ch03output

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```
# Code from Chapter 3 of R Companion for Sampling: Design and Analysis by Yan Lu
# and Sharon L. Lohr
# All code is presented for educational purposes only and without warranty.

##### Install the R packages needed for the chapter

library(survey)
```

```
## Loading required package: grid

## Loading required package: Matrix

## Loading required package: survival

##
## Attaching package: 'survey'

## The following object is masked from 'package:graphics':
##
##     dotchart
```

```
library(sampling)
```

```
##
## Attaching package: 'sampling'

## The following objects are masked from 'package:survival':
##
##     cluster, strata
```

```
library(SDAResources)

########## Allocation Methods ##########

##### Example 3.2, Compute allocations for stratified samples from agpop

data(agpop)  # load the data set
names(agpop) # list the variable names
```

```
##  [1] "county"   "state"    "acres92"  "acres87"  "acres82"  "farms92"
##  [7] "farms87"  "farms82"  "largef92" "largef87" "largef82" "smallf92"
## [13] "smallf87" "smallf82" "region"
```

```r
print.data.frame(head(agpop))  # take a look at the first 6 obsns
```

```
##                  county state acres92 acres87 acres82 farms92 farms87 farms82
## 1 ALEUTIAN ISLANDS AREA    AK  683533  726596  764514      26      27      28
## 2        ANCHORAGE AREA    AK   47146   59297  256709     217     245     223
## 3        FAIRBANKS AREA    AK  141338  154913  204568     168     175     170
## 4           JUNEAU AREA    AK     210     214     127       8       8      12
## 5  KENAI PENINSULA AREA    AK   50810   85712   98035      93     119     137
## 6        AUTAUGA COUNTY    AL  107259  116050  145044     322     388     453
##   largef92 largef87 largef82 smallf92 smallf87 smallf82 region
## 1       14       16       20        6        4        1      W
## 2        9       10       11       41       52       38      W
## 3       25       28       21       12       18       25      W
## 4        0        0        0        5        4        8      W
## 5        9       18       17       12       18       19      W
## 6       25       32       32        8       19       17      S
```

```r
nrow(agpop)  #number of rows, 3078
```

```
## [1] 3078
```

```r
unique(agpop$region) # take a look at the four regions, NC, NE, S, W
```

```
## [1] "W"  "S"  "NE" "NC"
```

```r
table(agpop$region)  # number of counties in each stratum
```

```
##
##   NC   NE    S    W
## 1054  220 1382  422
```

```r
### Proportional allocation

stratasize <- table(agpop$region)
stratasize
```

```
##
##   NC   NE    S    W
## 1054  220 1382  422
```

```r
propalloc <- 300*stratasize/sum(stratasize)
propalloc
```

```
##
##       NC       NE        S        W
## 102.7290  21.4425 134.6979  41.1306
```

```r
# Round to nearest integer
propalloc_int <- round(propalloc)
propalloc_int
```

```
##
##  NC  NE   S   W
## 103  21 135  41
```

```r
sum(propalloc_int) # check that stratum sample sizes sum to 300
```

```
## [1] 300
```

```r
### Neyman allocation

stratvar <- c(29618183543,7647472708,53587487856,396185950266) #numbers are from Table 3.1
# Make sure the stratum variances in stratvar are in the same
#  order as the table in stratasize
neymanalloc <- 300*(stratasize*sqrt(stratvar))/sum(stratasize*sqrt(stratvar))
neymanalloc
```

```
##
##         NC         NE          S          W
##  69.218781   7.341516 122.079817 101.359886
```

```r
neymanalloc_int <- round(neymanalloc)
neymanalloc_int
```

```
##
##  NC  NE   S   W
##  69   7 122 101
```

```r
sum(neymanalloc_int)
```

```
## [1] 299
```

```r
### Optimal allocation

relcost <- c(1.4,1.0,1.0,1.8)
# Make sure the relative costs in relcost are in same
# order as the table in stratasize
optalloc <- 300*(stratasize*sqrt(stratvar/relcost))/sum(stratasize*sqrt(stratvar/relcost))
optalloc
```

