The Future of E-Bikes on Public Lands: How to Effectively Manage a Growing Trend

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16. Abstract This report is the final deliverable of the "Future of E-Bikes in Public Lands" research project. The research was funded through the Federal Highway Administration (FHWA) Federal Lands Highway Innovation Research Council. This report represents the first national-scale effort to develop a comprehensive framework to study the opportunities and challenges related to electric bicycles (e-bikes) in a public lands context. The report relied on technical staff from land management agencies and public lands stakeholders to help develop research questions under four focus areas: ecological, safety, social, and process. The report identifies existing research to establish a uniform understanding of issues and opportunities to help land managers and stakeholders engage in science-based decisionmaking. The report also identifies research gaps and includes proposals for future studies to help fill those gaps.		

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Executive Summary

This report was produced by the U.S. DOT Volpe Center (Volpe) and the Federal Highway Administration (FHWA) Western Federal Lands Highway Division (WFL). The study team focused on e-bikes that fit within the 3-tier classification system (Class 1, 2, and 3) common throughout most states (People for Bikes, 2019).

This report highlights key findings as they relate to the four research focus areas defined in the *Study Methodology,* a framework used to organize considerations about e-bikes on public lands regarding: (1) Ecological, Cultural, and Historical Resources; (2) Safety factors; (3) Social factors; and (4) Processes for E-Bike Management. These findings are based on an in-depth review of published studies identified by the project team and stakeholders as well as conversations with land managers who have first-hand experience with e-bikes in a public lands context.

The *Study Methodology* is intended to serve as a framework for organizing existing knowledge, but also as a roadmap for future research, and an organizational structure for documenting conclusions from future research. By consolidating and organizing information into this singular framework, Volpe and WFL hope it can serve as a hub of knowledge, coordination, and collaboration among the broad array of stakeholders that are engaged in the continually evolving subject of e-bikes in public lands.

Key Findings and Areas for Further Research

Table 1 through Table 4 identify key findings from the literature review and conversation summary and identify gaps where further research is needed. This summary will help direct future research and data collection efforts.

Table 1: Ecological, Cultural, and Historical Resource Impacts, Considerations, and Opportunities

Key Findings	Areas for Further Research
• One primary study was conducted on e-bike impacts—e-mountain bike (eMTB) specifically—on natural surface trails, which demonstrated no significant difference in soil displacement between eMTBs and conventional mountain bikes. • Research on conventional bike impacts shows that their presence can disturb wildlife and impact ecosystems but less than other activities; e-bike impacts are expected to be similar but limited research is available. • E-bikes may serve as an effective alternative to motor vehicles and reduce tailpipe emissions; installing charging stations in public lands could power e-bikes using renewable energy sources.	• There is only one significant study on the impacts of eMTBs on natural surface trails. Additional experimental research is needed to better understand the impacts e-bikes may have on such trails and whether and how they differ from other trail uses. • There is little research on whether e-bikes have different impacts on cultural and historical resources when compared to conventional bicycles. • Prior research on mountain bikes could inform the methodologies researchers use to focus on future eMTBs studies.

Table 2: Safety Impacts, Considerations, and Opportunities

Key Findings	Areas for Further Research
• Overall e-bike injury and conventional bike injury patterns are similar, though e-bikers tend to be older and have a higher rate of brain trauma injuries. • A recent study found that e-bike and powered scooter injury patterns differ from conventional bicycles. E-bike related injuries were more than three times as likely to involve a collision with a pedestrian than either pedal bicycles or powered scooters. • Research suggests that crash risk is similar between Class 3 and Class 1 e-bikes; however, injury severity tends to be higher among Class 3 e-bikers. • E-bikes may help to fill an important role as emergency response vehicles and support search-and-rescue teams operating in remote areas.	• Further research could examine the safety differences between conventional bicycles and different classes of e-bikes. • Further research could study the difference in safety risks between e-bike classifications. Specifically, research could examine whether the presence of a throttle on Class 2 e-bikes has an impact on safety for users. • Additional research could consider typical pre-crash conditions on natural surface trails to determine whether they differ from conditions on paved surfaces.

Table 3: Social Impacts, Considerations, and Opportunities

Key Findings	Areas for Further Research
• E-bikes require less physical exertion than conventional bicycles and have the potential to support independent mobility for older populations and individuals with mobility impairments. • The high upfront cost of e-bikes is a barrier to e-bike ownership and ridership. • Surveys demonstrate that some public lands users fear interactions with e-bikes on public lands, based on perceived risks. • E-bikes allow people to ride more miles and/or over a longer period, increasing potential benefits and impacts of bicycle use in public lands. • E-bikes provided by rental companies may encourage use by novice riders who are unfamiliar with e-bike operation and safety.	• Further research is needed to examine if and how e-bikes change visitor use patterns on public lands. This research could address how increased e-bike use in public lands may affect resources and other recreational activities and users. • Additional research may focus on what educational resources could be disseminated to public land users to promote proper etiquette.

Table 4: Process for E-Bike Management

Key Findings	Areas for Further Research
• Bicycle advocacy organization People for Bikes asserts that e-bikes are similar enough to conventional bikes that they do not warrant different trail design standards. They refer to industry standards for sustainable mountain bike trail design and trail building process as a resource for land managers. • There is limited published information on agency coordination of managing e-bike use. However, conversations with existing land managers demonstrate the value of frequent and recurring coordination to effectively manage e-bike use in public lands.	• Further research is needed to determine if trail design standards need to be modified to accommodate the unique characteristics and rider behaviors on e-bikes. • Additional research is needed to determine how land management agencies coordinate management of e-bikes with other governments and private enterprise. This includes studying best practices in how Federal and State regulations can better align with one another.

1. Introduction

This report is the final deliverable of the "Future of E-Bikes in Public Lands" research project being funded through the Federal Highway Administration (FHWA) Western Federal Lands Highway Division (WFL). The study team comprises staff from WFL and the U.S. DOT Volpe Center (Volpe). This report represents the first national-scale effort to develop a comprehensive framework for the opportunities and challenges related to e-bikes in a public lands context. As such, it is intended as the first installment in a series of ongoing studies and future research to be conducted by U.S. DOT, as well as other public agencies, academic researchers, and practitioners.

1.1. Background

Land management agencies across the United States are adapting policies and regulations for the growing use of e-bikes[1] on public lands. In August 2019, the Department of the Interior (DOI) issued Order 3376 (2019), which aimed to "increase recreational opportunities for all Americans, especially those with limitations, and to encourage the enjoyment of lands and waters managed" by DOI. The order initiated several efforts to establish e-bike policies within DOI's Federal land management agencies (FLMA) including the Bureau of Land Management, National Park Service, Fish and Wildlife Service, and the Bureau of Reclamation. All four bureaus have adopted a definition of an e-bike within the respective agency's federal regulatory code. These definitions are similar to Title 23 U.S.C. 217 as modified by the Bipartisan Infrastructure Law to include a three-tier classification as promoted by the Bicycle Product Suppliers Association (BPSA). The U.S. Department of Agriculture Forest Service published rule changes (USFS 7700 Travel Management – Zero Code and 7710 Travel Management – Travel Planning) to the Forest Service Manual (FSM) that would increase access for e-bike use. See Appendix A for more information about FLMA regulations.

State and local authorities are also adapting to the increasing use of e-bikes within their jurisdictions. People For Bikes closely monitors regulatory updates of e-bikes. As of February 2022, most States and the District of Columbia specifically define e-bikes.[2] States absent from this list either do not define e-bikes or they designate them as a different vehicle class (i.e., as motorized vehicles, mopeds, or bicycles). Of the States that define e-bikes, most States use a three-tier classification that matches the industry standard recommended by bicycle advocates.

This report documents the study team's findings based on a literature review, a summary of conversations with e-bike stakeholders, and a gap analysis. The study team recognizes that research on e-bikes is ongoing. While specific research questions may be answered over time, the study team expects the framework established by this project to remain useful as a tool to organize new information. Periodic updates to this document will ensure the framework continues to provide current information to public lands managers and users regarding the use of e-bikes in a public lands context.

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1. Electric bicycles or "e-bikes" are bicycles with electric motors that provide assistance in generating momentum through pedaling or via a hand throttle. This research focuses on impacts and opportunities presented by e-bikes that fall within the three-tier classification described by model bike legislation. Under this classification, e-bikes may not exceed an assisted speed of greater than 20-mph (Class-I and II) or 28-mph (Class-III). E-bikes that fall outside of this classification system are considered motorized uses and not addressed as part of this study.
2. The source of this information is provided by People for Bikes. The National Conference of State Legislatures also maintains a map of states that define "e-bike" within state regulations.

2. Outreach and Engagement

Volpe and WFL convened two separate groups to inform this study.

Technical Review Group

The first, a "Technical Review Group" (TRG) comprising Federal, State, and local public land managers and academic researchers, shaped the direction of the research by helping define key issue areas related to e-bikes in a public lands context. The group included representatives of the National Park Service, U.S. Forest Service, Bureau of Land Management, Fish and Wildlife Service, Bureau of Reclamation, U.S. Army Corps of Engineers, Oregon Department of Transportation, Virginia Department of Conservation and Recreation, Pennsylvania Department of Conservation and Natural Resources, Larimer County Colorado Parks, Open Space, and Trails; and, Virginia Tech, University of Tennessee Knoxville, and Portland State University. See Appendix B for a complete list of TRG participants.

The TRG held two collaborative working sessions to 1) frame the issues, the backbone of a "study methodology," and 2) populate it with research questions on the topic of e-bikes in a public lands context.

TRG Work Session #1

During the first work session, the TRG elaborated on the initial research needs statement (RNS) developed by a smaller group of public lands managers and academic researchers; the RNS identified "natural impacts," "safety impacts," and "social impacts" as three primary categories of inquiry for research. With the guidance of the TRG, the study team broadened the categories to include both impacts (or challenges), as well as benefits (or opportunities), and to add a fourth "floating" category related the process of applying research to future actions, including the development of public policies and Federal, State, and local regulations of e-bikes in public lands. Also during the first working session, the TRG discussed and developed a series of initial subcategories and considerations nested within or between the three primary focus areas, which would help inform subsequent efforts to identify more specific issue areas. See Appendix C for a framework issues diagram showing the prompts and outputs of the first TRG working session.

Research Focus Areas

Following the first TRG work session, the study team developed the following description of the three research focus areas that would frame the emerging study methodology:

- **Natural (Ecological, Cultural, and Historical Resources)** – impacts on and considerations for ecological, cultural, and historical resources, and opportunities related to environmental and resource preservation benefits;
- **Safety** – injury risks both for e-bike users and (non-e-bike) public lands users, and opportunities related to e-bike use for emergency response and safety management administration;
- **Social** – impacts to and considerations for current public lands uses and user experiences; risks related to evolving e-bike technology; challenges related to communication, education, and enforcement; and opportunities related to increased access and accessibility;

The study team subsequently added a fourth research focus area:

- **Process** – recommended best practices to collaborate between land managers and public land users, align activities and locations and coordinate between multiple agencies.

Public Lands User Group Stakeholder Workshop

To ensure the study methodology reflects a broad and diverse cross-section of perspectives, the study team convened a second group for a workshop: a collection of stakeholders representing various national, regional, and local public lands user groups. The study team invited stakeholders that represent bicyclists, hikers, equestrians, hunters/anglers, and naturalist/conservationists, including groups recommended by members of the TRG and fellow stakeholders. See Appendix D for a complete list of workshop participant groups. The stakeholder group built upon output from the first TRG working session. The study team provided stakeholders with read-ahead materials and conducted live polling during the workshop. Poll questions asked stakeholders to prioritize the initial subset of considerations developed by the TRG. The study team then conducted three breakout sessions with the stakeholders, during which each subgroup refined and expanded upon the TRG's initial study methodology diagram and land management tools and strategies. See Appendix E for a synthesis of the stakeholder breakout session results.

TRG Work Session #2

During the second TRG work session, the study team presented an overview of the process to date, including a review of the initial framework from the first TRG session and a high-level summary of the stakeholder workshop. The study team then led the TRG in a detailed review and revision of the synthesis framework and the land management tools and strategies, confirming priorities and reorganizing elements. The second work session concluded with a preview of next steps, including development of the complete study methodology and development of a new literature review focused specifically on e-bikes in a public lands context.

Finalizing the Study Methodology

Following TRG work session #2, the study team developed a first draft of the complete study methodology. The study team crafted individual research questions based on the bulleted list of issues from the final framework. The study team then refined, circulated, and revised the complete study methodology over the course of several weeks. The study team solicited and incorporated input from the TRG, ultimately developing a comprehensive set of 60 research questions nested under twelve subcategories of the four primary focus areas, establishing the final study methodology. Table 5 in the following section of this report presents the complete study methodology.

3. Study Methodology, Literature Review, and Gap Analysis

With the completed study methodology, the study team set out to collect and review literature from published studies, reports, news articles, and other written sources. The study team also spoke directly with members of the TRG, and with several land managers and other contacts who are actively engaged in managing e-bike access, developing e-bike policies, and piloting novel approaches to regulating e-bike use in a public lands context. The study team also examined selected literature and studies about conventional bicycling, to provide context for considering issues where e-bikes and conventional bikes could potentially be shown to perform similarly. However, these "proxy" studies require further research to assess if and how e-bikes and conventional bikes may be performing similarly in various circumstances. Based on this comprehensive review of available information, the study team populated responses to as many of the study methodology research questions as possible.

3.1. Study Methodology as National Research Roadmap

Table 5 lists an entry for each of 60 research questions in the study methodology. Each entry in the table provides an assessment of the volume and completeness of knowledge or gaps that the study team found in the literature review. The study team identified several areas of moderate to significant knowledge. However, as the study of e-bikes in a public lands context is still a nascent field, there were many questions where the study team found only partial information or found no literature or other verbal documentation from contacts to help address the research questions.

While practitioners, land managers, and stakeholders may be disappointed in the lack of conclusive answers to many of these research questions, the study team hopes this report sets the table at a national scale for future research activity. The study methodology provides value in identifying knowledge gaps among a comprehensive list of research questions developed, vetted, and prioritized by a cross section of key public lands agencies, individuals, and organizations operating at the intersection of e-bikes and public lands. Future data collection and analysis, pilot projects, case studies, and primary field research will be able to leverage this literature review and gap analysis to continue to build a collective understanding of relevant issues, benefits, opportunities, and challenges, using the study methodology as a national research road map.

Following Table 5, this report provides a comprehensive narrative discussion of the literature that the study team reviewed and the conversations that the study team held with practitioners. This section not only identifies topics for future research, but also recommends specific actions – such as field studies or case studies – that can help advance knowledge to address research gaps.

