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Article

Invasive-Plant-Removal Frequency—Its Impact on Species Spread and Implications for Further Integration of Forest-Management Practices

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Abstract: For a given invasive plant species and control method, effective invasive plant eradication requires regular monitoring and management. While most previous studies characterize invasive plant species, develop appropriate control methods, or prioritize species for management using aggressiveness and other considerations, few study why some forestland owners are less likely than others to regularly remove invasive plant species. Such information is useful in prioritizing and targeting forestland owners who are at greater risk for invasion, with the stands threatening adjacent forestlands. Towards this end, we surveyed 1800 forestland owners in Virginia and Texas. We use data on forestland owners' socioeconomics and forestland features—such as acreage, forestland ownership objectives, and forest management activities—to determine how these factors affect the regularity of invasive-plant removal. For these purposes, we used the Cochran–Armitage trend test, the Cochran–Mantel–Haenszel regression, odds ratio estimates, and partition-analysis techniques. Our results suggest that female forestland owners, owners with smaller forestlands, and forestland owners without written forest-management plans are less likely than others to regularly remove invasive plant species. Forest-management activities, such as building/maintaining roads in the forestland, partially harvesting stands, and wildlife- and fisheries-improvement projects, also significantly predict a more regular invasive-plant-removal tendency. However, since these activities are potential pathways for the spread of invasive plant species, we controlled for the other significant covariates and measured the relationship between frequent practice of the given forest-management activities and having a tendency to regularly remove invasive plant species. The results suggest that forestland owners that regularly practiced the said forest-management activities have higher odds for tending to remove invasive plant species regularly, suggesting that, despite their demonstrated effort at removing invasive plant species from their forest, their management activities may be inadvertently contributing to the spread of invasive plant species. These results highlight the importance of integrating invasive-plant-removal plans with forest-management plans as well as forestland owners' educational and outreach needs.

Keywords: invasive plants; forestland owners; management practices; control methods

1. Introduction

Invasive species, exhibiting consistent spatial and density increase in a given area, are non-native to the ecosystem and pose economic and environmental threats [1,2]. Specifically, invasive plant species disrupt ecological balance, alter the physical and chemical properties of soil, and degrade ecosystem health [3–5]. They also affect the structure, composition, and native plants' succession, crowding out desirable plants, proving non-nutritious and potentially toxic to livestock and wildlife [6]. Invasive

plant species can also reduce the opportunity and experience of outdoor recreation, especially affecting recreation-dependent economies [7]. Spreading at 1.7 million acres per year, invasive plant species impose costs both for management expense and in terms of lost value, costing the US an excess of \$30 billion per year [2,7,8]. Along with the US, other countries, including China, Brazil, and Argentina, could experience considerable absolute cost from further species invasions. For these reasons, invasive species, including insects, pathogens, plants, wildlife, and fish species are among the highest threats to the national ecosystem [2].

Differences exist among invasive plant species in terms of their establishment chance, impact, and spread. Whereas some are easy to manage, others are not. Background plant species also have varying degrees of susceptibility to invasion. Taken together, these considerations show that invasive plant species pose different levels of risks to an ecosystem and the appropriate management strategy also varies accordingly. Given that some invasive plants are more aggressive than others, considerations such as their level of aggressiveness, ease of controlling their spread, and potential costs are used in assessing appropriate courses of actions [9,10].

Other things being the same, more regular monitoring and management efforts are more likely to be more effective than a single-time effort, which, in turn, may be more effective than never completing such projects at all [11,12].

As such, just as identifying and characterizing invasive plant species is relevant to prioritize them for management, similarly identifying the socioeconomic and forestland features that relate with more regular invasive-plant-species removal activities is useful to understanding which forestland owners face higher spread and reinvasion risks than others, what can be done to address the problem, and to adapting education outreaches to their relevant level of active invasive-plant-species removal efforts. It can also help federal, state, and local agencies adapt how they administer technical and financial support to the relevant invasive-plant-species removal efforts of the forestland owner. Furthermore, given the pathways through which different forest-management activities can contribute to the spread of invasive plant species, assessing if and which forest-management activities the land owner performed also allows us to determine if the forestland owners may be unintentionally contributing to the problem they are trying to solve.

