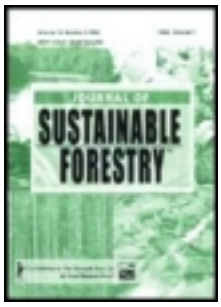

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Understanding the Relationships between American Ginseng Harvest and Hardwood Forests Inventory and Timber Harvest to Improve Co-Management of the Forests of Eastern United States

James L. Chamberlain [a] , Stephen Prisley [b] & Michael McGuffin [c]

[a] USDA Forest Service Southern Research Station , 1710 Research Center Drive, Blacksburg , VA , 24060

[b] Forest Resources and Environmental Conservation, College of Natural Resources and Environment, Virginia Polytechnic Institute and State University , Blacksburg , VA , 24060

[c] Michael McGuffin, President, American Herbal Products Association , Silver Spring , MD , 20910

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Understanding the Relationships between American Ginseng Harvest and Hardwood Forests Inventory and Timber Harvest to Improve Co-Management of the Forests of Eastern United States

JAMES L. CHAMBERLAIN, STEPHEN PRISLEY, andMICHAEL MCGUFFIN

[1] USDA Forest Service Southern Research Station, 1710 Research Center Drive, Blacksburg, VA 24060; jachambe@vt.edu; 540-231-1383 [Corresponding author].

[2] Associate Professor, Forest Resources and Environmental Conservation, College of Natural Resources and Environment, Virginia Polytechnic Institute and State University, Blacksburg, VA 24060

[3] Michael McGuffin, President, American Herbal Products Association, Silver Spring, MD 20910

The roots of American ginseng have been harvested from the hardwood forests of eastern United States, along-side timber, since the mid-1700s. Very little is known about this non-timber commodity relative to timber, although significant volumes of ginseng root have been harvested from the same forests along with timber. The harvest of ginseng correlated positively and significantly with hardwood forest area, hardwood growing stock volume and timber removals. Also, it correlated with hardwood growing stock on public forest lands in the region. The annual wholesale value of American ginseng was estimated at approximately $26.9 million compared to annual stumpage value of harvested hardwood timber of just over $1.27 billion. The volume of ginseng root harvested from natural forests represents substantial extraction of biomass, and the associated value represents substantial income for people living in an economically marginalized region. Co-management of eastern hardwood forests for timber and non-timber forest products could improve local economies and better conserve the bio-diversity of these forests.

KEYWORDS. American ginseng, forest inventory, medicinal plants, non-timber forest products, temperate hardwood forests, timber production.

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INTRODUCTION

Non-timber forest products have been significant contributors to the forest products industry in the United States (Chamberlain et al., 1998) since this country was established. Sassafras (*Sassafras albidum* Nutt.) root was one of this country's first exports, shipped from what is now Martha's Vineyard to England for its medicinal qualities (Norton, 1923). The United States has been a major supplier of herbal forest products such as American ginseng, though the economic contribution has not been accounted for in valuing the forest products industry.

American ginseng root has been commercially harvested from eastern hardwood forests for more than 300 years. In the early 1700s, a Jesuit priest living near Montreal, Canada learned of a plant (*Panax ginseng* C.A. Mey) used in Chinese medicine that might be growing in Canadian forests (Goldstein, 1975; Lockman, 1763; Pritts, 1995). Soon after American ginseng (*Panax quinquefolius* L.) was found in nearby forests a vibrant trade developed between the two countries. Commerical harvest began migrating south by the mid-1700s when natural populations of wild ginseng around Montreal were depleted, and the plant was discovered in New England (Nash, 1898). From the time of the American Revolutionary War (1775-1783) and the turn of the 20th century, the United States exported an estimated 9 million kilograms (20 million pounds) of dried ginseng root to China (Pritts, 1995). By 1903, concern was raised about

the diminishing supply of the wild American ginseng (Goldstein, 1975), yet commercial harvest continues today, though exports are controlled by the U.S. Fish and Wildlife Service.

The hardwood forests, from which American ginseng roots are harvested, are some of the most biologically diverse temperate forests in the world. In many of these forests, there is more biological diversity found in the area from the forest floor to about breast height (1.3 meters), than in the tree canopy. Many of the herbaceous species found in this rich forest layer are harvested for their commercial value (Anderson et al., 1993). More than 60 percent of the 20 species of plants tracked by the American Herbal Products Association (2007) grow naturally in eastern hardwood forests. Most tree species growing in the hardwood forests of ginseng's harvest region have commercial value, as well. The tremendous biodiversity of timber and non-timber producing flora has supported a dynamic and globally important economy and all need active management to ensure their long-term sustainability.

Timbering of the hardwood forests has, and continues to be, a major provider to rural economies in the region where ginseng is wild-harvested. Many people involved in timbering also harvest ginseng. There is a long traditional relationship between people who cut timber and those who harvest ginseng. Understanding the relationships between timbering and ginseng harvesting is critical to developing appropriate strategies to co-manage for these important commodities. Better insight into the deep ties between these resource uses allows for focused strategies that target critical habitats and communities. An initial place to start to better understand the relationship is the forests and their conditions.

Harvesting of wild American ginseng and hardwood timber has been occurring in the same forests, throughout this country's history, yet there is little documentation of ginseng's value relative to that of hardwood timber. The contribution of hardwood timber to rural economies is considerable, but the value of ginseng has not been calculated and has been assumed to be inconsequential. However, the international market value of American ginseng suggests otherwise (Persons and Davis, 2005; Taylor, 2006). Using data from the U.S. Fish and Wildlife Service and the U.S.D.A. Forest Service, we analyzed relationships between the reported harvests of wild American ginseng and hardwood forest inventory and timber harvests in the 19 states certified to export ginseng, to determine the importance and potential dependence between these products over the past decade. A goal of this study was to provide insight into the relative importance of wild American ginseng harvesting to rural forested counties that could lead to better co-management of the forests.

METHODS

The natural range of American ginseng extends throughout the eastern U.S, in biologically diverse mixed hardwood forests from Quebec south to Georgia, Alabama, Louisiana, Arkansas and Oklahoma (Goldstein, 1975; Nantel et al., 1996; Stockberger, 1928). Anderson et al. (1993) identified more than 49 species of herbs, six fern species and 11 species of vines growing in the herbaceous layer with ginseng in forests of central United States. Saplings of such trees as sugar maple (*Acer saccharum* Marsh.), eastern hophornbeam (*Ostrya virginiana* K. Koch.), slippery elm (*Ulmus rubra* Muhl.), sassafras and tulip poplar (*Liriodendron tulipifera* L.), were observed growing in the understory with ginseng (Anderson et al. 1993).

