Chapter 45
United States of America

Ronald E. McRoberts and Patrick D. Miles

45.1 The National Forest Inventory of the United States of America

45.1.1 History and Objectives of the National Forest Inventory

The national forest inventory (NFI) of the United States of America (USA) is conducted by the Forest Inventory and Analysis (FIA) programme of the U.S. Forest Service, an agency of the U.S. Department of Agriculture. The FIA programme has been in continuous existence since 1928 and is the only organisation that collects, compiles, archives, analyses, and publishes state, regional, and national forest information on all ownerships of forest land in the USA. The history of the programme is documented in numerous publications including LaBau et al. (2007), Gregoire (1992) and Van Hooser et al. (1992); recent history is documented in McRoberts et al. (2005, 2010) and Bechtold and Patterson (2005).

In 1998, the FIA programme began implementing a strategic forest inventory plan featuring an annual system, state reports every five years, a set of core variables with national definitions and measurement standards, and integration of the ground sampling components of the FIA and the Forest Health Monitoring programmes. This annual inventory programme uses the ends-ways-means strategic planning model to promote and facilitate national consistency (McRoberts et al. 2005). Ends are the criteria that must be satisfied for the programme to be characterised as nationally consistent; ways are the procedures that lead to achieving the

R.E. McRoberts (✉) · P.D. Miles
Northern Research Station, U.S. Forest Service, Saint Paul, MN, USA
e-mail: rmcroberts@fs.fed.us

P.D. Miles
e-mail: pmiles@fs.fed.us

C. Vidal et al. (eds.), *National Forest Inventories*,
DOI 10.1007/978-3-319-44015-6_45

ends; and means are the resources that are committed to the effort. The programme is defined in terms of six ends:

End 1: A standard set of variables with nationally consistent meanings and measurements.
End 2: Field inventories of all forested lands.
End 3: Consistent estimation.
End 4: Satisfaction of national precision guidelines.
End 5: Consistent reporting and data distribution.
End 6: Credibility with users and stakeholders.

These ends describe the major foci of the programme and provide direction for methodological research. To facilitate achieving the ends, 10 ways have been prescribed:

Way 1: A national set of prescribed core variables with a national field manual that prescribes measurement procedures and protocols for each variable.
Way 2: A national plot configuration.
Way 3: A national sampling design.
Way 4: Estimation using standardised formulae for probability-based (design-based) estimates.
Way 5: A national database of FIA data with core standards and user-friendly public access.
Way 6: A national information management system.
Way 7: A nationally consistent set of tables of estimates of prescribed core variables.
Way 8: Publication of state-wide tables of estimates for prescribed core variables at 5-year intervals.
Way 9: Documentation of the technical aspects of the programme including procedures, protocols, and techniques.
Way 10: Peer review of and public access to the technical documentation.

In summary, the FIA programme is nationally consistent in its crucial components and is implemented through four regional programmes (Fig. 45.1).

45.1.2 Sampling Procedures

The current FIA sampling design is based on a tessellation of the entire country into 2400 ha hexagons (Fig. 45.2). The federally funded portion of the sample consists of one permanent plot in a randomly selected location in each hexagon without regard to land cover, land use, ownership, or other factors. Across the entire country, the hexagons have been systematically assigned to five groups called panels such that no adjacent hexagons are assigned to the same panel (Fig. 45.2). Panels are selected for measurement of their plots on a rotating basis, and measurement of all plots in a panel in a state is completed before measurement of plots

