Climate change is affecting a number of ecological parameters, including but not limited to species ranges, migration timelines, spread of invasive species, length of growing season, and increased fire and flooding risks. These shifts in the environment are accelerating, predicted to persist into the future, and present across all types of lands, including rights-of-way (ROWs). These impacts of climate change are a threat to overall biodiversity; however, ROWs can play a critical role in ecological community resilience by adapting their vegetation management (VM) practices.

Making changes to the way ROW vegetation is managed for climate change adaptation without relevant guidance is challenging. This paper presents a number of guidance documents, scientific literature, case studies, and recommendations that can help ROW managers make these changes. Many of these recommendations are already occurring on ROWs, while others will require minimal changes to VM practices, resulting in concrete wins for both managers and biodiversity. The changes that ROW managers have made can be capitalized upon and for those interested in acting proactively and demonstrating a commitment to innovation, the integration of climate change adaptation strategies in ROW VM can offer a practical, tangible opportunity to contribute to large-scale objectives.

Climate Change Adaptation Strategies in VM

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Keywords: Adaptation Strategies, Climate Change, Preserving Biodiversity, Vegetation Management (VM), Rights-of-Way (ROW).

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INTRODUCTION

The modern wave of scientific research on the subject of climate change adaptation strategies only became mainstream in the 1990s with the Intergovernmental Panel on Climate Change (IPCC) First Assessment Report, despite the identification of climate change impacts as early as the 1950s (Hansen and Hoffman 2011). Today, it is widely accepted in the scientific community that climate change is occurring around the globe with observable effects—warming atmospheric and ocean temperatures, shrinking ice sheets, sea level rise, changes in precipitation patterns, and seasonal shifts in bloom and migration times—becoming more noticeable at regional and local levels (Hansen and Hoffman 2011). This shift toward observable effects at a finer scale has elevated the need for managing lands in respect to climate change into the private sector, including rights-of-ways (ROWs). These local impacts will be present in the future; therefore, the need for landowner and land manager actions is projected to become more important on a local and global scale (Hodgson et al. 2011).

The majority of current climate change strategies in the private and public sector target resilience of the built environment. The pipeline, railroad, and utility industry sectors, as well as departments of transportation, have made progress in evaluating the impacts of climate change on their operations and adopting adaptation strategies for infrastructure resiliency (ODOT 2012; Pacific Gas and Electric Company 2016; U.S. Department of Energy 2016). Few of these sectors' climate change strategies appear to integrate ecosystem resilience, despite the decision-making abilities of the groups regarding the respective lands managed.

The landscape-scale conservation literature in North America first identified ROWs as remaining connected lands for the conservation of species more than a decade ago (Clarke et al. 2006; Huijser and Clevenger 2006; Lensu et al. 2011; Haddad 2015; Lembrechts et al. 2017; Gardiner et al. 2018). Linearity in connected lands are thought to allow for the movement of species and habitats as the climate warms and species seek northern refuges. As ROWs are thought to contain the most connected landscapes in the U.S. and many other countries, there is an opportunity for ROW managers to become stewards by:

- Building awareness around land management practices that may positively contribute to climate resiliency and their potential compatibility with ROW management
- Identifying current vegetation management (VM) practices that already contribute to or that are already in place on managed lands/systems/area
- Adapting ROW VM practices for climate change to help create resilient natural communities

This paper presents research conducted to determine if adaptation strategies for managing vegetation on ROWs in the face of climate change are readily available. It also presents the outcomes of the evaluation of general climate change adaptation strategies for their compatibility with ROW management. The research and evaluation seek to inspire modifications in VM practices on ROWs to include actions to preserve biodiversity and create resilient ecological communities.

METHODS

To evaluate the current state of knowledge on climate change adaptation strategies in land management, specifically for linear features, literature reviews and peer-reviewed journal articles on climate change, VM, ROW management, land management adaptation strategies, and resilient ecological communities were compiled using several databases (Penn State Libraries, American University Libraries, Wiley Online Library, and Conservation Corridor). The information collected from these literature searches helped form the VM adaptation strategies recommended for ROW managers.

