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Inventorying Trees in Agricultural Landscapes: Towards an Accounting of Working Trees

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ABSTRACT

Agroforestry plantings and other trees intentionally established in rural and urban areas are emerging as innovative management options for addressing resource issues and achieving landscape-level goals. An understanding of the contributions from these and future plantings would provide critical information to policy and program developers, and a comprehensive inventory would contribute to estimating the cumulative effects of these plantings. Trees used in these practices are not explicitly inventoried by either of the two primary national natural resource inventories: the Forest Inventory and Analysis (FIA) program of the USDA Forest Service and the National Resources Inventory (NRI) of the USDA Natural Resources Conservation Service. The FIA program inventories trees in forests meeting specific size and density criteria. The NRI program compiles natural resource information on non-federal land in the United States. In this study, we estimate the agroforestry and other tree resources of Iowa and Missouri and document the obstacles to effective inventories of agroforestry practices. We propose minor modifications to national natural resource inventory programs that would lead to an improved assessment of agroforestry and other tree resources and practices.

KEYWORDS

agroforestry; inventory; monitoring; policy; natural resources; land use

INTRODUCTION

What are *working trees*?

Working trees are those intentionally established in rural and urban landscapes to achieve specific functions. Agroforestry is the use of *working trees for agriculture* and is distinguished from traditional forestry by having closely associated agricultural or forage production (USDA Natural Resources Conservation Service, 1996). Agroforestry includes a number of practices: field, farmstead and livestock windbreaks; riparian forest buffers; silvopasture systems; alley cropping; forest farming; and a variety of special applications to help manage natural resource issues such as waste management and wildlife habitat. Christmas trees and nut/fruit orchards generally are excluded from the definition. Specific details are available from the USDA National Agroforestry Center (www.unl.edu/nac/pubs.html#brochures).

Working tree plantings are deliberately composed, arranged and managed to enhance or restore key ecological services that we deem valuable (USDA Natural Resources Conservation Service, 1996). These services range from the maintenance of air, water and soil quality to enhancing crop productivity, conserving energy, and diversifying income (see other papers in this proceedings). A linked system of upland and riparian buffers, in conjunction with other conservation practices, can restore many ecological and economical functions while also reconnecting the many land uses and owners within watersheds (National Research Council, 1993; Schoeneberger *et al.*, 2001; National Research Council, 2002; USDA National Agroforestry Center, 2004). By increasing structural diversity in landscapes, *working trees* have ecological impacts far beyond the proportion of land they occupy and provide opportunities to integrate productivity and profitability with environmental stewardship (Guo, 2000; Olson *et al.*, 2000). One indirect benefit from these relatively small, fragmented

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plantings is the mitigation of greenhouse gas emissions and sequestration of carbon at regional and national scales while the bulk of the land remains in its original working land use (Schoeneberger, 2005).

Which programs promote *working tree* practices?

Some conservation programs promote the use of *working tree* practices by providing financial incentives to landowners for the establishment and management of these plantings. The Farm Security and Rural Investment Act of 2002 increased financial support for many of these practices through cost-sharing, incentive, maintenance, and rental payments, and producer grants (Table 1, and USDA National Agroforestry Center, 2003). Additional federal and state programs support the installation and management of these *working tree* practices. The public's growing awareness of these practices and the multiple services they can provide on private lands translates into greater support for regional programs like the multi-state *Chesapeake Bay*, the *White Water to Blue Water,* and the *Green Lands to Blue Water* initiatives.

Why do we need to account for *working trees*?

Despite addressing concerns like water quality and greenhouse gas emissions, *working tree* plantings are largely unknown to many who are responsible for developing or influencing natural resource investment directions. Agroforestry, by definition, straddles the agricultural and forestry sectors, but many times is not advocated by either one. The agronomic sector views agroforestry as forestry since trees are involved; the forestry sector categorizes these practices as agriculture since land use is not changed by their addition. This is problematic as new natural resource policies and programs are developed. Carbon sequestration efforts, for example, have largely focused on adaptive management of existing forests and conservation tillage of croplands. Many farm-accounting models and tools ignore tree-based practices as viable carbon sequestering options. The new Voluntary Reporting of Greenhouse Gases – Carbon Management Evaluation Tool (COMeT-VR) (www.cometvr.colostate.edu) calculates agriculture-sector carbon sequestration in the soil from shifts in cultivation, grazing and other non-tree-based

Table 1. Several USDA programs support *working tree* plantings. (Adapted from Godsey, 2003).

