Walden Passage Feasibility Study

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The faculty and research assistants who assembled this report gratefully acknowledge the time and assistance generously given to them by the many residents of Concord and Lincoln, the Advisory Board, Richard T.T. Forman of Concord and Harvard Graduate School of Design, and the staff of the towns of Lincoln and Concord.

Executive Summary

In 2004, the Federal Highway Administration (FHWA) awarded a Transportation, Community and System Preservation Program (TCSP) grant to fund this feasibility study. This grant is a result of a proposal for a wildlife/pedestrian overpass in historic Walden Woods initiated and advocated by the Walden Woods Project. The Metropolitan Area Planning Council (MAPC), the Regional Planning Council for the Boston metropolitan region, is administering the feasibility study. In 2006, the MAPC contracted with the University of Massachusetts Center for Economic Development who asssembled an interdisciplinary team from the University of Massachusetts to examine the feasibility of establishing a combined crossing for wildlife and recreational users along a predefined study area, a 2.5-mile section of Route 2 in Concord and Lincoln, Massachusetts--bounded by the Sudbury River on the west and Crosby's Corner to the east (Map 1).

Land use in the study area is mixed, including protected forests, single-family homes, condominiums, wetlands and agricultural land. The study area also borders the Walden Pond State Reservation, Brister's Hill Conservation Area, Goose Pond, the former Concord Landfill, Concord Carlisle Regional High School, and the Sudbury River floodplain. Four wildlife crossing culverts and associated retaining walls were installed in the study area in 2004 to allow wildlife to safely cross beneath Route 2. These improvements were included as part of a Route 2 improvement project by Mass Highways to reduce vehicle-animal conflicts.

Route 2, built in the 1930s, is recognized by citizens and officials of Concord and Lincoln as a significant barrier to humans as well as wildlife. The road corridor bisects the historic Walden Woods area and separates Concord center from Walden Pond. The division and separation created by the road corridor has a negative effect on the perception of the larger cultural landscape for residents of the area and for the thousands of tourists who come from all over the world to appreciate it, as well as for resident and migratory wildlife.

The study area is also part of a larger cultural landscape of great significance. Hundreds of thousands of people visit the area annually to see and learn about the American Revolution at the Minute Man National Historic Park, to learn about Henry David Thoreau, Ralph Waldo Emerson, the Transcendalists and Walden Woods, and to visit the historic town centers of Concord and Lincoln. Others experience the area by hiking the historic Bay Circuit Trail and many recreational trails in Concord and Lincoln.

This study for a wildlife and recreational crossing analyzed wildlife distribution in the study area using Massachusetts Natural Heritage data and data from the Wildlife Passages Task Force, a subcommittee of the Concord Natural Resources Commission. Wildlife tracking and monitoring was conducted in the study area, and included monitoring of the four wildlife crossing culverts. The wildlife analysis determined that there are no known endangered or state-listed species in the study area that would make use of an additional wildlife crossing. Furthermore, the existing wildlife crossing culverts under Route 2 are being used successfully by a majority of species that might be served by an additional crossing. However, an additional crossing could serve as a demonstration project for a crossing structure for arboreal species. Such crossings have not yet been implemented in North America but are being used in Australia.

Public participation was integral throughout the

study. Three potential alternative crossing locations were determined after analyzing historical and new data on the study area including: preliminary wildlife data, traffic and highway information, adjacent land uses, recreational activities, and cultural landscape significance. These alternatives plus a no-build alternative were presented and discussed at public workshops.

Based on the study team's investigations and input from the project's advisory board and citizens, an overpass structure to be located to the west of Sandy Pond Road, in the vicinity of Goose Pond showed the most merit. This location links protected and publicly-owned land on both sides of Route 2. This location provides the best terrain for implementing a demonstration arboreal crossing structure, with the primary target species being southern flying squirrels (Glaucomys volans). The major benefit of a combined wildlife-pedestrian passage at this location would be to provide significant recreational linkages with existing trails including the Bay Circuit Trail, Walden Pond State Reservation trails, Thoreau's Path on Brister's Hill, and the Emerson-Thoreau Amble (currently under construction)(Map 2). These trails could potentially be linked with those of the nearby Minute Man National Historical Park. All of these trail connections would contribute to a re-connection of Concord and Lincoln across the Route 2 corridor. This is the preferred alternative recommended by this study.

Other alternatives discussed and presented included a no-build alternative which would leave existing conditions as they are and make no additional grade-separated crossings of Route 2 in the study area. Under the no-build alternative, wildlife would likely continue using the existing wildlife passage culverts and railroad underpass in the study area. Primarily, because no improvement for recreational access of crossings would be provided by the no-build option, this option is not recommended.

A crossing at the Sudbury River would involve a new bridge for Route 2, raised to allow dry "shelves" for wildlife/recreational passage on one or both sides of the river underneath the bridge but above river levels. This location was determined to be potentially important at a regional scale for wildlife passage by enhancing linkages between the north and south sections of the Great Meadows National Wildlife Refuge, and to restore the continuity of the Sudbury River as a regional ecological corridor. As a combined wildlife-recreational passage, however, this alternative lacks any significant connections with existing recreational trails and would have little potential for cultural landscape interpretation. This alternative is therefore not recommended.

A crossing at the existing Fitchburg Railroad underpass would involve relocation and reconstruction of the existing highway bridge abutments to provide a wider underpass in which wildlife and recreational passage could occur on one or both sides of the existing railroad tracks, separated from the tracks by fencing or a wall to assure safety. This location is already used as a crossing by wildlife, although reconstruction of the underpass could increase its functionality. This location also has some potential for interpreting the cultural landscape, since Thoreau used the railroad as a favored path to his cabin on Walden Pond. Safety concerns and lack of linkages with recreational trails are serious detriments to this option. Furthermore, a crossing at this location also could provide unmonitored pedestrian access to the Walden Pond State Reservation from the northwest. This increased access could exacerbate capacity management challenges at the Reservation. This

option is, therefore, not recommended.

In addition to recommending the Goose Pond alternative as a feasible combined wildlife-human crossing, the study has several related recommendations:

- Although there is no funding identified for this passage structure at this time, Project Advisory Board members and comments at public workshops repeatedly recommended that the funding for the proposed passage structure remain independent from funding for the proposed Route 2 grade separation project known as the "Crosby's Corner" project, and that funding for the passage structure does not preclude, pre-empt, jeopardize, or delay the Crosby's Corner project.

- That any future reconstruction or replacement of the Route 2 Sudbury River bridge include provisions for safe wildlife passage beneath the bridge on both sides of the river (i.e. an elevated bench above normal high water level).

- That a recreational user needs study of the study area be conducted to investigate the possible costs and benefits of linking trails and public lands to enhance the use and interpretive potential of the combined crossing, specifically at the Goose Pond location.

It is clear that a pedestrian crossing in the study area has the potential to greatly enhance cultural interpretation and connectivity in the study area, and mitigate the impact of Route 2 on Concord and Lincoln. Given the dual purpose of the crossing (wildlife and recreational) the recommended alternative at the Goose Pond location would lend itself to strengthened pedestrian linkages and has potential opportunities for wildlife crossings. A crossing such as the one proposed could generate significant national and international interest.

In addition, the overpass provides an excellent opportunity to be used as a model for the construction of combined passages in other ecologically and historically significant landscapes throughout the United States, or internationally. By mitigating the impacts of the Route 2 highway on the local environment, and the communities of Lincoln and Concord, the passage would support the purposes of the Transportation Community and System Preservation Program of the Federal Highway Administration. Discussions and analysis of the recommended passage structure should continue under the guidance of the Metropolitan Area Planning Council's sub-regional group.

1. Introduction

In 2004, the Federal Highway Administration (FHWA) awarded a Transportation, Community and System Preservation Program (TCSP) grant to fund a feasibility study for a combined wildlife-recreational crossing of Route 2 in Concord, Massachusetts. The project was initially proposed by the Walden Woods Project and is administered by the Metropolitan Area Planning Council (MAPC), the Regional Planning Council for the Boston Metropolitan region. The MAPC contracted with the University of Massachusetts Amherst Center for Economic Development, who organized an interdisciplinary team from the University of Massachusetts Amherst to examine the feasibility of establishing a combined wildlife-recreational crossing of State Route 2 in a defined study area (Map 1). The project team included experts in: wildlife biology, conservation planning, landscape architecture, landscape history, regional planning, economic development and engineering. In addition, an advisory board was established including representatives of federal, state and local governments, members of relevant state, regional and local organizations, and representatives of non-governmental organizations. The Advisory Board was convened for three meetings to scope, analyze and debate the project. A list of the UMass study team and the Advisory Board members is included in the Appendix. The Advisory Board also contributed to the organization of the public participation program focusing on three public workshops (described below).

The goal of this feasibility study is to analyze existing conditions within the study area and surrounding community to determine the feasibility and preferred location for a combined wildlife-recreational passage structure. The study area for the combined wildlife-recreational crossing includes a 2.5 mile length of State Route 2 and the adjacent lands, beginning at the Sudbury River and running east to a major intersection known as Crosby's Corner. The siting of a wildlife-recreation passage in the study area has possible cultural and recreational significance as well as potential to support wildlife use.

In 2005 the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) became law. The SAFETEA-LU authorized the Transportation, Community and System Preservation (TCSP) Program to be administered under the Federal Highway Administration (FHWA). The TCSP Program is an initiative to provide research and grants to investigate and improve the relationships between transportation, community and system preservation plans and practices. Some of the goals of the initiative are to improve efficiency of the transportation system while reducing the environmental impacts of transportation. Assistance under the TCSP Program is intended to provide financial resources to states and communities to explore the integration of transportation programs with community preservation and environmental activities. Other projects that have been funded under the TCSP Program include pedestrian and bike trails, downtown and waterfront revitalization projects, wildlife corridors and road improvements. Since the inception of the program in 2001, this is the first project to consider a combined wildlife/pedestrian crossing (http://www.fhwa.dot.gov/tcsp/ accessed 11/11/07).

State highways with traffic volumes from 41,000-53,000 vehicles per day, such as Route 2, may represent a significant barrier for wildlife. The loss of habitat connectivity caused by roads disrupts the natural movement of wildlife and causes physical

isolation, increased wildlife mortality, and traffic hazards for drivers. In order to mitigate the effect of major highways on wildlife, ecologists, landscape architects, and engineers have joined together in projects across the United States and Europe to help wildlife gain safe passage over and under roads. The recently installed wildlife crossing culverts in the study area beneath Route 2 are important for wildlife, but were not intended to accommodate human use. Open space connectivity is not only important for wildlife, it is also important for humans who benefit from the opportunity to travel through connected and protected "green" spaces for recreation or cultural landscape interpretation. Therefore, this study will examine a wildlife passage structure that crosses over, or under, State Route 2 in the study area, accommodating both humans and wildlife.

Many thousands of people annually visit this area to experience this unique historical and cultural landscape. Concord and Lincoln represent one of the few landscapes in the United States with such significant historical associations, active farmland, woods, rivers, ponds, and trails. The colonial settlement of the region, together with its later military significance during the American Revolution, have made this landscape the setting of widely shared narratives of national origins and identity. In the nineteenth century, the same landscape witnessed the founding of equally significant traditions in American literature and philosophy, known as the Transcendentalist movement. The continued cultural and economic vibrancy of Concord and Lincoln in the twentieth century has helped preserve, interpret, and revitalize the regional landscape for residents and visitors alike. During the 20th Century the Minute Man National Historical Park and the Great Meadows National Wildlife Refuge were established in the area.

This storied landscape remains unique, and uniquely significant, in American history and culture. Thus, this project holds significant potential for regional, national and international recognition.

The study methodology included literature reviews, wildlife monitoring data analysis, case studies on existing highway crossings, research on economic data, review of local zoning and land use information, an engineering study, and an evaluation of preferred combined wildlife-recreational crossing locations using project-specific criteria. In addition to the research component, the project included a public participation process that was conducted in compliance with the requirements of the FHWA Sections 23CFR450.212(a) and 450.316(b)(1). The FHWA defines an effective public involvement process as an open exchange of information and ideas between the public and transportation decision makers. The overall objective of a project's public involvement process is that it be proactive, and provide complete information, timely public notice, full public access to key decisions, and opportunities for early and continuing involvement. It also provides mechanisms for the agency or agencies to solicit public comments and ideas, identify circumstances and impacts which may not have been known or anticipated by public agencies, and, by doing so, to build support among the public who are stakeholders in transportation investments which impact their communities. As part of the public process, a project website was created to inform the public throughout the project (www.umass.edu/waldenpassage). The website includes a project description, a schedule of public meetings, maps and photographs of the study area, and links to relevant information, including contact information to submit questions. The website also provided access to the two draft reports (down-loadable in pdf format). In addition, printed copies of both report drafts were made available at the public libraries of Concord and

Lincoln. Three public workshop meetings were held: October 2006, January and June 2007. The public was invited to these meetings through announcements in local and regional newspapers, the project website, through local organization's newsletters and email listings, and notices posted in public places in Concord and Lincoln. The advisory Board was also involved in announcing project workshops.

This report is organized to first provide a summary of published literature on wildlife and combined wildlife-recreational crossings and on cultural landscape history and interpretation. This is followed by a detailed analysis of existing conditions including planning and economic development, highway planning, land use, environmental and recreational issues, and the local cultural landscape context. Next we report findings on existing wildlife presence and movement in the study area, as determined by multi-year tracking and photographic surveillance. Based on this analysis of existing conditions, we identified and analyzed three alternatives for a combined wildlife-recreational crossing, plus a no-build alternative. The study concludes with a comparative analysis of the alternatives and a recommendation of a preferred alternative. The report includes an appendix and reference section which document important details and information sources used in the project.

2. Literature Reviews

2.A. Wildlife and Combined Wildlife-Recreational Crossings

Summary

Roads pose a key threat to wildlife conservation worldwide through their direct effects on wildlife populations via road mortality and indirect effects such as habitat fragmentation. Passage structures for wildlife across roads and highways are vaunted as partial solutions to these problems. Passage structures can take many forms, from broad overpasses, often known as 'ecoducts,' to underpasses that aim to allow movement of smaller species, such as salamanders traveling to critical breeding ponds. Most of these structures have been implemented in remote areas or in areas with little human traffic. Here, we examine opportunities for implementing a joint wildlife passage and human recreational corridor in eastern Massachusetts where large areas of remnant open spaces are interspersed with towns and suburban development.

We first review the literature on road effects and passage structures for wildlife alone, presenting guidelines for best designs and locations for species occurring in eastern Massachusetts. Our review identified no particular species or group of species of regional conservation concern as motivating the addition of a Walden Passage to Route 2. We note, however, that connectivity for many wildlife species could become more limited as the Boston Metropolitan Area expands along Route 2 in the Study Area.

Second, we review cases of combined human-wildlife crossings, evaluating whether or not human activity in passage structures compromises their effectiveness and addressing potential for human-wildlife conflict throughout the study area. We conclude that human activity has compromised the effectiveness of some combined human-wildlife passage structures. However, the species present in eastern Massachusetts are likely to be among those most resilient to human activity. Landscape context is a design consideration raised by both components of our review. Therefore, we direct our analysis of the alternative locations for the Walden Passage toward measuring the potential for each structure to increase connectivity between large protected forest tracts in the region. We conclude that combined passage structures for humans and wildlife, such as the proposed Walden Passage, may provide an additional tool for recreational planners and wildlife managers.

Defining the issues

Roads pose a key threat to wildlife conservation worldwide through their direct effects on populations via road mortality and habitat loss and indirect effects such as elevated noise levels and habitat fragmentation. Passage structures for wildlife across roads and highways present opportunities to ameliorate some of these problems. Here we present a review of the literature on road effects and passage structures, with a particular focus on species and solutions relevant to the Route 2 – Concord/Lincoln region of eastern Massachusetts.

The Route 2 - Concord/Lincoln region poses a set of unique challenges relative to most other places where wildlife passage structures have been implemented, that of higher human densities. Wildlife passage structures in North America have typically been implemented in remote areas or in areas with little human traffic, though as we discuss below, even these can be used by people. Furthermore, the Concord/Lincoln area is not simply populous in terms of residents, it is a major historical site with thousands of visitors daily in peak tourism seasons. Since these recreational users would

also benefit from increased opportunities to safely cross the busy Route 2 highway, the area presents a potential model location for attempting innovative combined solutions to issues of impeded movement both for wildlife and for humans. A central question for this review is therefore:

What process should be used to evaluate a combined wildlife/pedestrian passage among open spaces in a suburbanizing landscape?

Two major issues must be addressed in order to answer this question, and our review is divided accordingly into two parts: First, we address the consequences of the fragmented and partially suburbanized landscape for species use of a passage structure. Here, we review what is known about wildlife use of passage structures in general and how that information applies to the Route 2 - Concord/Lincoln region. The second issue is how to manage human-wildlife interactions both within the passage structure and as a consequence of its existence. Humans can be a deterrence to animal use of the passage. Likewise, certain animals using the passage have been implicated in human-wildlife conflicts elsewhere, though no adverse human-wildlife encounters have been noted for the study area.

Finally, we present the process by which we will use this information to evaluate the alternative locations and determine best designs for a potential passage structure in the Route 2 - Concord/Lincoln area.

2.A.1 Wildlife Passage Structures as Solutions to Road Impacts

Road impacts on wildlife

Roadways are known to affect wildlife through a number of mechanisms, including: direct loss of habitat where the road is constructed, changes in adjacent vegetation, local pollution from runoff, decreased ability of animals to move freely across the landscape, and direct mortality from wildlife-vehicle collisions (Forman and Alexander 1998; Forman and Deblinger 2000; Jackson 2000; Rudolph 2000; Trombulak and Frissell 2000). Many of these impacts are difficult to mitigate once a road is already in place. The habitat lost to road construction, for example, cannot be replaced. By contrast, road mortality and reduced wildlife movement are two impacts that can at least be partially addressed through the combined use of fencing and passage structures.

By restricting wildlife movement, roads effectively fragment previously contiguous wildlife habitat into many smaller, disconnected pieces. Concrete walls, high traffic volumes, altered vegetation, and altered topography collectively reduce the ability of animals to cross roadways. Effects of fragmentation by roads can be detected at multiple levels of organization from the individual to the population and metapopulation levels. The placement of roads often influences range boundaries of wildlife, disrupts seasonal migration, alters juvenile dispersal patterns, and prevents access to key habitats such as over-wintering, feeding, or breeding sites (Aresco 2005; Jackson 1996; Jackson 2000; Klein 1971; Rudolph 2000; Ruediger 2000). Species with large home ranges may be unable to sustain populations in the small patches of habitat left within road networks (Crooks 2002; Ruediger 2000). For species that are able to persist over the short term, long term fragmentation can prevent gene flow amongst populations (Epps et al. 2005; Jackson 2000; Mader 1984;

Reh and Seitz 1990), leading to loss of genetic diversity and therefore viability of local populations. In addition, small populations are more vulnerable to local extinction as a consequence of stochastic events, like disease, hurricanes or fire (reviewed in Forman and Alexander 1998). Connectivity within a network of small, interacting populations known as a metapopulation, is necessary to support such processes as recolonization after such local extinctions (Forman and Alexander 1998; Hudgens and Haddad 2003). Finally, the loss of connectivity at the metapopulation level takes time to manifest, and the major impacts of roads in terms of local extinction of species may not be felt for decades (Findlay and Bourdages 2000). Thus, actions to mitigate road impacts need to take a long term view, encompassing likely future land use changes.

The most direct and visible impact of roads on wildlife is the increased mortality from vehicles (roadkill, hereafter). Roadkill can have a significant impact on local populations, especially when the species are rare or have low recruitment rates (Forman and Alexander 1998). Slower moving organisms such as amphibians are more vulnerable to roadkill (Hels and Buchwald 2001). In eastern Massachusetts, species such as Blanding's turtles (Emydoidea blandingii) are especially sensitive to this threat, because their life history strategy depends upon very high survival rates of the adults, which are the individuals most likely to be killed by cars (Compton 2007; Gibbs and Shriver 2002; Sievert et al. 2003). Aside from the effects on wildlife, there are human costs of roadkill. In the United States, collisions with larger animals, most commonly deer, have been estimated to cost over $1 billion in vehicle damage and personal injuries, and to result in more than 200 human fatalities each year (Conover et al. 1995). Solutions to roadkill that protect both wildlife populations and humans are therefore of paramount importance.

Types of passage structures

A number of strategies may be employed to increase the permeability of roads to wildlife, and to reduce roadkill rates. This study focuses on passage structures built to pass animals safely underneath or above traffic, but it should be noted that simple warning signs (Messmer et al. 2000), and fencing (Clevenger et al. 2001b) have also effectively reduced the impacts of roads on wildlife. Passage structures built for wildlife include several design types: small diameter tunnels; culverts; large underpasses; and overpasses (Jackson and Griffin 2000). Culverts are typically constructed to channel surface water, and may include metal tunnels (Hunt et al. 1987) as well as concrete box designs (Kaye et al. 2005). Large underpasses include bridges built over local roads and drainages (Ng et al. 2004). Sizes of effective structures vary widely. The smallest tunnels may be just a few centimeters in diameter (Jackson 1996), while the largest overpasses may be tens of meters wide and planted with trees (Van Wieren and Worm 2001).

Researchers in this young field are beginning to understand which features of passage structures are important to successfully mitigate the impacts of roads on wildlife. Effectiveness of passage structures is thought to depend on species-specific responses of wildlife to a variety of passageway design variables which include: placement, vegetative cover, size, openness (ratio of cross-sectional area to length), substrate, noise levels, moisture, temperature, light, human disturbance, and the placement of associated fencing. Wildlife overpasses may accommodate more species of wildlife than underpasses because they are less confining, quieter, maintain ambient environmental conditions, and because the structure itself can serve as intervening habitat for small animals otherwise unlikely to move long distances (McDonald and St Clair 2004). By contrast, underpasses are likely to be better

suited for animals that prefer cover (Clevenger and Waltho 2005; McDonald and St Clair 2004) or semi-aquatic organisms (Jackson and Griffin 2000).

Most previous studies of the use of passage structures aim only to determine which species are using a structure and how often. These studies do not evaluate the effectiveness of the structures at the population or metapopulation level. However, a number of researchers have compared differing structures and their levels of use (Cain et al. 2003; Clevenger et al. 2001a; Clevenger and Waltho 2000; Henke et al. 2000; Jackson and Griffin 2000; Land and Lotz 1996; Mata 2003; McDonald and St Clair 2004; Pfister et al. 1997; Rodriguez et al. 1996; Servheen and Waller 2000). From these, we derive four main recommendations for the design and implementation of passage structures (Box 1).

Box 1. Design Considerations for Wildlife Passages

(1) A mix of structure types and sizes will benefit a wider variety of species.
(2) Passage structures should be built in natural travel corridors (e.g. stream valleys, ridges or migration routes).
(3) Vegetative cover within the structure should mimic the surrounding matrix.
(4) Extensive fencing should be used to guide animals towards passageways.

Differences among species in use of passage structures

In comparing species use among structure types, we focus on the three larger passage structure types, overpasses, underpasses, and culverts, which would allow for combined use with humans. In addition, several "wildlife crossing culverts" already exist along Route 2. Thus, the important question is whether one or more larger structures are needed to improve connectivity across Route 2.

We found little justification that one structure type would be more effective than the others at allowing passage of species local to eastern Massachusetts. The published literature allows for little direct comparison of species preferences for structure types, and most comparative studies compare details of design within one of the three categories. In addition, few studies have been conducted on wildlife use of overpasses (Table 1), most of which examined structures built in Europe, making application to North American wildlife uncertain. In North America, the primary target species thought to actively avoid underpasses in favor of overpasses are large carnivores such as grizzly bears (Ursus arctos) and wolves (Canis lupus) (Clevenger and Waltho 2005). While overpasses may also provide intermediate habitat for certain small mammals and maintaining sufficient openness required by large mammals, numerous published studies suggest that most of the species occurring in the Rte 2 study area would also use underpasses and culverts (Table 1).

It is generally thought that larger structures are required for larger species. The available data indicate that the five largest species of wildlife potentially occurring in the study area (moose, deer, black bear, coyote, and bobcat) will make use of passage structures beneath a roadway (Table 1). The most extensively studied

Table 1. Cases of Known Passage Structure Usage by Species

Only data on species occurring in eastern Massachusetts or select closely related species are included. A structure underneath a roadway (or railway) is considered a "culvert" when the authors described it with the term "culvert" or the cross section is smaller than 8m wide by 3m high. We exclude cases in which the structure type that a particular species used is not specified. Likewise, use of "bridges" in one study[5] is excluded due to a lack of dimensions descriptions of the structures.