In this paper, we study how socioeconomic attributes of forestland owners and forestland features relate with higher regularity in invasive-plant removal. Considering the potential role certain forest-management activities play as pathway for the spread of invasive plant species, we assess how the frequency in such management activities relates with having to regularly remove invasive plant species, holding other covariates constant. While understanding the invasive plant species and the appropriate management activity is an important part of managing the problem, better understanding the forestland owners tasked with acquiring, comprehending, and implementing the scientific information is also important.

2. Socioeconomics of Invasive-Species Management

For a given invasive plant species and relevant control method, effective invasive-plant-species management depends on regular monitoring and management. Forestland owners may be able to reduce invasive plants' impact on their stand by proactively managing for invasive plant species, doing a regular inventory and monitoring of the plant species on their forestland as well as adjacent forestlands, documenting the type and spread of invasive plant species, the type and rate of treatment they respond to, avoiding travel through infested areas, effectively removing the invasive plant's root system and properly disposing the plant material, completely burning wood and debris, working from the uninvaded area to the invaded area instead of the other way around, and understanding the selective effect of prescribed burning [12,13].

While understanding the invasive plant species and its distribution helps in developing the appropriate control method, it does not help us understand whether and why a forestland might regularly manage the land for invasive plant species, despite its important role. Some forestland

owners may be discouraged from regular invasive-plant removal activity by the intensity of work involved in regular monitoring and management; the labor intensity of mechanical control methods; permit requirements; reluctance to use chemicals and disturb the site; cost considerations; and lack of knowledge about the invasive plant, its impacts, and relevant control method [14,15].

Similarly, for a given invasive plant species and management strategy, forestland owners have different types and levels of forest-management practices that may create conditions for increased invasion. While an integrated and adaptive management approach recommends forest-management practices appropriate to the different phases of invasive-species progression [12,13], it presupposes that the forestland owner has regularly monitored the stand; identified the invasive plant species, its stage of progression, and its control method; and knows to postpone forest-management activities past the eradication of the invasive species. Limited work also assesses how higher regularity in these forest-management activities relates with higher regularity in having to remove invasive plant species after controlling for variables that explain high frequency in invasive-plant removal activity.

Another area of research focuses on quantifying the market and nonmarket impacts of invasive species and assesses how the cost–benefit analyses depends on invasive species' impact at different scales and speeds of damage [10,16,17]. Wu (2001) optimizes the application of herbicides in a way that maximizes discounted net benefit, Wu (2001) and Matta et al. (2007) study how the cost and frequency associated with eradicating invasive species using different approaches affect land expected value. Odom et al. (2003) determines optimal mix of different invasive-management approaches at varying levels of weed and seed density [18–20].

However, the invasive-plant removal activity is modeled discretely instead of being modeled as a continuous regular process. This approach considers all forestland owners that have removed invasive plant species once the same way as those that have done so more regularly; the differences have important implications for the eradication of invasive species and reinvasion of forestland. In addition to the frequency of the activity, how long ago the activity was done and if the forestland owner plans to do so in the recent future are not always specified. This would consider forestland owners that removed invasive plant species several years ago the same way as those that did it in the current year. Similarly, it would consider forestland owners that plan to remove invasive plant species several years into the future the same way as those that plan to do so in the current year. Because new invasive plant species may have grown on the forestland since the last invasion or invasive plant species that were once managed on that land may have reinvaded the stand, a failure to time when the activity was done can be misleading.

In studying why and how different stakeholders rank the importance of different invasive species, Lippitt et al. (2008) [21] notes that forestland owners' experiences and challenges in dealing with invasive plant species in forestlands should inform the relevant policies and management strategies. Lippitt et al. (2008) [22] also highlights the importance of integrating anthropogenic factors with ecological factors in accurately assessing the risk of invasive-species spread. Mortensen et al. (2009) [23] also showed that roads in forests serve as corridors for invasive-plant dispersal, highlighting the importance of accounting for relevant forestland features in designing management strategies. These studies highlight that forest-management activities and the socioeconomics of the forestland owner who is directly facing and managing the invasive plant species are an important part of understanding and addressing the practical invasive plant species management challenges [24–26].

3. Data and Method

3.1. Data Collection

Given the importance of the forest-based industry to the economic output of Virginia and Texas—a combined value in excess of \$22 billion per year—it is important to understand the threats invasive plant species pose to their forest resources. Towards this end, we targeted 1800 forestland owners in Texas and Virginia to participate in this survey. We used a random-number generator to avoid bias in

selecting survey participants. We also used rounds of peer review, focus group discussions, and a pilot test to improve the survey for completeness and ease of understanding.

