Change Analysis

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Contents

1 Introduction

This document presents change analysis of a GRTS survey design. The resource employed in the analysis is rivers and streams in the 48 contiguous United States. Data was obtained from two surveys conducted by the U.S. Environmental Protection Agency: (1) the Wadeable Streams Assessment (WSA) in 2004 (U.S. Environmental Protection Agency 2006) and (2) the National Rivers and Streams Survey (NRSA) in 2008 and 2009. Change analysis measures the difference between response variables that were estimated in two surveys. Both continuous and categorical response variables can be employed for change analysis. For a categorical response variable, change is estimated by the difference in category estimates for the two surveys, where a category estimate is the estimated proportion of values in a category. Note that a separate change estimate is calculated for each category of a categorical response variable. For a continuous response variable, change can be estimated for the mean, the median, or for both the mean and median. For a continuous response variable using the mean, change is estimated by the difference in estimated mean values for the two surveys. For change estimates using the median, the first step is to calculate an estimate of the median for the first survey. The estimated median from the first survey is then used to define two categories: (1) values that are less than or equal to the estimated median and (2) values that are greater than the estimated median. Once the categories are defined, change analysis for the median is identical to change analysis for a categorical variable, i.e., change is estimated by the difference in category estimates for the two surveys.

2 Preliminaries

The initial step is to use the library function to load the spsurvey package. After the package is loaded, a message is printed to the R console indicating that the spsurvey package was loaded successfully.

Load the spsurvey package

```
> # Load the spsurvey package
> library(spsurvey)
>
```

```
Version 3.3 of the spsurvey package was loaded successfully.
```

3 Load the survey design and analytical variables data set

The original data file contains more than 2,400 records for change estimation. To produce a more manageable number of records, rivers and streams located in the Western Mountains Level III Ecoregion (Omernik 1987) were retained in the data that will be analyzed, which produced a data set containing 668 records.

The next step is to load the data set, which includes both survey design variables and analytical variables. The data function is used to load the data set and assign it to a data frame named NRSA_2009. The nrow function is used to determine the number of rows in the NRSA_2009 data frame, and the resulting value is assigned to an object named nr. Finally, the initial six lines and the final six lines in the NRSA_2009 data frame are printed using the head and tail functions, respectively.

Load the survey design and analytical variables data set

```
> # Load the data set and determine the number of rows in the data frame
> data(NRSA_2009)
> nr <- nrow(NRSA_2009)
>
```

Display the initial six lines in the data file.

```
> # Display the initial six lines in the data file
> head(NRSA_2009)

       siteID   xcoord  ycoord       wgt Survey Revisit_Site Stream_Size NTL
1 WAZP99-0833 -1369578 1345072  17.17660    WSA            Y       Small 119
2 WAZP99-0545 -1221990 1291197  17.17660    WSA            Y       Small 324
3 WAZP99-0687 -1231441 1275327  13.70593    WSA            Y       Small  55
4 WCAP99-0991 -2038942 2002946 572.18276    WSA            Y       Small  55
5 WCAP99-0587 -2264511 2285650 100.41211    WSA            Y       Small 509
6 WCAP99-0503 -2035060 1880456 457.74621    WSA            Y       Small  63
  PTL Benthic_MMI NTL_Cond PTL_Cond Benthic_MMI_Cond
1   8    46.78965     Good     Good             Fair
2  92    27.15364     Poor     Poor             Poor
3  39    19.12938     Good     Fair             Poor
4   2    61.76663     Good     Good             Good
5  27    49.32376     Poor     Fair             Fair
6   1    68.57991     Good     Good             Good

>
```

