Citizen Monitoring Shadow Study

Report of Results and Findings

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Citizen-gathered Data

Volunteer efforts centered on natural resource management have been very successful in other parts of the country. However, many agencies are still skeptical and reluctant to use volunteer-gathered data due to issues of quality. The common perception is that many volunteer success stories come from homeowners monitoring limited water quality parameters on lakes using simple techniques or that a lack of participant continuity results "bad" data. Across the nation there is a need to evaluate the capacity of citizen monitors to gather valid and viable data, to understand the limitations, if any, of volunteer-gathered data, and to assess the effectiveness of training methods. Note that it should not be any state agency's intention to replace paid personnel with volunteers. The large volume of wetland research needed, especially in Utah, necessitates engaging as many qualified individuals as possible.

Wetland Partners

Wetlands are an integral component of the Great Salt Lake Ecosystem. These (wet)landscapes range from sites that the Utah Division of Wildlife Resources (UDWR) has identified as "essential habitat" to roadside ditches to numerous mitigation and restoration projects. In June 2000, in an attempt to inventory and assess these wetlands, UDWR enlisted the assistance of citizen monitors through the Wetland Partners program. UDWR personnel trained the volunteers in wetland ecology, monitoring protocol and data management to cultivate stewardship and the expertise embodied in our citizenry.

Wetland Partners benefits from the participation of interested and knowledgeable volunteers, many of which have had academic, professional, or organizational (e.g., Audubon) training in ecology and monitoring techniques. Our challenge is to make the most of the volunteers' abilities while at the same time providing them with an enriching experience. The solution centers on applying volunteer-gathered data. Management agencies benefit from these data in the decision-making process provided that certain quality control and quality assurance conditions are met. Citizens in their commitment to wetland conservation benefit from knowing that their data contributions are included in wetland management activities.

As of December 2001, citizens had been gathering data on wetlands in the Great Salt Lake Ecosystem for 14 months. At that time, we felt that it was necessary to evaluate the capacity of our citizen monitors to gather valid and viable data, to understand the limitations, if any, of volunteer-gathered data, and to assess the effectiveness of our training methods.

Major Goals of the Citizen Monitoring Shadow Study

- Evaluate the capacity of our citizen monitors to gather valid and viable data.
- Understand the limitations, if any, of volunteer-gathered data.
- Assess the effectiveness of training methods.

The project began in the Fall of 2002 and for the last year and a half, 16 citizen monitors participated in Wetland Partners' "Shadow Study." In order to see how good volunteer-gathered data really are we put volunteers up against a wetland consultant and state agency personnel who do this kind of work for a living. The four areas of comparison include macroinvertebrate sampling, macroinvertebrate identification, vegetation monitoring, and water quality sampling. Well, the results are in, and . . .

Macroinvertebrate Sampling and Identification

Background

The Utah Department of Natural Resources with the assistance of the National Aquatic Monitoring Center (Buglab) has embarked on a project to develop a bioassessment tool for wetlands in Utah. With this tool, macroinvertebrate data can be used to assess the condition of a wetland site based on community richness and diversity. As part of this Shadow Study, Wetland Partners engaged 4 volunteers in macroinvertebrate sampling and identification in order to compare their abilities with "professional" technicians conducting the same protocol. In addition we contracted a paid wetland consultant to conduct the same sampling and identification protocol. In this situation the question being asked is how capable are citizen monitors at collecting macroinvertebrate samples and identifying them to family-level for use in a bioassessment tool.

Protocol

Sampling protocol was developed by the Buglab for use in lentic systems. It is a semi quantitative technique in which collectors sample multiple microhabitats for as long as it takes to obtain 500 organisms using a 500 micron mesh kicknet. By sorting and identifying prior samples, this total reflects the composition of the wetland as a whole. Other techniques incorporate a time component, which in this case was not necessary. For this study each group (citizen monitors, Buglab, and wetland consultant) collected one sample on eight separate occasions from October 2002 to October 2003. Groups sampled at 6 different sites with two sites visited twice. These include Third Dam of the Logan River (2), Benson Bridge, Bear River Bottoms, Amalga Barrens (2) Sprig Creek, and Wellsville Pond.

Identification protocol consisted of counting 100% of the sample using binocular microscopes. For an overall comparison the Buglab identified organism in every sample to its lowest taxonomic level. The volunteers and wetland consultant identified organism in only the volunteer-collected samples to the family level. For a more detailed description of the protocol go to www.usu.edu/buglab/.

Sampling Results

In looking at the results we have decided to assess variation in sampling and identification ability using two values: 1) The total number of different types of organisms collected, identified to the lowest taxonomic level termed "richness" and 2) the total number of different families collected termed "families."

In six out of eight samples the Buglab found more macroinvertebrate richness and families. However at Bear River Bottoms and Spring Creek the citizen monitors and wetland consultant, respectively, had the highest invertebrate richness in their samples. See Figure 1. At Bear River Bottoms citizens had the highest total family while at Spring Creek both collected 12 different families compared to 10 by the Buglab. See Figure 2. Using ANOVA statistical analysis showed that there was no statistically significant difference between the means level of richeness in the three groups samples (Table 1). However n=8 and with a larger sample size one might expect that samples collected by the Buglab would be significantly different from the other two groups, while the citizens and wetland consultant would remain the same.