The overstory trees associated with American ginseng are valued worldwide for their timber. In Canada, these include sugar maple, northern red oak (*Quercus rubra* L.), butternut (*Juglans cinerea* L.), basswood (*Tilia americana* L.), American beech (*Fagus grandifolia* Ehrh.), and bitternut hickory (*Carya cordiformis* K. Koch.) (Charron and Gagnon, 1991; Lewis and Zenger, 1982). The primary overstory trees under which ginseng grow in forests of central United States are sugar maple, white oak (*Quercus alba* L.), red oak, tulip poplar, and basswood (Anderson et al., 1993; Fountain, 1986). The Appalachian forests, from which much of the ginseng originates, contributes more than one-third of the nation's hardwood resources, and have over 100 tree species of commercial importance (Appalachian Regional Commission, 2010).

The data sources for this analysis were state reported ginseng harvest records provided to the U.S. Fish and Wildlife Service (FWS), and records of forest inventory and removals developed by the U.S.D.A. Forest Service, Forest Inventory and Analysis (FIA) program. The FWS is the federal agency charged to oversee American ginseng harvests intended for export, as the plant is covered by the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES). The FWS must determine that the export of wild-harvested ginseng root will not be detrimental to the survival of the species and that the materials to be exported were lawfully acquired. The FIA "makes and keeps 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 U.S." (Frayer and Furnival, 1999). FIA collects, analyzes and reports on the status and trends of America's forests: how much and where it exists, who owns it, and how it is changing, as well as the health and well-being of forest trees and other vegetation.

Data Source – Ginseng

The United States has been tracking the harvest and export of American ginseng since 1975 when it was first listed on Appendix II of CITES (Robbins, 2000; U.S. Fish and Wildlife Service, 2009). For each of the years 2000-2010, the FWS determined that American ginseng could be exported from 19 states (Alabama, Arkansas, Georgia, Illinois, Indiana, Iowa, Kentucky, Maryland, Minnesota, Missouri, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia, and Wisconsin) without detriment to the survival of the species. Each state that is certified by the FWS to export American ginseng must report, annually, the amount of American ginseng root wild-harvested, by county. Ginseng harvest data, compiled by the states, are based on reports by ginseng dealers who obtain information from harvesters at the point of sale. Ginseng dealers report harvest amounts to the state agency that manages the ginseng program, as required by the FWS. The state agency compiles county harvest data and submits this to the FWS annually. Data presented is for wild-harvested ginseng and does not include wild-simulated, woods grown or cultivated root.

Ginseng harvest data for 2000 to 2007 were provided by the FWS and were used to create an electronic database of state-wide harvest quantities for each of the 19 states, and of county-level data for 18 states. County-level data for Minnesota were unavailable for the study period, and were missing for other states for certain years (Table 1). State-wide data for all states were used to calculate range-wide ginseng harvest volumes and valuation. The study covered a total of 1002 counties. County level harvest quantities were aggregated to the FIA unit level (Figure 1) to allow for comparisons with forest stand conditions.

American ginseng state-wide harvests were standardized and are presented on a dry weight basis (Table 2). Reported weights were converted from pounds and ounces to kilograms. Some states reported green weights (i.e., fresh roots), which had to be converted to dry weights. In these cases we used a factor of 1.36 kilograms green weight for each kilogram of dry weight; a conversion ratio that is used commonly in the industry. Some state records did not specify county names, yet merely indicated 'various' counties. When harvest volumes were not assigned to a specific county, they were allocated proportionally to counties where harvests were recorded. After all harvest data were entered into the database and checked for errors, we computed average annual harvest for each county.

We estimated the value of American ginseng by multiplying the harvest figures by prevailing price data. Price data for American ginseng root is less accessible than timber prices (Table 3). Ginseng price estimates were based on several sources. First, published estimates of prices paid to ginseng harvesters by dealers for 1982 through 2005 (Persons and Davis, 2005) provided a foundation for valuing ginseng harvests. Persons (pers. comm., March 2010) supplemented published prices with estimated prices for 2006 and 2007. A regional dealer provided additional price estimates (Tony Hayes, pers. comm., Ridge Runner Trading Company, March 2010). To further validate price estimates we surveyed and received estimates from ginseng buyers throughout the 19 states.

Data Source -- Forest Inventory and Timber Production

FIA inventory data are based on a sampling design involving plots randomly placed across the landscape, in which trees and some under-story vegetation are measured. FIA estimates growing stock (cubic-foot volume), which represents the volume of wood in live trees, and can be used as a relative indicator of forest age and density. Measurements on plots include tree removals based on observations of stumps remaining after harvest. Forest conditions include forest type (i.e., hardwood or softwood stands), age, and land ownership (public lands owned and/or managed by federal, state, or local governments, or private lands owned by corporations or individuals). We included as public lands federal, state, and municipal forests, but excluded military installations and national parks as ginseng harvesting is restricted on these lands.

A state inventory may take five years to complete (Gillespie, 1999) which means data for some states were incomplete for the study period (Table 1) and that estimates have low precision at a county level. Therefore, FIA data are aggregated to larger geographic areas, typically about 400,000 hectares (1 million acres) covering multiple counties with similar vegetation (FIA unit).

Forest inventory data were downloaded from the FIA DataMart (USDA Forest Service, 2011) for the states and years of interest (Table 1). Estimates of forest area, growing stock volumes, and tree removals were computed for hardwood species groups and broad ownership categories (public/private) by county, following the guidelines in the FIADB User Manual (Woudenberg et al., 2010). The resulting dataset was paired with the ginseng harvest data to select only those counties with reported ginseng harvest. This enabled creation of maps showing relevant

171 variables, as well as graphical analysis of relationships between ginseng harvest and forest
172 inventory estimates.

173 Data from selected counties were aggregated to the FIA unit level for analysis. We used
174 Spearman's rank correlation coefficient (ρ) which does not require the assumption of linearity
175 between variables. Graphical and statistical analyses were performed using the ArcGIS
176 geographic information system software and JMP statistical software (SAS Institute, 2007). A
177 major purpose of this study was to identify and better understand relationships between ginseng
178 harvest and various forest factors that might be useful in developing conservation strategies.

