The Economic Impact of Cogongrass among Non-Industrial Private Forest Landowners in Florida

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Cogongrass (*Imperata cylindrica* (L.) Beauv.) is an invasive rhizomatous perennial grass that negatively affects the agriculture and forestry industry. Some of the intrinsic characteristics that make this grass extremely invasive include: 1) blooms early in the spring and each plant can produce up to 3,000 seeds; 2) has very light seeds that can be dispersed by the wind for distances up to 15 miles; and, 3) has very strong rhizomes that allow this grass to survive during adverse environmental conditions (e.g., drought, fire, flooding) and also aid its rapid spread within short-distances (Onokpise et al. 2007). Once established, this grass may produce over three tons of rhizomes per acre and spread at an exponential rate. The sheer mass and persistence of rhizomes not only contributes to the ability of cogongrass to dominate an area, but it has also been reported that these rhizomes exude allelopathic substances which inhibit growth of other plants (Hagan et al., 2013). As the density of cogongrass increases, all other vegetation may be excluded and normal succession of other grasses and shrubs will not occur (Chikoye et al. 2005). Cogongrass grows in a wide range of soils from rich sandy loams to poor sands. Even though this alien species grows best in full sun, it also thrives in deep shade and will persist during severe droughts or through periodic inundations (MacDonald et al. 2006, Onokpise et al. 2007).

More than 1.2 billion acres of land have been infested with cogongrass worldwide (Dozier et al. 1998). In Asia, where an estimated 450 million acres are dominated by cogongrass, infested areas are increasing at a rate of 370,000 acres annually (Dozier et al. 1998). This grass has been reported as a serious economic problem in more than 35 annual and perennial crops, including rubber, coconut, oil palm, coffee, dates, tea, citrus, forests, field crops, and row crops (Waterhouse 1999).

In the United States at least 250,000 acres are estimated to be infested in the states of Alabama, Florida (FL) and Mississippi (Dickens 1975, Schmitz and Brown 1994). In FL Sandhill communities, cogongrass stands can destroy the habitat of endangered species such as gopher tortoises and indigo snakes (Shilling et al. 1997, Lippincott 2000). Cogongrass is also flammable and increases fine-fuel loads. Resultant fires tend to be hotter, taller, and potentially more frequent, even in communities adapted to frequent fire such as longleaf pine and wiregrass. In addition, extensive rhizome reserves of cogongrass enable it to quickly regrow after disturbance events (Onokpise et al. 2007).

Anecdotal evidence suggests that forest land owners in FL have spent significant amounts of money to control this invasive grass and may have experienced losses in forest production. However, there is no formal documentation of the economic effects of these lost revenues and lost productivity. Thus, the goal of this study is to document the direct losses of non-industrial private forest landowners (NIPF)[1] due to cogongrass infestation in FL. This information is used to estimate the direct, indirect, and induced economic impacts using an input/output regional economic model.

Evaluating and documenting the economic impact of invasive exotics on state and regional economies has received little attention in the literature. In one of the few studies on this issue, Hirsch and Leitch (1996) evaluated the impact of knapweed (*Centaurea maculosa*) infestation in Montana. These authors reported that knapweed caused a direct economic loss of $14 million per year in reduced grazing capacity, reduced wildlife associated recreational

[1] PNIF landowners are defined as private forest owners who do not own or operate wood processing facilities, and include farmers, miscellaneous individuals and non-forest industry operations.

spending, and higher rates of soil erosion and surface water runoff. Conversely, Bangsund et al. (1991) documented that the direct economic impacts of leafy spurge (*Euphorbia esula L*) in the Northern Great Plains on grazing land was close to $37 million per year, while its direct impacts on other lands totaled $3.4 million per year.

Harris et al. (2006) assessed the economic impacts due to the adverse influence of noxious invasive species on wildlife-related recreation. Using public lands in Nevada as a case study, these authors found that the impact of noxious invasive species on the recreational sector was estimated to range from $6 million to $12 million per year and the predicted discounted stream of negative economic impact over a future time horizon of five years ranged from about $30 million to $40 million.

