

## **Abstract**

The main objective of this study is to provide guidelines for site selection when establishing pollinator habitat on utility and transportation rights-of-way. The study uses Analytical Hierarchy Process (AHP) to identify factors of the highest relative importance when considering any of the three goals for prioritising green infrastructure created by the Chicago Wilderness Green Vision initiative. This study identifies areas of need, the presence of invasive and endangered species, proximity to natural and marginal areas and other rights-of-way as factors for consideration for rights-of-way landowners with goals to establish habitat. These factors were selected according to experts' opinions. The methodology helped determine the combination of factors and criteria most important for establishing habitat on rights-of-way that will offer the maximum benefit to pollinators.

### **1. Introduction**

Rights-of-way are an informal type of green infrastructure that can offer ecological value when managed to serve as refugia for endangered pollinators as human activity damages their habitat. Pollinators which include, but are not limited to, bees, insects, birds and butterflies, are critical components of a healthy ecosystem that are declining at an alarming rate. Globally, pollinator populations have declined by more than 40 per cent even as the worldwide demand for them to support agricultural and food production intensifies. Overlapping factors contribute to this unfortunate trend; however, as identified by the United States Department of Agriculture, the overdevelopment of the built environment is the biggest culprit behind pollinator decline in the U.S. Pollinators, a critical component of our ecosystem's health, help to maintain biodiversity and support our food production systems. In the U.S., pollinators are integral to food security and

the economy as they support the production of more than 90 locally-grown crops and contribute more than \$24 billion (The White House, 2014). The United States Department of Agriculture notes that without immediate interventions, pollinator populations will continue to decline at an alarming rate and have long-standing negative impacts on the ecosystem's health

Green infrastructure is vital for supporting biodiversity and a healthy ecosystem. While formal green infrastructure such as greenspaces can serve flora, fauna and people, informal green infrastructure such as utility and transportation rights-of-way can provide vital habitats. Rights-of-way refers to the "lands immediately adjacent to, under, or above energy and transportation infrastructure" (Rights-of-Way as Habitat Working Group, 2015). These include electric transmission and distribution lines, petroleum pipelines, corridors for railroads and roadsides (Rights-of-Way as Habitat Working Group, 2015).

When managed appropriately, utility and transportation rights-of-way can add ecological value to urban landscapes because they are long linear tracts that often cover large spaces and support connectivity between other forms of green infrastructure. In the Chicago Wilderness region, 1,850 miles of rights-of-way are located within or adjacent to protected land areas (Chicago Field Museum, n.d.). In the Chicago Wilderness region, the Forest Preserve District authorities designate specific spaces as "protected" because they are high-quality natural areas of extensive biological diversity (Illinois Department of Natural Resources, n.d.).

Most utility and transportation rights-of-way adopt integrated vegetation management (IVM) practices which promote "desirable, stable and low-growing plant communities that will resist invasion" (U.S. EPA, n.d), which are necessary for operational safety. For example, railroad rights-of-way follow strict integrated vegetation management guidelines, as wild vegetation may damage railroad tracks and equipment or, in extreme cases, limit the visibility of

signs and crossings (Lanracorp, n.d). These management practices support the growth of early successional plants that benefit pollinators. Milam et al. discuss in their piece “Bee Assemblages in Managed Early-Successional Habitats in Southern New Hampshire” that bees were clustering in these types of habitats, which are often dynamic and provide hosts and forage plants that are not found elsewhere (Milam et al., 2018).

The ideal pollinator habitat can be any open space protected from mowing or pesticide application. Pollinators require habitat conditions such as undisturbed ground for nesting, wildflowers to provide nectar and pollen, lack of invasive species, native plants which are generally more attractive to pollinators and fresh and shallow sources of water (University of Wisconsin- Madison, 2018).

Many utility and transportation companies in the United States have pledged a commitment to expanding green infrastructure by establishing habitats through voluntary conservation efforts such as the Monarch Candidate Conservation Agreement with Assurances (CCAA). Thus, there is evident industry interest and utility and transportation rights-of-way, which can offer critical habitat for endangered pollinators as they provide land area for species such as pollinators.