In addition to peer-reviewed research, governmental and intergovernmental reports were consulted from the following sources: United Nations (UN), Canada, U.S. (including a closer examination of the state-issued reports), the European Union (EU), and Australia. The government publications were reviewed, including State Wildlife Action Plans (SWAP), the EU Climate Adaptation Platform, the UN Strategic Plan for Biodiversity 2011-2020, the Australian Biodiversity Conservation Strategy, and the Canadian Biodiversity Strategy. These resources were selected for review based on credibility, accessibility, likelihood of addressing climate change adaptation recommendations, and depth of involvement in climate change. The information collected from these guidance documents helped form the VM adaptation strategies recommended for ROW managers.

The deeper examination of the state of knowledge and practices in the U.S. stems from the federally mandated State Wildlife Action Plans, which require the states to consider the effects of climate change when managing their habitats and species. One plan from each Environmental Protection Agency (EPA) region was examined, as a sampling approach. Within each state plan, the land-based and education-oriented recommendations were extracted. Distinction was made between general recommendations with limited implementation cues and those more specific recommendations with some details to guide actions.

With the list of generic and specific recommendations generated by the review of guidance documents and literature, those most compatible with ROW management and operations were identified. Those recommended adaptation strategies were then discussed with ROW managers to determine if the adaptation strategies

could be adopted by ROWs. These adaptation strategies were then liked to scientific literature supporting the actions to the desired outcome—ecologically resilient communities. These clear linkages could then be utilized as a means of communicating the support of climate change adaptation strategies into ROW management.

RESULTS & DISCUSSION

Impacts of Climate Change on VM

Climate change is expected to be an all-encompassing problem, touching on all aspects of resource and land use management in the immediate future (Hansen and Hoffman 2011). The main changes expected to impact vegetation managers are: fluctuations in temperature and precipitation patterns, increases in the frequency of pest, disease, and invasive species outbreaks, and variations to species ranges and migration patterns, all of which will impact VM.

Research has shown that certain areas of the American west will become drier and hotter, which is predicted to lead to an increased risk of drought and fire (Hansen and Hoffman 2011). The exact opposite is thought to be occurring in the eastern part of North America, with a projected increase of rain events. These increased rain events could easily lead to flooding, landslides, and increased plant growth. Both the increase and decrease in precipitation events present potential complications in ROW management and an increase risk in impact to the infrastructure due to the increased risks associated with fires and flooding.

In the last decade, an increase in the frequency and occurrence of tree pests and diseases have been observed (Hansen and Hoffman 2011). While these diseases and pest outbreaks would occur despite the changing climate, warm temperatures are thought to aid the spread the disease and the pests' ranges (Hansen and Hoffman 2011). These infestations and outbreaks can lead to an increase in tree death, the loss of soil stabilization, landslides, and potentially fires. In addition to pest outbreaks, invasive species encroachment is expected with the sudden and wide spread tree deaths projected to occur. Invasive species can colonize an area, forcing out the native vegetation, and often times have different propagation rates than the natives they replaced (Hansen and Hoffman 2011). The outcomes are likely to impact ROW maintenance costs due to increased monitoring and control efforts.

In recent years, scientists have documented range changes, shifting migration periods, and variations in expected versus observed bloom times for various species due to climate change (Chen et al. 2011; Hansen and Hoffman 2011). These changes in animal and plant behavior are predicted to increase as previously cooler areas stay warmer longer and atmospheric carbon dioxide increases. These changes may lead to adjustments in ROW maintenance schedules to accommodate longer growing seasons, changes in breeding seasons, and shifts in species ranges.

Current State of Knowledge on Climate Change Adaption Strategies

The availability of actionable strategies for non-government lands is extremely limited and hard to access, with most resources available being vague or general in nature. The most consistent and useful resources available found have been from governmental, intergovernmental, and peer-reviewed scientific research (see citations).

In the resources available, trends emerged, such as the stated need for more research and monitoring to better understand how flora and fauna will be impacted by climate change. This finding is not surprising due to the complexity of the climate change challenge and is also reflected in the lack of specificity in species adaptation recommendations. The majority of literature also calls for broad protection of existing habitats and provision of linkages and connections between those habitats. In addition to common and broad strategies, each guidance document consulted provides supplemental suggestions to adapt VM to protect biodiversity and foster ecosystem resilience.