```
##
##        NC        NE         S         W
##  66.61135   8.35938 139.00556  86.02371
```

```
optalloc_int <- round(optalloc)
optalloc_int
```

```
##
##  NC  NE   S   W
##  67   8 139  86
```

```
sum(optalloc_int)
```

```
## [1] 300
```

```
########## Selecting a Stratified Random Sample ##########

##### Example 3.2, Select a stratified sample from agpop

### Use the sample function with each stratum

# Select an SRS without replacement from each region with proportional allocation
# with total size n=300
regionname <- c("NC","NE","S","W")
# Make sure sampsize has same ordering as regionname
sampsize <- c(103,21,135,41)
# Set the seed for random number generation
set.seed(108742)
N<-nrow(agpop)
index <- NULL
for (i in 1:length(sampsize)) {
  index <- c(index,sample((1:N)[agpop$region==regionname[i]],
                          size=sampsize[i],replace=F))
}
index
```

```
##   [1] 1316 2034  864  553 1738 1325  921 2097  894 1870 1322 1233  562  746 1212
##  [16] 1443 1206 2342  558  753 1334  946 1790 2057  819 2026 1448 2371 2343  813
##  [31] 1771 2348 1430  755 1373 1346  604 1404 1365  943 2939  958 1474 2964  944
##  [46] 1268 1256 2018  738  763 2046 1436  616  730 1301 2397 2398 1742  887 2098
##  [61]  557 2069 2993 1402 1385 1415 1841  773 1239  802 1825 1263 2357  833 1446
##  [76] 1732 1815 1245 1477 2990  796 1431 2929  823 2347 2968 1753 1342  569 1862
##  [91] 2396 1358 1759  732  621 2938 2078 1355 1778  535 1326  745 2982 2247 1901
## [106] 2263 2877 1963 2217 2000  287 1156 2252 2246 1970 1955 1157 1898 1888 2265
## [121] 2232 1193 1992 1965 1524 2828 2598 2815 2683 2427  424 2432 2440  514 1708
## [136] 2172 2654 2849 2430  306   74 1135 2818  359 2448  313 2460 2417  360  971
## [151] 2115 1660 2429  135  404  375 3044  139 3048 2288 1493 3017  111  416 1083
## [166] 1054   67 3050  365   37 2787 1520 2116 1072 1120  378 1522 1662 2324 2782
## [181] 2690  989 1172 1023 2320   55 2438 3026 1168 1017 2523 3043  467  969 2481
## [196]  519  496 2717 2475 2615 2568   22  131 2468 3014  347  982 2304 1564 2861
## [211] 2566 1530 2549 2807 2811 1505 2166 1501  458 2500 1049  338 2501 2168   11
## [226] 2862 1103 2303   86 2682  459 1701 2656  101 2713 2806 2476 2721 1671 2573
## [241]   59  125 3005 1685 1171 3039 2693 1053   24 1125 1700 2813 1041 3018 1656
## [256]  129  421 2477 2645 2915  168  653  252  187 2914 1584 3070 2895 2203  250
## [271] 1579 1623    3  197 2751 3062 1919  269 2904  234 2192  267 3065 2190  240
## [286] 2758 2198  212 2208  232 1927 1586 2927  161 1903  210 1602 2773 2760 1573
```

```
strsample<-agpop[index,]
# Check that we have the correct stratum sample sizes
table(strsample$region)
```

```
##
##  NC  NE   S   W
## 103  21 135  41
```

```
# Print the first six rows of the sample to see
strsample[1:6,]
```

```
##                        county state acres92 acres87 acres82 farms92 farms87
## 1316             ISANTI COUNTY    MN  131563  142998  153003     680     817
## 2034          DEFIANCE COUNTY    OH  196759  206905  210781     830     987
## 864            ATCHISON COUNTY    KS  245099  233619  234730     686     694
## 553         DES MOINES COUNTY    IA  192467  210843  224770     681     753
## 1738              DUNN COUNTY    ND 1352738 1358843 1397141     650     733
## 1325 LAKE OF THE WOODS COUNTY    MN  103665  118959  119296     176     222
##      farms82 largef92 largef87 largef82 smallf92 smallf87 smallf82 region
## 1316     947       18       14        8       14       26       34     NC
## 2034    1033       25       20       18       40       50       50     NC
## 864      768       55       42       41       48       48       65     NC
## 553      815       33       30       24       56       56       72     NC
## 1738     697      358      368      361       19       13       34     NC
## 1325     230       30       35       26        4        4        1     NC
```