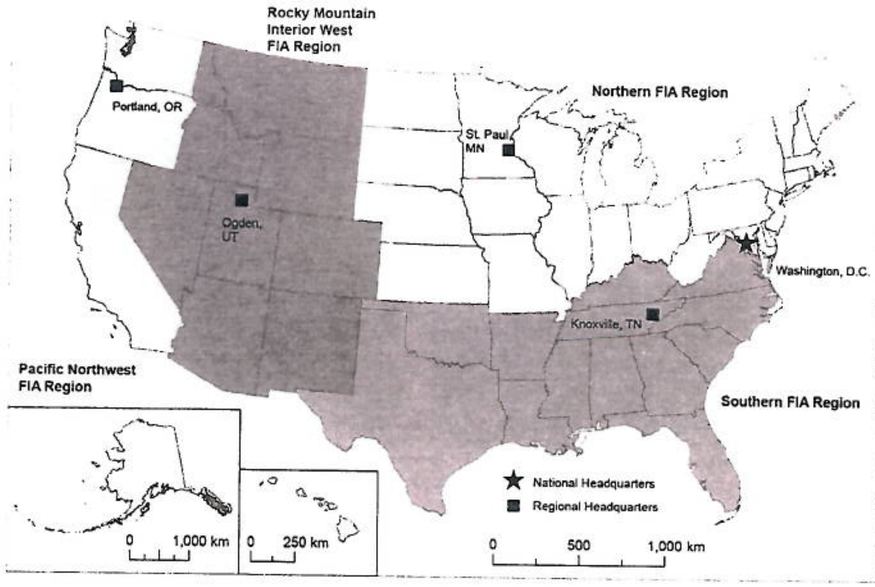

Fig. 45.1 FIA regions and headquarters

in a subsequent panel is initiated. With this approach a complete systematic sample of each state is obtained every year.

All ground plots conform to the national standard plot configuration and consist of four 7.31 m (24 ft) radius circular subplots configured as a central subplot and three peripheral subplots with centres located at a distance of 36.58 m (120 ft) and azimuths of 0, 120, and 240° from the centre of the central subplot. Each subplot includes a 2.08 m (6.8 ft) radius micro-plot on which seedlings and saplings are measured and a regionally optional 18.0 m (58.9 ft) radius annular macro-plot on which additional large trees are measured.

The FIA programme conducts inventories in multiple phases. The primary objective of Phase 1 is to stratify the population area for purposes of reducing the variances of estimates. The objective of Phase 2 is to establish and measure an array of permanent ground plots. Aerial photography is used to observe each plot to assure forest land use before sending a field crew to the plot location. Field crews visit locations of plots with current or previous forest land use or in close proximity to forest land use as determined via photo-interpretation. Plots are installed on all public forest land and on private forest land with permission of the land owner. A set of additional forest health variables including crown condition, vegetation structure, soils, and down woody material is also currently measured on 5–15 % of Phase 2 plots, depending on the variable.