Overpass (7 studies)	**Large Underpass (9 studies)**	**Culvert or Tunnel (17 studies)**
Black bear[23]	Black bear [7,12]	Black bear [9,12,16]
	Coyote [8,13]	Coyote [8,9,14,29]
Red fox [2,3,4,5,6]	Red fox [2]	Foxes [2,9,10,14,22,16,17]
	Domestic dog [8]	Domestic dog [8,14,22,16]
	Bobcat [7,8,10,11,13]	Bobcat [8,9,10,11]
Domestic cat [2,4]	Domestic cat [2,8,13]	Domestic cat [2,8,14,22,16]
	Otter [13]	Otter [10,15]
Marten [5]	Fisher [13]	Marten [15,19]
	Mink [13]	Mink [13]
	Weasel [13]	Weasel [2,13,15,16,19]
	Striped skunk [8,13]	Striped skunk [8,15,16]
	Raccoon [7,8,10,13]	Raccoon [8,9,10,13,14,15,16]
	Opossum [8,13]	Opossum [8,9,14,16]
	Moose [12]	Moose[12]
Deer [3,4,5,6,23]	Whitetailed/Mule deer [7,8,12,13,14]	Whitetailed/Mule deer [8,9,10,12,14,16]
European rabbits, hares [2,4,6]	Rabbits, hares [2,13]	Rabbits[9]
		Snowshoe hare [15,19]
	Groundhog [13]	Groundhog [13,14]
	Muskrat[13]	Muskrat [16]
Squirrels [6]	Squirrels, Chipmunks[13]	Squirrels, Chipmunks [14,15,19]
Mice, voles, shrews [1,2]	Mice, voles, shrews[1,2,13]	Mice, voles, shrews [1,2,15,17,19]
		Spotted turtle [18]
		Other turtles [9,20]
Snakes [2]	Snakes [2,9]	Snakes [2,20]
		Spotted salamander [21]
Frogs [2]	Frogs [2]	Frogs [2,17,20]
	Turkey [10,13]	Turkey [1]

[1]Alberta, (McDonald and St Clair 2004), [2] Spain, (Mata 2003), [3]Netherlands, (Van Wieren and Worm 2001), [4]Germany & Switzerland, (De Vries 1994) as reported in (Van Wieren and Worm 2001), [5]France, (Ballon 1985) as reported in (Van Wieren and Worm 2001), [6]Netherlands, (Niuwenhuizen and Apeldoorn 1994) as reported in (Van Wieren and Worm 2001), [7]Florida, (Foster and Humphrey 1995), [8]California, (Ng et al. 2004), [9]Florida, (Roof and Wooding), [10]Florida, (Land and Lotz 1996), [11]Texas, (Cain et al. 2003), [12]Alberta, (Clevenger and Waltho 2000), [13]Vermont, (N. Charney and M. Bellis, unpublished data), [14]Virginia, (Donaldson 2005), [15]Washington, (Singleton and Lehmkuhl 2000)., [16]Pennsylvania, (Brudin 2003), [17]Spain, (Yanes et al. 1995), [18]Massachusetts, (Kaye et al. 2005), [19]Alberta, (Clevenger et al. 2001a), [20]Florida, (Aresco 2005), [21]Massachusetts, (Jackson 1996), [22] Australia, (Hunt et al. 1987), [23] Alberta, (Clevenger and Waltho 2005)

animal in the context of wildlife passages, deer, are well served by a variety of structure types that have a minimum clearance of 2-3 meters (Brudin 2003; Clevenger and Waltho 2000; Donaldson 2005; Foster and Humphrey 1995; Land and Lotz 1996; Reed et al. 1975; Rosell et al. 1995; Rossel et al. 1997; Yanes et al. 1995). Moose (Alces alces) likely require greater vertical clearance than deer, but have been poorly studied. One published source (Clevenger and Waltho 2000) and information from moose researchers in Massachusetts indicate that moose will use underpasses (McDonald, personal communication). Black bears (Ursus americanus) have a known propensity to use small dark places (Clevenger and Waltho 2005), and in Massachusetts bears have been observed on several occasions using small culverts under interstates (McDonald, personal communication). Coyotes (Canis latrans) and bobcats (Lynx rufus) have been observed using underpasses and culverts in several studies (Table 1), and bobcats have even been known to rest inside culverts for protection from the elements (Cain et al. 2003). If, however, an overpass is to be used to facilitate movements of these larger mammals, the width of the structure becomes critical, and a minimum of 50 meters is recommended (Clevenger and Waltho 2005; Van Wieren and Worm 2001).

The shelter of underpasses appears to be especially beneficial for several species. McDonald and St.Clair (2004) found that voles much preferred the shelter offered by small culverts and underpasses compared to overpasses. Underpasses and culverts with flowing water or moisture levels higher than is typical on an overpass may be better suited for animals associated with water such as mink (Mustela vison), otter (Lontra canadensis), raccoons (Procyon lotor), and amphibians (Land and Lotz 1996; N. Charney and M. Bellis unpubl. data).

Underpasses and culverts have proved quite effective, and have even helped substantially in the recovery of endangered species such as the Florida panther (Puma concolor coryi) (Swanson et al. 2005). Unfortunately, until more overpasses are built and studied, we will not be able to compare the effectiveness of these structure types for species local to eastern Massachusetts. In summary, location, vegetative cover, and fencing may influence species' use of passages more than the type of structure used (e.g. Jackson and Griffin 2000, Clevenger and Waltho 2005).

One additional type of passage structure, arboreal passageway, is relevant to the study area but not covered in Table 1 due to a lack of published studies. In Australia, considerable attention is being paid to crossings for arboreal or tree-dwelling species. A set of rare and endangered arboreal species, including native Australian possums and squirrel gliders, are strongly affected by roads (Van der Ree 2006). A series of rope bridges are being installed in Victoria, New South Wales, but no literature addresses the effectiveness of these structures.

A final important consideration in evaluating the potential use of passage structures in the Route 2-Concord/Lincoln study area is the relatively suburban nature of the surrounding landscape. Although significant open spaces remain, they are interspersed with suburban development and town centers. Urbanization, as we generically refer to this process of development, reduces species diversity but leads to increased density of remaining species (see reviews in McKinney 2002; Shochat et al. 2006). Thus, the pool of species in the study area that are likely to benefit from passage structures is reduced relative to areas covered by previous studies with larger and more contiguous habitat patches, such as the studies in Banff, Canada. The species present are also more likely to be those with behavioral or other adaptations to human-

modified environments (Ditchkoff et al. 2006; Shochat et al. 2006). This makes it even more difficult to predict species use of passage structures from studies in non-urbanized areas. However, it also means that these species may be more likely to find and use any new passage structures that are built, and will be more resilient to interactions with humans than wildlife in more remote areas. In other words, suburban wildlife species, such as those typically found in the study area, do not appear to be deterred from using areas with human scent, as evidenced by the willingness of bears, coyotes, deer and other animals to forage on human garbage, domestic pets, landscape plantings, and even bird feeders. Thus, the presence of human signs and scents in passage structures is unlikely to deter them from making crossings. Finally, options for movements among remnant patches are constrained in the study area, making every remaining corridor used by wildlife even more important over the long term. Rapid, sustained urbanization will almost certainly continue to fragment habitats in eastern Massachusetts and around the world. The Route 2 corridor in eastern Massachusetts, therefore, represents a potential model for nationwide efforts to defragment wildlife habitat in complex suburban-wildland interfaces.

2.A.2 Human-Wildlife Interactions

Impacts of humans on wildlife use of passage structures

Conventional wisdom holds that wildlife is less likely to use a wildlife crossing when there is a human presence at the crossing. Very little empirical research exists, however, to support or reject this statement. We reviewed examples of existing structures that combine human and wildlife passage, research on the effectiveness of combining the two, and information regarding the design of such structures. Wildlife crossings are a relatively new phenomenon, especially in the United States. While there are numerous tunnels and underpass structures, there are few examples of overpass structures and there are even fewer examples of structures that are designed for combined human and wildlife use, and even fewer combined structures that are monitored after they are built for animal and human use (Clevenger and Waltho 2005; Romin and Bissonette 1996; Underhill and Angold 2000, Transportation Research Board 2002).

Most literature cites the same example when discussing the human impact on wildlife crossings (Jackson and Griffin 2000; Smith 2003; Cavallaro et. al. 2005). Clevenger and Waltho (2000) found that even the best designed and landscaped underpasses may be ineffective if human activity is not controlled, based on monitoring at Banff National Park, Canada. In crossings with higher human activity, carnivores were less likely to use underpasses than were ungulate species.

More recently Clevenger and Waltho (2005) re-examined the performance of wildlife crossing structures at Banff National Park, Canada. They found that, contrary to their previous analysis, structural factors including structure width, height, length, openness (width by height or length) and noise level

were the most important factors influencing wildlife use of crossing structures. Landscape variables such as nearest forest cover, closest drainage, proximity to the railroad, town site, and other crossing structures and human activity were of secondary importance (Clevenger and Waltho 2005). Human activity was quantified by counting the number of people on foot, bike, and horseback. However, the researchers point out that studies addressing the efficacy of wildlife structures often lead to spurious results because of the difficulty in separating out confounding variables.

Arizona recently added several overpasses and underpasses and monitored their use with video surveillance. A combined pedestrian and wildlife underpass 128 meters long with a width at the floor of 7-8 meters was completed in 2004 (Gagnon et. al. 2005). The researcher did not notice any significant effects of people on the wildlife at the pedestrian/wildlife underpass other than when people directly scared off wildlife. Human use has been documented at all of the underpasses, even though only one is designed for human use. The research team is in the process of analyzing the video data to determine if there are any changes in use by wildlife following use by people. Humans tend to use the underpass during the day and their use is greatest on weekends and during the summer months. It is also possible that animals living in close proximity with humans are less bothered by human use of the underpass. This combined human/wildlife underpass has very little vegetation, and there is no specific designated area for humans to walk (Gagnon, 2006 via e-mail). The researchers believe that particular species may react differentially to features such as cover on either side of an underpass, presence of ledges, lack of visual openings through the underpass, tunnel effect or openness ratios, and human activity. Long-term monitoring is needed to determine if animals adapt to the specific design and landscape context (Gagnon et al. 2005).

Phillips et al. (2002) studied an underpass on I-70 in Colorado. After construction of a pedestrian/cyclist path next to Interstate 70 on an elevated bridge near the underpass, the researchers found that highway traffic and the presence of humans walking near the crossing disturbed deer trying to use the underpass. A temporary screen to reduce the view of the humans was installed and helped reduce the disturbance to the deer. The result was a recommendation for a permanent screen (in Evink 2002).

South of Ocala, Florida, a combined wildlife, pedestrian, and equestrian land bridge was completed in 2000 over Interstate 75 for the Marjorie Harris Carr Greenway. This 50 foot wide crossing was designed so that wildlife and people could share a common path. Raised planters of native Florida vegetation line both sides of the land bridge to screen the highway, and to reduce highway noise. The raised planters were not designed for direct human or wildlife use. The central path is covered with crushed shells for compatibility with wildlife and trail users (pedestrians, equestrians, and mountain bicyclists). The bridge has over 3000 visitors per month (Thomason 2006, via e-mail). While there is no ongoing wildlife tracking, the overpass was monitored with cameras from 2002-2003. The cameras recorded sporadic use by coyotes, bobcats, raccoons, fox, opposum, and armadillos. The cameras are not able to record use by small animals and all animal use was recorded at night (Smith 2006, via phone). While there are deer in the area, no deer were recorded using the overpass. Dr. Smith speculates that this is due to the design of the bridge and the raised planters. Deer might be fearful that there are predators in the raised areas and the planters create a tunnel-like effect that deters the deer. Other monitoring has documented that two endangered species use the landbridge: Gopher

Tortise (Gopherus polyphemus), a species of special concern; and Drymarchon corais couperi (Indigo Snake), a species listed as threatened in Florida (Valerie Naylor 2006, personal communication).

In Europe, researchers have recently reviewed the use and effectiveness of highway crossings to improve landscape connectivity (Bank et al. 2002). The use of crossings was researched in five countries (Slovenia, Germany, France, Switzerland and Netherlands). Research in France found that an overpass was not well-used because of joint use by humans and because the passages were found to be too small (Van Weiren and Worm 2001). Researchers examining wildlife bridges in Poland found that among five wildlife bridges over a particular stretch of highway, only one was used by wildlife. The main reason for failure was the lack of information about animal migration routes in the area, resulting in improper placement of the crossings. Two other important reasons cited are the narrow structure of the bridges (most 9-12m wide) and their regular use by people (Brodziewska 2005).

Looking at the idea of human-wildlife conflict more generally, studies have shown that animals avoid the proximity of humans at points where wildlife cross roads, preferring to approach roads sheltered by tree and shrub cover (Bashore, Tzilkowski, and Bellis 1985; Jaren et al. 1991; Clevenger et al. 2003; Seiler 2003; Malo et al. 2004). Human traffic has also caused activity shifts or avoidance by sensitive species near trails, and increased numbers of unaffected or habituated species (Griffiths and van Schaik 1993).

The location of the Walden Passage in a suburban area makes it difficult to compare with the locations discussed in the literature cited, where wildlife crossings are largely in less densely developed areas, including national parks and agricultural landscapes. The particular species in the Concord and Lincoln area also make it difficult to draw conclusions based on published research involving other species, because the species living in the Walden Passage study area are likely to be more habituated to human activity and are thus more likely to use a crossing structure that is also used by humans. However, none of the literature reviewed provided detail on wildlife use of crossing structures with high levels of use by pedestrians. For example, the maximum human crossing rate recorded in the Canadian studies was 97 crossings per month or around 3 crossings per day (Clevenger and Waltho 2000, 2005). A recreational study is needed to determine what human usage levels might be expected in a recommended Walden Passage. In addition, careful consideration should be paid in the design phase to the amount and timing of human presence on and around the structure and strategies to control human use. For example, limiting human use to daytime periods should minimize human deterrence of wildlife crossings, since much of the wildlife use of the structure is likely to be nocturnal.

Design considerations for combined wildlife-recreational crossing structures

Whether or not wildlife will use a crossing structure is the most important design consideration as humans are likely to use a structure as long as it provides a necessary pedestrian connection to existing trails and links with recreational/hiking destinations. There is a growing body of research that examines the characteristics of wildlife crossing structures that are most frequently used by a wide variety of species. Researchers are quick to point out however, that the structural and landscape characteristics preferred by one species might not be the best for another species. It is therefore important to incorporate information about the species present and planned for in designing a combined wildlife-recreational crossing in the

Concord/Lincoln area. We list in Box 2 the primary design considerations for combined wildlife-recreational crossing structures.

Note that the locational-context features are similar to those we listed when solely taking wildlife into account (Box 1). Table 2 below shows some of the ways that these design considerations have been implemented for overpasses in Europe and North America. Only the Florida crossing, however, has targeted both humans and wildlife.

Box 2. Considerations for Combined Human-Wildlife Crossing Structures

Locational-Context Considerations

(1) Siting in the landscape context
(2) Drift fencing (to guide wildlife to the crossing)
(3) Integration with roadside/landscape context (vegetation, topography, moisture)

Specific Design Considerations

Overpasses: shape (hourglass, straight), length, width, vegetation cover, soil depth, side walls/fencing, target species /species expected, other users (pedestrians, equestrian, bicyclists) monitoring

Underpasses: openness (height/width/length), substrate, other users (pedestrians, equestrian, bicyclists) monitoring

Table 2. Characteristics of Existing Overpasses for Wildlife by Location

	Florida	**Canada (Banff)**	**Netherlands**	**Germany**	**France**	**Switzerland**
Plan Shape	Straight	Straight	Hourglass and straight	Hourglass	Hourglass and straight	Hourglass and straight
Dimensions (width at narrowest point, length)	15m wide	50m, 72m (2 overpasses)	17m, 50m	8.5m, 870m	8m, 800m	3.4m, 700m
Soil depth	1m in raised planters	Not specified, passage covered with trees, shrubs and bare ground	--	.33m grass .66m shrubs 1.5-2m trees	--	--
Side walls	Stone planters, with native shrubs	Earth berms, vegetation, fences	Plantings, stump walls	Fences, plantings	Fences	Fences, plantings
Highway fencing	Yes	Yes	Yes	Yes	Yes	Yes
Target wildlife species	Not specified	Large carnivores (grizzly, wolves)	Deer	--	--	--

Potential for passage structures to increase or abate human-wildlife conflict

High human activity in the study area means that passage structures have the potential to reduce the human costs of wildlife-vehicle collisions as well as to influence human-wildlife conflicts where species are able to establish in previously unoccupied areas. Changes in human-wildlife interactions due to passageway installation have not previously been investigated, perhaps because, as mentioned previously, of the more remote nature of most studies.

The species most frequently involved in wildlife-vehicle collision injuries are deer and moose, as they are drawn to the lush forbs maintained along roadways (Puglisi et al. 1974; Rea 2003). Passage structures give animals the opportunity to avoid roads though deer and other ungulates may actively seek to graze next to the pavement. Thus, adequate fencing may be more important than passage structures in reducing traffic accidents.

A driving motivation behind installation of passage structures is to reconnect previously fragmented habitat, allowing species with large home ranges to establish in unoccupied areas. Black bear, coyote, bobcat, and fisher fall in this category. Large carnivores living in close proximity to humans cause people to fear for their safety and that of their pets (DeStefano and DeGraaf 2003). An increase in top predator density has the potential to result in lowered densities of prey species such as deer and rodents that may conflict with people in other ways (DeStefano and DeGraaf 2003). However, such changes will not occur if carnivore densities prior to passageway construction are already at the local carrying capacity. Coyote and fisher are already known to be present and common within the study area (see Section 3D). Coyote even occur in much more highly developed areas than Concord, such as downtown Boston (Way et al. 2004), and have been observed to cross highways in the absence of passage structures (N. Charney and M. Bellis, unpubl. data). Monitoring data collected by the Wildlife Passages Task Force have detected no human or pet conflicts in the Study Area since 2005 despite an already significant presence of these predator species.

In summary, our review suggests that installation of new passage structures in the study area are unlikely to significantly increase or decrease human-wildlife conflicts.

Conclusions

In summary, passage structures appear to be an effective means of defragmenting habitat that is dissected by roads. In areas with high human densities, combining human use with wildlife passages may be necessary since humans already use even remote structures. However, careful design is needed to prevent human use from compromising the efficacy of wildlife passages, and may never be wholly effective at preventing some species from being deterred.

2.B. The Cultural Landscape of Concord and Lincoln

This section examines potential locations for a combined wildlife-recreational crossing of Route 2 as they relate to the history and significance of the cultural landscape of Concord and Lincoln. After reviewing how certain historic events and individuals are or are not associated with the Route 2 corridor study area, the first conclusion is that the interpretive potential for a new combined wildlife-recreational crossing is very high, including the history of Thoreau, Emerson and the Transcendentalists, the Revolutionary War, and the natural history of the Concord and Lincoln landscape.

Introduction

Few landscapes in the United States have more venerable historical associations than the farmland, woods, rivers, ponds, roads, and trails of Concord and Lincoln. The precocious colonial settlement of the region, together with its later military significance and fame, have made this landscape the setting of widely shared narratives of national origins and identity. In the nineteenth century, the same landscape witnessed the founding of equally significant traditions in American literature and philosophy. The continued cultural and economic vibrancy of Concord and Lincoln in the twentieth century has helped preserve, interpret, and revitalize the regional landscape for residents and visitors alike. This storied landscape remains unique, and uniquely significant, in American history and culture.

The cultural landscape enjoys a high degree of overall historical integrity, which has been both confirmed and enabled by the existence of two major federal landscape reservations, the Minute Man National Historical Park and the Great Meadows National Wildlife Refuge, as well as the Walden Pond State Reservation, numerous town forests and reservations, and other public and private historic places and sites preserved through various mechanisms and partnerships. Local residents historically have been vitally interested in the landscape character and historical associations of the area, and they continue to serve as active stewards of their legacy. Recently this civic engagement has again been demonstrated through the establishment and activities of the Walden Woods Project.

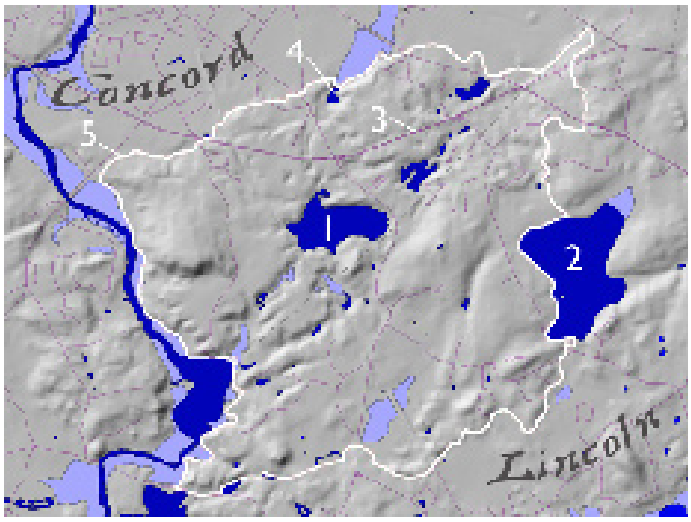


Figure 1: Map of Walden Woods
1-Walden Pond
2-Flint's (Sandy) Pond
3-Route 2
4-Fairyland Pond
5-Walden Woods Boundary
(Courtesy Walden Woods Project)

The above characterizations of the communities and landscape of Concord and Lincoln are no more than obvious; but they suggest the degree to which historical and cultural values may constructively inform the discussion of potential locations of a combined wildlife-recreational crossing of Route 2 between the Sudbury River and Crosby's Corner (the defined study area of this report). This part of Route 2 is a major highway that cuts through the northern portion of the area identified as Walden Woods, separating the woods and Walden Pond from the town of Concord.

It passes directly through a cultural landscape that is complex, possesses great integrity, and is among the most historically significant landscapes in the country. The proposed crossing structure over or under Route 2 therefore has tremendous potential to interpret the cultural significance of this landscape for residents, tourists, and others, and to enhance the appreciation and enjoyment of the area in general.

To begin considering how this potential may best be achieved, principal themes and periods of the region's history are briefly summarized in the following sections, with specific consideration and reference to the Route 2 corridor study area and Walden Woods. What were historical routes near or across this corridor, and what were their associations and significance? What is the potential today of the three locations being examined in this study for enhancing and interpreting the many narratives and layers of significance that occur in the cultural landscape of Concord and Lincoln?

Early Settlement

"Because I was content with these poor fields,
Low open meads, slender and sluggish streams,
And found a home in haunts which others scorned,
The partial wood-gods overpaid my love,
And granted me the freedom of their state,
And in their secret senate have prevailed
With the dear dangerous lords that rule our life,
Made moon and planets parties to their bond,
And pitying through my solitary wont
Shot million rays of thought and tenderness."

"Musketaquid" (first stanza)
-Ralph Waldo Emerson

The European settlers who arrived in 1635 were drawn to the river corridors, meadows, and arable land that made the region attractive for the first inland settlement of the Massachusetts Bay Colony. These same landscape characteristics had been enjoyed for many generations by Nipmuck peoples, who

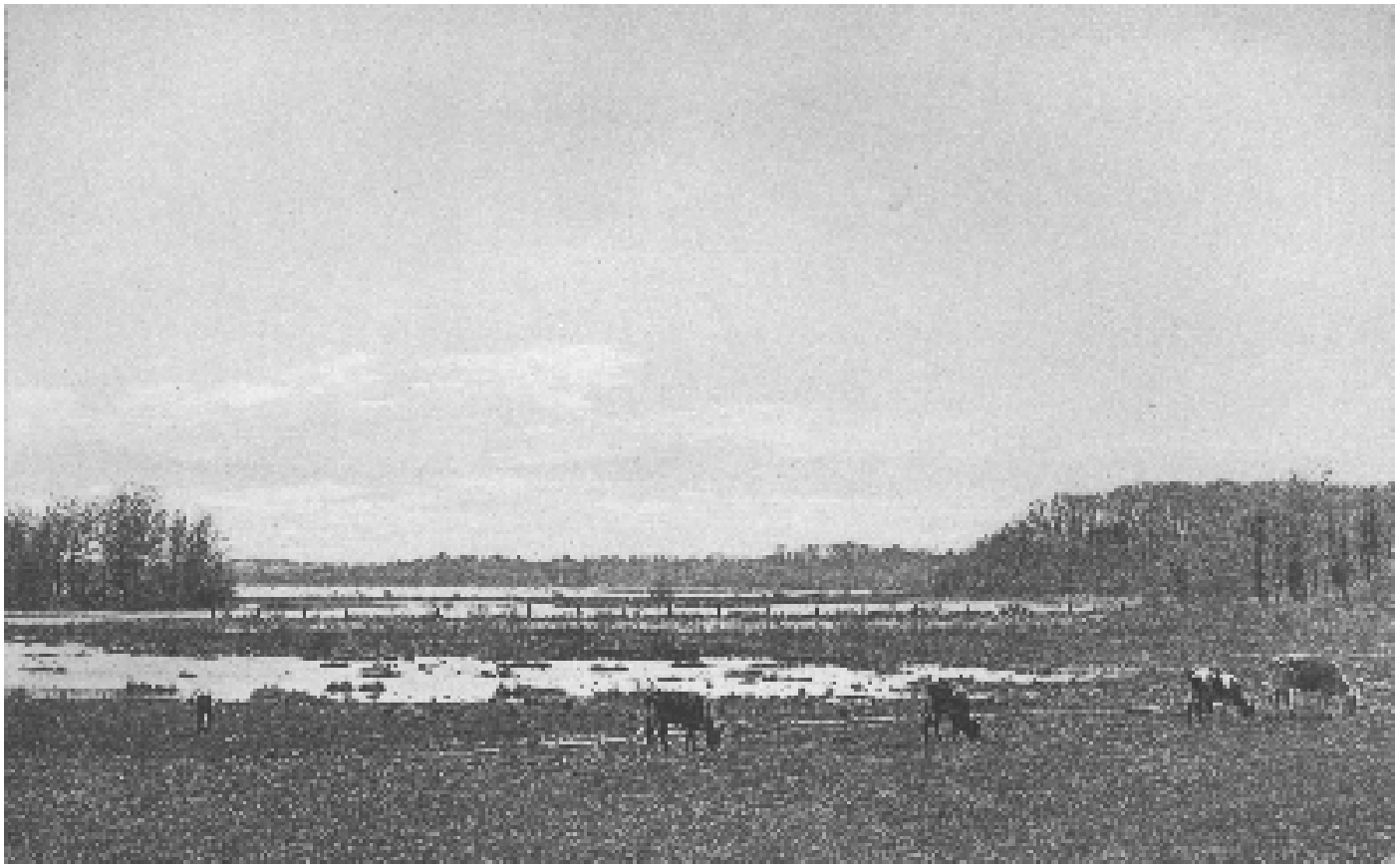


Figure 2: Great Meadows Pasture *(Courtesy of the Thoreau Institute at Walden Woods)*

had first settled the area as much as 12,000 years earlier. "Musketaquid" was the Algonquin name for this landscape of naturally occurring wet meadows, woods, and winding streams around the Concord, Assabet, and Sudbury rivers. As much as 90% of this region was probably forested in pre-settlement times.

The Puritans arranged to purchase land from tribal leaders and then began the small-scale farming, fishing, logging, and clearing of new pastures and fields that characterized seventeenth-century colonial life.

Disease and war decimated the Nipmuck population. Many survivors became Christians and adapted in other ways to the new society growing around them. Over 100 years later, when the town of Lincoln was established in 1754, there were about 200 farms in Concord. The area was growing, taking advantage of market roads that carried lumber and other products to larger settlements to the east.

Extensive clearing of forests took place during the first century of European settlement of the Musketaquid, and new farmsteads and settlements transformed the landscape. The sluggish rivers remained, however. Seasonal flooding and wet meadows also remained principal landscape characteristics, even as woods yielded to cattle pastures and plowed fields.

Revolutionary War

"Listen my children and you shall hear
Of the midnight ride of Paul Revere,
On the eighteenth of April, in Seventy-five;
Hardly a man is now alive
Who remembers that famous day and year."