The economic impact of yellow starthistle (*Centaurea solsitialis* L.) in the rangelands of Idaho was studied by Julia et al. (2007). In this case, the total economic loss was reported at $12.7 million of which 64% was attributed to the direct impact of the weed and the remaining was the result of the weed's indirect and induced cost to the region's economy. Using a similar approach Salaudeen et al. (2013) evaluated the impact of Tropical Soda Apple (Solanum valirum) on FL's cattle production. This study estimated that controlling Tropical Soda Apple resulted in annual economic losses of approximately $15 million throughout the state of FL. The present article contributes to this limited body of literature by documenting the economic costs of cogongrass on the forestry sector in FL. Given that the optimal strategy for prevention, eradication or control necessarily depends on the social costs of invasions (Olson 2006), this study offers policymakers and land managers the necessary information to justify future management programs. In addition, the framework developed in this study can be used as a model to study the economic impact of others invasive exotics on different sectors and geographical areas.

Data collection and Methods

Data collection

This study focuses on the impact of cogongrass on NIPF landowners in FL. According to the Forest Inventory and Analysis factsheet (Brown and Nowak 2009), the total forested area in FL is approximately 26,000 square mile. About 49% of the state is covered with forests and 94% of the forested land is classified as available for timber production. NIPF landowners control 63% of these forested lands, making them an interesting case study.

To assess the economic impact of cogongrass among NIPF landowners in FL, primary data were collected using a mail survey. The survey instrument was designed following Dillman's 'tailored design method' (TDM) (Dillman 2000) in order to enhance response rates from survey participants, yield unbiased answers, and minimize measurement error. The TDM is a set of procedures for conducting successful self-administered surveys that produce both high quality information and high response rates (Dillman 2000). Special attention was taken to develop efficient questions and graphical software was used in the final layout to give the instrument a professional look. The survey was pretested before being administered to the sample of NIPF owners.[2] Names and addresses of NIPF landowners in FL were obtained from the Forest Stewardship Program at the University of Florida Institute of Food and Agricultural

[2] The questionnaire is available upon request.

Sciences (UF/IFAS). The UF/IFAS Stewardship Program manages the most comprehensive list of NIPF landowners in FL.[3]

A total of 2,832 surveys were mailed to NIPF landowners in FL on 24 December 2010 followed by reminder postcards 10 days later. Non-respondents were mailed a second survey in March 2011 and the survey was concluded after 1,150 surveys were completed and returned and 350 surveys were counted as undeliverable. Of the 1,150 returned surveys, 1,060 were completed with no missing relevant data, yielding an adjusted response rate of 42.7%.

Estimating the statewide costs of cogongrass control

The first step in determining the economic impact of cogongrass is to estimate the direct losses to NIPF landowners as a result of the chemical or physical control of cogongrass patches. To estimate this direct impact at the regional level, our survey results must be extrapolated to the entire state. We estimate this direct impact as a function of total regional non-industrial forest land owned by private individuals, the level of cogongrass infestation, the proportion of woodland owners attempting to control cogongrass and cost of control. The regional cost (*RCi*) for cogongrass control can be expressed as:

$$RCi = Ii * Ai * Pi * Ci, \quad (1)$$

where *Ii* represents the cogongrass infestation rate for the geographic region *i*, *Ai* represents the number of acres of private non-industrial woodland in region *i*, *Pi* represents the proportion of woodland owners controlling cogongrass in region *i*, and *Ci* represents the average cogongrass

[3] More information on this program can be found at http://www.sfrc.ufl.edu/forest_stewardship.

control cost for region *i*. Figure 1 depicts the four geographic areas included in the study (these areas are the same as those used in Brown and Nowak (2009)).

Input-Output Analysis

We used input-output analysis to measure the economic impact of cogongrass among NIPF landowners in FL and the regional economy. Input-output models link the different sectors of an economy and measure the total regional business activity resulting from a change in one particular sector (Watson et al. 2007). Input-output models capture not only the direct impact but also the indirect and induced impacts that occur in multiple sectors of the economy. Direct effects represent the initial change in expenditures for the industry in question. Indirect effects are the changes in inter-industry purchases as supplying industries respond to the decreased demands of the directly affected sector. Induced effects reflect changes in spending from households as income increases or decreases due to changes in production (Mulkey and Hodges 2000). Total effects are the sum of the direct, indirect and the induced effects.