Within the Chicago area, utility and rights-of-way organisations have also registered interest in establishing habitat on their lands. Respondents noted their commitment to supporting ecologically valuable projects such as habitat establishment in a survey from the strategic roadmapping exercise conducted by the Rights-of-Way as Habitat Working Group. Moreover, they identified that one of the most significant barriers to such feats was a need for established guidelines on which lands are best suitable for habitat creation and prioritisation. This paper

looks at existing literature and discusses which specific environmental indicators suggest which land would be appropriate for establishing these habitats.



Fig. 1. Geographic location of Chicago Wilderness (CW) Area. Source: Lewis et. al (2015). Conservation of Urban Biodiversity Under Climate Change.

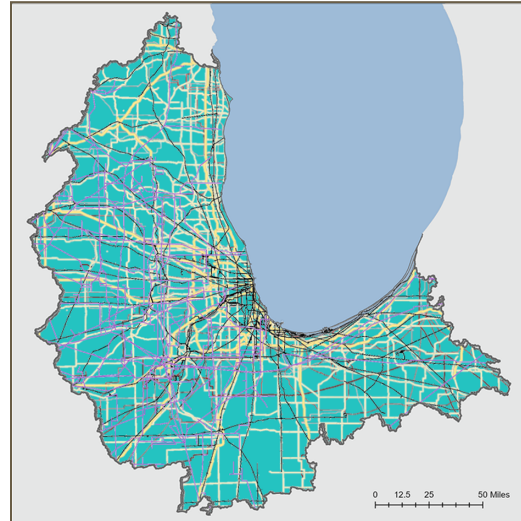


Fig. 2. Major Utility and Transportation Rights-of-Way in the CW area. Source: Field Museum (2022). Major ROWs in Chicago Wilderness Area.

## 2. Study Area

The area chosen for this current research is focused explicitly on rights-of-way land that adds maximum ecological value by providing habitat with maximum benefits for pollinators (Fig. 2). In this study, the maximum benefit is identified within the parameters of yielding the most significant per cent of ripe fruit or seeds relative to the initial number of available flower ovules (Forbes et. al, 2019). The project boundary is the Chicago Wilderness region, as identified by the Chicago Wilderness Alliance (Fig. 1). There is a temporal boundary to consider, as habitat creation can take anywhere from 3 years to 10 years, depending on how long it takes for native plants to bloom or nesting ground to form (Illinois Farm Bureau, 2021).

### 3. Materials and Methods

#### 3.1 Data Sources

Data used in this research was collated from various sources. Firstly, most secondary data were collected from the Chicago Wilderness Data Repository. The repository agglomerates vast data of natural layers in the CW region from various national and regional sources such as the Chicago Metropolitan Agency for Planning (CMAP), the National Land Cover Database (NLCD), ESRI Living Atlas, U.S. Fish and Wildlife Services (USFWS) into a single database. Data was also collected from other regional conservation groups such as The Nature Conservancy (TNC), Natural Connections, EDD Maps and other sources (Table 1).

Data	Source
Tree Canopy Coverage	University of Chicago (2021). Visualisation Tool for Tree Site Selection and Environment Exploration
Protected Lands	Protected Lands (2022). CW Data Hub
Pollinator Sites	Million Pollinator Garden Challenge Map (2022). CW Data Hub
Trails and Greenways	Chicago Wilderness Trails (2021). CW Data Hub
Wetlands	National Wetlands Inventory (2019). CW Data Hub
ROW Corridors	Chicago Wilderness Major ROWs (2022). CW Data Hub
Greenspaces/Green Deserts	Cook County Green Infrastructure Poster (n.d.) Natural Connections EJI Dashboard (2022). Centres for Diseases Control and Prevention Environmental Justice Index
Health Vulnerability Managed Habitat on ROWs	University of Illinois Chicago Energy Resources Centre (2022). Geospatial Database
Endangered Species	State DNR T&E Species Locations
Core Habitat Areas	Critical Habitats (2021). CW Data Hub.
Invasive Species	
Planned Development	Future Land Use Map (2022). Chicago Metropolitan Agency for Planning
Climate Change	The Nature Conservancy (2022). Resilience Land Mapping Tool

