water quality of rivers by constraining the insects to stagnant pools or completely removing their habitat when rivers are dewatered.

Water clarity: The clarity or turbidity of the water affects the depths to which light can penetrate and stimulate biological activity. This is usually the result of road building and sediment being deposited in the stream.

Shading: The shade provided by trees, shrubs, and banks helps moderate stream temperatures in the summer and provides food for stream animals.

Temperature: Some macroinvertebrates and fish are very sensitive to temperature levels and fluctuations. It also affects the amount of oxygen that water can hold (cold water can hold more oxygen than warm water) and that is available to macroinvertebrates and fish.

Percent of area of impervious surface and disturbed soil and plant communities: Studies have shown that as the total impervious area in a watershed exceeds as little as 5%, the benthic and macroinvertebrate communities begin to degrade rapidly (May et.al, 2000). Large fires or extensive overgrazing can severely alter runoff quantity and quality and flow patterns, which can have negative effects on macroinvertebrate communities.

2. Chemical Characteristics

Nutrients (phosphorus and nitrogen): Phosphorus and nitrogen are essential plant and animal nutrients that, in excess amounts, can cause rapid increases in biological activity of plants and bacteria and in high enough amounts may become toxic. Excessive amounts of plants reduce the amount of habitat available to some macroinvertebrates, fish eggs and fish. This may disrupt the stream ecology so that certain biological communities experience severe mortality.

Dissolved oxygen (DO): Water contains oxygen in dissolved form. Oxygen is added to the water through turbulence, gas exchange at the water’s surface, and as a by-product of plant photosynthesis. Oxygen gets removed from water by chemical oxidation, respiration of aquatic animals, and decomposition. Some aquatic life require high and stable levels in order to flourish.

3. Biological Characteristics

In-stream (autochthonous) versus Riparian (allocthonous) food production: This characteristic is the amount of living plant material produced in-stream versus that which drops in from the area along the stream. In-stream production depends on the availability of sunlight and the availability of nutrients. Some food types produced in the stream, like algae, are important food and habitat sources for some macroinvertebrates.

Behaviors and adaptations of invertebrates

Habitat
Refers to the place where an organism naturally lives and grows. Effected by the chemical and physical factors of a system, but organic substrates such as plants, logs, or detritus can be important biological components of habitat, running vs standing water, substrate size

Movement
Most freshwater invertebrates have special body shapes and behaviors that enable them to be in a place that meets their essential requirements for acquiring food and oxygen, avoiding competition with other invertebrates and hiding from predators. The major groups are clingers, climbers, crawlers, sprawlers, burrowers, swimmers, skaters.

Feeding invertebrate feeding is usually categorized according to the type of food that is consumed or how food is obtained. Typical foods for freshwater invertebrates are detritus, wood algae, live vascular plants, and other animals. Invertebrates are categorized but their body structure and behavioral habit they use to obtain their food. These categories are called functional feeding groups that include shedders, collectors, scrapers, piercers, engulfer-predators.

Breathing- Most kind of Fresh water invertebrates depend upon dissolved oxygen in the water for their breathing. Oxygen enters the organisms either thought their general body surface or through gills that are specialized for this purpose or both. These are referred to as closed breathing systems. Some invertebrate wiggle their bodies to increase oxygen diffusion.

Life history- Refers to biological events in an organism's life from birth to death. Reproduction usually involves mating by a male and female. There are also numerous examples of asexual reproduction among freshwater invertebrates. Most invertebrates hatch from eggs and are small immature forms that must undergo growth. These smaller growth forms are called larva, juveniles or, just immature. This is important to remember since most invertebrates will be studied in this larval or immature stage of development. They are only considered adults when they have developed structures and organs required for reproduction and laying eggs.

Stress tolerance- This term refers to the ability of organisms to withstand disturbances in their environment. There are many different types of disturbances that can occur in freshwater environments. Of these many are human caused others are forces of nature. These are often referred to as pollution by where substances or energy released into the environment that bring undesirable change or environmental stresses. Environmental stresses is a broader terms that refers to any action that bring about undesirable change. For the purpose of this lab groups will be rated according to NM Watershed Watch Order Key that rates them as pollution sensitive, somewhat pollution tolerant, or pollution tolerant.

Benthic macroinvertebrate collection and analysis methods

The workbook presents methods of collection and analysis of benthic macroinvertebrate samples.

Collection:
Frame dip-net sampling.

This method allows you to sample in several areas of the stream to create a composite sample that is more representative of the diverse **substrate** habitats than the kicknet sample.