Following the tailored Dillman method, we sent a first round of survey, a postcard reminder, and a final-round survey to the survey participants [27]. The survey asked forestland owners if they have completed an invasive plant species removal project in their forestland in the past five years and if they plan to do so in the next five years. While some respondents said ‘no’ to both, others said ‘yes’ at least to one, yet others said ‘yes’ to both, capturing different orders of invasive-plant removal regularity. A number of forest-management activities including partially harvesting stands and building/maintaining roads in the forestland, were also framed in a similar way. The survey also elicited: age, income, gender, acreage, the way land is acquired, forest-management objectives, absenteeism, membership in environmental/forestry associations, and participation in public-incentive programs. With 390 responses, we had a 21.6% response rate. The 229 most-complete responses are used for this study.

3.1.1. Partition Analysis

The partition analysis iteratively identifies a threshold value in a variable delineating a change in the nature of its relationship with a covariate. Instead of assuming a linear relationship with a constant slope, this approach determines a threshold value for continuous and multinomial variables that allows testing for significance, direction, and marginal effect of a variable on the other variable. Accordingly, it divides the population of observations into two optimal groups that have statistical similarity among themselves but have statistical difference when compared with each other. The threshold values were then used to determine dummy versions of the variables, presented under Reference (Ref.) and Alternative (Alt.) columns in the result tables.

3.1.2. Cochran–Armitage Trend Test

The Cochran–Armitage trend test assesses if the distribution of respondents that fall under the Alt. group relative to forestland owners that fall under the Ref. group have a statistically significant trend across the invasive-plant removal regularity [28,29].

For a correlation coefficient between two variable that is specified as:

$$r = \frac{\sum_{i,j}(x_i - \bar{x})(y_j - \bar{y})p_{ij}}{\sqrt{\left[\sum_i(x_i - \bar{x})^2 p_i\right] \left[\sum_j(y_j - \bar{y})^2 p_j\right]}} \quad (1)$$

where the numerator represents the weights cross-products of deviation scores by their relative frequency and denominator represents the product of the sample standard deviation for the independent and dependent variable, the test statistics T^2 has a chi-squared distribution with 1 degree of freedom [28].

$$T^2 = (n - 1)r^2 \quad (2)$$

A p value less than 0.05 suggest a statistically significant trend.

3.2. Cochran–Mantel–Haenszel Test

The Cochran–Mantel–Haenszel test estimates conditional independence between variables after adjusting for a confounding variable [28–30]. For a given level k of the confounding variable used for controlling and a 2×2 contingency table between high regularity in invasive-plant removal and the given forest-management practice,

$$\mu_{11k} = E(n_{11k}) = \frac{n_{1+k}n_{+1k}}{n_{++k}} \quad (3)$$

$$\text{Var}(n_{11k}) = \frac{n_{1+k}n_{2+k}n_{+1k}n_{+2k}}{n_{++k}^2(n_{++k} - 1)} \quad (4)$$

$$\text{CMH} = \frac{[\sum_k(n_{11k} - \mu_{11k})]^2}{\sum_k \text{Var}(n_{11k})} \quad (5)$$

n_{1+k} and n_{2+k} are row totals while n_{+1k} and n_{+2k} are column totals, and n_{++k} is the total sample in level k . Given Equations (3) and (4) that measure the expected value and variance, the Cochran–Mantel–Haenszel has a Chi-Square distribution with 1 degree of freedom. A p value less than 0.05 suggests a relationship between the regularity of invasive-plant removal and the other variables in at least one level of the confounding variable.

3.3. Odds Ratio

The odds ratio measures the relationship between given outcomes for different levels of a given covariate. In this specific case, it measures the odds that the forestland owner has a high invasive-plant-species removal regularity given the forestland owner has conducted a given forest-management activity both in the past and plans to do so in the future compared to the forestland owner having a high invasive-plant-species removal regularity given that the forestland owner has conducted the given forest-management activity neither in the past and nor plans to do so in the future.