Direct economic impacts will result from noxious invasive species that cause lost productivity and/or require increased control costs. In turn, the reduced economic activity in one sector will have secondary or indirect effects on other sectors and will also affect regional employment, income and expenditures throughout multiple sectors of the regional economy (Minnesota IMPLAN Group 2009). Because these effects are fully accounted for, input-output modeling is ideally suited to measure the economic impacts resulting infestations of noxious invasive species.

Results

Demographic Characteristics and Perception of Invasive Plants

The survey revealed that NIPF property acreage in FL is highly concentrated in the northwestern and northeastern regions and is lowest in the southern part of state, which is heavily urbanized (Table 1). These results follow the same pattern described in Florida's Forest Inventory & Analysis Factsheet published by the US Forest Service (Brown and Nowak 2010)

With respect to their operations, 83% of survey respondents claimed that they manage all or part of their property for timber production. The most commonly used timber management practices are pine production for sawtimber, plylogs or poles, followed by pine production for paper/pulp. Rapid growth species for carbon sequestration and agro-forestry are the least used practices preferred by NIPF landowners (Table 2).

The survey also shows that about 74% of respondents manage their woodland for purposes other than timber production. Among those purposes wildlife viewing was the most important, followed by hunting and other recreational activities. In addition, the results also showed that ornamental horticulture and agro-forestry were the least important practices for NIPF landowners (Figure 2).

A significant majority of NIPF landowners (83%) received technical advice about woodland or forestland during the last five years. The Florida Forest Service was the most common source of this information followed by private consultants and the Florida Fish & Wildlife Conservation Commission. Survey results also revealed that employees of non-profit groups, paper/timber companies and the Natural Resource Conservation Service were not very active in the transfer of technical advice (Table 3).

In order to assess the economic impact of cogongrass control it is critical to understand the importance of cogongrass as a problem relative to other problem plants found on forested lands. Respondents from all four regions reported that cogongrass is a major plant pest on forest property, but responses also yielded some interesting information about other invasive threats to woodlands. Japanese climbing fern, Japanese privet, Chinese tallow (Popcorn Tree) and blackberry plants are perceived as the biggest problems after cogongrass. The survey also revealed that a majority of respondents cannot identify many of these problem plant species. For instance, about 98% of respondents do not know anything about coral ardisia, which is a noxious weed that is toxic to livestock. Hence, survey responses about the distribution of many of these plants may understate their impact (Table 4).

Respondents were asked specifically about their familiarity with cogongrass and the source of their information about this invasive plant. About 51% of the sample reported some knowledge about cogongrass. The Florida Forest Service was their major source for information about this plant, followed by the Cooperative Extension Service Office. Results also showed that employees of the non-profit groups, logging contractors, paper/timber companies and the U.S. Forest Service were not a major source of information about cogongrass (Figure 3).

The survey results revealed that about 30% of respondents believed that cogongrass was present in their property and about 33% were not sure. Respondents also reported that they first encountered cogongrass about 7 years ago, but about 34% of our sample cannot recall when they first saw cogongrass.

To document the economic impact of cogongrass on NIPF landowners, the survey asked the targeted population whether they considered cogongrass a problem in their forests, and nearly 25% of the respondents considered this plant as a problem in their woodland. The survey also showed that approximately 5% of the total area of NIPF was covered with cogongrass. Also, about 41% of respondents believed that cogongrass has reduced the recruitment and/or growth of trees in woodlands, and close to 54% of woodland owners responded that cogongrass has increased the hazard for wildfire in the area of infestation (Table 5).

The survey also asked about respondents' plans for their woodlands or forest property in FL over the next five years. Forty three percent said they would prefer to do the minimum activity necessary to maintain their forest and about 40% would harvest the saw logs or pulpwood. Four percent claimed they would sell their forest property for residential development and only 1% would convert their forest to commercial development (Table 6).

The survey also revealed some interesting characteristics of NIPF landowners in FL. The typical respondent has owned their property for 22 years and about 33% had inherited their woodland. Respondents were asked about the importance of the income derived from their woodland to their household. On average they derived little of their household income from their forested land (average index value of 1.9 on a scale of 1 to 5). The approximate average household income for the survey respondents was about $104,630, which is much higher than the state median household income ($45,609) and the national median household income ($51,144) (Noss, 2012) (Table 7).