Table 5: Study Methodology, Research Questions, and Gap Analysis Summary

Research Focus Area	Study Methodology Question	Knowledge Coverage
1. Ecological, Cultural, and Historical Resource Impacts, Considerations, and Opportunities		
1.1 Natural Surface Trail Condition and Wildlife	A. What are potential natural ecological impacts associated with the recreational use of e-bikes, or electric mountain bikes (eMTBs), on natural surface trail environments?	**Moderate**
	B. Do e-bike impacts differ from conventional bike impacts? To what extent are differences in impacts, if any, between e-bikes and conventional bikes due to differences in the respective rider behavior (average speed, etc.)? Do bicyclists stay on designated trails, or venture onto habitat/vegetation beyond the trail boundaries?	**Partial ***
	C. Are there differences in natural surface impacts between classes and types of e-bikes (Class 1, 2 or 3)?	**None**
	D. What trail design practices encourage low-impact e-bike riding and sustainably maintain trail infrastructure (i.e., width, slope, sight line, drainage, volumes of riders, speed)?	**Moderate**
1.2 Historical and Cultural Resources	A. If bicycles have an impact on historical and cultural resources, is there a difference between the impact of conventional bikes and that of e-bikes?	**None**
	B. What factors do public land managers need to consider regarding the use of e-bikes on public lands while ensuring historical and cultural resource protection?	**None**
	C. What approaches can public land managers take to mitigate potential impacts, if any, of e-bikes to historical and cultural resources?	**None**
1.3 Mode Shift and Environmental Benefits	A. Does the use of e-bikes in public lands result in a net reduction of greenhouse gas emissions (through mode shift/vehicle trip replacement)?	**Moderate**
	B. Under what circumstances can e-bikes serve as an effective replacement for personal vehicles or shuttles to access trails or other points of interest? Do e-bikes replace any other modes such as walking, conventional bikes, or off-highway vehicles?	**Moderate**
	C. Is it feasible to provide e-bike charging facilities in and around public lands that rely on renewable energy sources to minimize the environmental impact and utility connections?	**Moderate**

* Volpe administered a field study in the summer of 2022. This study will inform answers to these research questions and establish a study protocol for future research. See Section 5 of this report for more information.

Research Focus Area	Study Methodology Question	Knowledge Coverage
2. Safety Impacts, Considerations, and Opportunities		
2.1 Behavior and Potential for E-Bike-Related Injury	A. Does rider behavior (average speed, passing other trail users, yielding to other trail users, etc.) in a public lands setting differ between e-bike and conventional bike riders?	Partial *
	B. Do injury rates and severity differ for e-bike and conventional bike riders?	Moderate
	C. In bicycle-related injury incidents, do injury rates and severity to non-bicyclists differ between e-bike riders and conventional bike riders (e.g., injuries to hikers, equestrians, and other non-motorized public lands users)?	Partial
	D. Are there different risks or severity of injuries associated with different types of e-bike classifications or modifications?	Moderate
	E. Are there different safety risks associated with e-bike use on different types of terrain or facilities?	Partial
	F. What are the typical pre-crash conditions for e-bike-involved incidents?	Moderate
	G. What are the injury risks to e-bike riders from sharing roadways or multiuse paths with other users (e.g., motor vehicles, shuttles, conventional bicyclists and other nonmotorized users), and how do these risks differ from those for conventional bike riders?	None *
	H. What educational and regulatory safety measures can effectively reduce the number and severity of e-bike crashes on trails open to e-bike use on public lands?	Partial
2.2 Emergency Response	A. Can e-bikes serve as effective emergency response vehicles?	Moderate
	B. Will e-bikes help to reduce emergency response time in remote areas?	Moderate
	C. Can e-bikes serve as vehicles for administrative use (e.g., visitor use management, crowd control, ranger, and law enforcement patrol, etc.), and do e-bikes provide any unique benefits for certain types or locations of administrative use over conventional vehicles?	None

* Volpe administered a field study in the summer of 2022. This study will inform answers to these research questions and establish a study protocol for future research. See Section 5 of this report for more information.

Research Focus Area	Study Methodology Question	Knowledge Coverage
3. Social Impacts, Considerations, and Opportunities		
3.1 Education and Communication to Trail User Groups	A. What etiquette practices are land use managers, municipalities, advocacy groups, and bike shops, among others, promoting specifically for e-bike riders? How are these different, if at all, from practices promoted to conventional bike riders?	**Partial**
	B. Are there commonly accepted codes of conduct for e-bike riders?	**Partial**
	C. How do e-bike users get information about where they can and cannot ride e-bikes?	**Partial**
	D. As another education option, are there social venues, online forums, or other areas that effectively promote safe and responsible e-bike riding with demonstrable successes in managing user behavior?	**Partial**
	E. Is there a learning curve for new e-bikes riders? If so, how does it affect their use, especially in the context of rentals to novice riders and/or people unfamiliar with a given public land?	**Partial**
	F. Are there common best practices for bike shop retailers and renters that provide customers with e-bikes?	**Partial**
	G. Are there effective programs to educate new users about operating e-bikes in public lands?	**Partial**
3.2 Visitor Use	A. Will e-bikes change public lands visitor use patterns?	**Partial**
	B. How can existing trail infrastructure be adapted to accommodate a higher volume of users, and should it?	**None**
	C. How will increased e-bike use in public lands affect other recreational activities?	**Partial**
	D. Will there be a need to offer additional facilities or resources to support increased access to public lands (e.g., more trailhead parking, additional restrooms, and trash collection maintenance)?	**None**
3.3 Equity and Accessibility	A. Are e-bikes legally considered "Other Power Driven Mobility Devices" under prevailing Federal ADA guidelines?	**Significant**
	B. How can e-bikes increase access to public lands for individuals with mobility impairments or others who are unable to effectively use conventional bikes or nonmotorized methods of access?	**Significant**
	C. How does e-bike use affect people with visual and hearing impairments in public lands?	**None**
	D. What potential conflicts exist for public land managers trying to provide access for e-bike riders while meeting ADA/ABA requirements?	**Partial**
	E. How do e-bikes affect access to public lands for conventionally underserved populations?	**Moderate**

	F. Do e-bikes skew toward more affluent public lands users, and does this affect less affluent public lands users?	**Partial**
3.4 Keeping up with Evolving Technology	A. What factors should public land managers consider regarding improvements to existing e-bike technologies?	**Partial**
	B. What lessons can the emergence of micromobility and the evolution of mountain bikes teach us about how to effectively manage emerging e-bike technologies?	**Partial**
3.5 Impacts to Existing Uses from Expansion of E-Bike Access	A. Will the presence of e-bikes in public lands have unintended consequences on future e-bike or conventional bike use?	**Moderate**
	B. Do e-bike riders exhibit behaviors that may positively or adversely affect the experience for those hiking, riding horses, or riding conventional bicycles?	**Partial ***
	C. Does average speed, passing behavior around other trail users, yielding behavior related to other trail users, etc., create problems or provide benefits to others traveling by different modes?	**None ***
	D. Would non-e-bike riders make different decisions based on their perception of e-bikes, even without experiencing them, if land managers allowed e-bikes on certain trails?	**Partial**
	E. Do e-bikes encourage more cyclists to ride in public lands? If so, how might increases in cyclists access lead to conflicts between trail users? Are such conflicts already occurring among various users (cyclists or other users) of different skill levels (e.g., is skill level, rather than use/device type, the more salient characteristic)?	**Partial**
	F. How are e-bikes potentially of use to reach more remote areas and to carry more equipment, or food/game? Examples may include hunters (including subsistence hunters), anglers, boaters, alpinists, photographers, scientists, and researchers, etc.	**Moderate**

* Volpe administered a field study administered in the summer of 2022. This study will inform answers to these research questions and establish a study protocol for future research. See Section 5 of this report for more information.

Research Focus Area	Study Methodology Question	Knowledge Coverage
4. Process for E-Bike Management		
4.1 User-Purpose-Place Alignment	A. What does a standard NEPA process for approving conventional bikes and e-bikes look like? How do these processes differ, if at all?	**Partial**
	B. Are there environmental conditions that are more appropriate for the use of a particular e-bike class?	**Partial**
	C. Are there reasons to restrict particular e-bike classes?	**Partial**
	D. Are there generally accepted design guidelines for modifying trails to accommodate e-bike use? If so, what are the guidelines and, generally, should Federal and State agencies follow them?	**Moderate**
	E. How can land managers modify trails, places, or other facilities to fit the conditions for e-bikes to coexist with other uses and the environment better? What is the cost of implementing and maintaining those modifications?	**None**
4.2 Multi-Agency Coordination	A. What planning processes and methodologies (public meetings, user surveys, pilot programs, etc.) do agencies and authorities use to work through issues relating to e-bikes?	**Partial**
	B. How do agencies and authorities use data-driven decision making when solving problems related to e-bikes? What are the most effective methods?	**Partial**
	C. What are best practices for agencies incorporating public input into the process of determining e-bike access in public lands?	**Partial**
	D. How do agencies make the process of determining e-bike access in public lands transparent to participants and observers?	**Partial**
	E. What are the current processes for consensus building and coordination between differing land management jurisdictions in the context of trail infrastructure?	**Partial**
	F. As a general practice, how can Federal and State regulatory processes better align with one another in regard to e-bikes?	**None**
	G. How do agencies coordinate enforcement resources when policies or regulations of e-bikes differ between jurisdictions?	**Partial**
	H. How do agencies best coordinate and/or leverage funding sources for facilities that support continuous access for specific or unique uses across their jurisdictions?	**None**

4. Detailed Findings

Significant detail and references to documentation in the following sections can aid public lands managers, informing their approach to developing and implementing policies and practices to manage e-bikes in public lands. Similarly, this section provides insights for public land users and other stakeholders seeking to understand and engage with public land managers in cooperatively developing those policies and practices.

To assist the reader, these headings and subheadings follow the same order as the study methodology; each question under each issue area is enumerated with a letter that keys back to Table 5.

4.1. Ecological, Cultural, & Historical Resource Impacts, Considerations, and Opportunities

Natural Surface Trail Condition and Wildlife

A. What are potential natural ecological impacts associated with the recreational use of e-bikes, or electric mountain bikes (eMTBs), on natural surface trail environments?

A scan of the literature identified only one study on natural resource impacts of e-bikes. The study was conducted by the International Mountain Bicycling Association (IMBA), a nonprofit mountain bike advocacy group. The study compared the soil displacements of a mountain bike, a pedal-assisted eMTB (Class 1), and a gas-powered dirt bike. The results indicated no significant difference in soil displacement due to the performance or speed of the rider between eMTBs and conventional mountain bikes (The International Mountain Biking Association, 2016). However, the heavier weights of eMTBs, when compared to conventional mountain bikes, can cause increased soil displacement in grade changes and turns. Compared to eMTBs and conventional MTBs, the gas-powered dirt bike caused considerably greater soil displacement in climbs and entering berms, and upon repeated laps over the same location.

Based on the 2016 IMBA study indicating that conventional mountain bikes and eMTBs are largely similar in their impacts, research about conventional mountain bike impacts on soft surface trails may offer additional insight about the impact of eMTBs. The research team leveraged an existing literature review on the environmental impacts of mountain biking related to vegetation, soils, and the disruption of wildlife (Marion & Wimpey, 2011). The authors conclude that impacts on trails where mountain biking is common are likely due to poor trail design and maintenance. Soil impacts can be limited through sustainable trail design, and off-trail environmental impacts can be minimized when trail users are restricted to designated trails. One of the co-authors' earlier papers indicates that the environmental degradation caused by mountain biking is generally equivalent to or less than that caused by hiking, and both are substantially less impactful than motorized and equestrian activities: the study reported less soil loss on mountain bike trails than on hiking trails, which in turn exhibited substantially less soil loss than observed on horse and ATV trails (Marion & Olive, 2006).

Studies featured in the Marion literature review (2011) have shown that most damage to plants and soils on a trail occur with the initial traffic and that the per capita increase in further impact diminishes rapidly with increasing subsequent traffic. Research also indicates that mountain bikes have a limited impact on vegetation loss. Thurston and Reader (2001) conducted a trampling study involving mountain bikers and hikers in Boyne Valley Provincial Park in Ontario, Canada. Researchers recorded the condition of a trail's vegetation before and after 500 one-way passes by bikers and hikers (Thurston, E & Reader, 2001). Conditions included plant density (number of stems/area), diversity (number of species present), and soil exposure (area of mineral soil exposed). Testing revealed that the impacts of hiking and biking were not significantly different from one another.

Mountain bikes appear to cause just as much damage, and in some cases less damage, than other modes of travel, such as hiking, on natural surface trails. In one study, researchers measured 78 miles of trail for soil loss in the Big South Fork National River and Recreation Area (Marion & Olive, 2006). The study examined the relative contribution of different types of use including horse, hiking, mountain biking, and all-terrain vehicles (ATV). Of the specific use type trails, mountain biking trails showed the least amount of erosion; by comparison, all-terrain vehicles displaced over 40 times more soil, horses over 26 times more soil, and hikers more than three times more soil. The study found that mountain bike impacts on flatter terrain are generally minimal, except when soils are wet or uncompacted and rutting occurs.

The impacts of mountain biking on wildlife are similar to those of hikers and other non-motorized trail users. Taylor and Knight investigated the interactions of wildlife and trail users (hikers and mountain bikers) at Antelope Island State Park in Utah (Taylor & Knight, 2003). A hidden observer recorded responses to an assistant who hiked or biked a section of trail. The observer measured wildlife reactions, including alert distance, flight response, flight distance, distance fled, and distance from trail. Observations revealed that 70 percent of animals located within 330 feet of a trail were likely to flee when a trail user passed. This response was statistically similar for both mountain biking and hiking. Wildlife reacted more to off-trail activities than those that remained on the trail. While this study found no biological justification for managing mountain biking any differently than hiking, they note that bikers cover more ground in a given time period than hikers. This suggests that mountain bikers potentially disturb more wildlife per unit time. However, mountain bike riders also tend to stay on established trails, which minimizes wildlife impacts, while hikers may be more likely to venture beyond trails.

However, another study that used a GPS/GIS-based rapid assessment tool to estimate the impacts of mountain biking in Western Australia noted that mountain bikers were observed to be creating informal trail networks beyond designated trail systems in John Forrest National Park (Newsome & Davies, 2009). A more recent study noted that non-motorized activities had a slightly greater negative effect on wildlife than motorized activities (Larson & et al, 2016). A literature review for the Boulder County Parks and Open Space speculated that the discrepancy between impacts may be because motorized trails tend to be located outside wildlife and in more conspicuous locations, while nonmotorized trails often travel through backcountry areas and can create opportunities to travel off trail, resulting in a less predictable travel pattern and more contact with areas where wildlife present (Nielsen & et al, 2019).

Conversely, a 2004 study in the Oregon Starkey Experimental Forest and Range found that the negative impact of motorized activities penetrates deeper into wilderness than that of nonmotorized activities. Elk and deer populations were monitored to measure the “disturbance” effect of hiking, horseback riding, mountain biking, and ATVs. Mountain bike riders, horse riders, and hikers were found to disturb wildlife up to at 750, 550, and 400 meters from the subject, respectively. In comparison, the disturbance effect for ATVs was observed at up to 1350 meters away from the rider (Wisdom & et al, 2004).