Display the final six lines in the data file.

```
> # Display the final six lines in the data file
> tail(NRSA_2009)

       siteID     xcoord  ycoord       wgt Survey Revisit_Site Stream_Size NTL
663 FW08WY041  -868099.9 2401874 1543.3105   NRSA            N       Small 452
664 FW08WY042  -688555.9 2408900  171.6259   NRSA            N       Large 343
665 FW08WY081 -1113106.7 2377400 4876.7431   NRSA            N       Small 301
666 FW08WY085 -1079717.5 2471045  936.4642   NRSA            N       Small  34
667 FW08WY089  -900074.7 2444794 1543.3105   NRSA            N       Small 124
668 FW08WY092 -1181999.6 2221639 1543.3105   NRSA            N       Small 540
         PTL Benthic_MMI NTL_Cond PTL_Cond Benthic_MMI_Cond
663  48.4950       28.72     Poor     Poor             Poor
664  13.3113        4.90     Poor     Good             Poor
665  69.6469       38.50     Poor     Poor             Fair
666  58.7781       44.43     Good     Poor             Fair
667  45.3413       17.83     Good     Poor             Poor
668 191.2206       10.92     Poor     Poor             Poor

>
```

The location of rivers and streams that were sampled in the Western Mountains Ecoregion is displayed in Figure 1. The sample sites are displayed using a unique color for each survey.