Table 1 compiles the information collected from various guidance documents on the implementation of climate change adaptation strategies by landowners.

The inter-governmental guidance documents (European Climate Change Adaptation Platform and the UN Strategic Plan for Biodiversity) contain a number of tangible and replicable adaptation strategies, as well as some more general statements. The EU guidance contained twice as many adaptation strategies than the UN's strategic plan, which is focused more on targets and metrics than implementation. The UN guidance contained only three adaptation strategies with two being concrete. The only recommendation to be found in both focuses on wildlife corridors and habitat linkages.

The national guidance documents reviewed included the Canadian Biodiversity Strategy and the Australian Biodiversity Conservation Strategy (2010–2030). The national guidance documents listed two common strategies: the creation of wildlife corridors & habitat linkages and protection & preservation of habitat. Only the Canadian guidance had a concrete and replicable strategy, while the Australian guidance contained seven vague strategies.

The U.S. government has not recently published a climate change strategy and therefore was not included in the national evaluation. Instead, relying on the mandate given to various agencies to integrate climate change in

Guidance Documents / Adaptation Strategies	European Climate Adaptation Platform	Canadian Biodiversity Strategy	Australia Biodiversity Conservation Strategy 2010-2030	U.S. State Wildlife Action Plans	UN Strategic Plan for Biodiversity 2011-2020
Adaptive management of existing habitats in response to climate change impacts - general	●			○	
Adaptive management of existing habitats in response to climate change impacts - forests	●			●	
Adaptive management of existing habitats in response to climate change impacts - grasslands				○	
Adaptive management of existing habitats in response to climate change impacts - wetlands			○	●	
Creation and enhancement of riparian buffers	●			●	
Creation/restoration of quality habitats			○	●	●
Creation of wildlife corridors/habitat linkages	○	○	○	●	○
Education for building capacity in deployment of climate change adaptation tactics				●	
Education for raising awareness about climate change			○	○	
Management of fire risk	●		○	○	
Management of invasive species			○	●	
Prevention of natural disasters using integrated land use planning	●				
Protection and preservation of habitat		○	○	●	●
Research/monitoring of the impacts of climate change on ecosystems and species		●		○	
Use of decision support tools				○	

● Concrete and replicable adaptation strategies

○ Broad (not concrete or replicable) adaptation strategies

Table 1 indicates what level of detail and replicability for climate change adaptation strategies have been recommended by selected national-level and intergovernmental biodiversity/climate change guidance documents. Most guidance documents reviewed either had all concrete or vague adaptation strategies across their recommendations and it is important to note that all acknowledged the need for more information on the subject of climate change adaptation in ecosystems. Overall, all guidance documents made some attempt to better guide land managers for the impacts of climate change.

Table 1. Level of detail and replicability for climate change adaptation strategies in selected national-level and intergovernmental biodiversity/climate change guidance documents

SWAP / Adaptation Strategies	NH	NY	MD	GA	MI	AR	IA	UT	CA	WA
Adaptive management of existing habitats in response to climate change impacts - general		○							○	
Adaptive management of existing habitats in response to climate change impacts - forests	○		●							
Adaptive management of existing habitats in response to climate change impacts - grasslands	○		●							
Adaptive management of existing habitats in response to climate change impacts - wetlands			●	○	○			●		
Creation and enhancement of riparian buffers								●		
Creation/restoration of quality habitats	○		●		○			●		○
Creation of wildlife corridors/habitat linkages	○			○		○		●		○
Education for building capacity in deployment of climate change adaptation tactics			●						○	
Education for raising awareness about climate change	○									
Management of fire risk	○					○			○	
Management of invasive species			●	○						○
Prevention of natural disasters using integrated land use planning	○		●					●		○
Protection and preservation of habitat			●	○		○				○
Research/monitoring of the impacts of climate change on ecosystems	○			○	○	○	○		○	○
Use of decision support tools			○							

● Concrete and replicable adaptation strategies

○ Broad (not concrete or replicable) adaptation strategies

Table 2 demonstrates that the most common adaption strategy for the U.S. was research and monitoring of existing habitats. Maryland had the most adaptation strategies present, with most being replicable and detailed. Utah's plan was the only other one that had some level of detail. Other SWAPs did contain vague adaptation strategies.