Figure 1

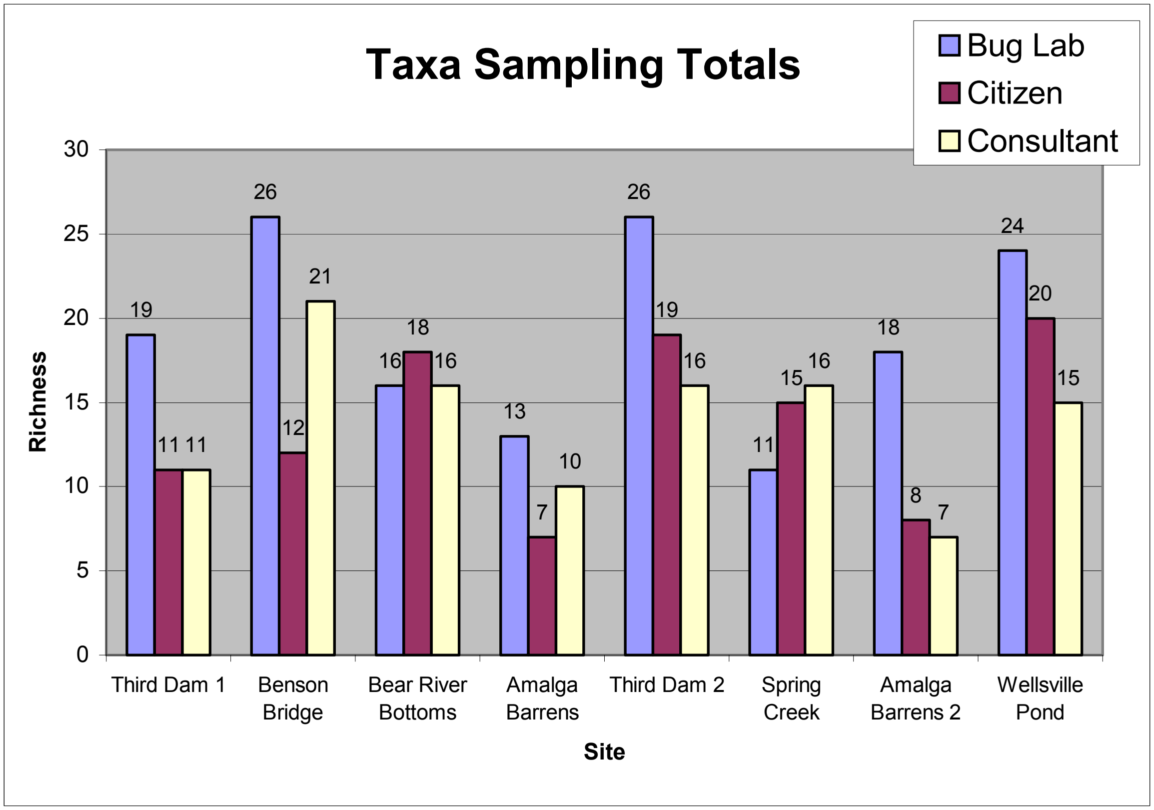


Figure 2

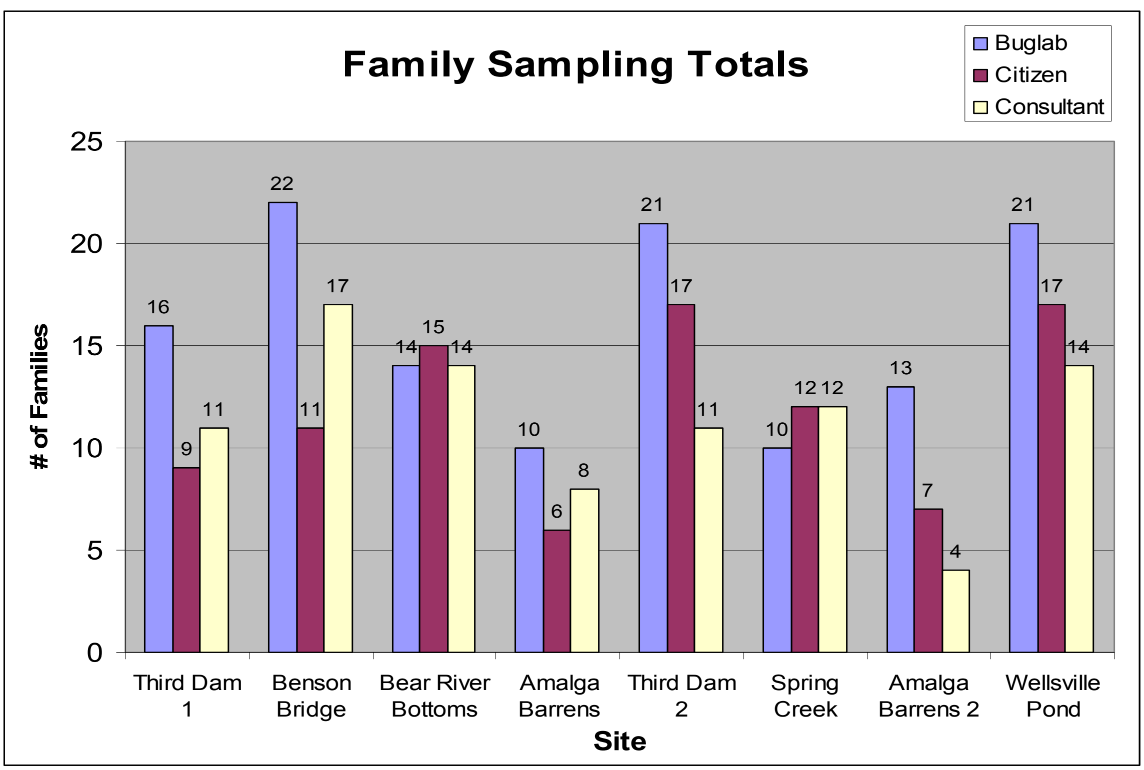


Table 1

Source	SS	df	MS	F	Prob>F
Columns	214.75	2	107.375	2.15	0.1412
Error	1047.88	21	49.899		
Total	1262.62	23			

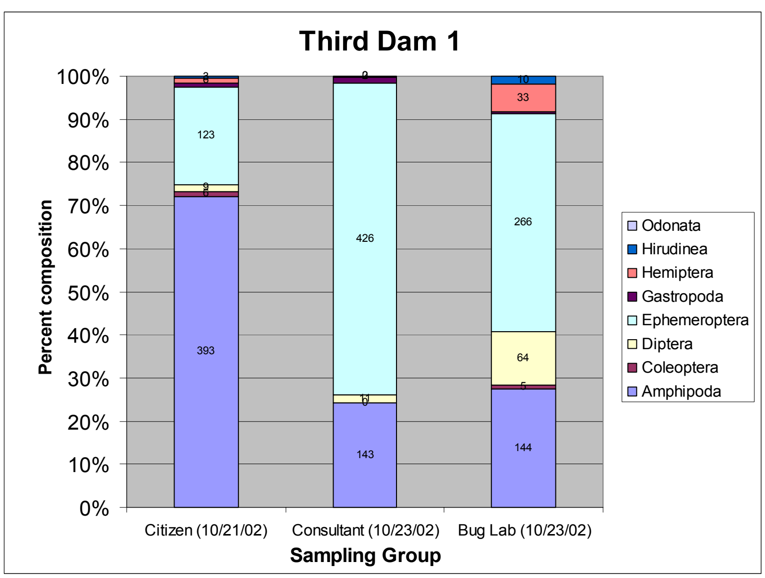
Results of statistical analysis describing variance between groups with respect to mean number of families collected provided similar results. See Table 2

