A Forest Inventory ESTimation and Analysis tool

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FIA’s Data and Estimation Tools

FIA DataMart
- Web-based tool to access FIA database through Microsoft Access Database downloads.

Forest Inventory Data Online (FIDO)
- Web-based tool to generate tables and maps of forest attributes without having to know underlying data structure.

EVALIDator
- Web-based or PC tool for producing population estimates with sampling errors.
FIESTA

A research tool for analysts that work in the R statistical programming environment that is based on and validated by existing FIA data and estimation tools.

It is a collection or ‘package’ of R functions that summarize and compile FIA plot data and spatial data for purposes of modeling or estimation.

It is flexible, customizable, and interfaces with other R tools.
Why the party?

We need a flexible estimation engine
That we can use to answer any question
Using ancillary data we think is best
FIA estimates for San Carlos Reservation

Objective:
FIA estimates within San Carlos Reservation – Forest Management Units (FMUs)

- Use a spatial layer of biotic communities to stratify plots.
- Produce estimates and standard errors of:
  - area by forest type
  - volume by forest type
  - basal area per acre by spp and forest type
- Use custom groupings of spp and forest type variables.
FIA estimates for San Carlos Reservation

Area & Per Acre estimates by Species Group (Ratio)
Nevada photo-based estimates

Objective:
Use large scale aerial photos to supplement field-based plot inventory

- Use a sample of photo-interpreted points collocated with FIA plot center.
- Use 250m resolution map of predicted timberland, woodland, and nonforest as strata.
- Produce photo-based estimates and standard errors of:
  - area by forest and nonforest types
  - % cover of photo-based objects (ex. trees)
  - % cover of objects within forest and nonforest types
Nevada photo-based estimates

Percent Cover of Trees

Pinyon-Juniper Forest Type
(543 locations, 23908 observations)

- Tree
- Shrub
- Other vegetation
- Barren
- Unknown

Percent Cover within Forest type

- Pinyon spp.
- Juniper spp.
- White fir
- Aspen
- Mtn mahogany
- Mortality
- Standing dead
- Down dead
- Limber pine
- Jeffrey pine
- Bristlecone pine
- Ponderosa pine
- Subalpine fir
- Engelmann spruce
- Other softwood
- Sugar pine
- Douglas-fir
- Black cottonwood
- Lodgepole pine
- Whitebark pine
- Red fir
- Other hardwood
- Incense cedar
- White pine

2012 FIA Symposium – Baltimore, MD
Cran R Environment

• R is a powerful statistical and graphical environment.
• Open-source, C-based programming language maintained and supported by community developers.
• Popular in scientific community.
• Extendible thru user-developed packages.
FIESTA - structure

- **Spatial Tools (sp)**
  - Clip rasters
  - Extract point values

- **Inventory Data (ORACLE)**
  - PLOT
  - COND
  - TREE

- **Data Tools (dat)**
  - Subset plot data
  - Sum tree data

- **Modules (GB, MM, ..)**
  - Green Book (GB) estimation
  - Small area (SA) estimation
  - Photo-based (PB) estimation

- **Analysis Tools (an)**
  - Species estimates by year
# FIESTA – functions

<table>
<thead>
<tr>
<th>Data Tools</th>
<th>Spatial Data</th>
<th>Modules</th>
<th>Analysis Tools</th>
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<td>datBarplot()</td>
<td>spExportShape()</td>
<td>GBestArea()</td>
<td>anFIAdata()</td>
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<td>DBtestACCESS()</td>
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Green Book (GB) Module
1. Get initial data
   • Compile inventory data
   • Get population boundary spatial layer (Area of Interest (AOI))
   • Get post-stratification spatial layer (if desired)
   • Clip inventory data and spatial data to population boundary (if needed)
   • Check for errors in dataset..