Table 2. Level of detail and replicability for climate change adaptation strategies in selected SWAPs

their efforts where and when relevant, a sampling of SWAPs were consulted as a proxy to a national strategy for the U.S. When the combined state-level recommended strategies are compared to the national strategies, the U.S. appears to similarly promote research and monitoring of existing habitats as well as encouraging wildlife corridors and habitat enhancement. Individually, the states provide a varying degree of relevant information, from none to highly applicable.

Individual SWAPs were examined to indicate the U.S. strategy as a whole and were examined more closely. When the SWAPs were taken as a whole guidance document, all adaptation strategies were touched upon but one: integrated land use planning to prevent natural disasters. However, upon examining the individual SWAPs, great discrepancies between the individual plans were seen. The randomly chosen SWAPs (one from each EPA district) were New Hampshire (NH), New York (NY), Maryland (MD), Georgia (GA), Michigan (MI), Arkansas (AR), Iowa (IA), Utah (UT), California (CA), and Washington (WA) (Table 2). For each recommended action, if one of the SWAPs examined indicated a concrete and replicable adaptation plan, this was reflected in the overall U.S. rating by indicating a full circle for that recommendation. This method was also followed for broad, undetailed plans that would be difficult to replicate, resulting in a hollow circle.

The plans for the states of Maryland and Utah proved to be innovative in their inclusion of tangible climate change adaptation strategies specifically targeting land managers and the states' perceived interest in moving away from additional research and data collection. The Maryland SWAP mentions the use of a decision support tool, a practical recommendation only found in one other national plan. This level of specificity was expected to be part of the California plan—a more environmentally progressive state, which, surprisingly, only included very broad recommendations with limited replicability in other regions. Restoring habitats and pursuing wetland management were the most cited methods to adapt to climate change that were supported with a concrete action plan. Less common recommendations included grassland management and educational awareness.

Adaptation strategies presented in Tables 1 and 2 indicate that increased connectivity and reduced fragmentation are meaningful tactics to maintain biodiversity as the climate continues to change. Protection, restoration, and preservation of habitats, while general, is equally promoted as a versatile approach. A focus on fire management emerges as a locally relevant recommendation to prioritize in target regions. The overall absence of education and awareness as a key strategy remains an unforeseen finding.

Recommendations

Research confirms that climate change adaptation strategies recommendations for VM on ROW are non-existent, despite the connection between linear features and the strategies in Tables 1 and 2. The majority of recommendations provided by authors and government remains at this time very general and not reissued for various context. The recommendations for climate change adaptation for land owners and managers, however, are familiar and can be translated into tangible adaptation strategies that are compatible with the ROW context (Table 3).

When first consulting with VM professionals on the topic of climate change adaptations, the consensus among the group was that integration of climate change adaptation considerations in VM planning and execution would be complicated, outside the technical comfort of the on-the-ground teams, expensive, and likely incompatible with traditional operations. However, the research highlights simple and accessible strategies that do not rely heavily on new technologies, expensive materials, or highly specialized labor. These recommendations can be easily translated into actions for VM teams or contractors and implemented within varied scopes and scaled to fit with available resources and objectives.

By implementing these recommendations, clear, definitive links can be drawn to climate change adaptation and ecosystem resilience (Table 4). These links are shown through current research on climate change adaptation strategies and have been tested on managed lands throughout the globe. While no one recommendation can be utilized on all ROWs nor will one lead to the most benefit to biodiversity, it is important that ROW managers understand the link to ecosystem resilience before implementing these strategies. By having a clear vision for their desired outcomes, strategies are more likely to be implemented and followed by employees.

Many of the adaptation strategies recommended in the ROW context are likely already in place across many ROW systems, whether pipeline, transmission, railroad, or roadside. Yet very few efforts are accurately portrayed as supporting resilient ecosystems or being linked to climate change adaptation. Opportunities to communicate existing actions and progress to support climate change efforts internally and externally is within reach. The communication relies to the tie between the recommendations and their support of adapting to the ever-changing environment under the effects of climate change.

