Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

# Balancing the management of powerline right-of-way corridors for humans and nature

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### ARTICLE INFO

Handling Editor: Jason Michael Evans

Keywords: Cultural ecosystem services Ecosystem service trade-off Electric transmission right-of-way Informal urban greenspace Prairie restoration Suburban ecology

# ABSTRACT

Green space in electric powerline rights of way (ROWs) can be a source of both ecosystem services and disservices in developed landscapes. Vegetation management within the ROW may influence tradeoffs that maximize potential services or disservices. Frequently mowed ROWs managed as lawn harbor less biodiversity than ROWs with taller vegetation, but may be preferred by people for aesthetic reasons and because they provide space for recreational activities. We conducted a survey of residents living by ROWs in the Chicago, Illinois USA metropolitan area to determine if residents prefer ROWs managed as lawn over those managed as native prairies or allowed to grow freely with only woody vegetation removed ("old-field ROWs"). We found that respondents did not prefer mowed over prairie or old-field ROWs. Furthermore, respondents living near mowed ROWs were least likely to think that the ROW is attractive, while those living near prairie ROWs were most likely to. Survey respondents tended to believe it was important for ROWs to provide habitat for wildlife, and wildlife observation was the most frequently reported activity conducted in the ROW. Finally, we found that a respondent's perception of biodiversity in the ROW was more closely correlated with positive feelings about the ROW than measured biodiversity levels. Our results suggest that managing ROWs for wildlife habitat is fully compatible with managing them for human enjoyment. We therefore recommend that where possible, ROW vegetation is managed in a more "natural" way than lawn because it has the potential to benefit both wildlife and people.

### 1. Introduction

Ecosystem services are essential to the functioning of developed landscapes (Luederitz et al., 2015). Urban and suburban green spaces can provide a wide variety of these services, from regulating services such as air purification or flood control (Buchel and Frantzeskaki, 2015; Derkzen et al., 2015), to cultural services such as recreational opportunities (Bertram and Rehdanz, 2015; Dickinson and Hobbs, 2017; Edwards et al., 2022), aesthetic appreciation, and increasing psychological well-being (Bratman et al., 2019). Informal urban greenspaces such as brownfields or electric powerline rights-of-way are not set aside purposefully for conservation or recreational purposes (Rupprecht et al., 2015) but can also be important sources of ecosystem services (Gardiner et al., 2013; Rupprecht et al., 2015).

Because ecosystem services result from a vast array of ecosystem functions, there are often trade-offs in services within a given area (Howe et al., 2014). For instance, Raudsepp-Hearne et al. (2010) found major trade-offs between provisioning and almost all cultural and regulating ecosystem services in Quebec, Canada. Vegetation management is key to determining which ecosystem services will be provided by a given greenspace (e.g. Dupras et al., 2016). For instance, parks with large lawns may provide cultural services in the form of space for recreational activities, but may not support high levels of biodiversity or regulating services such as carbon sequestration. Similarly, there may also be complex trade-offs, synergies, or cascading effects between ecosystem services and disservices (Roman et al., 2021; Saunders, 2020), which are further influenced by vegetation management. For instance, greenspaces that are managed for biodiversity may also be perceived as attracting unwanted weeds or animal pests (Larson et al., 2019). Therefore, decisions about the vegetation management of informal greenspaces should be made with these tradeoffs in mind.

The issue of ecosystem service and disservice tradeoffs is further

https://doi.org/10.1016/j.jenvman.2022.117175

Received 9 August 2022; Received in revised form 26 December 2022; Accepted 28 December 2022 Available online 5 January 2023

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complicated by the subjective nature of some cultural ecosystem services. While some ecosystem services (such as carbon sequestration, pollination, etc.) exist whether or not people are aware of them, many cultural services (such as aesthetic value) are more personal and linked to how a stakeholder views them (Larson et al., 2019). Cultural identity and individual values can strongly affect the way a person values a landscape or habitat, which may have little to do with how that ecosystem actually functions (Scholte et al., 2015). Furthermore, many cultural ecosystem services are linked to perceptions of biodiversity, but people may not accurately perceive biodiversity levels (e.g. Dallimer et al., 2012). Thus, cultural ecosystem services may be more closely linked to perceived than to actual biodiversity (e.g. Belaire et al., 2015; Dallimer et al., 2012). Together, these trends indicate that managing vegetation to increase ecosystem services may not have a straightforward effect on cultural services.