B. *Do e-bike impacts differ from conventional bike impacts? To what extent are differences in impacts, if any, between e-bikes and conventional bikes due to differences in the respective rider behavior (average speed, etc.)? Do bicyclists stay on designated trails, or venture onto habitat/vegetation beyond the trail boundaries?*

As mentioned in the previous section, there is only one comparison study of e-bike and conventional bike impacts on natural resources. The study compared the soil displacements of a mountain bike, a pedal-assisted eMTB (Class 1), and a gas-powered dirt bike. The results indicated that there was not a significant difference in soil displacement between eMTBs and conventional mountain bikes except for some observed differences at grade changes and turns (International Mountain Bicycling Association, 2016). The heavier weights of eMTBs, when compared to conventional mountain bikes, can cause different levels of soil displacement in grade changes and turns.

The IMBA research suggests that eMTBs do not have significantly different impacts when compared to conventional mountain bikes; however, there is a need for additional research to complement IMBA's 2016 findings with more recent eMTB models and potentially new research methods.

Field research being conducted by the study team in the summer of 2022 examines the differences between conventional bikes and e-bikes on an unpaved multi-use trail. The study uses video and GPS data and will assess whether there are significant differences between e-bike and conventional bike rider behavior, such as speed, acceleration, and braking. See Section 5 of this report for more information. The protocol for this research can inform future research on natural surface road and trail networks to expand upon the findings from the 2016 IMBA study.

C. Are there differences in natural surface impacts between classes and types of e-bikes (Class 1, 2, or 3)?

The study team did not identify relevant literature.

D. What trail design practices encourage low-impact e-bike riding and sustainably maintain trail infrastructure (i.e., width, slope, sight line, drainage, volumes of riders, speed)?

The Bureau of Land Management and People for Bikes developed the eMTB Land Manager Handbook to provide guidance on accommodating Class 1 eMTB on natural surface trail networks (Bureau of Land Management & People for Bikes, 2020). Many of the guidelines reflect common approaches to sustainable trail design for conventional mountain bikes. The Bureau of Land Management and IMBA *Guidelines for a Quality Trail Experience* are a commonly referenced source for information about trail design that minimizes erosion and drainage issues and encourages safe and responsible trail user behavior and interaction (Bureau of Land Management & International Mountain Bicycling Association, 2018). People for Bikes lists additional eMTB resources on their website (People for Bikes, 2021).

Collectively, these guides and other resources advise land managers and trail builders to employ trail designs and features that encourage riders to safely manage their speed, minimize user conflicts, and stay on designated trail surfaces.

Historical and Cultural Resources

A. If bicycles have an impact on historical and cultural resources, is there a difference between the impact of conventional bikes and that of e-bikes?

The study team did not identify relevant literature.

B. What factors do public land managers need to consider regarding the use of e-bikes on public lands while ensuring historical and cultural resource protection?

The study team did not identify relevant literature.

C. What approaches can public land managers take to mitigate potential impacts, if any, of e-bikes to historical and cultural resources?

The study team did not identify relevant literature.

Mode Shift and Environmental Benefits

A. Does the use of e-bikes in public lands result in a net reduction of greenhouse gas emissions (through mode shift/vehicle trip replacement)?

The environmental impacts and reduction of greenhouse gas (GhG) emissions from e-bike use depend on the mode that e-bikes replace (Fishman & Cherry, 2015). Studies have modeled how an increase in e-bike mode share would yield GhG emission reductions due to mode shift from cars to bicycles. One such study found that a 15 percent increase in e-bike mode share would result in an approximately 10 percent decrease in person-miles-traveled by car (McQueen, MacArthur, & Cherry, 2019). Additionally, the research found that a 15 percent increase in e-bike mode share would result in an 11 percent decrease in carbon dioxide emissions. The research shows that increasing the e-bike mode share is a beneficial way to meet carbon emission reduction goals and reduce driving; however, substantial political will is needed to promote the e-bike ridership needed to seize the e-bike potential to reduce GhG emissions.

Because e-bikes do not have tailpipe emissions, air pollution associated with e-bikes occurs at power plants rather than in urban centers. A recent study found that e-bikes decrease human exposure and intake of pollutants as power plants are typically located in areas with lower population density (Abagnale & et al, 2015). While the degree of pollution is dependent on the source of electricity, this suggests that the production and use of e-bikes results in less pollutants when compared to vehicles. If an e-bike trip replaces a walking or conventional bike trip, it will likely increase emissions, depending on how the power for the e-bike battery was generated.

These findings highlight the opportunity for e-bikes to help lower GhG emission through vehicle trip replacement, though certain incentives may be needed to use this strategy to meet emission reduction goals.

B. Under what circumstances can e-bikes serve as an effective replacement for personal vehicles or shuttles to access trails or other points of interest? Do e-bikes replace any other modes such as walking, conventional bikes, or off-highway vehicles?

Research suggests that e-bikes lower the barriers of entry to bicycling and as a result help to increase ridership among individuals deterred from bicycling by physical limitations, topographic barriers, perceived safety risk, and distance to cycle (MacArthur & et al, 2018). In a number of Chinese cities where e-bike market penetration is much higher than in North America, studies have found e-bikes to replace short trips on public transportation more often than operating as a substitute for trips taken by private vehicles (Cherry & Cervero, 2007). A separate study of an e-bike share system in California found that e-bikes were most commonly replacing trips taken by personal automobile or a ridehailing service (Fitch, Mohiuddin, & Handy, 2020). While the focus of this research has not been on public lands, these findings suggest that e-bikes may serve as an effective replacement for personal vehicles or shuttles to trails in locations that are in urban or suburban locations and are underserved by public transportation.

Due to COVID-19, a group of public and private sector stakeholders instituted a reservation system in the summer of 2020 for the shuttle that runs from Aspen Highlands to the Maroon Bells Scenic Area in the White River National Forest.[3] This system enabled the shuttle provider (Roaring Fork Transportation Authority) to plan on how many shuttles (that ran at half capacity that season) it should have in operation throughout the season. Because more people than available shuttle tickets wanted to visit the Bells, rental shops periodically

[3] During shuttle operating hours, cars are not allowed on the road from Aspen Highlands to the Bells. This has been the arrangement for over a decade.

sold out of their e-bike rentals; this demand was augmented by people who did not want to ride the shuttle during the pandemic and/or preferred to take an e-bike than a shuttle to the Bells. In response, rental shops increased their fleet and new rental outlets opened to accommodate more visitors who wanted to visit the Bells via e-bike. The popularity of renting e-bikes to access the Bells increased in 2021 and is anticipated to continue in the 2022 season and beyond.

C. Is it feasible to provide e-bike charging facilities in and around public lands that rely on renewable energy sources to minimize the environmental impact of utility connections?

Mountain bike tourist destinations around the world are beginning to market their locations to attract eMTB riders. Some destinations are expanding their infrastructure to meet this growing need by providing charging stations for e-bikes on trails (Schlemmer, Barth, & Schnitzer, 2019). Public lands sites may adopt similar practices to encourage the use of e-bikes as a reliable transportation mode.

Research from the University of Massachusetts-Amherst suggests that it is feasible to develop e-bike charging facilities that rely exclusively on solar power (Wamburu & al, 2020). Equipping an e-bike charging station with a single grid-tied solar panel is adequate to meet the annual charging demand from e-bikes and achieve net-zero emissions using net-metering. An off-grid setup would require twice as many solar panels but remains feasible as an option for public lands managers hoping to provide e-bike charging stations in more remote locations. The Tahoe National Forest has considered installing charging stations but has yet to do so; staff there noted that a significant amount of trenching would be necessary.

Future research may focus on implementing these charging facilities to provide public lands sites with a model for their use.

4.2. Safety Impacts, Considerations, and Opportunities

Behavior and Potential for E-Bike-Related Injury

A. Does rider behavior (average speed, passing other trail users, yielding to other trail users, etc.) in a public lands setting differ between e-bike and conventional bike riders?

Some studies have used GPS devices to track rider behavior in non-public lands contexts. A study from Tennessee that tracked riders' GPS data when using a university bikeshare system that included both e-bike and conventional bikes (Langford, Chen, & Cherry, 2015).

The study found that conventional bikes speeds varied more than e-bike speeds. The study assumed this difference was due to e-bikes being able to maintain consistent speeds over hills and rolling terrain. The average speed for e-bikes was higher than conventional bikes for on-road trips, but lower on greenways or shared-use paths. The authors suspect the higher speed of conventional bikes on the greenways and shared-use paths may be due to riders making exercise trips, rather than riding for transport.

The two groups exhibited similar wrong way violations on one-way and two-way streets, although e-bikes traveled slower when traveling the wrong way, relative to their average speed. Stop sign violations were also similar between the two groups. However, when running a stop sign, conventional bikes, on average, did so at higher speeds than e-bikes. This was assumed to be due to the desire of conventional bike riders to maintain their momentum, whereas e-bike riders could further reduce and then increase their speed more easily because of the motor assistance.

One caveat to this study is that the motor in the system's e-bike model cut off assistance at 15 mph and produced only 180 watts, less than the 250 watts of power available on most Class 1 e-bikes today. New field research being conducted by the study team in the summer of 2022 examines the differences between conventional bikes and e-bikes on an unpaved multi-use trail. See Section 5 of this report for more information. The study uses video and GPS data and will assess whether there are significant differences between e-bike and conventional bike rider behavior, such as speed, acceleration, and braking, and will complement the 2015 study described above with new data from e-bikes with higher watt motors and a higher assistance speed cut-off of 20 mph.

B. Do injury rates and severity differ for e-bike and conventional bike riders?

According to one study, the overall pattern of injury between e-bike and conventional bike riders is similar: traumatic brain injury, pelvic injury, and upper extremity injury; however, the severity of those injuries tends to be higher with e-bikers (Spörri & et al, 2021). People involved in e-bike crashes were almost 14 years older and had a higher incidence of moderate traumatic brain injuries than patients involved in crashes using a conventional bicycle. Surprisingly, this difference persisted despite e-bike riders being nearly twice as likely to wear a helmet as conventional riders. The rate of pelvic injuries in e-bike crashes was twice as high compared with bicycle crashes, whereas the rate of upper extremity injuries was higher following conventional bicycle crashes. The study authors speculate that contributing factors that result in these differences include that older people with less cycling-specific training generally have slower reaction times and less control over e-bikes.

A recent study compared injury patterns and trends associated with e-bikes and conventional bicycles from 2000 to 2017 using the U.S. National Electronic Injury Surveillance System. There are some caveats the conclusions of this study, which does not distinguish between classes of e-bikes. The authors indicate the nominative increase in e-bike injuries in the last few years of the data set may be due to increasing e-bike use, not increasing risk of injury. The study notes that a better metric would be to normalize injuries to person-miles traveled, which was not possible with this data set. The study did find that e-bike injury patterns differ from those for riders of conventional bicycles. People involved in e-bike crashes were more likely to suffer internal injuries and be hospitalized compared to conventional bicyclists. In the study, people injured using e-bikes were older, averaging 31.9 years old compared with 25.2 years for conventional bikes (DiMaggio, 2019).

A study was conducted in the Netherlands to compare the injury risk of e-bike and conventional bicycle users by using emergency room data and a survey of cyclists who have not been involved in a bicycle crash. The study found that overall e-bike users had poorer health than conventional bicycle users; however, general health status is unrelated to the likelihood and severity of bicycle crashes. E-bike users were not more likely to be involved in a crash or to sustain serious injuries with the exception of older, female cyclists who did have an elevated risk of injury on e-bikes and tended to sustain more serious injuries (Schepers, 2019). Other studies have shown that e-cyclists are more likely than conventional cyclists to be involved in single bicycle crashes, suggesting to the authors that high speeds, difficulties mounting and dismounting, or problems maneuvering may be causal factors in the crashes (Papoutsi & et al, 2014).

It is difficult to have definitive answers on e-bike injury risk in the United States due to several complicating factors including the lack of consistent reporting and the difference in use between e-bikes and conventional bicycles (Cherry & MacArthur, 2019). Additional studies should build on this research, seeking to normalize data for more comparable results, and capture additional information to differentiate e-bike and conventional bike injury outcomes and causality more precisely. Future research could control for contributing factors such as age and e-bike experience to develop a deeper understanding of the differences in injury risks between e-bike riders and conventional bicyclists.

C. In bicycle-related injury incidents, do injury rates and severity to non-bicyclists differ between e-bike riders and conventional bike riders (e.g., injuries to hikers, equestrians, and other non-motorized public lands users)?

The above referenced injury study found that, compared with conventional bike or electric scooter crashes, e-bike crashes were three times more likely to involve a collision with a pedestrian (DiMaggio, 2019). However, as noted earlier, this study does not normalize the crash incidents to person-miles traveled, so it may overrepresent the rate of crashes involving e-bikes, especially toward the end of the dataset as e-bikes became more prevalent with consumers. While conditions and users on trails and within public lands are likely different than those of this study, this conclusion suggests that e-bikes may present a greater hazard to other public lands users than conventional bikes, though several improvements to this kind of research are needed.

A larger and richer crash injury dataset with the ability to normalize crash events to person-miles traveled, and with distinction between e-bike classes, would help clarify risks. Crash data that are specific to relevant public lands contexts, such as natural surface trail systems, multiuse paths, and roads, would help researchers develop more definitive findings on the difference in injury rates and severities to non-bicyclists from e-bike riders and conventional bike riders.

D. Are there different risks or severity of injuries associated with different types of e-bike classifications or modifications?

A comprehensive white paper review of emerging research on e-bike safety found that Class 3 e-bikes have the same crash risk as Class 1 e-bikes, but injury severity is slightly higher among Class 3 e-bikes when they do crash (Cherry & MacArthur, 2019). Class 1 e-bike riders travel marginally faster than conventional bicycles (3.0 km/hr) and their speed results in slightly higher conflict rates and safety-oriented maneuvers. Class 3 e-bikes travel substantially faster than conventional bicycles, about twice the speed on average. The review identified no definitive answer regarding whether e-bikes are more or less safe than conventional bicycling, and under which circumstances.

This research shows that injury severity is slightly higher for Class 3 e-bikes when compared to Class 1 e-bikes. Future research could examine whether the presence of the throttle on Class 2 e-bikes has any impact on safety.