"Paul Revere's Ride" (first stanza)
-Henry Wadsworth Longfellow

Figure 3: Concord's Battle Ground *(Courtesy of the Thoreau Institute at Walden Woods)*

By the rude bridge that arched the flood,
Their flag to April's breeze unfurled;
Here once the embattled farmers stood;
And fired the shot heard round the world.

"The Concord Hymn" (first stanza)
-Ralph Waldo Emerson

By the mid-eighteenth century the towns of Concord and Lincoln had assumed new levels of significance in colonial Massachusetts. Concord now prospered as a regional center and market for agricultural products and natural resources. Market roads complemented river transportation and commercial and social networks extended farther than during Puritan days.

The scene was set for the extraordinary events of April 1775, when the armed struggle for independence from Great Britain began. Concord's strategic location—an inland center of trade that was accessible by road yet distant from the British Navy—had made it a logical choice for an arms depot. When British troops arrived to confiscate the arms, a small battle took place at the North Bridge over the Concord, within view of the Reverend William Emerson's home. It is unnecessary to review this history in detail here, except to note that the study area itself was not directly associated with the battle at the North Bridge or the subsequent skirmishes as the British retreated back to Boston.

One of the reasons events at Concord in 1775 were so significant was that they were subsequently recognized and memorialized as defining moments of the young republic's birth. Commemoration and interpretation of the historic landscape began early, and included dedication of the obelisk at the North Bridge site in 1837 (and the composition of Ralph Waldo Emerson's "Concord Hymn" for the occasion), the erection of Daniel Chester French's Minute Man statue in 1875, and the establishment of Patriots' Day. The culmination of efforts to commemorate this era of the region's history began in 1959, with the establishment of Minute Man National Historical Park. Through acquisitions and restorations over a period of decades, this national park has attempted to preserve and restore the landscape of 1775, particularly at the North Bridge site and along the historic "battle road" (Route 2A, Lexington Road/Massachusetts Avenue)

Nineteenth Century

In the nineteenth century, the landscape around Concord and Lincoln continued to change dramatically. Further population growth, increased numbers of farms, and continued logging and land clearing brought the landscape to its maximum state of cultivation and openness. Perhaps only 10% of the landscape was forested by mid-century. In 1844, the opening of the Fitchburg Railroad through Concord and Lincoln (and along the edge of Walden Pond) heralded the further changes to come through industrialization and closer links to the Boston metropolitan region.

Figure 4: Fitchburg Railroad, ca. 1890s
(The Thoreau Society Archives, Courtesy the Thoreau Society and the Thoreau Institute at Walden Woods)

The nineteenth-century literary and intellectual history of the area was as significant to American cultural history as the events of 1775 were in American political history. Ralph Waldo Emerson, the minister grandson of William Emerson, was raised in Boston but moved to Concord in 1834. The Sage of Concord soon gathered

Figure 5: Map of Concord
(The Thoreau Society)

around him a remarkable group of intellectuals and writers, including Henry David Thoreau, and together they made Concord a national cultural center. Other major intellectuals and writers of the period who lived in Concord were Bronson Alcott, Louisa May Alcott, Margaret Fuller, and Nathaniel Hawthorne.

The individuals and events of the nineteenth-century cultural history of Concord have direct associations with the Route 2 corridor study area. This is mainly because of the penchant of Emerson, Thoreau, William Ellery Channing, and others to frequently walk all around the surrounding landscape of Concord and Lincoln. Much of the surrounding area can claim some association with the members of the Transcendental Club and other local figures through their frequent meditative "saunterings." But Walden Woods and Walden Pond were particular destinations for the ruminative and intellectually productive excursions that were so important to this group of thinkers.

In 1845 Thoreau famously retreated to a cabin he built on Walden Pond, and his journals and 1854

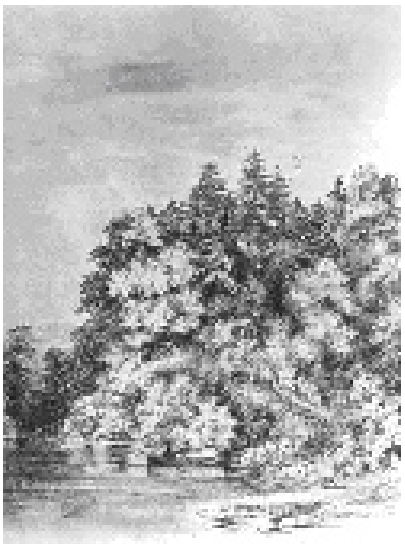


Figure 6: L. May Alcott's 1869 Sketch of Thoreau's Cabin
(Courtesy of the Thoreau Institute at Walden Woods)

Figure 7: Walden Pond from Emerson's Cliff
(Courtesy of the Thoreau Institute at Walden Woods)

book Walden subsequently made the pond and its surrounding forests one of the most famous and significant landscapes in American letters.

Because the Route 2 corridor lies between Concord and Walden Woods, Emerson, Thoreau, other Concord literary figures, eminent visitors, and anyone else wishing to go for a walk in the "nature" around Walden Pond necessarily crossed the area that was later to contain Route 2.

The construction of Route 2 (beginning in the 1930s) created a formidable barrier between Walden Woods and Concord and cut off the northern portion of Walden Woods. But in the nineteenth century, the connections between Walden Woods and the town of Concord were close and significant for many residents. Since the significance of Walden Woods and Walden Pond was so great for so many key figures of nineteenth century American cultural history living in or visiting Concord, the points at which they crossed what is now the Route 2 corridor on their walks to Walden Woods are of particular interest for this study.

Twentieth Century

During the twentieth century Concord and Lincoln continued to be the homes of influential citizens as they made transitions from independent New England towns to suburbs more economically and socially linked to the Boston metropolitan region. The cultural landscape changed dramatically as the population soared; residential and commercial development expanded and took on new, lower density patterns; and automotive highway construction widened and paved old turnpikes, market roads, and streets that previously had been relatively narrow and quiet byways.

Such dramatic change was accompanied and facilitated by major public land acquisitions by the town, state, and federal governments, including the Walden Pond State Reservation, the Hapgood Wright Town Forest, and the Minute Man National Historical Park, all of which are near, or within, the study area. Twentieth-century public works projects also radically altered the landscape. The construction of Route 2 through Walden Woods created the Route 2 corridor being examined in this study. Subsequent widening of Route 2 to increase its capacity as a commuter arterial were made later in the century.

In 1922, Emerson's heirs made the gift of land that began what became the Walden Pond State Reservation. The towns of Concord and Lincoln have been active in the twentieth century acquiring town forests and other lands, as well as easements and other forms of cooperative protection of the landscape. Established in 1959, Minute Man National Historical Park has become not only one of the country's most visited and significant historic sites, but also a unique experiment in landscape preservation, as park managers attempt to maintain the agricultural landscape from forest succession through various techniques and means. In 1990, the Walden Woods Project was established

and began unprecedented efforts to identify and preserve the Walden Woods that Emerson and Thoreau knew. If the twentieth century has seen much change and destruction of the landscapes of Concord and Lincoln, remarkable national and local initiatives were also started that recognized the significance of the area and have successfully preserved vital portions of the cultural landscape.

The twentieth century also experienced a related rise in diverse recreational uses of public lands of all types. While the purposeful walks of Emerson and Thoreau were a related form of thoughtful recreation, the twentieth-century interest in "outdoor recreation" was a far broader phenomenon, involving many forms of physical activities and a wide variety of public landscapes and facilities.

In 1929 a regional trail/conservation system known as the Bay Circuit Trail was proposed, and although it was not immediately implemented, the suggestion became an important basis for later proposals, and in 1955 the idea was revived and became established through state legislation. In the 1980s money was finally appropriated to implement the Bay Circuit Trail, and in the 1990s the Bay Circuit Alliance was established to advocate and assist in the cooperative maintenance of it. Walden Woods are one destination along this regional circuit, which in general follows a route through the outer periphery of the Boston metropolitan area. The Bay Circuit trail crosses the Route 2 corridor study area, using Walden Street, near Walden Pond.

With the development of the Walden Pond State Reservation, the creation of trails in Hapgood Wright Town Forest, and the potential links to the Emerson/Thoreau Amble and the Battle Road Trail in Minute Man National Historical Park, the Route 2 corridor study area features both existing and potential links to trails of local, regional, national and international significance. The existence of this partly existing and partly proposed trail network has important implications for considering the alternative combined wildlife-recreational crossing locations in the study area. The existing association with the historic Bay Circuit Trail concept, in particular, is a significant feature of this cultural landscape. Other aspects of outdoor recreation history, such as the development of the Walden Pond Excursion Park, the later development of the Walden Pond State Reservation, and the creation of the Minute Man National Historical Park, have only indirect association with the study area alternatives.

***Figure 8: Walden Pond Excursion Park**, established by the Fitchburg Railroad in the 1860s, created a more active recreational opportunity at Walden Pond. It is seen here sometime before 1902 when it burned.*

(The Thoreau Society Archives, Courtesy of the Thoreau Society and the Thoreau Institute at Walden Woods)

In addition to the human development that so transformed Concord and Lincoln in the twentieth century, natural processes have also changed much of the landscape. Above all, reforestation, both of newly acquired public lands and other undeveloped areas, has made the region once again one characterized by a significant amount of forest cover. The Walden Woods visited by nineteenth-century intellectuals was a more

scattered forest, with clearings and at least one very famous bean field. Concord and Lincoln, in general, were surrounded by open, agricultural areas. By the end of the twentieth century, many of the fields and pastures—at least those not covered in pavement and houses—had reverted to forest.

In the twentieth century Concord and Lincoln became known as residential suburbs that boasted many affluent and influential residents, such as the architect Walter Gropius who built his modernist residence in Lincoln in 1938. The communities also have been known for residents willing to take active and passionate roles in preserving the history and landscape of the towns, even as greater and greater development pressure has occurred.

Figure 9: Walter Gropius House, Lincoln, MA

Although the twentieth century created the Route 2 corridor that is the study area for this project, there are no specific landscape features or characteristics associated with historically significant events of the twentieth century in the study area. In other words, while some twentieth-century features of the cultural landscape are highly significant (Gropius's house, for example), none of them are directly associated with the Route 2 corridor. Route 2 itself is not considered here to be a historically significant, or contributing feature of the cultural landscape.

3. Existing Conditions

3.A. Planning and Economic Development

The project study area includes lands and water bodies belonging to the towns of Concord and Lincoln. Both of these communities are among the best planned and most professionally governed in Massachusetts. Moreover, they are economically healthy and prosperous.

This section provides a snapshot of the economic and planning positions of these towns in a regional context for the coming decade. This is important for understanding the drivers of change in the towns, and how these changes could influence, or even be influenced by, a Walden Passage. The section is divided into four parts. Part one focuses on the towns' economic strengths and characteristics while part two centers on their weaknesses and threats. Part three describes the opportunities that could be embraced. Finally, part four, places the discussion in the context of the Walden Passage Project.

Strengths

Concord and Lincoln, located north-northwest of Boston, have had strong transportation linkages with Boston and its metropolitan region from the Colonial Period to the present. The legacy of the past, indeed still remains. Route 2, for example, lies, in parts, upon the roadbed of the Concord Turnpike which connected Concord center and Lincoln to Cambridge and to Boston. The Fitchburg Railroad line, originally constructed in the 1850's, is now a commuter line carrying passengers from the City of Fitchburg to Boston. Both of these systems "touch" Walden and have been critical to defining its history and use.

The regional location context of both communities is a significant factor in their economic development. Lincoln is in close proximity to Interstate Route 95

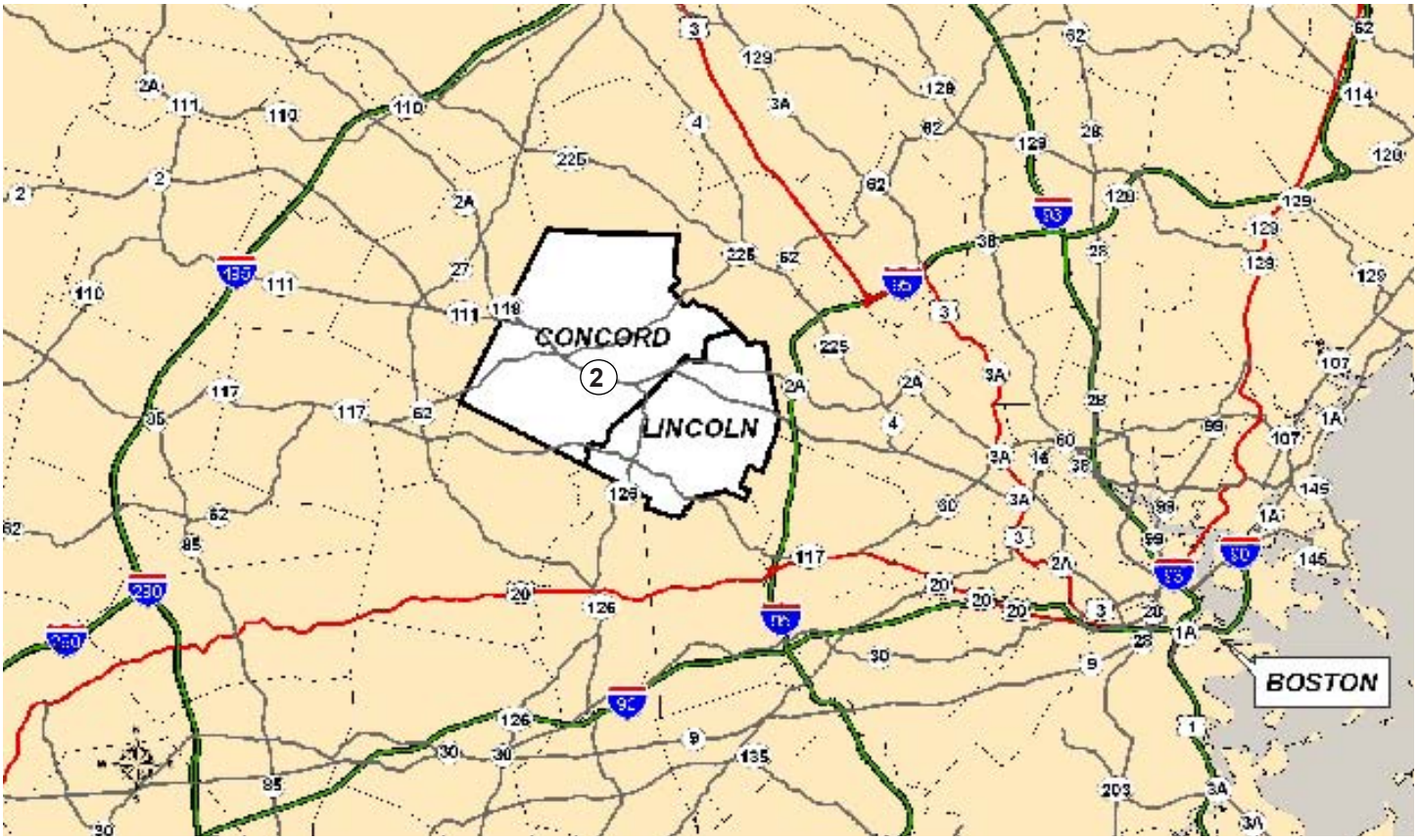


Figure 10: Regional Context Map *(Source: MassGIS)*

(also known as State Route 128). Moreover, State Routes 2, 117, 126 and 27 serve as key connectors between Lincoln and major employment centers. Concord, just to the west of Lincoln, is also in commuting range of most of the employment centers of the region. Perhaps more importantly, the town's residents can move rapidly to the Route I-495 outer-circumferential highway where extensive economic growth can be expected well into the future.

Very recently the Massachusetts legislature approved the designation of a scenic byway, extending from Arlington, through Lincoln to the North Bridge in Concord to be known as the "Battle Road: Road to Revolution". The stated purpose for this designation is to "recognize, protect and enhance the unique historic, scenic, cultural and recreational resources along the byway, including preservation of the character of the corridor, expansion of economic opportunities, development of balanced tourism and a context in which to evaluate proposed roadway changes. The towns of Arlington, Concord, Lexington and Lincoln shall work in cooperation with the National Park Service to preserve the resources and improve the experience of the byway for both residents and visitors" (Massachusetts Senate and House of Representatives in General Court assembled 2006). This designation affirms the value of this byway as an historic corridor representing significant opportunities for the future.

The land use patterns of Concord and Lincoln, are an asset, in an economic sense. The fact that considerable acreage is still in agriculture brings value to both towns. Agricultural uses provide jobs (full and part time) and tax revenues while providing open space, and helping to prevent sprawl. They also encourage sustainable local economies by employing local farmers and reduce dependence on fossil fuels needed to transport out-of-state produce and meats. Perhaps more importantly, agricultural lands, as well as those in forestry categories, contribute immeasurably to the character of the communities (Map 6).

Economic Characteristics

The retail character of both communities is primarily oriented towards the needs of the residents with the exception of Concord center, which, by its historic nature, delicately balances a tourism market with those of the citizenry. Lincoln's retail activities are concentrated in its small center. There are no regional malls in the towns.

The commercial, professional, and service sectors of the economy are quite strong. Firms in these sectors are attracted to places where there is a high quality of life. These firms require highly skilled, highly educated, management-savvy, and technology proficient workers. Both Concord and Lincoln have workers with these attributes (Table 5). Workers with these skills often attract corporate headquarters. Both Concord and Lincoln have attracted such companies.

The contributions of the institutional sector are strong. These uses, ranging from private schools, museums, the national and state parks, and wildlife refuges to individually significant structures and hospital/life care facilities add jobs, attract tourists and help to define the character of the two communities. These may be as small as Lincoln's Walter Gropius House to as large as Emerson Hospital. In a direct sense, they add dollars to the town's economies through employment and the purchases of goods and services by tourists, residents and a transient workforce. In one indirect sense, they contribute substantially to the uniqueness and cachet of these two special communities.

Finally, both towns are fiber-optically connected with state of the art connectivity. This provides workers the option to work from home. Given the changing economic climate where this work arrangement is

increasingly common, communities that are well connected have a strong economic asset.

Table 3: Occupation

	Concord (% of total)	Lincoln (% of total)	Boston-Worcester area (% of total)
Management, professional, and related	66.4	65.5	37.5
Service	5.9	9.0	19.5
Sales and office	21.4	19.8	22.8
Farming, fishing and forestry	0.1	0.0	Not available
Construction, extraction and maintenance	3.1	2.8	10.2

(Source: U.S. Census 2000)

Table 4: Employment by Industry

	Concord (% of total)	Lincoln (% of total)
Agriculture, forestry, fishing, hunting & mining	0.3	0.0
Construction	2.1	2.5
Manufacturing	5.1	0.0
Wholesale trade	2.6	0.0
Retail trade	6.5	3.2
Transportation, warehousing, utilities	1.2	2.5
Information	3.6	7.3
Finance, insurance, real estate, rental and leasing	2.8	5.7
Professional management and administration	19.0	15.1
Education, health, and social services	38.0	38.9
Arts, entertainment, recreation, accomodation, and food	9.8	0.0
Other services	2.9	24.8
Public administration	6.1	0.0

(Source: Department of Employment and Training, Massachusetts, 2005)

Table 5: Educational Attainment

	Concord (% of total)	Lincoln (% of total)	Massachusetts (% total)
Less than 9th grade	1.9	0.3	5.1
9th to 12th grade, no diploma	4.3	1.0	7
High school graduate	11.4	6.5	27.4
Some college, no degree	10.4	15.5	16
Associates degree	5.8	7.5	7.7
Bachelor's degree	31.4	28.5	21.1
Graduate or professional degree	34.7	40.7	15.8

(Source: U.S. Census 2000)

Weaknesses and Threats

While most communities would be quite happy to have the economic profile of either Concord or Lincoln, there are some weaknesses and threats. Like most Massachusetts towns, both towns have a lack of affordable housing. This may not affect the high tech and professional workers and managers that are increasingly common to the towns but will strongly impact the agricultural, retail, manufacturing and non-professional service sector. It will also impact those town employees to whom the responsibility of teaching children, protecting the citizenry, and maintaining the quality of life have been entrusted. Indeed, throughout our work on this project, we have asked ourselves how many workers at Walden Pond, Minute Man National Historical Park or the Great Meadows National Wildlife Refuge could afford to buy a home in either community today? We recognize and applaud the efforts of both communities to date to address the issue. In fact, in the very near future, both towns are expected to meet the state requirement of insuring that 10% of their housing units meet the criteria for affordability.

The fact that both towns have aggressively pursued the purchase of open space and the protection of lands from development is a strength. However, there are still parcels of land that remain undeveloped and are unprotected. The development of these parcels could seriously erode the character of the two communities. Current residents, modern corporations and tourists come to the two towns in part to enjoy their views, sites, sounds and feel of their overall character. Open space, whether to frame the experiences or whether it is an asset by itself must continue to be protected.

The potential "over exposure" of the institutional, historic, cultural and natural character of Concord and Lincoln has been mentioned in our public workshops and in town documents. At some point, if tourists "over run" the area their expectations will have been diminished and the experience will have been disappointing. Moreover, a drain on public services may result.

During the warm summer months, Walden Pond is frequently at full parking capacity and visitors park at great distances to gain access (specifically at the Concord Carlisle Regional High School on Walden Street). There are an increased number of tourist buses coming to the two town's tourism attractions.

Table 6: Housing Value (per unit)

	Concord	**Lincoln**	**Massachusetts**
% of houses with value less than $100,000	0.5	0.8	1.7
% of houses with value greater than $300,000	82.2	91.2	68.0
Median house value	$453,400	$590,300	$361,500
Median rent	$1,106	$950	$902

(Source: U.S. Census 2000)

Table 7: Open Space

Land (acres)	Concord	Lincoln
Total area	16,570	9606
Protected open land	5,803	3,296

(Source: Concord data from 2005 Comprehensive Long Range Plan, Lincoln data from Lincoln Draft Open Space and Recreation Plan, April 2007)

There is clearly a need for tourism balance and the achieving of such is no easy task. The towns have a responsibility to be welcoming but not to the extent that would destroy the meaning, ambiance and uniqueness of the experience. On one side, no one wants the creation of a "Paul Revere Bowling Alley" or the Hollywood-esque character of pseudo-witch museums as found in Salem, Massachusetts. On the other side, no one wants to be so restrictive that only those who are affluent can afford the experience. Where does all this lead? As the towns are aware, there is a need to create an understanding of the requirements of tourists including: parking, food and sanitary conveniences. At the same time, there is a distinct need to understand the capacities of the tourist activities such that experiences are not diminished. Decisions on how best to determine this balance must be comprehensive and involve a wide variety of participants ranging from local citizens and institutions to state and national organizations.

One must also recognize the potential impacts upon the two towns concerning the long term impacts of Hanscom Field, the Massachusetts Department of Corrections' prison lands and Crosby's Corner. As a result of the most recent of BRAC (Base Relocation and Closure), Hanscom Field is currently secure and is not slated to be closed. It will continue to be a regional asset due to its contributions to the economy and to the fact that it attracts highly educated, highly skilled workers to the area. On the other hand, one can expect further BRAC activity. The fact that it has been a subject of intense inquiry in the past does not provide a guarantee of long term security.

As well, regardless of the military future of Hanscom, there is also the potential of increased civilian air traffic in the area. At some point, given air traffic demand, one could see the potential for expanded civilian use of Hanscom Field as a passenger facility. We note the

Figure 11: Hanscom Field
(Source: www.massport.com)

concerns of residents over this in the past. We think, however, that this issue will not go away.

The future use of the Massachusetts Department of Corrections' prison lands, largely adjacent to Route 2 in Concord, are also a planning concern. These lands are in large parcels, historically and currently farmed, easily accessible and with the availability of water and sewer infrastructure, they have enormous potential for a wide variety of uses ranging from agriculture to residential and office park uses. These lands remain under the control of the Commonwealth. At some point, one could expect these properties to be released. If this happens, it is essential that both the town and the Metropolitan Area Planning Council have a critical role in their planning and development.

The impact of the Route 2 Crosby's Corner grade-separation improvement project will help to lessen congestion, increase safety and increase speed at the junction of Routes 2 and 2A in Concord and Lincoln (Crosby's Corner). When the improvements are completed, the intersection of Rte 126 and Route 2 at Walden Pond will become the initial signalized intersection to the west of Tracy's Corner in Lincoln. Increased traffic queuing is expected at this intersection. The need for improvements is clearly understood and

long overdue. What is not understood is the impact that this highway improvement will have on the tourist destinations in Concord. Given that it will lower the travel time to get to Concord as a destination, it stands to reason that it will expand the population base that typically travels to tourist activities. Clearly, a greater understanding of this impact is needed as part of an ongoing comprehensive planning process.

Conclusions

Given the above what can we conclude? We answer this question first in terms of key economic trends and then more specifically in terms of the Walden Passage Project. We conclude with thoughts on issues that will need to be further studied or monitored to insure the continued health and livability of the towns.

The towns are professionally run and well planned at the local level. Their citizens, highly-educated and skilled, provide a tremendous resource base for town government. Moreover, there are a plethora of institutional and non-government organizations that are vigilantly involved in insuring the high quality, long term planning, development, and management of the communities. At the local level, looking inward, we conclude that both towns have a clear understanding of their present economic needs and future prospects. Once one moves beyond the local level however, the future is somewhat cloudy. In fact, the towns are, in part, dependent upon actions of federal and state agencies. This dependency at a state level ranges from the extent of staffing at Walden Pond Reservation (Massachusetts Department of Conservation and Recreation) to the design of improvements on Route 2 (Massachusetts Highway Department) and the dispersion of the prison lands (Massachusetts Department of Corrections, Division of Capital Assets Management). The state and federal governments will be key players in the future use of both Hanscom Air Force Base at Hanscom Field and the future planned highway improvements along Route 2. In short, the towns are well programmed locally for their futures but must play a constant and vigilant role concerning the activities of higher government.

The economic status of the towns is quite sound. These towns are home to highly educated people and modern firms. The tax base, while heavily skewed toward residential uses, will continue to expand. The major concern is that the price of housing will continue to attract only the affluent. Despite the efforts of the towns, this trend is likely to continue.

The most dramatic change beyond the future of the Concord Prison lands and long term prospects of Hanscom rests with the potential of conversion of agricultural land into residential use. In fact, the agricultural lands owned by the Commonwealth function as a highly scenic gateway to Concord from the west along Route 2. While the towns can absorb such uses in a financial sense, the loss of this space in terms of community character would be priceless.