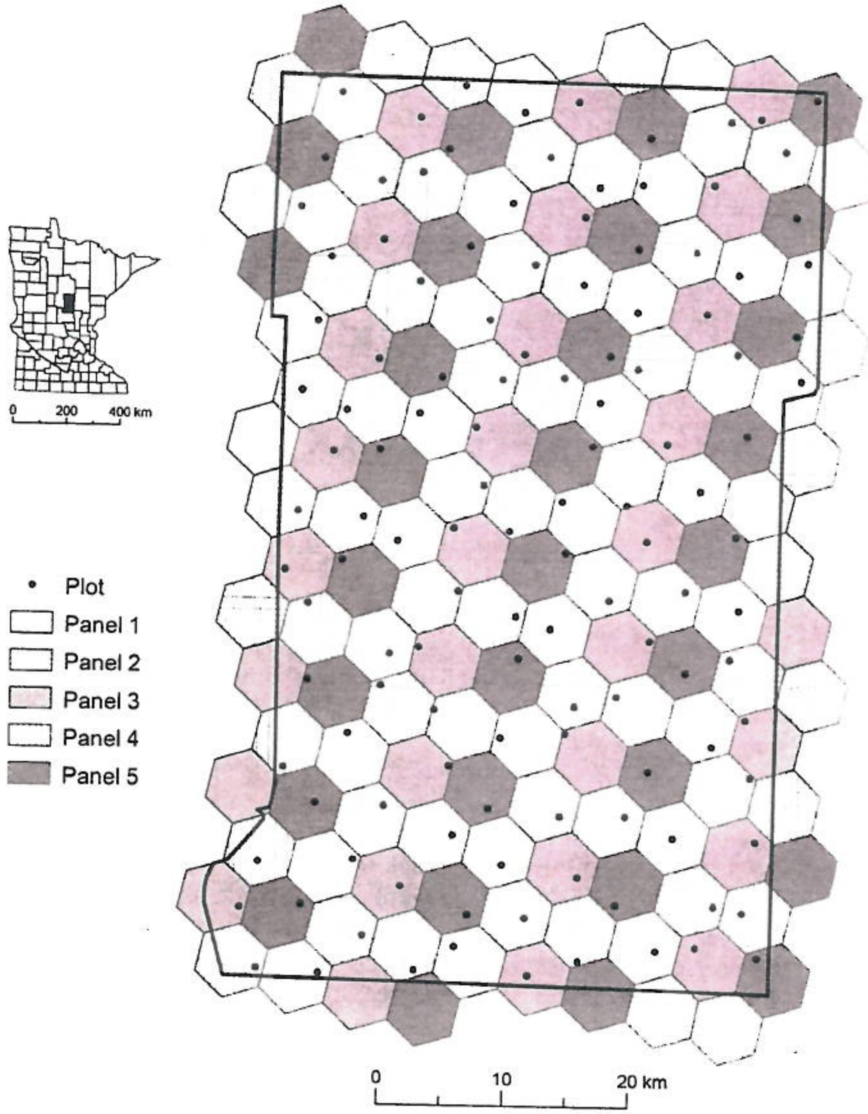

Fig. 45.2 Sampling hexagons with random plot locations for Crow Wing County, Minnesota, USA

45.1.3 Data Collection

Plot-level observations include ownership, land use and land use change, forest type, stand age, disturbance, and regeneration counts. Tree-level observations include species, diameter, height, damage, grade, and cull (decay and rot). FIA field crews identify distinct conditions on plots where conditions are defined as different classes of seven variables: land use, reserve status, owner group, regeneration type, tree density, forest type and tree size class. If multiple conditions are identified on a plot, field crews assign tallied trees to the condition class in which they occur and record information necessary for estimating the portion of the total plot area that is within each condition.

45.1.4 Data Processing, Reporting and Use of Results

Statistical models are used to estimate stem volumes for individual trees with dbh of at least 12.7 cm (5 in.) as volumes of central stems above a 30.48 cm (1 ft) stump and to a minimum top diameter of 10.16 cm (4 in.). The models are constructed regionally and are based on observations and measurements for species, diameter, and height. The effects of the uncertainty in the model predictions on large area volume estimates are regarded as negligible (McRoberts and Westfall 2014). All live volume includes stem volumes for all trees, while growing stock volume excludes volume for the cull portions of trees and all volume for cull trees.

FIA inventories are designed to produce data to estimate components of change which are aggregated to estimate net change. Estimates of growth, mortality, removals, and regeneration are obtained by comparing observations and measurements for the same plots from previous inventory cycles. For all components, change is estimated for elapsed time between successive inventory cycles. Components of change include ingrowth estimated as the volume of trees that first exceed the minimum dbh, reversion estimated as the volume of trees on land that reverts from nonforest to forest land use, mortality estimated as the volume of trees that die from natural causes, cut estimated as the volume of trees cut, and diversion estimated as the volume of trees on land diverted from forest to nonforest land use. Growth is estimated for trees that survive between inventory cycles and between the midpoint of the cycle and either the beginning or the end of the cycle for each category of components of change.

Estimates of parameters related to the term *increment*, as used in Europe to mean the ratio of the difference between inventories in estimates of volume and the interval between inventories, are not commonly reported in the USA. However, similar concepts such as net annual growth of growing stock are commonly used and related parameters are routinely reported (Table 45.3). Similarly, the term *drain* is not routinely used, although the estimated components of change can be used to estimate the equivalent of parameters related to drain.

In general, FIA areal estimation techniques are characterised as probability-based (design-based) and rely heavily on Cochran (1977). FIA estimation procedures have been documented, peer-reviewed and published to achieve four objectives: (1) to ensure a common understanding and practice among the regional FIA programmes, (2) to facilitate development of the national programme including the national information management system, (3) to provide a defensible statistical basis for the sampling and estimation components of the programme, and (4) to promote credibility with clients and stakeholders (Bechtold and Patterson 2005; McRoberts et al. 2005).