Geographic Extent of Cogongrass Infestation

The rate of cogongrass invasion was calculated as regional averages from the collected survey data using Equation 1. Individual woodland owners were asked to estimate the proportion of their woodland infested with cogongrass, and their responses were averaged by region. The mean rates of infestation of cogongrass were then calculated as 3.89%, 5.11%, 7.02%, 4.33% and 5.01% for northeast FL, northwest FL, central FL, south FL and the entire state, respectively.

Management and Control Responses and Costs

In terms of control of this invasive plant, nearly 78% of the respondents have tried to control cogongrass using different methods. The most preferred method of control identified is chemical herbicide (80%) followed by mechanical methods (Figure 4). Among all chemicals, Roundup™ was the leading herbicide used for chemical control, but several NIPF owners had begun using Arsenal™ and Chopper™. Our survey results indicate that NIPF landowners in FL spent about $81.56 per acre for cogongrass control.

The number of acres owned by NIPF landowners for each region and the entire state is reported in Brown and Nowak (2010). Each region's estimate was used to obtain total regional NIPF land in Table 1.

The proportion of NIPF owners who tried to control cogongrass were estimated from the number of respondents who answered positively to the item "tried to control cogongrass". Regional rates of control for cogongrass were 74%, 78%, 86%, 1% and 78% for northeast FL, northwest FL, central FL, south FL and the entire state respectively. Cogongrass control costs were calculated as the average amount spent per acre by respondent for the control of cogongrass. Average costs for control of cogongrass were $127.62, $115.24, $133.64, $76.25 and $81.56 for northeast FL, northwest FL, central FL, south FL and the entire state, respectively. These averages were used to estimate total regional costs of control of $6,693,955; $6,906,136; $5,883,239; and $16,547 in the northeast, northwest, central and south regions of the state, respectively. Upper and lower bounds for regional cost estimates were then calculated for a 95% level of confidence (Table 8). These bounds on cost estimates represent direct losses to

NIPF landowners due to cogongrass invasion and they serve as input to the regional economic model.

Overall, Central FL was the region most heavily impacted by cogongrass. This may be due to the high infestation rate and proportion of NIPF landowners that control the exotic plant relative to other regions.

Impact of Cogongrass on Florida's Economy

We applied an input-output economic model utilizing multipliers linked to the FL economy to account for the losses associated with the industries that are directly affected by the infestation of cogongrass and losses associated with industries that are economically linked to them. This model also estimated economic losses to household income. A summary of these economic losses, which are the result of expenses by PNIF land owners for the control of cogongrass infestations in the four regions of FL (northeast, northwest, central, south) and statewide is provided in Table 9.

The total average economic impacts associated with cogongrass control are $10,513,427; $9,836,942; $13,211,987; and $32,445 annually for the northeast, northwest, central and south regions of the state respectively. These were revenues lost to all supportive business sectors as a result of reduced sales of supplies to forest producers, the timber industry and reduced household incomes.

Included in this total cost was the direct cost due to cogongrass control, $6,693,955; $6,906,136; $5,883,239; and $16,547 in the northeast, northwest, central and south regions of the state respectively. This direct loss represents the expenditures to control cogongrass, which are modeled as a reduction in the production of the forest products and timber industry. The indirect effects were calculated at $2,251,638; $1,791,038; $4,601,164; and $10,064 for northeastern, northwestern, central and southern regions of the state respectively. These figures represented revenues lost to the supporting sectors as they respond to the reduced sales of forest products by the directly affected woodland owners who are controlling their cogongrass infestations. The induced effects are changes in spending by households as income decreased due to reduced production of forest products and timber industry support goods and services, and were estimated to be $1,567,834, $1,139,768, $2,727,584 and $5,834 for the northeast, northwest, central and south regions of the state respectively.

The combined effect of cogongrass control by PNIF landowners in FL resulted in average direct economic losses of $14,492,548 which represents 48.53% of the total economic impact of cogongrass. These are the total costs of control measures for cogongrass. The remaining losses are the results of indirect and induced effects in the state and will include $9,496,251 in indirect cost which represents 31.80% of the total impact of cogongrass and $5,875,589 in induced cost which represents 19.67% of the total impact of cogongrass. Adding across the average regional impacts, results in a statewide impact or total loss to the economy of FL of $29,864,388.