Table 1. List of all data and their sources

### *3.2 Methods*

The AHP weights were calculated using Microsoft Excel. The main steps for producing the site suitability guidelines for establishing pollinator habitat are: (a) developing goals/scenarios for ROW organisations to consider before habitat creation, (b) establishing a series of factors to be considered for each goal/scenario, (c) assigning weights to each factor within each scenario (d) determining an overall suitability score for each scenario (e) creating land suitability guidelines for habitat creation.

### *3.3 Determination of Objectives, Factors and Criteria*

#### *3.3.1 Scenarios*

This study identifies the following objectives to guide ROW landowners focused on establishing pollinator habitat. (a) Expand and connect areas of high biodiversity using the surrounding ROWs (b) Protect existing habitat on ROWs, (c) Restore and enhance Marginal ROWs. The three scenarios were developed in line with goal 3 of the Chicago Wilderness Green Vision Initiative, which builds upon the Illinois 30 by 30 Conservation Task Force Act that encourages the prioritisation of green infrastructure across the CW region (Chicago Wilderness Alliance, 2022). The green vision initiative explains that ecologically valuable green infrastructure will address the fragmented state of green infrastructure in the region, protect the existing green infrastructure, and provide these infrastructures in marginalised areas.

The study dissects these recommendations for prioritising green infrastructure to develop simplified goals for ROW landowners to consider when establishing habitat. A survey of ROW landowners by the Rights-of-Way as Habitat Working Group revealed that the most significant barrier to establishing habitat was low stakeholder buy-in due to dense parameters for consideration for habitat projects (Rights-of-Way as Habitat Working Group, 2021). Mindful of

this concern, the study uses these scenarios to distinguish between the recommendations of the Chicago Wilderness Green Vision Initiative. Using AHP, the study ranks these scenarios to determine which factors are of greatest importance when considering these three goals to select suitable land for establishing habitat that creates green infrastructure and offers maximum ecological benefits for pollinators.

### *3.3.2 Factors and Criteria*

The study identifies these factors as indicators of suitability for pollinator habitat within the three scenarios as follows:

- Expand and Connect areas of high biodiversity using the surrounding ROWs
  - Existing natural areas, proximity to other rights-of-way, and areas in need of habitat.
- Protect existing habitat on ROWs
  - Presence of habitat, presence of rights-of-way, and presence of threats.
- Restore and enhance Marginal ROWs
  - Proximity to marginal areas, proximity to other rights-of-way, and access to formal greenspaces.

Expand and Connect High Biodiversity Area on ROWs							
Factors	Criteria	Unit	Factor Suitability Rating				
			High	Moderate	Marginal	Not Suit	
Existing Natural Areas	Protected Lands	class	High	Moderate	Marginal	Not Suit	
	Proximity to Pollinator Sites	kilometres	0-5km	5-10km	10-15km	<15km	
	Proximity to Trails and Greenways	kilometres	0-5km	5-10km	10-15km	<15km	
	Tree Canopy Coverage	class	High	Moderate	Marginal	Not	
Rights-of-Way	Proximity to Wetlands	kilometres	0-5km	5-10km	10-15km	<15km	
	Proximity to other ROWs	kilometres	0-5km	5-10km	10-15km	<15km	
	Visibility of ROW	class	High	Moderate	Marginal	Not Visible	
Areas of Need	Proximity to Green Deserts	kilometres	0-5km	5-10km	10-15km	<15km	
	Proximity to Critical Habitat	kilometres	0-5km	5-10km	10-15km	<15km	