In a 2×2 contingency table setting, it can be computed as:

$$\text{Odds Ratio} = \frac{P_{11} * P_{22}}{P_{12} * P_{21}} \quad (6)$$

where P_{ij} is the count in the two levels for the forest-management activity and whether or not the forestland owner has high invasive-plant-species removal regularity.

4. Result

4.1. Descriptive Data

The data used for this study are part of a larger project that required targeting forestland owners who can operate an economically viable biomass production, approximated by owning at least 20 acres of forestland [31–33]. As such, the average acreage for our data is slightly higher than the average acreage for both states. However, a comparison of our data with the national woodland-owner survey data, done across time and over a larger sample size, to assess representativeness after adjusting for a 20-acre cutoff point, shows a reasonable comparability. Accordingly, while 91.4% of Virginia's forestland owners and 92.5% of Texas' forestland owners are white, the values for our data are 94.8% and 89.1%, respectively. While 61.2% for Virginia's forestland owners and 55% for Texas' forestland owners have their primary residence on the forested property, the values for our data are 55.8% and 43.7%, respectively. While 83.15% of Virginia's forestland owners and 84.3% of Texas' forestland owners are male, the values for our data are 78% and 82.1%, respectively. A t -test assessing statistical difference between late and early respondents did not produce a significant result.

4.2. Covariates of Invasive-Plant Removal Regularity

55.87% of the respondents have neither removed nor plan to remove invasive plant species from their land in the 10-year span, while 22.91% have done or plan to do so. Only 21.23% of the respondents said that they have removed plant species in the past five years and still plan to do so in the next five years. Table 1 presents the reported frequency of invasive plant removal.

Table 1. Percentage distribution of forestland owners' stated frequency of removing invasive plant species in a 10-year span.

Regularity of Invasive-Plant-Species Removal Rate in the 10 Year Span	Percentage of Total Respondents
Did not and do not plan to remove invasive plant species	55.87%
Either removed or plan to remove invasive plant species	22.91%
Removed and still plan to remove invasive plant species	21.23%

The Cochran–Armitage trend test results suggest that invasive-plant removal regularity is associated with gender, acreage, and various forest management activities that are market and nonmarket oriented as well as consumptive and nonconsumptive. Age, income, way land is acquired, absenteeism, membership in environmental/forestry associations, and participation in public-incentive programs were not significant. Table 2 presents a summary of the significant results.

Table 2. Trend in the invasive-plant-species removal regularity and forestland owner features, management activities.

	Reference	Alternative	Cochran–Armitage Test Statistic	p Value
Forestland acreage	<55	≥55	2.11	0.035
Pass land to heirs	1, 2	3, 4, 5	2.13	0.033
Partially cut stand	No	Yes	4.33	<0.0001
Harvest fuelwood for sale or own use	No	Yes	4.24	<0.0001
Build or maintain road in the forestland	No	Yes	2.25	0.024
Develop a written forest management plan	No	Yes	3.69	0.001
Wildlife habitat/fisheries improvement project	No	Yes	5.58	<0.0001
Gender	Male	Female	−2.23	0.026

Forest-management objectives are related with the regularity of invasive-species removal practice. Accordingly, forestland owners that consider passing land to heirs as an important forest-management objective are more likely to have higher invasive-species removal regularity. If this objective is at least a 3 on a scale of 1 to 5, with 5 being a 'very important' reason for owning and managing land, then the forestland owner is more likely to remove invasive plant species regularly. However, the statistical analyses did not produce a significant result for other forest-management objectives, such as generating profit from the land, protecting nature and biodiversity, producing nontimber products such as boughs and grapevine, obtaining carbon sequestration payments in the future, and enjoyment of privacy.

Female forestland owners are less likely than male forestland owners to regularly remove invasive plant species. Developing a written forest-management plan is also related with more regular invasive-plant removal activity. Developing a written forest-management plan involves reaching out to a professional and specifying forest-management objectives and timelines. Such a process indicates expectations of the forestland owner about the forestland and hints at possible active forest-management practice that follows from such planning. Removing invasive plant species may emerge as an objective or as a means to other objectives.

Forestland owners with smaller lands are less likely than others to remove invasive species regularly. Specifically, threshold analysis indicates that forestland owners with acreage lower than 55 acres are less likely than forestland owners with higher than 55 acres to remove invasive plant species regularly. Small acreage is related with lower timber production potential and a less active forest-management tendency.