```
### Use the strata function from the sampling package

# Sort the population by stratum
agpop2<-agpop[order(agpop$region),]
# Use the strata function to select the units for the sample
# Make sure size argument has same ordering as the stratification variable
index2<-strata(agpop2,stratanames=c("region"),size=c(103,21,135,41),
               method="srswor")
head(index2)
```

```
##    region ID_unit       Prob Stratum
## 2      NC       2 0.09772296       1
## 9      NC       9 0.09772296       1
## 27     NC      27 0.09772296       1
## 36     NC      36 0.09772296       1
## 42     NC      42 0.09772296       1
## 43     NC      43 0.09772296       1
```

```
table(index2$region)  # look at number of counties selected within each region
```

```
##
##  NC  NE   S   W
## 103  21 135  41
```

```
head(index2)
```

```
##    region ID_unit       Prob Stratum
## 2      NC       2 0.09772296       1
## 9      NC       9 0.09772296       1
## 27     NC      27 0.09772296       1
## 36     NC      36 0.09772296       1
## 42     NC      42 0.09772296       1
## 43     NC      43 0.09772296       1
```

```
strsample2<-getdata(agpop2,index2) # extract the sample
head(strsample2)
```

```
##              county state acres92 acres87 acres82 farms92 farms87 farms82
## 526    ADAMS COUNTY    IA  239800  243607  254071     643     688     737
## 533   BREMER COUNTY    IA  236668  235086  250402    1058    1140    1287
## 551  DECATUR COUNTY    IA  261494  278714  300684     648     715     769
## 560  FREMONT COUNTY    IA  302352  308796  306786     596     719     771
## 566   HARDIN COUNTY    IA  332358  337990  355823     986    1065    1208
## 567 HARRISON COUNTY    IA  399155  387190  408601     919    1024    1192
##     largef92 largef87 largef82 smallf92 smallf87 smallf82 region ID_unit
## 526       38       32       21       40       50       33     NC       2
## 533       25       18       11       96      116      109     NC       9
## 551       52       54       56       20       34       37     NC      27
## 560       91       72       51       37       59       50     NC      36
## 566       56       36       42       90      115      132     NC      42
## 567       88       62       51       60       60       66     NC      43
##           Prob Stratum
## 526 0.09772296       1
## 533 0.09772296       1
## 551 0.09772296       1
## 560 0.09772296       1
## 566 0.09772296       1
## 567 0.09772296       1
```

```
# Calculate the sampling weights
# First check that no probabilities are 0
sum(strsample2$Prob<=0)
```

```
## [1] 0
```

```
strsample2$sampwt<-1/strsample2$Prob
# Check that the sampling weights sum to the population sizes for each stratum
tapply(strsample2$sampwt,strsample2$region,sum)
```

```
##   NC   NE    S    W
## 1054  220 1382  422
```

```
########## Computing Statistics from a Stratified Random Sample ##########
```

```
##### Example 3.2 and 3.6

data(agstrat)
names(agstrat)  # list the variable names
```

```
##  [1] "county"   "state"    "acres92"  "acres87"  "acres82"  "farms92"
##  [7] "farms87"  "farms82"  "largef92" "largef87" "largef82" "smallf92"
## [13] "smallf87" "smallf82" "region"   "rn"       "strwt"
```