Table 2. Factors and Criteria Table; Goal 1

Protect Existing Habitat on ROWs							
Factors	Criteria	Unit	Factor Suitability Rating				
			High	Moderate	Marginal	Not Suit	
Habitat Areas	Proximity to Wetlands	kilometres	0-5km	5-10km	10-15km	<15km	
	Number of endangered species recorded	class	High	Moderate	Marginal	Not	
	Proximity to Critical Habitat	kilometres	0-5km	5-10km	10-15km	<15km	
	Number of remnant oak systems recorded	value	<50	<20	<10	<5	
Rights-of-Way	Proximity to other ROWs	kilometres	0-5km	5-10km	10-15km	<15km	
	Visibility of ROW	class	High	Moderate	Marginal	Not Visible	
Threats	Number of invasive species recorded	class	<50	<20	<10	<5	
	Total planned development	kilometres	0-5km	5-10km	10-15km	<15km	

Table 3. Factors and Criteria Table; Goal 2

Restore and Enhance Marginal ROWs							
Factors	Criteria	Unit	Factor Suitability Rating				
			High	Moderate	Marginal	Not Visible	
Marginal Areas	Proximity to Wetlands	kilometres	0-5km	5-10km	10-15km	<15km	
	Proximity to Critical Habitat	kilometres	0-5km	5-10km	10-15km	<15km	
	Number of invasive species recorded	class	High	Moderate	Marginal	Not	
	Distribution of Green Infrastructure	class	Not	Marginal	Moderate	High	
	Marginal agriculture	class	High	Moderate	Marginal	Not	
Rights-of-Way	Proximity to other ROWs	kilometres	0-5km	5-10km	10-15km	<15km	
	Visibility of ROW	class	High	Moderate	Marginal	Not Visible	
Access to nature	Park acreage	class	High	Moderate	Marginal	Not	
	Health Vulnerability	score	High	Moderate	Marginal	Not	

Table 4. Factors and Criteria Table; Goal 3



### 3.4 Determining of Weight Value for each Criterion using AHP

Analytical Hierarchy Process (AHP) is the most popular Multi-Criteria Decision Making (MCDM) method. Initially developed by Saaty, AHP provides decision-makers with a framework to compare alternatives effectively. AHP uses a pairwise technique to compare decisions with multiple criteria. (Soltani et. al, 2014). The method unravels various goals into single scores and allows decisions to be made based on alternatives with the highest score. AHP facilitates the calculation and aggregation of weights standardised by “dividing the geometric mean of each criterion by the sum of geometric means of all criteria” (Soltani et al., 2014). It examines the relative importance of all parameters by assigning weights in a hierarchical order. Expert suggestions for AHP typically determine each factor’s priority.

Each factor for all three goals was ranked on a scale of 1-5 based on the expert’s opinion. The AHP method was used to determine the relative importance of each factor. The calculations of the pairwise comparison matrix are shown in Tables 6, 7 and 8, respectively.

#### Goal 1: Expand and Connect areas of high biodiversity using the surrounding ROWs

Factor	F1	F2	F3	
Existing Natural Areas (F1)	1.00	0.75	4.00	<b>F1: 0.4332</b>
Rights-of-way (F2)	1.33	1.00	2.00	<b>F2: 0.4166</b>
Areas of Need (F3)	0.25	0.5	1.00	<b>F3: 0.1501</b>
<b>Total</b>	<b>2.58</b>	<b>2.25</b>	<b>7.00</b>	

Table 6. Pairwise Comparison of Goal 1 Factors and Overall Importance Scores

Goal 2: Protect existing habitat on ROWs

Factor	F4	F5	F6	
Habitat Areas (F4)	1.00	4.00	1.25	<b>F4: 0.5060</b> <b>F5: 0.1480</b> <b>F6: 0.3461</b>
Rights-of-way (F5)	0.50	1.00	0.25	
Threat (F6)	0.80	2.00	1.00	
<b>Total</b>	<b>2.30</b>	<b>7.00</b>	<b>2.50</b>	