Program	Agroforestry practice				
	Alley cropping	Riparian buffer	Windbreak	Silvo-pasture	Forest farming
Conservation Reserve Program (CRP)	C/M/R				
Continuous CRP (CCRP)		C/I/M/R	C/I/M/R		
Conservation Reserve Enhancement Program (CREP)		C/I/M/R			
Environmental Quality Incentive Program (EQIP)	C/I	C/I	C/I	C	C
Wetlands Reserve Program (WRP)		C/R			
Conservation Security Program (CSP)	C/R	C/R	C/R	C/R	
Forest Land Enhancement Program (FLEP)	C	C	C	C	C
Sustainable Agriculture Research & Education (SARE)	PG	PG	PG	PG	PG

C: cost share, I: incentive, M: maintenance, PG: producer grant, R: rental

practices. COMeT-VR thus inadvertently promotes non-tree based management options as the primary carbon sequestering practices for the agricultural sector.

Which programs are capable of inventorying *working trees* in the United States?

Ultimately, the contributions from *working trees* would be better estimated by a comprehensive inventory. Trees used in agroforestry practices are not explicitly inventoried by either of the two primary national natural resource inventory programs: the Forest Inventory and Analysis (FIA) program of the USDA Forest Service and the National Resources Inventory (NRI) of the USDA Natural Resources Conservation Service.

For more than 75 years, FIA has been charged by Congress to "make and keep current a comprehensive inventory and analysis of the present and prospective conditions of and requirements for the renewable resources of the forest and rangelands of the United States" (McSweeney-McNary Act of 1928). FIA is the primary source for information about the extent, condition, status and trends of the forest resource across all ownerships in the United States (Smith, 2002). FIA traditionally concentrated on the nation's timber resources, but a change in focus was codified by the passage of the Agricultural Research, Extension and Education Reform Act of 1998, integrating FIA with the Forest Health Monitoring (FHM) program. Annual FIA inventories are underway or completed in 45 of the 50 states, and the data are critical to state, national and international assessments (Smith, 2002; Stolte *et al.*, 2002).

NRI compiles natural resource information on non-federal land in the United States, about 75 percent of the total land area. NRI has been designed and implemented to assess conditions and trends of soil, water, and related resources (Nusser and Goebel, 1997). NRI is mandated by Congress to complete the inventory at intervals of 5 years or less (Rural Development Act of 1972 and the Soil and Water Resources Conservation Act of 1977). It is conducted in cooperation with the Iowa State University Center for Survey Statistics and Methodology and captures data on land cover/use, soil erosion, prime farmland soils, wetlands, habitat diversity, selected conservation practices, and related resource attributes.

OBJECTIVES AND METHODS

This study had three objectives: 1) to estimate the area of *working trees* using Iowa and Missouri as case studies; 2) to evaluate the effectiveness of current inventories of *working trees*; and 3) to propose improved methods for *working tree* inventories.

FIA applies a nationally consistent sampling protocol using a quasi-systematic design covering all ownerships in the entire nation (Brand *et al.*, 2000). This sampling design is based on an array of hexagons assigned to separate interpenetrating, non-overlapping annual sampling panels (Brand *et al.*, 2000) (Figure 1). Each hexagon represents approximately 2403 ha (5937 ac.), and plots in two adjacent hexagons are not measured during the same year (Brand *et al.*, 2000). Permanent fixed-area plots are installed in each hexagon, and tree measurements (*e.g.*, species, height, and diameter) are taken on four subplots (Figures 2

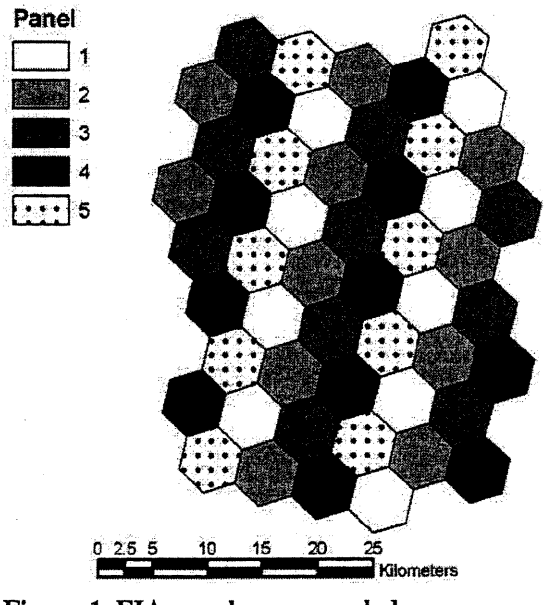

Figure 1. FIA panels are sampled on a rotating basis. At least one FIA plot is installed in each hexagon.

and 3) where they meet the definition of forest land provided below:

> "(a) the condition is at least 10-percent stocked by trees ... of any size or has been at least 10-percent stocked in the past. Additionally, the condition is not subject to nonforest use(s) that prevent normal tree regeneration and succession such as regular mowing, intensive grazing, or recreation activities; or
>
> "(b) in several western woodland species ... where stocking cannot be determined, and the condition has at least 5 percent crown cover by trees of any size, or has had at least 5 percent cover in the past. Additionally, the condition is not subject to nonforest use that prevents normal regeneration and succession such as regular mowing, chaining, or recreation activities." (USDA Forest Service, 2004)

Further, the condition generally must be at least 36.6 m (120 ft.) wide and 0.40 ha (1.0 ac.) in area to qualify as forest land (USDA Forest Service, 2004). Additional forest health measurements (crown condition, damage, down woody material, lichens, ownership, ozone, soils, and vegetation diversity and structure) are taken at prescribed locations (USDA Forest Service, 2004).