2. Get strata info
   • Assign values of strata layer to each plot
   • Calculate area by strata layer

3. Generate estimates
   • Identify sampled proportion of population
   • Check number of plots by strata & Check strata acreage for each plot
   • Calculate adjustment factor for each plot by..
     sampled proportion of plots / total plots sampled
   • Summarize tree data to condition-level
   • Calculate strata weights
     area of each strata / total area of population
   • Calculate mean and sum of squares for attribute of interest
   • Calculate estimate and variance using strata weights
FIESTA

Plot data → PLOT/COND data

Strata layer → Extract values

Estimation

estTree

estArea

estRatio

TREE data → Area by strata
FIESTA – FIA inventory data

**Plot data**

**PLOT/COND data**

**TREE data**

**FIA inventory data**

**ORACLEgetdata()** Extracts data from FIA Oracle database (RODBC)

**Data tables**

- **PLOT data** Coordinates, measurement year, ..
- **COND data** Variables defining proportion of plots sampled, domain variables (i.e. FORTYP, ..)
- **TREE data** Tree per acre variables (to expand sample tree data to acre level)

**Subset data tables**

**datBNDdata()** Subsets data to polygon shapefile boundary
FIESTA – get initial data

ORACLEgetdata()

- Programmable parameters/pop-up windows
- Actual or fuzzed/swapped coordinates
- Public or Regional data
- Plot/Cond/Tree/Seed/Veg + derived variables (ex. NBRCND, NBRCNDFOR, BA, JBIOTOT, …)
- User-defined filters
- Shapefile of plot-level variables.
FIESTA – Add data

datLUTnm()

- Programmable parameters/pop-up windows
- Merges user-defined look-up table or built-in look-up table
- Flexible for multiple variables
- Handles class ranges (min/max)
- User-defined filters
- Shapefile of plot-level variables.

### Built-in tables

<table>
<thead>
<tr>
<th>FORTYPDCD</th>
<th>OWNCD</th>
<th>SPCD</th>
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</thead>
<tbody>
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<td>FLDTPDCD</td>
<td>OWNGRPCD</td>
<td>SPGRPCD</td>
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<td>FORTYPCDCALC</td>
<td>RESERVCD</td>
<td>AGENTCD</td>
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<td>FORTYPGRP</td>
<td>LANDCLCD</td>
<td></td>
</tr>
<tr>
<td>FORINDCD</td>
<td>STDSZCD</td>
<td></td>
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<tr>
<td>DSTRBCD</td>
<td>FLDSZCD</td>
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</table>

### Example LUT: DIACLASS

<table>
<thead>
<tr>
<th>VARCLNM</th>
<th>MIN</th>
<th>MAX</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>10</td>
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<tr>
<td>3</td>
<td>10</td>
<td>15</td>
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<tr>
<td>4</td>
<td>15</td>
<td>20</td>
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<tr>
<td>5</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>25</td>
<td>50</td>
</tr>
</tbody>
</table>
FIESTA – strata

For estimation:
Strata table – area by strata
Plots – assigned strata value
... by estimation unit

GBstrata()

- gets point values from spatial layers
- calculates area by strata
- generates shapefiles
- clips spatial layers with boundary shapefile
- reprojects on the fly
- user-defined filters (ex. live trees only)
1. Compile inventory data
   • Get population boundary spatial layer
   • Get post-stratification spatial layer (if desired)
   • Clip inventory data and spatial data to population boundary (if needed)
   • Check for errors in dataset..

2. Get strata info
   • Assign values of strata layer to each plot
   • Calculate area by strata layer

3. Generate estimates
   • Identify sampled proportion of population
   • Check number of plots by strata & Check strata acreage for each plot
   • Calculate adjustment factor for each tree by..
     sampled proportion of plots / total plots sampled
   • Summarize tree data to condition-level
   • Calculate strata weights
     area of each strata / total area of population
   • Calculate mean and sum of squares for attribute of interest
   • Calculate estimate and variance using strata weights
FIESTA - estimation

GBestArea()
  gets area estimates by domain (ex. forest type)

GBestTree()
  gets tree estimates by domain (ex. forest type) or tree domain (ex. Species)

GBestRatio()
  get per-acre ratio estimates for tree data
FIESTA – GBestArea() / GBestTree()