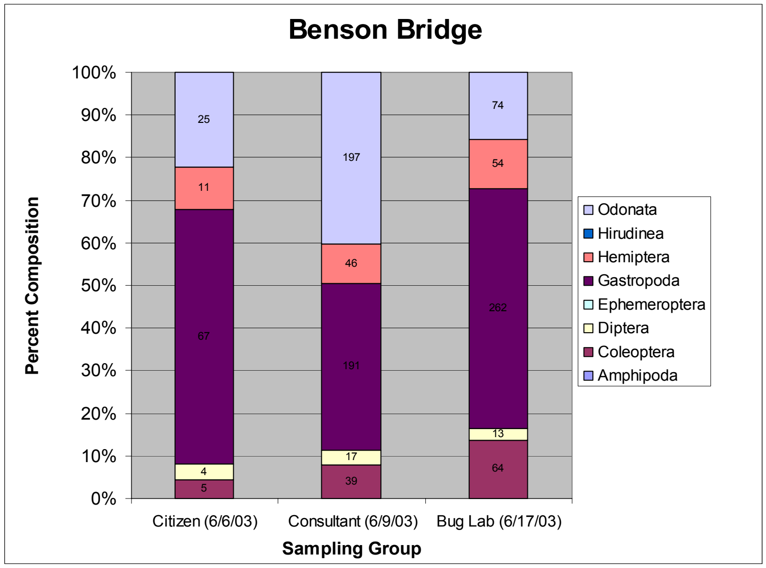
Table 2

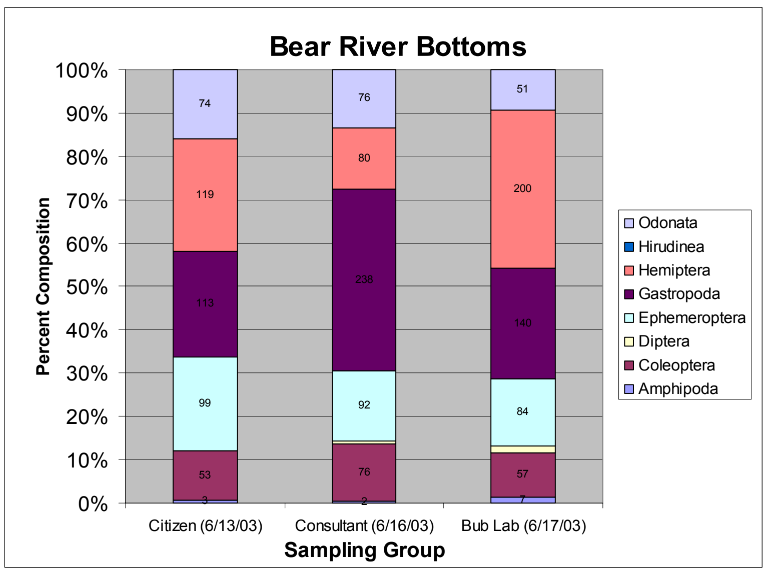
Source	SS	df	MS	F	Prob>F
Columns	103.083	2	51.5417	2.62	0.0968
Error	413.875	21	19.7083		
Total	516.958	23			

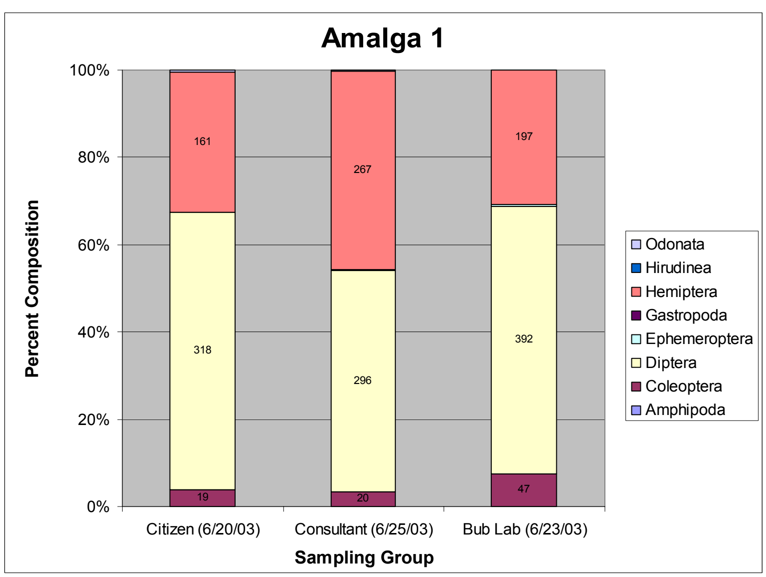
At this point it is appropriate to discuss statistical significance and ecological significance. Simply stated, just because the results above indicated no statistical significance that does not mean there is no ecological significance. On average the Buglab collected 25 different organisms per sample while the citizens and consultant collected 20 and 22, respectively. Missing 3 to 5 organisms per sample may have an affect if these data where to be used in bioassessment.

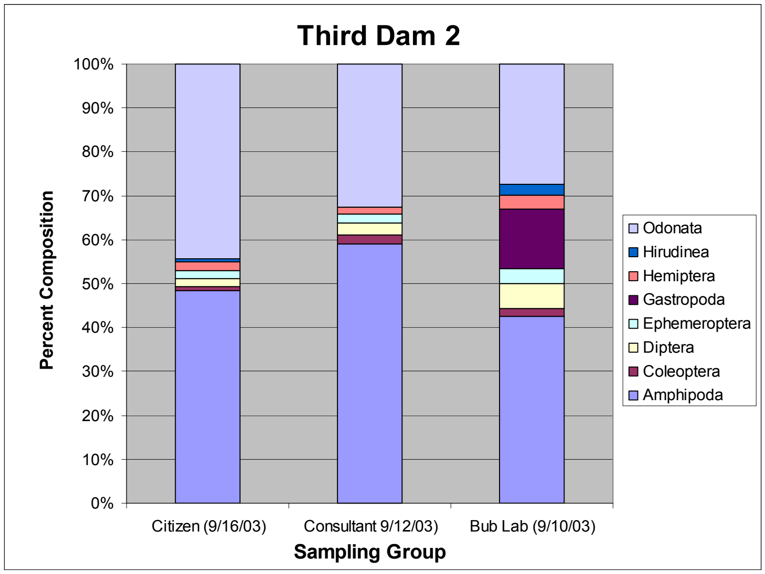
One final comparison of the abilities of the different groups to collect samples can be seen in sample composition. In many cases more than 500 organisms were collected in the kick net. The task for each group was to pick out a representative sample of 500 "bugs" from the larger population. The following charts illustrate the variation in samples at the Order level.



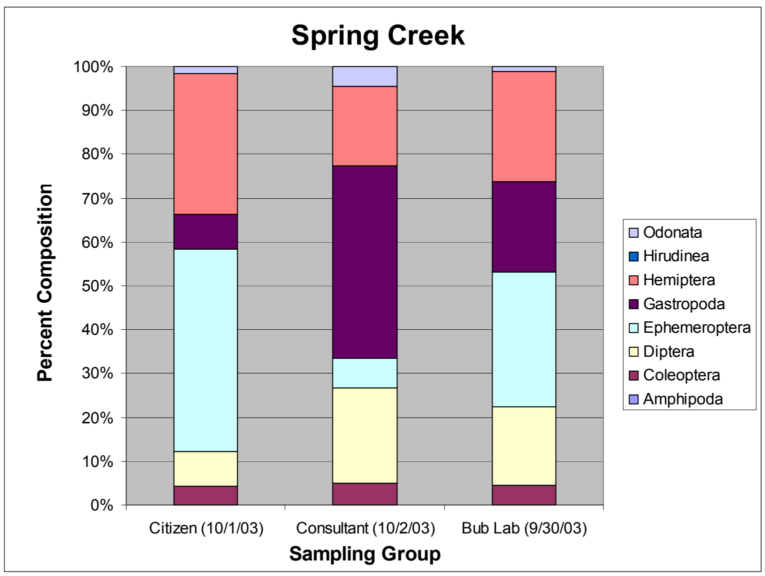

Benson Bridge
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
25
11
67
4
5
197
46
191
17
39
74
54
262
13
64
Odonata
Hirudinea
Hemiptera
Gastropoda
Ephemeroptera
Diptera
Coleoptera
Amphipoda
Citizen (6/6/03)
Consultant (6/9/03)
Bug Lab (6/17/03)
Sampling Group