Plot of WSA and NRSA Sample Sites Color−Coded by Survey

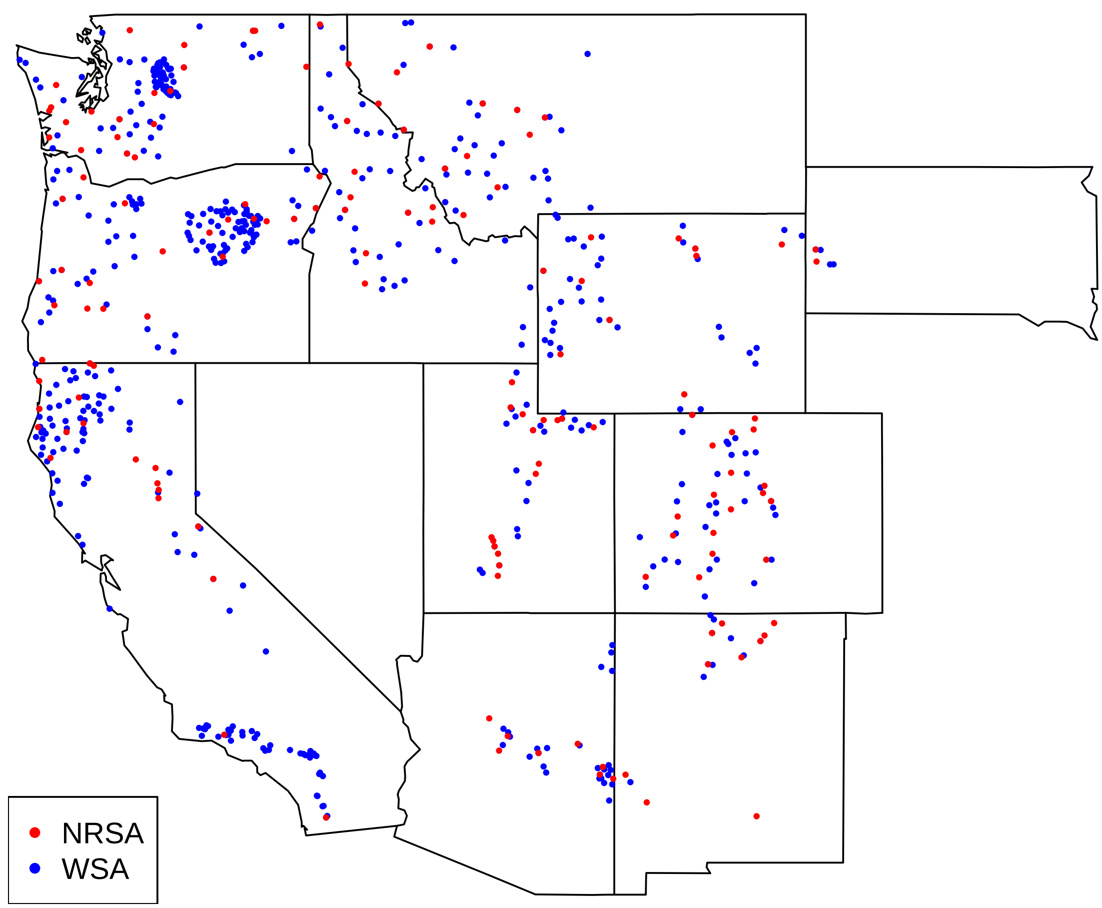

Figure 1: Location of rivers and streams that were sampled in the Western Mountains Ecoregion by the U.S. Environmental Protection Agency during the Wadeable Streams Assessment (WSA) conducted in 2004 and the National Rivers and Streams Assessment (NRSA) conducted in 2008-2009.

4 Change analysis

Change analysis will be investigated by examining three continuous response variables and three categorical response variables. The continuous response variables are total phosphorus concentration, total nitrogen concentration, and benthic macroinvertebrate multimetric index (MMI) score. The categorical response variables are condition class variables for each of the continuous response variables. Condition classes are created by grouping values for a continuous response variable into categories that reflect the impact of a response value on the overall ecological condition of a site. Categories used for condition classes are: "Good", "Fair" and "Poor".

The change.analysis function will be used to calculate change estimates. Six data frames constitute the primary input to the change.analysis function. The site ID provides the unique identifier for each sample site and is used to connect records among the data frames. The siteID variable in the NRSA_2009 data frame is assigned to the siteID variable (or variables in one case) in the data frames. The six data frames that will be created are named as follows: sites, repeats, subpop, design, data.cat, and data.cont. In order to obtain change estimates for the continuous variables using both the mean and median, the test argument of the change.analysis function is assigned the following value: c("mean", "median"). Note that the default value for the test argument is "mean".

The sites data frame identifies sites to use in the analysis and contains three variables: (1) siteID - site ID values, (2) Survey1 - a logical vector identifying sites for survey one, and (3) Survey2 - a logical vector identifying sites for survey two. The Survey1 variable is created by assigning the value TRUE to every site for which the Survey variable in the NRSA_2009 data frame equals the value "WSA". Similarly, the Survey2 variable is created by assigning the value TRUE to every site for which the Survey variable in the NRSA_2009 data frame equals the value "NRSA".

The repeats data frame identifies repeat visit sites and contains two variables: (1) siteID_1 - the site ID value for survey one and (2) siteID_2 - the site ID value for survey two. The siteID_1 variable is created by selecting values of the siteID variable in the NRSA_2009 data frame for which the the Survey variable in the NRSA_2009 data frame equals the value "WSA" and the Revisit_Site variable in the NRSA_2009 data frame equals "Y". The siteID_2 variable is created using an analogous process. For each row of the repeats data frame, the two site ID values must correspond to the same site. Note that the NRSA_2009 data frame has been organized so that repeat visit sites for WSA occur in the same order as repeat visit sites for NRSA.

The subpop data frame defines populations and, optionally, subpopulations for which estimates are desired. Unlike the sites and design data frames, the subpop data frame can contain an arbitrary number of columns. The first variable in the subpop data frame identifies site ID values and each subsequent variable identifies a type of population, where the variable name is used to identify type. A type variable identifies each site with a character value. If the number of unique values for a type variable is greater than one, then the set of values represent subpopulations of that type. When a type variable consists of a single unique value, then the type does not contain subpopulations. For this analysis, the subpop data frame contains three variables: (1) siteID - site ID values, (2) Western_Mountains - which will be used to calculate estimates for all of the sample sites combined, and (3) Stream_Size - which will be used to calculate estimates for each of the two classes of stream size (large and small). The rep (repeat) function is used to assign values to the Western_Mountains variable in the subpop data frame, and the Stream_Size variable in the NRSA_2009 data frame is assigned to the Stream_Size variable in the subpop data frame. Recall that nr, which is included in the call to the rep function, is an object containing the number of rows in the NRSA_2009 data frame.