```
agstrat[1:6,1:8] # take a look at the first 6 obsns from columns 1 to 8
```

```
##     county state acres92 acres87 acres82 farms92 farms87 farms82
## 1 PIERCE C    NE  297326  332862  319619     725     857     865
## 2 JENNINGS    IN  124694  131481  139111     658     671     751
## 3 WAYNE CO    OH  246938  263457  268434    1582    1734    1866
## 4 VAN BURE    MI  206781  190251  197055    1164    1278    1464
## 5  OZAUKEE    WI   78772   85201   89331     448     483     527
## 6 CLEARWAT    MN  210897  229537  213105     583     699     693
```

```
nrow(agstrat)  # number of rows, 300
```

```
## [1] 300
```

```
unique(agstrat$region) # take a look at the four regions, NC, NE, S, W
```

```
## [1] "NC" "NE" "S"  "W"
```

```
table(agstrat$region)  # number of counties in each stratum
```

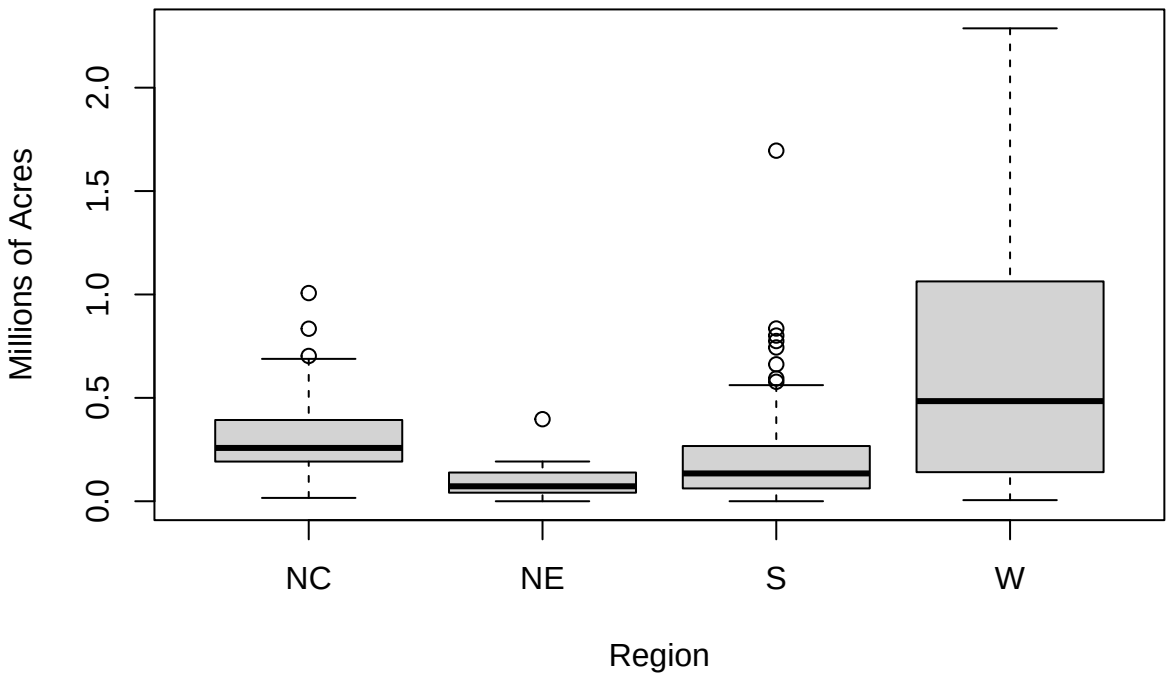
```
##
##  NC  NE   S   W
## 103  21 135  41
```

```
# check that the sum of the weights equals the population size
sum(agstrat$strwt)  #3078
```

```
## [1] 3078
```

```
### Draw a boxplot of the stratified random sample

boxplot(acres92/10^6 ~ region, xlab = "Region", ylab = "Millions of Acres",
        data = agstrat)
```