Bear River Bottoms
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
74
119
113
99
53
3
76
80
238
92
76
2
51
200
140
84
57
7
Odonata
Hirudinea
Hemiptera
Gastropoda
Ephemeroptera
Diptera
Coleoptera
Amphipoda
Citizen (6/13/03)
Consultant (6/16/03)
Bub Lab (6/17/03)
Sampling Group

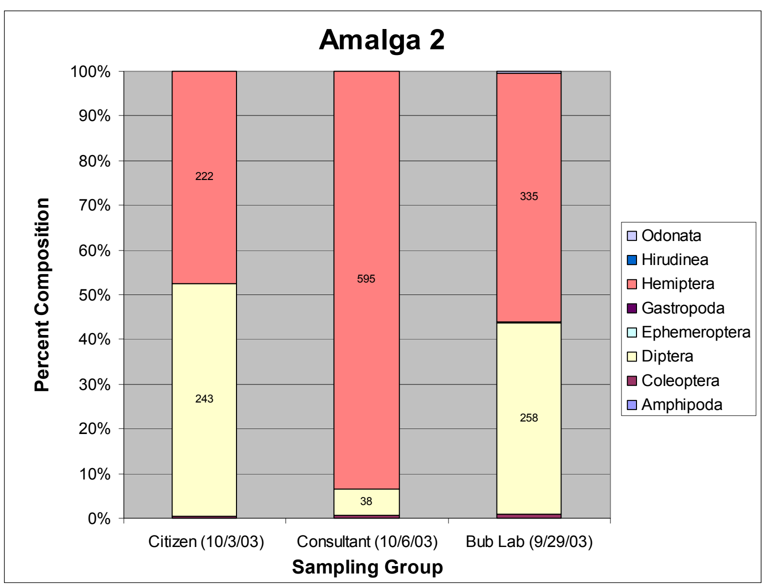

Amalga 1
100%
80%
60%
40%
20%
0%
Percent Composition
161
318
19
267
296
20
197
392
47
Odonata
Hirudinea
Hemiptera
Gastropoda
Ephemeroptera
Diptera
Coleoptera
Amphipoda
Citizen (6/20/03)
Consultant (6/25/03)
Bub Lab (6/23/03)
Sampling Group



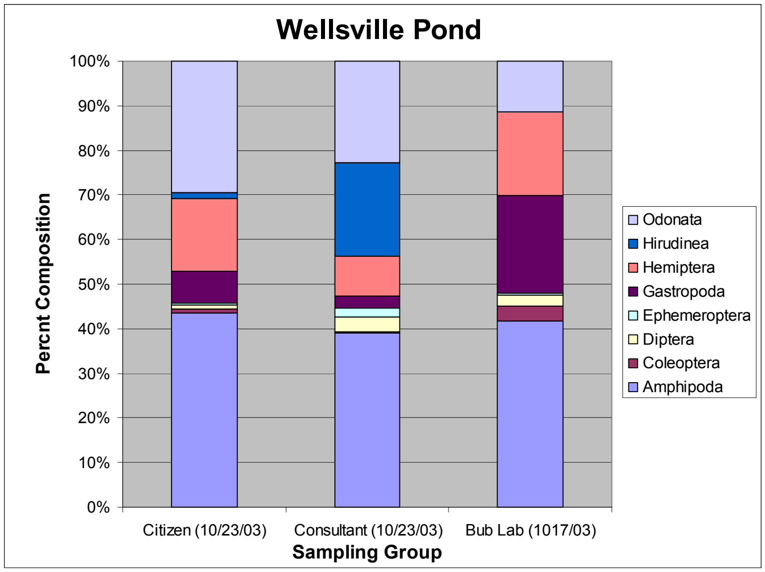
Third Dam 2
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
Citizen (9/16/03)
Consultant 9/12/03)
Bub Lab (9/10/03)
Sampling Group
Odonata
Hirudinea
Hemiptera
Gastropoda
Ephemeroptera
Diptera
Coleoptera
Amphipoda



Spring Creek
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
Citizen (10/1/03)
Consultant (10/2/03)
Bub Lab (9/30/03)
Sampling Group
Odonata
Hirudinea
Hemiptera
Gastropoda
Ephemeroptera
Diptera
Coleoptera
Amphipoda



Amalga 2
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
222
243
595
38
335
258
Citizen (10/3/03)
Consultant (10/6/03)
Bub Lab (9/29/03)
Sampling Group
Odonata
Hirudinea
Hemiptera
Gastropoda
Ephemeroptera
Diptera
Coleoptera
Amphipoda



In terms of the representativeness of taxonomic orders in each sample, there was some variation. However in most cases each group collected organisms representing each order.

Macroinvertebrate Sampling Comments

On average volunteers and the wetland consultant contributed 15 to 2.5 hours per sample collected at each site. On a scale of 1 (very confident) to 5 (not confident) all citizens and the wetland consultant felt very confident in their ability to perform the protocol. Likewise all felt that the sampling training prepared them very well to perform the protocol (1 on a scale of 1 to 5 where 1 was "very well" and 5 was "not well." When asked what part of the monitoring activitie they enjoyed the most all responded, "getting out in the field to different sites and looking for macros". People's least favorite aspect of the monitoring was picking out 500 organisms. When asked, how confident participants were in citizens' ability to gather valid and viable data given adequate training and supervision all replied, "very confident."

Identification Results

For this part of the Shadow Study citizens and the wetland consultant identified samples to the family level. Buglab employees identified samples to the lowest taxonomic level as per their normal protocol. Therefore comparisons between groups centered on the variation between three different citizen monitors and the wetland consultant relative to the findings of the Buglab.

In terms of average richness and the number of different families ANOVA analysis showed no statistically significant difference in samples identified by the three volunteers and the wetland consultant See Tables 3 and 4. Have had the sample size been larger volunteer 3 (V3) would have been significantly different as they consistently had low numbers for richness and total families. One caveat when discussing identification ability is that greater numbers to not necessarily relate to accuracy. Low totals may mean that families were missed and high totals may mean that organisms were misidentified as a new family when in actuality they were not. This is another reason why we chose not to include samples identified by the Buglab in this analysis but used them only as a reference.