FIA inventories are designed to determine the area of forest land and the volume of woody biomass. North Central FIA (NCFIA) has a history of using specific land use categories that combine forest cover with land use (Table 2); other regions use different, but similar, categories reflecting land use activities within their region.

NRI uses a stratified two-stage sampling design that can be modified for specific national survey objectives and used as frame for special studies. The strata, generally 3.2 km (2 mi.) by 9.7 km (6 mi.) in size, were developed to provide nation-wide coverage. Within the strata, two-stage samples were randomly selected. The first stage sampling unit is the segment, sometimes referred to as the Primary Sampling Unit (PSU). Segments are generally 65 ha (160 ac.) in size. Within each segment, generally three secondary sampling units (points) were selected, and data are collected both at the segment- and point-level. While data for the first

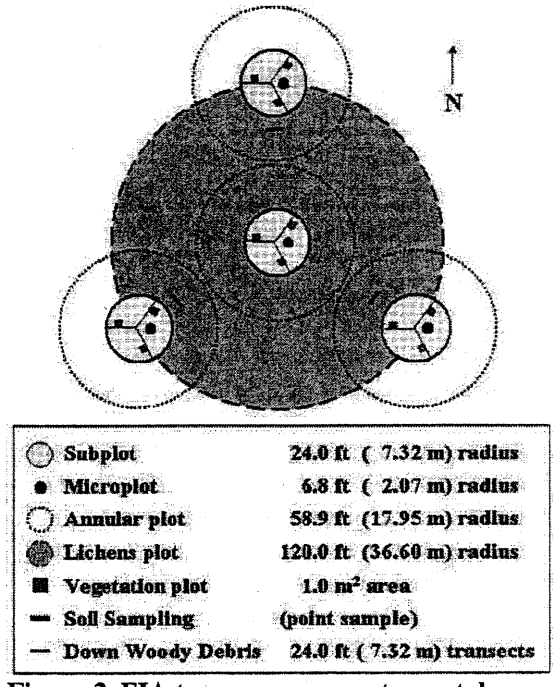

Figure 2. FIA tree measurements are taken on four subplots within each plot. Non-tree measurements occur at specific locations. (Source: FIA Fact Sheet Series).

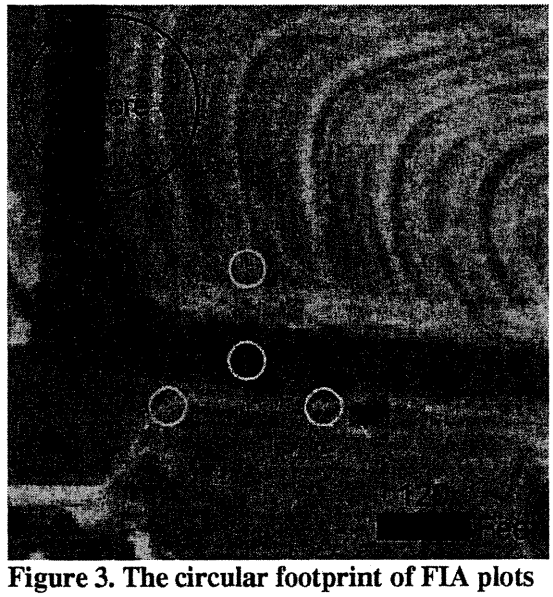

Figure 3. The circular footprint of FIA plots does not match the linear structure of many *working tree* plantings. Only those fractions of subplots meeting the definition of forest land are inventoried.

Table 2. Several different land uses inventoried by the North Central FIA unit include *working trees*. Only trees on accessible forest land are measured. (Adapted from USDA Forest Service, 2004).