Electric powerline rights-of-way (ROWs) are informal greenspaces that are ubiquitous in urban and suburban landscapes across the United States, where underground transmission lines are still relatively rare (Glass and Glass, 2019). They include the area under and near electric transmission towers and overhead powerlines, and are managed to keep vegetation from touching the wires and disrupting service. ROWs encompass extremely large land areas across the country (Russell et al., 2005), and consequently have the potential to provide major benefits by supporting ecosystem services at a large geographic scale. Therefore, it is important to understand the types of ecosystem services provided by ROWs, tradeoffs between services and/or disservices, and how they are affected by different kinds of vegetation management.

Many techniques are used to manage vegetation in ROWs, including mowing, pruning, spot-spraying or blanket-spraying of herbicides, or combinations of these techniques (Appelt and Beard, 2006). The surrounding landscape frequently dictates the way ROW vegetation is managed. For example, in rural areas, ROWs often intersect farm fields and are therefore planted in crops. In residential areas, ROW vegetation management can take a variety of forms, and is influenced by stakeholders such as the local municipality, nearby homeowners, or the electric utility company itself (Li et al., 2010). In the Chicago suburbs (Illinois, USA), ROWs are sometimes converted to mowed lawn after residents or towns complain about overgrown ROW vegetation (Sara Race, Environmental Services Department at Commonwealth Edison, personal communication March 17, 2021). Residents may appreciate mowed ROWs, as lawns are often considered aesthetically pleasing and provide a place for recreational and social activities (Ignatieva et al., 2020). However, urban lawns produce net carbon emissions (Gu et al., 2015), and ROWs that are kept as lawn support lower levels of biodiversity than ROWs managed in other ways (Garfinkel et al., 2022). Several studies have found that people may actually prefer greenspace with higher biodiversity (e.g. Fuller et al., 2007; Gunnarsson et al., 2017; Hepburn et al., 2021). This suggests that there may be a trade-off in ecosystem services provided by ROWs, with lawn-type ROWs maximizing some cultural ecosystem services (such as recreational opportunities), and ROWs with more diverse vegetation maximizing other cultural ecosystem services (such as wildlife viewing), as well as regulating ecosystem services such as pollination and carbon sequestration. Because people have different aesthetic preferences, it is currently unclear which type of ROW maximizes aesthetic cultural ecosystem services.

The goal of this study is to examine cultural ecosystem services and disservices provided by ROWs in residential landscapes, and how they are affected by vegetation management. Using a survey of residents living next to powerline ROWs, we aim to answer three main questions: 1) Does vegetation management predict whether people are happy with the way their local ROW is maintained? 2) Which best predicts the cultural ecosystem services and disservices that people obtain from the ROW: vegetation management, measured biodiversity in the ROW, perceived biodiversity in the ROW, or their innate feelings towards nature? 3) How do people actually use the ROWs and which qualities do

they prefer in these spaces? We expect that the results of this study will help to inform stakeholders about how to manage vegetation in ROWs to benefit both humans and wildlife.

### 2. Methods

#### 2.1. Study sites

We conducted this study at 12 electric powerline ROW sites in northern Illinois, USA, during the summer of 2021. All electric powerlines in these ROWs were owned by the Commonwealth Edison company ("ComEd"). The ROWs were selected from four different geographic locations in the Chicago Metropolitan Area (Fig. 1), which is the third-largest metropolitan area in the United States. All sites within a geographic location were separated from each other by at least 1 km, except for one pair of sites which were 500 m apart. The ROWs at these sites ranged in width from 35 to 60 m (X = 50, SD = 8.3).

The vegetation in each ROW site was managed either as lawn, "old-field", or prairie; one of each of the three ROW management types was represented at each geographic location (Fig. 2). Lawn-type ROWs are mainly turf-grass which is mowed and kept under approximately 30 cm (Garfinkel et al., 2022). Old-field ROWs are managed on a five-year cycle using brush mowing and herbicides to keep woody vegetation from growing too tall, and they contain weedy vegetation that is generally taller than that found in lawn ROWs. Prairie ROWs are remnant or restored prairie sites that are initially managed through re-seeding with native plants, and then maintained using a variety of methods including mowing, controlled burning, and spot-spraying of herbicides to control invasive species. All of our study ROWs were located in residential areas, and each had at least six houses directly adjacent to the ROW itself (although generally many more houses were next to the ROW).