Generally, the biggest economic costs from cogongrass infestation were in central FL. This may be due to the high infestation rate and proportion of PNIF owners that control the exotic plant relative to other regions.

Summary and Conclusions

This study documented the direct losses to NIPF landowners as a result of cogongrass infestation in the state of FL. We also implemented a framework to assess the economic losses to the study sample and extrapolate these results to the whole population of NIPF landowners. The empirical analysis uses data collected from 1,060 NIPF owners in FL. The results show that close to 25% of the respondents considered cogongrass as a problem in their woodland. In addition, 41% of respondents believed that this invasive grass has reduced the recruitment and/or growth of trees in woodlands and approximately 54% of woodland owners responded that cogongrass has increased the hazard for wildfire in the area of infestation, illustrating the large negative impact that this invasive grass is having on commercial woodland throughout FL. The economic input/output analysis revealed that cogongrass control costs resulted in economic losses throughout FL of $29 million to the forestry supporting business sectors. The results obtained in this study can be used by policymakers and land managers to justify the implementation of management programs to control this invasive weed. In addition, the framework developed here can be used as an example to study the economic impacts of other invasive exotics on different sectors and geographical areas.

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Table 1: Descriptive Statistic for the Sample and Population.

Region	Sample		Population*	
	N. of NIPF	Mean Acreage	Total Woodland (Acres)	NIPF Woodland (Acres)
Northeastern	544	472.65	6,554,049	1,949,000
Northwestern	474	658.31	5,509,477	1,608,220
Central	111	357.09	2,752,210	779,740
Southern	17	237.78	1,183,455	536,070

* Source: Brown and Nowak (2010).

Table 2: Type of timber management practices.

Timber management Practices	Percentage
Pine production for sawtimber, plylogs or poles	66.3
Pine production for paper/pulp	60.9
Mixed hardwood and pine	26.1
Hardwood production for pulp/paper	14.8
Cypress or other bottomland	11.9
Agro-forestry	9.0
Rapid growth species for carbon sequestration	1.7

Table 3: Source of technical advice or information about woodland.

Source of Information	Percentage
Florida Forest Service	70.8
Private Consultant	34.5
Florida Fish & Wildlife	29.4
Cooperative Extension Service Office	21.5
Other forest landowner, neighbor or friend	16.9
Logging contractor	12.4
U.S. Forest Service	9.2
Natural Resource Conservation Service	8.9
Paper/Timber company	8.7
Employee of a non- profit group	2.4

Table 4: Relative importance of common weeds found in Woodlands.

Common Weeds	Mean Likert Scale*	% Don't Know
Cogongrass	1.86	37.3
Japanese climbing fern	1.76	55.8
Japanese privet	1.72	73.1
Chinese tallow (Popcorn Tree)	1.71	39.2
Blackberry	1.59	17.5
Muscadine grape	1.54	21.8
Tropical soda apple	1.52	52.9
Mimosa	1.50	29.8
Air potato vine	1.39	54.9
Kudzu	1.37	21.5
Japanese honeysuckle	1.33	58.7
Morning glory vine	1.31	34.6
Coral ardisia	1.14	97.9

* Likert Scale: 1: Not a Serious Problem – 5 Serious Problem.

Table 5: Perceived cogongrass-caused problems in Woodlands.

Category	Percentage
Have problem with cogongrass	25
% of cogongrass in woods or forest	5.1
Negative effect of cogongrass on tree growth.	41
Causes wildfire	54

Table 6: Plans for woodland or forest in Florida in next five years.

Plans	Percentage
Minimum activity to maintain.	42.6
Harvest saw logs/ pulpwood.	39.6
Bequest	30.0
Leave it as is- no activity.	19.3
Enroll for Carbon credit program.	13.0
Harvest firewood.	11.1
Expansion-Buy more forestland	10.6
No plans at this time	9.6
Harvest non-timber forest products.	7.8
I don't know	5.4
Sell some or all woodland	5.2
Sell for Residential Development	4.0
Sell for Commercial Development	1.4

Table 7: Survey questions, how long owned forest property in Florida, Importance of woodland income and Annual income.