Category	NCLU[a]	Definition
		Accessible forest land
Timberland	20	Forest land that is capable of producing in excess of 1.4 cubic meters per hectare (20 cubic feet per acre) per year of roundwood products, excluding fuelwood, and is not withdrawn from timber utilization by statute, administrative designation, or exclusive use for Christmas tree production. (If land is used for grazing, see codes 21 and 59.)
Pastured timberland	21	Forest land used for wood production and grazing. (If land has a stocking value of less than 10 in trees over 2.5 cm (1.0 inch) DBH or less than 25 in growing-stock trees of any size, see codes 52 and 59.)
Plantations	22	An artificially reforested area, sufficiently productive to qualify as commercial forest land, established by planting or by direct seeding. Planted species is not necessarily predominant. The forest type, stand age, and stand size class should reflect the planted species. If the plantation has failed, give the plot a GLU code 20. Unless the land is used primarily for grazing, code 22 is preferred over codes 21 and 59.
Wide windbreaks	57	A group of trees, greater than 36.6 m (120 ft.) wide and 0.4 ha (1 ac.) in size, protecting buildings in use. Area would qualify as timberland except that the primary land use is protection of buildings. As a guideline, consider using code 22 if there are more than 12 rows of trees or the area is larger than 2 ha (5 ac.).
Wooded pasture	59	Grazed land with a stocking value of more than 10.0 in all live trees 2.5 cm (1 inch) DBH or larger, but less than 25.0 in growing stock (20 class) trees of any size. Two situations are possible. The first is that the land could qualify as pastured timberland except that the low stocking in growing stock trees indicates that the land is not being used for wood production. The second is that the land is unproductive for timber, due to livestock or intrinsic site factors, and is being used for forage. If evidence indicates that the primary use is wood production or the protection of buildings see code 21 and 57.
Urban forest land	71	Land that normally would meet the criteria for timberland, but is in an urban-suburban area surrounded by commercial, industrial, or residential development. It is extremely unlikely that such land is used for timber products on a continuing basis. Example: wooded creek bottom surrounded by houses.
		Non-forest land with trees
Cropland with trees[b]	51	Cropland with scattered inclusions of single trees or small groups of trees. Orchards are also included in this class.
Pasture and rangeland with trees[b]	52	Land used for grazing with a stocking value of less than 10.0 in all live trees 2.5 cm (1 inch) DBH or larger.
Wooded strip[b]	53	An acre or more of continuous forest land that meets the definition of forest land (code 20, 21, 22, 40, 41, 45) except that it is less than 36.6 m (120 ft.) wide.
Narrow windbreaks[b]	56	A group of trees, less than 36.6 m (120 ft.) wide, used for the protection of buildings in use.
Shelterbelt[b]	58	A group of trees, less than 36.6 m (120 ft.) wide, used for the protection of soil and crop fields.
Urban and other with trees	72	Area with trees that is developed for residential, industrial, recreational, or other urban use. For example City Park, cemetery, golf course, maintained backyard, farmsteads with trees. The 36.6 m (120 ft.), 0.4 ha (1 ac.) rule does not apply in the case of a maintained yard.

[a] NCFIA land use code.
[b] These land uses must have one or more trees, 13 cm (5.0 inch) DBH or larger, within the visual 0.4 ha (1 ac.) surrounding the plot center.

years of the inventory were collected through site visits, more recent inventories employ a combination of high-quality color imagery, field office records, historical records and data, ancillary materials, and a limited number of onsite visits (USDA Natural Resources Conservation Service, 2002). The boundaries and locations of the strata, segments, and points remain unchanged over all years of the inventory, so NRI may provide estimates of land use change, what it was, and what it has become (Nusser *et al.*, 1998). Trends and changes in land use and resource characteristics over 15 years can be examined and analyzed using data available from 1982, 1987, 1992, and 1997. The release of the 2001 Annual NRI estimates ushered in the newest stage of NRCS natural resource inventory activity. Data for a subset of the 800,000 sample locations are now collected on an annual basis.

NRI uses a slightly different definition of forest land than FIA, to wit:

> "A land cover/use category that is at least 10 percent stocked by single-stemmed woody species of any size that will be at least 4 meters (13 feet) tall at maturity. Also included is land bearing evidence of natural regeneration of tree cover (cutover forest or abandoned farmland) and not currently developed for non-forest use. Ten percent stocked, when viewed from a vertical direction is a canopy cover of leaves and branches of 25 percent or greater" (USDA Natural Resources Conservation Service, 2002).

NRI, like FIA, requires the condition to be 0.40 ha (1.0 ac.) in size, but the minimum width is 30.5 m (100 ft.) (USDA Natural Resources Conservation Service, 2002). NRI has also adopted its own categories for land cover/use classification (Table 3).

Crosswalk tables between agroforestry practices and each inventory's land use classifications were developed by reviewing current inventory protocols (USDA Natural Resources Conservation Service, 2002; USDA Forest Service, 2004) in consultation with inventory personnel. FIA inventories do not incorporate accepted definitions of agroforestry practices as such; *working trees* in NCFIA are distributed among many different possible land use codes related more to the amount of trees than to agroforestry definitions (Table 4). A primary goal of NRI is to document land use change, not specific management practices, so individual agroforestry practices are distributed across several different land cover/use categories (Table 5). Using this information, the extent of each land use/land cover/use was calculated with queries to the respective inventory databases.