```
# notice the large variability in western region

### Set up information for the survey design

# create a variable containing population stratum sizes, for use in fpc (optional)
# popsize_recode gives popsize for each stratum
popsize_recode <- c('NC' = 1054, 'NE' = 220, 'S' = 1382, 'W' = 422)
# next statement substitutes 1054 for each 'NC', 220 for 'NE', etc.
agstrat$popsize <- popsize_recode[agstrat$region]
table(agstrat$popsize)  #check the new variable
```

```
##
##  220  422 1054 1382
##   21   41  103  135
```

```
#order data if region is not in order of NC, NE, S, and W, agstrat is already ordered by region
agstrat2<-agstrat[order(agstrat$region),]

# input design information for agstrat
dstr <- svydesign(id = ~1, strata = ~region, weights = ~strwt, fpc = ~popsize,
                  data = agstrat)
dstr
```

```
## Stratified Independent Sampling design
## svydesign(id = ~1, strata = ~region, weights = ~strwt, fpc = ~popsize,
##     data = agstrat)
```

```r
# or you can use
dstr <- svydesign(id = ~1, strata = ~region, fpc = c(rep(1054,103),rep(220,21),
          rep(1382,135),rep(422,41)), weight = ~strwt, data = agstrat)
dstr
```

```
## Stratified Independent Sampling design
## svydesign(id = ~1, strata = ~region, fpc = c(rep(1054, 103),
##     rep(220, 21), rep(1382, 135), rep(422, 41)), weight = ~strwt,
##     data = agstrat)
```

```r
### Calculate the statistics using the design object

# calculate mean, SE and confidence interval
smean<-svymean(~acres92, dstr)
smean
```

```
##           mean    SE
## acres92 295561 16380
```

```r
degf(dstr) # Show the degrees of freedom for the design
```

```
## [1] 296
```

```r
confint(smean, level=.95, df=degf(dstr)) # note that df = n-H = 300-4
```

```
##          2.5 %   97.5 %
## acres92 263325 327796.5
```

```r
# calculate total, SE and CI
stotal<-svytotal(~acres92, dstr)
stotal
```

```
##             total       SE
## acres92 909736035 50417248
```

```r
# calculate confidence intervals using the degrees of freedom
confint(stotal, level=.95,df= degf(dstr))
```

```
##             2.5 %     97.5 %
## acres92 810514350 1008957721
```

```r
### Alternative design specifications

# Get same result if omit weights argument since weight = popsize/n_h
dstrfpc <- svydesign(id = ~1, strata = ~region, fpc = ~popsize, data = agstrat)
svymean(~acres92, dstrfpc)
```

```
##           mean    SE
## acres92 295561 16380
```

```r
# If you include weights but not fpc, get SE without fpc factor
dstrwt <- svydesign(id = ~1, strata = ~region, weights = ~strwt, data = agstrat)
svymean(~acres92, dstrwt)
```

```
##           mean    SE
## acres92 295561 17241
```

```r
### Calculating stratum means and variances

# calculate mean and se of acres92 by regions
svyby(~acres92, by=~region, dstr, svymean, keep.var = TRUE)
```

```
##    region   acres92       se
## NC     NC 300504.16 16107.59
## NE     NE  97629.81 18149.49
## S       S 211315.04 18925.35
## W       W 662295.51 93403.65
```

```r
# calculate total and se of acres92 by regions
svyby(~acres92, ~region, dstr, svytotal, keep.var = TRUE)
```

```
##    region   acres92       se
## NC     NC 316731380 16977399
## NE     NE  21478558  3992889
## S       S 292037391 26154840
## W       W 279488706 39416342
```

```r
# formula calculations, using tapply
# variables sampsize and stratasize were calculated earlier in the chapter
# calculate mean within each region
strmean<-tapply(agstrat$acres92,agstrat$region,mean)
strmean
```

```
##        NC        NE         S         W
## 300504.16  97629.81 211315.04 662295.51
```

```r
# calculate variance within each region
strvar<-tapply(agstrat$acres92,agstrat$region,var)
strvar
```

```
##           NC           NE            S            W
##  29618183543   7647472708  53587487856 396185950266
```

```r
# verify standard errors by direct formula
strse<- sqrt((1-sampsize/stratasize)*strvar/sampsize)
# same standard errors as from svyby
strse
```