Year/ Income	N	Mean
Years owning forest property in FL	1,073	22.8
Importance of woodland income to household (1-5); 1=unimportant, 5= important	1,060	1.9
Annual household income ($)	934	$ 104,630.6

Table 8: Estimation of regional cost for cogongrass control

Region with # acres	Bounds	Infestation rate (%)	Proportion that control (%)	Cost of control /acre ($)	Regional cost of control ($)
Northeastern (1,949,000)	Average	3.89	74	127.62	7,159,982
	Lower	2.89	73.88	43.39	1,808,224
	Upper	4.88	74.11	211.85	14,951,489
Northwestern (1,608,220)	Average	5.11	78	115.24	7,386,934
	Lower	3.6846	77.932	75.30	3,477,890
	Upper	6.5354	78.068	155.17	12,731,888
Central (7,79,740)	Average	7.022	86	133.64	6,292,824
	Lower	3.4304	85.87	10.2	234,280
	Upper	10.613	86.13	257,08	18,323,596
Southern (536,070)	Average	4.33	1	76.25	17,699
	Lower	0.664	1	0	0
	Upper	7.996	1	119.11	51,055
State (4,873,030)	Average	5.009	78	81.56	15,501,506
	Lower	3.9946	77.946	63.54	9,641,540
	Upper	6.0234	78.054	99.57	22,813,790

Table 9: Estimated economic impact of cogongrass control with 95% confidence interval

Regions	Output	Direct ($)	Indirect ($)	Induced ($)	Total output ($)
Northeastern	**Average**	**6,693,955**	**2,251,638**	**1,567,834**	**10,513,427**
	Lower	1,690,531	568,642	395,950	2,655,123
	Upper	13,978,331	4,701,875	3,273,954	21,954,160
Northwestern	**Average**	**6,906,136**	**1,791,038**	**1,139,768**	**9,836,942**
	Lower	3,251,522	843,250	536,621	4,631,394
	Upper	11,903,199	3,086,977	1,964,468	16,954,644
Central	**Average**	**5,883,239**	**4,601,164**	**2,727,584**	**13,211,987**
	Lower	219,031	171,300	101,547	491,878
	Upper	17,130,956	13,397,780	7,942,247	38,470,983
Southern	**Average**	**16,547**	**10,064**	**5,834**	**32,445**
	Lower	0	0	0	0
	Upper	47,732	29,030	16,829	93,591
State	**Average**	**14,492,548**	**9,496,251**	**5,875,589**	**29,864,388**
	Lower	9,013,994	5,906,425	3,654,466	18,574,884
	Upper	21,328,892	13,975,771	8,647,189	43,951,850