The design data frame consists of survey design variables. For the analysis under consideration, the design data frame contains the following variables: (1) siteID - site ID values; (2) wgt - survey design weights; (3) xcoord - x-coordinates for location; and (4) ycoord - y-coordinates for location. The wgt, xcoord, and ycoord variables in the design data frame are assigned values using variables with the same names in the NRSA_2009 data frame.

The final two data frames, data.cat and data.cont, provide values of categorical response variables and continuous response variables, respectively. Like the subpop data frame, the data.cat and data.cont data frames can contain an arbitrary number of columns. The first variable in the data.cat data frame identifies site ID values and each subsequent variable identifies a categorical response response variable. For this analysis, the categorical response variables are Nitrogen_Condition, Phosphorus_Condition, and Benthic_MMI_Condition, which are assigned, respectively, variables NTL_cond, PTL_cond, and Benthic_MMI_cond in the NRSA_2009 data frame. For benthic MMI score, there are four sites (three in WSA and one in NRSA) for which the MMI score could not be calculated. Those sites are coded as NA for the Benthic_MMI variable and as category "Not Assessed" for the Benthic_MMI_cond variable.

The data.cont data frame is organized analogous to the data.cat data frame. The first variable in the data frame identifies site ID values and each subsequent variable identifies a continuous response response variable. For this analysis, the continuous response variables are Log_Total_Nitrogen, Log_Total_Phosphorus, and Benthic_MMI, which are assigned, respectively, variables NTL, PTL, and Benthic_MMI in the NRSA_2009 data frame. Note that total nitrogen and total phosphorus are analyzed using the base ten log scale, which are created by use of the log10 function.

Create the sites data frame.

```
> sites <- data.frame(siteID=NRSA_2009$siteID,
+                     Survey1=NRSA_2009$Survey == "WSA",
+                     Survey2=NRSA_2009$Survey == "NRSA")
```

Create the repeats data frame.

```
> repeats <- data.frame(siteID_1=NRSA_2009$siteID[NRSA_2009$Survey == "WSA" &
+                          NRSA_2009$Revisit_Site == "Y"],
```

```
+                         siteID_2=NRSA_2009$siteID[NRSA_2009$Survey == "NRSA" &
+                            NRSA_2009$Revisit_Site == "Y"])
```

Create the subpop data frame.

```
> subpop <- data.frame(siteID=NRSA_2009$siteID,
+                        Western_Mountains=rep("Western Mountains", nr),
+                        Stream_Size=NRSA_2009$Stream_Size)
```

Create the design data frame.

```
> design <- data.frame(siteID=NRSA_2009$siteID,
+                        wgt=NRSA_2009$wgt,
+                        xcoord=NRSA_2009$xcoord,
+                        ycoord=NRSA_2009$ycoord)
```

Create the data.cat data frame.

```
> data.cat <- data.frame(siteID=NRSA_2009$siteID,
+                          Nitrogen_Condition=NRSA_2009$NTL_Cond,
+                          Phosphorus_Condition=NRSA_2009$PTL_Cond,
+                          Benthic_MMI_Condition=NRSA_2009$Benthic_MMI_Cond)
```

Create the data.cont data frame.

```
> data.cont <- data.frame(siteID=NRSA_2009$siteID,
+                           Log_Total_Phosphorus=log10(NRSA_2009$PTL+1),
+                           Log_Total_Nitrogen=log10(NRSA_2009$NTL+1),
+                           Benthic_MMI=NRSA_2009$Benthic_MMI)
```

Calculate change estimates.

```
> Change_Estimates <- change.analysis(sites, repeats, subpop, design, data.cat,
+    data.cont, test=c("mean", "median"))

During execution of the program, 37 warning messages were generated.  The warning
messages are stored in a data frame named 'warn.df'.  Enter the following
command to view the warning messages: warnprnt()
To view a subset of the warning messages (say, messages number 1, 3, and 5),
enter the following command: warnprnt(m=c(1,3,5))
```