179 Timber Product Output (TPO) assessments are based on surveys of primary processing facilities
180 and include production estimates by product and by county of origin. Estimates of timber
181 production at the county level are possible with TPO data (Johnson et al., 2008), but for this
182 study we aggregated to the FIA unit. County-level data from report years between 2001 and 2006
183 were averaged to obtain annual estimates. To estimate timber value we simply multiplied
184 hardwood sawtimber and pulpwood production data obtained from the TPO reporting tools
185 (USDA Forest Service, 2011a) by estimated prices for the period.

186 Obtaining coarse estimates of timber harvest value (to compare with ginseng harvest value) is
187 challenging. Stumpage prices (i.e., prices paid to the landowner) for timber are available from
188 Timber Mart South (2011) and the U.S. Forest Service Southern Research Station Forest
189 Economics and Policy (2011) research unit. Stumpage prices were converted to a cubic-meter
190 basis using factors of 160.7 board feet per cubic meter for sawtimber prices per thousand board
191 feet, and 2.1 cubic meters per cord for pulpwood prices per cord. Prices are highly variable

between seasons, between years, geographically within a state, and between species. Recognizing these limitations we compiled a set of representative prices for hardwood sawtimber and pulpwood for most of the states in the study area for years close to the midpoint of the study period. When price data for a state were unavailable, such as for Iowa, prices from neighboring states were used to estimate value. We acknowledge that ginseng prices are more analogous to delivered prices than stumpage prices in that they are prices paid upon delivery to a dealer. Because of this, our estimates of timber harvest value are conservative when compared to estimates of ginseng harvest value.

RESULTS

More than 200,000 kg (~500,000 pounds) of American ginseng were harvested from natural hardwood forests in 19 states (Table 2), during the period, 2000-2007. Kentucky accounted for more than 25% of the total ginseng harvest, followed by Tennessee (13%), North Carolina (12%), West Virginia (9%), and Indiana (8%). Virginia and Ohio accounted for 5.7% and 5.5%, respectively. These seven states accounted for approximately 70% of the total American ginseng harvest for the period 2000-2007. Vermont reported the lowest harvest of less than 453.5 kilograms. The overall average annual ginseng harvest across the 19 states during the period of study was 28,667 kilogram. Annual harvest ranged from a high of 35,449 kilograms in 2003 to a low of 20,375 kilograms in 2005.

The reported ginseng harvest is greatest in Kentucky, West Virginia, southwest Virginia, Tennessee and North Carolina (Figure 2). The majority of the states reported county level harvest of less than 40 kilograms, annually. Fourteen states reported having counties with annual

harvests greater than 40 kilograms. Two counties in Indiana, one in Tennessee and two in Virginia reported annual harvests between 163.8 and 272 kilograms. Counties with reported annual harvests of more than 272 kilograms (600 pounds) are located in eastern Kentucky, western North Carolina, southwest Virginia, and southern West Virginia.

The average annual ginseng harvest ranged from 0.36 to 505 kilograms, across the 1,002 counties in which ginseng harvest was reported between 2000 and 2007. The top 10 percent of counties reported at least 75 kilograms per year and together accounted for about 55 percent of the overall reported harvest. The top 10 producing counties accounted for approximately 3,907 kilograms or 14 percent of the overall average ginseng harvest (Table 4). Half of the counties are in Kentucky and four are in North Carolina.

Reported ginseng harvest was found to be positively and significantly correlated with (Table 5) forest area ($\rho = 0.43$, $P < 0.0001$), hardwood forest area ($\rho = 0.51$, $P < 0.0001$), forest growing-stock volume ($\rho = 0.45$, $P < 0.0001$), and hardwood growing-stock volume ($\rho = 0.55$, $P < 0.0001$). There were only 58 FIA units with tree removal estimates and 76 FIA units for other variables, because tree removals data are incomplete for some states. The relationships indicate that more ginseng harvest occurs in areas with more hardwood forest and with more growing-stock volume. As hardwood forest area increases and these forest stands increase in volume, reported harvest of American ginseng increases. Further, the analysis also shows a positive and significant relationship between hardwood tree removals and reported ginseng harvest.

We found a significant correlation between reported ginseng harvest and hardwood growing stock on public lands ($\rho = 0.32$, $P = 0.005$). This suggests that as the amount of public land

increases within an FIA unit there is an associated increase in reported ginseng harvest. The proportion of hardwood growing stock on public land within an FIA unit was found to be unrelated to reported ginseng harvest.

The relationship between reported annual ginseng harvest and hardwood growing stock volume, which had the strongest correlation ($\rho = 0.55$, $P < 0.0001$) for the 76 FIA units, shows tremendous variability with a general trend of increasing harvest in units with higher growing stock volumes (Figure 3). The FIA unit (labeled "A" in Figure 3) with the highest hardwood growing stock volume was found to have very low ginseng harvest. Several units had relatively low hardwood growing stock yet have large ginseng harvests. Approximately 87 percent of the units had hardwood growing stock volume less than 10 billion ft^3 (280 million m^3) and reported ginseng harvests of less than 2,000 pounds (900 kilograms). Almost 11 percent of the FIA units had less than 10 billion ft^3 of hardwood growing stock volume and reported ginseng harvest between 2,000 pounds (900 kilograms) and 5,000 pounds (2,300 kilograms). The remaining units had very high hardwood growing stock (> 12 billion ft^3 [340 million m^3]) and low ginseng harvest (< 500 pounds [227 kilograms]) or high hardwood growing stock (~ 10 billion ft^3 [280 million $m^{3]}$) and high ginseng harvest (> 7,000 lbs [3,000 kilograms]).

The majority of FIA units have hardwood growing volumes less than 6 billion cubic feet (170 million m^3) and annual reported ginseng harvest of less than 3000 pounds (1,300 kilograms) (Fig. 3). The 6 "outlier" units are intriguing as they exhibit situations that are atypical to conditions found throughout the harvest region. Two units (A & B) had high hardwood growing stock volume, but low reported annual ginseng harvest. Two (C & D) had high hardwood

growing stock volume, and high reported annual ginseng harvest. And, two (E & F) had low hardwood growing stock volume and high reported annual ginseng harvest.