E. Are there different safety risks associated with e-bike use on different types of terrain or facilities?

The literature on safety risks associated with e-bike use aligns with the research on typical pre-crash conditions, which is provided below. This research focuses on incidents in urbanized areas and does not cover public lands or trails. The Tahoe National Forest allowed e-biking for a period in 2019 and then again once the East Zone Connectivity Project was approved in 2021. Forest Service staff there said that safety risks are minimally different with Class 1 e-bikes; more depends on rider skill and etiquette. Anecdotally, they believe that e-bike riders are usually more skilled (e.g., they used to ride conventional mountain bikes but switched to e-bikes because of age or injury, and/or they want to go on longer rides) than beginners. They said that since e-bikes are so expensive, people take e-biking seriously and are therefore generally cautious and risk-adverse. However, no data

F. What are the typical pre-crash conditions for e-bike-involved incidents?

A study of the characteristics of single-vehicle crashes involving e-bikes in Switzerland found that the primary pre-crash conditions were a slippery road surface, falling while crossing a threshold, riding too quickly, and an inability to keep balance (Hertach & et al, 2018). The study found that women, elderly people, and e-bike riders who consider themselves to be less fit had an increased risk to suffer a more serious injury.

A separate literature review of risky riding behaviors of urban e-bikes identified a set of key risk factors that often lead to crashes and near-misses (Ma & et al, 2019). The literature identifies the illegal turning movements, speeding, running red lights, and riding against the flow of traffic as the primary risky riding behaviors seen with e-bikes.

This research does not explicitly cover pre-crash conditions on off-road trails that may be more prevalent in a public lands context. This is an existing gap and area for future research.

G. What are the injury risks to e-bike riders from sharing roadways or multiuse paths with other users (e.g., motor vehicles, shuttles, conventional bicyclists, and other nonmotorized users), and how do these risks differ from those for conventional bike riders?

The study team did not identify relevant literature. However, field research to be conducted by the study team will focus on a public lands setting and assess whether there are significant differences between e-bike and conventional bike rider behavior. Behavior related to speed and yielding, such as speed at conflict zones like trail junctures or blind corners, may indicate a different risk of crashes for e-bike riders that could lead to injury. Future research can help replicate findings and produce additional insights in different public lands contexts.

H. What educational and regulatory safety measures can effectively reduce the number and severity of e-bike crashes on trails open to e-bike use on public lands?

Trail etiquette among all trail users is typically reinforced through signs, educational campaigns, and peer communication. Signs and educational campaigns provide clarity about the rules for access, yielding, speed, and other factors. Peer communication, whether on the trail or in places that cater to trail users—bike shops, outfitters, outdoors clubs, etc.—can help reinforce those rules. Because e-bikes are a relatively new phenomenon, the use of demonstrations may serve as an effective tool to change users' perceptions of e-bikes and their role on trails or on roadways; such demonstrations could include allowing public lands visitors to try e-bikes and receive instruction on safe and courteous riding behavior (Nielsen & et al, 2019).

These findings suggest educational campaigns and increasing familiarity with e-bike operation may help to improve trail etiquette, reduce negative perceptions, and reduce the risk of e-bike crashes in public lands.

Emergency Response

A. Can e-bikes serve as effective emergency response vehicles?

There is limited literature on the effectiveness of e-bikes as an emergency response vehicle; however, several jurisdictions have equipped first responders with e-bikes to quickly respond to incidents in areas that are difficult for larger vehicles to access. Israel's emergency response network recently added 1,000 e-bikes to its fleet of rescue vehicles to assist patients in hard-to-reach areas more easily (Leichman, 2017). The unit, which equips staff with resuscitation equipment and a medical kit, was designed to support ambulances by reaching crowded areas such as markets and boardwalks more quickly.

In France, one company is developing an emergency response cargo e-bike with an insulated container for medical supplies. The company's intention is to provide a redundant mode of transport to deliver first responders to incident sites, potentially more quickly than via motor vehicles (Gorgan, 2020). The City of Portland's Bureau of Emergency Management holds annual Disaster Relief Trials, in which participants use bicycles outfitted to carry cargo and simulate delivery of emergency supplies to residents in need. They recently experimented with developing a prototype cargo e-bike ambulance (Maus, 2022).

This research suggests that e-bikes can serve as effective emergency response vehicles, though future research that focuses on a public lands setting may help improve understanding in such context.

B. Will e-bikes help to reduce emergency response time in remote areas?

A growing number of search and rescue teams have begun to rely on e-bikes to reach locations that are inaccessible by ATVs. E-bikes, which typically rely on an electric motor that does not create noise, offer a key advantage over ATVs as they allow rescuers to listen for voices yelling for help while traveling along trails (Rodriguez, 2020). Anecdotal evidence suggests that e-bikes may help to reduce emergency response time in remote areas when compared to rescuers on foot; however, more research is needed to compare emergency response time with ATVs and other motorized devices.

Existing literature on this topic is largely anecdotal and there are no significant studies to date addressing these questions. This is a gap and potential area for further research.

C. Can e-bikes serve as vehicles for administrative use (e.g., visitor use management, crowd control, ranger and law enforcement patrol, etc.), and do e-bikes provide any unique benefits for certain types or locations of administrative use over conventional vehicles?

The study team did not identify relevant literature specific to public lands. However, many local police departments use e-bikes for patrols, community engagement, and incident response. A recent article in an industry publication noted many benefits of e-bikes over conventional bikes or cruisers for police. These include faster response times in dense areas; easier and longer travel time on a variety of surfaces such as trails, parks and open spaces, sidewalks, and inclines; a “stealthy” approach to suspects; more personable interactions with the public; and less risk of officer injury and fatigue (Shrubb, 2018).

While not directly related to public safety, Federal staff discussing this research with the study team noted anecdotal or potential use of e-bikes to perform administrative duties. On a recent project to evaluate parking conditions at Lake Berryessa, a Bureau of Reclamation site, a Federal Lands Highway transportation planner used an e-bike to travel between sites over the course of day. Using an e-bike rather than a regular bike to collect data proved more efficient due to the hilly terrain. Using a bicycle was also more practical than using a motor vehicle to navigate through parking lots and record observations; the bicycle’s small scale did not inhibit visitors’ circulation or require a vehicular parking space. On the Olympic National Forest, roads segments that were selected for an annual deferred maintenance assessment were unreachable by motor vehicles due to storm damage; e-bikes or all-terrain vehicles were noted as a potential method to access the specific segment to be assessed. Finally, the National Park Service has been piloting the use of e-bikes outfitted with cameras, tablets, and accelerometers to assess roughness of multi-use trails. The e-bikes allow staff to cover longer distances and populate a geodatabase with 360-degree panoramic images, which are captured at one-second intervals, along with GPS coordinates, and additional annotations as recorded by the rider.

4.3. Social Impacts, Considerations, and Opportunities

Education and Communication to Trail User Groups

A. What etiquette practices are land use managers, municipalities, advocacy groups, and bike shops, among others, promoting specifically for e-bike riders? How are these different, if at all, from practices promoted to conventional bike riders?

The Boulder County Parks and Open Space Literature Review (2019) briefly references the importance of educational and outreach campaigns focusing on etiquette and on-trail behavior to help reduce conflicts. The report suggests e-bike demonstrations—allowing people to test ride and learn about e-bikes—could inform and possibly change users' perceptions of the e-bikes themselves and their place on the road (Nielsen & et al, 2019). The authors also emphasize the importance of encouraging proper etiquette to all of trail users and not just eMTB riders to further mitigate conflict scenarios.

Some Federal, State, and local authorities that allow e-bikes provide informational resources to educate e-bike riders on proper rider etiquette. A few examples include: the U.S. Department of Interior (DOI), which published a list of tips to follow on their website in October 2020 (US Department of Interior, 2020); the City of Durango, which published eMTB riding etiquette on their website and on trifold flyers that are handed out to residents as well as bike shops (Durango, 2022); and the Maroon Bells transportation partnership, which developed a *How to E-Bike in Aspen* video and also created and distributed flyers to area e-bike rental shops about bicycling etiquette on Maroon Creek Road (Aspen Chamber Resort Association, 2021). Some of the tips are specific to the use of e-bikes including yielding to other users.

Online forums, blogs, and promotional articles offer advice on proper eMTB etiquette from Oregon E-bikes (Oregon E-Bikes, 2020) and the women-centric bicycle design company Liv (Liv Global, 2020). YouTube channels, such as the Electric Mountain Bike Network, visually show how e-bike riders should behave on trails. IMBA publishes a guide that provides their Rules of the Trail for conventional mountain bikes (International Mountain Bicycling Association, 2021). Such guidance provides an example that could inform future studies to confirm whether these rules are applicable to eMTBs as well. Per guidelines published by People for Bikes, eMTB riders should yield to all other trail users regardless of direction (PeopleForBikes, 2020).

Existing research demonstrates that etiquette practices are typically similar between e-bike and conventional bike riders and at times focus on clarifying the locations where e-bikes can or cannot be ridden.

B. Are there commonly accepted codes of conduct for e-bike riders?

Although not documented in research, a review of e-bike etiquette tips shows commonalities across many different sources: yielding to other trail users, yielding to uphill bike riders, calling out or using a bell before overtaking other users, using hand signals to indicate turning, slowing, or stopping intent, etc. Such tips are commonly accepted mountain bike and hiking etiquette tips. Only a few sources, like those mentioned above, have tips that are unique to e-bike use. Additional research is needed to determine commonly accepted codes of conduct and to evaluate their effectiveness at achieving desired outcomes.

C. How do e-bike users get information about where they can and cannot ride e-bikes?

Some public lands provide general information on e-bikes use within their jurisdictions via websites, videos, and printed material. Since the DOI's order allowing e-bikes on public lands, many Federal land management agencies have published information about e-bikes including where they are allowed and prohibited as described, for example, in the NPS Minute Man National Historic Park Superintendents Compendium

(National Park Service, 2022). The most extensive and thorough online tool identifying where e-bikes can be ridden on trails is managed by People for Bikes. The eMTB Routes and Trails map is an interactive open-source catalog displaying trails across the 50 US states that are reported to allow some form of e-bike access by general users (PeopleForBikes, 2022). Because it is open source it may include inaccuracies. Trailforks is a popular mobile and web-based application that provides crowd-sourced content, including information about where e-bikes are allowed, subject to the same caveat about potential inaccuracies (Trailforks, 2022).

Future research could utilize survey or cellular data to better understand the most popular mediums for users to get information and allow land management agencies to target their outreach appropriately.

D. As another education option, are there social venues, online forums, or other areas that effectively promote safe and responsible e-bike riding with demonstrable successes in managing user behavior?

National organizations like IMBA (International Mountain Biking Association, 2022) and People for Bikes (PeopleForBikes, Trail Etiquette Guidelines, 2020) promote e-bike rider etiquette via their communication materials and websites. The Bureau of Land Management (Bureau of Land Management, 2021) has an e-bike page on their website that includes trail etiquette practices.

E. Is there a learning curve for new e-bikes riders? If so, how does it affect their use, especially in the context of rentals to novice riders and/or people unfamiliar with a given public land?

The study team did not identify relevant literature. Anecdotally, visitors to the Maroon Bells who rented e-bikes did exhibit behavior that suggests they are new to bicycle riding on such facilities as Maroon Creek Rd. These include riding two and three-abreast and not allowing faster vehicles, including the designated shuttle buses, to safely pass them. Additional research is needed to further investigate whether this kind of behavior is common among e-bike renters and new e-bike riders.

F. Are there common best practices for bike shop retailers and renters that provide customers with e-bikes?

The study team did not identify relevant literature. In practice, the City of Aspen and Pitkin County asked rental bike shops prior to and during the 2021 summer season to have their customers view a how-to e-bike video and/or view a flyer on proper e-bike etiquette on Maroon Creek Rd., which is a County-owned road that provides exclusive access through the White River National Forest to the Maroon Bells Scenic Area. Unfortunately, according to County officials, few bike shops voluntarily complied with this educational campaign and e-bike users continued to exhibit poor e-bike etiquette compared to the 2020 season.

G. Are there effective programs to educate new users about operating e-bikes in public lands?

The study team did not identify relevant literature. In practice, at the behest of the Pitkin County Board of County Commissioners, the City of Aspen, Pitkin County, and other stakeholders in the Aspen area developed an e-bike rental tracking system that they are piloting during the 2022 season to improve e-bike etiquette and safety on Maroon Creek Rd. E-bike rental shops and other e-bike fleet owners will be given microchipped passes to be adhered to each e-bike rental. These passes will be scanned every time they pass the Maroon Bells entrance station on Maroon Creek Rd. Rental shops are again being asked to show the video and/or go over the rules of the road with customers prior to each rental. Not only will this system provide the stakeholders with valuable data about e-bike rental usage, but renters exhibiting poor or dangerous etiquette will be noted and rental shops may lose their ability to rent e-bikes to access the Maroon Bells in subsequent years.

Visitor Use

A. Will e-bikes change public lands visitor use patterns?

A standard battery can power an e-bike for roughly 20-40 miles of range depending on route characteristics like terrain and the level of assistance chosen by the rider (Karni, 2021). The assistance provided by an e-bike may change how some people access and travel within public lands. If a rider can travel further with assistance from an electric motor, then all other conditions being the same, it is likely e-bikes will allow visitors to access more remote parts of public lands. It may also mean that more visitors can access public lands that require steeper ascents. As technology advances, it is likely that range will increase.

This research does not explicitly cover visitor use patterns for e-bike riders in public lands. Due to the relatively nascent data collection around this topic, this is a gap and opportunity for future research.

B. How can existing trail infrastructure be adapted to accommodate a higher volume of users, and should it?

The study team did not identify relevant literature.

C. How will increased e-bike use in public lands affect other recreational activities?

The study team did not identify relevant literature. In the Tahoe National Forest, the new East Zone Connectivity Project Class 1 e-bike trails were previously non-motorized trails (US Forest Service, 2022). According to the NEPA Decision document, "These trails would remain open to existing non-motorized use. Potential environmental impacts and user conflicts were carefully considered in selecting existing trails to propose for Class 1 e-bike use. The proposed trails are not popular equestrian trails; are not experiencing known recreation user group conflicts; have no substantial existing resource impacts; and have trail management objectives specifically aimed at mountain bike use." Staff on the Tahoe National Forest confirmed that they have seen no impacts, negative or otherwise, to other recreational activities or users on these trails.

D. Will there be a need to offer additional facilities or resources to support increased access to public lands (e.g., more trailhead parking, additional restrooms, and trash collection maintenance)?

The study team did not identify relevant literature.