Like other functions in the spsurvey package, the change.analysis function generates warning messages when certain situations are encountered in the data. When warning messages are generated, the functions print a message to the R console window stating the number of warning messages and explaining the procedure for recovering the messages. The call to the change.analysis function generated thirty-seven warning messages. These messages fall into two categories: (1) cases where the number of repeat visit sites was less than two and (2) cases where a category level was not present among the repeat visit sites in one of the surveys. For both cases, covariance among the revisited sites was not included in calculation of the standard error estimate. The warnprnt function is used to display two of the warning messages.

Display warning messages 1 and 3.

```
> warnprnt(m = c(1, 3))

Warning Message 1
Function: change.est
Population Type: Stream_Size
Subpopulation: Large
Indicator: Nitrogen_Condition
Warning: The number of nonmissing repeat visit sites was less than two in one of the
surveys.
Action: Covariance among the revisited sites was not included in calculation of
the standard error estimate.

Warning Message 3
Function: changevar.prop
Population Type: Western_Mountains
Subpopulation: Western Mountains
Indicator: Benthic_MMI_Condition
Warning: Category level "Not Assessed" was not present among the repeat visit sites
in one of the surveys.
Action: Covariance among the repeat visit sites was not included in calculation of
the standard error estimate.
```

The change estimates are displayed using the print function. For categorical response variables and continuous response variables using the median, change estimates are printed for the complete set of sites only. For continuous response variables using the mean, all change estimates are printed. The object produced by change.analysis is a list composed of three data frames. The first data frame, named catsum, contains estimates for categorical response variables. The second data frame, named contsum_mean, contains estimates for continuous response variables using the mean. The third data frame, named contsum_median, contains estimates for continuous response variables using the median. The catsum and contsum_median data frames will be described first. The initial four columns in those data frames identify the population (Type), subpopulation (Subpopulation), response variable (Indicator), and category of the response variable (Category). The next four columns provide results for change estimates using the percentage scale: the change estimate (DiffEst.P), standard error of the estimate (StdError.P), lower confidence bound (LCB95Pct.P), and upper confidence bound (UCB95Pct.P). Argument conf for change.analysis allows control of the confidence bound level. The default value for conf is 95, hence the column names for confidence bounds contain the value 95. Supplying a different value to the conf argument will be reflected in the confidence bound names. Confidence bounds are obtained using the standard error and the Normal distribution multiplier corresponding to the confidence level. The next four columns provide results for change estimates using the size (units) scale: the change estimate (DiffEst.U), standard error of the estimate (StdError.U), lower confidence bound (LCB95Pct.U), and upper confidence bound (UCB95Pct.U). For this data, the units are kilometers of stream length. The next nine columns provide estimates for survey one: the first column is the number of response values for a category (NResp); the next four columns contain survey one estimates, standard errors, and confidence bounds in the percentage scale; and the final four columns contain survey one estimates, standard errors, and confidence bounds in the units scale. The final nine columns of the catsum data frame provide estimates for survey two using the format described for survey one.