Case Studies

Case Study 1: Superior Streets

Exelon's subsidiary, Commonwealth Edison (ComEd), manages their Superior Street Prairie in a way that provides connected habitat linkages to surrounding protected prairies and forest preserves. ComEd's 5.66-hectare (ha) (14-acre) transmission ROW is located 16 kilometers (km) (10 miles

Recommended adaptation strategies	Implementation adaptation strategies for ROWs
Establishment of native plant communities on ROWs	New ROWs can be seeded with native seed mixes, existing corridors can be enhanced by controlling for incompatible invasive species, and specific spans of the ROW can be targeted for restoration.
Creation of wildlife corridors/habitat linkages	Segments of the ROW can be managed to mimic the objectives and management techniques of high quality adjacent off-ROW patches, creating continuous habitat. Linkages can also be created on ROW by minimizing obstacles and drastic changes in vegetation communities.
Creation/restoration of quality habitats	New ROWs can be seeded using native seed mixes, existing ROWs can be enhanced with overseeding with natives or planting natives.
Translocation of species	ROW managers can assist in the movement of species (plants and animals) by partnering with their local wildlife agency to relocate the species on their land.
Creation/management of buffer zones	ROWs can be narrowed in length and by working with neighboring properties, ROWs can be managed in a way consistent with neighboring partners.
Management of invasive species	ROWs can be monitor for invasive species and pests; ROW managers can also track the movement of invasive pests and diseases in an area to prevent the spread into their lands. By working with neighboring land owners, ROW managers can make coordinated efforts to prevent the spread of invasive species and pest.
Utilize seed mixes that are more adaptive to climatic extremes	ROW managers can select fire and drought tolerant plants to lower the risk of fire damage to assets and species on the ROW.
Manage for shifting northern boundary of species ranges	ROWs can be seeded with mixes that include grasses and forbs that are found in the lower range of the ROW for the whole area that falls within that range, assisting in the movement of species as the climate forces species to shift their ranges northward.
Recategorize invasive species selected for management control (fugitive species)	ROW managers should monitor invasive species that have moved into a new area; however, if the species is providing an unmet need in the habitat, caution should be exercised before outright removal.
Reduce non-climate stressors	ROW managers can reduce non-climate stressors by managing invasive species, increasing soil health by use of lime or fertilizers and preventing habitat fragmenation by managing lands close together in a similar way.
Increase biodiversity on ROWs	ROWs can be seeded with a variety of native species with different blooming times and varieties that meet different and changing habitat/species needs.
Education for raising awareness about climate change	Joining committees and regional groups, leading or creating opportunities to increase employees' and community members' awareness of climate change and adaptation tactics being used can help build public support for these activities on ROWs. who work to manage climate change
Education for building capacity in deployment of adaptation tactics	Contractors can be trained to recognize native communities and invasive species to implement adaptation techniques. Working with employees and contractors on proper seed mix selection can lead to more effective management of ROWs and reduce costs associated with fixing ineffectively-deployed techniques.
Research/monitoring of the impacts of climate change on ecosystems	ROWs can be managed using the techniques mentioned above and actively publish research on test plots associated with climate change adaptation strategies.

Table 3 shows the ways in which the implementation actions of climate change adaptation strategies are diverse for ROW managers. The wide variety of adaptation strategies indicates that almost any can be adopted on ROWs to foster biodiversity and ecologically resilient communities.

Table 3. Recommended implementation of climate change adaptation strategies for ROW management