In terms of Walden Pond State Reservation, the critical question centers upon how much growth in visitation it can absorb before it begins to be negatively impacted. A comprehensive study of the impact of a wildlife-pedestrian passage on the Walden Pond State Reservation is beyond the scope of this study. It is expected, however, that the recreational users of a combined passage would be distributed through the spring, summer and fall seasons (not primarily on midsummer “swimming” days when capacity is currently a serious concern), and that they would perhaps be more likely to integrate a visit to the passage with visits to other landmarks and features of Concord and Lincoln, and into the broader region via the Bay Circuit Trail which crosses Route 2 in the study area. Moreover, we do not believe that the

answer should be oriented toward Walden Pond alone. It must be found in looking at all tourist activities comprehensively and with a commitment to managing the quality of the experience rather than only in terms of numbers of visitors.

Finally, we conclude that the Walden Passage Project holds the potential to contribute to the historic and cultural legacy that is so important to Concord and Lincoln, provided that it is not treated in an isolated sense. It must be connected to local and regional planning efforts, to the historic, environmental and cultural landscape, to the needs of both the local citizenry and tourists and, above all, to the maintenance and improvement of these towns as special places.

3.B. Zoning, Land Use, Trails and Open Space

The study area includes a 2.5 mile section of State Route 2 and the immediate adjacent lands, beginning at the western end at the crossing of the Sudbury River extending to the east to the intersection known as Crosby's Corner (Map 1). The majority of the study area is located within the town of Concord. However, a small portion of the study area near Crosby's Corner is located in the town of Lincoln. Here we address the zoning and land use patterns in Concord and Lincoln and how they may impact future population growth and conservation in the study area. Open Space and Recreation goals for each town focus on conserving the existing large tracts of open space as well as on the impacts of future development on these resources. Both towns emphasize the importance of maintaining connectivity and preserving open spaces for the vitality of wildlife as well as humans.

3.B.1 Concord

Concord is a rural suburb located approximately twenty miles west of Boston. The town area is 16,550 acres, or approximately 25.89 square miles, and is surrounded by the communities of Carlisle, Bedford, Lincoln, Sudbury and Acton.

Population and Demographics

Concord supports a population of approximately 16,993 (U.S. Census 2000); with a population density of 682 people per square mile. In their MetroFuture projections, the Metropolitan Area Planning Council (MAPC) projects a population growth of 2000 to 5000 residents between the years 2000 and 2030. A relatively young population resides within the town with a median age of 42 years. As indicated in Table 8, the majority of the inhabitants are school-aged children and adults aged 25 to 64.

Table 8: Population Distribution by Age (Concord)

Age (years)	*Percentage of population (%)*
Under 18	*21.8*
18 to 24	*4.2*
25 to 44	*25.8*
45 to 64	*28.4*
65 and older	*16.5*

(Source: Town of Concord Open Space and Recreation Plan)

Zoning

There are currently seven zoning districts and sub-districts identified in the Town of Concord Zoning Bylaws (Concord Zoning By-Laws):

- Residence AA, A, B, and C
- Commercial
- Medical-Professional
- Industrial (Industrial Park, Light Industrial Park)
- Conservancy (Flood Plain, Groundwater, Wetlands)
- By-Pass
- Personal Wireless Communication Facilities.

Approximately ninety-five percent of the town of Concord is zoned for Residential use. According to the Concord Zoning Map (Map 3), the majority of the land within the study area is Residential (AA, A, and B). Two parcels associated with Brister's Hill located on the north side of Route 2 are zoned Limited Business. However, one of the parcels is owned by the Walden Woods Project and the second parcel is owned by the Town of Concord Natural Resources Commission. Therefore, development on these parcels is not likely.

In an effort to protect existing natural resources, the town of Concord has identified and implemented conservation districts and overlays for: wetlands; ponds; rivers; historic districts; agricultural; permanent conservation trusts and restrictions; and Chapters 61, 61A, and 61B land. Work in these districts requires approval from at least one municipal Board and/or state authority. Any work within wetlands, floodplain, the 200-foot Riverfront Area of perennial streams, and within 100 feet of wetlands would also require approval from the Natural Resources Commission, in accordance with the Massachusetts Wetlands Protection Act (M.G.L. Chapter 31, Section 40) and its implementing regulations (310 CMR 10.00).

Wetlands were identified within the study area as part of the Route 2 Improvements Project, and include the marshes, wet meadows and the flowing waters of the Sudbury River (Map 5). Since this part of the study area includes the river as well as the associated wetlands, any proposed uses or alterations would be subject to the regulations of Concord's Wetlands Conservancy District, as well as those of the Massachusetts Wetlands Protection Act (WPA) (Chapter 131, Sect. 40 of the Massachusetts General Laws) and Rivers Protection Act. The WPA regulates development and/or alteration of land located within wetland resource areas and those areas within a 100 foot buffer from some wetland resource. Any uses or alterations within these areas or the buffer zone are subject to review and approval by the Concord Natural Resources Commission (NRC) and the Massachusetts Department of Environmental Protection (DEP). Wetland Resource areas include those areas within 200 feet of perennial streams such as the Sudbury River. The local Natural Resources Commission and the DEP review projects to ensure that the riverfront area is protected for the interests in the Wetlands Act. The Wetlands Conservancy District is a zoning overlay. Any work proposed in this district needs to obtain Zoning Board of Approvals approval. The state Wetlands Protection Act is much more stringent in that it deals with specific wetland resource areas and requires field verification of wetland boundaries.

Under the WPA, applicants must show that they meet performance standards for each resource area and

are limited to certain thresholds of impact for each resource area (Delia Kaye March 9, 2007, personal communication). Therefore, any proposed uses and alterations that would be associated with a combined wildlife-recreational passage structure would be subject to approval by the Concord Zoning Board and the Natural Resources Commission. In the Zoning Bylaws, permitted uses in Wetland, Groundwater, and Flooplain Conservancy Districts include wildlife management, boating, duckwalks, bicycle, equestrian and foot paths or bridges, and unpaved recreation areas which do not alter the existing topography.

Land that is protected under Chapter 61 regulations has also been identified within the study area (Map 4). Land located adjacent to Route 2 in the vicinity of the railroad underpass (Arena Farms) and to the west of Arena farms south of Route 2 are protected under Chapter 61A regulations. Chapter 61A is a tax abatement option enabled by Massachusetts General Laws designed to encourage the preservation and enhancement of agricultural and horticultural land. The program offers significant local tax reductions to property owners willing to make a long-term commitment to agricultural and/or horticultural use. In exchange for these benefits, the city or town in which the land is located is given the opportunity to exercise the right of first refusal. While Chapter 61 is not permanent protection, given that the town has the opportunity to prevent future development of existing agricultural land, it is expected that this land will remain in agricultural use.

Land Use

Although ninety-five percent of Concord is zoned for residential use, only fifty percent is actually used for homes. The remaining forty-five percent is currently used for parks, playgrounds, conservation land, farms, schools and governmental uses.

As of 2001, approximately thirty-eight percent of the town was developed land. Development in the town has remained slow over the past few decades, with an average of 21.4 new lots per year built in the decade 1990-99 (mainly by subdivision, planned residential development, and approval-not-required), and an average of 23 new housing units were built each year. According to town records referenced in Concord's 2004 Open Space and Recreation Plan (OSRP), the total number of housing units grew from 4,440 to 6,153 from 1970 to 2000, but only 230 were added during the 1990's. However, in contrast, protected open space has increased markedly, according to the Concord 2004 Open Space and Recreation Plan (OSRP).

Approximately 27% of the Concord is "uncommitted land," that is, neither developed nor protected. In addition to town conservation land, Concord has over 50 parcels of land designated for municipal, school, cemetery or other purposes (Map 5).

As stated earlier, the population for the Town of Concord is projected to increase over the next 20 years. A build-out analysis has been prepared by the town to predict future development under the current zoning bylaws. Concord predicts that under the current zoning bylaw there are between 500-550 new buildable residential lots. According to the map of buildable areas, the lands near the former town landfill (specifically Goose Pond area) and Bigelow Field (located adjacent to the south of the study area

in the vicinity of the Sudbury River) will be subject to residential development pressure in the future. The town addresses these areas in the 2004 OSRP, and has identified these as priority areas to protect from future development. In addition, two lots currently zoned Limited Business were identified within the study area as developable. However, with the exception of an easement along Route 2, these areas have been placed under private trusts and town conservation. Therefore, development of the Limited Business areas within the study area is not likely to occur in the future.

Future Development – 2004 Open Space and Recreation Plan

The slow development rate as well as the increase in the amount of protected open space indicates that the residents of Concord are conservation-minded and have made development decisions to reflect the desire to protect the existing natural resources in the town. Plans for the future growth of the town are outlined in the 2004 Open Space and Recreation Plan as well as the 2005 Comprehensive Long Range Plan. Some of the goals of these documents that are applicable to this study include:

- Preserve significant open space and agricultural land by intensifying land uses in already developed areas and by clustering new development.
- Provide a supportive environment that welcomes visitors and insures that all visitors receive a coordinated, positive experience.
- Promote open space use and access by increasing the number of trails, and working with regional towns and agencies to identify and protect common wildlife, water and human corridors.
- Develop a broad range of passive recreational resources to accommodate the interests and needs of all citizens.
- Create a system of pedestrian/bike pathways to provide a safe alternative network for moving around Concord – optimize usefulness of existing paths and connections and identify new opportunities for paths and connections.

The town of Concord has identified the protection of open space as a priority. Pressure from growth and development in the region is seen as a threat to the large intact natural areas. Through evaluating the present state of open space and the goals for preservation in the future, the town has prioritized large open spaces that should be protected in order to maintain connectivity and reduce effects on wildlife by the fragmentation of these patches:

- Estabrook Woods Area (Harvard University and others)
- Walden Pond State Reservation (Massachusetts Department of Conservation and Recreation), Walden Woods, Concord Town Forests, and Brister's Hill
- Great Meadows National Wildlife Refuge (U.S. Fish and Wildlife Service)
- Second Division Brook Area (Town land and others)
- Virginia Road Woods (MassPort)
- Annursnac Hill/Strawberry Hill Road (Town land and others)
- Jennie Dugan Kames Area (Private owner and golf course)

The areas of interest that are located in and within the vicinity of the study area are Walden Woods/Brister's Hill, Hapgood Wright Town Forest area and the Jennie Dugan Kames area (Map 4).

The Concord 2004 OSRP identifies the Walden Woods/Town Forest area as containing 1180 acres

extending from the Hapgood-Wright Town Forest southward across Brister's Hill, Route 2, the town landfill, Walden Pond and Fairhaven Woods. The town has identified four major threats to Walden Woods: use of the former landfill, housing development, heavy recreational use, and the effects of Routes 2 and 126. Measures to mitigate these threats include finding alternative locations for the current uses at the landfill and preserving the grassland ecosystem that has been established on the capped landfill. The housing development threats are mostly in the Fairhaven Hill area, which is south of the study area in land between the Sudbury River and the railroad.

The Jennie Dugan Kames area is located in the western portion of the study area and includes land south of Route 2 adjacent to the Sudbury River and lands to the southwest. In the 2004 OSRP, the town recognizes preservation of this area as important for maintaining its high habitat diversity, natural processes (wetlands) and connecting other natural areas on the west side of town with Walden Woods. Only a portion of the Jennie Dugan Kames area is already protected under a conservation land trust. According to the 2004 OSRP, sewer expansion plans into the unprotected portions of this area could have two important effects on open space: local water quality and aquatic ecosystems in and near the affected areas may improve somewhat; however, the proposed large natural area, Jennie Dugan Kames, will be largely converted from septic to sewer wastewater treatment, with consequent long-term potential to stimulate new residential development. However, even though the sewer expansion will increase development pressure, the town has determined that the preservation of this entire area is an achievable goal.

In general, the study area in Concord contains a number of large parcels in public or private ownership, which are unlikely to be developed. The parcels zoned residential that are not currently developed have been identified as priority land to be protected from future development. In addition, the parcels in the Limited Business district are currently under private trusts and town conservation and, therefore, are not likely to be developed. As of the date of this report, the only proposed development within the study area are new soccer fields on the Concord-Carlisle High School property, just to the north of Rte 2. This project is currently underway. Other than the new recreational fields, limited, if any, future land use changes are expected in the study area.

Trails

Existing trails in the Towns are depicted in the Study Area Trails Map (Map 2). Regional walking and hiking paths that cross through the town of Concord for walking and bicycling include: Bay Circuit Trail; Minuteman Commuter Bikeway; Battle Road Trail; Emerson-Thoreau Amble; and an informal path on a Town-owned abandoned railroad bed linking Concord to Bedford. The Bay Circuit Trail extends westward from Concord Center entering Acton south of Strawberry Hill Road, and southeastward from Concord to enter Lincoln near Walden Pond in the study area. Route 2 has acted as a barrier for the Bay Circuit trail.

One of the goals of the Concord 2004 OSRP is to improve existing trails, increase the total number of trails, and increase the number of accessible trails. The Concord 2004 OSRP identifies trails as important routes of transportation, recreation, and connections between points of interest and for movement in and out of town. The 2004 OSRP supports the programmed movement of people through these trails as helpful in protecting farmland and other large remote areas of natural vegetation, and as a means of educating people to the beauty of natural areas.

Recent trail improvements in Concord that connect to the study area include the Fairhaven Trail, Brister's Hill and former landfill trails, and the Emerson-Thoreau Amble. The Fairhaven Trail includes loop trails through open space in the study area located south of Route 2 in the vicinity of the Sudbury River (Map 2) and links to existing trails in Lincoln and Carlisle. The Brister's Hill trail was completed in 2006 as a loop trail located northeast of the Route 2/126 intersection. The former landfill trail is a loop trail across the top of the former landfill. There is an opportunity for connectivity between these two trails as well as connections to the many existing trails located in the Walden Woods State Reservation. However, Routes 2 and 126 act as barriers and raise pedestrian crossing-related safety concerns. The Emerson-Thoreau Amble is a partially completed trail that will connect the Town Forest to Concord center as well as the Hapgood Wright Town Forest to Brister's Hill.

There is a great opportunity for connectivity between many large natural, historical, and cultural resources within the town of Concord and surrounding communities. However, Route 2 represents a significant barrier for this connectivity. Concord has placed an emphasis on the importance of connectivity and has outlined goals and objectives to increase the quality of trails and the connectivity. A passage structure over Route 2 was briefly mentioned in the 2004 OSRP as a solution to this issue. In Advisory Board and public meetings on the project, there was a clear consensus of support for some form of passage within the study area.

3.B.2 Lincoln

Lincoln is a rural suburb located approximately fifteen miles west of Boston. The town area is 5,858 acres, or approximately 15 square miles, and is surrounded by the communities of Concord, Bedford, Lexington, Waltham, Weston and Wayland.

Population and Demographics

The town of Lincoln supports a population of approximately 5,455 residents, with an additional 2,904 people residing at the Hanscom Air Force Base (Lincoln Open Space and Recreation Plan draft 2007). In their MetroFuture projections, the Metropolitan Area Planning Council (MAPC) projects a population growth of less than 1,000 residents between the years 2000 and 2030. A relatively young population resides within the town, with a median age of 35 years.

As indicated in Table 9, the majority of the inhabitants are school-aged children and adults aged 45 to 64. In the Draft Open Space and Recreation Plan, the Town of Lincoln reported that there was over a 40% increase in student enrollment in grades K-8 (draft OSRP April 2007).

Table 9: Population Distribution by Age (Lincoln)

Age (years)	*Percentage of population (%)*
Under 18	*31*
18 to 44	*19*
45 to 64	*33*
65 and older	*17*

(Source: Town of Lincoln Draft Open Space and Recreation Plan)

Zoning

Currently there are seven zoning districts in the Town of Lincoln:

- Single Family Residence District;
- General Residence District;
- Open Space Residential Development (OSRD) District;
- Planned Community Development (PCD) District;
- Retail Business District;
- Service Business District;
- Selected Light Industrial District.

The majority of the town is zoned for residential use (Map 3). Land located within and adjacent to the study area is zoned for residential use. The town of Lincoln has not prepared a build-out analysis.

The Town of Lincoln has designated overlay districts for open space and wetland protection. Approximately 21.5% of the total town area is conserved as open space owned by the town of Lincoln or the Lincoln Land Conservation Trust. Approximately 18% of the town is protected under the wetlands conservation bylaw, however, there are no wetlands located within the study area.

Land Use

The major open spaces in Lincoln include: portions of Minute Man National Historical Park; Great Meadows National Wildlife Refuge; Walden Pond State Reservation; Massachusetts Audubon Society; Codman Farm; Mt. Misery; Flint's Pond; and the connecting trail system. Large tracts of public open spaces protected under Lincoln's open space protection bylaws in the vicinity of the study area include Walden Pond State Reservation, Flint's Pond Conservation Land, and Minute Man National Historical Park. In addition, open space identified as "Public and Institutional Land" is located to the southeast of Crosby's Corner, identified as Bethany School.

As stated earlier, the population for the Town of Lincoln is projected to increase over the next 20 years. A build-out analysis prepared by the MAPC predicted that under current zoning bylaw there are approximately 326 new buildable residential lots and 16,542 square feet of commercial/industrial development in the town.

Future Development – Open Space and Recreation Plan

The town of Lincoln is currently (June 2007) in the process of drafting a new Open Space and Recreation Plan. A status report was provided by the OSRP committee listing the goals and objectives that will be part of the new plan. The goal of the OSRP is to protect existing cultural, recreational and natural resources from the pressures of future development.

As with the town of Concord, the residents of Lincoln are conservation-minded and have developed, or are in the process of developing, regulations that will protect the existing natural resources and reduce impacts for future development.

Trails

Within the town of Lincoln, there are eighty (80) miles of trails going through wooded hills, lowlands, edges of ponds and swamps, orchards and fields, extending over land owned by the town (controlled by Conservation Commission), Lincoln Land Conservation Trust, private institutions, and private ownership (Map 2). Loop trails within the study area connect residential areas with natural areas south of the study area. The Bay Circuit Trail also travels through Lincoln connecting to Walden Woods. The connection to Concord and communities to the north is impeded by Route 2 which acts as a barrier and raises pedestrian safety concerns. The Lincoln OSRP committee has identified the importance of improving the condition of existing trails as well as acquiring trail

easements to improve the connectivity of the existing trail system in the goals for the new OSRP.

3.B.3 State Route 2

The study area includes the land located along a 2.5 mile section of State Route 2. The Study Area begins at the crossing of the Sudbury River and runs east to the traffic intersection known as Crosby's Corner.

State Route 2 is a major route managed by the Massachusetts Highway Department that runs east-west from Boston to the New York state border in western Massachusetts. Over its length, Route 2 varies in width, and is four lanes wide in the study area, with a recently installed central Jersey barrier for most of the study area. According to information provided by the Massachusetts Highways Department, traffic volume through the study area has been measured at approximately 50,000 cars per day, quite consistently over a five year period. There are three traffic signaled intersections in the study area.

Since its construction in 1935, Route 2 has been identified as a major barrier to both wildlife and pedestrians. Specifically, the effects of Route 2 on the Hapgood Wright Town Forest and the larger Walden Woods area include safety concerns for pedestrians, a wildlife barrier separating the Town Forest and Walden Woods, and traffic/noise disturbance. In addition, pollution from road salt and other potential hazardous chemicals is considered to be a concern. See Section 3.E. for further discussion of Route 2.

3.B.4 Railroad

The Massachusetts Bay Transportation Authority (MBTA) Commuter Rail services both Lincoln and Concord on the Fitchburg Line. There are two stations in Concord (Concord and West Concord Stations), and one station in Lincoln. The MBTA owns the two parallel sets of railroad tracks that run through the study area (Map 1). The tracks are maintained by the Massachusetts Bay Commuter Rail, an entity that is under contract with the MBTA.

The town of Concord has identified the railroad easement and underpass as a major wildlife corridor for movement between large tracts of natural areas. In addition, although currently forbidden under MBTA regulations, pedestrians regularly use the railroad easement for recreational purposes and for crossing under Route 2.

Figure 12: The Fitchburg Railroad Underpass in the Study Area

3.B.5 Conclusion

The study area in Concord and Lincoln contains several large land parcels that are protected as municipal conservation land or owned by local land trusts. In addition, the towns have identified large tracts of natural land in the study area and adjacent land as priorities for future preservation. Limited, if any, future land use changes are expected to occur in the study area.

Wetland and river protection areas exist within the study area, in the vicinity of the Sudbury River, and are considered to be important natural resources and wildlife habitats. Any proposed alterations will be subject to a review and permitting process by state and local agencies. However, the proposed alterations associated with a passage structure are considered likely to be in the scope of uses considered to be acceptable by these agencies.

Trails have been identified as important resources in both the towns of Lincoln and Concord. Improving the quality and accessibility of existing trails and creating new trails to increase connectivity have been identified as specific goals for both of the towns. Local and regional trails run through or nearby the study area, providing opportunities for movement for humans and wildlife. The existing railroad right-of-way has been identified as another opportunity for connectivity for both humans and wildlife. Recent trail improvements in Concord that connect to the study area include the Fairhaven Trail, Brister's Hill and former landfill trails, and the Emerson-Thoreau Amble. The Fairhaven Trail includes loop trails through open space in the study area located south of Route 2 in the vicinity of the Sudbury River (Map 2) and links to existing trails in Lincoln and Carlisle. The Brister's Hill trail was completed in 2006 as a loop trail located northeast of the Route 2/126 intersection. The former landfill trail

is a loop trail located within the former landfill. Due to proximity, there is an opportunity for connectivity between these two trails as well as connections to the many existing trails located in the Walden Woods State Reservation. However, Routes 2 and 126 act as barriers and raise pedestrian safety concerns. Phase I of the Emerson-Thoreau Amble trail has been constructed with funding from a state grant. As of June 2007, the Town of Concord has received state funds to construct Phase 2. Upon completion, this trail will link Concord Center to Brister's Hill via the Hapgood Wright Town Forest. The Bay Circuit Trail is a 200-mile regional trail that connects both towns through the Walden Woods area. However, Route 2 acts as a major barrier and safety concern. The Bay Circuit Trail Alliance has emphasized the importance of increasing safety for hikers crossing Route 2 at the eastern end of the study area.

The study area has several open space resources and connectivity opportunities. Preservation of these resources is considered to be a priority for both of the towns that will be impacted by a passage structure. A need for a passage structure to reduce the impacts of Route 2 on wildlife and humans has been identified by both of the towns.

3.C. Cultural Landscape Context

In this section we address the historical and cultural context in Concord and Lincoln and how they may relate to the study area. Concord and Lincoln both have regionally and nationally significant resources associated with the shaping of this country. This important cultural landscape would be enhanced by increasing connectivity and accessibility to these resources through a recreational passage structure.

While no outstanding cultural associations with the study area belong to the period of early settlement, the importance and identity of "Walden Woods," with a number of associated ponds, was already established.

The Route 2 corridor study area was not the scene of specific, dramatic events associated with the start of the Revolutionary War. However, its proximity to a very significant national historical park should be considered and does affect the potential of various crossing locations for interpreting the cultural landscape. The eastern portion of the study area—the part of the corridor which is closer to Minute Man National Historical Park—will have better potential for both physical and conceptual connections to the trails, facilities, and interpretive themes of the National Park. Hundreds of thousands of people visit Minute Man every year, and many of them take advantage of the excellent interpretive trail (Battle Road Trail) that creates a viable alternative to driving through the park. A connection between the park's trails and other trails—both in Concord and in the Walden Pond State Reservation—could increase the use, functionality, and impact of a Route 2 combined wildlife-recreational crossing structure.

The Route 2 corridor study area (which of course would not become a defined corridor until the twentieth century) was probably characterized during

the Revolutionary War period most notably by nearby natural features, such as Walden, Goose, and Crosby's Ponds.

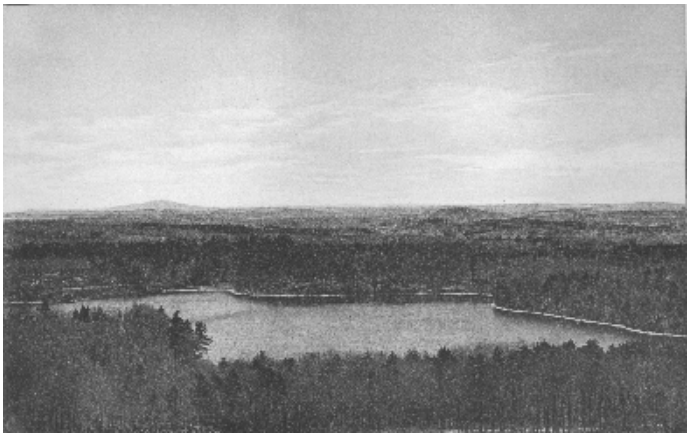


Figure 13: Walden Pond from Emerson Cliff
(Courtesy of the Thoreau Institute at Walden Woods)

Because the area was less suitable for agriculture, it was also destined to remain at least partially wooded, even as clearing intensified in coming decades. Lying midway between Concord and the newly established Lincoln, it was probably already valued as a source of firewood and timber. Scholars have suggested that the name Walden, which dates to this early period, derives from Germanic roots, such as wald or weald, implying a wooded area. The 18-20th Century land use history is another interpretive theme suited to parts of the study area.

The study area along the banks of the Sudbury River was probably not used by many such nineteenth-century walkers. Such a route would have taken them far out of their way. If the river did offer canoeing, fishing, or other outdoor pursuits, it would not have been a logical route from Concord to Walden Pond and the woods around it. In many areas, in fact, wet meadows or other overflow areas may have made walking along the river in this area somewhat problematic.

Figure 14: Leaning Hemlocks on Concord River
(Courtesy of the Thoreau Institute at Walden Woods)

The Fitchburg Railroad underpass in the center of the study area, adjacent to the Walden pond State Reservation, was frequently used, in particular by Thoreau. The railroad "cut," although not an underpass at the time (since there was no Route 2) was along Thoreau's most frequently used route between his cabin and town center. The railroad had only just been completed a year earlier when Thoreau repaired to the Walden Woods for his experiment in simple living. The railroad right-of-way passed through the center of town, near the homes of friends and family in Concord, and along the edge of Walden Pond, near his chosen cabin site. While he was ambivalent about what the arrival of this form of industrialization might mean for the future, he often used the easy grade and direct route offered by the new railroad right-of-way during his stay in his cabin and later. He describes this route in his writings. Other Concord walkers may have preferred less direct and more scenic routes to Walden Woods (as Thoreau himself did at times). But the walk along the railroad tracks between Concord and Walden Pond has a direct association with Thoreau, as a walk he made often and wrote about, especially during the crucial years of his cabin residence.