Sorting:
1. Identification, sorting and counting to the taxonomic level of Major Groups which include some groups in Genus, Order and Class. This level of analysis provides a general idea of the richness of biodiversity of the benthic macroinvertebrate community. Key indicator insect groups include stoneflies, mayflies and caddisflies. This level of analysis is most appropriate for younger students and schools short on time in the field and class to identify, sort and count the insects.

Sample collection methods

When to Collect

Collect at least one sample per year during the fall after the summer monsoons have ended. Sample every year at about the same time to do a long-term study. This provides much more valuable information than data from one sample. Fall samples are valuable since they reflect the effects of summer high temperatures (and in some rivers, low flows) that place stress on organisms. If you have time, collect a second sample in the spring just before spring runoff occurs from snowmelt.

Where to sample

Where to sample depends on the purpose of your research. Sample in **riffles** if you want to learn the most information about the insects that have low tolerance to pollution. Over the years most schools and professionals in New Mexico have sampled in riffles. However, to learn about the broad diversity of benthic insects in your stream, you want to sample in a variety of habitats such as slow water areas, small logs, undercut banks, leaves, and in riffles using the dip net method in Collection Level 2.

Collection

Frame dip-net sampling.

This method allows you to create a composite sample from several areas of the stream that is more representative of the diverse **substrate** habitats than the kicknet sample. In addition, little sample gets lost around the sides if care is taken while scraping rocks.

Collection Steps

Assemble a team of three people, one to hold the kicknet and two to scrape all rocks in a 18 inch x 18 inch square area just upstream of the kicknet bar in the substrate. Make sure to bury the lower edge of the frame well (up to 2 inches once past the cobbles) into the substrate so that no specimens are lost under the net. Have two students turn over each rock in the sample area and then one student kick (more like do the "twist") inside the sample area. Carefully lift the frame and net bag towards the current to prevent sample loss.

Take the net and gently gather the sample in a five gallon paint bucket or white tray by pouring water through the net, gently scraping the net with a wide paint brush and finally picking the net with forceps. Pour the sample from the paint bucket through a sieve bucket lined with 500 µm (micron) net. Once the entire sample is in the sieve bucket, gently scrape the sample with fingers and the brush into a 1 quart Mason jar. Check the sides of the buckets for clinging critters during every transfer step. Remove these with forceps and place them into the sample.

Sample sorting methods in the field and in the classroom/lab

Analysis to the Orders and Classes

This level of analysis provides a general idea of the richness of biodiversity of the benthic macroinvertebrate community. Key indicator insect groups include mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Tricoptera). This level of analysis is most appropriate for younger students and schools short on time in the field and class to identify, sort and count the insects.

Order level analysis can be done in the field or in the classroom. Set students in groups of 2-3 people per workstation. Each work station needs to have the same number of forceps as students, a white tray filled with sample, and labelled petri dishes. The number of labelled petri dishes depends on the time you have to sort the sample and level of detail you expect for the research.

Site Instructions for Field Methods for Macro-invertebrate Collection and Sorting

I. Field Sampling

Choosing a site – This choice depends on the purpose of your study. You will be looking to compare riffle and pool sections of the same reach, to compare riffles and/or pools from different reaches of the same stream, to compare different streams, or to monitor the condition of your stream over time. Fall is the best time to collect samples if collecting on a yearly basis. You and your students should make a plan and consistently follow it.

Macro-invertebrate collection – If you are using a square net try to consistently collect from the same amount of river bottom area each time - 3 samples at a site that in total encompass approximately one square meter. Gently disturb the bottom material with your hands – large rocks with attached organisms should be carefully brushed to dislodge organisms for capture into the net. If performing Field sorting omit Storage handling and labeling instructions, unless sample will be preserved for later lab analysis.

II. Field Sorting

Equipment – magnifying tools, 2 trays, forceps, Petri dishes with names of Major groups, Pipets, 500 micron sieve, identification keys, ethyl and isopropyl alcohol, labels for vials, and much patience. [Vial labels should match sample labels – additionally include organism's identity i.e. mayfly]

First sort – Put entire bolus in a sampling tray. Have students sort through sample tray and pick out as many organisms as they can have them sort into a clean sample tray for easy identification. If the water is too cloudy, re-rinse the material. If there is much debris redistribute the sample into several trays. Retrieving insects is most efficient in a tray with clear water and a relatively white background for good contrast. As you carefully and systematically move bugs and debris from one side of the tray to the other remove each organism. Pay special attention to collect even the tiniest invertebrates, Allow adequate time to perform sorting making sure that at least 100 individuals are sorted. Identify major groups of Invertebrates and sort into corresponding petri dish. Utilize magnifying tool if required to see and identify smaller invertebrates. Record the information collected on recording sheet for analysis.