Unit "A," located in North Central Pennsylvania ranked number 1 among all 76 FIA units with hardwood acreage and hardwood growing stock on public forest land. The unit ranked 3rd and 4th for hardwood removals and for percent of hardwood growing stock on public forests. Unit "B", located in Northeast West Virginia ranked 2nd for hardwood acreage and 3rd among all units for hardwood growing stock volume on public lands. Unit "B" is in the top twenty for hardwood removals (13th) and percent of hardwood growing stock on public lands (17th). Unit "C" is located in Western North Carolina and ranked 2nd for hardwood growing stock on public forests. This unit is in the top 10 units for overall hardwood acreage (6th) and percent of hardwood growing stock volume on public forest lands (7th). Unit "D" in Southwest West Virginia ranked 2nd for hardwood removals and 4th for hardwood acreage. The unit is 22nd among the 76 units for hardwood growing stock volume on public forest lands, and 55th for percent of hardwood growing stock on public forest land. Units "E" and "F" are located in Eastern and Southern Kentucky, respectively. While Unit "E" ranked 33rd unit "F" is 25th among all units for hardwood growing stock volume. Unit "E" ranked 49th for hardwood growing stock on public lands and 70th for hardwood removals. This unit, also ranked 60th for the percent of hardwood growing stock on public forest land. Unit "F" ranked 18th for hardwood growing stock on public forest land, 63rd for hardwood removals and 21st for percent of hardwood growing stock on public lands.

We examined the harvest level of ginseng relative to hardwood forest area to get an indication of harvest per unit area. Ginseng harvest varied widely, with the highest reported level of 2,615 pounds per million acres (1,186 kilograms) per million acres (400,000 hectares) of hardwood forest, in eastern Kentucky (Figure 4). The eight-county area reported harvests of 27,375 pounds (12,417 kilograms) of ginseng in the years for which we had data. An annual harvest of 4,562 pounds (2,069 kilograms) was derived from a hardwood forest area of 1.74 million acres (700,000 hectares). The top ten FIA units each had harvests over 1,000 pounds (453 kilograms) of ginseng per million acres (400,000 hectares) of hardwood forest.

Prices indicate the relative magnitude of the economic value of the timber and ginseng harvests, though they may not reflect variability over time and the geographic region. For a simple comparison of timber revenue to ginseng revenue, we used an average price of $937 per dried kilogram of ginseng (Table 3). The weighted-average representative price for hardwood timber in the study region at the midpoint of the study period was about $33.82 per cubic meter for sawtimber and $6.32 per cubic meter for pulpwood. Based on these values, the annual hardwood timber revenue from the study area was slightly more than $1.27 billion, while the annual average value of American ginseng was approximately $26.89 million (Table 6).

The total nominal value of American ginseng for the period (2000-2007) ranged from $172.7 million to $446.9 million, depending on price estimates. Using the medium price provided, we estimate the total nominal value for this period exceeded $268.9 million. Annually, the average overall harvest of American ginseng root ranged from $21.6 million to $43.4 million.

DISCUSSION

American ginseng is one of many non-timber forest products harvested from hardwood forests in eastern North America. At one time wild-harvesting of this plant occurred from forests near Montreal, Canada, to forests of north Georgia in the United States. Over the last 300 years the harvest area for this important forest herbal product has declined. Today the harvest is limited to a 19 state region, although the plant is still found throughout its natural range. Within this harvest region, American ginseng harvest is reported from approximately 1000 counties. One hundred counties account for 60% of the total annual ginseng harvest. The analysis for this study focused at the county-level and then aggregated to the FIA unit-level, though more concentrated investigation could be done with additional data collection and/or modeling, which could lead to more efficient and effective co-management of the forest resources.

Coarse assessment of the relationships between American ginseng harvest and forest stand conditions is possible at the FIA unit level. There is a positive relationship between hardwood forest area, stand age and this understory herbaceous plant that could lead to better joint forest management (Gilliam and Turrill, 1993). Reported ginseng harvests occur more frequently on large tracts of mature forest. As hardwood forest area and growing stock volume increase there is an associated increase in ginseng harvest. Further, as hardwood growing stock volume increases on public forest lands in FIA units, there is more ginseng harvested, suggesting that diversity increases as forests mature (Gagnon and Bradfield, 1986). Ginseng harvest also is positively correlated with removals of hardwood species, as recorded in forest inventory plots. This information could aid in targeting management actions to conserve ginseng.

Inventory data allows for assessment of the trees of the forested region where American ginseng is wild-harvested. The data allow for estimations of forest stand conditions, based on measurements of trees greater than 2.5 *cm* at breast height (1.3 meters above the ground) (USDA Forest Service, 2007). No data are collected in forest inventory plots of the herbaceous plants that have commercial value. Including these forest plants in collection of inventory data would improve efforts to correlate harvest data to hardwood forest stand conditions. Simple presence/absence observational data on herbaceous plants would provide valuable information on forest health conditions and biodiversity. It would allow for a better representation of forest stand conditions and valuations.

Explaining why the units, identified in Figures 3 and 4, are atypical will require additional research focused on the local situations. Four units (A, B, C and D) have relatively large amount of hardwood growing stock indicating mature forests that should be good habitat for ginseng production, and yet only two (C & D) have high reported annual ginseng harvest. Unit "A" is in the northern range of American ginseng and may have had changes in forest habitat that affect ginseng growth. Unit "B" is adjacent to one of the highest ginseng producing units. Unit "C" has a high percent of public lands with mature forests which may be conducive to conserving natural populations of American ginseng. The forests found in unit "C" are known to be of great biological diversity; the Great Smokey Mountain National Park is proximal to this unit. Units "E" and "F" have some of the highest reported ginseng harvests, low hardwood removals, and have a large proportion of hardwood growing stock on private forests. Perhaps there are other factors affecting the harvest of American ginseng in these FIA units that could be elucidated through additional research.

The nominal value of hardwood timber, from the same harvest region, far exceeds that of American ginseng, although managing forests for just timber may not provide the highest or best economic returns (Armstrong, 1987). The contribution of American ginseng to rural economies is significant, although its estimated value is only about 2 percent of hardwood timber. The annual sale of American ginseng could support a thousand full-time harvesters, at a mean annual income of $25 thousand. Integrating American ginseng into the management of hardwood forests, with timber, may enhance the livelihood of rural communities, while improving biodiversity conservation (Negi et al., 2011; Niese and Strong, 1992).

American ginseng is one of a suite of native plants collected from hardwood forests with historical medicinal use and contemporarily found as ingredients in herbal dietary supplements. Twelve of the 20 plants tracked by the American Herbal Products Association (2007) grow naturally in the eastern hardwood forests. Many, such as black cohosh (*Actaea racemosa* L.), bloodroot (*Sanguinaria canadensis* L.), bethroot (*Trillium erectum* L.), and goldenseal (*Hydrastis canadensis* L.), share the same forest habitat as ginseng (Burkhart and Jacobson, 2006; Sanders and McGraw, 2005). Large quantities of these and other native forest plants are harvested annually from natural populations for commercial purposes. For example, between 1997 and 2005 more than 2.3 million pounds (1 million kilograms) of black cohosh roots were harvested from natural forests (American Herbal Products Association 2007). Our understanding of the importance and impacts of wild-harvesting these and other herbal forest products would be much improved if reporting was done for them as well. Similar data for the other plant species would improve conservation management actions.

