Bridging the gap between remotely-sensed data and FIA estimation with FIESTA

Tracey S. Frescino

USDA Forest Service, Rocky Mountain Research Station

Forest Inventory and Analysis

FIA National User Group Meeting April 5, 2017

What FIA does really well...

- Strategic-scale, sample-based, forest inventory
- Reports current status and trends of forest resources
- Nationally consistent estimation techniques





International N-Inch rule

What FIA does really well...

User-friendly online tools (EVALIDator, DATIM, etc..) for fast, reproducible estimates using traditional estimation techniques.



FIA Estimation Process

FIA Base Grid

Forest type Tree biomass Trees per acre

. .



Remotely-sensed Data

Classified Landsat 30m imagery



Estimators Green book



Bechtold and Patterson 2005

FIA Estimation Process

FIA Base Grid

Forest type Tree biomass Trees per acre



Remotely-sensed Data

Classified Landsat 30m imagery Landsat-based disturbance MODIS Large-scale aerial photography Lidar



Green book Nonresponse bias Photo-based Model-Assisted Small-Area Time series





5 USDA Forest Service, RMRS IW-FIA





We need a party!



We need a flexible estimation engine..

That we can use to answer any question..

Using ancillary data we think is best..

Whenever we want.

What is FIESTA?



FIESTA (Forest Inventory ESTimation and Analysis) tool

- A research estimation tool designed for analysts that work in the opensource, R statistical programming environment.
- A collection or 'package' of R functions that can access FIA databases, summarize and compile plot and spatial data, and generate estimates of forest resource data.
- Supports and is validated by current FIA data and estimation tools, such as EVALIDator/FIDO.
- It is flexible, customizable, and interfaces with other R tools.

FIESTA Accommodates . .

- Unique population boundaries.
- Different evalidation time periods (i.e. Annual).
- Customized stratification schemes.
- Non-standard population characteristics and filters (ex. NFS dominance types).
- Non-standard variance equations (ex. NonResponse).
- Supplementary inventory data (ex. photo-based inventory).
- Integration of remotely-sensed and other ancillary data.
- Interface with other useful tools available on CRAN.

FIESTA



Remotely-sensed data and FIESTA!

Outline

- Using high-resolution aerial photography to supplement field inventory.
- Using non-traditional estimation strategies for integrating remotely-sensed data to increase precision of estimates.
- How FIESTA is an integral component of each.



$$\overline{Y_{hd}} = \frac{\sum_{i}^{n_h} y_{hid}^2 - n_h \overline{Y_{hd}}^2}{n_h (n_h - 1)}$$

USDA Forest Service, RMRS IW-FIA

High Resolution Aerial Photography

Plot-level observations

- Prefield all plots are observed using aerial photography to determine whether a plot meets FIA's forest land definition and is visited in field. Land use and land cover is recorded on non-visit plots.
- Tree Canopy Cover 109 grid point sample of live tree classification to support development of National Land Cover Dataset (NLCD), Tree Canopy Cover (TCC) map product.

Population estimates

- Estimates of all cover types Nevada Photo-based Inventory Pilot (NPIP)
- Estimates of change Image-based Change Estimation (ICE)

USDA Forest Service, RMRS IW-FIA

Nevada Photo-based Inventory Pilot (NPIP)

Collaboration – IW-FIA, GTAC, formerly RSAC

Objectives

- Characterize all lands, including vegetation cover on forest and nonforest lands (condition, tree, shrub, other veg, barren)
- Dot grid sample of 49 points within 250m radius on FIA sample grid
- ~6 in (.15m) resolution

Digital Mylar Image Sampler (RSAC)





Nevada Photo-based Inventory Pilot (NPIP)

Accomplishments

- Developed procedures for a large scale photo-based inventory
- Derived photo-based estimation techniques
- Reported estimates, characterizing all lands in the state of NV