### 2.2. Resident surveys

We created a digital survey using the platform Qualtrics (Provo, UT, USA) to ask residents who lived on properties adjoining our study ROWs about the ways they use and feel about the ROW (the full survey is available in Supplement A). The Office for the Protection of Research Subjects at the University of Illinois Chicago (Institutional Review Board) approved our study at the exempt level (protocol # 2021-0780). Our study was also approved at the exempt level by the Office of Research Services at DePaul University (protocol #IRB-2021-421). Before finalizing the survey, we conducted cognitive pre-testing interviews (Collins, 2003) to ensure that our questions would be interpreted in the way we intended. We conducted three of these interviews, each lasting 20-30 min, with homeowners that lived adjacent to a corridor we did not intend to sample. We made changes to our survey questions according to the information we gathered during cognitive pre-testing. Our pre-testing revealed that homeowners had strong opinions about whether powerlines could affect their health (generally via electromagnetic fields). We therefore added a question asking whether the respondent was concerned about health effects of the ROW to determine if that influenced their other survey answers.

Surveys (Supplement A) were distributed to all households with properties that bordered a study corridor (n = 212 households). We began by knocking on each door and asking if an adult would answer the survey questions. If they agreed, we offered the option to either take the survey in person, or complete the survey online. If no one answered the door, we left a letter at the door with information and a link to the survey. After approximately two weeks, we mailed a reminder letter to all households that had not complete the survey.

Our survey asked questions about how residents use the ROW, and about their feelings and preferences about the ROW. We also asked several questions to gauge how people feel about nature in general (Box 1). We used questions about the different activities that residents



Fig. 1. Study sites used in this study, northern IL USA. N = 4 geographic locations (circled in red), 12 ROW sites. The top map shows impervious surfaces in darker orange.



Fig. 2. Examples of three types of vegetation management in ROWs used in this study: A) Prairie; B) Old-field; C) Lawn.

perform in the ROWs to determine which cultural ecosystem services are provided, and we also asked questions about ecosystem disservices (Box 2). In addition, we asked respondents to estimate how many species of

birds, plants, and pollinating insects could be found in the ROW near their home. For these questions, we retained the lowest value when respondents answered with a range (e.g. "100–150", "100+", or

# Box 1

Questions used to calculate a "Nature Appreciation Score."

All questions were answered on a 5-point Likert scale of "strongly agree" (5) to "strongly disagree" (1). Scores for statements 1, 5 and 6 were reversed so that a high score indicated a high appreciation of nature for all questions.

Please respond to the following statements based on your preferences for natural areas and suburban green spaces such as the transmission rightof-way (ROW).

- 1. Tall grass and vegetation looks untidy in a ROW
- 2. I'd prefer a ROW that is wild and natural to a well-groomed and ordered one
- 3. Being out in nature is a great stress reducer for me
- 4. I enjoy spending time in natural settings just for the sake of being out in nature
- 5. I think spending time in nature is boring
- 6. I am often bothered by bugs and other pests when I am out in nature

### Box 2

Ecosystem Service and Disservice Questions

All questions were answered on a 5-point Likert scale of "strongly agree" to "strongly disagree."

How strongly would you agree or disagree with the following statements about the transmission right-of-way (ROW) near your property?

- 1. I enjoy living next to a transmission right-of-way (ROW)
- 2. The ROW is aesthetically pleasing or attractive
- 3. The ROW provides habitat for wildlife
- 4. The ROW introduces weeds to my property
- 5. The ROW attracts pests to my property (e.g. raccoons, rodents, pest insects, etc.)

"hundreds" would all be recorded as 100). These estimates were then log-transformed to a normal distribution. Questions concerning feelings about nature or the ROW, or preferred qualities of the ROW, were answered on a 5-point Likert scale of "strongly agree" to "strongly disagree" or "extremely important" to "not at all important." Finally, we asked several demographic questions, as well as an open ended question for respondents to comment on anything else they wanted us to know about the ROW.