The FIA programme uses stratified estimation to obtain estimates of population parameters for most variables. Because all plots are permanent, post-sampling stratification (post-stratification) is used where strata are derived from the predicted classes of satellite imagery (McRoberts et al. 2002, 2006, 2010). FIA plots are assigned to the stratum associated with the satellite image pixel containing the plot centre, and strata weights are calculated as the proportions of pixels assigned to strata. Cochran (1977) provides the basic stratified estimators as,

$$\hat{\mu} = \sum_{h=1}^{L} w_h \bar{y}_h \tag{45.1}$$

and

$$Var(\hat{\mu}) = \sum_{h=1}^{L} w_h^2 \frac{\hat{\sigma}_h^2}{n_h}, \tag{45.2}$$

where h indexes strata, and w_h, $\bar{y}_h$, $\hat{\sigma}_h^2$, and n_h are the within-stratum weight, mean, variance, and sample size, respectively. Strata weights may be adjusted to compensate for random within-strata sample sizes resulting from post-stratification rather than stratified sampling. The positive results of stratification are that variances may be reduced by factors as great as 5.0 for area estimates and 3.0 for volume estimates with no additional sampling or associated costs.

Per unit area estimates by condition class (e.g. volume by forest type) are calculated using a ratio estimator of the general form,

$$\bar{y} = \frac{\sum_{i=1}^{n_h} y_i}{\sum_{i=1}^{n_h} a_i}, \tag{45.3}$$

where y_i is the plot-level observation or measurement of the variable of interest on the *i*th plot and a_i is the area of the condition on the same plot (Särndal et al. 1992).

Estimates of uncertainty are expected to satisfy precision (PREC) for estimate of a parameter, $\hat{\mu}$, expressed as,

$$PREC = \sqrt{\frac{\hat{Var}(\hat{\mu})}{\hat{\mu} \cdot S}}, \tag{45.4}$$

where,

$$S = \begin{cases} 40,469\,\text{ha}\,(10^6\,\text{acres})\ \text{for area} \\ 28,316,980\,\text{m}^3\,(10^9\,\text{ft}^3)\ \text{for volume} \end{cases}, \quad (45.5)$$

with precision guidelines of

$$\text{PREC} = \begin{cases} 0.03 & \text{for area estimates} \\ 0.05 & \text{for volume estimates in the eastern USA} \\ 0.10 & \text{for volume estimates in the western USA} \end{cases}.$$

Inventory data and estimates are made available annually for each state, and on a 5 year cycle each state receives a comprehensive analytical report that includes an assessment of the current status and trends of forest resources and ecosystem condition, analysis and discussion of probable factors influencing the status and trends, and 50 year predictions of likely trends in key resource attributes. The FIA programme also reports national assessments on a 5 year cycle.

45.2 Land Use and Forest Resources

45.2.1 Classification of Land and Forests

The land use classes, Other Wooded Land (OWL) and Trees outside Forest (TOF), are not used in the USA and are not assessed separately from other lands with tree cover. The class closest to OWL and TOF is Woodland which is defined as land with trees whose cover is in the range 5–10 %. Most woodland is in the arid, Southwestern region of the USA and consists of juniper, mesquite, scrub oaks, and some woody vines, all with short stature of less than 5 m. Inclusion of this class has been the subject of much debate in the last century. The primary reasons for its current assessment include ecosystem fragility and susceptibility to fire.

Forest area in the USA totals more than 300 million ha (Table 45.1) and has generally been increasing since the 1920s, despite a near tripling of the human population. Currently, more than 30 % of the country is characterised as forest land with 58 % of it in various categories of private ownership (Table 45.2; Fig. 45.3). Unlike in many European countries, private forest land owners in the USA have considerable freedom to convert their land from forest to non-forest uses and vice versa in response to varying commodity prices and other factors. This feature of private land ownership at least partially explains substantially varying forest areas over time.