Equity and Accessibility

A. Are e-bikes legally considered "Other Power Driven Mobility Devices" under prevailing Federal ADA guidelines?

Federal Americans with Disabilities Act (ADA) guidelines define Other Power Driven Mobility Devices (OPDMD) as "any mobility device powered by batteries, fuel, or other engines—whether or not designed primarily for use by individuals with mobility disabilities—that is used by individuals with mobility disabilities for the purpose of locomotion, including golf cars and electronic personal assistance mobility devices (EPAMDs), such as the Segway, or any mobility device designed to operate in areas without defined pedestrian routes, but that is not a wheelchair" (U.S. Department of Justice, 2021). Thus, e-bikes can be considered OPDMDs, though public and private agencies may be able to restrict their use in certain locations due to safety requirements. Any person with a mobility disability is allowed to use OPDMDs. Individuals may be asked to provide credible assurance that the mobility device is required due to a disability; this may include a disability parking placard or other state-issued proof of disability. For areas where e-bikes are generally disallowed, public land managers assess whether e-bikes can be accommodated as an OPDMD in accordance with Department of Justice guidance, upon request. In deciding whether e-bikes can be accommodated as OPDMDs, public land managers may develop and publicize rules for people with disabilities using e-bikes as OPDMDs. Some emerging mobility devices may fall under the definition of OPDMD as described above. Some States, such as California, consider e-bikes to be OPDMDs, however, federal law has not designated them specifically as such. This may cause confusion among users who are accustomed to their State public land's policies.

B. Public lands managers should continue to track any changes to the characterization of e-bikes under prevailing ADA guidelines to ensure that individuals with disabilities have access to and mobility within public lands. How can e-bikes increase access to public lands for individuals with mobility impairments or others who are unable to effectively use conventional bikes or non-motorized methods of access?

E-bikes require less physical exertion than conventional bicycles and have the potential to support independent mobility for older populations and individuals with mobility impairments (Leger, 2019). Existing research suggests that older riders and individuals with physical limitations are more likely to use e-bikes for recreational purposes, while younger riders tend to use e-bikes for utilitarian and commuting purposes (Nielsen & et al, 2019). In a public lands context, this may result in an increased use of e-bikes among older adults for recreational purposes.

This research suggests that e-bikes may provide individuals who were not previously interested or physically capable of experiencing public lands sites and trails by bicycle with the ability to do so. This is an existing gap that future research could address.

C. How does e-bike use affect people with visual and hearing impairments in public lands?

The study team did not identify relevant literature.

D. What potential conflicts exist for public land managers trying to provide access for e-bike riders while meeting ADA and ABA requirements?

Although e-bikes can help users overcome the physical requirements of operating a bicycle, an e-bike is not considered an adaptive device in and of itself according to the legal ADA definition of a mobility device (US Department of Justice Civil Rights Division, 2014). This definition states that a mobility device is "a manually-operated or power-driven device designed primarily for use by an individual with a mobility disability for the main purpose of indoor or of both indoor and outdoor locomotion." Any device that does not meet these standards and have electrical assist are subject to motorized rules. For some public lands, this distinction could cause confusion and conflict for visitors (Haas & Ahearn, 2022). For instance, although bicycles are not allowed in wilderness areas, wheelchairs are permitted. FLMAs are required to follow the Architectural Barriers Act (ABA).

E. How do e-bikes affect access to public lands for conventionally underserved populations?

The high upfront cost of e-bikes is a significant barrier to greater e-bike ownership and ridership (MacArthur & et al, 2018). Additional recurring costs, including charging and battery replacement, may limit the ability of lower income households to purchase e-bikes (Dill & Rose, 2012). Separately, studies in the United States have noted that that e-bike users feared intimidation and harassment on the road for using an e-bike and at times felt apologetic or self-conscious due to being viewed as "cheating" for riding an e-bike (Jones, Harms, & Heinen, 2016). The threat of targeted harassment combined with barriers of affordability may deter ridership among lower income populations and other conventionally underserved groups (Yanocha & Allan, 2019).

On the contrary, the incorporation of e-bikes into existing bikeshare systems has helped to increase access to e-bikes for conventionally underserved populations by allowing users to experiment with these modes without committing to their high upfront costs. A review of dockless e-bikes and e-scooters in Washington, DC, found that black residents adopted dockless services at a significantly higher rate than to docked services when compared to white residents (Clewlow, 2018). Nice Ride MN, which is now operated by Lyft, provides discounted memberships and fees for qualifying individuals (residents 18 and older who qualify for a state or federal assistance program like the Supplemental Nutrition Assistance Program, Supplemental Security Income, etc.) (Nice Ride, 2022). Nice Ride and its partners hope that enrollees will use these discounted bikes, e-bikes, and scooters for work, shopping, and recreational trips to and along destinations like the nearby Mississippi National River and Recreation Area.

More research and policy action are needed to ensure that individuals without smartphones or credit cards are able to access shared e-bikes; however, this research suggests that e-bikes may help to improve access to public lands for conventionally underserved populations in areas where these systems are present. Public land sites that are exploring offering e-bikes to visitors may require operators to offer an equitable pricing scheme and provide alternative means of access similar to how a number of cities have negotiated permitting requirements with bikeshare and micromobility operators (Yanocha & Allan, 2019).

F. *Do e-bikes skew toward more affluent public lands users, and does this affect accommodations for less affluent public lands users?*

There is limited research on the demographics and socioeconomic status of individuals using e-bikes on public lands. The demographics of e-bike users generally tend to skew older and have higher income and higher educational attainment than conventional bicycle users (MacArthur & et al, 2018).

Additional research is needed to determine whether these trends would translate to the public lands context and whether the use of e-bikes affects accommodations for less affluent public lands users.

Keeping up with Evolving Technology

A. *What factors should public land managers consider regarding improvements to existing e-bike technologies?*

Improvements in e-bike technology have been focused on only a few design elements because advancements in speed are constrained by regulation. Battery life and motor durability will likely continue to improve, allowing e-bike users to travel farther. Land managers may need to extend search and rescue operations if an e-bike rider becomes missing in a public land.

The Bipartisan Infrastructure Law Section 11133 codifies the three-tier classification of e-bikes. The Code of Federal Regulations stipulates requirements for bicycles under 16 CFR 1512, include mechanical, braking, steering, testing procedures, as well as labeling requirements (Infrastructure Investment and Jobs Act, 2021). However, there are no Federal requirements to label e-bikes by class, nor are there prohibitions on modifying e-bikes in ways that would alter their performance or capabilities beyond the original class at the point of sale. In addition, as motors and batteries become smaller and more integrated into bicycle frames, it will be harder to distinguish e-bikes from conventional bikes, let alone differentiate between the classes of e-bikes. This will challenge public lands enforcement of e-bike policies.

Future research may examine mechanisms for enforcement and identify effective strategies to ensure that public land managers are able to manage sites.

B. What lessons can the emergence of micromobility and the evolution of mountain bikes teach us about how to effectively manage emerging e-bike technologies?

Bicycles have been ridden on natural surfaces since their first inception. The Marin Museum of Bicycling explains that very few roads were paved in the 19th century when bicycling first emerged (Marin Museum of Bicycling, 2022). Mountain biking as a sport and recreation emerged in the 1970s and became commonplace by the 1980s. Advances in design and technology have encouraged interest in mountain bikes and places to ride them since that time. Innovations in suspension, frame materials, and component technology has led to bikes that are more capable on rugged terrain, more durable over longer distances, and easier for novice riders to use. Some of the technology upgrades industry experts have cited as pivotal in expanding interest in mountain biking include the inception of suspension, advancements in frame geometry, the advent of dropper seat posts, and the introduction of disc brakes (Shankland, 2020). As manufacturers modernized mountain bikes, trail builders have also innovated on trail design. For instance, modern mountain-bike specific trail designs often feature berms and other shaping to increase rider "flow," resulting in a smoother, faster experience. Advancements in mountain bike design transfer to eMTBs, which enjoy the same technology in addition to electric motors. In many ways, eMTBs represent a continuation of innovations that allow people to ride farther, more comfortably, and on more challenging terrain.

In 2005, public land management agencies partnered with industry representatives to develop a plan on how to manage mountain bike access to public lands (Gleason, 2008). This partnership led to the National Park Service (NPS) making a rule change to allow individual park Superintendents to designate biking trails within their jurisdiction. As of 2015, there were 40 national parks that offered mountain bike access of some kind (Congressinal Research Service, 2014). A public private partnership between e-bike advocates and land managers could identify appropriate methods for regulating e-bike use in public lands.

Another advancement in related mountain biking technology that can be seamlessly adopted by e-bike users is trail global positioning system (GPS) mapping services. Mobile phone applications that provide GPS mapping services for trail riders are beginning to indicate which trails allow eMTBs. Online crowd sourced trail maps are also displaying locations of trails that allow eMTBs (PeopleForBikes, 2022). It should be noted that most of these applications do not indicate what classifications are permitted.

As an initial management tool, a public land management agency could partner with trail map application developers to indicate which trails permit specific classifications of e-bikes. This research shows that it is important for land management agencies to remain up to date on technological iterations and adapt rules and regulations as needed.

Impacts to Existing Uses from Expansion of E-Bike Access

A. Will the presence of e-bikes in public lands have unintended consequences on future e-bike or conventional bike use?

The presence of e-bikes on public lands could lead to unintended consequences for future e-bike use due to perceptions of e-bikes. The Boulder County Parks and Open Space literature review identified studies showing that trail users who are unfamiliar with e-bikes prefer not to share the trail with them; however, most of these users did not notice that they were sharing the trail with e-bikes. These studies found that once trail users were exposed to e-bikes, their concerns decreased (Nielsen & et al, 2019). This suggests that the presence of e-bikes on trails or in public lands could impact the visitation of certain user groups who may be unfamiliar with new recreation technologies like e-bikes. The studies also suggest the importance of strong communication and messaging to ensure that the public are exposed to e-bikes in a safe manner.

Future research could take a closer look at these unintended consequences by analyzing trail use by all groups before and after permitting e-bikes to better understand any changes to trail use.

B. *Do e-bikes or e-bike riders have behaviors that may adversely affect the experience for those hiking, riding horses, or riding conventional bicycles?*

The study team did not identify relevant literature speaking directly to this question. However, a member of the Technical Review Group stated anecdotally that trail users are seeing higher speeds on natural surface trails and altered behavior off trails. Professional resource managers, public lands staff, trail designers, and industry or user group advocates, are advising that entirely different trail systems and segment designs are needed to safely accommodate eMTB use on natural surface trails. Further research is needed to better understand this gap.

In the Maroon Bells, stakeholders have noticed that e-bikers exhibit poor etiquette more frequently than conventional bicyclists along Maroon Creek Rd., a two-lane road that provides frequent shuttle bus access to the Maroon Bells throughout the summer season. This sentiment is attributed to the belief that conventional bicyclists are local residents who ride up the winding, moderately steep road to the Bells several times every season. Stakeholders note that these riders seem to better understand the importance of proper bicycle etiquette, such as riding single file, staying to the right side of the road, allowing faster vehicles and riders to pass, and that they are used to the presence of shuttle buses.

E-bikers are generally visitors who have rented their e-bike, in some cases riding an e-bike for the first time and are unfamiliar with the road and the presence of shuttle buses. These e-bike renters have been observed to ride multiple people abreast, ride in the middle of the road, stop in the middle of the road for breaks and taking photos, not wear helmets, and wear earbuds. The feeling among stakeholders is that these e-bike renters make bicycling and taking the shuttle to and from the Bells more dangerous and unsafe for all visitors.

C. *Does average speed, passing behavior around other trail users, yielding behavior related to other trail users, etc., create problems or provide benefits to others traveling by different modes?*

The study team did not identify relevant literature. However, the team's planned field study will evaluate rider behavior and note differences between people riding e-bikes and conventional bikes, as well as whether any differences may impact other trail users traveling by different modes.

D. *Would non-e-bike riders make different decisions based on their perception of e-bikes, even without experiencing them, if land managers allowed e-bikes on certain trails?*

The Arizona Trail Association conducted a study to gather opinions from the public on allowing e-bikes on the Arizona National Scenic Trail. Most survey respondents disapproved of e-bikes being allowed on the trail with mountain bike rider respondents being less likely to disapprove of allowing e-bikes on non-motorized trails and equestrian respondents being more likely to disapprove (Baechle & Kressler, 2020). The most frequent argument in support of e-bikes was making the trail more accessible to individuals with mobility impairments. The most frequent argument in opposition to e-bikes focuses on the potential for allowing e-bikes to create a slippery slope for the introduction of other motorized user groups on non-motorized trails.

Future research could better assess how visitation changes when e-bikes are allowed on certain trails by collecting visitor counts for all modes before and after e-bikes are permitted on trails. This may help to answer how allowing e-bikes affects visitation among hikers, horseback riders, and other recreational users.

E. *Do e-bikes encourage more cyclists to ride in public lands? If so, how might increases in cyclists lead to conflicts between trail users? Are such conflicts already occurring among various users (cyclists or*

other users) of different skill levels (e.g., is skill level, rather than use/device type, the more salient characteristic)?

The study team did not identify relevant literature. Though on a paved roadway and not on a trail, stakeholders in the Maroon Bells have noticed conflicts between e-bikers, conventional bikers, and vehicle traffic along Maroon Creek Rd. Though there have not been any serious injuries, several "near misses" have been observed between e-bikes and shuttle buses. Shuttle bus drivers recently underwent additional training to raise awareness of inexperienced e-bikers who are not following proper bicycling etiquette.

F. How are e-bikes potentially of use to reach more remote areas and to carry more equipment or food/game? Examples may include hunters (including subsistence hunters), anglers, boaters, alpinists, photographers, scientists, and researchers, etc.

There is evidence that hunters are using e-bikes to easily reach remote areas. A resource produced by the Rocky Mountain Elk Foundation describes e-bikes that are designed for use by hunters (RMEF, 2022). These bikes are typically designed with added stability to manage rougher conditions in the backcountry, increased battery range, and a higher weight limit to accommodate the use of trailers to haul equipment or game.

There is no research examining the practicality of e-bikes for other users to reach remote areas for professional or recreational purposes; however, the experience of search and rescue teams and hunters suggest that e-bikes could help individuals to meet this need. This is an existing gap and area for future research.

4.4. Process for E-Bike Management

User-Purpose-Place Alignment

A. What does a standard NEPA process for approving conventional bikes and e-bikes look like? How do these processes differ, if at all?

The study team did not identify relevant literature. However, as a recent example of e-bike trails being approved in practice, the U.S. Forest Service approved the East Zone Connectivity Project in the Tahoe National Forest in 2021, which, among other trail changes in the Forest, included the designation of thirty-five miles of existing non-motorized trail as open to Class 1 e-bikes. The Forest Service prepared an Environmental Assessment (EA) for the project in compliance with the National Environmental Policy Act (NEPA) and other relevant laws and regulations. The EA discloses the direct, indirect, and cumulative effects that would result from the proposed trail alternatives. At the end of the process, the Forest Supervisor issued a Finding of No Significant Impact (FONSI). The FONSI describes the factors used in determining that the decision does not cause significant impacts on the human environment and therefore does not require preparation of an environmental impact statement (US Forest Service, 2022). There does not appear to be any notable difference between the NEPA process followed for this project and a NEPA process followed for conventional bike trails.