Forest-management activities also have a significant relationship with invasive-plant-species removal regularity. Accordingly, the relative distribution of forestland owners that have partially harvested their stand in the past five years is such that they have more regularity than forestland owners that have not partially harvested their stand.

Having built or maintained roads in a forested area is also related with high regularity in invasive-plant removal. Forestland owners' investment in hiking trails suggests a plan to enjoy

natural beauty and scenery, with invasive plant species needing to be removed. If the road was built or maintained for easy access to the forest for timber harvest, that would also suggest active land-management tendency and an interest in protecting a productive resource.

Having harvested fuelwood for sale or for own use in the past five years is also related with high regularity in removing invasive plant species. The forestland owner may have harvested the invasive plant species together with the fuelwood. Similarly, having done wildlife habitat/fisheries-improvement projects in the past five years is related with a high regularity in invasive-plant removal. The less active forestland owners are in terms of these activities, the less likely they are to remove invasive species regularly.

4.3. Predicting Relationships between Regularity in Forest-Management Activities That Are Potential Pathways for Spread of Invasive Species and Having to Regularly Remove Invasive Plants

Forestland owners can unknowingly introduce and spread invasive species during the practice of traditional silviculture, wildlife-habitat improvement, and other land use practices. Forestland-management activities disturb the ground and remove native plants and their canopy, lay soil bare, and increase light penetration, creating conducive conditions for the establishment and spread of invasive species [12,13,31,32]. As such, while the process of partially harvesting stands and collecting fuelwood may allow for the removal of invasive plant species along the way, these practices can also become pathways for spreading invasive plant species [13]. Road-building materials, such as sand, gravel, and filling, introduce offsite material that may carry invasive seed or plant material [12,23]. Similarly, use of untreated equipment, moving even dry and clean-looking firewood, and skidding can also transport invasive plant seeds and material throughout the forest [12,13].

Even if the forestland owner regularly removes invasive plant species while continuing to engage in such forest management activities, the effort will not immediately result in the complete management of the invasion, if at all. Even if the forestland owner knows and strictly follows the best relevant management practices, reducing the risk of spreading invasive species in the forestland, the more effective preventive approach is to postpone planned forest-management activities that are potential pathways for spreading invasive plant species until the invasion is eliminated [13].

Like invasive-plant removal activities, forest-management activities are also recorded on the same level (neither past nor planned, either past or planned activity, both past and planned activity). Reinterpreting higher regularity in invasive-plant removal activity as an indicator of higher need to do so, we test a hypothesis that forest-management activities may be contributing to invasive species spread by assessing if the odds of having to regularly remove invasive plant species increases, decreases, or stays the same as the forest-management activity regularity increases. We use the Cochran–Mantel–Haenszel approach to control for other variables that are significantly related with high regularity in invasive-plant removal, suppressing their effect and determining how the higher frequency in the said management activities relates with having to regularly remove invasive plant species. Although this does not establish causation, it would show a strong association that future research can explore in greater depth.

Table 3 presents the odds ratio that the forestland owner has removed invasive plant species in the past five years and still plans to do so in the next five years at different levels of regularity in forest-management activity. The right half of the table presents the *p* value testing the significance of that relationship after controlling for the respective variables.

Table 3. Odds ratio and Cochran–Mantel–Haenszel results for the relationship between planning to remove invasive plants after having done so in the past five years and regularity in forest-management activity.

Forest-Management Activity		Odds Ratio		<i>p</i> Value of CMH Test Controlling for			
Type	Regularity	Value	95% Confidence Interval	Forest Acreage	Written Management Plan	Bequeathing Objective	Gender
Partially cut stand	Past and Future	4.48 *	[2.075–9.672]	<0.0001 *	0.0002 *	0.0004 *	<0.0001 *
	Past or future	2.38	[0.886–6.399]	0.1511	0.1307	0.0557 *	0.0509 *
	None	0.25	[0.106–0.579]	0.0013 *	0.0011 *	0.0012 *	0.0005 *
Harvest fuelwood for sale or own use	Past and Future	8.33 *	[3.786–18.342]	<0.0001 *	<0.0001 *	<0.0001 *	<0.0001 *
	Past or future	0.78	[0.203–2.995]	0.4115	0.5921	0.8743	0.8286
	None	0.25 *	[0.115–0.546]	0.0009 *	0.0003 *	0.0002 *	0.0004 *
Build or maintain road in the forestland	Past and Future	2.50	[1.121–5.577]	0.0406	0.0348	0.126	0.0215
	Past or future	1.26	[0.512–3.108]	0.7047	0.8385	0.7173	0.5619
	None	0.54	[0.265–1.115]	0.1617	0.1431	0.2496	0.0859
Wildlife habitat/ fisheries improvement project	Past and Future	6.11	[2.627–14.217]	<0.0001	<0.0001	<0.0001	<0.0001
	Past or future	1.60	[0.645–3.952]	0.3517	0.3296	0.412	0.511
	None	0.33	[0.154–0.688]	0.0054	0.003	0.0087	0.0148