Goose Pond, at the eastern end of the study area also is near places that Thoreau describes in his writings. Many of these associations have been established by the Walden Woods Project, as part of their planning and design of the Brister's Hill landscape. They include nearby Brister's Hill itself, and Fairyland

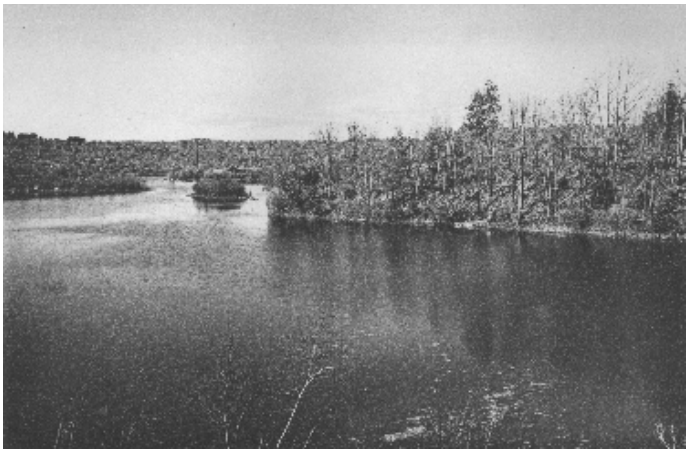


Figure 15: Goose Pond
(Courtesy of the Thoreau Institute at Walden Woods)

Pond (named by Thoreau), which is in the Hapgood Wright Town Forest- adjacent to Brister's Hill in the study area.

It should also be noted that while the railroad provided a more direct route into Concord center, the Goose Pond area is closer to Emerson's home, which was an important center of cultural life in the town. Emerson received many visitors at his home, including his local colleagues and guests from all over the country and abroad. Emerson often invited such friends and guests to join him on a walk. Walden Woods, a frequent destination, would have been most quickly accessed by walking south on Walden Street, which is now a busy automotive route.

A partially-implemented trail project, the Emerson/ Thoreau Amble, would recreate this important connection between the Emerson House and the trails of Hapgood Wright Town Forest and the Brister's Hill landscape. By creating access from the house to the trails in the town forest, visitors could avoid having to walk along the busy Walden Street. Visitors to Emerson House could walk directly from Emerson's home to the trails in Hapgood Wright Town Forest (including Fairyland Pond), to the Brister's Hill interpretive landscape trails built by the Walden Woods Project, and ultimately to Walden Woods and Walden Pond (if there were an adequate crossing of Route 2).

Such a trail itinerary would avoid Walden Street while providing needed trail connectivity back to Concord center (at Emerson House). It would also provide a vital interpretive experience—a walk that recreated the kinds of walks Emerson would have taken—that would suggest to visitors something about the nineteenth-century intellectual life of Emerson, Thoreau, and Concord that they could never understand from a house museum visit alone.

3.D. Wildlife Issues at Multiple Scales

The central issue to be addressed for wildlife in this feasibility analysis is whether the addition of a passage structure at each of the three alternative locations would enhance existing potential for wildlife crossings. Answering this question depends first upon knowledge of the species present and second on quantifying their use of the existing wildlife passage culverts and other crossing locations. Here, we provide detailed data from 16 months of monitoring of the existing wildlife crossing culverts as well as from 3 previous years of animal monitoring in the study area. These data also provide insights into the level of human use in the existing wildlife crossing culverts.

A key consideration in our analysis is scale. Roads impact different species at different levels of organization depending on their scale of movement. Thus, appropriate methods of enhancing connectivity depend on the relevant scale of interest for the conservation objective (Table 10). For example, a road bisecting a small habitat patch might only affect bobcats at the individual level, since a single bobcat home range is large enough to encompass the entire patch. By contrast, the same road might affect less mobile animals like voles at the population level, subdividing a previously viable population. We present our evaluations of the wildlife potential of the three Walden Passage alternatives with reference to three scales of interest: movements of individuals, sustainability of populations, and maintenance of metapopulations.

Using the available data, we conducted an indirect assessment of movements at these three scales. Based upon published home range sizes of each local species, we assessed the relevant scale of analysis for each species (individual, population, metapopulation), and from this predicted the minimum crossing frequency that would be required to maintain the scale-specific dynamics. We then used wildlife monitoring data to identify any species for which crossing rates may be below the minimum benchmark.

Table 10. Relevant Scales of Analysis for Mammal Species

Categories are approximate, and based on comparing published home ranges and densities of species to the smallest tract of conservation land adjacent to Route 2, Bristers Hill (64 ha). Smaller tracts require greater connectivity for species to persist. If existing crossing levels exceed the minimum necessary to sustain populations in Bristers Hill, they are likely to also exceed that needed for persistence in other tracts within the study area. The rule of thumb that 50 individuals are needed to sustain a population was used as a guideline in assigning categories. Since all rodent species should be analyzed at the scale of the metapopulation, we present them in general groupings (e.g. 'mole species' rather than listing the three species).

Metapopulation	Population	Individual
Eastern Cottontail	White-tailed Deer	Moose
Snowshoe Hare	Striped Skunk	Black Bear
Common Muskrat	American Mink	Bobcat
Eastern Gray Squirrel	Long-tailed Weasel	Coyote
Red Squirrel	Short-tailed Weasel	Northern River Otter
Southern Flying Squirrel	Woodchuck	Common Gray Fox
Eastern Chipmunk	Common Porcupine	Red Fox
Mole species		Common Raccoon
Vole species		Virginia Opossum
Mouse species		Fisher
Shrew species		American Beaver

Our analysis of the monitoring data found no evidence of endangered or state-listed species in the study area that would make use of an additional wildlife crossing. Furthermore, we found that the existing wildlife passage culverts under Route 2 currently support successful crossings by a majority of species that might be served by any additional crossing. However, an additional crossing could improve crossing rates for these species and could accommodate other species that may be present but that are not currently crossing Route 2 by using the wildlife crossing culverts. In particular, we focus on arboreal species as those least likely to be using the existing Route 2 wildlife crossing culverts.

3.D.1 Existing Connectivity

Currently, there are four kinds of larger wildlife crossings along Route 2 within the study area: through one of four wildlife crossing culverts, through the Fitchburg railroad underpass, along the Sudbury River under the Route 2 bridge, and directly across the road surface. There are also 3 smaller culverts: at the outlet to Crosby Pond on the north side of Route 2, on the south side between Sudbury River and Sudbury Road, and outflow of a small stream west of Route 126. Each of these crossing locations and means is limited to varying degrees. The wildlife crossing culverts are small and enclosed, which could deter some species from crossing. The culverts are even smaller with virtually no usage detected in all but one of them. The Fitchburg railroad underpass is open and exposed with little cover, which again could deter some species from using it. High water levels along the Sudbury River seasonally restrict crossings in at least two of the wildlife tunnels and make the Sudbury River Bridge impassable at least for terrestrial species for much of the year. Road surface crossings are always risky for wildlife. In addition, the existence of Jersey barriers inhibits these crossings along 2.5 miles of Route 2. Nevertheless, the existence of multiple safe crossing locations raises the question of whether an additional structure would significantly add to the existing crossing potential.

3.D.2 Biological Scale Evaluation

As described in the literature review, roads have impacts on wildlife at three important levels of biological organization: individuals, populations, and metapopulations, which are networks of interconnected populations. Ameliorating road impacts at each of these levels represents a distinct set of goals with distinct solutions (Table 11). At the individual level, an important goal is avoiding road mortality or providing access to a full home range or critical habitat for one individual or a breeding pair. Reducing road kill may

Table 11. Connectivity Objectives and Recommended Solutions
Each objective addresses increasing levels of biological organization, from individuals to populations

Wildlife Objectives	Recommendations	Example Species
Reduce or avoid road kill mortality	Effective barriers are more important than passage	White-tailed deer, Blandings turtle
Access to vital habitats	Passage for all or most animals	Salamanders using vernal pools
Population continuity	Passage for enough individuals to maintain a cohesive gene pool	Bobcat, bear, moose, fisher
Metapopulation dynamics	Occasional passage for a small number of individuals; perhaps juveniles	Many small mammals, snakes, frogs, etc.

be of interest either for public safety (e.g. deer) or to protect rare or endangered species (e.g. Blandings turtles or Florida panthers) in which every individual is critical to the persistence of the species. Roadkill is thus also important at the population level to prevent loss of whole populations from road mortality. This is most commonly a concern for amphibian and reptile species. In either case, fencing appears to be the most effective tool for preventing roadkill (Table 11).

Other population level issues include: maintaining population continuity or providing access to vital habitats required by a population, such as amphibian breeding habitat, turtle nesting habitat, and snake hibernacula. Population continuity is of greatest significance when habitat fragments are too small to support a breeding population. On the other hand, increasing connectivity through passage structures will only achieve the objective if: a) the linked habitat fragments across the road provide enough habitat to support a viable population and b) enough individuals pass through the structure to maintain a cohesive gene pool (Table 10).

At the metapopulation scale, issues include maintaining gene flow, supporting source-sink relationships among populations, and providing sufficient opportunities to recolonize habitat fragments after local extinction events. Metapopulation dynamics are of greater significance when habitat fragments are large enough to support small, but viable breeding populations but are vulnerable to genetic drift and local extinction. Because metapopulation dynamics may require only a few individuals per generation to move between populations, achieving this objective does not require passage structures to be as efficient as for the individual or population level.

Because population density data are not available for species in the study area, we used the home range size and typical population density of species known or likely to occur in the study area to classify the scale of benefit for the proposed Walden Passage (Table 10). Species classified at the individual scale are expected to occur at low densities and therefore require permeability of Route 2 in order to access sections of their home range on both sides of the highway. The timescale at which individuals need access to all parts of their home range, however, is on the order of days. In order to maintain population level continuity across Route 2, individuals generally need yearly access to other individuals in the population for breeding purposes. Finally, species at the metapopulation scale need only cross at the rate of a few individuals per generation in order to maintain the potential for gene flow and re-colonization events. We use these approximate categories in combination with measured crossing rates from the monitoring data to evaluate whether any species lack sufficient connectivity along Route 2.

3.D.3 Results of Monitoring Data

Monitoring Methods

Members of the Wildlife Passages Task Force (WPTF), a subcommittee of the Concord Natural Resource Commission and the Mass Audubon Ecological Extension Service (Mass Audubon, hereafter) staff conducted winter wildlife tracking surveys. In addition, the WPTF maintained track beds and remote cameras in the some of the existing wildlife passage culverts and did targeted track and sign surveys at the railroad crossing to identify species using each crossing location.

The tracking surveys took advantage of snow cover to locate and identify animal tracks and sign. These surveys also provided insight into the frequency with which species approached or crossed Route 2 without

using a passage structure. Trained wildlife trackers visited the study area after each snowfall during the winter of 2004-2005 (Mass Audubon) and from 2001-2007 (WPTF). Field visits were scheduled to fall within the 24-48 hour period following the end of snowfall. During the survey, trackers explored a band transect consisting of the area within 100 meters of Route 2, employing a directed search method to record as many animal tracks as possible.

These data were summarized along with track bed and camera data as lists of species detected per observation period, grouped by location. From these data, we estimated minimum annual crossing rates as the total number of detected crossings divided by the number of sampling days multiplied by the number of days in a year (365). This allowed us to estimate comparable annual crossing rates for both track beds and cameras (Figure 16) despite different sampling periods for each method. These crossing rates should not be interpreted as the number of distinct individuals using the passage structures, as the same individual might be responsible for multiple crossings.

Amphibians and Reptiles

Few reptiles or amphibians were detected using the available monitoring methods. The majority of reptile and amphibian species likely to occur in the study area have small home ranges, and thus would only need to cross Route 2 occasionally to maintain metapopulation dynamics (Table 12a). These species also would typically be served by underpasses similar to those already installed. In fact, several salamanders and frogs were detected crossing through the easternmost wildlife crossing culvert in the study area (Figure 16). However, four salamanders were found dead in the middle of the culvert, perhaps due to desiccation. Direct mortality from roadkill is a more significant threat to many amphibians and reptiles than the lack of connectivity posed by the roads. Improved fencing, rather than adding passage structures, may be more effective at reducing roadkill for these species.

Mammals

Track-bed and camera data show that the majority of mammal species present in the area are using the existing crossing structures (Figs. 16-17, Table 12b). Species observed using the wildlife crossing culverts constitute a diverse set of mammals, including small herbivores, large herbivores, small carnivores, and large carnivores (Figures 16-17).

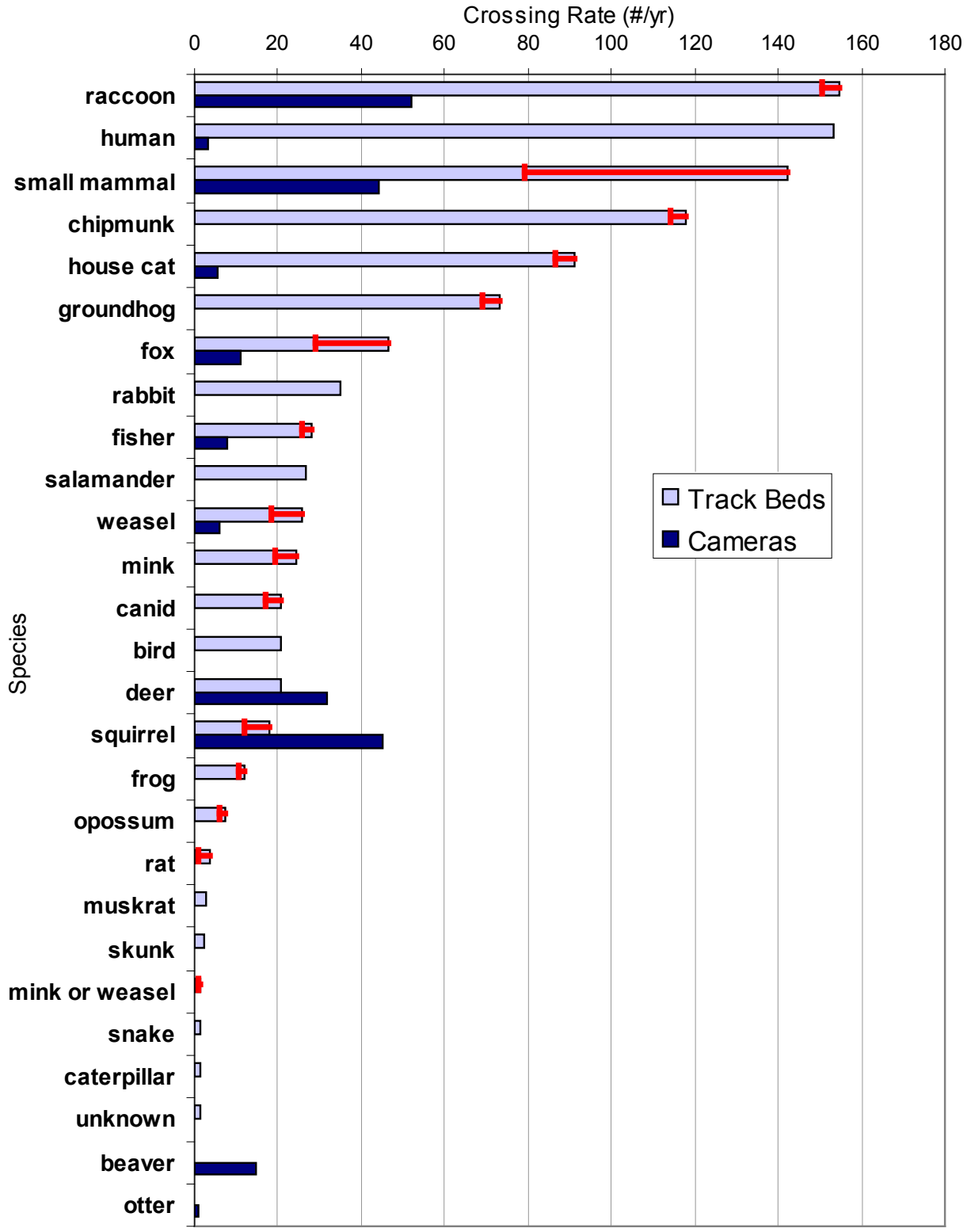
Of the species detected in the study area, all were seen to cross Route 2 at a rate that at least exceeds a few individuals per generation. Thus, for all detected species with home ranges small enough to maintain viable populations on either side of Route 2 (Table 12a) in the study area, we can consider the highway not to be a significant barrier at any scale. All but a handful of the remaining species crossed at rates exceeding 15 times per year. The species that were detected crossing

Table 12a. Amphibian and Reptile Species Detected in the Study Area
Only a small number of surveys were conducted in 2005. More species are likely to be present. Frogs, salamanders, and snakes of unknown species identity have all been detected in the underpasses (Figure 16).

Common Name	**Latin Name**	**Home range (m^2)**
Wood frogs	*Rana sylvatica*	239-368
Spring peepers	*Hyla crucifer*	-
Red-backed salamanders	*Piethodon cinereus*	13-24
Eastern Spotted newt	*Notophthalmus viridescens*	270
Garter snake	*Thamnophis sirtalis*	20000-140000

Figure 16. Minimum Crossing Rates of Species Based on Track Bed and Camera Data

Track bed data includes nearly continuous monitoring of tunnel A and occasional monitoring of other tunnels over 16 months. Camera data represents 15 months of monitoring, with nearly continuous coverage of tunnel C and approximately one month's coverage in each of tunnels A, B and D. Similar species were grouped together, such as: red and gray fox ("fox"); mice, voles, and shrews ("small mammal"); red and gray squirrel ("squirrel"); long tailed weasel and ermine; all dog tracks that resembled domestic dog ("canid"); all birds; all salamanders; all frogs; and all snakes. Red error bars indicate tracks for which observers were less than 95% confident of species identification.



at rates lower than expected were: coyote, skunk, otter, and muskrat. In addition, there were several species that may occur in the study area and would have left distinctive tracks, but were never detected in the study area: bobcat, moose, black bear, porcupine, snowshoe hare, and mole. Of these, moose and black bear populations are increasing regionally and are the most likely to occur there in the future. Flying squirrels were also not detected crossing Route 2, but were detected in the study area through snow tracking. It is possible, though unlikely, that they were present but not distinguished from other small mammals in the track bed monitoring. Thus, flying squirrel appears to be the only mammal species present in the study area that was not detected in the passage structures. These data only include animals that crossed through the four wildlife crossing culverts. We presume that northern river otter and American muskrat, two riverine species, can regularly use the Sudbury River beneath Route 2. Supplementary snow tracking data shows that coyotes cross directly over the road surface. Both skunks and coyote tracks were found near the railroad underpass, which, based on past studies, should be large enough to serve as a good passageway for many

Figure 17. Animals Detected by Cameras in Existing Wildlife Crossing Culverts
From top to bottom: white-tailed deer, coyote, fisher, red fox, eastern cottontail, common raccoon, northern river otter, American beaver, mouse, gray squirrel, long-tailed weasel, and snapping turtle. The coyote and snapping turtle shown here represent the first confirmed usage of the mitigation tunnels by these species.

Table 12b. Mammal Species Detected in the Study Area (2002-2007)

The table shows typical home range sizes (in hectares) and population densities (numbers per hectare) derived from the literature. For the category "Detection," a "Y" indicates that a species was detected in the monitoring conducted by WPTF. Some species indicates as "N" or not detected, are know to occur in the vicinity of the study area. See text for further discussion. Annual rates refer to the minimum number of crossings per year through the 4 mitigation tunnels that were detected for each species over 16 months of monitoring by WPTF. The final column lists the number of tracks in the tunnels that were unclear to be identified with strong certainty. (Summarized from Degraaf and Yamasaki 2000)

Common Name	Latin Name	Home Range range (ha)	Density (#/ha)	Detection	Annual Rate (#/yr)		
					Cameras	Tracks	Unclear Tracks
Moose	*Alces alces*	200-15300	0.00077-0.016	N			
White-tailed Deer	*Odocoileus virginianus*	59-804	0.058-0.116	Y	32	21	
Black Bear	*Ursus americanus*	1500-15000	0.001-0.013	N			
Bobcat	*Lynx rufus*	10.5-20100	0.0004-0.027	N			
Domestic Cat*	*Felis catus*			Y	5	91	
Coyote	*Canis latrans*	630-6800	0.0005-0.0057	Y		21	4
Domestic Dog*	*Canis familiaris*	-	-	Y			
Red Fox*	*Vulpes vulpes*	27-2000	0.001-0.03	Y	11	47	18
Common Gray Fox	*Urocyon cinereoargenteus*	20-5000	0.012-0.021	Y			
Common Raccon	*Procyon lotor*	5-5000	0.036-0.56	Y	52	155	4
Virginia Opossum	*Didelphis virginiana*	-	-	Y		7	1
Striped Skunk	*Mephitis mephitis*	60-1160	0.005-0.26	Y			
Northern River Otter	*Lutra canadensis*	180-5700	-	Y			
Fisher	*Martes pennanti*	1630-3090	0.0005-0.0036	Y	8	28	2
American Mink	*Mustela vison*	7.8-20.4	0.033-0.085	Y		24	5
Long-tailed Weasel	*Mustela frenata*	10-160	0.004-0.3	Y	6	26	7
Ermine	*Mustela erminea*	4-20	0.06-0.11				
Snowshoe Hare	*Lepus americanus*	1.6-7.7	0-10	N			
Eastern Cottontail*	*Sylvilagus floridanus*	0.2-16.2	1.1-3	Y		35	
American Beaver	*Castor canadensis*	60-90	0.0048-0.032	Y	14		
Common Muskrat	*Ondatra zibethicus*	0.29-0.11	18.1-22.6	Y			
Woodchuck	*Marmota monax*	0.1-55.6	0.12-0.91	Y		73	4
Common Porcupine	*Erethizon dorsatum*	2.4-14.6	0.012-62	Y			
Eastern Gray Squirrel	*Sciurus carolinensis*	0.5-20	3-21	Y	45	18	6
Red Squirrel	*Tamiasciurus hudsonicus*	0.35-2.4	2.5-4	Y			
Southern Flying Squirrel	*Glaucomys volans*	0.17-9.9	12-0	N			
Eastern Chipmunk	*Tamias striatus*	0.01-1	0.3-38	Y		117	
Norway Rat*	*Rattus norvegicus*	0.042-0.196	-	Y		4	3
Vole	*2 probable sp*	0.02-0.1	0-15	Y	44	142	62
Mouse	*5 probable sp*	0.02-4	0.6-90				
Shrew	*3 probable sp*	0.1-	2-240				
Mole	*2 probable sp*	0.1-1	3-40				

*Introduced or feral species. Note, however, that the introduced vs. native status of the red fox is under dispute.

species. Past studies also suggest that the wildlife crossing culverts would be effective for bobcat, black bear, porcupine, and snowshoe hare if they did occur in the study area. Moles may have difficulty using the substrate and getting past small barriers in the wildlife crossing culverts (sand, branches). One set of mole tracks was discovered crossing through a culvert, and only a few individuals of these species would need to cross in order to maintain a metapopulation.

Moose are the one mammal species for which the wildlife crossing culverts are presumed to be too small. The railroad underpass is large enough for moose, and moose are known to travel long distances along railroads (Macdonald personal communication.). Moose may also swim through the Sudbury River underpass, as they frequently enter water, and deer were photographed swimming through a wildlife crossing culvert next to the river during a flood event. A larger passageway at Goose Pond may improve the ability of moose to cross Route 2 at that location. However, given the surrounding levels of urbanization, it is unclear whether moose would find a crossing at that location and even more critically, whether it would be desirable for them to do so. Moose crossing into Concord at the Goose Pond location would likely be considered nuisance animals that may need to be relocated.

Potential to Improve Regional-scale Connectivity

Two of the largest tracts of conservation land in reach of the study areas are within the Great Meadows National Wildlife Refuge, composed of two separate tracts, one to the north and one to the south of the study area. For animals to travel between Great Meadows North and Great Meadows South, there are two travel routes with relatively light urban-suburban development: along the Sudbury River; or through the forest east of Concord center. Rivers generally serve as natural travel corridors for wildlife. Thus, improving the permeability of Route 2 next to the Sudbury River is likely to be the most effective approach to enhancing regional connectivity along this stretch of highway. However, there are four other bridges over the river within a few hundred meters downstream of Route 2, and very little forested land remains between the river banks and the residential development in the center of Concord. Both of these factors may limit the ability of a single project at Route 2 to improve the function of the river as a wildlife travel corridor. An additional crossing structure located under Route 2 at the Sudbury River would be more effective on the west side of the river than the east side for two reasons: (1) from Great Meadows North to Great Meadows South, the west side of the river contains the least development and the most contiguous forest, and (2) two of the current wildlife crossing culverts are already placed very close together on the East side of the river under Route 2. Anecdotal accounts indicate high levels of roadkill along Route 2 on the west side of the river (just west of the Study Area).

Other regional travel corridors for wildlife may exist on the east side of Concord Center, connecting Walden Reservation with Minuteman National Historical Park. A new crossing structure at the two other alternative locations, Goose Pond and the Fitchburg railroad, could enhance this possible travel corridor. However, one wildlife crossing culvert and the Fitchburg railroad underpass already allow animals to cross Route 2 at these locations. In addition, this corridor would rely upon animals traveling through a residential neighborhood between Routes 2A and 62. These neighborhoods likely present a current barrier to movement for some species, and the future of this corridor could be altered by private landowners' decisions to remove trees, build houses, or fence yards. Planning efforts in the Town of Concord could

also improve the efficacy of wildlife movement corridors through settled neighborhoods by way of land acquisitions, easements, and voluntary wildlife-friendly management.

Human Crossings

Human crossings were recorded regularly in monitoring the wildlife tunnels. These data give some insights into the degree to which human presence would impact animal crossings in any new structure. According to data from the track beds, there were 200 total human crossings in 16 months (average of 13±2 human crossings per month) in the tunnel near the Goose Pond location. In one of the other tunnels near the Sudbury River, only 2 humans crossed in 17 months of monitoring. We did not detect changes in the number or species composition of animal crossings during observation periods in which humans used the tunnels. Human use of the tunnels is far lower than that detected in studies in Banff National Park, where tunnels near the town of Banff received an average of 97 human visitors per month (Clevenger and Waltho 2000, 2005). While the low levels of current human traffic in the tunnels do not appear to deter animals, the higher levels found in Banff do reduce animal usage of tunnels (Clevenger and Waltho 2000, 2005). A recreational study is needed to determine what level of usage the proposed passage structure might receive.

