

Luckiamute Watershed Survey Design

This document is presented as an example and recommended format for documenting a GRTS design. It is recommended that this example be followed, prior to initiating efforts to produce a design to meet a particular objective. Due to the randomization scheme within `psurvey.design`, each execution of the R code will produce a different set of sampling points and output files and will not exactly reproduce the example files.

Materials needed for this example:

R version 2.0 or later

`psurvey.design` package

R script or text file: `luckiamutedesign.R`

Frame materials as ArcGis files:

`luck-ash.dbf`

`luck-ash.prj`

`luck-ash.sbn`

`luck-ash.sbx`

`luck-ash.shp`

`luck-ash..shx`

Example includes:

Designs		files produced
1	Equal Sites – 50 sites, equal wts	Equal Sites.dbf Equal Sites.prj Equal Sites.shp Equal Sites.shx
2	Stratified Sites – Perennial 50 sites, Oversample 50 sites, Intermittent 50 sites, Oversample 50 sites.	Stratified Sites.dbf Stratified Sites.prj Stratified Sites.shp Stratified Sites.shx)
3	Unequal Sites – Perennial w/ 3 Strahler categories (25,25,25 sites) plus Oversample (36) – Intermittent w/ 3 Strahler categories (17,5,3 sites)	Unequal Sites.dbf Unequal Sites.prj Unequal Sites.shp Unequal Sites.shx
4	Panel Over Time Sites – Perennial w/ 3 Strahler categories (17,17,16), Oversample (50) – Intermittent w/ 3 Strahler (17,5,3)	Panel Sites.dbf Panel Sites.prj Panel Sites.shp Panel Sites.shx)

An ArcGis map is included, Luckiamute Design, as a visual aid for the resulting designs for this example.

[Design File Documentation would routinely begin here:](#)

Contact:

Name
 address of person requesting the design
 Voice:
 Fax:
 email:

Description of Sample Design

Survey Design: A Generalized Random Tessellation Stratified (GRTS) survey design for a linear stream resource is used for this example. The GRTS design includes reverse hierarchical ordering of the selected sites.

Target population: All perennial and intermittent streams/rivers in the Luckiamute Watershed Council basin. Watershed boundaries defined by Luckiamute Watershed Council.

Sample Frame: GIS stream network coverage from PNW portion of RF3. [Example files: luck-ash, including Luck_map (ArcGis map)]

Sample Frame Summary

The total stream length (km) is 822.4882 km (including intermittent).

Strahler Order	Length (km)	
	Perennial	Intermittent
0	10.64198	10.825986
1	189.88902	294.699772
2	133.10086	20.512487
3	60.84859	3.027805
4	68.24550	0
5	30.69616	0
3+4+5	159.79025	3.027805

Multi-density categories: Strahler order categories: 1st, 2nd, and 3rd+

I. Equal Probability GRTS Survey Design

Stratification: None

Expected sample size: 50 sites

Oversample: None

Site Use: The base design has 50 sites. Sites are listed in SiteID order and must be used in that order. All sites that occur prior to the last site used must have been evaluated for use and then either sampled or reason documented why that site was not used.

Site Selection Summary

Equal Probability	Strahler Order 1	Strahler Order 2	Strahler Order 3+
Perennial	11	7	14
Intermittent	16	2	0
Total	27	9	14

II. Stratified GRTS Survey Design with Over Sample

Stratification: Stratify by Perennial and Intermittent streams.

Expected sample size: 50 sites for Perennial stratum and 50 sites for Intermittent stratum, plus in each stratum, sites selected with equal probability within stratum.

Oversample: 50 sites for Perennial stratum and 50 sites for Intermittent stratum.

Site Use: The stratified design has 50 sites, plus an over sample of 50 sites, in each stratum. Sites are listed in SiteID order and must be used in that order. All sites that occur prior to the last site used must have been evaluated for use and then either sampled or reason documented why that site was not used.

Site Selection Summary

Stratified	Strahler 0	Strahler 1	Strahler 2	Strahler 3+	Total
Perennial	1	17	17	15	50
Intermittent	1	43	6	0	50
Over Sample					
Perennial	1	20	10	19	50
Intermittent	3	42	5	0	50

III. Unequal Probability GRTS Survey Design with Over Sample and Stratification

Stratification: Stratify by Perennial and Intermittent streams.

Expected sample size: 75 sites with approximately an equal number within each Strahler order category for Perennial stratum. For Intermittent stratum, 25 sites with an expected sample size of 17, 5, and 3 for Strahler order categories 1st, 2nd, and 3rd+, respectively.

Oversample: 36 sites for Perennial stratum and none for Intermittent stratum.

Site Use: The unequal probability design has 75 sites, plus an over sample of 36 sites, for the Perennial stratum and 25 sites for the Intermittent stratum. Sites are listed in

SiteID order and must be used in that order. All sites that occur prior to the last site used must have been evaluated for use and then either sampled or reason documented why that site was not used.