The U.S. has been tracking the harvest of American ginseng since 1976 when the plant was put on Appendix II of CITES (Robbins, 2000). This international agreement requires that the U.S. Fish and Wildlife Service track and monitor the harvest and export of American ginseng (U.S. Fish and Wildlife Service, 2009). The listing of goldenseal (*Hydrastis canadensis*, L.) in Appendix II of CITES in 1997 is adding to the body of knowledge regarding this important species and providing valuable information that will aid in conservation efforts (Burkhart and Jacobson, 2006; McGraw, 2001; Sinclair et al., 2005). More is known about these two species because of their listing in CITES, than any other non-timber forest product being harvested from hardwood forests. The information gathered on these species is critical to our understanding about these globally significant herbal forest products.

Further analysis of the relationship between ginseng harvest and forest conditions (including timber harvest) is possible and warranted. Combining the spatial patterns of ginseng harvest (e.g., Figure 2) with other spatially-defined data may help to explain ginseng occurrence (Guisan and Zimmermann, 2000). For example, temperature, precipitation, elevation, soil conditions, and other environmental parameters that are associated with ginseng's habitat could be modeled with harvest data to identify suitable habitat (Bonn and Schroder, 2001). Such analyses might provide further insights about factors explaining ginseng harvest amounts relative to population sizes and natural expansion rates, and enhance the conservation management of this valuable resource (Young et al., 2011).

CONCLUSIONS

This study could have significant implications for the sustainable management of eastern hardwood forests, as the results identify where ginseng is reportedly harvested and define the value of this important forest commodity relative to timber. Our results illustrate the spatial distribution of the wild-harvest of this important forest product and demonstrate the clear relationships between hardwood forests of eastern United States and ginseng harvests. The findings provide an important comparison of the value of ginseng to timber, which begins to develop more comprehensive valuation of our forest resources. Further, it confirms the value of American ginseng to specific counties throughout the region. This coarse analysis could be instrumental for targeting management efforts to places where ginseng harvest demands and value are greatest. In particular it provides forest lands managers a way to focus efforts to conserve an important non-timber forest products based on value and location of harvest. The knowledge gained from this study could improve efforts to co-manage for timber and non-timber forest products.

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484 **Tables**

485 **Table 1** American ginseng harvest and FIA data availability. The FIA data years indicate the
486 time period used for each state. Cells with 'X' represent years in which county-level ginseng
487 harvest data are missing for given states. No county-level data were available for Minnesota.

488 **Table 2** American ginseng harvest by state and year (kilograms dry weight).

489 **Table 3** Prices reported paid to harvesters per kilogram of dried American ginseng root

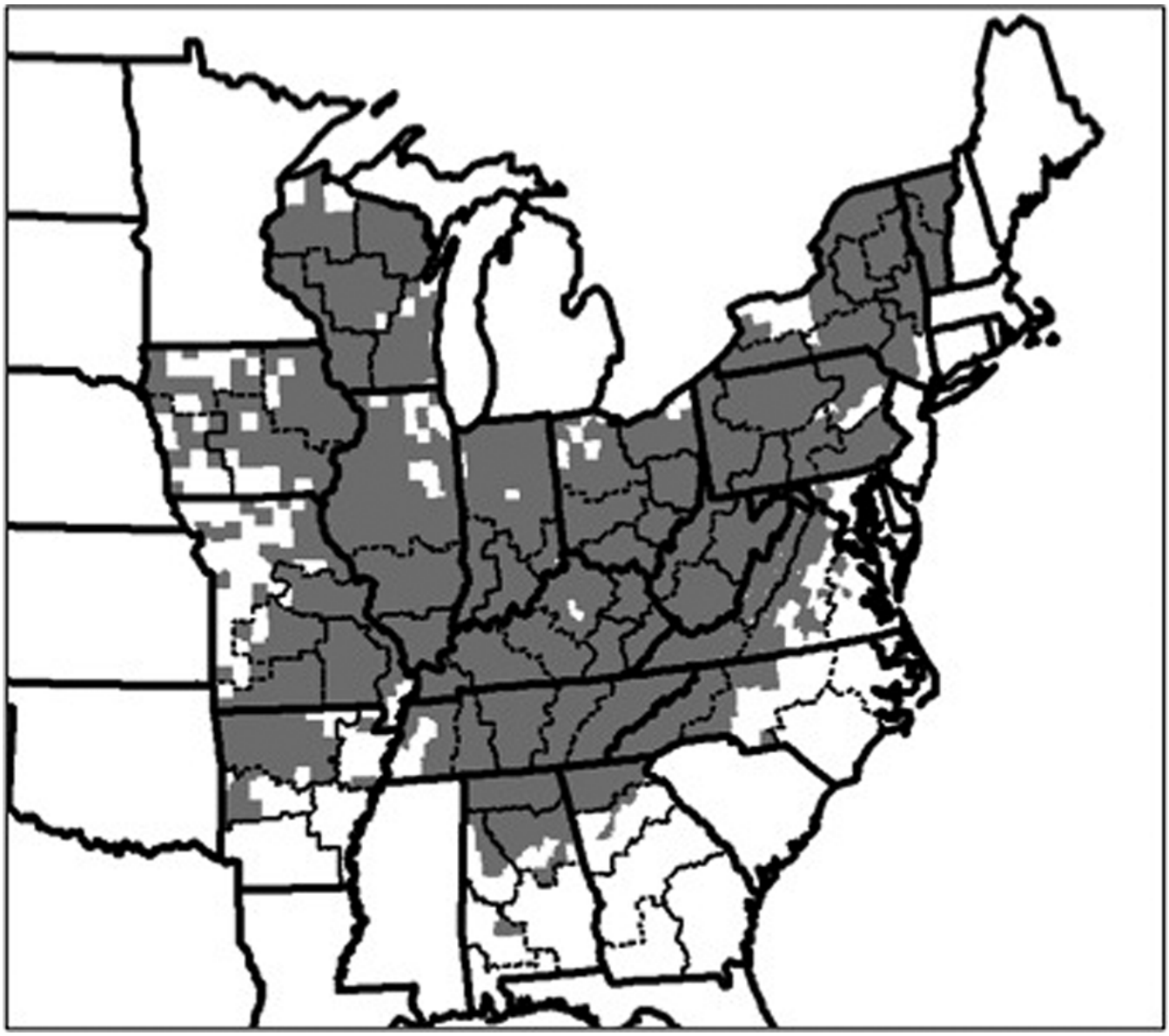
490 **Table 4** Top ten counties for average annual American ginseng harvest, 2000 – 2007.