We calculated a "nature appreciation score" for each respondent based on six survey questions about their preferences for natural areas and nature (Box 1). These six survey questions were answered on a 5point Likert scale of "strongly agree" (scored 5) to "strongly disagree" (scored 1). We inverted the scores for questions 1, 5, and 6 during analysis so that all answers were on the same scale. We then summed the scores for all six questions to create the nature appreciation score, with higher values indicating more positive feelings towards nature.

### 2.3. Ecological data collection

We collected data on the pollinators, flowering plants, and birds at each study ROW between June and September 2021. We selected these three taxonomic groups because we thought they were most likely to be noticed by residents. The full methods for these biodiversity surveys are described in Supplement B. In short, we used Pollard Walks (Pollard, 1977) to evaluate the pollinating insect community (non-ant Hymenoptera and Lepidoptera, hereafter "pollinators"), floral surveys to record the species of plants currently in bloom, point counts to characterize the bird communities detected within the ROW (Ralph et al., 1995), and a modified Robel pole (Jackson and Paine, 2006; Robel et al., 1970) to measure the plant density and height at each site. We selected Pollard walks as our pollinator survey technique because they are designed to measure easily detected species such as large bees (especially *Bombus* and *Apis*) and butterflies, which are the pollinators that would be most apparent to residents living near the ROWs. We did not sample micro-pollinators like tiny moths or flies. The floral surveys included only currently blooming flowers because several studies have suggested that people respond more to flower color diversity and abundance rather than plant species richness when viewing green spaces (e.g. Graves et al., 2017; Hoyle et al., 2018). Overall, our ecological variables measured at each ROW site included: species richness of pollinators, flowering plants, and birds; a plant density index based on Robel pole measurements; and the maximum height of dead vegetation at each site. We also calculated a "biodiversity index" for each site by summing the standardized values (z-scores) of the species richness of pollinators, flowering plants, and birds.

## 2.4. Statistical analysis

Before addressing our three main questions, we first checked whether survey responses differed by respondent gender or by level of concern about health risks of the ROWs. We did not have enough variation in our sample to determine how race, education, or income affected survey responses. We used chi-square goodness of fit tests to determine if the responses to two focal statements differed with the self-reported gender of the respondent. These focal statements were: 1) "I enjoy living next to a transmission ROW," and 2) "I am happy with the way that ComEd maintains vegetation in the ROW by my house." We simulated p-values for the chi-square test based on a Monte Carlo simulation with 9999 replicates due to a high frequency of expected values < 5 (Hope, 1968; Lin et al., 2015). We next used a Spearman rank correlation test to determine whether the response to question 1 above was correlated with the response to the statement "I am concerned about the transmission lines affecting my, or my family's, health."

# 2.4.1. Does management category predict whether people are happy with the way their local ROW is maintained?

We used a chi-square goodness of fit test to determine whether the response to the statement "I am happy with the way that ComEd maintains vegetation in the ROW by my house" differed significantly by management category (lawn, old-field, or prairie). We also used a chi-square test with simulated p-values to determine if there was a significant difference in whether respondents had filed a formal complaint about ROW vegetation management among ROW management categories. All analyses were conducted using R version 3.6.1 (R Core Team, 2022).

# 2.4.2. Which variables best predict the ecosystem services and disservices that people obtain from the ROW?

We used several tests to determine whether vegetation management, measured biodiversity in the ROW, perceived biodiversity in the ROW, or people's innate feelings towards nature best predict the ecosystem services and disservices provided by the ROW. We first used chi-square tests with simulated *p*-values to determine if responses to three questions about ecosystem services and two questions about ecosystem disservices provided by the ROW (Box 2) were significantly predicted by ROW management category. We then used Pearson's correlations to test whether measured species richness of birds, pollinators, and plants were significantly correlated with log-transformed respondent-estimated richness of the three taxa. Next, we used Spearman rank correlation tests to determine if the service and disservice question responses were significantly correlated with measured species richness of three taxa, respondent-estimated richness of three taxa, the biodiversity index, plant vegetation density or dead plant height, or the nature appreciation score. We calculated standard p-values for each test as well as False Detection Rate (FDR) correction adjusted p-values to account for repeated testing (Benjamini and Hochberg, 1995). Finally, we used PerMANOVA tests to determine whether site location, ROW management type, biodiversity index, plant vegetation density, or the nature appreciation score significantly predicts the grouped responses to the five ecosystem service and disservice questions.