Table 7. Pairwise Comparison of Goal 2 Factors and Overall Importance Scores

Goal 3: Restore and Enhance Marginal ROWs

Factor	F7	F8	F9	
Marginal Areas (F7)	1.00	4.00	1.33	<b>F7: 0.5232</b> <b>F8: 0.1651</b> <b>F9: 0.3112</b>
Rights-of-way (F8)	0.25	1.00	0.67	
Access to Nature (F9)	0.75	1.50	1.00	
<b>Total</b>	<b>2.00</b>	<b>6.50</b>	<b>3.00</b>	

Table 8. Pairwise Comparison of Goal 3 Factors and Overall Importance Scores

*3.6 Suitability Guidelines*

The land suitability guidelines have been created based on criteria from the factors with the highest importance scores. This is shown in figures 3, 4, and 5, respectively. The guidelines are divided into proximity and class attributes operating under the assumption that the most suitable sites for habitat establishment or conservation are those that include all listed criteria in the guideline.

Site Selection Guidelines for ROW Landowners Focused on Establishing Habitat by Expanding and Connecting High Biodiversity Areas		
Proximity:	Yes	No
Is the site within 5 kilometres of known pollinator sites?		
Is the site within 5 kilometres of wetlands?		
Is the site within 5 kilometres of trails and greenways?		
<b>Class:</b>		
Is tree canopy coverage of the site high (i.e., > 40 per cent)?		
Is there high clustering of protected lands within the site (i.e., > 40 per cent)?		
If yes for only one criterion, the site is not suitable		
If yes for two criteria, the site marginally suitable		
If yes for at least three criteria, the site is moderately suitable		
If yes for more than three criteria, the site is highly suitable		
Each criterion carries a 20% weight*		

Figure 3. Site Selection Guidelines for ROW Landowners Focused on Establishing Habitat by Expanding and Connecting High Biodiversity Areas

Site Selection Guidelines for ROW Landowners Focused on Protecting Existing Habitat on Rights of Way		
Proximity:	Yes	No
Is the site within 5 kilometres of known critical habitat?		
Is the site within 5 kilometres of wetlands?		
<b>Class:</b>		
Is it an endangered species hotspot (i.e., greater than four species recorded)?		
Are there a record number of remnant oak systems recorded (i.e., >5 acres of land covered by remnant oak)?		
If yes for only one criterion, the site is not suitable		
If yes for two criteria, the site marginally suitable		
If yes for at least three criteria, the site is moderately suitable		
If yes for more than three criteria, the site is highly suitable		
Each criterion carries a 25% weight*		

Figure 4. Site Selection Guidelines for ROW Landowners Focused on Protecting Existing Habitat on Rights of Way

Site Selection Guidelines for ROW Landowners Focused on Restoring Marginal ROWs		
Proximity:	Yes	No
Is the site within 5 kilometres of known critical habitat?		
Is the site within 5 kilometres of wetlands?		
<b>Class:</b>		
Is it an invasive species hotspot (i.e., greater than four species recorded)?		
Are there a record number of marginal agriculture recorded (i.e., >5 acres of land covered by marginal flora)?		
Do adjacent areas lack green infrastructure? (i.e., >7 acres of developed open space per 1,000 population)		
If yes for only one criterion, the site is not suitable		
If yes for two criteria, the site marginally suitable		
If yes for at least three criteria, the site is moderately suitable		
If yes for more than three criteria, the site is highly suitable		
Each criterion carries a 20% weight*		

Figure 5. Site Selection Guidelines for ROW Landowners Focused on Restoring and Enhancing Marginal ROWs.

## **4. Results and Discussion**

### *4.1 Goal 1: Expand and Connect Areas of High Biodiversity*

Out of the three factors for consideration, (F1) scores 0.43323, comparable to (F2) 0.41656 but significantly greater than (F3) 0.15010. The AHP ranking shows that the most suitable sites for establishing a habitat that expands and connects areas of high biodiversity are within natural areas.