```
##
##       NC       NE        S        W
## 16107.59 18149.49 18925.35 93403.65
```

```
### Estimating proportions from a stratified random sample

# Option 1: Use a 0-1 variable and find its mean
# Create variable lt200k
agstrat$lt200k <- rep(0,nrow(agstrat))
agstrat$lt200k[agstrat$acres92 < 200000] <- 1
print.data.frame(head(agstrat))
```

```
##     county state acres92 acres87 acres82 farms92 farms87 farms82 largef92
## 1 PIERCE C    NE  297326  332862  319619     725     857     865       54
## 2 JENNINGS    IN  124694  131481  139111     658     671     751       14
## 3 WAYNE CO    OH  246938  263457  268434    1582    1734    1866       20
## 4 VAN BURE    MI  206781  190251  197055    1164    1278    1464       23
## 5  OZAUKEE    WI   78772   85201   89331     448     483     527        6
## 6 CLEARWAT    MN  210897  229537  213105     583     699     693       34
##   largef87 largef82 smallf92 smallf87 smallf82 region   rn    strwt popsize
## 1       54       42       58       67       48     NC  805 10.23301    1054
## 2       13       14       42       36       38     NC  241 10.23301    1054
## 3       19       16      175      186      184     NC  913 10.23301    1054
## 4       17        9       56       66       55     NC  478 10.23301    1054
## 5        5        5       56       49       48     NC 1028 10.23301    1054
## 6       32       23        8       19       13     NC  496 10.23301    1054
##   lt200k
## 1      0
## 2      1
## 3      0
## 4      0
## 5      1
## 6      0
```

```
# Rerun svydesign because the data set now has a new variable
dstr <- svydesign(id = ~1, strata = ~region, fpc = ~popsize,
  weights = ~strwt, data = agstrat)
# calculate proportion, SE and confidence interval
smeanp<-svymean(~lt200k, dstr)
smeanp
```

```
##           mean     SE
## lt200k 0.51391 0.0248
```

```
confint(smeanp, level=.95,df=degf(dstr))
```

```
##            2.5 %    97.5 %
## lt200k 0.4651188 0.5627107
```

```
# calculate total, SE and CI
stotalp<-svytotal(~lt200k, dstr)
stotalp
```

```
##         total     SE
## lt200k 1581.8 76.318
```

```r
confint(stotalp, level=.95,df=degf(dstr))
```

```
##           2.5 %   97.5 %
## lt200k 1431.636 1732.024
```

```r
# Option 2: Create a factor variable lt200kf
agstrat$lt200kf <- factor(agstrat$lt200k)
# Rerun svydesign because the data set now has a new variable
dstr <- svydesign(id = ~1, strata = ~region, fpc = ~popsize,
                  weights = ~strwt, data = agstrat)
# calculate proportion, SE and confidence interval
smeanp2<-svymean(~lt200kf, dstr)
smeanp2
```

```
##             mean     SE
## lt200kf0 0.48609 0.0248
## lt200kf1 0.51391 0.0248
```

```r
confint(smeanp2, level=.95,df=degf(dstr))
```

```
##              2.5 %    97.5 %
## lt200kf0 0.4372893 0.5348812
## lt200kf1 0.4651188 0.5627107
```

```r
# calculate total, SE and CI
stotalp2<-svytotal(~lt200kf, dstr)
stotalp2
```

```
##           total     SE
## lt200kf0 1496.2 76.318
## lt200kf1 1581.8 76.318
```

```r
confint(stotalp2, level=.95,df=degf(dstr))
```

```
##             2.5 %   97.5 %
## lt200kf0 1345.976 1646.364
## lt200kf1 1431.636 1732.024
```

```r
# Option 3: Construct asymmetric confidence intervals
# calculate proportion and confidence interval with svyciprop
svyciprop(~I(lt200k==1), dstr, method="beta")
```

```
##                       2.5% 97.5%
## I(lt200k == 1) 0.514 0.464  0.56
```