RESULTS AND DISCUSSION

How extensive are *working trees*?

A review of recent FIA and NRI inventories of Iowa and Missouri demonstrates the challenges these two programs face when estimating the acreage of *working trees* in the landscape.

FIA estimates show the treed land of Iowa and Missouri to be dominated by timberland, but sizable areas of other land uses exist. Pastured timberland, wooded pasture, and pasture and rangeland with trees together account for 26% and 19% of the total treed land in Iowa and Missouri, respectively (Table 6). It cannot be guaranteed that all of this land is silvopasture, but this is still a large proportion of the landscape. Curiously, wide windbreaks were observed in Iowa but not in Missouri; the reverse occurred with narrow windbreaks and shelterbelts (Table 6). Significant gaps exist in the FIA inventories of *working trees* of Iowa and Missouri; approximately 19% of the *working trees* in Iowa are not inventoried, and approximately 13% are not inventoried in Missouri (Table 6). Even larger gaps exist in the Great Plains states of North Dakota, South Dakota, Nebraska; and Kansas.

NRI estimates provide a different perspective of *working tree* plantings. By focusing on land cover/use, NRI cannot inventory practices occurring within that land use; the scale of *working tree* plantings generally will not be sufficient to meet the NRI definition of forest land. As a result, *working tree* practices are included in the adjacent land cover/use. The ability to distinguish CRP land from other land, however, provides valuable information on landowner participation in funding programs that support *working trees* (Table 7).

Table 3. Definitions of NRI land cover/use categories. (Adapted from USDA Natural Resources Conservation Service, 2002).

Category	Definition
Cropland	A land cover/use category that includes areas used for the production of adapted crops for harvest. Two subcategories of cropland are recognized: cultivated and noncultivated. Cultivated land comprises land in row crops or close-gorwn crops and also other cultivated cropland; for example, hayland or patureland that is in a rotation with row or close-grown crops. Noncultivated cropland includes permanent hayland or horticultural cropland.
CRP land	Conservation Reserve Program (CRP) land is a land cover/use category that includes land under a CRP contract.
Developed land	This category combines Urban and built-up areas with Rural transportation land.
Farmsteads and ranch headquarters	A land cover/use category that includes land used for dwellings, buildings, barns, pens, corals, feedlots next to buildings, farmstead or feedlot windbreaks, and family gardens associated with operating farms or ranches.
Forest land	A land cover/use category that is at least 10% stocked by single-stemmed woody species of any size that will be at least 4 meters (13 feet) tall at maturity. Also included is land bearing evidence of natural regeneration of tree cover (cutover forest or abandoned farmland) and not currently developed for nonforest use. Ten percent stocked, when viewed from a vertical direction, is a canopy cover of leaves and branches of 25% or greater. The minimum area for classification of forest land is 0.4 ha (1 ac.), and the area must be at least 30.5 m (100 ft.) in width.
Other land in farms	A land cover/use category that includes land used for field windbreaks, commercial feedlots, greenhouses, nurseries, poultry facilities, and airplane landing strips that are not associated with farmsteads. These areas are not classified as part of cropland, pastureland, rangeland, forest land, barren land, farmsteads and ranch headquarters, or rural transportation.
Other rural land	This category combines Farmsteads and Ranch Headquarters with Other land in farms.
Pastureland	The land cover/use category of land managed primarily for the production of introduced or native forage plants for livestock grazing, regardless of whether the land is currently being grazed by livestock or not.
Rural transportation	A land cover/use category that consists of all highways, roads, railroads, and associated rights-of-way outside urban and built-up areas; private roads to farmsteads; logging roads; and other private roads (field lanes are not included).
Urban and built-up areas	A land cover/use category consisting of residential, industrial, commercial, and institutional land; construction sites; public administrative sites; railroad yards; cemeteries; airports; golf courses; sanitary landfills; sewage treatment plants; water control structures and spillways; other and used for such purposes; small parks [less than 4.0 ha (10 ac.)] within urban and built-up areas; and highways, railroads, and other transportation facilities if they are surrounded by urban areas. Also included are tracts of less than 4.0 ha (10 ac.) that do not meet the above definition, but are completely surrounded by urban and built-up land.

It is not possible to make conclusive statements about the extent of *working trees* from either inventory, but the data suggest widespread *working tree* practices, particularly pasture- and windbreak-affiliated land uses. *Working tree* conservation practices funded by CRP are a small fraction of the total land area in these states.

What are the obstacles to an inventory of *working trees*?

Land with *working trees* is a subset of all land with trees. Agroforestry is distinguished from traditional forestry by its association with an agricultural or forage crop (USDA Natural Resources Conservation Service, 1996). The

Table 4. Agroforestry practices in the North Central FIA region are distributed across many different land use categories. These codes are only applied in the North Central FIA region. A different system is used in other regions.