491 **Table 5** Spearman's rank correlation coefficients relating FIA-derived variables to average
492 annual American ginseng harvest at the FIA unit level. Prob > |p| indicates the likelihood of the
493 observed correlation being due to chance: small values indicate a highly significant correlation.

494 **Table 6** Average annual revenue from American ginseng and hardwood timber harvest by state
495 for 2000-2007.

496 **Figures**

497 **Figure 1** States for which American ginseng harvest data were provided. The area shown in gray
498 had ginseng harvest recorded during 2000-2007. Dashed lines indicate boundaries of FIA units,
499 which are approximately 400,000 hectares (1 million acres) each, across multiple counties with
500 similar forest vegetation



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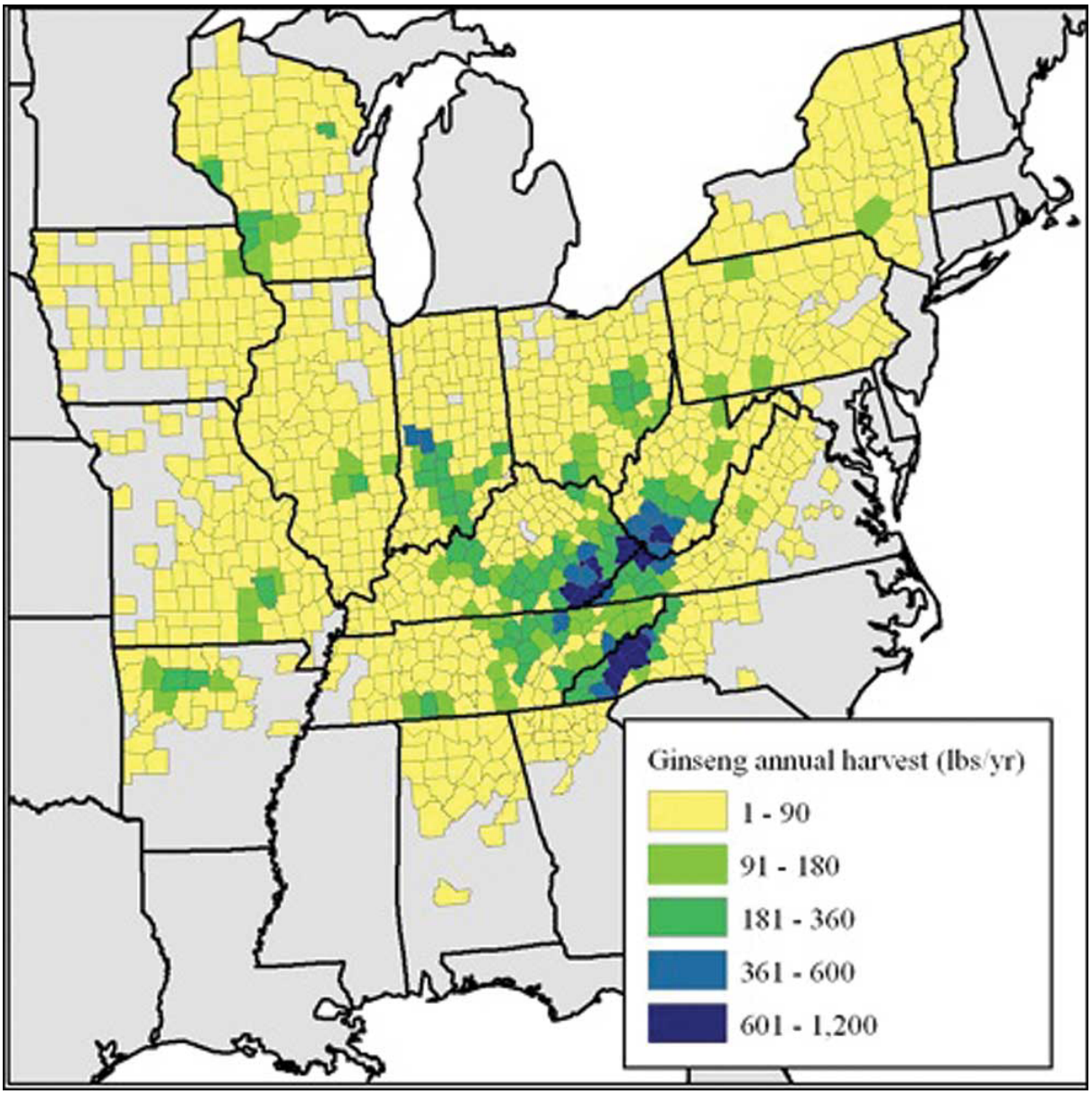
503 **Figure 2** Average annual reported American ginseng harvest by county across the 19 states for
504 which legal harvest was approved by the U.S. Fish and Wildlife Service for the years 2000-2007