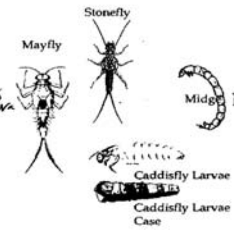
Common group names to label petri dishes

E	P	T	D	C	O
Ephemeroptera	Plecoptera	Trichoptera	Diptera	Chironomidae	Other
Mayfly	*Stonefly*	*Caddisfly*	*True Flies*	*Midge*	*Assorted*

III. *Recording field data*

Data –After performing identification according to New Mexico Watershed Watch Order key and counting the numbers of individuals in each major group, perform multiple sweeps over the trays to ensure a representative sample has been collected. Have you students determine whether major invertebrates are from Group One Taxa- Pollution sensitive, Group Two Taxa-Somewhat Pollution tolerant, or Group Three Taxa- Pollution tolerant. Compare the numbers of individuals and percentages within each group to determine what is the most dominant group represented at the site. This will give you a rough idea as to the quality of the water. Calculate Water Quality Value According to Watershed Watch group tolerance index score.

Benthic Macroinvertebrate Sorting & Recording Sheet



Stream name:	Jaramillo creek/valles Caldera
Site name:	site 2
Date of Sampling:	5/1/2012
Date of counting bugs & completing sheet:	5/1/2012
Names of bug sorters:	Los Alamos Middle school

Scientific Name of Group	Common Name	Presence or Absence	Number found	Est. # of taxa/ group	% of total (If counted)
Order: EPHEMEROPTERA	Mayflies	X	18		10%
Order: PLECOPTERA	Stoneflies				
Order: TRICHOPTERA	Caddisflies	X	9		5%
Order: DIPTERA, *Family: CHIRONOMIDAE*	Midges	X	21		12.5%
Order: DIPTERA, *Family: SIMULIIDAE*	Blackflies	X	58		34.5%
Order: DIPTERA, *Family: TIPULIDAE*	Craneflies	X	21		12.5%
Order: COLEOPTERA	Beetles	X	14		8%
Order: ODONATA	Dragonflies & Damselflies				
Order: MEGALOPTERA	Dobsonflies				
Order: LEPIDOPTERA	Moths				
Order: AMPHIPODA	Scuds	X	1		0.6%
Order: ISOPODA	Sowbugs				
Order: HEMIPTERA	True Flies	X	18 creeping water Bug		10%
Class: OLIGOCHAETA	Briste Worms				
Class: GASTROPODA	Snails	X	1		0.6%
Class: PELECYPODA	Clams				
Class:PLANARIAN	Flat Worms	X	2		1.2%
Class: Hirundinea	Leeches				
Other types (not listed)	Aquatic Worm	X	5		3%
	Grand Total:		168		

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I.III Sample Storage

Storage and handling – Carefully sieve the organisms (and probably debris) from each sampling and place in a 1 quart freezer bag. Try not to include much water. Add 90% ethyl alcohol to cover and preserve the organisms. The three sample bags should be stored together in a 1 gallon freezer bag for that site. Make sure to add enough alcohol to cover entire sample. Recheck, mix, and add additional alcohol to the sample to adequately fix the sample.

Labeling – Put a composite sample in one bag or keep riffle samples separate from multi-habitat samples. Each sample must be properly labeled with a tag inside the bag – remember to use a pencil to ensure the labeling survives the alcohol solution. Each label should record:

River
Location id/ sample #
State
County
Collector
Date

Example

Santa Fe River
La Bajada riffle/ samp 2
New Mexico
Santa Fe County
C Herrera
4 Sept 08

IV. Lab Work

Work on each sample bag separately – the data from all three samples can be combined for analysis.

Equipment – magnifying tools (especially dissecting microscopes), trays, forceps, tiny water color brushes, good lighting, Petri dishes, 500 micron sieve, identification keys, 6 stoppered vials, ethyl and isopropyl alcohol, labels for vials, and much patience. [Vial labels should match sample labels – additionally include organism's identity i.e. mayfly]

First sort – Carefully rinse the contents of a sample in the sieve with cold water to remove the alcohol. Put the organisms and debris in a tray and cover with several centimeters of water. If the water is too cloudy, re-rinse the material. If there is much debris redistribute the sample into several trays. Retrieving insects is most efficient in a tray with clear water and a relatively white background for good contrast. As you carefully and systematically move bugs and debris from one side of the tray to the other remove each organism and place into the appropriate vial. Vials should be designated for each of the six major groups including Mayfly, Stonefly, Caddisfly, True flies, Midges, and Other assorted.