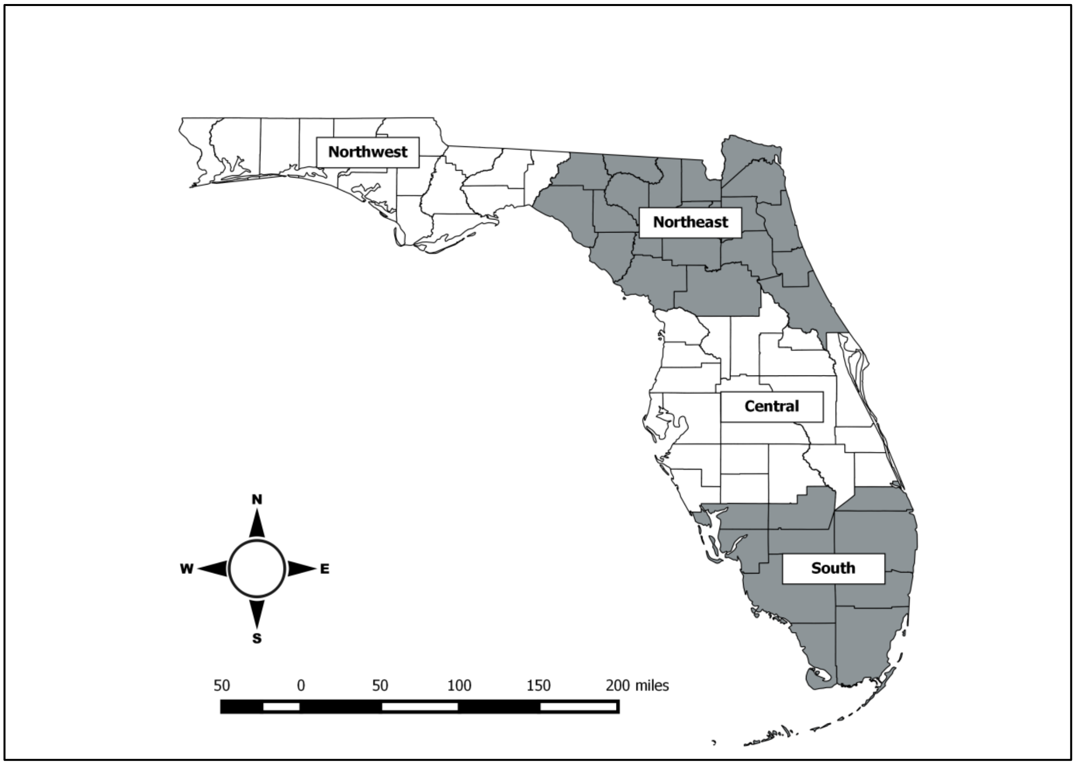

Figure 1: Geographic areas

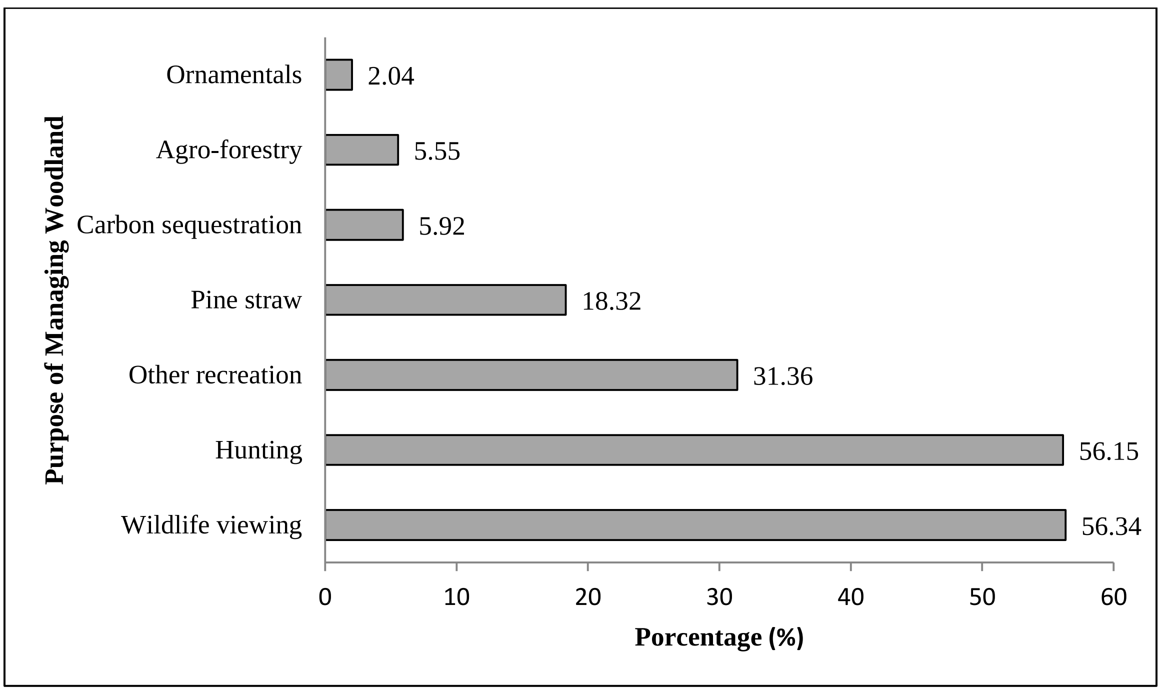

Figure 2: Purpose of managing woodland