Site Selection Summary

Unequal	Strahler 0+1	Strahler 2	Strahler 3+	Total
Perennial	18	32	25	75
Intermittent	16	5	4	25
Over Sample				
Perennial	12	11	13	36

IV. Panels for Surveys Over Time with Unequal Probability GRTS Design with Over Sample and Stratification.

Stratification: Stratify by Perennial and Intermittent streams.

Panels: For Perennial stratum, three panels. Year1 sites will be visited in year 1 and then year 3, year 5, etc. Year2 sites will be visited in year 2, year 4, year 6, etc. YearAll sites will be visited every year. Intermittent stratum has a single panel of sites that will be visited only once.

Expected sample size: 50 sites with approximately an equal number within each Strahler order category for Perennial stratum. For Intermittent stratum, 25 sites with an expected sample size of 17, 5, and 3 for Strahler order categories 1st, 2nd, and 3rd+, respectively.

Oversample: 50 sites for Perennial stratum and none for Intermittent stratum.

Site Use: The base design has 50 sites in Perennial stratum. Sites are listed in SiteID order and must be used in that order. All sites that occur prior to the last site used must have been evaluated for use and then either sampled or reason documented why that site was not used. As an example, if 30 sites are to be sampled in the watershed, then the first 30 sites in SiteID order would be used.

Site Selection Summary

Perennial Sites

Panel	Strahler 0+1	Strahler 2	Strahler 3+	Total
Year1	7	4	6	17
Year2	7	4	6	17
YearAll	6	4	6	16
OverSamp	15	17	18	50
Sum	35	29	36	100

Intermittent Sites

Panel	Strahler 0+1	Strahler 2	Strahler 3+	Total
YearOnce	17	5	3	25

Description of Sample Design Output:

The sites are provided as a shapefile that can be read directly by ArcMap. The dbf file associated with the shapefile may be read by Excel.

The dbf file has the following variable definitions:

Variable Name	Description
SiteID	Unique site identification (character)
arcid	Internal identification number
x	Albers x-coordinate
y	Albers y-coordinate
mdcaty	Multi-density categories used for unequal probability selection
weight	Weight (in meters), inverse of inclusion probability, to be used in statistical analyses
stratum	Strata used in the survey design
panel	Identifies base sample by panel name and Oversample by OverSamp
auxiliary variables	Remaining columns are from the sample frame provided

Luckiamute Design is an ArcMap that displays the stream network and sampling sites for the 4 example designs.

Projection Information

```
PROJCS["Clarke_1866_Albers",
GEOGCS["GCS_Clarke_1866",
DATUM["D_Clarke_1866",
SPHEROID["Clarke_1866",6378206.4,294.9786982]],
PRIMEM["Greenwich",0.0],
UNIT["Degree",0.0174532925199433]],
PROJECTION["Albers"],
PARAMETER["False_Easting",0.0],
PARAMETER["False_Northing",0.0],
PARAMETER["Central_Meridian",-96.0],
PARAMETER["Standard_Parallel_1",29.5],
PARAMETER["Standard_Parallel_2",45.5],
PARAMETER["Latitude_Of_Origin",23.0],
UNIT["Meter",1.0]]
```

Evaluation Process

The survey design weights that are given in the design file assume that the survey design is implemented as designed. That is, only the sites that are in the base sample (not in the over sample) are used, and all of the base sites are used. This may not occur due to (1) sites not being a member of the target population, (2) landowners deny access to a site, (3) a site is physically inaccessible (safety reasons), or (4) site not sampled for other reasons. Typically, users prefer to replace sites that can not be sampled with other sites to achieve the sample size planned. The site replacement process is described above. When sites are replaced, the survey design weights are no longer correct and must be adjusted. The weight adjustment requires knowing what happened to each site in the base design and the over sample sites. EvalStatus is initially set to "NotEval" to indicate that the site has yet to be evaluated for sampling. When a site is evaluated for sampling, then the EvalStatus for the site must be changed. Recommended codes are:

EvalStatus Code	Name	Meaning
TS	Target Sampled	site is a member of the target population and was sampled
LD	Landowner Denial	landowner denied access to the site
PB	Physical Barrier	physical barrier prevented access to the site
NT	Non-Target	site is not a member of the target population
NN	Not Needed	site is a member of the over sample and was not evaluated for sampling
Other codes		Many times useful to have other codes. For example, rather than use NT, may use specific codes indicating why the site was non-target.

Statistical Analysis

Any statistical analysis of data must incorporate information about the monitoring survey design. In particular, when estimates of characteristics for the entire target population are computed, the statistical analysis must account for any stratification or unequal probability selection in the design. Procedures for doing this are available from the Aquatic Resource Monitoring web page given in the bibliography. A statistical analysis library of functions is available from the Aquatic Resource Monitoring web page to do common population estimates in the statistical software environment R (psurvey.analysis)

ARM Web Page: <http://www.epa.gov/nheerl/arm>

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