Description of the contsum_mean data frame follows. The initial four columns in that data frame identify the population (Type), subpopulation (Subpopulation), response variable (Indicator), and statistic employed for the change estmate (Statistic). The Statistic column contains the value "Mean" as a reminder that change estimates for continuous response variable use the mean. The next four columns provide results for the change estimates: the change estimate (DiffEst), standard error of the estimate (StdError), lower confidence bound (LCB95Pct), and upper confidence bound (UCB95Pct). The next five columns provide estimates for survey one: the first column is the number of response values for a category (NResp); the next four columns contain survey one estimates, standard errors, and confidence bounds. The final five columns of the contsum_mean data frame provide estimates for survey two using the format described for survey one.

```
> # Print Western Mountains change estimates for categorical variables
> print(subset(Change_Estimates$catsum, Type == "Western_Mountains"))

               Type     Subpopulation             Indicator     Category
1  Western_Mountains Western Mountains    Nitrogen_Condition         Fair
2  Western_Mountains Western Mountains    Nitrogen_Condition         Good
3  Western_Mountains Western Mountains    Nitrogen_Condition         Poor
10 Western_Mountains Western Mountains  Phosphorus_Condition         Fair
11 Western_Mountains Western Mountains  Phosphorus_Condition         Good
12 Western_Mountains Western Mountains  Phosphorus_Condition         Poor
19 Western_Mountains Western Mountains Benthic_MMI_Condition         Fair
20 Western_Mountains Western Mountains Benthic_MMI_Condition         Good
21 Western_Mountains Western Mountains Benthic_MMI_Condition Not Assessed
22 Western_Mountains Western Mountains Benthic_MMI_Condition         Poor
    DiffEst.P StdError.P LCB95Pct.P UCB95Pct.P  DiffEst.U StdError.U
1  -8.5432080   3.810749 -16.012138  -1.074278 -17946.688   8395.978
2   8.0514935   4.619531  -1.002621  17.105608  21684.775  16484.007
```

3	0.4917145	3.251915	-5.881922	6.865351	2026.684	7167.314
10	-8.0018563	3.842896	-15.533795	-0.469918	-16614.900	8735.346
11	-12.0570460	5.499675	-22.836211	-1.277881	-23754.653	14805.495
12	20.0589023	5.143497	9.977833	30.139972	46134.325	12423.393
19	0.4641174	5.209334	-9.745990	10.674225	2633.944	13136.374
20	3.1916027	5.386772	-7.366276	13.749482	10016.622	13816.453
21	-0.6911747	1.273905	-3.187982	1.805633	-1470.634	2840.759
22	-2.9645454	3.397343	-9.623216	3.694125	-5415.160	7693.388

	LCB95Pct.U	UCB95Pct.U	NResp_1	Estimate.P_1	StdError.P_1	LCB95Pct.P_1
1	-34402.502	-1490.8736	118	23.563946	2.610170	18.44811
2	-10623.285	53992.8360	303	60.554135	2.706990	55.24853
3	-12020.993	16074.3613	101	15.881919	1.646566	12.65471
10	-33735.863	506.0627	119	25.445973	2.796803	19.96434
11	-52772.889	5263.5834	315	60.551675	2.842622	54.98024
12	21784.922	70483.7282	88	14.002353	1.934169	10.21145
19	-23112.877	28380.7644	112	27.497661	2.781613	22.04580
20	-17063.127	37096.3719	262	48.649879	2.801831	43.15839
21	-7038.419	4097.1511	3	1.582266	1.012512	0.00000
22	-20493.924	9663.6033	145	22.270194	2.334555	17.69455

	UCB95Pct.P_1	Estimate.U_1	StdError.U_1	LCB95Pct.U_1	UCB95Pct.U_1	NResp_2
1	28.679786	51889.065	5996.625	40135.90	63642.234	30
2	65.859737	133343.431	8129.499	117409.91	149276.957	76
3	19.109130	34972.831	3513.873	28085.77	41859.896	40
10	30.927605	56033.388	6798.708	42708.17	69358.609	34
11	66.123112	133338.013	6904.461	119805.52	146870.509	51
12	17.793254	30833.927	4439.806	22132.07	39535.786	61
19	32.949522	60551.314	6778.412	47265.87	73836.757	29
20	54.141366	107129.625	6320.259	94742.14	119517.106	66
21	3.566754	3484.235	2255.171	0.00	7904.288	1
22	26.845839	49040.154	5477.911	38303.65	59776.661	50