The recommendations listed in the suitability guidelines for each goal are divided on a 20 per cent scale where highly suitable (100%), moderately suitable (60%), marginally suitable (40%) and not suitable (20%). The scale classes build upon the United Nations Food and Agriculture Organisation's framework for land evaluation.

Regarding the analysis of the results for sites best for establishing pollinator habitat, for rights-of-way, landowners with goals to expand and connect areas of high biodiversity, highly suitable ROW sites should be located within five kilometres of wetlands, pollinator sites, trails and greenways. It provides opportunities to establish habitat that can connect these high biodiversity areas that are typically fragmented in the Chicago Wilderness region (Chicago Wilderness, 2022). Additionally, the sites should have tree canopy coverage greater than 40 per cent, the benchmark for good coverage by the American Forests conservation organisation (American Forests, 2010). These sites should also be located within areas with a greater concentration of protected lands. In the Chicago Wilderness region, approximately 7 per cent of total utility and transportation rights of way are located within protected lands.

As indicated by the guidelines, the key determinant of site suitability when expanding and connecting fragmented habitat is a combination of all five criteria within F1, the factor of highest relative importance.

#### *4.2 Goal 2: Protect Existing Habitat on Rights-of-Way*

The three factors evaluated scored as follows: (F4) (F5) (F6). The recommendations listed in the suitability guidelines for each goal are divided on a quartile scale where highly suitable (100%), moderately suitable (75%), marginally suitable (50%) and not suitable (25%).

The selected methodology indicates that the pollinator habitat in need of the highest priority for protection should be within 5 kilometres of wetlands and critical habitats but should also have recorded a high number of endangered species and remnant oak ecosystems. Pollinator habitat projects that look to preserve the existing habitat infrastructure consider the role of space in ecosystem recovery. It recognises the endangered state of pollinators, such as bees which have lost 45.5 per cent of their colonies (Woods, 2021) and looks to conserve habitat which offers these protective services to threatened pollinators. The results from the importance scores show that existing habitat most suitable for protecting pollinators considers a combination of all four criteria, and suitability reduces when the site does not account for all indicators.

#### *4.3 Goal 3: Restore and Enhance Marginal Rights of Way*

Of the three factors considered, F7, had the highest importance score of 0.5232. This indicates that for rights-of-way landowners with goals to restore and enhance marginal rights-of-way, suitable land will be sites with marginal agriculture that feature wetlands and invasive species. Similar to goal 1, the recommendations listed in the suitability guidelines for each goal are divided on a 20 per cent scale where highly suitable (100%), moderately suitable (60%), marginally suitable (40%) and not suitable (20%), building upon the same framework for

land evaluation by the United Nations Food and Agriculture Organisation (United Nations, 1976).

#### *4.4 Discussion Summary*

As shown in tables 3, 4, and 5, there is an overlap of factors in each goal category. However, in the context of this study, the weight of the factor is directly related to the specific goal. For ROW landowners looking to establish and connect these high biodiversity areas, the sites should focus on building upon the existing natural areas in proximity to the proposed site(s). For landowners focused on protecting existing rights-of-way, the entry point should be sites threatened by invasive species or with a high concentration of endangered species. These sites should also have high biological diversity, which is typically found in wetlands (Denny, 1994). Thirdly, for those looking to restore marginal rights of way, the site(s) should be located in areas of high need, such as those with minimal green infrastructure co-located within marginal agricultural and invasive species hotspots.

### **5. Planning and Policy Implications**

The study reveals the importance of informal green infrastructure in offering ecological value. It challenges contemporary discourse on environmental conservation feats and sheds light on environmental policy that can be expanded to incorporate these informal structures into ecosystem preservation.

Another critical policy implication from this study is the consideration of ecological planning in policy making. The vital role of rights-of-way and similar spaces in offering valuable ecosystem services should be embedded in future policy development. As discussed in Blažo et al., a significant setback in the success of environmental policies is the disconnect between the

sciences, ecosystem needs and the subsequent laws enacted (Blažo et al., 2019). The cognisance of the value of a consolidated approach can shape future environmental policies that conserve ecologically sensitive yet valuable components of the ecosystem.