Summary of Wildlife Issues

Existing crossings provide good connectivity for the wildlife communities across Route 2. The marginal benefit to wildlife of adding a new crossing structure is small. Surrounding habitat fragmentation may be a more limiting factor to regional scale wildlife movement than Route 2 itself. An additional crossing structure will likely have impacts at the scale of individual animals, and individual parcels. For instance, individual coyotes may not have access to certain parcels of habitat at present, but there are no unique resources identified on these parcels that are essential for coyotes to persist in the study area. There are no populations identified as threatened by Route 2, and there are no rare vertebrate species known to occur in the area. Among the three alternative locations, the west side of the Sudbury River would be the most effective place to increase the permeability of Route 2 for wildlife. At the Goose Pond location, connectivity might be improved using an overpass for arboreal species, such as flying squirrels.

We recommend that any future reconstruction or replacement of the Route 2 Sudbury River Bridge should include provisions for safe wildlife passage beneath the bridge on both sides of the Sudbury River.

3.E. Route 2

Existing Highway Conditions

The study area consists of a 2.5 mile section of Route 2, commonly known as the Concord Turnpike. The roadway alignment follows the original design of the Turnpike that dates from the 1930s. The project study area initiates on the west end at a bridge over the Sudbury River (Mass Highway bridge number C-19-021) and ends at the east at the signalized intersection between the Concord and Cambridge Turnpikes (Crosby's Corner). The highway has two traffic lanes in each direction divided by a concrete median barrier along most of the study area. The highway width is approximately fifty feet throughout the study area, except at regions close to the location of signalized street intersections where a third lane is provided for left turns onto streets. At these locations, the highway width increases to approximately 62 feet.

There are four road intersections within the project study area. The two intersections that cross the highway median are signalized (Sudbury Road and Walden Street intersections), while the other two intersections feed onto Route 2 on the North and or South side of the highway (Fairhaven Road and Sandy Pond Road intersections).

Traffic and Safety Conditions

Route 2 is used primarily by daily commuters traveling to and from Boston. The average daily traffic during the last five years has ranged from 41,000 to 53, 000 vehicles including eastbound and westbound directions. Data have been collected at a station located approximately 0.1 miles east of the Concord rotary. This station lies approximately 1.6 miles west of the Sudbury River crossing that marks the west end of the study area. Figure 19 show the location of accidents that have been reported within the project study area between 2002 and 2005. The dots indicate areas along Route 2 where accidents are prone to occur.

Observation of Figure 19 reveals that most of the reported collisions took place close to locations of intersections or access points to Route 2. The collisions reported within this period have been reported primarily as collisions against other vehicles or highway features such as utility poles, median barriers and guardrails. No accidents were reported involving wildlife during this period, however, field observations and anecdotal information from Advisory Board members and the Wildlife Passage Task Force (WPTF) indicated that

Figure 18: Examples of Divided (near Walden St) and Undivided Highway (near Crosby's Corner) in the StudyArea

large mammal-vehicle conflicts still occur in the study area. Table 13 gives a summary of the data collected from accident reports exceeding $1,000 in damage during this period.

Figure 19: Location of Reported Accidents from 2002 to 2005
(Source MassSafe)

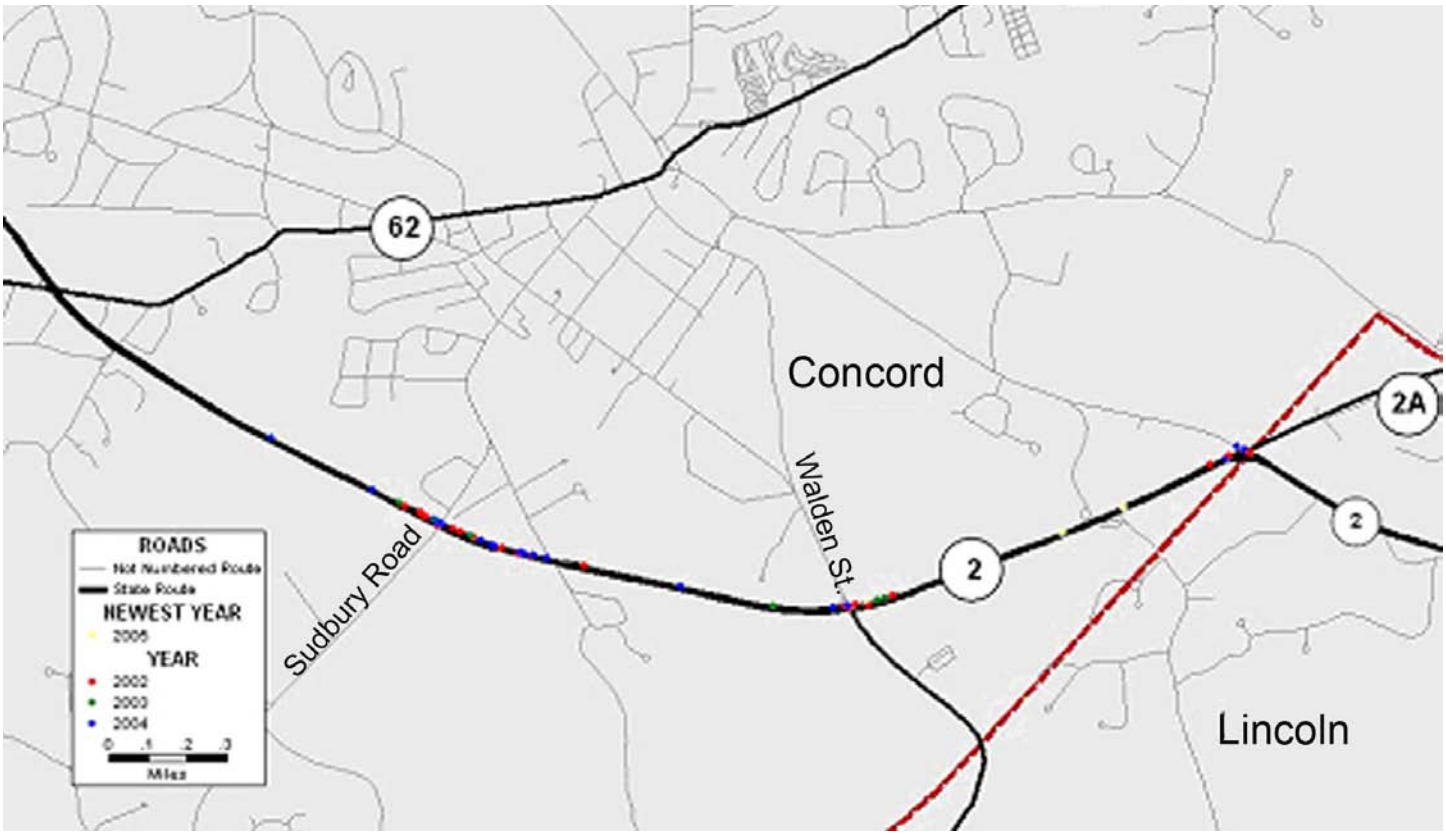


Table 13. Details of Accident Reports from 2002 to 2005
(Source MassSafe)

		Roadway conditions				Impacted Object				
Year	**Total number**	**Wet**	**Dry**	**Snow/ Ice**	**NR***	**Curb**	**Median or guardrail**	**Vehicle**	**Pole**	**NR***
2002	49	13	34	0	2	3	1	38	2	5
2003	32	6	24	2	0	0	2	25	0	5
2004	44	5	35	3	1	0	0	37	0	7
2005	31	3	28	0	0	0	2	17	2	10
Totals	156	27	121	5	3	3	5	117	4	27

*Not Reported

Future Projects within Study Area

There are two major projects scheduled within the study area for the next 5 to 10 years. These two projects are geographically located right at the west and east ends of the project area (Sudbury River Bridge and Route 2 at Crosby's Corner). These two projects are at different stages in their development as described in the following sections.

Crosby's Corner Grade Separation (Concord-Lincoln Limited Access Highway at Route 2 and 2A MHD # 602626)

The Crosby's Corner Project (MHD # 602626) will change westbound traffic patterns as vehicles will no longer be required to slow down or stop at Crosby's Corner. However, the project is not expected to impact existing traffic conditions at the Route 2 and Route 126 Intersection (Concord Road and Walden Street) (Massachusetts Highway Department, Route 2 Crosby's Corner Final Environmental Impact Report, p.36). Because the recommended passage structure will be over 2000 feet to the east from this intersection and will be constructed in accordance with state bridge design standards, no traffic or safety impacts are expected.

Sudbury River Bridge Repair

Preliminary design is being conducted to repair the existing arch bridge that carries Route 2 over the Sudbury River on the west end of the study area (Bridge No. C-19-021). The reinforced concrete arch bridge was constructed in 1934 and spans 26.8 m. It provides minimum vertical clearance for navigation along the Sudbury River. Repair of spandrel walls and work on the highway approaches are planned as part of this project. The current bridge is not posted, that is, it does not have any restrictions on the loads that can be carried across the span. This project has an anticipated start date in the winter of 2009/2010.

4. *Alternative Combined Wildlife-Recreational Crossing Locations and Design*

4.A. Crossing Engineering Design and Structural Principles

This section discusses general issues that may affect the structural design of the wildlife/recreational crossing. Wildlife crossings can consist of an overpass (bridge), an underpass, or an at-grade crossing structure. Each of these structure types will have significantly different design considerations and objectives. A successful design must satisfy functional requirements (as defined by the other sections of this report) and provide an aesthetically pleasing structure at a reasonable cost. The ideal solution would be one satisfying all major design requirements, represented schematically as the intersection of the three design criteria shown in Figure 20. In this diagram, the three criteria are given equal weight. A solution may be also reached where weights are given to design criteria based on the importance that an owner/user places on them.

Depending on the functional needs, the potential structural systems can be defined, and then the approximate costs evaluated. However, these qualities are all interlinked, and also depend on issues relating to the soil conditions and topography in the immediate area.

Function, Aesthetics and Cost

Overall function of the passage structure will drive most of the decisions, as the size of the structure must be determined based on requirements for the expected species use and need for separation between wildlife and human access and use. The layout of Route 2 must also be considered to ensure proper crossing functionality, as any crossing must span the highway. For overpass structures, loads will also be dictated by function, as specific vegetation may be required for targeted species crossing, determining soil requirements for vegetation root depth. Loads in underpass structures are controlled primarily by vehicular loading requirements as dictated by existing highway codes.

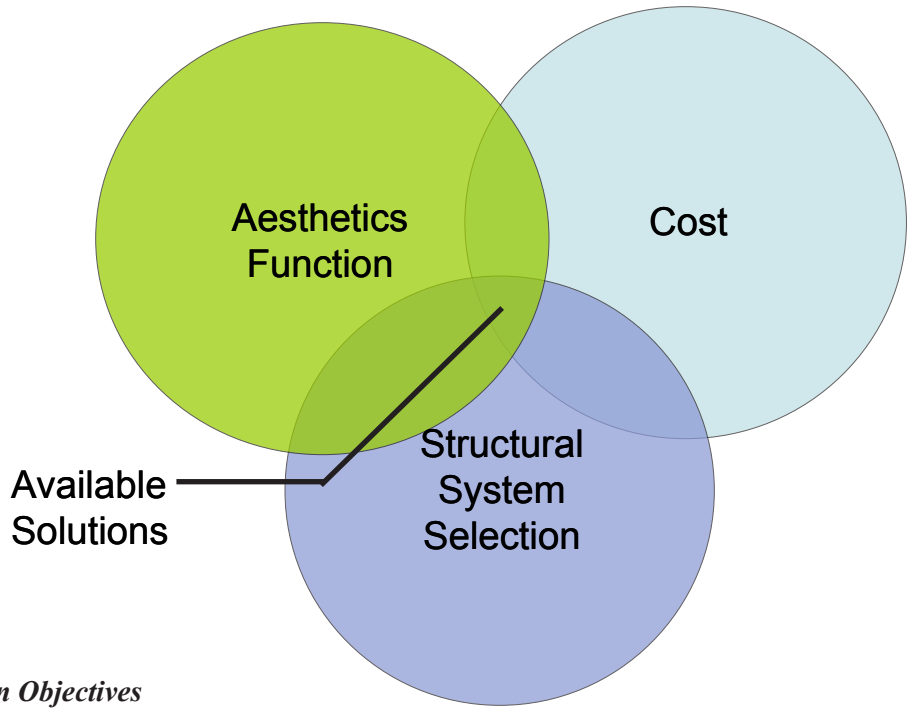


Figure 20: Design Objectives

Aesthetics plays an important role in satisfying wildlife/pedestrian crossing functionality. One of the criteria from a functional concern is that it fulfills its purpose aesthetically, whether this is blending into the surroundings or acting as a gateway, or landmark, structure.

Within any structural design, there are many levels where one should address aesthetics. An aesthetically pleasing solution can only be met if this criterion is addressed throughout the planning and design, starting at the conceptual design level. The type of structure, material selection, structural configuration, support placement and design will affect project aesthetics. These issues are addressed below.

Cost can be minimized by decreasing the load, span, and/or width of the structure. The foundations for the structure also have a significant impact on overall cost. Certain structural configurations may lend themselves to shorter construction times, or minimize interference with Route 2 traffic. These may increase the monetary cost of the structure itself, but decrease the overall project cost. Using structure types that lend themselves to the load and configuration of the structure can minimize cost. Aesthetic concerns can increase cost, though typically these increases are modest.

As was indicated in Figure 20, an acceptable structural solution is one in which the function can be accommodated, desired aesthetics are met, and the cost is within the budget allotted.

Structural Types

Bridge types can include slab-stringer systems (beam), cantilever spans, truss systems, rigid frames, arch types, or suspension and cable-stayed designs. Each of these types of structures typically lends itself to certain spans and/or materials to be effective. For underground structures, structural system selection depends primarily on the opening size. Small openings (up to approximately 8 to 10 ft wide) may be designed efficiently using prefabricated culverts. The opening may be spanned using prefabricated beams between tunnel walls. For wider openings intermediate supports placed perpendicular to the roadway direction may be required. The type of construction procedure is particular to each type of structural system.

Slab–stringer systems are typical for shorter spans such as overpasses. They typically include beam elements spanning between foundations. The beams can consist of cast in place concrete, precast concrete, steel, or wood sections for typical structures. Steel beams are often in an “I” shape, though box shapes made of steel or concrete can be more effective for longer spans, higher loads, and better aesthetic designs. These types of structures are often cost effective due to simplified fabrication and wide use in the construction industry.

Cantilever bridges include structure built out from each abutment as a cantilever, with a suspended span dropped in between them. The advantage of this type of construction is in longer spans where one does not want to impact the area below the construction, yet the span is too long for a slab-stringer design.

Truss systems of steel or timber are typically not as efficient as other bridge types due to the fabrication costs. However, they can be aesthetically pleasing and may be worth considering for moderate spans or high load conditions.

Arch bridges are generally effective in areas where a structure is to span between rocky slopes, otherwise a tied arch is typically used. These structures are generally more expensive to erect and fabricate, though they can have significant aesthetic advantages

However, the shape of the bridge often requires significantly more vertical clearance, or may require structural elements above the surface of the overpass. This structural system is best suited for locations underlain by stiff soil or rock because of the high demands placed on the foundations.

Suspension and cable-stay structures are generally considered for very long spans and/or structures where a significant visual statement is required. Because these structures tend to concentrate forces at a few locations along the span, highly competent soil or deep foundations are required for their construction.

Structural Design Considerations

For a wildlife/pedestrian overpass, two general types of structures could be considered. One would be a traditional bridge type structure. In this configuration a "superstructure" of beam elements would be placed to span between foundations (supports). The superstructure could be as simple as beams, or a more complicated system of trusses, arches, or other systems. The effectiveness of each system is generally a function of the span and load applied to the structure. Alternatively, the crossing could be achieved by constructing earth abutments on each side of Route 2 and creating a tunnel for traffic. This solution would require major earthwork placement to build up to the topography required to satisfy traffic clearance as dictated by appropriate codes. This type of structure works well when the infill required can be minimized, such as when the roadway runs between two steep embankments. When existing grade is near or below the roadway the soil would need to be built up to provide clearance above the tunnel structure with adequate depth for plant roots. It would also require three dimensional merging with the existing topography. Therefore, in the study area this is not likely to be a functional alternative.

Span

The span (length) of a member will affect the forces that must be resisted. Therefore, the size of members, acceptable materials, and possible structural configurations are influenced by the span. In turn, the cost and aesthetics of the structure are dependent on the span. Certain structural configurations are often identified as being more efficient for specific spans (short, medium, long).

One way to minimize the effect of overall bridge span is to provide intermediate supports. This breaks an overall structure into several shorter spans which may act independently or be continuous. The provision of a central support foundation on the median of Route 2 would significantly reduce the loads, and therefore would reduce the cost of the overall structure.

In considering span, the potential for future Route 2 widening must be accommodated. Placement of abutments as close to each other as possible will minimize construction cost. However, interference with future road expansion would prove to be a very large future cost, as all aspects of the existing overpass would need to be strengthened and modified. Proximity of supporting elements to traffic lanes must also be considered to comply with safety requirements as stipulated by highway codes.

Width

Bridge width and geometry will define many aspects of the structural design. One could think of a very wide structure as being made up of a series of thinner structures placed side by side, with associated increases in cost. Therefore, it would be advantageous to provide the least width possible, while still maintaining optimal function for the structure. The width will therefore be based on intended species use, vegetation, pedestrian use, and methods of dividing the two uses within the overpass.

Clearance

In accordance with the Massachusetts Highway Department Project Development and Design Guide (2006), in order to maintain adequate overhead capacity for traffic on Route 2 a minimum vertical clearance of approximately 16.5 feet must be provided. This clearance must extend to the exterior edge of the traveled way, including any potential future widening of the highway. In addition, the minimum horizontal clearance to any roadway obstruction, defined as the recovery area, must be set to satisfy the current MassHighway Bridge Manual (2005 MassHighway Bridge Manual).. A minimum of approximately 30 ft of clearance should be provided from the edge of the traveled roadway to the abutment faces. If a 30-ft recovery area cannot be provided, adequate roadside barriers must be provided to shield the bridge abutments as indicated in the MassHighway Bridge Manual .

Load

The load that the structure must resist is directly related to acceptable structural solutions. Higher load will result in higher costs, and may drive a solution toward certain materials and/or structural configurations. The highest variable concerning loads on the overpass is the type of vegetation expected to be sustained. Larger vegetation will require thicker layers of soil to support root structure, increasing the load on the structure. Decisions on whether larger vegetation (such as trees and shrubs) can be contained at distinct locations along the span, or whether design loads should consider these to be sustainable over the entire area. Other issues, such as the drainage system provided under the soil and control of soil buildup, will also affect the loads considered in design. During design, provisions for weight of soil in saturated conditions should be considered.

Aesthetics

As was previously noted, aesthetics affect the functionality of the structure. From a design perspective, there are many ways of meeting the design requirements. In general, it is typically preferred to preserve clarity in design, avoiding complicated structures. Slender structures are often preferred, as defined by the span to depth ratio, because they give a sense of transparency that is generally pleasing to users. Based on the materials used, features such as texture, contrast, and light and shadow delineation can be very effective aesthetic features at minimal cost. In the end, however, aesthetics are often a very personal decision, and so a public structure should have several options presented which address aesthetic concerns.

Aesthetics for this project will be very different depending on whether a solution is an apparent overpass/bridge type structure, has the impression of being a natural feature which Route 2 “tunnels” through, or provides an underpass which is not observable to traffic on Route 2. The aesthetic appeal to pedestrian traffic is also essential, as these users will have a very close view of the structure. A structural solution should therefore address the overall aesthetics of the structure as well as the detailing, which will be observed by pedestrians. Finally, the aesthetic features that are incorporated into the structure should not deter the use of the structure by wildlife.

Material

Materials considered for the structure are inherently linked to the structural system type, loading, availability, and span. Typical materials for these types of structures are concrete (cast in place or precast), steel, and timber. Due to the expected heavy load and long span for an overpass, it is expected that steel or precast concrete will prove to be effective solutions. For underpass options, concrete (cast in place or precast) might be the preferred alternative.

Site Selection Issues

Site selection criteria as concerned with structural design will be discussed in this section. Criteria related to issues such as wildlife migration and connectivity (which are critical to the site selection) are discussed elsewhere in this report. In general, site selection from an engineering perspective is dependent on local soil conditions, topography, existing access roads, and safety.

Soil Conditions

The type of soil available at a site will determine the amount of work required to support a structure. Foundation type is determined by local soil conditions, with shallow foundations being sufficient to support moderate weight structures when located in competent soil. Deep foundations are required to transfer superstructure forces to deeper stiff soil layers to avoid settlement problems if the site is overlain with lake or fill deposits. Soil type also affects the ease of excavation of a tunnel structure for underpass options. Excavations in weak soils often require lateral support during construction.

Bridge foundations are difficult or expensive in poor soil. A characteristic property of soil would be the pressure that can be supported safely. Poor soil will not support large foundation pressures, resulting in either much larger foundations or "deep foundations" which consist of drilled shafts or driven piles to better soil or rock. Therefore, foundations can be situated on poor soil, but at a much higher cost.

The landfill site could be very problematic for placing foundations. In general, the fill material is unreliable, and so foundations would need to extend below the capped material. In doing so, foundations would need to penetrate the capped landfill. Depending on the type/existence of a liner this could result in significant work required to ensure that contamination of surrounding soil and water is not possible, nor release of gases/odor. Therefore, unless shown to be of a significant advantage for non-structural criteria, the landfill area should be avoided.

Topography

For an overpass structure, existing grade should be above or at the level of the Route 2 elevation. Use of sites with grade dropoff from the Route 2 elevation would require significant fill material to be added, extending the effective area impacted by the construction and overall cost. This would also add difficulty in merging with existing terrain, which could hinder a smooth transition from existing land features. This could require the removal of existing vegetation and thus cause a negative effect on wildlife comfort with using the structure.

An underpass would benefit from existing grade being below the Route 2 elevation. Expected maximum flood water level should be evaluated in the case of underpass structures.

Safety

The site location should not interfere with existing intersections or decrease their safety. This is especially true for overpass structures which could impede vision or cause distraction for drivers. Appropriate distance between existing intersections and the proposed wildlife/pedestrian overpass should be provided. This distance is determined from design speed and traffic volume as specified in the Massachusetts Highway Department Project Development and Design Guide (2006).

Supports for an overpass should also not cause safety problems. Abutments should be placed away from existing or future roadway limits. Any central supports for a structure would need to fit within existing roadway layout and be approved by MassHighway. As noted in

other sections the provision of a central support could significantly lessen the overall project cost. If middle support is required, appropriate collision protection should be provided to ensure motorist and structural safety.

Function

As determined elsewhere in this report, the site location must satisfy the required function as relates to potential wildlife use, pedestrian use, and land ownership.

4.B. Process/Criteria to Identify and Evaluate Alternatives

This study is charged with examining the feasibility of alternative locations and types of combined wildlife/recreational crossings within the Walden Passage study area. In keeping with the FHWA public participation requirements, the process used to identify and evaluate alternative locations and types of crossings was developed with direct input from the project Advisory Board and was discussed at the public workshops, the minutes of which were posted on the project website. Comments on the process for selecting alternatives, and the specific alternatives were received from the public and the Advisory Board. (See Advisory Board and Public Workshop minutes in Appendix).

With input from the Advisory Board and the Public Workshops, 11 principles and guiding policies were discussed and agreed upon for identifying alternative locations and passage types. In Chapter 5, we list criteria for evaluating the alternative locations and associated crossing types.

Principles and Policies for Identifying Alternative Passage Locations and Crossing Types:

1. Evaluate the feasibility of a combined wildlife and recreational crossing, geographically located within a pre-defined study area (Sudbury River to Crosby's Corner, Rte 2 in Concord Lincoln Massachusetts).

2. Consider only reasonable and feasible alternatives in terms of: highway safety, wildlife and recreational use, environmental context, cost, and community concerns. Consider both overpass and underpass alternatives.

3. Crossing locations should be a safe distance from all Route 2 intersections, located so as not to impair driver's visibility at or approaching intersections, or to cause parking problems.

4. Locate crossing in an area with significant existing wildlife activity according to tracking data, link existing forested areas the extent possible. Be specific about which species of wildlife are expected to use, or benefit from, the structure.

5. Avoid existing wetlands, and other environmentally sensitive areas to the extent possible.

6. Link "protected" or public lands on both sides of highway, including Walden Woods, no eminent domain takings of private land or structures will be required to implement the crossing.

7. Avoid neighboring residential and commercial sites to the extent possible, be aware of community/neighborhood impacts in terms of parking and access.

8. Consider existing local and regional trail connectivity, provide ADA accessibility if possible.

Trail use is planned for pedestrian recreation only, no bicycle or equestrian use is planned, in keeping with the policies of the host communities.

9. Be sensitive to the issue of access control at Walden Pond State Reservation.

10. Select locations to minimize the need for earth moving/regrading to construct the passage structure (integrate the structure into the landscape, visually and physically).

11. Consider the aesthetic appearance of the structure.

With these 11 principles and policies in mind, the project team identified three alternatives within the study area, plus a no-build alternative, that were developed for further examination, analysis and public discussion. These alternative locations are shown in Map 1, and discussed in the following sections of this chapter.

4.C. Crossing Alternative Location 1: Sudbury River

Locating a combined wildlife/recreational crossing at the Sudbury River is the first alternative to be examined. This location was selected because of the regional significance of improving connectivity for wildlife along the Sudbury River, with potential benefits to link the north and south sections of the Great Meadows National Wildlife Refuge. The significance of this linkage will become more important as future urban development likely will cause additional habitat fragmentation in the region. While there are three existing wildlife passage culverts located on Route 2 near the Sudbury River, none are large enough to accommodate large mammals, such as Moose.