Each vial should be half-filled with ethyl alcohol and when finished insert the appropriate label. Collect all the macro-invertebrates in the sample. If the quantity of certain organisms is exceptionally high you may have to do an appropriate subsampling. Sieve the remaining debris and return to the original freezer bag with label. Re-preserve this with 70% isopropyl alcohol and save.

V. Analysis / Interpretation

Preliminary analysis – At this point you have performed a rough separation into 5 taxa – Ephemeroptera (order level), Plecoptera (order), Trichoptera (order), Diptera (order), and Chironomidae (family level). Count and record the organisms at this level. Notice that taxa refer to two different levels of identification – taxon is flexible term that refers to the level of identification made – for example if you were to further identify mayflies to families you would have additional taxa and not count the order Ephemeroptera as a taxon. The "Other" vial's contents can be separated into taxa – i.e. orders and in some cases classes. Record your results on the appropriate data collection sheet.

Advanced sorting and analysis – From this starting point samples may be further identified to family, genus and species levels, thus yielding additional data and allowing more advanced analysis. (see Benthic Macroinvertebrate Metrics guidance).

Water Quality Biotic Index
Use the benthic macroinvertebrate sorting and recording sheet to complete Biotic Index Calculation Sheet. This will give you a score between 0 and 3 with 3 representing good

Benthic Macroinvertebrate Biotic Index Calculation Sheet

Data Collector's Names____

Date________________________ Begin Time______________ End Time______________

Sensitive Groups		***Somewhat Sensitive Groups***		***Tolerant Groups***	
	Put a "X" if found		Put a "X" if found		Put a "X" if found
Caddisfly larvae	_____	Clams larvae	_____	Aquatic worms	_____
Mayfly larvae	_____	Crane fly larvae	_____	Blackfly larvae	_____
Stonefly larvae	_____	Crayfish	_____	Leeches	_____
Dobsonfly larvae	_____	Damselfly larvae	_____	Midge Fly Larva (Red)	_____
Riffle beetle larvae	_____	Dragonfly larvae	_____	Pouch/pond snail	_____
Gilled snails larvae	_____	Scuds	_____	Tubificid worm	_____
Water penny larvae	_____	Sowbugs	_____		
		Midge fly larvae (not red)	_____	Total # of animals with "X"	_____
Total # of animals with "X"	_____				
	x 3=______	Total # of animals with "X"	_____		x 1=______
			x 2=______		
Group score:		Group score:		Group score:	

a) Total # sensitive ____ + Total # somewhat sensitive ____ + Total # tolerant ____ = ____________
Total # of animals (a)

Sensitive Group Score___ + Somewhat Sensitive Group Score____ + Tolerant Group Score______=___________
Total value (b)

Divide total value (b) _______ ÷ total # of animals __________ = __________ for water quality index score

How healthy is the stream?	
Excellent …………..	.2.3 – 3.0
Good ……………….	1.5 - 2.2
Fair …………………	0.8- 1.4
Poor ………………….	0.0 - 0.7

Name: ________________________ Date: ___________________

Benthic Macroinvertebrate Adaptations & Behavior

Select two organisms from the Watershed Watch Order Key, draw each in the boxes including key features. Then research or use your imagination to identify the behaviors and adaptions. Use **Reese Voshell** Jr's book *A Guide to Common Freshwater Invertebrates of North America* as a primary reference, if possible. Check the box to right with your best estimate.

Moving
___ Jumper, ___ Floater, ___ Climber, ___ Skater, ___ Swimmer,
___ Crawler, ___ Burrower, ___ Clinger

Eating Style
___ Scraper, ___ Shredder,
___ Collector (filterer), ___Predator

Place in Food Chain
___ Herbivore (eats plants), ___ Carnivore (eats animals), ___ Omnivore (eats plants and animals), ___ Detrtivore (eats dead and decaying matter)

Tolerance to Pollution
___ Intolerant (suggests good water quality),
___ Somewhat tolerant(wide range of quality
___ Tolerant (suggests poor water quality)

Moving
___ Jumper, ___ Floater, ___ Climber, ___ Skater, ___ Swimmer,
___ Crawler, ___ Burrower, ___ Clinger

Eating Style
___ Scraper, ___ Shredder,
___ Collector (filterer), ___Predator

Place in Food Chain
___ Herbivore (eats plants), ___ Carnivore (eats animals), ___ Omnivore (eats plants and animals), ___ Detrtivore (eats dead and decaying matter)

Tolerance to Pollution
___ Intolerant (suggests good water quality),
___ Somewhat tolerant(wide range of quality
___ Tolerant (suggests poor water quality)