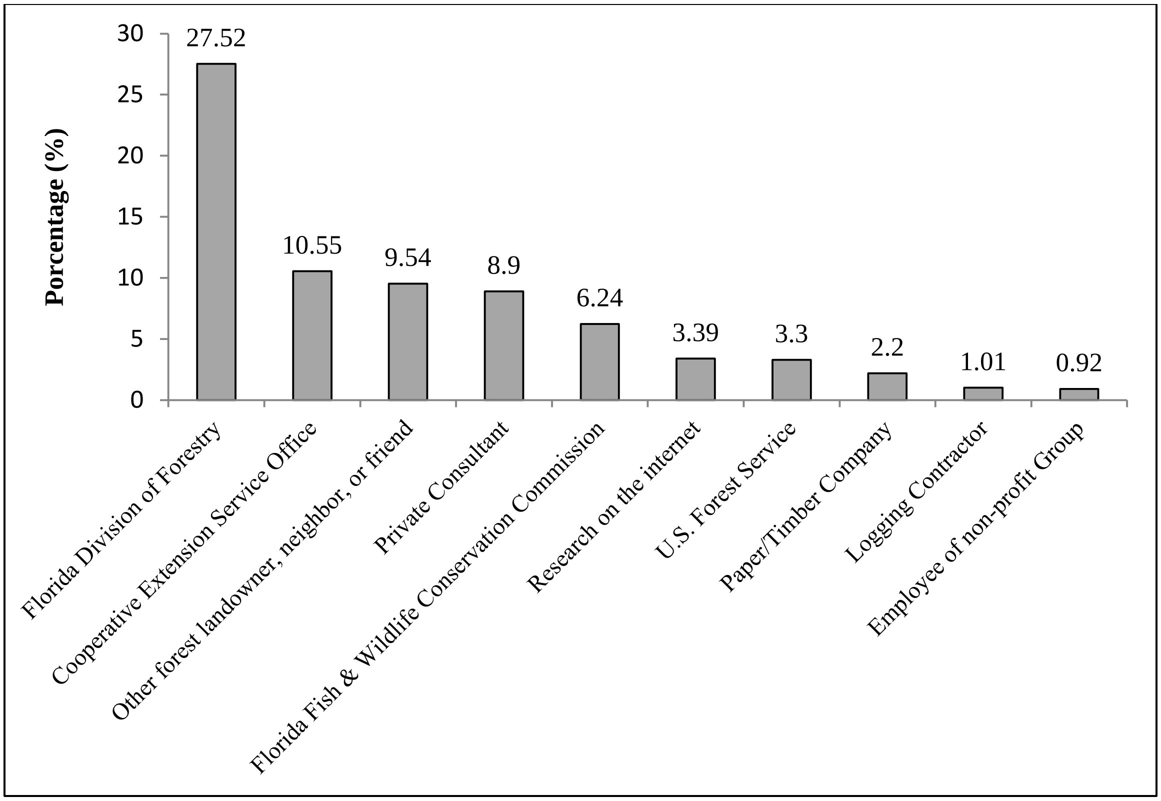

Figure 3: Source of information about cogongrass

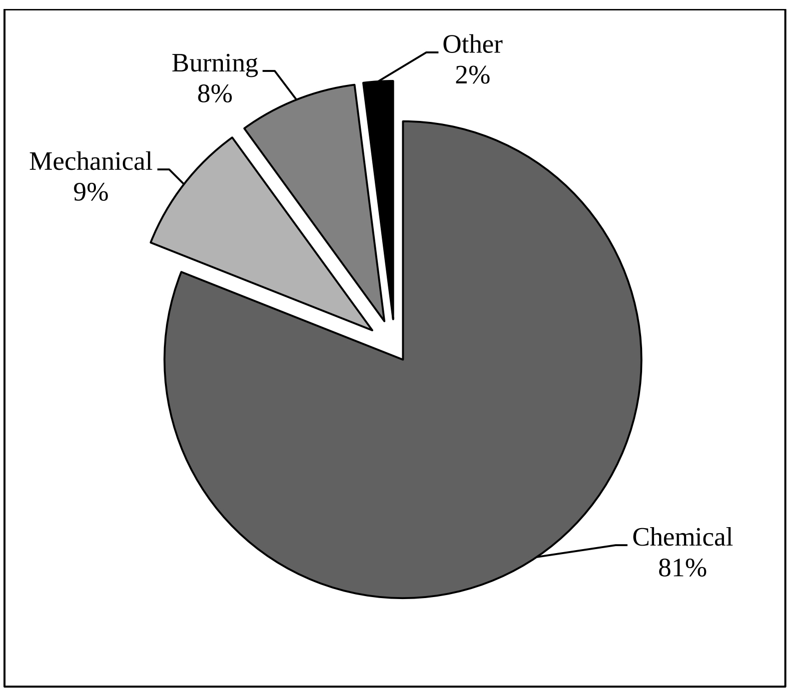

Figure 4: Cogongrass control methods