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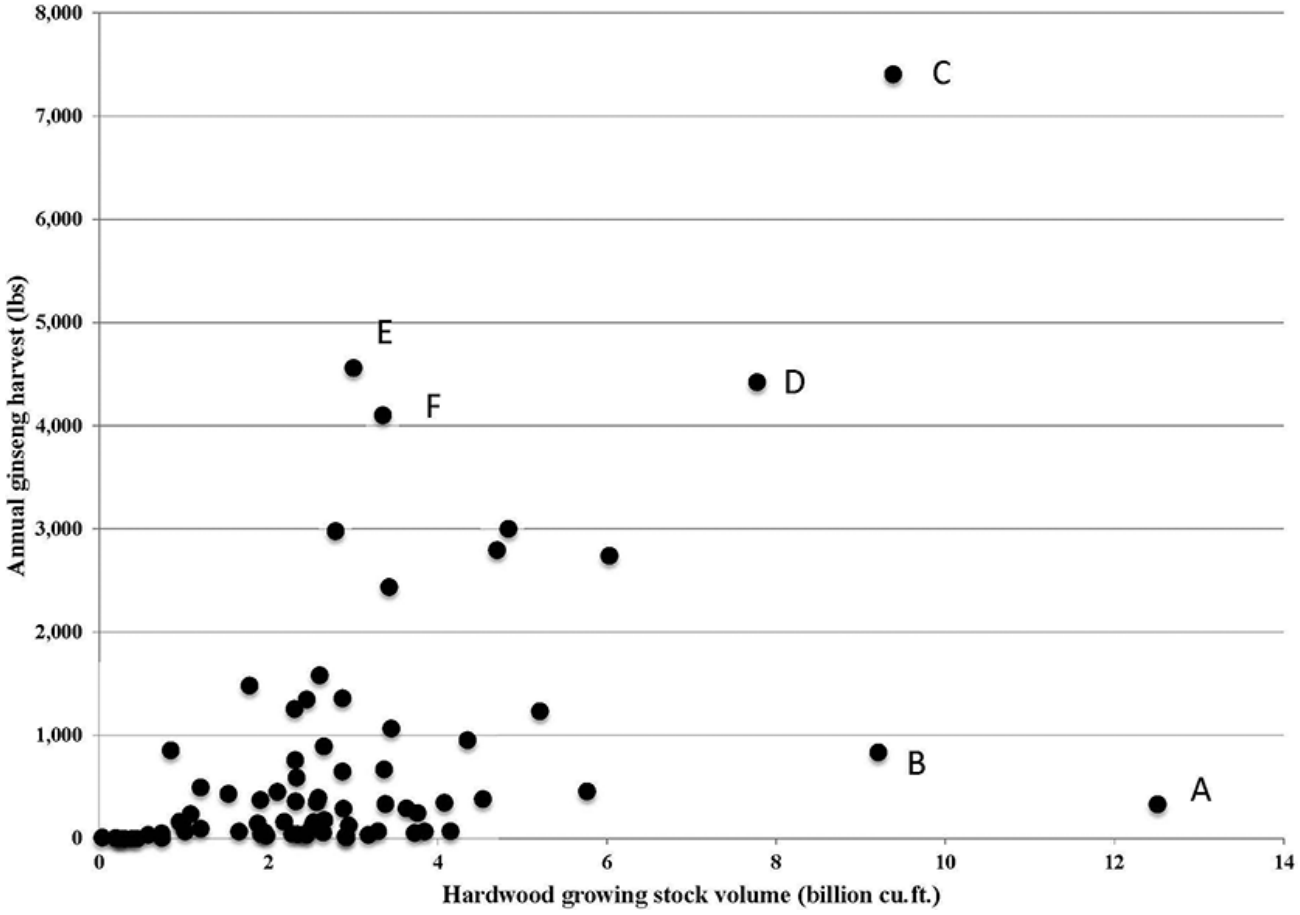
507 **Figure 3** Scatterplot of hardwood growing stock volume and annual reported American ginseng
508 harvest for the 76 FIA units ($\rho = 0.55$, $P < 0.0001$). FIA units identified by a letter are atypical of
509 conditions found throughout the harvest region



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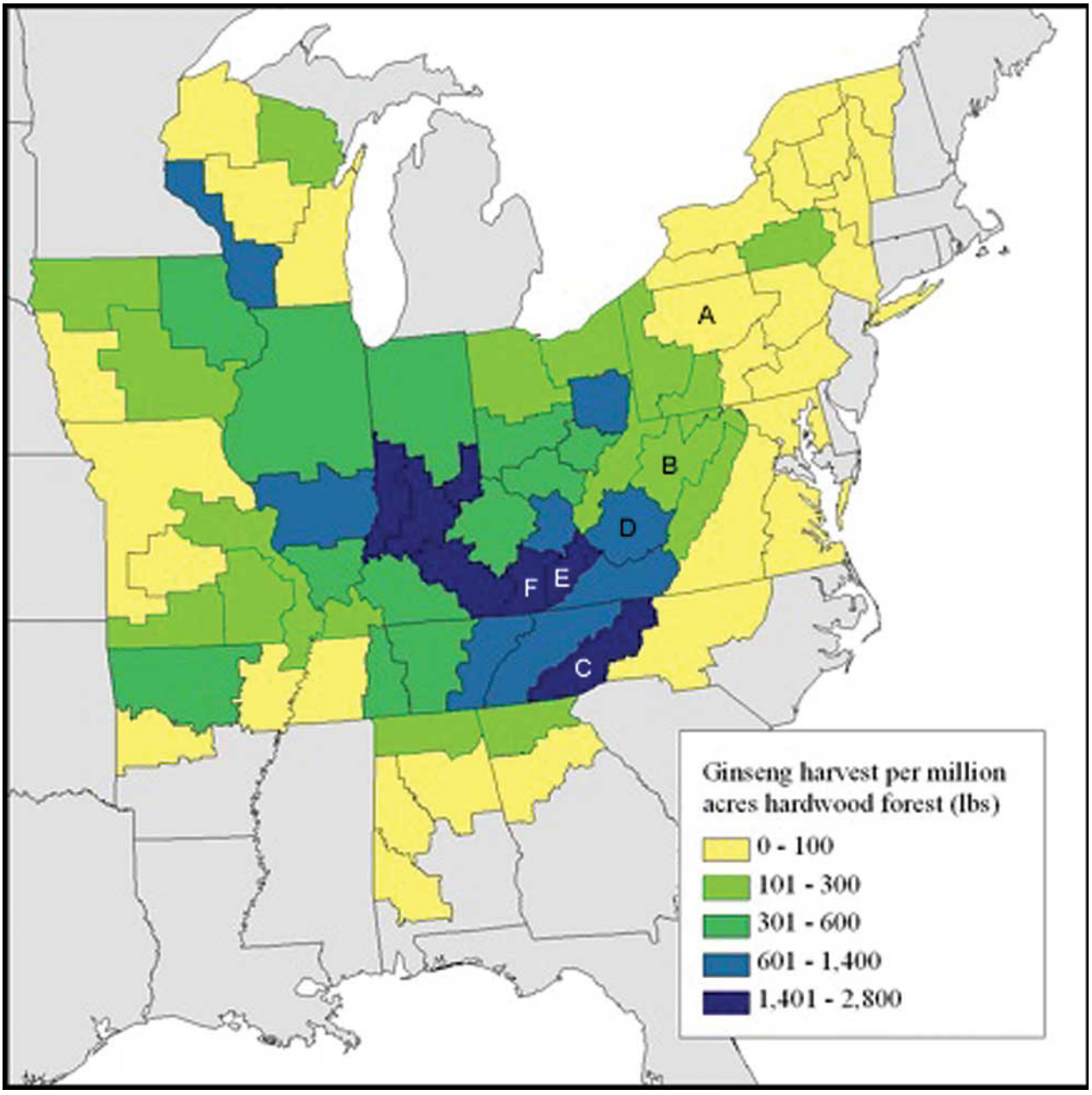
512 **Figure 4** Reported American ginseng harvest aggregated by FIA unit, each of which is
513 approximately 400,000 hectares (1 million acres) of forest with similar vegetation across
514 multiple counties



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517 Table 1. American ginseng harvest and FIA data availability. The FIA data years indicate the
518 time period for the FIA data used for each state. Cells with 'X' represent years in which county-
519 level ginseng harvest data are missing for given states. No county-level data were available for
520 Minnesota.