FIESTA



USDA Forest Service, RMRS IW-FIA

High Resolution Photography

NAIP





1.0-meter (39-inch) natural color; orthorectified Image server (2006)



0.15-meter (6-inch) pixel natural color; georeferenced direct-to-digital/scanned (2004/2005)

FIA Symposium Knoxville, TN, Oct. 5-7, 2010

Collaboration – FIA, GTAC, formerly RSAC

Objectives

- Generate estimates of land cover and land use changes on a more rapid schedule than FIA's temporal schedule for return visits (5-10 yrs).
- Initiated in response to 2014 Farm Bill, FS Strategic Plan, and a 2009 resolution by NASF.
- Leverages 2-3 year temporal schedule of USDA's 1m National Agriculture Imagery Program (NAIP) photography



Methods

- Dot grid sample of 45 points within 1 acre surrounding FIA plot center
- Photo-interpretation at Time 1 and Time 2
- Land Use, Land Cover, Agent of Change
- Classifications align with FIA, IPCC





Time 2 Attributes For Plot 13

- - X

Gain Loss

Accomplishments so far...

- Pilot/Prototype completed
- Currently ~20 states on board
- Automated estimation and reporting techniques
- More analyses and comparisons to be presented and FIA Stakeholder Meeting
- Peer-reviewed pub on ICE methods to follow

Net Land Use Change Among All Classes

95% Confidence Interva



NAIP



Land Use / Land Cover Portfolio

Coordination of efforts within FIA for reporting estimates of change (Lead: Sean Healey, IW-FIA)

Can we get enough from FIA, as is?

- 5-10 year cycles, panel/subpanel
- Forest field visit; Nonforest prefield (~ 2006+)

Landsat Time Series (TimeSync)

- Annual (1984+)
- 30 m resolution

ICE

- 2-3 year NAIP schedule
- 1 m resolution

Improving Precision with Remotely Sensed Data

Post-stratification

Works well when plots are effectively grouped into strata

FIA current post-stratification strategy

- NRS/SRS NLCD Tree Canopy Cover Map
- IW Classified Map of Forest/Nonforest
- PNW NLCD Tree Canopy Map, plus elevation, precip for AK

Ownership to reduce bias of nonresponse

Customized Stratification

Objective: Test use of forest disturbance map for estimating areas disturbed post-stratification (Schroeder et al. 2014).

Conclusion: Significant improvement from simple random sample based on relative efficiency



	FIA	LTS	FIA + LTS
Insect	1,11	1.20	1.26
Disease	1.01	-	1.01
Stress	-	1.02	0.99
Fire	1,10	1.16	1.15
Harvest	0.97	0.99	1.00
Weather	0.96	-	0,96
Mechanical	-	1.00	1.00
Animal	0.94	-	0.94
Other	0.93	1.07	0.95
Total	1,15	1.43	1.50

Relative efficiency of post-stratification



Schroeder, Todd A.; Healey, Sean P.; Moisen, Gretchen G.; Frescino, Tracey S.; Cohen, Warren B.; Huang, Chengquan; Robert E. Kennedy, Robert E.; Yang, Zhiqiang. 2014. Improving estimates of forest disturbance by combining observations from Landsat time series with U.S. Forest Service Forest Inventory and Analysis data. Remote Sensing of Environment.

USDA Forest Service, RMRS IW-FIA

Other Estimation Techniques

Objective

Utilize more remote-sensing and other auxiliary data with designbased, model-assisted approaches.

Model-Assisted Estimation

Collaboration with Kelly McConville, Swarthmore College In progress: R package (MASE) and Shiny App

Small-Area Estimation

Composite approach (Direct and Synthetic estimators) Linear mixed models (JoSAE R package – Breidenbach)

FIESTA



USDA Forest Service, RMRS IW-FIA

Summary

- Remotely-sensed information is becoming more available and is getting better, so let's use it.
- Having a tool that is flexible for research is very helpful for testing and automation.
- FIESTA, Version 1.0, coming soon...

Questions?