	Estimate.P_2	StdError.P_2	LCB95Pct.P_2	UCB95Pct.P_2	Estimate.U_2
1	15.0207384	2.9277034	9.282545	20.75893	33942.38
2	68.6056284	3.9698939	60.824779	76.38648	155028.21
3	16.3736332	2.9533868	10.585102	22.16216	36999.52
10	17.4441164	2.7560875	12.042284	22.84595	39418.49
11	48.4946287	5.0086922	38.677772	58.31148	109583.36
12	34.0612550	4.9066246	24.444447	43.67806	76968.25
19	27.9617781	4.6008866	18.944206	36.97935	63185.26
20	51.8414817	4.7868394	42.459449	61.22351	117146.25
21	0.8910915	0.7730795	0.000000	2.40630	2013.60
22	19.3056487	2.6390704	14.133166	24.47813	43624.99

	StdError.U_2	LCB95Pct.U_2	UCB95Pct.U_2
1	6203.537	21783.67	46101.087
2	15236.562	125165.09	184891.320
3	6561.709	24138.80	49860.229

```
10     5753.495     28141.84    50695.131
11    14240.877     81671.75   137494.966
12    11908.016     53628.97   100307.534
19    11717.757     40218.88    86151.639
20    12850.603     91959.53   142332.968
21     1727.460         0.00     5399.359
22     5751.028     32353.19    54896.801

> # Print change estimates for continuous variables using the mean
> print(Change_Estimates$contsum_mean)

              Type     Subpopulation            Indicator Statistic
1 Western_Mountains Western Mountains Log_Total_Phosphorus      Mean
2       Stream_Size             Large Log_Total_Phosphorus      Mean
3       Stream_Size             Small Log_Total_Phosphorus      Mean
4 Western_Mountains Western Mountains   Log_Total_Nitrogen      Mean
5       Stream_Size             Large   Log_Total_Nitrogen      Mean
6       Stream_Size             Small   Log_Total_Nitrogen      Mean
7 Western_Mountains Western Mountains          Benthic_MMI      Mean
8       Stream_Size             Large          Benthic_MMI      Mean
9       Stream_Size             Small          Benthic_MMI      Mean
       DiffEst    StdError    LCB95Pct    UCB95Pct NResp_1 Estimate_1
1   0.28048779  0.05511323   0.1724678  0.38850773     522   1.077315
2   0.06992848  0.16844500  -0.2602176  0.40007461       8   1.592550
3   0.28496217  0.05607767   0.1750520  0.39487238     514   1.067896
4  -0.13898630  0.04683131  -0.2307740 -0.04719862     522   2.095254
5   0.18594596  0.15987119  -0.1273958  0.49928775       8   2.291269
6  -0.14385707  0.04793736  -0.2378126 -0.04990158     514   2.091671
7   0.66121946  1.53852011  -2.3542245  3.67666346     519  49.014131
8 -13.22855538 10.14257203 -33.1076313  6.65052052       8  44.325181
9   0.87835322  1.54413067  -2.1480873  3.90479371     511  49.101251
  StdError_1 LCB95Pct_1 UCB95Pct_1 NResp_2 Estimate_2 StdError_2 LCB95Pct_2
1 0.02708917   1.024221   1.130409     146   1.357803 0.05122909   1.257396
2 0.15404633   1.290625   1.894475      24   1.662479 0.06814282   1.528921
3 0.02724145   1.014504   1.121289     122   1.352859 0.05216151   1.250624
4 0.01536527   2.065139   2.125369     146   1.956268 0.04603932   1.866032
5 0.14757094   2.002035   2.580503      24   2.477215 0.06149485   2.356687
6 0.01552844   2.061236   2.122106     122   1.947814 0.04702752   1.855641
7 1.03521685  46.985144  51.043119     145  49.675351 1.25700084  47.211675
8 8.86140780  26.957140  61.693221      24  31.096625 4.93429015  21.425594
9 1.04319033  47.056636  51.145866     121  49.979604 1.25059598  47.528481
  UCB95Pct_2
1   1.458210
2   1.796036
```

```
3   1.455093
4   2.046503
5   2.597743
6   2.039986
7  52.139027
8  40.767656
9  52.430727

> # Print change estimates for continuous variables using the median