Agroforestry practice	Relevant FIA land use code (NCLU) [a]											
	20	21	22	51	52	53	56	57	58	59	71	72
Alley cropping			X	X					X			
Forest farming	X		X									
Riparian forest buffers	X		X			X			X			
Silvopasture systems		X		X	X					X		
Special applications	X	X	X	X	X	X	X	X	X	X		
Urban and community applications	X		X			X	X	X			X	X
Windbreaks or shelterbelts			X				X	X	X			

[a] See Table 2 for NCLU definitions.

Table 5. Agroforestry practices are distributed across many different NRI land cover/use categories.

Agroforestry practice	NRI land cover/use category[a]					
	Cropland	CRP land	Developed land	Forest land	Other rural land	Pastureland
Alley cropping	X					X
Forest farming				X		
Riparian forest buffers	X	X	X	X[b,c]	X	X
Silvopasture systems				X		X
Special applications	X	X	X	X[b,c]	X	X
Urban and community applications			X	X[b,c]	X	
Windbreaks or shelterbelts	X	X	X	X[b,c]	X	X

[a] See Table 3 for NRI land cover/use definitions
[b] Although the practice is not generally applied in forest land, the practice itself may be considered forest land if the minimum size and stocking requirements are met.
[c] A planting greater than 4.0 ha (10 ac.) within an urban and built-up area would be classified as forest land.

definition of agroforestry also specifies that these plantings are deliberately composed, arranged, and managed to enhance or restore key ecological services (USDA Natural Resources Conservation Service, 1996). Woody encroachment on rangelands used for grazing would not be considered *working trees*. Orchards and Christmas tree plantations are not

Table 6. NCFIA estimates of the area of distinct land uses that may include *working trees*. Tree inventories only occur on accessible forest land. Data are taken from the 1999-2004 inventories.

Land use	NCLU	Iowa		Missouri	
		Area	Std. error	Area	Std. error
		Accessible forest land			
		---------- thousands of hectares ----------			
Timberland	20	778.1	29.3	4767.5	51.0
Pastured timberland	21	236.2	20.8	783.8	34.1
Plantation	22	1.3	1.3	12.2	4.2
Wide windbreak	57	3.0	2.2	n/a	n/a
Wooded pasture	59	34.3	8.6	144.8	15.4
Urban forest land	71	7.5	3.9	40.8	8.5
		Non-forest land with trees			
		---------- thousands of hectares ----------			
Cropland with trees	51	19.4	6.9	103.8	14.0
Pasture/range with trees	52	81.8	12.9	393.6	25.4
Wooded strip	53	65.7	12.3	147.8	16.8
Narrow windbreaks	56	n/a	n/a	3.9	2.8
Shelterbelt	58	n/a	n/a	4.4	2.8
Urban and other with trees	72	88.6	14.2	242.6	20.7
Total treed land[a]		1363.7	36.0	6852.2	54.82

[a] Including reserved land and other land uses without *working trees*.

Table 7. NRI estimates of the area of distinct land cover/uses that may include *working trees*. Data are taken from the 1997 inventory. (Adapted from USDA Natural Resources Conservation Service, 2004)

Land cover/use	Iowa	Missouri
	thousands of hectares	
Cropland	10242.6	5564.9
CRP land	703.9	650.0
Developed land	688.8	1018.8
Non-federal forest land	882.9	5030.6
Other rural land	352.2	256.5
Pastureland	1445.5	4390.3

generally established to enhance or restore key ecological services, so they also would not be considered *working trees*.

FIA and NRI use different definitions of land use. Both programs are implemented nationally, and definitions are critical to collecting data that can be integrated at that level. Because of historic practices, both inventories use strict definitions of forest land, and neither program classifies land use in a manner that matches agroforestry practices on a one-to-one basis. In general, the assignment of a specific NCFIA land use code will account for, in order of preference, the size of the stand, the size and number of trees (stocking), and the observed evidence of past and present land management. For example, trees obviously established artificially would be classified as a plantation if the stand was large enough to meet the definition of forest land. The same planting would be classified as a wide windbreak if it protected buildings. Agroforestry specialists may classify *working tree* plantings as riparian forest buffers if they are adjacent to a water

body, but NCFIA does not specify any riparian land uses. Smaller plantings, not meeting the forest land definition, could be classified as narrow windbreaks (protecting buildings) or shelterbelts (protecting cropland). Similarly, an active pasture with trees (silvopasture in the agroforestry community) would be classified as pastured timberland if it met the size and stocking requirements for forest land. Fewer trees would yield a classification of wooded pasture. As the number of trees and the size of the stand continued to decline, the classification would grade into pasture and rangeland with trees.