Although the term Forest Available for Wood Supply (FAWS) is also not commonly used in the USA, the concept is prevalent (Table 45.1). For example, the definition of the land use category Timberland includes the specification that the land must not be withdrawn from timber utilisation. Conversely, the land use

Table 45.1 Land use categories

Category	Definition	Estimate (1000 ha)	Standard error (%)
Total land area		914,995	0.01
Forest land	0.4 ha (1 ac), 36.58 m (120 ft) minimum width, 10 % cover or equivalent stocking with trees able to reach 5 m at maturity, forest land use	310,091	0.14
Timberland	Same as forest land plus capable of producing 1.37 m^3/ha (20 ft^3/ac) per year and not withdrawn from timber utilisation	210,908	0.16
Reserved forest land	Forest land where management for the production of wood products is prohibited through statute or administrative designation; examples include national forests, wilderness areas, national parks, and national monuments	29,753	0.91
Woodland	Land with tree cover in the range 5–10 %	2174	1.22

Table 45.2 Categories of forest area by ownership

Category	Forest land (1000 ha)	Timberland (1000 ha)	Reserved forest land (1000 ha)
Public	129,974	65,147	29,621
Private (corporate)	59,680	45,034	6
Private (non-corporate)	120,437	100,727	127

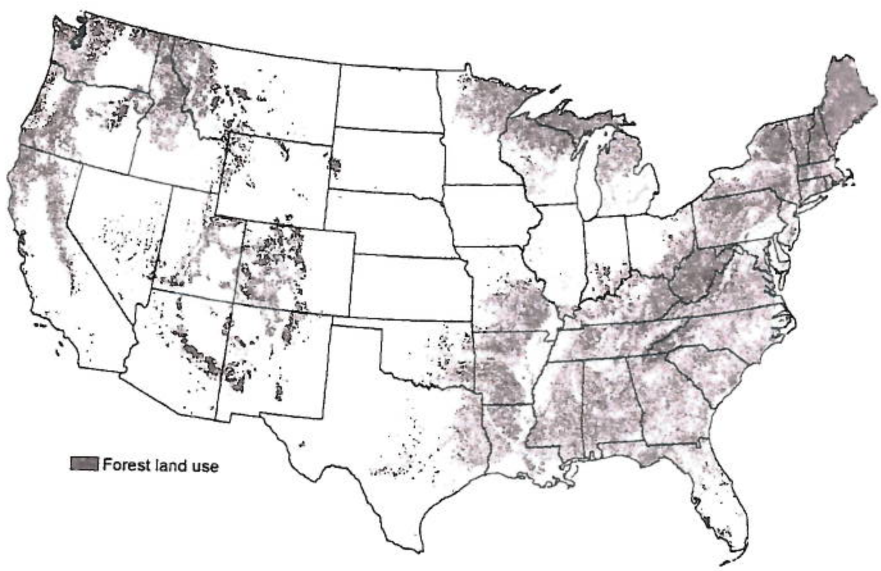

Fig. 45.3 Forest land in the USA. *Data Source* National Land Cover Database, 2011

category Reserved forest land is defined to be land where management for production of wood products is explicitly prohibited. Reserved forest land constitutes 7–10 % of forest land, includes mostly State and Federal parks and wilderness areas, has doubled in area since the early 1950s, and is concentrated in western States.

45.2.2 *Wood Resources and Their Use*

Wood resources are generally available for use on all private non-reserved forest lands and most public non-reserved forest lands. Local exceptions include buffer zones established for aesthetic purposes and for filtering purposes such as near water sources. Net growing stock volume on timberland, one measure of wood resources, totals nearly 30 billion m^3 (Table 45.3) and has increased by more than 50 % since 1953. Most of the increase has been in the eastern USA (Oswalt et al. 2014). Between 2007 and 2012, the southern region of the country had 63 % of removals (Oswalt et al. 2014), hence the characterisation of this region as the "woodbasket of the country."

Over the past 50 years, growth has generally exceeded removals throughout the USA. Although removal levels have stabilised in recent years, the source of removals has shifted decidedly from public land in the West to private land in the East. In 1996, coniferous removals in the South exceeded growth for the first time since 1952, when data were first reported.