If the forestland owner neither partially harvested stands in the past five years nor plans to do so in the next five years, the odds ratio that the forestland owner will have removed invasive plant species in the past five years and plans to do so in the next five years are less than 1, suggesting that it is unlikely. However, a forestland owner that has both partially cut stands in the past five years and plans to do so in the next five years will have also removed invasive plant species in the past five years and plans to do so in the next five years is 4.48, well above 1 and suggesting that it is highly likely. Similarly, as the regularity of the forest-management activity increases from ‘None’ to ‘Past and Future’, the odds ratio of regularity in invasive-plant removal activity also increases from less than 1 to higher than 1 for the other management activities, both being significant and the trend suggesting higher likelihood. A similar pattern persists even after controlling for the relevant variables that significantly relate with high regularity in invasive-plant removal activity.

The results suggest that the forestland owners may be having to remove invasive plant species in high regularity because the invasive-plant removal activity is not integrated into their forest-management activities well enough as not to contribute to the spread of the invasive plants itself. These results highlight the need to integrate invasive-plant-species management plans with forest-management plans and forestland owners’ need for educational outreach programs to that effect. By postponing the forest-management activity until the invasion is managed, the forestland owners may be able to limit the spread of the invasive plant species and having to regularly remove it [12,13]. Such practice might help reduce the impact of the invasive plant species on the forest ecosystem as well as reducing the management cost and lost value. This could also ensure that forestland owners’ investment of time and money on removing invasive plant species is more effective.

While forestland features such as small acreage, and socioeconomic features such as being female and not developing a written forest-management plan, describe profiles of forestland owners that can be helped towards having a more regular invasive-plant-species removal activity, the forest-management activities that are potential pathways for the spread of the invasive plant species highlight the need to ensure that high regularity in invasive-plant-species removal is done for the right reasons. Epanchin-Niell et al. (2009) also noted that measures, including bottom-up approaches, require active engagement by all resource managers, including all public and private land managers in an invaded, or potentially invadable, region. Epanchin-Niell et al. (2009) [34] Further notes that coordination among such active stakeholders can contribute to regional invasive-species control, as would spatially referencing households and their invasive-plant removal practices.

5. Conclusions

More than 55% of the forestland owners did not remove invasive plant species in their stand in the past five years and neither do they plan to do so in the next five years. Only 21% of the forestland owners have removed invasive plant species in the previous five years and still plan to do so in the next five years. Female forestland owners, owners with forestlands less than 55 acres, forestland owners that attach relatively lower importance to passing land to heirs, and forestland owners that have not partially cut their stand, harvested fuelwood, built/maintained roads in the forestland, made wildlife/fisheries-habitat improvements, and developed a written forest-management plan have relatively lower regularity in removing invasive plants. Test of relationship between having to regularly remove invasive plant species and regularity in forest-management activities that the literature suggests to be potential pathways for invasive-plant-species spread yields significant results. The odds ratio of having to regularly remove invasive plant species increases as the regularity in the practice of building roads in the forest, wildlife/fisheries-habitat improvement, partially harvesting stand, and harvesting fuelwood increases. This pattern holds even after controlling for the other variables that significantly relate with high regularity in invasive-plant-species removal.

Future studies can use a similar approach for specific invasive plant species and assess if and which factors relate with regularity in removing the invasive species. Such studies can also adapt the approach to other invasive species, such as insects, pathogens, wildlife, and fish. Such studies can also assess how much removing invasive plant species is costing forestland owners, how they finance it, how it affects the property value, what returns they expect for such investment, if and which types of public-incentive programs may encourage them to remove invasive species more frequently.

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