# 2.4.3. What qualities do people prefer in a ROW and how do they actually use the ROWs?

We used summary statistics to characterize people's ROW preferences, frequency of use, and activities performed in the ROW. We also used chi-square tests with simulated *p*-values to determine if there were significant differences in the overall frequency of use or frequency of different activities conducted in the ROW by ROW management type, or by the presence of a path through the ROW.

### 3. Results

### 3.1. Participants and demographics

We received 65 completed and 5 partially completed surveys (18 were completed in person, and the rest online). We approached 212 households, and our response rate for completed surveys was 30.6%. The self-reported demographics of survey respondents, and the distribution of ROW management adjacent to their homes, are described in Table 1. Of those that completed the survey, 30 included an answer to our open-ended question which asked for any additional comments.

Responses to our two focal questions did not significantly differ with respondent gender (p = 0.059 and 0.828 respectively, Supplement C). We did not find a significant correlation between enjoyment of the ROW and health concerns from the ROW (Spearman's  $\rho = -0.150$ , p = 0.233).

# 3.2. Does management category predict whether people are happy with the way their local ROW is maintained?

Overall, 38% of respondents strongly or somewhat agree that they are happy with the way the electric company maintains vegetation in the ROW, 22% neither agree nor disagree, and 41% strongly or somewhat disagree. However, there was no effect of vegetation management on the response to the statement "I am happy with the way that ComEd maintains vegetation in the ROW by my house" ( $|_{8 DF}^2 = 9.85$ , p = 0.27, Fig. 3A). In addition, there was no effect of vegetation management on whether a formal vegetation management complaint was made ( $|_{2 DF}^2 = 1.53$ , p = 0.47). Of those that answered the question, 15.7% (11 respondents) had filed a request, 80% (56) had not, and 4.3% (3) were unsure.

Several respondents made comments in our open-ended question about a desire for increased vegetation management, but none specifically indicated that they wanted the ROW converted to turf grass. One respondent stated "Please keep it cut," but more comments were about weeds, such as this statement: "... The weeds, trees, and VINES along the fence grow through and over my fence onto my property and I must trim it every two weeks. It is a constant battle" (emphasis original).

# 3.3. What best predicts the ecosystem services and disservices that people obtain from the ROW?

Of the five questions about ecosystem services and disservices (Box 2), management category was a significant predictor only of the statement, "The right of way is aesthetically pleasing or attractive" (Fig. 3B–F). Respondents living near mown ROWs tended to disagree with that statement more than those living by old-field or prairie ROWs. Although not a statistically significant trend, we found that respondents

Table 1

Self-reported	demographics and	l ROW mana	gement distri	bution of surv	vev respondents.
<b></b>			0		· · · · · · · · · · · · · · · · · · ·

-	• •	•		• •					
Gender (n = 60)	% Respondents	Adjacent ROW management (n = 70)	% Respondents	Race/ Ethnicity (n = 58)	% Respondents	Highest Level of Education (n = 63)	% Respondents	Yearly Income Bracket (n = 48)	% Respondents
Female	47%	Prairie	25.7%	White/ Caucasian	84%	High school graduate	9.5%	\$20,000 to \$49,999	10%
Male	53%	Old-field	28.6%	Asian	14%	Some college/tech training	20.6%	\$50,000 to \$99,999	29%
		Lawn	45.7%	Hispanic/ Latinx	2%	College graduate	34.9%	\$100,000 to \$149,999	15%
						Postgraduate work	34.9%	\$150,000 to \$199,999	21%
								\$200,000 to \$249,000	15%
								\$250,000 to \$300,000	4%
								Greater than	6%



Fig. 3. Responses to six survey questions categorized by respondent's ROW management type. The x-axis shows the percent of responses across a 5-point Likert score, with neutral responses centered on zero. *P*-values are from chi-square tests and are calculated using Monte Carlo simulation.

### Table 2

Spearman's  $\rho$  (rank correlation coefficients) between ten variables and five ecosystem service/disservice questions. Each question included a statement that respondents ranked on a 5-point Likert scale from "strongly agree" (scored 5) to "strongly disagree" (scored 1). We calculated both unadjusted and False Detection Rate correction adjusted (Benjamini and Hochberg, 1995) p-values. Cells marked with \* and highlighted in light gray have significant unadjusted p-values ( $\alpha = 0.05$ ) but insignificant adjusted p-values. Cells marked with \*\* and highlighted in dark gray have significant unadjusted p-values ( $\alpha = 0.05$ ).