In terms of a descriptive analysis, as might be expected, uncommon families were the most difficult to identify. This was often the case with certain types of aquatic beetle (Coleoptera) and fly (Diptera) larvae. In general citizen monitors and the wetland consultant were able to correctly identify damselfly, dragonfly and mayfly larvae as well as common wetland snails at the family level. There also appeared to be difficulty in identifying families of Amphipoda even though they were ubiquitous across most samples.

Again there was no statistically significant difference between the three volunteers and the wetland consultant in their ability to identify macroinvertebrates. This is not surprising as all four individuals were trained starting from roughly the same level. One would expect that with more practice (only seven samples were identified) there would be less confusion surrounding the more uncommon families. However, we most note that macroinvertebrate identification is not for everyone, but, while a tedious activity, it seemed to get easier over time.

Table 3

Report

IDER		richdifID	DIFIDFER	FAMDIFID	FAMIDPER
V1	Mean	-8.57	-.4008102	-.57	-.0200535
	N	7	7	7	7
	Std. Deviation	4.756	.12612123	2.299	.20769564
V2	Mean	-9.43	-.4464384	-1.14	-.1334952
	N	7	7	7	7
	Std. Deviation	4.894	.16523078	1.574	.15302881
V3	Mean	-11.57	-.5244321	-3.14	-.2233730
	N	7	7	7	7
	Std. Deviation	6.373	.14536715	2.734	.20318381
WC	Mean	-9.71	-.4468754	-1.57	-.1026847
	N	7	7	7	7
	Std. Deviation	5.251	.14820135	2.637	.18555032
Total	Mean	-9.82	-.4546465	-1.61	-.1199016
	N	28	28	28	28
	Std. Deviation	5.172	.14568363	2.424	.19261433

Table 4

ANOVA Table[a]

			Sum of Squares	df	Mean Square	F	Sig.
richdifID * IDER	Between Groups	(Combined)	33.536	3	11.179	.390	.762
	Within Groups		688.571	24	28.690		
	Total		722.107	27			
DIFIDPER * IDER	Between Groups	(Combined)	.055	3	.018	.854	.478
	Within Groups		.518	24	.022		
	Total		.573	27			
FAMDIFID * IDER	Between Groups	(Combined)	25.536	3	8.512	1.534	.231
	Within Groups		133.143	24	5.548		
	Total		158.679	27			
FAMIDPER * IDER	Between Groups	(Combined)	.148	3	.049	1.388	.271
	Within Groups		.854	24	.036		
	Total		1.002	27			

a. The grouping variable IDER is a string, so the test for linearity cannot be computed.

Macroinvertebrate Identification Comments

There was considerable variation in them amount time participants spent identifying macroinvertebrates in the lab. Total times included 4.5, 8, 14 (consultant), and 20 hours to process seven samples. It is possible that the person who spent only 4.5 hours only identified and counted samples that had already been sorted. Sorting, although roughly done in the field also took time in the lab. On a scale of 1 (Very Confident) to 5 (Not Confident) all participants selected “2” to describe their ability to perform the protocol. The consultant indicated that we was well prepared by the training to perform the protocol, selecting “1” on a scale of 1 to 5. The three volunteers circled 2, 2, and three in response to this question. All participants enjoyed learning to identify “bugs” and looking at them under a microscope but found the tediousness of the task less enjoyable. For example, the consultant responded, “Very tedious- seemed like a daunting task at first, but turned out to be very enjoyable.” Finally there was variation in participants opinion on citizens’ ability to gather valid and viable data given adequate training and supervision. On a scale of 1 “Very Confident” to 5 “Not Confident” scores ranged from 1, 2, 3 (consultant), to 4.

Lessons Learned

1) Sort samples in the field to reduce identification time in the lab
2) Consider the length of time need for sampling for different size groups. Allow for long periods of time if done by one person
3) Emphasize the interesting parts of sampling, i.e being outdoors, comparing samples at different sites.
4) Realize that sort 500 organisms from a sample is time consuming.
5) Have adequate amounts of volunteers to make tasks enjoyable.
6) Stress the positive things about macroinvertebrate identification such as learning the different families, using a binocular scope, and that it gets easier over time.

Vegetation Monitoring

Background

As part of a wetland hydrogeomorphic modeling project the Utah Division of Wildlife Resources monitors vegetation at sites in the Great Salt Lake Basin. Not only is hydrophytic vegetation a defining feature of wetlands but in Utah it is also a variable which predicts characteristics such as salinity and altitude. Eight citizen monitors with varying levels of botany experience assisted in vegetation monitoring during the summer of 2003.

Protocol

Many different protocols exist that monitors can use to assess wetland vegetation and determine species composition. For this study we used a transect/plot approach. At four (4) sites, monitoring teams established 1 to 3 transects (dependent on wetland size) perpendicular to the flow of surface water. Sites included Mehraban Wetland Park, South Jordan Mitigation, Amalga Barrens, and Bear River Bottoms. Centered along each transect monitors identified 1' x 6' vegetation plots spaced 10' to 20' apart depending on the size of the site. Each wetland had a total of 20 to 30 plots. Monitoring protocol included taking a species inventory, determining percent composition of each species, and measuring average vegetation height within each plot. Sites were monitored once, at a time when the most plant species were identifiable. The equipment needs included waders or appropriate footwear, plant identification guides, a site plant list and a six foot folder ruler or pole. Participants received training in wetland plant identification and monitoring techniques before and during the actual monitoring.

Results

In reviewing the data there is apparent variation in each group's findings at the plot level. Estimating percent composition is a subjective activity that results in variation. This variation can be reduced through training and practice which if done successfully leads to calibration The challenging is getting individuals to agree on what "X" percentage looks like in terms of species composition. Additional sources of variation include time elapsed between monitoring by the three groups and the possibility that plots were not in exactly the same place. This is illustrated in Table 2 which presents data from three plots along the transect at Bear River Bottoms.

In this example each group conducted the vegetation protocol within a span of eleven days, from July 4th to the 15th yet came up with different estimates of percent composition. For example, in plot one the citizen monitors, UDNR agent, and wetland consultant estimated that 30%, 20%, and 17% of the plot was composed of *Phalaris arundinacea*. In some cases one group found a species that the other group(s) did not. For example in Plot 1, the citizen monitors found 2% *Rumex martimus*, the UDNR agent found 15% bare ground, and the wetland consultant found 10% *Scirpus maritimus*. Finally there is variation in each group's ability to identiy a plant to the species level. In the case of all three plots the wetland consultant identified a specimen to the genus level, *Chenopodium*, while the citizen monitors identified the plant as *Chenopodium album* (The UDNR agent did not record *Chenopodium* spp on these plots). Variation in results similar to those described in Table 2 are found at all sites, along all transects, in all plots. In general the variation increased as the time between monitoring events increased and with the complexity of the site.