> print(subset(Change_Estimates$contsum_median, Type == "Western_Mountains"))

                Type      Subpopulation           Indicator           Category
1  Western_Mountains Western Mountains Log_Total_Phosphorus Greater_Than_Median
2  Western_Mountains Western Mountains Log_Total_Phosphorus    Less_Than_Median
7  Western_Mountains Western Mountains   Log_Total_Nitrogen Greater_Than_Median
8  Western_Mountains Western Mountains   Log_Total_Nitrogen    Less_Than_Median
13 Western_Mountains Western Mountains          Benthic_MMI Greater_Than_Median
14 Western_Mountains Western Mountains          Benthic_MMI    Less_Than_Median
    DiffEst.P StdError.P LCB95Pct.P UCB95Pct.P   DiffEst.U StdError.U
1   19.993073   5.329139   9.548152  30.437994  48065.0542   15968.94
2  -19.993073   5.329139 -30.437994  -9.548152 -42300.2824   12852.20
7   -9.172204   5.218530 -19.400334   1.055926 -17837.0098   11977.46
8    9.172204   5.218530  -1.055926  19.400334  23601.7816   16267.11
13   1.921212   5.488400  -8.835855  12.678278   7953.6486   14054.77
14  -1.921212   5.488400 -12.678278   8.835855   -718.2427   14693.78
   LCB95Pct.U UCB95Pct.U NResp_1 Estimate.P_1 StdError.P_1 LCB95Pct.P_1
1   16766.500  79363.608     270     50.07461     2.796763     44.59306
2  -67490.127 -17110.438     252     49.92539     2.796763     44.44383
7  -41312.402   5638.382     265     50.12217     2.831757     44.57202
8   -8281.173  55484.736     257     49.87783     2.831757     44.32769
13 -19593.202  35500.499     264     50.45979     2.809366     44.95353
14 -29517.523  28081.038     255     49.54021     2.809366     44.03396
   UCB95Pct.P_1 Estimate.U_1 StdError.U_1 LCB95Pct.U_1 UCB95Pct.U_1 NResp_2
1      55.55617     110267.0     7655.957     95261.56     125272.4     113
2      55.40694     109938.4     6795.463     96619.50     123257.2      33
7      55.67231     110371.7     6862.229     96921.96     123821.4      80
8      55.42798     109833.6     7717.698     94707.24     124960.1      66
13     55.96604     109357.0     6322.352     96965.42     121748.6      67
14     55.04647     107364.1     7836.067     92005.68     122722.5      78
   Estimate.P_2 StdError.P_2 LCB95Pct.P_2 UCB95Pct.P_2 Estimate.U_2
1      70.06769     4.536281     61.17674     78.95863    158332.02
2      29.93231     4.536281     21.04137     38.82326     67638.08
7      40.94996     4.383401     32.35865     49.54127     92534.67
8      59.05004     4.383401     50.45873     67.64135    133435.43
```

```
13     52.38100     4.714870     43.14002     61.62197    117310.65
14     47.61900     4.714870     38.37803     56.85998    106645.85
   StdError.U_2 LCB95Pct.U_2 UCB95Pct.U_2
1     14014.046    130864.99    185799.04
2     10908.743     46257.34     89018.82
7      9816.791     73294.11    111775.23
8     14319.779    105369.18    161501.68
13    12552.471     92708.26    141913.04
14    12429.933     82283.63    131008.07

>
```

The write.csv function is used to store the change estimates as comma-separated value (csv) files. Files in csv format can be read by programs such as Microsoft Excel. The three data frames created by the change.analysis function are stored in separate files.

```
> write.csv(Change_Estimates$catsum, file="Change_Estimates_Categorical.csv", row.names
> write.csv(Change_Estimates$contsum_mean, file="Change_Estimates_Continuous_Mean.csv",
> write.csv(Change_Estimates$contsum_median, file="Change_Estimates_Continuous_Median.c
```

References

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