		ENVIRONMENTAL RESULTS VARIABLES					ES	SURVEY RESULTS VARIABLES			
	Likert Statement	Bird richnes s	Floral richnes s	Pollinat or richness	Bio diversit y Index	Mean plant density index	Max. thatc h heigh t	Responde nt Estimated bird richness	Responde nt Estimated plant richness	Responde nt Estimated pollinator richness	Nature Appreciatio n Score
+ *	I enjoy living next to a ROW	-0.16	0.18	0.12	-0.01	-0.02	0.16	0.19	0.27*	0.44**	0.17
+	The ROW is attractive	-0.07	0.25*	0.16	0.16	0.04	0.31	0.14	0.28*	0.29*	0.29*
+	The ROW provides habitat for wildlife	0.04	0.25*	0.14	0.21	-0.05	0.14	0.46**	0.41**	0.46**	0.45**
-	The ROW introduces weeds to my property	0.42**	0.07	-0.11	0.24	0.23	0.11	0.05	0.05	-0.04	-0.13
-	The ROW attracts pests to my property	0.35**	0.15	-0.13	0.32**	0.42**	0.20	0.05	0.10	< -0.01	-0.27*

\* The "+" indicates that the statement describes an ecosystem service, and "-" indicates that the statement describes an ecosystem disservice

\* The "+" indicates that the statement describes an ecosystem service, and "-" indicates that the statement describes an ecosystem disservice.

living by old-field ROWs tended to agree more that the ROW introduces pests or weeds to their property (Fig. 3 E–F).

Variation in species richness among sites is described in Supplement Table D. We found a significant correlation between respondentestimated plant richness and measured floral richness (Pearson's r = 0.38, p = 0.003) but not between estimated and measured bird or pollinator richness. Respondent species richness estimates were more frequently significant predictors of ecosystem services provided by ROWs than measured species richness (Table 2). Respondents reported higher agreement with the ecosystem service statements when they estimated higher species richness. We also found that respondents with a higher nature appreciation score were more likely to agree with two of the ecosystem service statements and disagree with one disservice statement (Table 2). A PerMANOVA test indicated that the nature appreciation score was the only variable which significantly predicted the grouped responses to the ecosystem service/disservice questions (Table 3).

# 3.4. What qualities do people prefer in a ROW and how do they actually use the ROW?

We found that 63.6% of respondents believed that it was extremely or very important that the ROW provides habitat for wildlife (Fig. 4). Of the five ROW qualities described in the survey, the ability to use the ROW for recreation or travel was most frequently ranked as not important. The most common activity that respondents reported conducting in the ROW was wildlife observation, followed by active recreation (Fig. 5). We did not find any significant differences (p > 0.05 in all cases) in the frequency of respondents reporting using the ROW for different activity types by vegetation management category (i.e. each ROW activity was equally likely to be conducted by respondents living by each of the ROW management categories). We also did not find any significant difference in the overall frequency of use of the ROW by management category or by the presence of a path through the ROW (p> 0.05 for both tests).

While two respondents wrote negative comments about wildlife, the majority of comments about nature and wildlife were positive. The following quotations have been lightly edited for spelling and grammar for the sake of clarity.

Negative Comments.

- "Coyotes are very aggressive and wild. Dangerous!!"
- "We found by experience there are a lot of ticks on the ROW"

Select positive comments.

- "Love the ROW. I know travel patterns of deer, coyote. We have a red tail [hawk] who nests yearly and sits on my roof. Sandhill Cranes were seen last year walking down ROW. Currently watching coyote mom teaching mousing skills to pups. Always something to see."
- "Keep it in a natural state. Enjoy seeing the deer, hawks, coyotes using the right-of-way."

#### Table 3

Results of PerMANOVA test of significance of grouping of Likert question responses. Bray-Curtis distance was used to create a similarity matrix based on the responses to the 5 statements about ecosystem services and disservices listed in Box 2. *P*-values <0.05 are marked with \*.