Table 5

Plots	Date	Days	Group	BG	CheAlb	Che sp.	DipFul	FWD	PhaAru	RumMar	SciAcu	SciMar	TypAng	Forb
1.1	7 Jul 03	8.00	CM		10		2	11	30	2	25		20	
1.1	15 Jul 03	0.00	UDNR	15				2	17		4		16	46
1.1	4 Jul 03	11.00	WC			10		10	25		25	10	20	
1.2	7 Jul 03	8.00	CM		20			25			5		60	
1.2	15 Jul 03	0.00	UDNR	32				32			6		25	5
1.2	4 Jul 03	11.00	WC			20					20		60	
1.3	7 Jul 03	8.00	CM		25			5				50	20	
1.3	15 Jul 03	0.00	UDNR	44				15				27	10	4
1.3	4 Jul 03	11.00	WC			20		10				50	20	

CM= Citizen Monitors, UDNR= State Employee, WC= Wetland Consultant
BG (Bare Ground), CheAlb (Chenopodium album), Che sp. (Chenopodium species), DipFul (Dipsacus fullonum), FWD (Fine Woody Debris), PhaAru (Phalaris arundinacea), RumMar (Rumex maritimus), SciAcu (Scirpus acutus), SciMar (Scirpus maritimus), TypAng (Typha angustifolia)

However when "clumping" the findings by ranking the most abundant plants along each transect, variation between each group decreased (See Table 3)

Table 6

Site and Group	1	2	3	4	5	6	7	8
Amalga 1								
CM	DisSpi	FWD	SciMar	BG				
UDNR	FWD	DisSpi	BG	SciMar				
WC	DisSpi	OW	SciMar					
Amalga 2								
CM	DisSpi	BG	SalEur					
UDNR	BG	FWD	SalEur	DisSpi	SciMar			
WC	DisSpi	OW	SalEur	BG				
Bear River Bottoms								
CM	AliPla	BG	SciMar	RumMar	TypAng	FWD	CheAlb	
UDNR	Pot spp.	AliPla	FWD	SciMar	BG	TypAng	RumCri	
WC	AliGra	BG	SciMar	RumMar	TypLat	FWD	TypAng	
Mehraban								
CM	BerEre	Ele sp.	SciAme	JunBal	TypAng	SolDul	OW	FWD
UDNR	ElePal	FWD	BerEre	JunBal	OW	SciAme	SolDul	PhrAus
WC	ElePal	TypLat	SciAme	BerEre	JunBal	OW	PhrAus	SolDul
South Jordan 1								
CW	ElyRep	FWD	BroTec	OW	CarDra			
UDWR	AgrTra	FWD	ElyRep	ElePal	Pol spp.			
WC	ElyRep	ElePal	ConArv	Bro spp	Pol spp.			
South Jordan 2								
CW	ElyRep	BG	RumCri	FWD	PucDis			
UDWR	AgrTra	OW	RumCri	PolPer	FWD			
WC	ElyRep	RumCri	PucNut	HorJub	BG			

South Jordan 3								
CW	FWD	ElyRep	BG	PlaLan	GriSqu			
UDWR	AgrTra	OW	PlaLan	BG	FWD			
WC	FWD	ElyRep	BG	PlaMaj	GriSqu			
SoJo (combined)								
CW	ElyRep	FWD	BG	BroTec	OW	PlaLan	RumCri	CarDra
UDWR	AgrTra	OW	FWD	PlaLan	BG	ElyRep	ElePal	Pol spp
WC	ElyRep	FWD	BG	ElePal	PlaMaj	RumCri	ConArv	Bro spp

At this level of observation, one gets an overview of each transect which may be the most appropriate scale for comparing transects that have been monitored by different people. Below is a list of common species found at the four sites, their code and common name.

CODE	SCIENTIFIC	COMMON
AgrTra	Agropyron trachycaulum	Slender wheatgrass
AliGra	Alisma gramineum	Narrowleaf water plantain
AliPla	Alisma plantago	American Water plantain
BerEre	Berula erecta	Water Parsnip
BG	Bare Ground	Bare Ground
Bro spp.	Bromus species	Brome species
BroTec	Bromus tectorum	Cheatgrass
CarDra	Cardaria draba	Hoary Cress
CheAlb	Chenopodium album	Pigweed (Lamb's-quarters)
ConArv	Convolvulus arvensis	Field Bind Weed
DisSpi	Distichlis spicata	Saltgrass
ElePal	Eleocharis palustris	Creeping spikerush
Ele spp	Eleocharis species	Spikerush Specceis
ElyRep	Elytrigia repens	Quackgrass
FWD	Fine Woody Debris	Fine Woody Debris
GriSqu	Grindelia squarrosa	Curlycup Gumweed
HorJub	Hordeum Jubatem	Foxtail Barley
JunBal	Juncus Balticus	Baltic Rush
OW	Open Water	Open Water
PhrAus	Phragmites australis	Common Reed
PlaLan	Plantago lanceolata	Buckhorn Plantain
PlaMaj	Plantago major	Broadleaf Plantain
PolPer	Polygonum persicaria	Lady's Thumb
Pol spp	Polygonum species	Smartweed
Pot spp.	Potamogeton species	Pondweed
PucDis	Puccinellia distans	Weeping alkaligrass
PucNut	Puccinellia nuttalliana	Nuttall’s alkaligrass
RumCri	Rumex crispus	Curly Dock
RumMar	Rumex maritimus	Golden Dock
SalEur	Salicornia europeae	Pickleweed
SciMar	Scirpus maritimus	Alkali Bulrush
SolDul	Solanum dulcamara	Bittersweet Nightshade
TypAng	Typha angus	Narrow Leaf Cattail
TypLat	Typha latifolia	Common cattail

Vegetation Monitors and Wetland Consultant Comments

Five out of the eight volunteers and the wetland consultant responded to the questionnaire. On average volunteers spent 2 to 3 hours completing the vegetation monitoring at each site as did the wetland consultant. On a scale of 1 to 5, (1 = “very confident” and 5= “not confident”) volunteers scored 2.2 when asked about their ability to perform the protocol. On the same scale with 1 equal to “very well” and 5 equal to “not well” volunteers scored 2.4 when asked how well the training prepared them to perform the protocol. The wetland consultant indicated “very confident” and “very well” respectively. Volunteers indicated that positive aspects of vegetation monitoring included getting out in the field (wetland), learning more about plants and identification, and contributing to a scientific effort. On the other hand the least enjoyable aspects of the project included hot weather, traveling and estimating percent composition. By comparison the consultant indicated plant identification and mosquitoes at Amalga Barrens. When asked about citizens’ ability to gather valid and viable data given adequate training and supervision volunteers scored 2.6 on a scale of 1 (Very Confident) to 5 (Not Confident). The wetland consultant indicated “3” on the same scale saying he thought it would take an interested and dedicated volunteer to get accurate results identifying plants to species level.