Recommended adaptation strategies	Link to Climate Change Adaptation & Ecosystem Resilience
Establishment of native plant communities on ROWs	Native plants provide habitat and sources of food to the native species in an area. As the climate continues to warm, ensuring native food sources supply can enable species to inhabit the area for a longer period of time (Lambrecht et al 2017).
Creation of wildlife corridors and habitat linkages	Wildlife corridors and habitat linkages facilitate the movement of species as their ranges shift with climate change impacts, which is critical for enabling access to areas with more suitable conditions in fragmented landscapes (Fowler 2015, McGuire et al. 2016). Corridors may also facilitate the spread of genotypes that can tolerate warmer temperatures (Krosby et al. 2010).
Creation and restoration of quality habitats	Creating new and restoring existing habitats increases the available habitat refugia for species to move to permanently as their ranges change or temporarily when fleeing from disturbance and therefore increases resiliency to drastic ecosystem changes (Timpane-Padgham et al. 2017).
Translocation of species	Translocation involves moving species to new areas outside of their historical range. It can reduce extinction risk for species with limited/no ability for movement (e.g., lack of corridors), or can be used to move species from populations adapted to warmer conditions to cooler areas to increase the probability of subsequent adaptation as the climate warms in these newer areas (Hoegh-Guldberg et al. 2008).
Creation and management of buffer zones	Buffer zones can be used to protect important/high-quality natural areas against climate change impacts and non-climate stressors exacerbated by climate change, such as reducing edge effects and moderating impacts (e.g., urban heat island, excess stormwater runoff) that may be stronger in more developed areas (U.S. Forest Service Climate Change Resource Center 2018).
Monitoring and management of invasive species	Increasing temperatures may allow invasive species to expand their ranges northward and further outcompete native species in ecosystems weakened by rising temperatures and other impacts of climate change (Georgia Department of Natural Resources 2015). Monitoring for new infestations and responding quickly to control them can help prevent the northward spread of invasive species and prevent them from impacting native species and habitats that are already stressed by climate impacts (U.S. Forest Service Climate Change Resource Center 2018).
Utilization of seed mixes adaptive to climatic extremes	Selecting native species that are better adapted to a range of climatic conditions in seed mixes can increase the resilience of native plant communities along ROWs by reducing the communities' sensitivity to climatic changes (Washington Department of Fish and Wildlife 2015).
Management of ROW for shifting northern boundary of species ranges	Potential refugia (species having to move from the effects of climate change) can be protected and managed in the historical northern reaches of species' ranges, and potentially more northerly areas they may move to in the future, to ensure species continue to have adequate habitat as their ranges shift northward (Heller & Zavaleta 2009)
Recategorization of invasive species selected for management control (fugitive species)	As the climate warms, species ranges for both native and non-native species will shift northward and the distinction between invasive and non-invasive species may become blurred. Reclassifying invasive species as "fugitive species" and selecting which ones to manage for may provide greater clarity for future discussions about habitat management (Heller and Zavaleta 2009, Hodgson et al. 2011).
Reduction of non-climate stressors	Reducing the impacts of non-climate stressors (e.g., poor soil health, low biodiversity, fragmentation) on ecosystems can reduce the likelihood of rapid, acute reactions to climate change and maintain a greater ability for resilience against climate stressors like extreme weather events and increasing temperatures (Maryland Department of Natural Resources 2016; Staut et al. 2013).
Increase of biodiversity on ROWs	Managing ROWs for a greater diversity of species can increase resilience to climate change impacts, helping ensure that ecosystem processes continue to function and that habitat resources are available to a broader range of wildlife species and supporting a greater overall number of plants and animals in the habitat, both now and in the future as the climate and species ranges change (Timpane-Padgham et al. 2017).
Climate change education and awareness	Educational activities designed to raise awareness about climate change can build support for climate change adaptation tactics by enhancing understanding of why they are being implemented (Maryland Department of Natural Resources 2016).
Capacity-building for adaptation tactics deployment	Engaging in activities to increase knowledge about implementation of climate change adaptation tactics enhances capacity for effective adaptive management of habitats and species, both on-site and in the surrounding community (Anderson 2010).
Research and monitoring of the impacts of climate change on ecosystems	Research can generate data to track the effects of climate change on the distribution and abundance of plant and animal species, track changes in habitat conditions, create models to predict changes in habitats and species populations, inform landowners' management decisions as conditions change, provide insight for risk management, and assess the effects of adaptation activities on species and ecosystems (Fowler 2015, New Hampshire Fish and Game Department 2015).

Table 4: Recommended adaptation strategies are presented here with explanations provided by literature sources. Many of these strategies may be already in place currently on ROWs. Leveraging these actions and expanding upon them with additional strategies can lead to more resilient communities and foster biodiversity.