- Programmable parameters/Pop-up windows
- Adjusts for Non-Sampled conditions by strata
- Summarizes tree data with adjustment factor
- Estimates area/tree attributes by domain(s) and/or estimation unit
- User-defined population
- User-defined strata
- User-defined filter(s)
- User-defined domain(s)
- Generates comma-delimited files of estimation table(s)
FIESTA – GBestRatio()

Per-acre estimates of trees by domain(s) and estimation unit
  
  tree estimate / area estimate

  Ex. basal area per acre within lodgepole forest type
  basal area / area of forest type domain

Per-tree estimates by domain(s) and estimation unit
  
  tree estimate / tree estimate

  Ex. proportion of dead trees within population
  basal area per acre of dead trees / basal area per acre of all trees
Identify sampled proportion of plot
COND_STATUS_CD != 5

Check number of plots by strata & strata acreage for each plot..
GBstrataCount()
  warning - there is acreage present for a stratum with less than 10 plots
  stop – there is plot(s) in stratum with zero acreage
  stop – there is acreage present for a stratum with less than 2 plots

Calculate adjustment factors..
Area estimates – based proportion of plots sampled (by strata/estimation unit)

Tree estimates – based on proportion of plots sample (by strata/estimation unit)
  and trees per acre

  sampled proportion / total plots – by strata and estimation unit
**Summarize tree data to condition-level**

- `datSumTree()` - Aggregates tree-level attributes to plot (ex. volume)

- `datSumTreeDom()` - Aggregates tree domain attributes to plot (ex. volume by species)

Tree-level attributes are multiplied by trees per acre (TPA) and then multiplied by adjustment factor before summing to plot.
FIESTA – estimation (GB)

Calculate strata weights
Iwtcalc() – internal function
area of strata / total area of population

Calculate mean and sum of squares for attribute of interest
..and..
Calculate estimate and variance multiplied by strata weights
Iestgreenbook() – internal function for area and tree estimates by domain
(green book methods)
Iestgreenbookrat() – internal function for ratio estimates by domain
(green book methods)

Generate cross tables of estimates (by domain)
Igetcrossord() – internal function to get a pivot table of estimates
ModelMap (MM) Module
FIESTA – mapping procedure

Steps for mapping

1. Get plot-level data
   • Compile inventory data
   • Check inventory data for errors
   • Summarize tree data to plot level

2. Get predictor data
   • Get spatial predictor layers
   • Adjust spatial layers to have save extent, pixel size, and projection (for ModelMap)
   • Assign values of spatial layers to each plot

3. Build model (ModelMap)
   • Build statistical model with plot data as response and predictor data as explanatory variables

4. Make map (ModelMap)
   • Apply model across each pixel of spatial predictor layers

5. Accuracy (ModelMap)
   • Assess accuracy of map
FIESTA - data

By condition

- **Estimation**: adjstrat – to compensate for plots that have partial non-sampled plots.

By plot

- **Models/Maps**: adjplot – to summarize condition-level data to plot-level.
FIESTA - mapping

Aggregate data to plot-level

datSumCond() - Aggregates condition-level attributes to plot (ex. %cover)
datSumTree() - Aggregates tree-level attributes to plot (ex. volume)
datSumTreeDom() - Aggregates tree domain attributes to plot (ex. volume by species)
datSumTreeDomIndex() - Generates index from output from datSumTreeDom

adjplot:
to summarize tree-level data to plot-level (ex. basal area (BA))

<table>
<thead>
<tr>
<th></th>
<th>NONE</th>
<th>WEIGHTED</th>
<th>FVS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\sum_{i=1}^{m} BA_i * TPA_i$</td>
<td>$\sum_{i=1}^{m} BA_i * TPA_i * \text{CONDPROP}_i$</td>
<td>$\sum_{i=1}^{m} BA_i * TPA_i * \sum \text{CONDPROP (Forested)}$</td>
</tr>
</tbody>
</table>
FIESTA – datSumTree() / datSumTreeDom()

- Programmable parameters/Pop-up windows
- Aggregates tree-level data
  - By plot or by condition
  - By tree domain (i.e. species, diacl, ...)
- User-defined summary function (i.e. sum, mean, max..)
- User-defined filters (ex. live trees only)
- Strata or plot-level adjustment factors
FIESTA – Spatial tools for mapping

spMakeFocal()
Generates a new raster layer with focal values by applying a moving window function across the raster pixels.

spRasterClip()
Clips raster layer to a polygon boundary, with option of specifying a NODATA value for background.

spExtractValue()
Extracts values of raster or polygons from a table with coordinate values or a shapefile.