Lessons Learned

1) When working with plots along transects, make sure the plots are permanently flagged. At a few of the sites each group identified plots along flagged transects using standardized protocol. However if plots were off by a few feet there may be variation in the results among different monitors
2) Vary the complexity of vegetation when selecting sites. This allows for different levels of comparison.
3) Make sure to use scientific names as common names may vary. However in some cases one plant species may have two scientific names.
   e.g.: Agropyron repens = Elytrigia repens and Juncus arcticus = Juncus balticus
4) Realize that identifying plants to species level requires considerable training
5) Take advantage of local specialists
6) Create site plant lists or reference collections for use by volunteers
7) As it appears that with training even moderately experienced volunteers are able to identify plants to species level using field guides and a list of likely plants, future projects might selectively target more experienced volunteers such as Master Gardeners or Native Plant Society members.
8) We are still unsure of the effectiveness of volunteers in identifying plants using a dichotomous key.

Water Quality Sampling

Background

Water quality is often a parameter in which citizens are asked to monitor by state agencies. Frequently the work is done by homeowners at lakes on which they live for ecological and aesthetic purposes. Water quality is also an important factor in wetland systems especially considering how this ecosystem functions as a filter and biogeochemical processor. Wetland Partner volunteers have been monitoring water quality using field test kits since 2000 and it made sense to include this component in the study in order to compare data and test the effectiveness of our equipment

Protocol

Utah Division of Water Quality (DWQ) employees monitor many sites within the Jordan and Little Bear River (a tributary of the Bear River) watersheds on a weekly or monthly basis. Three (3) sites along each river were used in this study. In coordination with DWQ, two teams of citizen monitors and the wetland consultant monitored water quality within as short a period of time as possible as agency personnel. All three groups sampled the following parameters, pH, dissolved oxygen, temperature, conductivity, nitrate, total phosphorous, and total suspended solids (TSS). Field tests, e.g. pH and conductivity, will be conducted using a Hydrolab consistent with manufacturer's instructions. For other parameters, i.e., nitrate, phosphorous, and TSS, samples will be collected following UDWQ protocol for which a QAPP currently exists. Using proper chain of custody requirements, samples were brought to the Utah Division of Laboratory Services for analysis.

Because of the geographic distance between the rivers, two different citizen groups were involved in this component of the "shadow" study. Prior to monitoring the eight (8) citizen monitors and the wetland consultant received 4 hours of training on sampling protocol and issues of contamination and chain of custody.

Results

The study design of the project made it difficult to compare results using common statistical tests. Even thought there were many replicates, each site and sampling activity is a unique variable given the spatial/temporal variation that exists with water quality in nature. Therefore comparing results across these diverse conditions is not appropriate. What we were able to do is look at mean difference in the results of using monitoring group and method of analysis as variables across four parameters (Nitrate, Temperature, pH, and Dissolved Oxygen.) See Table

Citizens and the wetland consultant tested nitrate levels using Chemetrics field test kits and took grab samples which were sent to the lab. We ran comparison of these two methods for measuring Nitrate. In addition we measured the mean difference between the results of samples citizens and the wetland consultant collected and the results sent to the State Lab by UDWQ personnel. When comparing field test kits and Lab analysis, citizen monitors on average had a 32% difference in results. The wetland consultant's average difference was 28%. The difference between the results of the two tests is likely a function of the accuracy of the field test kits. That the consultant had a lower percent error may be a function of the fact that he was able to standardize his nitrate readings over time while many different volunteers took nitrate readings over the course of the project. Mean percent difference in grab samples sent to the State Lab and UDWQ samples sent to the State Lab were approximately 13%. Percent error in this case could be a function of sampling error but is more likely to be associated with the time elapsed between samples. This difference ranged from 45 minutes to 198 hours. This is to say that in one occasion the volunteers got tot a site 45 minutes after the crew from UDWQ. Conversely there was often confusion about which week UDWQ personnel were monitoring and the difference between sampling events was almost a full week.

Variation in measuring temperature was much less. The cheaper thermometers often used in the field were usually within tenths of a degree when compared to the temperature probe on the Hydrolab. See Table 7. Variation in pH measurements taken using color strips and the Hydrolab ranged from 12.7 for the citizens and 8.5 for the consultant. Again this can be explained by the number of different volunteers taking pH readings vs. just one consultant. As a standard, the mean percent difference between UDWQ Hydrolab measurements and water sample analysis by the State lab was on 2.5%. Finally, variation in dissolved oxygen measurements fell between nitrate and temperature differences. Citizen error on average was 11% while the consultant was 17% when comparing the results of a Chemetrics test kit and the DO probe on the HydroLab.

Table 7

Comparison	Mean % Difference	Lower 95% CI*	Upper 95% CI*
Nitrate			
Citizen Kit vs. State Lab	32.6	16.3	48.9
Consultant Kit vs. State Lab	28.7	17.8	39.4
Citizen Lab vs. UDWQ Lab	13.1	7.4	18.8
Consultant Lab vs. UDWQ Lab	13.3	1.6	24.8
Temperature			
Citizen Kit vs. HydroLab	2.8	1.4	4.1
Consultant Kit vs. HydroLab	1.5	0.5	2.4
pH			
Citizen Kit vs. HydroLab	12.7	9.5	16.0
Consultant Kit vs. HydroLab	8.5	5.0	12.1
DWQ Hydrolab vs. State Lab	2.5	1.4	3.4
Dissolved Oxygen			
Citizen Kit vs. HydroLab	11	7.4	14.7
Consultant Kit vs. HydroLab	17	3.2	31.0

*CI= Confidence Interval. These values are also in %.

Notice that Table 7 provides lower and upper 95% confidence intervals. Assuming normal distribution, one can be 95% certain that mean percent difference will fall between the two values.

Water Quality Monitors and Wetland Consultant Comments

Volunteer water quality monitors spent 2 to 3 hours on each sampling activity. An activity reflects a circuit of three sites, conducting all parameter protocols. The wetland consultant spent approximately 1 hour on each sampling activity. When citizens and the consultant were asked how well they were able to perform the protocol and how well the training prepared them for the task there was a distinct relationship. For example participants that selected 1 on a scale from 1 (Very Confident) to 5 (Not Confident) also selected 1 on a scale from 1 (Very Well) to 5 (Not Well). Responses to this question included 1, 1, 1, 1 (consultant), 3, and 4. Positive aspects of the monitoring included getting out to wetland sites, learning something new, and seeing that phosphorous and nitrate levels were not as high as expected. Less enjoyable aspects of the sampling activities included weather, travel, too few participants, getting stuck in the mud, and not really understanding what skill(s) someone could bring to the table to help. When asked on a scale of 1 (Very Confident) to 5 (Not Confident) how confident he was in citizens' ability to gather valid and viable data given adequate training and supervision the wetland consultant indicated "1." The mean for the volunteers themselves was 1.6 (answers included 1,1,1,2,3) for the same question.