Table 3. Correlation between recommended adaptation strategies for ROW management and support of resilient ecosystems as cited by scholarly articles and governmental strategies

[mi]) south of Chicago and is contiguous with Calument City's Superior Street Prairie, the Forest Preserve of Cook County's Sand Ridge Nature Preserve, and Green Lake Savanna. The combined linkage with these sites enables wildlife to move within a complex ecosystem of 101.7 ha (250 acres) in an otherwise urban area. ComEd continues to maintain the habitat linkage by controlling invasive species, participating in prescribed burns, and practicing annual site inspections. The Superior Street Prairie is an example of how utilities can maintain reliable electricity while working with local and regional groups to provide quality habitat linkages to allow for climate change adaptation.

Case Study 2: Salamander Stepping Stones

In 2014, Atlantic City Electric became one of the first companies to actively implement climate change adaptation strategies on its ROW in Middle Township, New Jersey to benefit the rare eastern tiger salamander. As sea levels are projected to rise due to climate change, many state and federal agencies are concerned the salamanders' breeding habitat will be restricted to levels that will place the species near extinction. The state's Department of Environmental Protection contacted Atlantic City Electric with a proposal to create vernal pools on the company's ROW that would allow for the ease of movement along the corridor for the protected salamander. These stepping stones are maintained by adaptive management and will allow for the species to continue to breed in its known range in a quality habitat.

CONCLUSIONS

Including climate change adaptation strategies in VM is possible. It is also essential to help address the likely growing risk to biodiversity from climate change. By relying on research outside of the ROW world and applying existing practices, direct and meaningful actions can be made to protect biodiversity and create resilient communities on ROWs. While this approach will not be the same as integrated VM (IVM) with industry leading the way for the past 50 years, there is a chance for the industry sector to play a vital role in rolling out a suite of actions on transmission lines, pipelines, railroads, and roadsides to test the methods suggested by researchers.

The findings of this research truly encourage ROW managers to show leadership and innovation by taking specific steps:

1. Identifying actions that have already been adopted and can be communicated differently to show support for resilient ecological communities.
2. Selecting compatible new climate change adaptation actions from the options presented here to adopt.
3. Implementing voluntary actions in the immediate future for reclamation, restoration, community engagement, and capital projects to show a commitment to the environment.
4. Factoring in long-term planning and maintenance cycles in bids to include climate change adaptation strategies.
5. Measuring, monitoring, and communicating efforts, which can be used to contribute to the key objectives of corporate sustainability.
6. Communicating efforts and outcomes related to climate change adaptation internally and externally.

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Since joining the Wildlife Habitat Council in 2005, Bonneau has occupied various positions within the organization, as Biologist, Director of Field Programs, and, currently, Senior Director, Conservation Strategy & Planning. Bonneau focuses on the development of mechanisms and launch of industry strategies for corporations to embrace conservation as a tried-and-tested business value. With her team, she maintains a technical support system to translate this value into tailored contemporary conservation actions across the globe.

Bonneau specializes in natural resources management in the mining industry, linear infrastructure planning, and remediation projects. She balances her passion for biodiversity with participation in industry committees and focus groups, including the Board of Director of the ROW Stewardship Council (ROWSC). While attending Université du Québec à Montréal, Bonneau received a Bachelor of Science in Ecology. Prior to joining WHC, she dedicated close to a decade to the field of emergency management before joining the timber industry as a scientific consultant.

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As Manager of Conservation Planning, Mucha focuses on corporate conservation in regulated industries such as Utilities and Remediation. She also works collaboratively with other members of the department, the entire WHC staff, and partners to ensure member organizations are receiving current guidance on conservation methods.

Prior to joining the Wildlife Habitat Council, Mucha worked as an Environmental Scientist at a consulting firm ensuring government clients' compliance with environmental regulations and sustainability goals. Mucha has also worked as a research and teaching assistant at American University where she also earned her Master's in Environmental Science with a focus in Green Infrastructure and Sustainability. Before coming to the nation's capital, Mucha earned her Bachelor's in Environmental Science and a minor in Sustainability Studies from Davis & Elkins College in Elkins, West Virginia. Complementing her love of sustainability, Mucha also actively maintains her LEED Green Associate Certification and volunteers at the National Zoo.