Sawtimber is defined to be live trees of commercial species containing at least a 3.66 m (12 ft) log or two non-contiguous 2.44 m (8 ft) or longer logs that satisfy regional quality specifications. Coniferous species must have dbh of at least 22.9 cm (9 in.), whereas deciduous species must have dbh of at least 27.9 cm (11 in.). Tree grade is based on tree diameter and the presence or absence of knots, cull primarily in the form of decay, and curvature of the bole. Trees with the greatest quality receive a grade of 1, whereas trees with poorest quality receive a grade of 4. Sawtimber volume by grade and coniferous/deciduous classes is typically reported at the State-level. At the national level, all live volume includes stem volume for all trees, whereas growing stock volume excludes volume for the cull portions of trees (Table 45.3).

45.2.3 *Additional Assessments of Wood Resources*

FIA data are the primary source of large area forest information for use by public land management and planning agencies, forest industry, environmental groups, and non-governmental organisations. In addition, the FIA programme conducts special studies related to utilisation of timber outputs, forest ownership patterns and trends, and non-timber resources such as recreation, hydrology, and wildlife habitat.

Table 45.3 Forest resource definitions and estimates

Category	Definition	Estimate	Standard error (%)
Volume parameters			
Net volume of growing stock on timberland	Live trees with dbh ≥ 12.7 cm of commercial species meeting standards of quality or vigour; excludes volume of rot and poor form; estimated for central stem above 30.48 cm stump to minimum of 10.16 cm top diameter outside bark	29,907,000,000 m^3	0.32
Net annual growth of growing stock timberland	Average annual net change in wood volume of trees with dbh ≥ 12.7 cm excluding losses from cutting (gross growth minus mortality) during the inter-survey period, the total volume of trees entering all of the diameter classes with dbh ≥ 12.7 cm through ingrowth; volume losses from natural causes	747,937,000 m^3	0.57
Net annual removals of growing stock on timberland	Average annual wood volume of trees ≥ 12.7 cm dbh. removed from the inventory by harvesting, cultural operations (such as timber-stand improvement), land clearing, or changes in land use during the intersurvey period, in addition to the volume in logging residues or mortality due to logging damage (harvest removals). This component of change also includes the volumes of growing-stock trees removed due to land use changes (other removals)	363,976,000 m^3	1.32
Volume of sound dead wood on timberland	Net volume in salvageable dead trees on timberland	1,286,884,000 m^3	1.00
Volume per unit area parameters			
Net annual growth of growing stock per unit area on timberland	Net volume of growing stock on timberland divided by area of timberland	3.55 m^3/ha	0.29
Net annual removals of growing stock per unit area on timberland	Net annual removals of growing stock on timberland in cubic meters divided by area of timberland in hectares	1.73 m^3/ha	1.38

45.2.4 *Timber Products Output*

The Timber Products Output (TPO) component of the FIA programme conducts studies to estimate industrial and non-industrial uses of roundwood in each state. All primary wood-using mills in a state are canvassed using questionnaires designed to determine the locations, sizes, and types of mills; the volume of roundwood received by product species and geographic origin; and the volume, type and disposition of wood residues generated during primary processing. Logging utilisation studies are conducted to relate TPO to inventory volume by visiting a sample of logging operations to characterise the sites logged, trees cut, products taken, and residues left behind.

The term assortment, meaning size classes of logs, often with reference to particular categories of wood products, is not used in the USA. However, the concept is prevalent, and parameters related to classes such as sawlogs, pulpwood, fuelwood, veneer, and poles, posts, and mulch are estimated by the TPO component of the FIA programme (Oswalt et al. 2014). In 2011, timber harvested for industrial products and domestic fuel wood totalled 362 milllion m^3, an approximately 15 % decline since 2006. Since the 1970s, veneer output has been stable, pulpwood has increased, and both pulpwood and fuelwood have varied considerably (Oswalt et al. 2014).

45.2.5 *National Woodland Owner Survey*

The National Woodland Owner Survey (NWOS) is a survey of forest owners conducted to increase understanding of woodland owners as the crucial link between forests and society (Butler 2008). The NWOS inquires of forest owners regarding their forest land, how they use and manage it, their concerns and issues, and their future intent. Information from the NWOS is used to design and implement services and formulate policies that affect interested parties including government agencies, non-governmental organisations, landowner organisations, private service providers, forest industry companies, and academic researchers.