By contrast, agroforestry practices are generally inventoried by NRI according to the land cover/use to which the practice is applied. For example, agroforestry-oriented USDA NRCS conservation practice standards (USDA Natural Resources Conservation Service, 2005) applied to Conservation Reserve Program (CRP) land would be inventoried as CRP land. Practices implemented outside of CRP may be classified as forest land if the area size and percent canopy closure definition for forest land was met; if not, they would be included in the surrounding NRI land cover/use category. Similarly, alley cropping would generally be classified by NRI as cropland or pastureland, depending on the land cover/use to which the agroforestry practice is applied. Silvopasture would be classified as either pastureland or forest land, depending on its size and percent canopy closure. NRI does have two subcategories of forest land (grazed and not grazed), but not all grazed forest land would meet the specifications of silvopasture. An additional restriction occurs in urban and community applications of agroforestry; forest land must be at least 4.0 ha (10 ac.) to be defined as such when occurring within urban and built-up areas.

While both FIA and NRI have the same minimum size requirement, the two programs use different minimum widths, 36.6 m (120 ft.) and 30.5 m (100 ft.), respectively. Definitions of stocking (the aggregate number and size of trees) also differ. *Working trees* in riparian buffers, windbreaks, and shelterbelts often do not meet the minimum size requirements for forest land. Silvopasture, on the other hand, may meet the size requirements, but not those for stocking.

Perhaps most importantly, the public and their elected decision-makers have not advocated an inventory of *working trees*. The mandates of both NRI and FIA have focused on more traditional resources, so sufficient resources are not allocated to measure agroforestry systems at present.

The obstacles to a more comprehensive inventory are definition-oriented and thus tied directly to the original purpose of each program.

A proposal for an improved *working tree* inventory

It is possible to capitalize on the strengths of FIA and NRI to improve the inventory of *working trees*. NRI typically classifies areas of conservation practices, both with or without trees, as part of the surrounding land use. However, in one special NRI study data collectors were asked to delineate the footprint of specific conservation practices, including wind breaks, within the segment boundaries on the aerial photograph of the sampling region (USDA Natural Resources Conservation Service, 1998). This enabled the estimation of area features (*e.g.*, length, width and acreage) that are generally included within other land cover/use categories. A similar approach is proposed in which NRI data collectors digitize the footprint of agroforestry practices within segment boundaries. This would provide estimates of the extent of *working trees*.

FIA conducts inventories only on accessible forest land. Since any one agroforestry practice could occur in either accessible forest land or non-forest land with trees (Table 4), FIA cannot estimate the area or volume of woody biomass in specific agroforestry systems. One simple change would be to measure trees on every plot whether the condition meets the definition of forest land or not – an all-tree inventory. Within NCFIA, there are several land use categories similar to standard agroforestry definitions, but new data element(s) could be collected in the field that actually specify agroforestry practices. FIA could thus provide estimates of *working tree* volume by land use nationwide. A pilot study is being developed to improve FIA

inventories of windbreaks, shelterbelts, and riparian tree resources (D. Haugen, pers. comm., 2005).

The combination of FIA volume estimates with NRI estimates of spatial extent would provide unit area estimates of biomass in *working trees*. Such a collaborative effort may not completely fulfill the needs of the agroforestry community, but it would be one step closer to an inventory of *working trees*. Therefore, our answer to the question of whether the lack of consistent definitions must limit our ability to estimate *working trees* resources is an emphatic, "No!"

CONCLUSIONS

The growing interest in *working trees* is an excellent example of how some of the most challenging management decisions occur at the interface between disciplines. The Forest Inventory Analysis (FIA) program of the USDA Forest Service and the National Resources Inventory (NRI) of the USDA Natural Resources Conservation Service have mandates to conduct national inventories of forests and soil, water, and related resources, respectively. Unfortunately, neither FIA nor NRI are particularly effective at providing relevant information to the agroforestry community. Each program has historically focused on traditional forestry and agricultural resources. The definition of forest land emphasizes productive stands of sufficient size to yield economic benefit. However, a review of woody resources in Iowa and Missouri suggest that substantial areas of *working trees* are not inventoried. A review of FIA's pre-field work suggests that an approximately 9% increase in effort (*i.e.*, funding) is required to inventory all *working trees* in these two states. In practice this collaboration would require FIA crews to visit every plot with trees, regardless of land use, and NRI crews would need to delineate the footprint of more specific conservation practices. The necessary investment is not small, but minor modifications to the two national natural resource inventories would facilitate an effective inventory of the country's *working trees*. The resulting information would prove invaluable to managers and decision-makers confronted with significant environmental issues across the nation's working lands.