B. Are there environmental conditions that are more appropriate for the use of a particular e-bike class?

A particular e-bike may be better suited for different types of terrain depending on the e-bike's features to include the size of the motor and the size of the battery. Manufacturers face a design trade off when making e-bikes: performance versus riding range. There is a broad range of variables that affect the capabilities of e-bikes regardless of class. For instance, manufacturers note that riding of an e-bike can be determined primarily by six factors: the speed the bike is traveling; the weight of the rider; the combined aerodynamic drag of the rider and bike: how much the rider is pedaling; the grade of the terrain; the efficiency of the motor drive system; and the energy capacity of the battery (OPTIBIKE, 2022). Depending on the weight of the bike, weight of the rider, and the terrain a larger battery with an efficient motor will increase the riding range (Toll, 2020). However, external environmental circumstance may limit the capabilities, such as range or load, of an e-bike. Smaller motors, like the 500 Wh batteries typically paired with Class 1 e-bikes, may struggle with steep terrain. Smaller motors of e-bikes may also struggle carrying or pulling heavy loads like cargo. In contrast, Class 3 e-bikes typically have larger 500-watt motors with 500 Wh batteries to assist with consistent faster speeds.

Future studies may compare the ecological impact and individual comfort of riding each class of e-bike along both paved and unpaved surfaces to better understand whether there are certain conditions that favor an individual class of e-bike.

C. Are there reasons to restrict particular e-bike classes?

Some States and local municipalities restrict e-bike access by their classification for safety reasons. Class 1 e-bikes are the most accepted class of e-bikes where e-bikes are permitted. Except where use of motor vehicles by the public is allowed, per 36 CFR 4.30(i)(3), NPS prohibits Class 2 e-bike riders from "using the electric motor exclusively to move an electric bicycle for an extended period of time without pedaling." A scan of literature and regulations suggest that Class 3 e-bikes are the most restricted class of e-bikes. A common justification for restricting Class 3 e-bikes is their top assisted speed of 28 mph. Some States restrict the use of Class 3 e-bikes unless explicitly permitted by localities, while other States, like California, restrict users under 16 years of age from using Class 3 e-bikes. In other cases, Class 3 e-bikes are permitted on roads and multi-use paths, but not allowed on natural surface trails. States and localities have also restricted e-bikes because they consider them motor vehicles and restrict this mode from operating in certain areas to include natural surface areas.

Future research could look to develop a data-driven framework that guides land management agencies on whether it is necessary to restrict particular e-bike classes. This framework could use studies around safety and ecological impact rather than relying primarily on perceptions of higher safety risks resulting from increased speeds.

D. Are there generally accepted design guidelines for modifying trails to accommodate e-bike use? If so, what are the guidelines and, generally, should Federal and State agencies follow them?

The eMTB Land Manager Handbook describes general best practices for trail design specifically for eMTBs (Bureau of Land Management & People for Bikes, 2020). The handbook reviews e-bike classifications and basic sustainable trail design principles. A few differences between eMTBs and mountain bikes are highlighted including the heavier weight and potential for higher speed of e-bikes. Although eMTBs can navigate some technical sections with greater ease, descending trails can be more difficult due to their heavier frames and motors. Furthermore, eMTB riders may not experience the same physical challenge as a mountain bike rider because of the motor assist. Best management practices for both eMTBs and mountain bikes are developed based on the IMBA impact study and presented throughout the handbook. The designs and construction tips primarily reference the IMBA trail design guide for conventional mountain bikes. The publication emphasizes that in "general, eMTB trail construction mimics that of mountain bike trail construction, which in turn hews closely to the guidelines for sustainable trail development regardless of user type."

However, there are some design decisions and features to consider incorporating to take advantage of eMTB capabilities and provide unique riding experiences. For instance, the increased uphill speed of an eMTB may cause more user conflicts and recommends designating descending-direction trails. An example of a feature to incorporate into a trail is the backslope, which is the slope adjacent to the trail on the uphill side, and which can be shaped to allow riders the challenge of riding up onto the off-camber surface. Other features include anchors to help keep riders on the trail surface, and filters, which are features at the beginning on trails that illustrate the level of difficulty a rider can expect on that trail. None of these features are specific to eMTBs alone but encourage varying levels of challenge as well as speed management and safer trail user interaction.

The eMTB Land Manager Handbook provides public land managers with a useful resource to guide the design of trails to accommodate e-bike use. Future research may be needed to account for iterations in the technology that further modify the differences between conventional and eMTB rider capabilities.

E. How can land managers modify trails, places, or other facilities to fit the conditions for e-bikes to coexist with other uses and the environment better? What is the cost of implementing and maintaining those modifications?

The study team did not identify relevant literature.

Multi-Agency Coordination

A. What planning processes and methodologies (public meetings, user surveys, pilot programs, etc.) do agencies and authorities use to work through issues relating to e-bikes?

The study team did not find any published sources on municipal and agency planning processes for e-bike implementation. To better understand this research gap, the study team conducted a short discussion with

Jefferson County ("JeffCo") Colorado Open Space to learn about their decision-making process in permitting e-bikes. They were chosen because of their early adoption mentality and their reputation for being an example of e-bike adoption efforts for other agencies. An insight that emerged from this discussion was that JeffCo Open Space developed policies independently from what the proposed State e-bike legislation was going to be. There was too much uncertainty from the legislature and little coordination between the State and counties. JeffCo Open Space wanted to have flexibility in their own policies with the expectation of adapting to future State policy changes when needed (Bonnett, 2022).

JeffCo Open Space conducted an e-bike pilot study to determine public perceptions of e-bike use on managed trails. The philosophy of JeffCo Open Space was that if e-bike users were unnoticeable by the public and behaved appropriately, then they should not be restricted from park use. To determine if this would hold true, public managers recruited "ghost riders" (staff and volunteers) to inconspicuously ride e-bikes throughout the managed trails during the pilot. During this time public managers surveyed the public to ask their opinions of e-bikes and whether they had noticed e-bikes within the open space. Initially, public opinion was mixed with most unsure (forty-one percent) about e-bikes being allowed on trails. About sixty-five percent did not notice e-bikes on the trails during the pilot despite ghost riders riding the trails at that time (JeffCo Open Space, 2017).

JeffCo Open Space public managers also offered e-bikes for the public to ride in parks for 30-minute trial periods. Land managers surveyed participants before and after their rides. Sixty-five percent of participants changed their perceptions towards e-bikes after riding one (JeffCo Open Space, 2018). One notable takeaway from the pilot was that the public had little to no tolerance for throttle e-bikes and recognized them instantly. This led the park to restricting e-bike use to peddle-assist e-bikes only with Class 1 e-bikes permitted on both natural surface and paved trails and Class 2 e-bikes permitted on only paved trails. Also germane to this research question are the Maroon Bells' previously noted strategies and upcoming e-bike rental tracking system pilot project, which are aimed at improving e-bike rider etiquette and safety.

B. *How do agencies and authorities use data-driven decision making when solving problems related to e-bikes? What are the most effective methods?*

The study team did not identify relevant literature. However, Maroon Bells stakeholders purchased and installed a bike counter to collect bike data on Maroon Creek Rd. for the 2021 season. In 2022, this data collection will continue and will be augmented by the previously described e-bike rental tracking system. This data will allow the stakeholders to better understand when bicyclists and specifically e-bike renters are accessing the Bells. These data sources will help inform any future changes in e-bike access along Maroon Creek Rd. For example, if the data shows that there is an overwhelming number of bicyclists at certain times and/or during certain days, the stakeholders may decide to limit the access of e-bike renters and/or other bicyclists to the Bells at peak times by instituting a reservation system and/or an incentive program to spread out the peak usage to other times.

C. *What are best practices for agencies incorporating public input into the process of determining e-bike access in public lands?*

The study team did not identify relevant literature. As part of the EA conducted by the Tahoe National Forest, the public submitted 54 comments over two 30-day scoping periods concerning the East Zone Connectivity and Restoration Project (US Forest Service, 2022). The local newspaper published legal notices twice before the comment period opened and the Forest distributed a scoping letter and map to more than 120 individuals, groups, and Tribes disclosing information and seeking public comment.

The Forest also invited people to review and comment on the preliminary EA for 30 days following a legal notice published in the local newspaper and another letter distributed to potentially interested individuals, organizations, agencies, and Tribes. As a result, written timely comments were received from 114 individuals and organizations. Forty-nine commenters were supportive of the proposed project; the remaining 65 comment letters were carefully reviewed and used to consider issues and refine both the proposed action and the project effects analysis. The Decision Notice and FONSI includes an appendix with written responses to the comments categorized by topic.

D. How do agencies make the process of determining e-bike access in public lands transparent to participants and observers?

Public comments or minutes are published online for most survey and public input meetings. As described above, the Tahoe National Forest responded to over 160 public comments regarding the East Zone Connectivity and Restoration Project. For the Maroon Bells, the Pitkin County Board of County Commissioners met to discuss the issue of unsafe bicycle etiquette along Maroon Creek Rd. in early 2022. The stakeholder group made a presentation about previous efforts, impacts, and possible future strategies to address this issue. The presentation and other meeting materials were posted to the County's website several days in advance of the meeting and the local newspaper ran a few articles and op-eds on the topic. The Commissioners garnered input from their constituents before the meeting and made their recommendations for next steps based on this input and the discussion at the meeting, which was open to the public.

E. What are the current processes for consensus building and coordination between differing land management jurisdictions in the context of trail infrastructure?

There is limited scholarly research on multi-agency coordination of managing e-bike use. Seattle Parks and Recreation (SPR) was part of a successful e-bike regulation harmonization effort among State, County, Federal, and private sector partners. In 2018, Washington State passed SB 6434 allowing class 1 and 2 e-bikes on multi-use paths, unless otherwise prohibited by a local jurisdiction. At that time the only jurisdiction in Seattle prohibiting e-bike use was SPR. The agency's existing policies caused an inconsistent regulatory patchwork among local agencies and entities. To remedy this inconsistency, SPR consulted with those other agencies on their e-bike policies, which included Seattle Department of Transportation (SDOT), Port of Seattle, and the University of Washington. Their insight helped inform SPR's Multi-Use Trail Pilot that allowed the same types of e-bikes on multi-use trails as those owned or operated by partner agencies. During the pilot, SPR received input from community organizations, gathered trail data, and conducted a community perceptions and conflict (Morrison, 2020).

Once the pilot was completed, SPR worked with adjacent jurisdictional partners to harmonize their policies with one another. During this period one of their partners, SDOT, indicated that they were expanding their bike share program to include e-scooters. SPR adopted a broader and more flexible policy language that allowed it to adapt to emerging technologies and remain synchronized with adjacent jurisdictional policies. The new SPR e-bike policy allowing e-mobility devices on multi-use trail sections was put into effect in 2020 and remains consistent with Seattle's multi-use trail network.

F. As a general practice, how can Federal and State regulatory processes better align with one another regarding e-bikes?

The study team did not identify relevant literature.

G. How do agencies coordinate enforcement resources when policies or regulations of e-bikes differ between jurisdictions?

There is limited scholarly research on multi-agency coordination of managing e-bike use. One limited example was provided during discussions with SPR. After establishing e-bike policy for their multi-use trails the agency collaborated with SDOT to install speed limit and safety signs. The new policy instituted a 15 miles per hour (m.p.h.) speed limit for all recreation devices on multi-use trails (Morrison, 2020). The speed limit is consistent with SDOT and King County's managed trail speed limits, which in some areas connect to SPR lands. However, despite the presence of signs on trails it was not clear what the level of enforcement may be to impose the speed limit.

I. How do agencies best coordinate and/or leverage funding sources for facilities that support continuous access for specific or unique uses across their jurisdictions?

The study team did not identify relevant literature.

5. Conclusion

New technology, features, formats, and marketing have contributed to an explosion in the popularity of e-bikes over the last several years. E-bikes are here to stay, and their use will likely continue to be a growing part of the transportation landscape in public lands. Understanding the benefits and challenges they pose for public lands requires additional research, as note throughout this report. The study team hopes the study methodology and research questions help guide future primary research to address the many gaps in empirical knowledge about e-bike use in public lands, to inform science-based, data-driven decision making.

5.1. Future Research

Table 6 provides a high-level matrix of recommended strategies to address the various issues areas under the study methodology, where future research is needed. These recommendations are not applicable in all cases. However, they demonstrate how specific research methods may be able to yield insights across multiple issue areas. Future research study proposals may wish target multiple issue areas, even if pursuing a single research method. Conversely, they also demonstrate how multiple research methods may be combined to yield insights into specific issues. While combining research methods is more challenging, researchers may benefit from coordinating to tackle complex issues from different angles using multiple research methods, to achieve richer results.

Table 6: Potential Future Research Strategies Matrix
Source: U.S. DOT Volpe Center

Focus Area	Issue Area	Data Review		Interactive Study			Field Experiment		
		Market Analysis	Analysis of Ridership & Injury Data	Survey	Interview	Case Studies	User Behavior Study	Enforcement Trials/Pilot Study	Trail Condition & Design / Engineering
1. NATURAL	1.1 Natural Surface Trail Condition and Wildlife				X	X	X		X
	1.2 Historical and Cultural Resources			X	X	X			
	1.3 Mode Shift and Environmental Benefits	X		X	X	X	X		
2. SAFETY	2.1 E-Bike-Related Injury		X	X	X				
	2.2 Emergency Response				X	X			
3. SOCIAL	3.1 Education and Communication to Trail User Groups	X		X	X	X	X	X	
	3.2 Visitor Use		X	X	X	X			X
	3.3 Equity and Accessibility		X	X	X	X			X
	3.4 Keeping Up with Evolving Technology	X			X	X		X	
	3.5 Expanded E-Bike Access and Existing Uses		X	X	X	X	X		X
4. PROCESS	4.1 User-Purpose-Place Alignment		X		X	X	X		
	4.2 Multi-Agency Coordination				X	X	X	X	X

5.2. Field Research

As the first national-scale literature review on the subject of e-bikes in a public lands context, this report is broad in nature. The study team was able to answer some research questions more thoroughly than others. For some research questions, the study team found little or no published information.

To begin filling the gaps they identified in current research, the study team also embarked on a human factors field research task. As of the writing of this report, Volpe is soliciting participants and collecting primary data in a natural experiment that will evaluate and compare e-bike and conventional rider behavior on the Battle Road Trail, a meandering crushed stone multi-use path in Minute Man National Historical Park, in Concord and Lincoln, Massachusetts.