			Missing county-level ginseng harvest data							
State	**# Counties**	**FIA Data Years**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Alabama	67	2001-2005		X						
Arkansas	75	2000-2005								
Georgia	159	1998-2004							X	
Illinois	102	2002-2006								
Indiana	92	2002-2006								
Iowa	99	2002-2006								
Kentucky	120	2000-2004	X	X						
Maryland	24	2004-2006				X	X		X	
Missouri	115	2002-2006								
New York	62	2002-2006								
North	100	2003-2006				X				
Ohio	88	2001-2006								
Pennsylvania	67	2002-2006	X		X					X
Tennessee	95	2000-2004	X	X	X	X			X	
Vermont	14	2003-2006								
Virginia	136	2002-2007								
West Virginia	55	2004-2006								

Wisconsin	72	2002-2006									
Count	1,542		15	15	16	15	17	18	15	17

521

522

523 Table 2. American ginseng harvest by state and year (kilograms dry weight).

State	2000	2001	2002	2003	2004	2005	2006	2007	Total
Alabama	170	396	207	465	340	100	345	144	2,167
Arkansas	240	420	940	1,194	803	229	420	449	4,696
Georgia	141	320	121	193	120	183	76	127	1,280
Illinois	1,764	1,510	860	1,297	1,137	525	1,012	913	9,017
Indiana	2,845	3,197	1,448	3,137	2,186	2,233	2,314	1,752	19,111
Iowa	457	356	362	257	179	105	276	668	2,659
Kentucky	7,355	10,326	6,842	10,243	7,583	4,260	6,220	5,146	57,976
Maryland	1,030	410	50	49	73	44	28	67	1,750
Minnesota	688	591	745	658	555	567	333	496	4,633
Missouri	719	727	1,133	1,071	731	1,028	717	555	6,681

New York	528	342	225	321	282	274	130	217	2,318
North Carolina	3,817	3,079	3,987	2,970	1,936	2,824	3,066	5,835	27,514
Ohio	1,647	1,704	1,388	2,067	1,795	1,502	1,027	1,418	12,548
Pennsylvania	793	657	785	421	503	454	662	751	5,026
Tennessee	3,703	3,963	2,638	4,911	3,942	2,395	3,698	3,944	29,193
Vermont	93	54	83	53	51	22	35	52	443
Virginia	2,637	1,733	1,728	2,121	1,558	713	1,305	1,383	13,179
West Virginia	3,914	2,453	2,362	3,255	2,672	2,192	2,082	1,883	20,813
Wisconsin	1,671	1,130	1,171	767	882	727	973	1,090	8,411
Totals	34,214	33,368	27,074	35,449	27,327	20,375	24,720	26,888	229,417

524

525 Table 3. Prices reported paid to harvesters for a kilogram of dried American ginseng root

Harvest Season	Low	High	Average
2000	$705	$1101	$ 870
2001	$485	$ 881	$ 639
2002	$551	$1101	$ 837
2003	$661	$ 881	$ 767
2004	$551	$1101	$ 791
2005	$551	$1101	$ 819
2006	$661	$1322	$1000
2007	$881	$2533	$1775
Average	$631	$1267	$ 937

526 Table 4. Top ten counties for average annual American ginseng harvest, 2000 – 2007.

Rank	County	Harvest (kg)
1	Pike County, KY	505.0
2	Harlan County, KY	485.8
3	Buncombe County, NC	457.5
4	Madison County, NC	399.8
5	Wyoming County, WV	370.5
6	Knox County, KY	358.6
7	Haywood County, NC	350.1
8	Bell County, KY	343.1
9	Jackson County, NC	330.4

10	Perry County, KY	306.8

527

528

529 Table 5. Spearman's rank correlation coefficients relating FIA-derived variables to average
530 annual American ginseng harvest at the FIA unit level. Prob > |p| indicates the likelihood of the
531 observed correlation being due to chance; small values indicate a highly significant correlation.

Variable	Correlation Coefficient	Prob > |p|	Number of FIA Units*
Forest area	0.4346	< 0.0001	76
Hardwood forest area	0.5127	< 0.0001	76
Forest growing-stock volume	0.4510	< 0.0001	76
Hardwood growing-stock volume	0.5506	< 0.0001	76
Average growing stock per acre	0.0825	0.4787	76
Hardwood growing stock on public lands	0.3189	0.0050	76
Percent of hardwood growing stock on public lands	-0.0173	0.8822	58
Removals from all species	0.2990	0.0226	58

Removals of hardwood species	0.3894	0.0025	58
Removals as a percent of growing stock	-0.1458	0.2747	58
Hardwood removals as a percent of growing stock	-0.0708	0.5972	58

* FIA unit is defined as approximately 1 million acres with similar forest vegetation across multiple counties

535 Table 6. Average annual revenue from American ginseng and hardwood timber harvest by state
536 for 2000-2007. No data were available to estimate timber revenue for Minnesota.

State	Average Annual Ginseng Harvest (kg)	Ginseng Revenue* (thousand $)	Timber Revenue (thousand $)
Alabama	271	$254	$46,401
Arkansas	587	$551	$30,137
Georgia	160	$150	$9,401
Illinois	1,128	$1,057	$30,404
Indiana	2,391	$2,241	$75,251
Iowa	333	$312	$9,942
Kentucky	7,254	$6,797	$78,843
Maryland	219	$205	$7,079

Minnesota	580	$543	
Missouri	836	$783	$81,739
New York	290	$272	$82,157
North Carolina	3,442	$3,225	$56,968
Ohio	1,570	$1,471	$55,216
Pennsylvania	629	$589	$228,374
Tennessee	3,652	$3,422	$137,345
Vermont	55	$52	$22,986
Virginia	1,649	$1,545	$73,176
West Virginia	2,604	$2,440	$150,099
Wisconsin	1,052	$986	$90,749

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Totals	28,703	$26,895	$1,266,266

*Based on an average of $937 per kilogram (dried).

537