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REFERENCES

Brand G.J., Nelson M.D., Wendt D.G. and Nimerfro K.K. 2000. The hexagon/panel system for selecting FIA plots under and annual inventory. In: McRoberts R.E., Reams G.A. and Van Deusen P.C. (eds) Proceedings of the first annual forest inventory and analysis symposium. Gen Tech Rep NC-213. USDA Forest Service, St. Paul, MN, pp 8-13.

Godsey L. 2003. Funding incentives for agroforestry in Missouri. 5-2002. Available at agebb.missouri.edu/umca/pubs/fundincent.pdf (verified 20 Apr 2005). University of Missouri Center for Agroforestry, Columbia, MO.

Guo Q. 2000. Climate change and biodiversity conservation in Great Plains agroecosystems. Global Environ Chang 10: 289-298.

National Research Council. 1993. Soil and water quality: an agenda for agriculture. National Academy Press, Washington, D.C., 516 pp.

National Research Council. 2002. Riparian areas: functions and strategies for management. National Academy Press, Washington, D.C., 428 pp.

Nusser S.M. and Goebel J.J. 1997. The National Resources Inventory: a long-term multi-resource monitoring programme. Environ Ecol Stat 4: 181-204.

Nusser S.M., Breidt F.J. and Fuller W.A. 1998. Design and estimation for investigating the dynamics of natural resources. Ecol Appl 8: 234-245.

Olson R., Schoeneberger M.M. and Aschmann S. 2000. An ecological foundation for temperate agroforestry. In: Garrett H.E., Rietveld W.J. and Fisher R.F. (eds) North American Agroforestry: An Integrated Science and Practice. American Society of Agronomy, Madison, WI, pp 31-61.

Schoeneberger M.M., Bentrup G. and Francis C.F. 2001. Ecobelts: reconnecting agriculture and

communities. In: Flora C. (ed) Interactions Between Agroecosystems and Rural Human Communities. CRC Press, Boca Raton, FL, pp 239-260.

Schoeneberger M.M. 2005. Agroforestry: working trees for sequestering carbon on ag lands. In: Brooks K.N. and Ffolliott P.F. (eds) Moving Agroforestry into the Mainstream. Proc. 9th North American Agroforestry Conf., Rochester, MN. 12-15 June 2005 [CD-ROM]. Dept. Forest Resources, Univ. Minnesota, St. Paul, MN, 13 pp.

Smith W.B. 2002. Forest inventory and analysis: a national inventory and monitoring program. Environ Pollut 116: S233-S242.

Stolte K., Conkling B., Campbell S. and Gillespie A. 2002. Forest health indicators: Forest Inventory and Analysis program. FS-746. USDA Forest Service, Washington, D.C., 24 pp.

USDA Forest Service. 2004. Forest inventory and analysis national core field guide. Volume 1: field data collection procedures for phase 2 plots, version 2.0 [Online]. Available at www.fia.fs.fed.us/library/field-guides-methods-proc (verified 15 Apr 2005). USDA Forest Service, St. Paul, MN.

USDA National Agroforestry Center. 2003. Incentives for agroforestry: 2002 Farm Bill. In: Inside Agroforestry [Online]. Available at www.unl.edu/nac/ia/winter03/winter03.pdf (verified 20 Apr 2005). USDA National Agroforestry Center, Lincoln, NE.

USDA National Agroforestry Center. 2004. Working trees for water quality [Online]. Available at www.unl.edu/nac/brochures/wtwq/wtwq.pdf (verified 15 Apr 2005). USDA Forest Service and USDA Natural Resources Conservation Service, Lincoln, NE.

USDA Natural Resources Conservation Service. 1996. Agroforestry for farms and ranches. Agroforestry Technical Note No. 1 [Online]. Available at www.nrcs.usda.gov/technical/ECS/forest/technote1.html (verified 15 Apr 2005). USDA Natural Resources Conservation Service, Lincoln, NE.

USDA Natural Resources Conservation Service. 1998. 1998 Special Study National Resources Inventory [Online]. Available at www.ncgc.nrcs.usda.gov/products/nri/1998nri.html (verified 2 May 2005). USDA Natural Resources Conservation Service, Fort Worth, TX.

USDA Natural Resources Conservation Service. 2002. National Resources Inventory data collection instructions [Online]. Available at www.ncgc.nrcs.usda.gov/products/nri/2002nri.html (verified 15 Apr 2005). USDA Natural Resources Conservation Service, Fort Worth, TX.

USDA Natural Resources Conservation Service. 2004. State of the land. [Online] Available at www.nrcs.usda.gov/technical/land/ (verified 22 Apr 2005). USDA Natural Resources Conservation Service, Fort Worth, TX.

USDA Natural Resources Conservation Service 2005. National conservation practices standards - NHCP [Online]. Available at www.nrcs.usda.gov/technical/standards/nhcp.html (verified 15 Apr 2005). USDA Natural Resources Conservation Service, Fort Worth, TX.