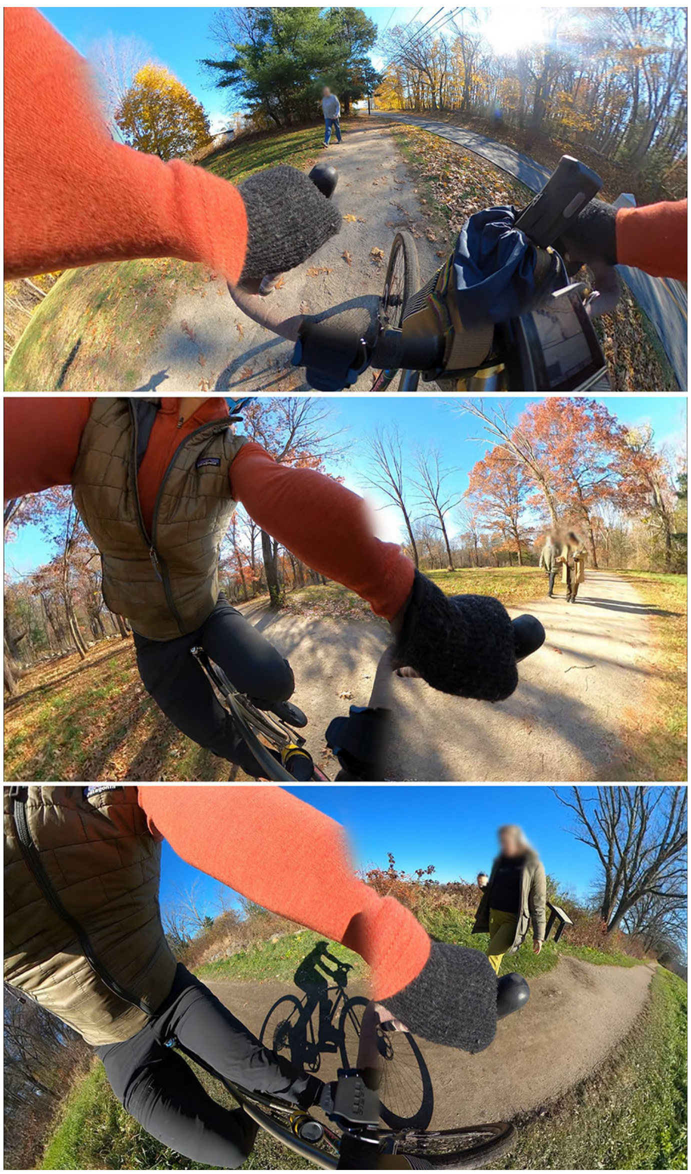

Figure 1: Still frames from video footage on Battle Road Trail
Source: U.S. DOT Volpe Center

The study assesses rider behavior by capturing and analyzing 360-degree video and telematics data from a handlebar mounted, GPS-enabled video camera. The Volpe Center will collect participant data over the spring and summer of 2022 and will complete analysis in the fall of 2022. A field study report, to be published as an addendum to this final report, is anticipated to be released in the winter of 2022/23.

A sample of participant video and speed data is posted online. (U.S. DOT Volpe Center, 2022)

Western Federal Lands and the Volpe Center will undertake a Phase 2 of this project in 2023. Phase 2 will design and conduct additional field studies to continue filling the research gaps identified in this report. Interested parties should contact the study authors for more information.

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Appendix A: Federal Laws and Regulations

Innovations in electric motors and battery technology have made e-bikes into an attractive low-speed alternative mode of transportation. U.S. Federal law has been amended to define e-bikes, general safety specifications they must be built to, and where they can be used. The Consumer Product Safety Commission (CPSC) is charged with regulating the manufacturing of low-speed electric bicycles while the National Highway Transportation Safety Administration (NHTSA) covers regulation of vehicle safety standards. Distinguishing e-bikes from other modes of transportation provides manufacturers with greater certainty in what safety and product designs would be acceptable on the market.

Title 23 of the U.S. Code, Section 217(j), as modified by the Bipartisan Infrastructure Law, defines e-bikes as a bicycle "equipped with fully operable pedals, a saddle or seat for the rider, and an electric motor of less than 750 watts." The definition also employs the three-tier classification and describes each class of e-bike. 23 U.S.C. 217(h)(4) restricts where an e-bike can be used on nonmotorized trails and pedestrian walkways that use Federal highway program funds, except where State or local regulations permit their operation. An FHWA memorandum clarifies these requirements by formulating a framework for considering motorized use on nonmotorized trails and pedestrian pathways.

For projects funded under the Recreational Trails Program (RTP), the term "motorized recreation" means off road recreation using any motor-powered vehicle, except for a motorized wheelchair (23 U.S.C. 206(a)(1)). Therefore, for RTP-funded projects, e-bikes are motorized use.

In 2002, Congress passed H.R.727 - Public Law 107-319, codified as Title 15 U.S.C. § 2085, which amends the Consumer Product Safety Act to define an e-bike as, "a two- or three-wheeled vehicle with fully operable pedals and an electric motor of less than 750 watts (1 horse power), whose maximum speed on a paved level surface, when powered solely by such a motor while ridden by an operator who weighs 170 pounds, is less than 20 miles per hour (mph)." Furthermore, H.R.727 states, "For purposes of motor vehicle safety standards issued and enforced pursuant to chapter 301 of title 49, United States Code, a low-speed electric bicycle (as defined in section 38(b) of the Consumer Product Safety Act) shall not be considered a motor vehicle as defined by section 30102(6) of title 49, United States Code." Therefore, e-bikes are subject to product safety regulations governing conventional bicycles and are not subject to NHTSA vehicle standards. The Consumer Product Safety Act only applies to product safety regulation and does not preempt traffic laws or vehicle codes.

For purposes of Federal highway programs, e-bikes are defined under 23 U.S.C. § 217(j)(2), amended in 2021 with the passage of the Infrastructure Investment and Jobs Act (Public Law 117-58), as "a bicycle equipped with fully operable pedals, a saddle or seat for the rider, and an electric motor of less than 750 watts; that can safely share a bicycle transportation facility with other users of such facility; and that is a class 1 electric bicycle, class 2 electric bicycle, or class 3 electric bicycle" (Infrastructure Investment and Jobs Act, 2021). The Infrastructure Investment and Jobs Act also revised 23 U.S.C. § 405, which provides funding for safety programs, establishing that an individual using an electric bicycle is considered a nonmotorized road user.

23 U.S.C. § 217(h)(4) restricts where an e-bike can be used on nonmotorized trails and pedestrian walkways that use Federal highway program funds, except where State or local regulations permit their operation. An FHWA memorandum clarifies these requirements by formulating a framework for considering motorized use on nonmotorized trails and pedestrian pathways (FHWA, 2021).

2.2 Federal Land Management Agency Approaches

The Secretary of the Interior issued Secretarial Order 3366 in April 2018 "to ensure [DOI] public lands and waters … are open and accessible for recreational pursuits." On August 29, 2019, the Secretary issued Secretarial Order 3376, which directed DOI bureaus to revise their regulations to define the term "electric bicycle" and to exempt e-bikes from the definition of motor vehicle to "increase recreational opportunities for all Americans, especially those with physical limitations, and to encourage the enjoyment of lands and waters managed by the Department of the Interior." The order initiated several efforts to reform existing e-bike policies of Federal land management agencies. Four DOI bureaus (Bureau of Land Management, National Park Service, Fish and Wildlife Service, and the Bureau of Reclamation) and the US Forest Service have finalized rule changes regulating the use of e-bikes within their jurisdictions (Federal Highway Administration, 2022).

One of the reasons given for the rule change was to harmonize regulations between Federal, State, and public land regulatory systems that already allow e-bikes. In general, the DOI e-bike rules (Order No. 3376) aim to:

- Remove e-bikes from the definition of a motor vehicle in each agency's respective regulations.
- Provide land managers with authority to permit e-bikes in nonmotorized areas.
- Afford operators of e-bikes the same access as those riding a conventional bicycle.
- Allow land managers greater flexibility to manage e-bikes at their jurisdictional level.

Table 7 summarizes the rules changes for the DOI bureaus and Forest Service.

Table 7: Federal Land Management Agency E-bike Regulatory Code Changes

Agency	Code	Rule Changes
Bureau of Land Management	43 CFR 8340.0-5	• Adopts an e-bike definition and BPSA classifications. • Excludes e-bikes from the definition of motor vehicle when used on roads and trails where mechanized, nonmotorized use is allowed or if the e-bike is not being used in a manner where the motor is being used exclusively to propel the rider. • Discretion for district and field managers to determine when e-bikes should be used in areas during the land-use planning or implementation decision-making process. • Applies standard bicycle laws to e-bike riders. • Prohibits throttle-only use of e-bikes in nonmotorized areas.
National Park Service	36 CFR 1.4	• Adopts an e-bike definition and BPSA classification. • Excludes e-bikes from the definition of motor vehicle. • States that superintendents may allow e-bikes, or certain classes of e-bikes, on roads, parking areas, administrative roads, and trails that are open to conventional bicycles. • Requires that if superintendents open locations to e-bikes, that they notify the public pursuant to 36 CFR 1.7. • Clarifies that superintendents have the authority to limit or restrict e-bike use after taking into consideration public

		health and safety, natural and cultural resource protection, and other management activities and objectives. • Applies certain regulations that govern the use of conventional bicycles to the use of e-bikes. • Prohibits the possession of e-bikes in designated wilderness areas. • Prohibits throttle-only use of e-bikes in non-motorized areas.
Fish and Wildlife Service	50 CFR 27.31	• Adopts an e-bike definition and BPSA classification. • Discretion for refuge managers to designate roads and trails as open to e-bikes. • Prohibits the possession of an e-bike in designated wilderness. • Provides an off-road vehicle exclusion when used on roads and trails where mechanized, nonmotorized use is allowed or if the e-bike is not being used in a manner where the motor is being used exclusively to propel the rider. • Affords people riding e-bikes the rights, privileges, and duties of the operators of nonmotorized bicycles on roads and trails where e-bikes are allowed. • Encourages managers to limit, restrict, or impose conditions on both conventional bikes and e-bike use where necessary to manage safety conflicts and resource protection.
Bureau of Reclamation	43 CFR 420	• Adopts an e-bike definition and BPSA classification. • Excludes e-bikes from the definition of an "off-road vehicle." • Authorizes discretion for regional directors to allow e-bikes on roads and trails where bicycles are permitted. • Provides an off-road vehicle exclusion when used on roads and trails where mechanized, nonmotorized use is allowed or if the e-bike is not being used in a manner where the motor is being used exclusively to propel the rider. • Affords people riding e-bikes the rights and privileges and be subject to all the duties, of nonmotorized bicycles.

Forest Service	E-bikes in FS Lands (link to updated FSM directives and FAQ)	• Defines an e-bike as a type of motor vehicle with two or three wheels, fully operable pedals, and an electric motor of not more than 750 watts that meets the requirements of one of the following three classes:
		  ◦ Class 1 E-Bike. An e-bike equipped with a motor that provides assistance only when the rider is pedaling and that ceases to provide assistance when the e-bike reaches the speed of 20 miles per hour.
		  ◦ Class 2 E-Bike. An e-bike equipped with a motor that may be used exclusively to propel the e-bike and that ceases to provide assistance when the e-bike reaches the speed of 20 miles per hour.
		  ◦ Class 3 E-Bike. An e-bike equipped with a motor that provides assistance only when the rider is pedaling and that ceases to provide assistance when the e-bike reaches the speed of 28 miles per hour.
		• Establishes new criteria for designating Class 1, 2 and 3 e-bikes on Forest Service trails, roads and lands.
		• Creates specific criteria for designation of motor vehicle use on trails and guidance for designated e-bike use on trails. This includes an additional category (Trails Open to Electric Bicycles Only) to identify classes of motor vehicles on a motorized vehicle use map.
		• Adds an objective to consider emerging technologies, such as e-bikes, that are changing the way people access and recreate on National Forest System (NFS) lands.
		• Provides an off-road vehicle exclusion when used on roads and trails where mechanized, nonmotorized use is allowed or if the e-bike is not being used in a manner where the motor is being used exclusively to propel the rider.
		• Affords people riding e-bikes the rights and privileges and be subject to all the duties, of nonmotorized bicycles.

Appendix B: TRG Members

Table 8: Technical Review Group (TRG) Members

Agency	Category	Name
Bureau of Land Management	Federal Land Manager	Dave Jeppesen
Bureau of Reclamation	Federal Land Manager	Matthew Dayer
Fish and Wildlife Service	Federal Land Manager	Mike Carlo
National Park Service	Federal Land Manager	Krista Sherwood / Steve Suder
US Army Corps of Engineers	Federal Land Manager	Meredith Bridgers
US Forest Service	Federal Land Manager	Penny Wu
Kentucky Federal-Aid Division Office	FHWA Division Office	Darrin Grenfell
Oregon Department of Transportation	State DOT	Jessica Hornig
Virginia Dept. of Conservation and Recreation	State Parks/Rec	Jennifer Wampler
Pennsylvania Department of Conservation and Natural Resources	State Parks/Rec	Nathan Reigner
Larimer County Parks, Open Space, and Trails	Local Parks/Rec	Zac Wiebe
Virginia Tech	Public Institution/Research	Jeremy Wimpey
University of Tennessee Knoxville	Public Institution/Research	Chris Cherry
Portland State University	Public Institution/Research	John Macarthur

Appendix C: Technical Review Group #1 Documentation

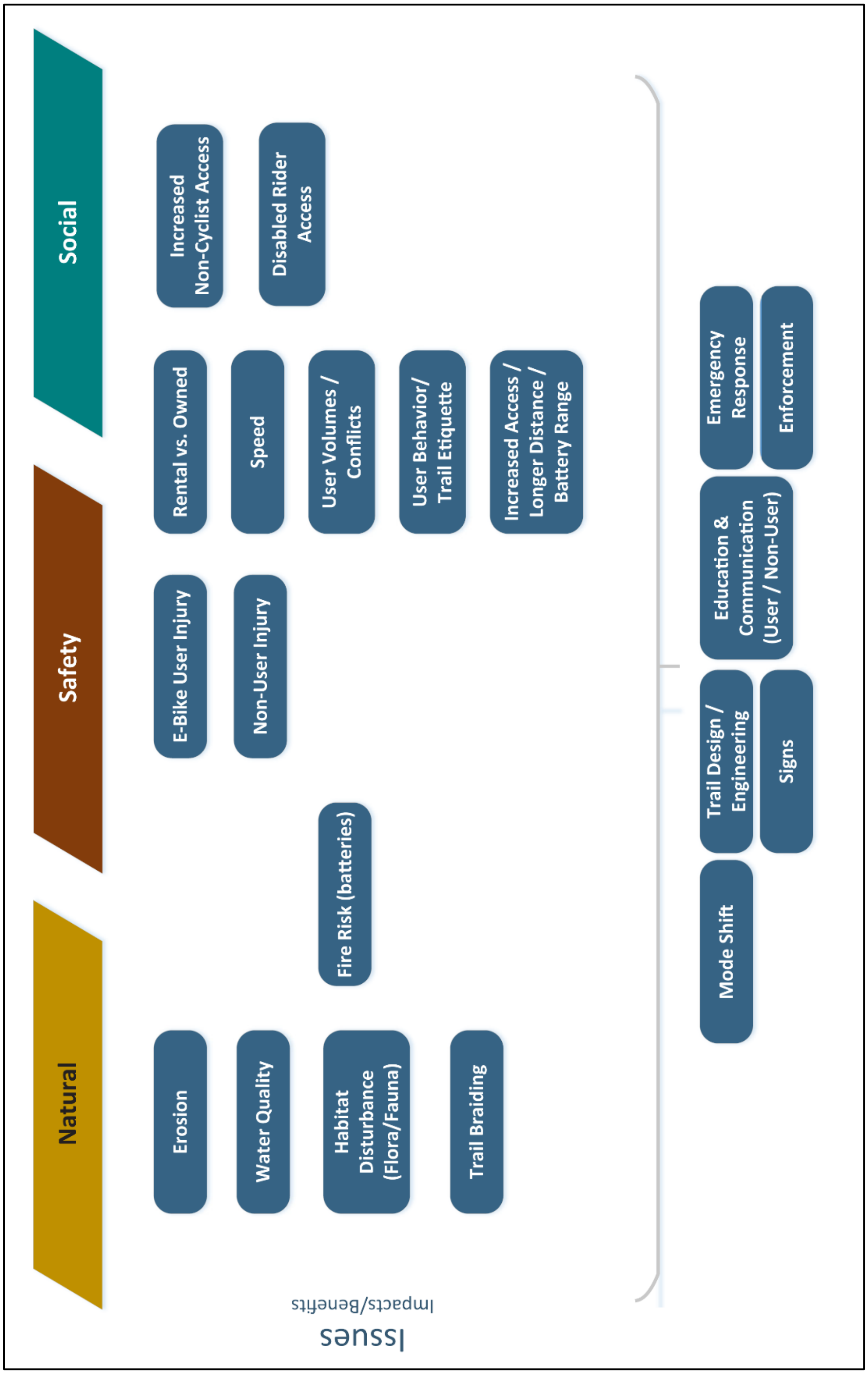

Figure 2: Technical Review Group #1 Workshop Prompt Diagram
Source: U.S. DOT Volpe Center