Predictor Variable	Df	Sum of Squares	$\mathbb{R}^2$	F	<i>p</i> -value
Site location	3	0.20	0.07	1.50	0.178
ROW management	2	0.10	0.03	1.11	0.356
Nature appreciation score	1	0.22	0.07	4.86	0.007*
Biodiversity index	1	0.03	0.01	0.63	0.588
Mean plant density index	1	0.04	0.01	0.81	0.481
Residuals	53	2.39	0.80		
Total	61	2.98	1		

- "I really like the transmission right-of-way because I enjoy having nature at the edge of my property rather than a neighbor's yard."
- "I enjoy the quiet and love that there is no activity behind my home. This is one of the reasons we picked this place."

### 4. Discussion

Our results indicate that, overall, respondents did not have a preference for mowed over prairie or old-field ROWs. In fact, our results suggest that mowed corridors may be less preferred than other types of ROWs. We found that respondents living near mowed ROWs were least likely to agree that the ROW is attractive, while those living near prairie ROWs were most likely to agree (Fig. 3C). Furthermore, we found a pattern (though statistically insignificant) that those living near mowed ROWs were more likely to disagree with the statement "I enjoy living next to a ROW" (Fig. 3B). In addition, respondents tended to believe it was important for ROWs to provide habitat for wildlife (Fig. 4) and were more likely to use the ROW for wildlife observation than any other activity (Fig. 5). Together, these results suggest that managing vegetation for wildlife habitat in ROWs is compatible with managing ROWs for human enjoyment.

We did not find a significant correlation between any species richness measurement and respondent enjoyment of living by a ROW. Several previous studies (e.g. Cameron et al., 2020; Fuller et al., 2007; Gunnarsson et al., 2017; Hepburn et al., 2021) have found a direct positive relationship between biodiversity and human well-being or positive feelings towards a space. Most of these studies, however, examined sites with fairly high variation in biodiversity. In contrast, even our most biodiverse sites did not have many species compared to intact native ecosystems such as established prairies (Supplement Table C). This is likely due to the fact that several of the prairie sites in our study were recent restorations. It is possible that had we been able to examine ROW sites with more variation in biodiversity, including prairies that had been established for more years, we may have detected a correlation between biodiversity and enjoyment of the ROW.

Interestingly, we instead found that respondent-estimated pollinator and plant species richness was a better predictor of enjoyment of living next to a ROW than field measured pollinator or floral species richness. Dallimer et al. (2012) also determined that human well-being was associated with perceived rather than actual species richness and that perceived and actual biodiversity were not correlated. They attributed this to the fact that most people are not skilled at identifying biodiversity. While we found no significant correlation between actual and respondent-estimated richness of birds and pollinators in our study, we did find a significant positive correlation between actual floral richness and estimated plant richness. Similarly, Fuller et al. (2007) also determined that people were able to accurately perceive plant species richness. As in the study by Fuller et al. (2007), our study sites were often not very ecologically complex, whereas the riparian sites used by Dallimer et al. (2012) were more varied. This may explain why the respondents in our study were better able to perceive plant species richness than those in Dallimer et al. (2012). And because plants are stationary and highly visible, respondents may be better able to accurately perceive plant than pollinator or bird richness.

The nature appreciation score was the only significant predictor of the grouped responses to the ecosystem service and disservice questions (Table 3). This suggests that a person's innate feelings about nature are most likely to affect their perceptions of ecosystem services and disservices. We found that respondents with higher nature appreciation scores were more likely to agree that the ROW provides ecosystem services and disagree that it provides disservices (Table 3). In fact, Vaz et al. (2017) suggest that ecosystem functions do not have an intrinsic value, and the valuation of benefits or nuisances depends on societal context. We note, however, that we are unable to disentangle correlation from causation in our data; it is unclear whether people appreciate nature because they think it provides services, or whether they think it provides services



How important are the following qualities of the transmission right-of-way to you?

Fig. 4. Percent of respondents that ranked five ROW qualities from extremely to not at all important.



Fig. 5. Percent of survey respondents who reported using the ROW for various activities; percentages do not sum to 100 because respondents could report using the ROW for multiple activities. N = 70.

# because they appreciate nature.

ROW vegetation management category was not a significant predictor of respondent satisfaction with current vegetation management practices, nor with the probability that a respondent filed a formal complaint about vegetation. Although ROWs are sometimes transformed to lawn in response to complaints by residents, land managers may be giving oversized attention to a small but outspoken number of dissatisfied residents. We therefore suggest that stakeholders ensure that major changes in vegetation management regimes reflect actual majority resident preferences.