45.2.6 *Urban Forests*

The U.S. Forest Service acquires information on urban tree canopy distribution, species composition and health, and urban tree benefits. Information is reported at state, county, and sub-county levels and is used for multiple purposes: (1) to identify trends in urbanisation and the growth and decline of urban forests, (2) to determine priority areas for urban reforestation, (3) to quantify ecosystem services that urban forests provide such as carbon sequestration and storm water management, and (4) to support urban and community forest management and green infrastructure planning. Research efforts combine satellite, local field, and national urban map data to facilitate understanding of the magnitude and composition of the resource, how urbanisation is expanding, and factors that lead to changes in tree species health and distribution in the future (Nowak et al. 2013).

45.3 Auxiliary Uses of FIA Data

FIA data are used by a wide array of other public and private organisations. The data are the primary source of forest information for reporting on the nation's renewable resources to the U.S. Congress every 10 years (Oswalt et al. 2014) and for international carbon reporting (Birdsey and Lewis 2003; O'Neill et al. 2005: Heath et al. 2011; Woodall 2012; US EPA 2014). In response to extensive forest wildfires in the western USA, FIA data were the primary source of information for a biomass assessment for western states (Rummer et al. 2003). FIA data were used for accuracy assessment of a national satellite image-based land cover product constructed by the U.S. Geologic Survey and for describing major vegetation cover types by the U.S. Fish and Wildlife Service. FIA data were also used by the Heinz Center which was best known for its reports on the state of the nation's ecosystems. These reports became seminal references for policy makers and environmental managers (Heinz 2008, 2010). The Forests on the Edge project used data from multiple sources including FIA to identify areas where private forest timber resources might be adversely affected by housing development, fire, insects, pests and diseases (Stein et al. 2005, 2010).

45.4 Summary

The basic features of the national sampling design and plot configuration have remained unchanged since the mid- to late 1990s, and will remain the same for the foreseeable future. Parameters associated with primary variables such as forest area, volume, and volume by species are estimated using stratified estimation where strata are constructed from classified satellite imagery. Although stratified estimation will continue to be used, the kind, date and resolution of the product from which strata are derived may change. Plot data (except for exact plot locations) and estimates of primary parameters are made available annually via the Internet. A complete report for each state is published every five years. The report includes discussions of trends, health and disease issues, and spatial depictions of resources.

References

Bechtold WA, Patterson PL (eds) (2005) The enhanced forest inventory and analysis program—national sampling design and estimation procedures. Department of Agriculture, Forest Service, Southern Research Station. General Technical Report SRS-80. Asheville, NC, USA

Birdsey RA, Lewis GM (2003) Carbon in U.S. forests and wood products, 1987–1997: state-by-state estimates. General Technical Report NE-310. Department of Agriculture, Forest Service, Northeastern Research Station. Newtown Square, PA, USA

Butler BJ (2008) Family forest owners of the United States, 2006. General Technical Report NRS-27. Department of Agriculture, Forest Service, Northern Research Station. Newtown Square, PA, USA

Cochran WG (1977) Sampling techniques. Wiley, New York

Gregoire TG (1992) Roots of forest inventory in North America. In: Proceedings of the national convention of the Society of American Foresters. Bethesda, Maryland, USA, A-1 Inventory Working Group, Society of American Foresters, p 57–66

Heath LS, Smith JE, Skog KE, Nowak DJ, Woodall CW (2011) Managed forest carbon estimates for the US greenhouse gas inventory, 1990–2008. J For 109(3):167–173

Heinz (The H. John Heinz III Center for Science, Economics and the Environment) (2008) The state of the nation's ecosystems 2008: measuring the lands, waters, and living resources of the United States. The H. John Heinz III Center for Science, Economics and the Environment. Island Press, Washington, DC