The proposed alternative consists of replacing the existing concrete arch bridge (Figure 21) with a three-span continuous steel-girder bridge to accommodate

Figure 21: Existing Stone Arch Bridge, Sudbury River Crossing of Route 2 in the Study Area

pedestrian-wildlife paths along both river banks. This solution would have to be incorporated into the future plans for a replacement project of the current bridge. Construction would have to be conducted in phases to provide traffic passage throughout construction. The total bridge length would be between 150 to 175 ft, with exterior spans between 40 and 55 ft, and an interior span length of approximately 80 ft (Figure 23). The bridge surface level would be raised 4-6' over existing to provide passage underneath the bridge and above seasonal high water levels on the Sudbury River. The total bridge width would be approximately 75 ft to accommodate two traffic lanes and a breakdown in each direction of Route 2. The superstructure for this bridge could consist of spliced steel girders located transversely at approximately 6 to 8 ft (Figure 22, for each direction of traffic). The deck would be constructed compositely with the steel girders following current practice for highway bridges. The two interior pier bents supporting the superstructure would be located on the banks of the river to minimize the environmental impact to wildlife currently using the river. The total cost for a bridge of this type (including the edge spans to accommodate paths along the river banks) is estimated between $8M-$10M. The approximate cost of a new steel-girder bridge over the Sudbury River only is estimated at approximately $5M-$6M, so the added cost of constructing the edge spans would be approximately $3M-$4M. This additional cost includes pathways on either side of the river. This cost could be reduced by providing a path on only one side.

While the Sudbury River has always been a principal and defining feature of the regional landscape, there are no significant historical associations directly connected to this point along the river, which was a relatively anonymous spot until the construction of Route 2 required a bridge in 1934. This floodplain area possesses great natural beauty and is currently an important wildlife corridor. But walking to this point on the Sudbury River from Concord Center, for example, would take visitors away from the historic sites of Concord and Minute Man National Historic Park, and away from any physical or conceptual links to Walden Woods. While Thoreau or Emerson may have certainly boated or walked near this point along the Sudbury, it was not near or on the way to any of the specific places that Thoreau describes. Neither is this location associated directly with other events

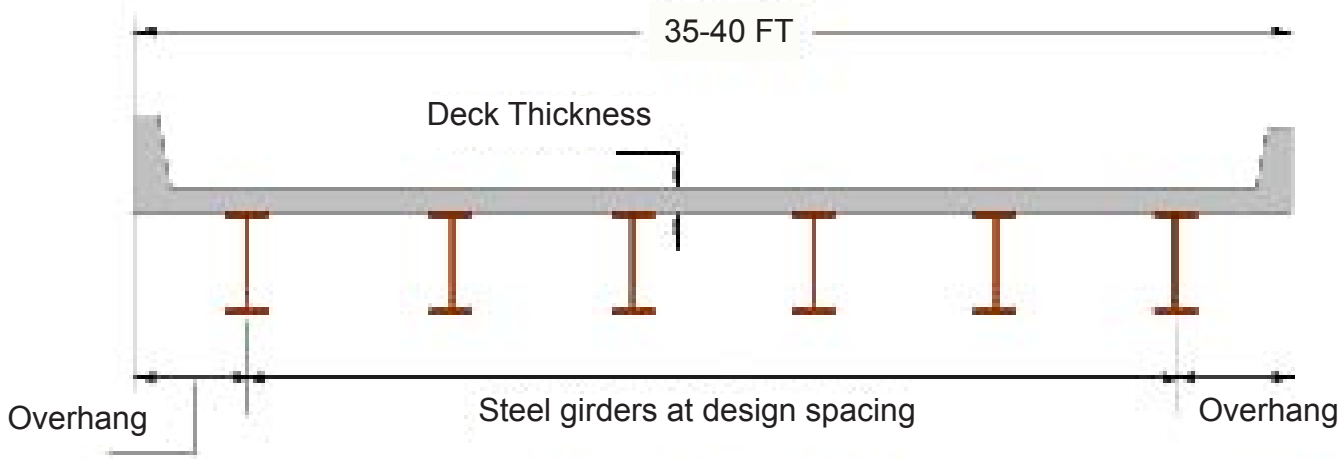


Figure 22: Schematic Illustration of Bridge Cross Section over Sudbury River (for each direction of traffic)

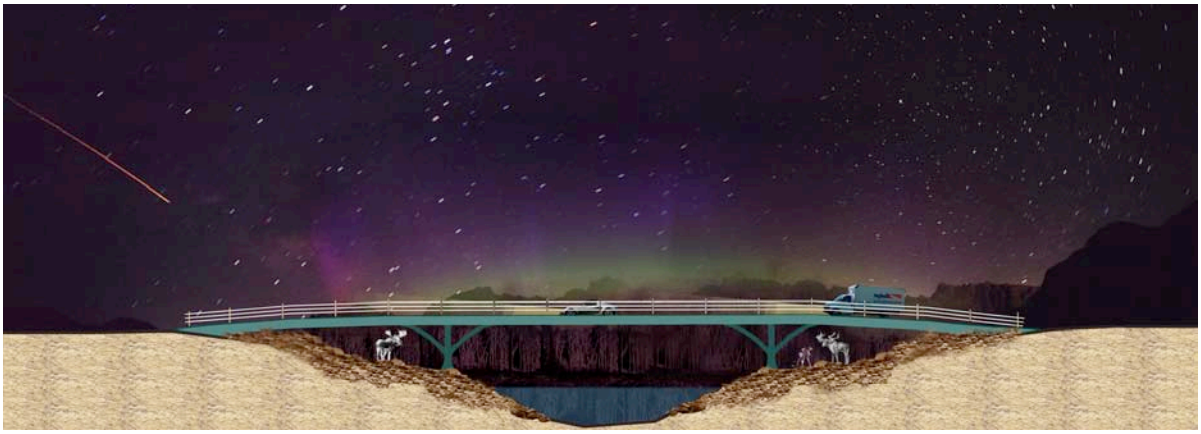


Figure 23: Conceptual Illustration of a New Sudbury River Bridge with Wildlife Crossings Incorporated Underneath

or individuals associated with Concord and Lincoln history.

In terms of archeological resources or potential resources, this site may be the most sensitive. There are identifiable shell middens nearby, and locations along the river were in general likely to have been the scenes of Nipmuck settlements and camps over many centuries. While this history may have potential for interpretation, archeological resources could also be put at risk by bringing attention to them while they are in situ.

Of the three locations considered, this alternative has the best potential for linking wildlife habitats along the Sudbury River, specifically the north and south sections of the Great Meadows National Wildlife Refuge. However, this location seems to have the least potential for interpreting the cultural landscape or making connections to specific features and places known to readers of Emerson, Thoreau, or other American authors, in particular. When existing and potential patterns of pedestrian circulation are considered, the location is again problematic. It is in fact not within convenient walking distance of the Minute Man National Historical Park, the historic sites of Concord, connections to the Bay Circuit Trail, or Walden Woods. The potential for interpretation of the cultural landscape is very limited.

4D. Crossing Alternative Location 2: Fitchburg Railroad Underpass

Alternative location 2 is the site of an existing railroad underpass on the Fitchburg Railroad as it passes beneath Route 2. To the southeast of the crossing is the Walden Pond State Reservation, and private forested land on the southwest. To the northeast is the campus/grounds of Concord Carlisle Regional High School and the Arena Farms on the northwest. The crossing is bordered by significant forested land on both sides, and much of this land is publicly owned. The use of this underpass by wildlife has been documented by project monitoring and is identified as an important wildlife corridor in Concord's Open Space and Recreation Plan. The underpass is also informally used by joggers and hikers in the region.

This alternative would involve relocating one, or both of the abutments in the existing bridge to allow creation of a restricted access path that would accommodate passage of pedestrians and wildlife. This path would approximately be 40 ft wide, on one or both sides, so a new superstructure would have to be constructed to span over the wildlife-pedestrian path. Construction would have to be conducted in phases to provide traffic passage throughout construction. The superstructure for the bridge over the pedestrian-wildlife path would consist of a concrete deck supported on steel girders, similar to that proposed for the Sudbury River crossing.

Figure 24: The Fitchburg Railroad Underpass Beneath Route 2

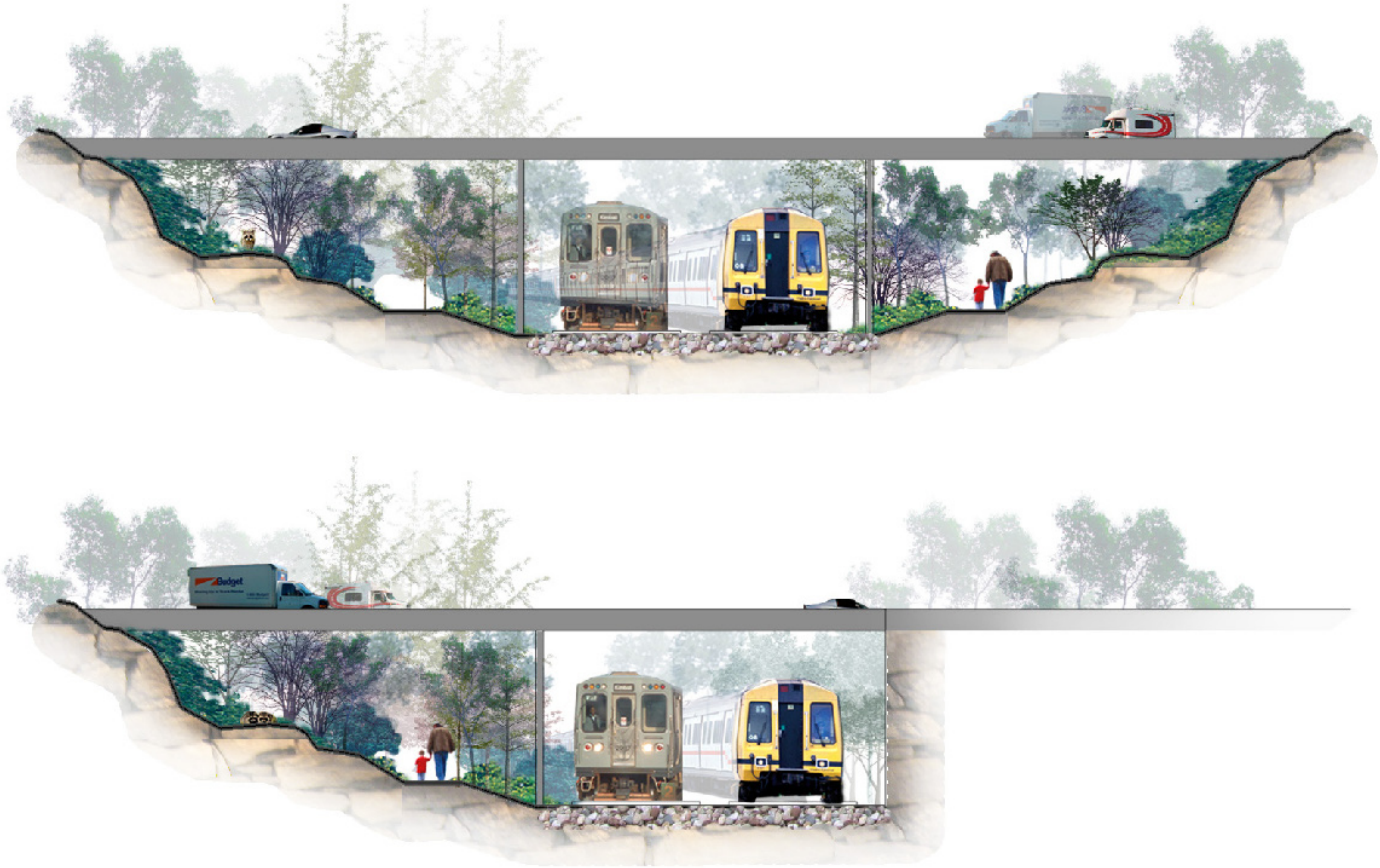


Figure 25: Conceptual Design Alternatives for the Fitchburg Railroad Underpass Crossing Beneath Route 2 *(showing a separated crossing on one (lower) and both (upper) sides of the railroad).*

Girder depth, however, would possibly be shallower because of the shorter span length of 40 ft. The steel girders would be simply supported on a new abutment constructed on one side of the path and a bent at the location of the existing abutment wall (current wall may be able to be used for this purpose) as the interior support. Extensive excavation under the existing roadway would add significantly to the difficulty of the project, unless it was incorporated into a future replacement for this bridge structure. Use of a wall for the interior support would effectively separate the railroad tracks and the wildlife-pedestrian path. The additional cost for this alternative is estimated to be approximately $2M-$3M if implemented as part of a replacement project, but would be higher as an isolated project.

To improve safety for pedestrians, in this alternative we would recommend that the railroad tracks be separated from the crossing with a fence within the Railroad underpass itself (Figure 26); beyond the underpass hiking trails could be directed away from the railroad to assure safety, without fencing - as the area currently is used – and without any reported accidents at the location. The conceptual designs (Figure 25) illustrate how the underpass could be widened on one or both sides, separated from the active railroad, and could allow combined recreation/wildlife use.

If the existing underpass is widened on one or both sides, additional individuals and species could be expected, and establishing a soil and vegetated substrate could attract use by smaller mammals, amphibians and reptiles. While there are no current plans to rebuild this underpass, if it were rebuilt or expanded in the future, the combined wildlife and recreational crossing could be included with significantly less cost.

There is some potential for connecting this underpass

Figure 26: Conceptual Design for the Fitchburg Railroad Underpass Crossing (*showing the fence to separate pedestrians safely from the actively-used railroad tracks)*

site to the existing network of trails, such as the Bay Circuit Trail, which could potentially be rerouted across, or around the Concord Carlisle High School property from Walden Street and through the RR underpass. Also, trails could connect on either end to Concord Center (although not Emerson House) through the Concord-Carlisle High School campus, and to the Walden Pond State Reservation trails. This location is less than one mile from the Concord railroad station, making it somewhat accessible by public transportation. Making this underpass location trail more attractive to pedestrians would likely raise the issue of access control at Walden, because the west side of the Walden Pond State Reservation where the underpasses would be located currently has no access control. Thoreau's use of this railroad right-of-way as his most direct route between friends and family in Concord Center and his cabin on Walden Pond make this historical association significant, with a significant interpretation potential.

4E. Crossing Alternative Location 3: Goose Pond

This alternative is located at the eastern end of the study area linking a forested area and a location adjacent to the former landfill site with the Town Forest and Brister's Hill on the north side of Route 2 (Figure 27). This location would require an overpass structure and could be integrated with the existing elevated topography on both sides of Route 2, as shown on Figure 28. This location has the potential to provide passage for arboreal species and mammals from protected lands in Lincoln, including Walden Pond, with protected parcels in Concord including the Hapgood Wright Town Forest and the Brister's Hill site. While this location is close to the easternmost existing wildlife crossing culvert, construction disturbance of the culvert would not be required to build a passage at this location.

Figure 27: Route 2 at the Goose Pond Crossing Site

This alternative consists of building a 20 foot wide bridge over Route 2 connecting the area near Goose Pond and Brister's Hill. The proposed bridge passage would include abutments at either side of Route 2 located approximately 30 ft from the existing roadway. All foundations for this structure would be located outside of the former landfill, not on capped landfill areas. An interior pier bent would be located on the current median to avoid major roadway realignment. The total length of the bridge (between abutments) would be approximately 110 ft. Appropriate grading would be required to provide a 16.5 ft clearance for traffic along Route 2. The proposed structural system for the bridge superstructure consists of prestressed box beams with a clear spacing of approximately 4 ft between them. These box beams would be simply supported on abutments and interior support during construction and would be made continuous through an interior closure pour at the interior pier bent. The superstructure would be designed to support 3 to 4 ft depth soil embankments on both sides to allow small plantings and an overhead structure to support vines. Adequate drainage for the soil and moisture barriers would be required. The cost for this type of structure is estimated to be approximately $2M-$3M for a 20 foot wide crossing. The proposed solution is illustrated schematically in Figure 28. Costs for wider crossings could be estimated by a ratio of widths. For instance, a 40 foot wide crossing would be approximately twice the cost of the 20 foot wide crossing.

The Goose Pond area includes a number of landscape features directly associated with nineteenth-century intellectual life of Concord. Fairyland Pond, named by Thoreau, and the surrounding area were frequently visited by a number of notable walkers. Goose Pond, Brister's Hill, Brister's Spring, and other nearby (and still extant) landscape features are all mentioned by

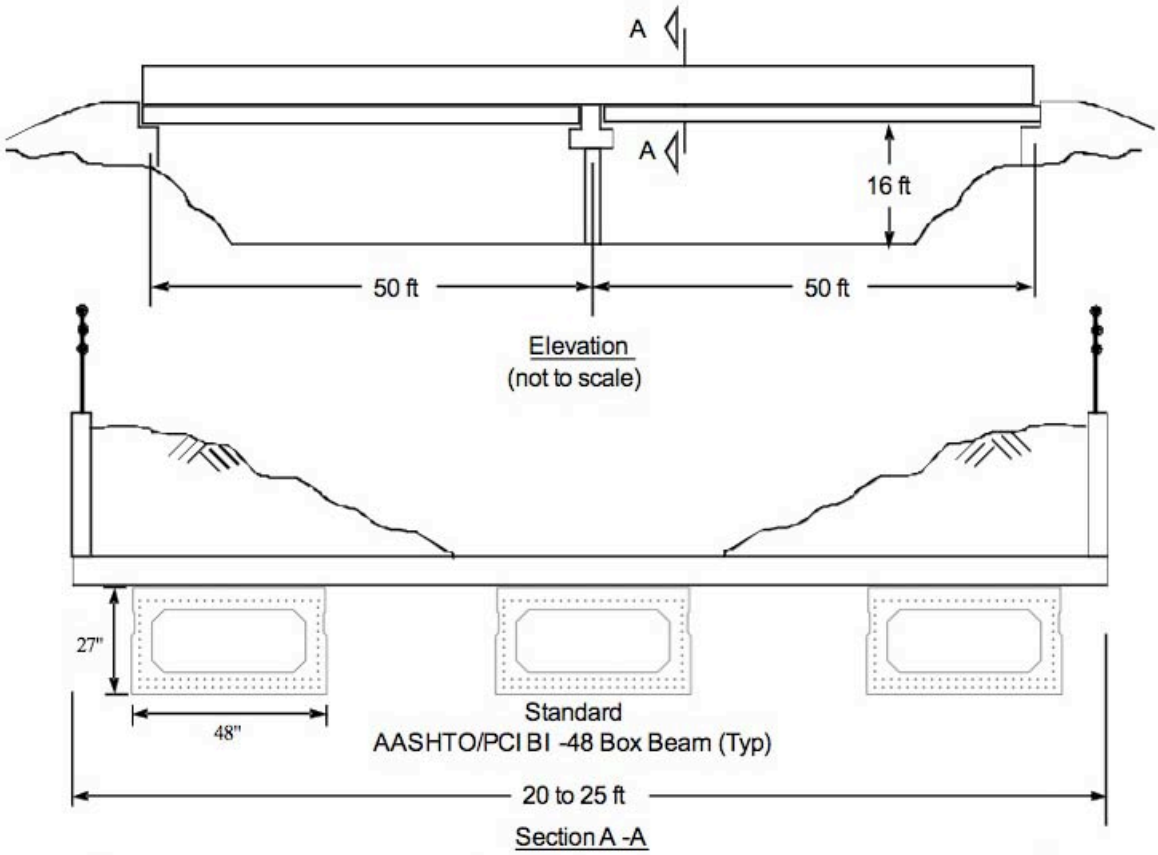


Figure 28: Proposed Solution for Goose Pond Overpass Crossing

Thoreau in his journals or in Walden. Of the three alternatives, this location has the highest number of nearby features with historical associations and with a good degree of integrity. It therefore offers the most potential for conveying the significance of the cultural landscape—particularly as it relates to the nineteenth century—to human users of the crossing.

The Goose Pond location also offers the best opportunity for locating the Bay Circuit Trail away from Walden Street and along a more appropriately wooded and scenic route (Figure 29). This location for the human/wildlife crossing also would directly facilitate the connectivity of the Emerson/Thoreau Amble. This connection in turn would activate the new Brister's Hill landscape by making it a destination along the route from Emerson House to Walden Woods (or the reverse). This would allow larger visitation of the Brister's Hill landscape without necessitating parking for it. These factors further enhance its potential for interpreting historical themes.

Figure 29: The Current Route of the Bay Circuit Trail *(Source MassGIS)*

The Goose Pond location complements the Open Space and Recreation Plans (OSRP) of both Lincoln and Concord. Both towns emphasized the goal of linking existing trails to improve passive recreational use of trails. The proposed location also addresses the impact of Route 2 in bisecting Walden Woods, also noted in Concord's OSRP.

The Goose Pond location is also the closest to Minute Man National Historical Park, and so offers the best opportunity for connection to the Battle Road interpretive trail and to complement the recent designation of the Minute Man Scenic Byway. Such a connection would exist already, in fact, if visitors walked to Emerson House and from there were able to access the Emerson/Thoreau Amble.

The Goose Pond location is the only one that would require an overpass rather than an underpass. As an

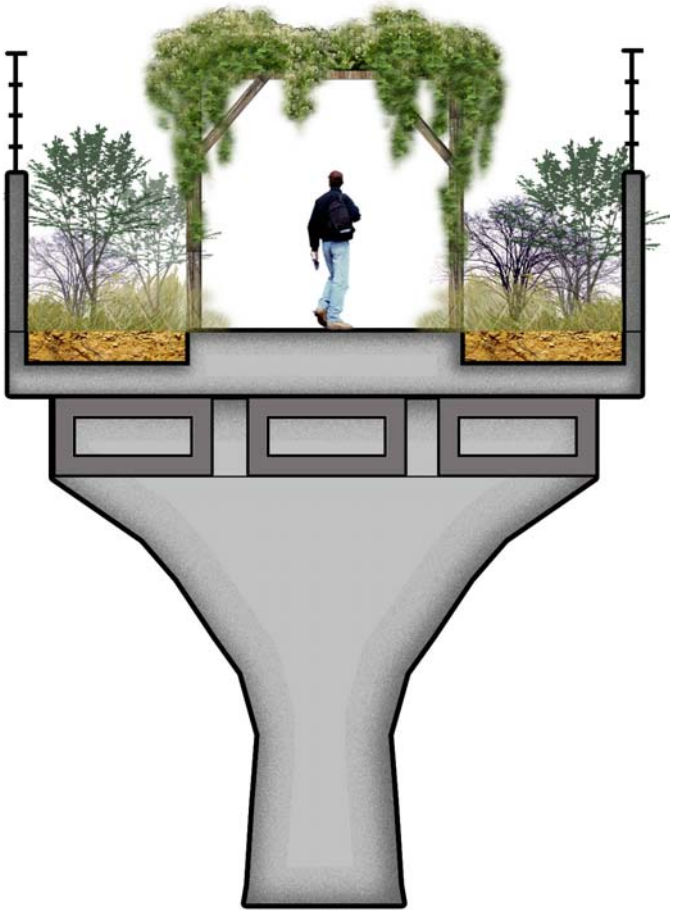


Figure 30: Conceptual Cross-Section View of the Goose Pond Crossing

above ground, visible element in the landscape, the potentials for views of the surrounding landscape are greater, as are the possibilities for making the structure itself a kind of interpretive display that would both facilitate and convey the significance of walking as a meditative activity and of and appreciating the natural world. The conceptual sketches of this alternative (Figures 30 and 31) provide an example of how the passage structure could be planted and integrated with the adjacent topography.

4F. No-Build Alternative

A no-build alternative was examined to understand the consequences associated with no action in terms of a new passage. There is obviously no cost for this alternative. In terms of wildlife benefits, the no-build alternative provides no improvements over the existing condition and, as indicated in the wildlife section, wildlife can be expected to continue to use the existing wildlife passage culverts while future urban development is expected to cause additional fragmentation of wildlife habitat in the area which may affect certain species more than others. The no-build alternative provides no new impacts on the adjacent neighborhoods in terms of increased tourist, or trail user-parking needs. This alternative has little or no impact on the Walden Pond Reservation access control issue.

By not building a crossing, the potential benefits for cultural landscape interpretation and recreational trail connectivity are not realized and existing problems and conflicts with Route 2 crossing can be expected to continue, or to deteriorate as traffic on the state highway increases in the future.

Figure 31: Conceptual Elevation of the Goose Pond Overpass with Side and Overhead Plantings

5. Evaluation of Alternatives

Three alternative crossing locations for a combined wildlife and recreational passage of Route 2 were identified after the study team analyzed wildlife data, traffic and highway information, adjacent land uses, recreational activities, and the significance of the cultural landscape in Lincoln and Concord, and of the study area in particular. These three alternatives, plus a no-build option, were presented and discussed at public workshops, and with the project Advisory Board. The preceding chapter explains the details of these alternatives in terms of: potential benefits to wildlife, trail use, cultural landscape interpretation, community issues and impacts, and cost.

The wildlife analysis determined that there are no known endangered or state-listed species in the study area that would make use of an additional wildlife crossing. Furthermore, the existing wildlife crossing culverts under Route 2 are already being used successfully by a majority of species that might be served by an additional crossing. An additional crossing could improve crossing rates for these species, however, and could accommodate other species that may be present but not currently crossing Route 2 by using the wildlife crossing culverts.

The study team used an evaluation matrix to identify the multiple criteria that should be used to evaluate the 4 alternatives. This matrix was included in the first draft report, and was distributed to the Advisory Board and to the public at the final workshop for comments (Table 14).

Based on the study team's investigations and input from both the Advisory Board and citizens, and with due consideration of the 10 criteria used in the evaluation matrix, an overpass structure located to the west of Sandy Pond Road, in the vicinity of Goose Pond showed the most merit.

The Goose Pond alternative is therefore determined to be feasible and the study recommends that discussion, planning, and analysis of the Goose Pond alternative continue under the direction of the Metropolitan Area Planning Council's subregional group, MAGIC, with involvement of the host communities, local stakeholders and residents, and related public and non-profit agencies. The Goose Pond location links protected and publicly owned land on both sides of Route 2. It could also provide passage for arboreal and other wildlife species that are not currently using the wildlife crossing culverts and that would prefer an overpass of some type. A combined passage at this location would provide very significant recreational linkages with existing trails including the Bay Circuit Trail, Walden Pond State Reservation trails, Thoreau's Path on Brister's Hill, and the Emerson-Thoreau Amble (under construction). These trails could potentially be linked with those of the nearby Minute Man National Historical Park, and the recently designated Battle Road Scenic Byway. All of these trail connections would contribute to a re-connection of Concord and Lincoln across the Route 2 corridor, thereby mitigating the impact of the highway on the local environment, one of the key goals of the Transportation, Community and System Preservation (TCSP) Program - the sponsor of this study. This is the preferred alternative recommended by this study.