Limitations of this study include the relatively small sample size of survey participants, and the fact that more surveys were completed by residents living near lawn-type than near prairie or old-field ROWs (Table 1). However, this distribution roughly reflected the number of houses near each ROW management category, as housing was often denser near the lawn ROWs. Furthermore, the majority of our respondents self-identified as middle-to upper-income Caucasians with some level of post-high school education. While this is likely representative of the population living near suburban ROWs in our study sites as indicated by US census data (comparison not shown), it may not represent the feelings of residents living near ROWs in other regions or in more urban or rural areas. One study (Arnberger and Eder, 2012) found that urban residents actually valued their greenspace more highly than suburban residents. It's possible that urban residents may receive more or different cultural services from ROWs than suburban residents because urban greenspace is more limited. We recommend that future studies incorporate both a multi-region study design and include sites along an urban-rural gradient.

Despite the ecosystem benefits of powerline ROWs, some controversial evidence suggests that both humans and wildlife may be negatively affected by the electromagnetic field (EMF) generated by electric current running through the powerlines. Although no experimental studies on animals or cells have shown consistent negative biologic or health effects of EMF (Boorman et al., 1999), epidemiological studies have identified slight increased risk of childhood leukemia associated with exposure to EMF (Seomun et al., 2021), yet much research is inconclusive. Moreover, potential negative effects of EMF on wildlife has largely been unappreciated and understudied (Levitt et al., 2022). The US Environmental Protection Agency recommends that if you are concerned about EMF health effects, you should increase your distance from the source (i.e. powerlines, United States Environmental Protection Agency, 2022). In addition, many powerline ROWs (including those in this study) are actually private property. This means that technically individuals do not have permission from utility companies to physically enter or manage the vegetation in the ROW, despite the regularity of this occurrence. Together, these facts indicate that cultural services that can be enjoyed from a distance, such as aesthetic benefits and wildlife watching rather than recreational activities, may be more suitable activities for ROWs.

Clearly, the residents in our study perceived many ecosystem services provided by ROWs regardless of their management type. However, we recommend that whenever possible ROWs should be managed as "natural" habitat (rather than maintained as lawn) to benefit both humans and wildlife. In the Midwestern region of the United States, we consider both prairie and old-field vegetation to be "natural" habitat, although in other regions of the world different low-canopy habitats may be more appropriate. In addition, we recommend that land managers educate residents that live near ROWs about the benefits of allowing the vegetation to grow in a more natural state. The strong positive relationship we found between enjoyment of the ROW and estimated pollinator richness suggests that people feel invested in their greenspace's ability to support wildlife. Further education may help to close the gap between perceived and actual biodiversity, and thus strengthen the relationship between habitat quality within the ROW and human enjoyment of it.

#### 5. Conclusions

Our study demonstrates that greenspace vegetation management can simultaneously support both cultural and supporting/regulating ecosystem services. While lawn-type ROWs may be more convenient for certain activities like active recreation, there are other formal greenspaces (such as parks) in many neighborhoods that already provide space for those activities. In our study, the majority of respondents believed that the ROW should provide habitat for wildlife, and found less-manicured ROWs attractive. Managing ROWs to support wildlife, therefore, can provide a win-win scenario for both humans and nature.

#### Credit author statement

Megan Garfinkel: Conceptualization, Methodology, Formal Analysis, Investigation, Writing- Original Draft, and Review and Editing, Visualization, Sheryl Hosler: Investigation, Writing- Review and Editing; Michael Roberts: Investigation; Jess Vogt: Methodology, Writing-Review and Editing; Christopher Whelan: Methodology, Writing- Review and Editing, Supervision; Emily Minor: Methodology, Writing-Review and Editing, Supervision, Funding acquisition.

### Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Emily Minor reports financial support was provided by Commonwealth Edison Company.

### Data availability

Our ecological plant, bird, and pollinator data are available via Figshare: https://doi.org/10.6084/m9.figshare.21698903.v1

### Acknowledgements

The authors thank all of the residents who participated in our survey. We also thank Justin Le and Moizzuddin Rizwan for aiding in ecological data collection. Finally, we thank two anonymous reviewers for their feedback. This research was supported by a grant to E.M. and C.W. from the Commonwealth Edison company.

# Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2022.117175.

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