Heinz (The H. John Heinz III Center for Science, Economics and the Environment) (2010) Forest sustainability in the development of bioenergy in the U.S. The H. John Heinz III Center for Science, Economics and the Environment. Pinchot Institute for Conservation and The H. John Heinz III Center for Science, Economics and the Environment. Washington, DC

LaBau VJ, Bones JT, Kingsley NP, Lund HG, Smith WB (2007) A history of the forest survey in the United States: 1830–2004. FS-877. Department of Agriculture, Forest Service. Washington, DC, U.S

McRoberts RE, Westfall JA (2014) Effects of uncertainty in model predictions of individual tree volume on large area volume estimates. For Sci 60:34–43

McRoberts RE, Wendt DG, Nelson MD, Hansen MD (2002) Using a land cover classification based on satellite imagery to improve the precision improve the precision of forest inventory area estimates. Remote Sens Environ 81:36–44

McRoberts RE, Bechtold WA, Patterson PL, Scott CT, Reams GA (2005) The enhanced forest inventory and analysis program of the USDA forest service: historical perspective and announcement of statistical documentation. J For 103(6):304–308

McRoberts RE, Holden GR, Nelson MD, Liknes GD, Gormanson DD (2006) Using satellite imagery as ancillary data for increasing the precision of estimates for the forest inventory and analysis program of the U.S. For Serv Can J For Res 36:2968–2980

McRoberts RE, Hansen MH, Smith WB (2010) United States of America. In: Tomppo E, Gschwantner T, Lawrence M, McRoberts RE (eds) National forest inventories, pathways for common reporting. Springer, Heidelberg, pp 567–582

Nowak DJ, Greenfield EJ, Hoeh RE, Lapoint E (2013) Carbon storage and sequestration by trees in urban and community areas of the United States. Environ Poll 178:229–236

O'Neill KP, Woodall C, Amacher M, Holden G (2005) Linking soils and down woody material inventories for cohesive assessments of ecosystem carbon pools. In: McRoberts RE, Reams GA, Van Deusen PC, McWilliams WH, Cieszewski CJ (eds) Proceedings of the fourth annual forest inventory and analysis symposium; Gen Tech Rep NC-252 St. Paul, MN, USA Department of Agriculture, Forest Service, North Central Research Station, p 27–32

Oswalt SN, Smith WB, Miles PD, Pugh SA (2014) Forest resources of the United States, 2012, a technical document supporting the Forest Service update of the 2010 RPA assessment. General Technical Report WO-91. Department of Agriculture, Forest Service, Washington Office. Washington, DC, USA

Rummer B, Prestemon JP, May D, Miles P, Vissage JS, McRoberts RE, Liknes G, Shepperd WD, Ferguson D, Elliot W, Miller S, Reutebuch SE, Barbour J, Fried J, Stokes B, Bilek E, Skog K, Hartsough B (2003) A strategic assessment of forest biomass and fuel reduction treatments in western states. General Technical Report RMRS-149. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Fort Collins, CO, USA

Särndal CE, Swensson B, Wretman J (1992) Model assisted survey sampling. Springer-Verlag, New York

Stein SM, Carr MA, McRoberts RE, Mahal LG (2010) Threats to at-risk species in America's private forests. General Technical Report NRS-73. Department of Agriculture, Forest Service, Northern Research Station, Newtown Square, PA, USA

Stein SM, McRoberts RE, Alig RJ, Nelson MD, Theobald DM, Eley M, Dechter, M, Carr M (2005) Forests on the edge. Housing development on America's private forests. General Technical Report PNW-636. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR, USA

US EPA (U.S. Environmental Protection Agency) (2014) Forest sections of the land use, land use change, and forestry chapter, and Annex. In: US Environmental Protection Agency, Inventory of US Greenhouse Gas Emissions and Sinks 1990–2012

Van Hooser DD, Cost ND, Lund HG (1992) The history of the forest survey program in the United States: In: Preto, G. and Koch, B. (eds) Proceedings of the IUFRO Centennial Meeting, August 31-September 4, 1992, Berlin, Germany Tokyo: Japan Society of Forest Planning Press, Tokyo University, p 19–27

Woodall CW (2012) Where did the US forest biomass/carbon go? J For 110(2):113–114