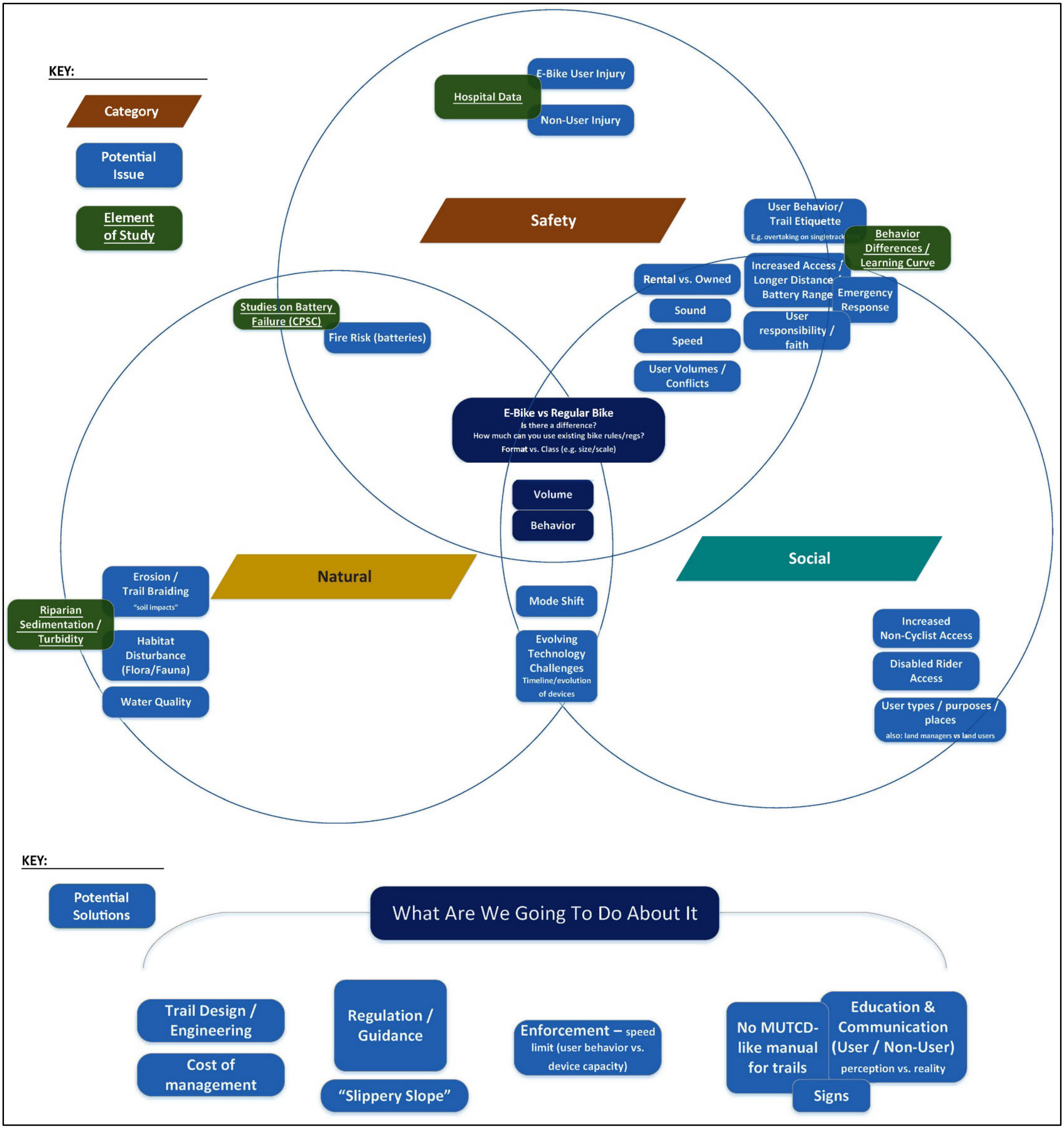

Figure 3: Technical Review Group #1 Workshop Results Diagram
Source: U.S. DOT Volpe Center

Appendix D: Stakeholder Workshop Participants

Table 9: Participants in Stakeholder Workshops and Draft Document Reviews
Source: U.S. DOT Volpe Center

Organization	Primary User Group Represented
Adventure Cycling Association	Bicyclists
International Mountain Bike Association	Bicyclists
New England and San Diego Mountain Bike Associations	Bicyclists
People for Bikes	Bicyclists
League of American Bicyclists	Bicyclists
American Hiking Society	Hikers
Pacific Crest Trail Association	Hikers
Partnership for the National Trails System	Hikers
The American Long Distance Hiking Association-West	Hikers
American Horse Council	Equestrians
Backcountry Horsemen of America	Equestrians
Equine Land Conservation Resource	Equestrians
Backcountry Hunters and Anglers	Hunters/Anglers
Izaak Walton League of America	Hunters/Anglers
Coalition to Protect America's National Parks	Naturalists/Conservationists
National Parks Conservation Association	Naturalists/Conservationists
Recreational Equipment Incorporated	Naturalists/Conservationists

Appendix E: Stakeholder Workshop Documentation

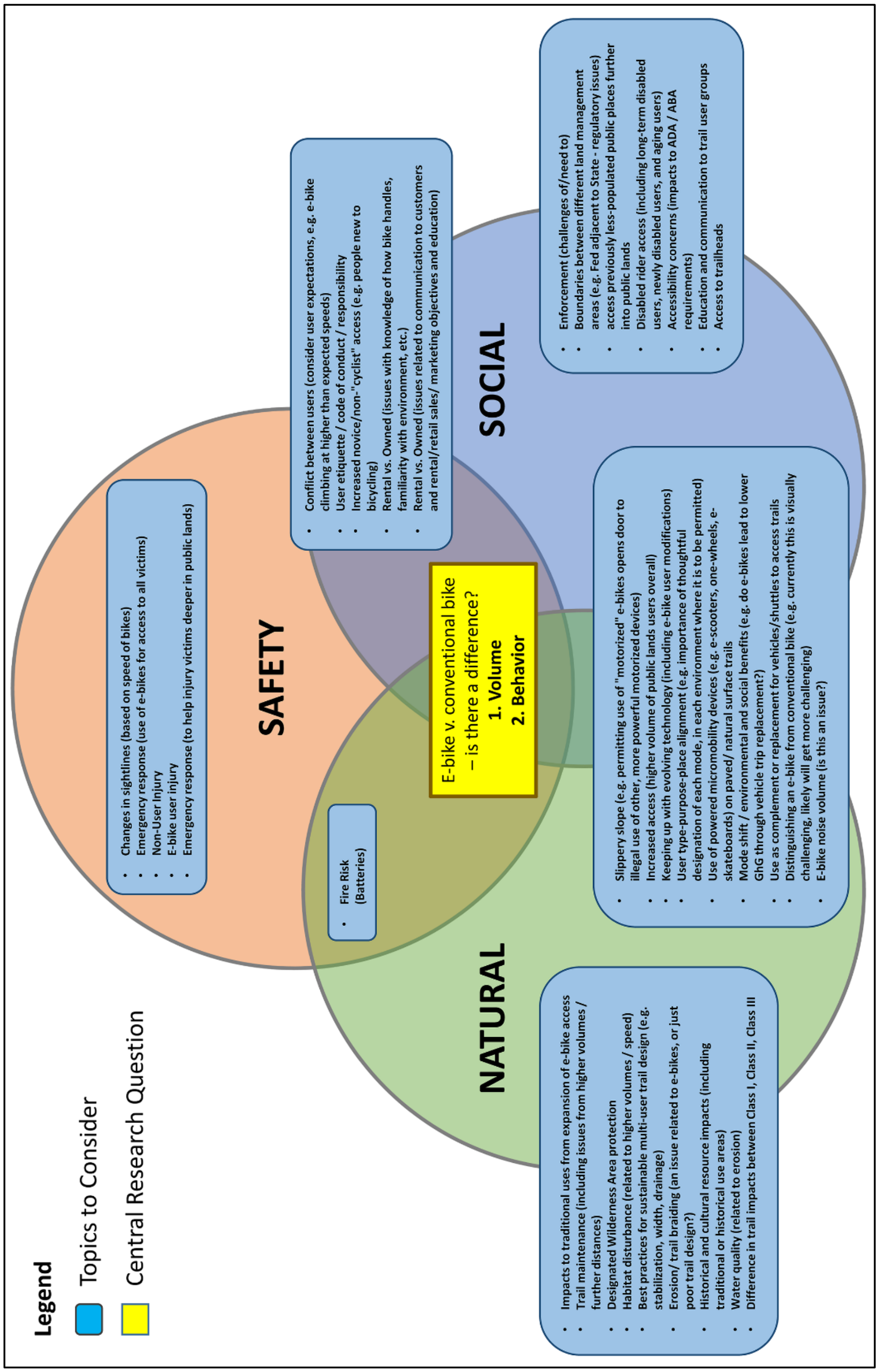

Figure 4: Stakeholder Workshop - Breakout Group Issues Framework Synthesis
Source: U.S. DOT Volpe Center

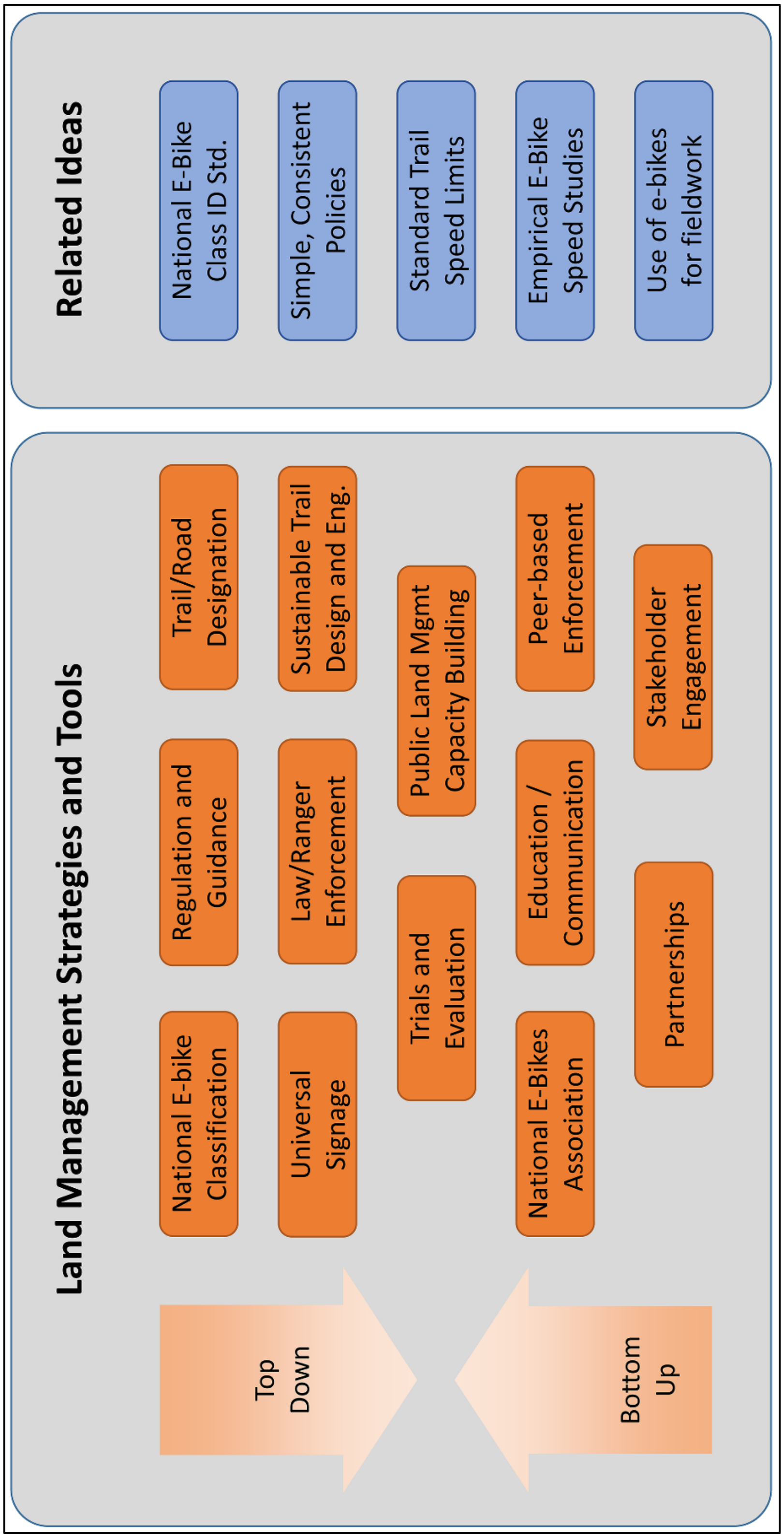

Figure 5: Stakeholder Workshop - Breakout Group Strategies, Tools, and Ideas Synthesis
Source: U.S. DOT Volpe Center