The scale of rights-of-way in the project area, which expands to part of Indiana, Michigan and Wisconsin, highlights the role of regional planning efforts, particularly for environmental conservation. The transboundary nature of pollinator decline and its impact on the ecosystem reinforces the need for extensive and collaborative partnerships to expand, protect, and/or restore habitat for these critical yet endangered species.

## **6. Limitations**

The main limitation of this study was that it assumes that for stakeholders to buy into habitat establishment projects, the three goals as defined by the Chicago Wilderness Green Infrastructure Vision should be the initial guiding principles for site selection. It follows the assumption that ROW landowners in the Chicago Wilderness area cannot collectively address all three goals stated in the Green Infrastructure Vision, and most approach habitat creation by following one goal. This is partly influenced by the results of the Rights of Way as Habitat Working Group's Strategic Roadmapping Exercise results (see Appendix), in which the barriers to ROW landowners indicated that there should be simplified entry points defined for ROW landowners interested in establishing pollinator habitat.

Another limitation of the study was the fragmented state of Chicago Wilderness-specific data. While the Field Museum has extensive raw data layers of the various natural and habitat areas in the project area, other data, such as invasive and endangered species and green deserts, were difficult to obtain for the wider project area. There was available data for specific

municipalities but not for the collective Chicago Wilderness region. This reiterates the need for a comprehensive and consolidated data hub to assist regional environmental planning feats.



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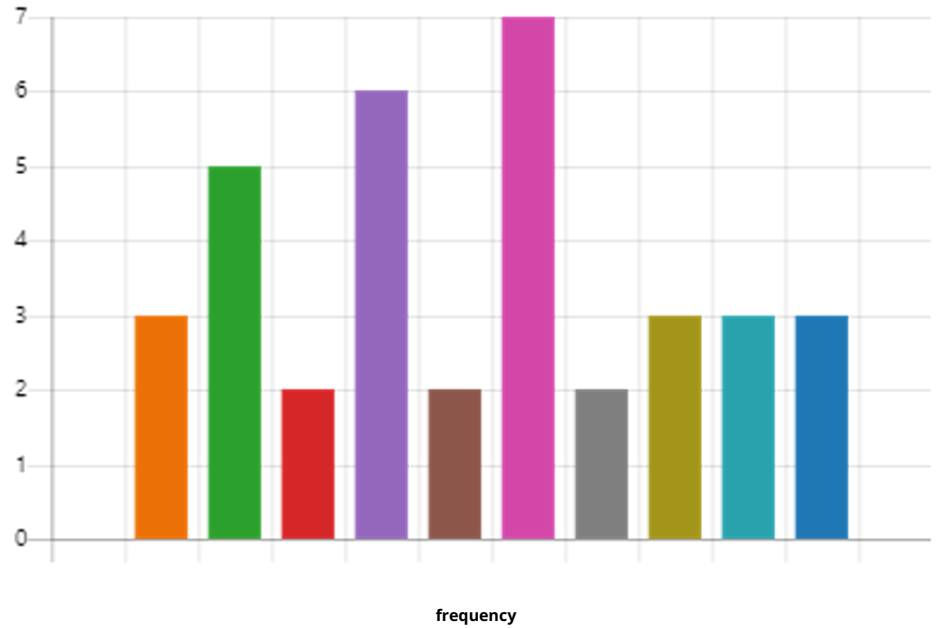
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## Appendix

- Lack of landowner support
- Lack of general public support
- Lack of internal management support
- Regulatory impacts
- Higher upfront costs
- Uncertainty about long-term costs
- Lack of knowledgeable staff or contractors
- Logistics of changing practices at large-scale
- Uncertainty about long-term management requirements
- Management of invasive species
- Safety concerns
- Concern about negative wildlife impacts



Survey of Barriers to Habitat Establishment by ROW landowners.  
Source: Rights-of-Way as Habitat Working Group (2021)