Lessons Learned

1) Make sure everyone is monitoring at the same site. Written directions to a site can be confusing. Taking the time to have all groups meet at all the sites will be well spent.
2) Keep equipment clean and calibrated.
3) Do as many replicates as possible for statistical analysis
4) Reduce the time between different group's sampling activities to as little as possible to reduce natural variation.

General Project Lessons Learned

1) Develop statistical analysis as part of the project study design
2) Conduct as many samples as possible as the higher the number the more rigorous the statistics
3) For statistical purposes always do replicates.
4) Budget money for assistance with statistical analysis as needed
5) As part of the training insure that the different monitoring groups are present at the same time at least once to standardize protocol
6) Review findings periodically to minimize additional sources in variation.
7) Give monitors as much advanced notice as possible.
8) If traveling from site to site in the same day as was the case with Water Quality monitoring select sites for the easiest travel and least amount of time if possible.
9) Give groups periodic updates that tells them how they are doing and allows them to ask questions
10) Accurately inform monitors of the conditions in which they are going to work.
11) Rigorously calibrate equipment to insure useable data
12) Prepare an equipment checklist so that no tests are forgotten thereby avoiding data gaps

Recommendations relevant to the project goals

Goal 1. Evaluate the capacity of our citizen monitors to gather valid and viable data.

Results are mixed both in terms of three different protocols and citizen response. In general macroinvertebrate sampling and water quality sampling were close to the standards defined by the Buglab and UDWQ, respectively. Variation in macroinvertebrate sampling could be reduced with periodic supervision over time while variation in water quality sampling could be reduced be shorting the time between sampling activities by different groups being compared. The volunteers themselves and the wetland consultant felt most comfortable with citizens conduction these protocol.

Vegetation monitoring results between the three groups appear to be similar at larger (transect) scales. At the plot level there might be variation in results even if monitoring was conducted by professionals as was the case between the wetland consultant and botanist from UDNR. Regardless, this protocol, as made evident in the comments, is for a certain type of volunteer, one that has a real interest in learning to identify wetland plants or comes with prior botanical experience.

Finally macroinvertebrate identification had the greatest variation between the standard (The Buglab) and the other groups. In some ways this protocol is similar to vegetation monitoring because of the level of detail required to achieve valid and viable results. This challenge was not overcome as it was in vegetation monitoring. Since there was no significant difference between the work done by the volunteers and the consultant we expect that all individuals were starting from the same level of experience. With practice volunteers whether paid or unpaid could familiarize themselves with wetland macroinvertebrate families provided they had the time and interest. Going below family level might not be appropriate given the amount of time and issues of accuracy.

Goal 2. Understand the limitations, if any, of volunteer-gathered data.

As with any group of individuals participating in ecological monitoring each brings a set of skills, experiences and interests. In this Shadow Study we attempted, through training, to get every participant to standardized level of skill. Experience and interest therefore may cause variation in monitoring results. For this reason we recommend that difficult, tedious, or time consuming protocol be attempted by volunteers that not only have the appropriate training but also the interest and if possible additional experience. For example, protocol such as macroinvertebrate identification and vegetation monitoring require skills that might not be appropriate for all volunteer monitors. One volunteer decided during the macroinvertebrate identification phase that this activity was a waste of her time. She would rather collect “bugs” and sort them in the field than spend time in a lab identifying aquatic insects knowing that the Buglab can do it faster and more accurately.

Volunteers, like the rest of us have other time commitments. It is important to represent as clearly as possible the time commitment necessary for each protocol and the overall project. In addition as much advance notice on specific monitoring activities is both polite and appropriate. In some cases water quality monitoring might be related to storm events. Therefore only volunteers that can realistically participate in time sensitive activities should do so.

Finally from this study we have anecdotal evidence about continuity. Of the sixteen volunteers that participated in the study, only three that began monitoring in early 2003 where no longer active by the end of the season. In two cases the reason for this related to time constraints, i.e., the monitoring activities were on days that they were not available. In the third case, the volunteer felt that identifying macroinvertebrates was not a very good use of her time.

Overall we are pleased with the quality and quantity of data gathered by citizen monitors. Issues for volunteer coordinators to keep in mind are often a function of the protocol. All protocol needs comprehensive training. The harder the protocol, the more training, initial supervision, and possibility of retraining are needed. Lack of these components and confusion concerning the how's and why's of the protocol may demoralize the volunteers.

Goal 3. Assess the effectiveness of training methods.

In the study design we suggested that training was a key variable in the success of a citizen monitoring program. Prior to Shadow Study implementation, Wetland Partners allocated 8 to 12 hours per volunteer for training in wetland ecology, monitoring protocol, and data management. The format of these trainings included classroom and field work as well as theoretical and experiential instruction. Adapting this model, the sixteen participants received background information on the purpose of the Shadow Study, their role in the research, a review of existing protocol, and hands-on training in the new protocol.

In general water quality monitoring protocol was the simplest of the components and required the least about of training and clarification. Specific attention was paid to issues of sample handling and contamination and the use of the HydroLab. In their comments all participants stated they were very capable of performing the protocol and that the training prepared them well.

Macroinvertebrate sampling was also relatively simple and the afternoon spent with BugLab Staff was sufficient to learn and practice sampling protocol. However, while the goal of the protocol was to collect 500 organisms on three occasions volunteers collected less than the required amount. In the future more effort should be placed on effectively and efficiently sorting a sample in the field in addition to collecting in the various microhabitats of a wetland. Similarly all participants felt very prepared to conduct the protocol as a result of the training. Macroinvertebrate identification was more difficult and required an eight hour taxonomy lesson spread over 4 days. This training was considered an enjoyable component of the training by all participants. The consultant stated that it prepared him "very well" to identify organisms in the lab; the volunteers said in prepared them "well."

Vegetation monitoring, like macroinvertebrate identification, was a difficult activity. This aspect of the Shadow Study would have benefited from a lesson on plant identification in addition to more practice sessions in the field. Volunteers felt the least prepared and least capable of performing this protocol when compared to the other three techniques evaluated in the study.

Overall recommendation for training relative to the Shadow study include:

a. Get volunteers, the wetland consultant, and the state agency personnel together for at least one training and "run through" to calibrate methods
b. Clarity is especially important and events in which all participants can ask questions will result in group learning and hopefully less variation due to human error.
c. As one would expect, it appears that the better the training the better the performance. Spend appropriate time and energy on training before getting volunteers out in the field.

d. Be prepared to retrain volunteers and/or spend time clarifying issues that result from working in the field
e. When conducting a comparative study such use a pilot sampling event to find gaps in the training or participants understanding of the protocol. The results can be used to calibrate the performance of the different groups involved in the study.

This report summarizes the major findings of UDWR's Citizen Monitoring Shadow Study. However, not all data are described in the narrative. We encourage readers to review the three data sets for a more detailed look at the results when developing similar studies or designing their own monitoring program.