Other spatial functions:
spReadShape – Imports a shapefile to R
spExportShape – Exports a shapefile from R
spMakeShape – Generates a shapefile from a table with XY coordinates
spReprojectShape – Reprojects a shapefile
spRasterFun – Applies a function across raster pixels
Analysis Tools
Examples

Area of forest type GROUP by National Forest, Utah

Live volume of lodgepole pine by measurement year, Colorado 2002-2009
Examples

Area of forest type group by National Forest, Utah

User-defined strata layer – Elevation classes
User-defined groups - forest type (timber/woodland/nonforest)
User-defined population - NFS boundaries

<table>
<thead>
<tr>
<th>NFS</th>
<th>STRATA</th>
<th>ACRES</th>
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</thead>
<tbody>
<tr>
<td>Dixie National Forest</td>
<td>1</td>
<td>36,711</td>
</tr>
<tr>
<td>Dixie National Forest</td>
<td>2</td>
<td>324,357</td>
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<tr>
<td>Dixie National Forest</td>
<td>3</td>
<td>303,646</td>
</tr>
<tr>
<td>Manti-La Sal National Forest</td>
<td>1</td>
<td>45,783</td>
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<tr>
<td>Manti-La Sal National Forest</td>
<td>2</td>
<td>438,644</td>
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<tr>
<td>Manti-La Sal National Forest</td>
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<td>317,154</td>
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<tr>
<td>Uinta National Forest</td>
<td>1</td>
<td>151,211</td>
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<tr>
<td>Uinta National Forest</td>
<td>2</td>
<td>453,412</td>
</tr>
<tr>
<td>Uinta National Forest</td>
<td>3</td>
<td>125,512</td>
</tr>
</tbody>
</table>
Examples

Area of forest type group by National Forest, Utah

Dixie National Forest

Manti-la Sal National Forest

UINTA National Forest

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Examples

NET LIVE volume of lodgepole pine by year, Colorado 2002-2009
Current & Future Applications

**Small Area Estimation** – Adding capability to generate estimates for areas within user-defined boundaries that contain only a few FIA field-sampled plots.

**Remote Sensing** – Adding functionality to integrate remotely sensed observations, such as photo interpretation from large scale aerial photographs or measurements from Landsat or Light Detection And Ranging (LIDAR).

**Moving Average** – Exploring alternatives to the moving average.

**FVS** – Communication with Forest Vegetation Simulator (FVS) to generate estimates of future growth simulations.
FIESTA Forest Inventory Estimation for Analysis

Documentation for package ‘FIESTA’ version 2.0

- DESCRIPTION file

Help Pages

FIESTA-package
- datBarplot
- datBNDdata
- datCombineTables
- datFilter
- datFreq
- datLUTnm
- datPivot
- datSumCond
- datSumTree
- datSumTreeDom
- datSumTreeDomIndex
FIAnamelst
FIESTA
GBestArea
GBestRatio

FIESTA - Forest Inventory Estimation for Analysis
Data - Generates frequency barplot.
Data - Clips data to a spatial polygon boundary.
Data - Appends annual and periodic data tables into 1 table.
Data - Filters data table.
Data - Get frequency table for specified variable.
Data - Gets variable description or class.
Data - Generates a pivot table.
Data - Aggregates CONDPROP_UNADJ variable to plot level based on condition filters.
Data - Aggregates one or more tree variables to the plot or condition-level.
Data - Aggregates a tree variable by a tree domain (i.e. species) to the plot or condition-level.
Data - Generates index of tree domain variables.
List of reference tables.
FIESTA - Forest Inventory Estimation for Analysis
GreenBook - Get area estimates by domain.
GreenBook - Get ratio estimates.
CHEERS ?