Other alternatives discussed and presented included the no-build alternative which would leave existing conditions as they are and make no additional grade-separated crossings of Route 2 in the study area. Under the no-build alternative, wildlife would be expected to use the existing wildlife crossing culverts and railroad underpass in the study area, but no improvement for recreational access of crossings would be provided. This option is not recommended.

A crossing at the Sudbury River would involve a new bridge for Route 2, raised to allow dry "shelves" for wildlife passage on both sides of the river underneath the bridge. This location was determined to be potentially important at a regional scale for wildlife passage by enhancing linkages between the north and south sections of the Great Meadows National Wildlife Refuge, and to restore the continuity of the Sudbury River as an ecological corridor. As a combined human/recreational passage, however, this alternative lacks any significant connections with existing recreational trails and would have little potential for cultural landscape interpretation. This alternative is therefore not recommended.

A crossing at the existing Fitchburg Railroad would involve relocation of one or both of the existing highway bridge abutments to provide a wider underpass in which wildlife and recreational passage could occur, separated from the tracks by fencing or a wall to assure safety. This location is already used as a crossing by wildlife, although reconstruction of the underpass could increase its functionality. This location also has at least some potential for interpreting the cultural landscape, since Thoreau used the railroad as a favored path to his cabin on Walden Pond. Safety concerns and lack of linkages with recreational trails are serious detriments to this option. Furthermore, a crossing at this location also could provide unmonitored pedestrian access to the Walden Pond State Reservation from the northwest. This increased access could exacerbate capacity management challenges at the Reservation. This option is not recommended.

In addition to recommending the Goose Pond alternative as a feasible combined wildlife-human crossing, the study has several related recommendations based on Advisory Board and public meetings, and new research conducted as part of this study and intended to mitigate the effects of Route 2 on the human and wildlife communities in Concord and Lincoln:

- That any future funding for a proposed passage structure be kept independent from funding for the proposed improvements to Route 2 known as the "Crosby's Corner" project, and that the passage structure does not jeopardize, or delay the Crosby's Corner project.

- That any future reconstruction or replacement of the Route 2 Sudbury River bridge include provisions for safe wildlife passage beneath the bridge on both sides of the river. This would likely require elevating the Route 2 roadbed at and approaching the bridge for the necessary vertical clearance.

- That a recreational planning study of the area be conducted to investigate the possible costs and benefits of linking trails and public lands in and around the study area including the Goose Pond location and the Walden Street/Route 126 crossing of Route 2 where existing pedestrian vehicular conflicts are significant. The study should also determine the number, seasonal distribution, origin and destination of prospective users of a passage structure. Such a study would provide important information to help to determine if the costs of the project are commensurate with the expected benefits.

It is clear that a pedestrian crossing in the study area has the potential to greatly enhance cultural interpretation and connectivity in the study area, and thereby partially mitigate the impact of Route 2 on Concord and Lincoln. Given the dual purpose of the crossing (wildlife and recreational) the recommended alternative at the Goose Pond location would lend itself to strengthened pedestrian/recreational linkages

and has potential opportunities for supporting wildlife crossings, although wildlife are benefiting from the wildlife crossing culverts recently installed. A crossing such as the one proposed could generate significant national and international interest, and through monitoring could generate new knowledge on combined human-wildlife use of road passage structures.

The recommended passage could significantly mitigate the impacts of Route 2 on the environment and on the communities of Lincoln and Concord, as intended by the Federal Highway Administration's Transportation Community and System Preservation (TCSP) program, the Federal sponsor of this feasibility study. The TCSP is an initiative to provide research and grants to investigate and improve the relationships between transportation, community and system preservation plans and practices. Some of the

Table 14. Evaluation Matrix

Issue/Item/Criteria	Sudbury River	Railroad Underpass	Goose Pond: Brister's Hill	No-build
Passage Type	Underpass incorporated into Rte 2 –Sudbury River bridge (needs structure improvement)	Underpass, widening of existing structure on one or two sides of RR tracks	Overpass, with low native vegetation, earth berms and overhead structure.	No new structure, the four existing mitigation tunnels will remain.
Highway Safety	Not visible to drivers, no impact.	Not visible to drivers, no impact	Visible from Rte 2, sited away from Crosby's corner realignment, and Rte. 126 crossing.	No impact on current situation.
Wildlife Use	Potential to enhance regional habitat connectivity (Great Meadows NWR), especially for larger species that do not presently use the existing tunnels in the area.	Existing wildlife crossing use at location likely to continue, crossing possibly to accommodate additional species. Wildlife could become trapped along railroad tracks due to safety walls/fencing.	Potential use by species currently in the study area, possible use by arboreal species, less beneficial for reptiles, amphibians.	Existing wildlife species will continue to use existing tunnels, future land use change in study area may increase fragmentation. .
Trail Connections	Few existing trails in vicinity, difficult to build new trails due to flooding/wetlands.	Linkage with Walden Pond St. Reservation and Concord Carlisle High School, improved safety for current (informal) users. Potential for rerouting Bay Circuit Trail through underpass.	Linkages with Goose Pond, Walden Reservation, Bay Circuit, Brister's Hill, and Emerson-Thoreau Amble.	Continued informal use of RR underpass, some existing trails cross Rte 2, continued human use of wildlife tunnels likely.

Continued on next page

goals of the initiative are to improve efficiency of the transportation system while reducing the environmental impacts of transportation. Assistance under the TCSP Program is intended to provide financial resources to states and communities to explore the integration of transportation programs with community preservation and environmental activities.

The study team finds that the Goose Pond is a feasible alternative for the reasons summarized, and that the construction of the passage would address the goals of the TCSP program, by reducing the impacts of Route 2, and by integrating the crossing with community preservation and environmental plans in the host communities. Discussions and analysis of the recommended passage structure should continue under the guidance of the Metropolitan Area Planning Council's sub-regional group.

(Table 14. continued)

Evaluation Criteria	Sudbury River	Railroad Underpass	Goose Pond	No-build
Cultural Landscape Interpretation	Low potential, access for pedestrians limited	Medium potential, Thoreau's historic route to town, access to Walden	High potential, Walden Pond, Brister's Hill, Emerson-Thoreau Amble, proximity (potential link to Minute Man NHP)	No new potential for cultural landscape interpretation
Cost	$8-10 Million to replace the entire bridge with $0.5-1 Million additional to provide wildlife crossings beneath the bridge.	$5-8 Million, depending on replacement of 1 or both abutments.	$2-6 Million, depending on dimensions and design.	No cost
Archaeological Resources	Potential impacts due to presence of Native American Shell middens in vicinity	No known impacts	No known impacts	No known impacts
Neighborhood Impacts	Potential impacts: Southfield Rd, Elisnore St., Coolidge Rd.	No neighborhoods affected	Potential for parking impacts on Sandy Pond Road neighborhoods, Concord and Lincoln.	No impacts
Walden Pond Reservation Access	No impact	Could affect northwestern access control from RR tracks	Little or no increase in pedestrian access expected	No impact
Potential national landmark	Low, not visible	Low, not visible	High, prominent location, overpass	No potential

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Appendices

A. Walden Passage Feasibility StudyAdvisory Board Members
B. University of Massachusetts Project Staff
C. Project Schedule
D. Minutes of Advisory Board Meetings
E. Minutes of Public Meetings

Appendix A:
Walden Passage Feasibility Study Advisory Board Members

Affiliation	Name	Title
Members		
Bay Circuit Alliance	Alan French	Chairman, Bay Circuit Alliance
Dept of Conservation and Recreation (DCR)	Jack Lash	Ecology Program Director
Lincoln Land Conservation Trust	Buzz Constable	President
Mass Audubon	Taber Allison	VP for Conservation Science and Ecological Management
	Jeff Collins	Director, Ecological Extension Service
Mass Highway Office of Transportation Planning	Guy Bresnahan	Executive Office of Transportation and Public Works
Minute Man National Historical Park (MMNHP)	Nancy Nelson	Superintendent
	Lou Sideris	Chief of Planning and Communications
Office of Congressman Martin Meehan	Betsy Fierman	Congressional Aide
Office of Senator Susan C. Fargo	David Johnson	Staff
Office of Senator Edward M. Kennedy	Julie Ryder	Congressional Aide
Town of Concord	Dinny (Virginia) McIntyre	Chair, Board of Selectman
	Peggy Briggs	Board of Selectman and Corridor Advisory Board
	Delia Kaye	Natural Resources Administrator
Town of Lincoln	Tom Gumbart	Conservation Director
	Angela Seaborg	GIS/Conservation
Trust For Public Land	Craig MacDonnell	Massachusetts Director
Walden Woods Project	Kathi Anderson	Executive Director
	Matt Burne	Land Conservation Coordinator
Advisors/non-members		
Town of Concord	Christopher Whelan	Town Manager
Town of Lincoln	Timothy Higgins	Town Administrator
Harvard Graduate School of Design	Richard T. T. Forman	Professor, Department of Landscape Architecture

Appendix B:
University of Massachusetts, Amherst - Project Staff

Name	Duties/Role	Department/Affiliation
Jack Ahern	Co-Project Leader	Department of Landscape Architecture and Regional Planning (LARP)
John R. Mullin	Co-Project Leader	Dean of the Graduate School and LARP Faculty
Zenia Kotval	Project Manager	LARP Adjunct Faculty
Ethan Carr	Cultural Landscape Architecture Research	LARP
Paige Warren	Lead Scientist on Wildlife Issues	Department of Natural Resources Conservation (NRC)
Scott Jackson	Advisor on Wildlife Crossings	NRC and UMass Extension
Sergio Breña	Crossing Engineering	Department of Civil and Environmental Engineering
Scott Civjan	Crossing Engineering	Department of Civil and Environmental Engineering
Beth Fenstermacher	Research Assistant	LARP
Lee Jennings	Research Assistant	LARP
Mark Bellis	Research Assistant	NRC
Noah Charney	Research Assistant	NRC
Jinglan Wang	Research Assistant	LARP

Appendix C:
Project Schedule

Month	Date	
2006		
September	14	Initial Advisory Board meeting
October	21	First Public Workshop
2007		
January	4	Second Advisory Board meeting
January	27	Second Public Workshop
March	16	Draft Report Distributed for Comments
April	16	Comments returned
May	10	Third Advisory Board Meeting, Second Draft of report submitted
June	2	Final Public Workshop
June	22	Second Draft Distributed for Comments
July	30	Comments Returned
August	30	Final Report Submitted

Appendix D:
Minutes of Advisory Board Meetings

Walden Woods Project – Initial Advisory Board Meeting
September 14, 2006, 3-5 pm
Noah Brooks Tavern, Concord, Massachusetts

Advisory Board Attendees:
Kathi Anderson, Walden Woods Project
Matt Burne, Walden Woods Project
Jeff Collins, Mass Audubon
Buzz Constable, Lincoln Land Conservation Trust
Betsy Fierman, Office of Rep. Martin Meehan
Alan French, Bay Circuit Alliance
Tom Gumbert, Town of Lincoln
David Johnson, Office of Sen. Susan Fargo
Delia Kaye, Town of Concord
Jack Lash, Mass. Dept. of Conservation and Recreation
Craig MacDonnell, Trust for Public Land
Nancy Nelson, Minute Man National Park
Julie Ryder, Office of Sen. Edward Kennedy
Angela Seaborg, Town of Lincoln

Advisory Board Members Absent:
Taber Allison, Mass Audubon
Guy Bresnahan, Mass Highway
Peggy Briggs, Town of Concord
Dinny MacIntyre, Town of Concord

UMass Attendees:
Jack Ahern
Noah Charney
Scott Civjan
Beth Fenstermacher
Scott Jackson
Lee Jennings
Zenia Kotval
John Mullin

Introduction and meeting mediation by John Mullin, UMass
Project Background and Goals Presented by Jack Ahern, UMass
Mass Audubon Wildlife Tracking Presentation by Jeff Collins, Mass Audubon

Meeting called to order at 3pm by John Mullin.

Project Background and Goals
Jack Ahern introduced the project background. In 2004, the Federal Highway Administration (FHWA) awarded a Transportation, Community and System Preservation Program (TCSP) grant to fund a feasibility study of a highway overpass for pedestrians and wildlife crossing Route 2 in Concord, Massachusetts. The project, initially proposed by the Walden Woods Project, is now managed by the Metropolitan Area Planning Council (MAPC), the Regional Planning Council for the Boston Metropolitan region. The MAPC has contracted with an interdisciplinary team of UMass Amherst faculty and graduate research assistants to examine the feasibility of establishing a wildlife and recreation overpass.

Project goals: To explore and analyze the feasibility of establishing a combined wildlife and pedestrian crossing of Mass. State Route 2 in Concord, MA.

The study will examine the proposed crossing from neighborhood to national perspectives and consider associated benefits and impacts on:

transportation
wildlife movement
recreational use
the economy of the host communities and the region

In summary, there is a three-fold intent with this project: wildlife, vehicular and pedestrian safety and access and aesthetics (honor significance of the landscape).

Wildlife Tracking Data

Jeff Collins from Mass Audubon presented a brief summary of findings of a wildlife tracking study conducted in the winter of 2004/2005. The purpose of the study was to determine what species are present in the study area, where they are going and how the landscape features and Route 2 affect their movement. Jeff presented GIS maps detailing tracking data for deer, mice/voles, red fox, and coyote. The study showed that Route 2 was acting as a significant barrier to wildlife movement. There was a question of when the jersey barriers were established on Route 2 and if they were present at the time of the study.

Issues to be Addressed

Each Advisory Board attendee provided their initial vision for the project.

- an opportunity to showcase an innovative approach to crossing design
- an important educational opportunity
- potential local economic benefits
- better circulation for wildlife could reduce traffic accidents and roadkill
- the passage could raise environmental awareness by bringing people closer to the environment
- it would increase recreational opportunities
- this is a critical project for an important literary landscape as well part of Charles Elliot's vision for a system of connected open spaces for the metro-Boston area.

The biggest concerns that should be addressed include:

- increased visitors/traffic;
- need clarification of funding sources
- concern over special interests/prioritization of other important infrastructure projects (particularly the Crosby's Corner Improvement project)
- impact of increased wildlife in the towns
- safety and security
- traffic impacts
- effects on property value

At the conclusion of the meeting, attendees were asked to provide an answer to "what are the most important issues associated with this project?". Answers included:

- habitat connectivity
- cultural connectivity
- finances
- long way to go
- wildlife-human conflicts need to be addressed
- multiple potentials
- multi-organizations, multi-constiuency (knitting together)
- need examples
- it can be done
- it can be precedent setting

- symbolic connection for Walden Woods
- balance
- determination of whether it works

Next Steps
It was suggested that the project be presented at a Board of Selectmen's meeting or all-boards meeting once there are results (Lincoln and Concord) .

Project Workshop Saturday October 21, 2-5 PM
Advisory Board members were invited to attend a Public Workshop on Saturday, October 21, from 2-5 pm at the Concord-Carlisle High School cafeteria. This first workshop will focus on introducing the project and identifying issues and opportunities for the study to address.
A press release will be forwarded to Board members to distribute to their respective organizations, newsletters, email lists and listserves. The press release will also be sent to local and regional newspapers.

Next Advisory Board Meeting: Thursday, January 4, 2007, 3-5 pm, Noah Brooks Tavern

A project website will be launched before the Oct. 21 workshop at:
www.umass.edu/waldenpassage

Future Workshop Dates
January 27, 2-5 PM, Concord Carlisle High School Cafeteria (Presentation of Alternatives)
February 3, 2007, (snow date for Jan. 27 Meeting) 2-5 PM, Concord Carlisle High School Cafeteria
June 2, 2007, 2-5 PM, Concord Carlisle High School Cafeteria (Final workshop, Recommendations)

Meeting Minutes by Beth Fenstermacher and Lee Jennings, UMass

Meeting Minutes
Walden Woods Project – Second Advisory Board Meeting
January 4, 2007, 3-5 pm
Noah Brooks Tavern, Concord, Massachusetts

Advisory Board Attendees:
Kathi Anderson, Walden Woods Project
Guy Bresnahan, Mass Highways
Matt Burne, Walden Woods Project
Dinny McIntyre, Town of Concord
Alan French, Bay Circuit Alliance
Tom Gumbart, Town of Lincoln
Delia Kaye, Town of Concord
Nancy Nelson, Minute Man National Park
Angela Seaborg, Town of Lincoln

Advisory Board Members Absent:
Taber Allison, Mass Audubon
Peggy Briggs, Town of Concord
Julie Ryder, Office of Sen. Kennedy
Buzz Constable, Lincoln Land Conservation
Betsy Fierman, Office of Rep. Meehan
David Johnson, Office of Sen. Fargo
Craig MacDonnell, Trust for Public Land

UMass Attendees:
Jack Ahern
Sergio Brena
Noah Charney
Beth Fenstermacher
Paige Warren

Additional attendees:
Katherine Garcia for Jack Lash, Mass. Dept. of Conservation and Recreation
Peter Hoffman, DCR
Denise Morrissey, DCR

Introduction and meeting mediation by Jack Ahern, UMass

Meeting called to order at 3pm by Jack Ahern.

Meeting Agenda:

- Introduction
  - Overall Project Summary and Goals
- Summary of October 21, 2006 Public Workshop
- Discussion of proposed study process
- Presentation of mapping data
- Presentation of proposed alternative locations
- Closing comments and questions

Project Background and Goals

Jack Ahern re-introduced the project background and goals of the project. In 2004, the Federal Highway Administration (FHWA) awarded a Transportation, Community and System Preservation Program (TCSP) grant to fund a feasibility study of a highway overpass for pedestrians and wildlife crossing Route 2 in Concord, Massachusetts. The project, initially proposed by the Walden Woods Project, is now managed by the Metropolitan Area Planning Council (MAPC), the Regional Planning Council for the Boston Metropolitan region. The MAPC has contracted with an interdisciplinary team of UMass Amherst faculty and graduate research assistants to examine the feasibility of establishing a wildlife and recreation overpass.

Project goals: To explore and analyze the feasibility of establishing a combined wildlife and pedestrian crossing of Mass. State Route 2 in Concord, MA. Jack Ahern placed emphasis on the following three main points of the study:

- Study area is pre-defined (Crosby's Corner to Sudbury River)
- Study is intended to study feasibility for *combined* wildlife and recreation uses
- The final product will include a preferred alternative and options

Following the introduction of the study goals, there was a discussion of whether the "no build" option would be considered as one of the presented alternatives. It was recommended by Guy Bresnahan and agreed upon by group that "no-build" should be one of the alternatives.

Members of the DCR recommended inviting a member of the Mass Wildlife to provide comments.

1. Review of the Public Workshop and findings

Following a presentation of the major concerns and ideas generated during the Public Meeting, the floor was open to reactions to findings and comments.

- Existing capacity at Walden Woods State Reservation:

  Alan French from the Bay Circuit Alliance voiced concerns over DCR's concerns regarding increased capacity at Walden Woods. He mentioned that he would like to work with them directly and feels the new structure would enhance use, not increase. He additionally commented about his concerns regarding the importance of continuity/connectivity of regional open space and if that would be addressed in the study.

  Denise Morrissey of the DCR responded that her biggest concern is the Rte 2/126 intersection. They are not concerned about the hikers that would be on the Bay Circuit, just the hordes of people coming once they see the parking lot is full.

- Addressing combined wildlife/recreational uses:

  Delia Kaye from the Town of Concord questioned the feasibility of the combination use (recreation and wildlife). She wanted to know if we have data that we can provide to the people that question the feasibility. Jack Ahern replied that we will reference the existing overpass in Ocala, Florida, and provide data from that site. The overpass is meant for recreation use; however, studies show wildlife (including endangered species) are using it also. Paige Warren from UMass discussed that her portion of the study will be looking at the species based on their home range, sizes, etc.; what will be there and which species could potentially be served; which species will use an underpass versus an overpass. In addition, Noah Charney from UMass indicated that their research should show that the design, forest structure, and connection of habitat will be more important to the wildlife, more than whether or not people are using it.

  Tom Gumbart from Lincoln discussed that the design of the passage will be important: the size of the structure will have impact on the activity; people will be more interested in looking out and seeing vegetation versus being in a dark underpass.

  Guy Bresnahan indicated that we need to show that there is a need for the wildlife. Questioned whether CAPS (Conservation Area Priority System) could be used. Paige replied that it is not appropriate for such a small scale, and that supporting data to implement CAPS willl not be available until after this study is completed.

- Study Area/Scope

  There was discussion regarding the limited scope and the limited area, and the presence of four wildlife crossings already within the study area. Guy Bresnahan and Jack Ahern reiterated that the scope and study area were provided by the initial applicant for the grant (Walden Woods Project); therefore, the study area and scope will remain as they are defined in the grant.

2. Process:
Jack Ahern introduced the study process and discussed that the study is only looking at potentially feasible alternative locations (no "throw away" options), including a no-build alternative (as decided on at the beginning of the meeting). The following issues/concerns will be addressed in the study:

- Transportation is the #1 thing to look at since it is a Federal Highway grant, there are 50,000+ cars per day on Rte 2, safety, etc.
- Wildlife: level of expected usage
- Recreation use: linkage, cultural users
- Community support: parking, access, neighbors
- Other: appearance, aesthetics, cost

Response:

Nancy Nelson from MMNP recommended looking at cultural and historical as its own category, do not group with recreational uses. Tom G. questioned if the study will only look at federally-owned land. Jack responded that the preferred alternatives will look at lands that do not require takings, but not ruling out connecting with private, or NGO-owned land.

3. Review of GIS maps:

Digital images of the GIS maps depicting land use, open space, conservation land and ownership for the Towns and study area were presented.

Response
Clarification of proposed athletic fields at Concord Carlisle High Schoool – approximately 300' west of existing neighborhood.

4. Presentation of 3 location alternatives:
Jack Ahern presented the three location alternatives that the study will focus on:

Option 1: New bridge with underpass across Sudbury River, suitable for human crossing (larger than existing)
Option 2: Expand existing rail road underpass
Option 3: Overpass to west of the landfill

Responses

There was a discussion amongst all meeting participants regarding each option. The key points are summarized below.

- Option 1: Sudbury River – New Bridge and Underpass
    - hard to get data regarding current wildlife use of underpasses near the Sudbury River since it floods so often
    - issue of underpass redundancy (3 existing tunnels in the vicinity)
    - Engineering issues
    - not feasible for people/no existing trial connections?
    - land shelf/boardwalk could be constructed

- Option 2: Railroad underpass
    - Safety: do not want to draw people to the tracks
    - MBTA may not agree
    - Response: Discussion of Rails with Trails movement and MBTA has existing rails with trails in Boston

- Option 3: Landfill/Brister's Hill area
    - Could location be moved closer to the Rte 2/126 intersection?
    - Safety and traffic concerns, and that the location would be required to be a designated distance from the intersection for visibility, etc.
    - Structural issues with building on landfill,
    - Different type of habitat (open grassland on one side/forest on other)

- Additional Suggestions

  Crosby's Corner:
  Angela Seaborg from Lincoln recommended looking at Crosby's Corner as a 4th alternative. She indicated that since it has not yet been constructed, there may be opportunity for collaboration. In addition, there is a large parcel of land adjacent to Crosby's Corner that is being developed with Senior Housing, which will include new trails. Also, since the railroad option at first seems infeasible, why not look at Crosby's Corner which also at first seems infeasible.

  Response: The design for the new road is rigidly set and that such a major change may be impossible to implement now. In addition, the design includes surface roads, and it would hard to have wildlife and pedestrians to cross two surface roads as well as go under Route 2.

  Separate Structures:
  The question was raised as to whether an option could be to construct separate wildlife and pedestrian crossings at locations that are best suited for each.

  Response: scope of grant says the study should be for the feasibility of a combination passage. It was suggested that if our study finds that a combination is not feasible, then the study may recommend separate crossings.

  Guy Bresnahan indicated that he believes the scope of the study can be changed: "if during the course of study, due to constraints, we find another alternative that includes separate structures…" (recommends going over wording with Steve Winter at MAPC). Forcing something that doesn't fit is inappropriate. We need to consider constructibility, cost, and whether it'll ever actually get built.

5. Final Comments:

- Interesting discussion, looking forward to thinking over
- Hard Sell (wildlife/suburbia issue, hard sell since the wildlife already seems to be moving just fine)
- Hard sell because no data regarding combination uses and need more concrete examples of it working, especially rail road site
- Interested in seeing costs for each alternative
- DCR should have say in best outcome of trail connections

Next Steps

Second Public Workshop Saturday January 27, 2-5 PM
Advisory Board members were invited to attend a Public Workshop on Saturday, January 27, from 2-5 pm at the Lincoln Town Hall; snow date is the following Saturday, February 3.

A press release will be forwarded to Board members to distribute to their respective organizations, newsletters, email lists and listserves. The press release will also be sent to local and regional newspapers.

Next Advisory Board Meeting:
Next meeting is still to be determined, the two options include

Thursday, May 10, 3-5 pm, or Thursday, May 17.

Future Workshop Dates
January 27, 2-5 PM, Lincoln Town Hall (Presentation of Alternatives)
**February 3, 2007, (snow date for Jan 27 Meeting) 2-5 PM, Lincoln Town Hall*
June 2, 2007, 2-5 PM, Location to be announced (Final workshop, Recommendations)

Meeting Minutes by Beth Fenstermacher, UMass

Meeting Minutes
Walden Woods Project – Advisory Board Meeting
May 10, 2007, 3-5 pm
Noah Brooks Tavern, Concord, Massachusetts

Advisory Board Attendees:
Guy Bresnahan, Mass Highways
Matt Burne, Walden Woods Project
Tom Gumbart, Town of Lincoln
Delia Kaye, Town of Concord
Nancy Nelson, Minute Man National Park
Angela Seaborg, Town of Lincoln

Advisory Board Members Absent:
Taber Allison, Mass Audubon
Kathi Anderson, Walden Woods Project
Peggy Briggs, Town of Concord
Buzz Constable, Lincoln Land Conservation
Betsy Fierman, Office of Rep. Meehan
Alan French, Bay Circuit Alliance
David Johnson, Office of Sen. Fargo
Craig MacDonnell, Trust for Public Land
Dinny McIntyre, Town of Concord
Julie Ryder, Office of Sen. Kennedy

UMass Attendees:
Jack Ahern
Sergio Brena
Noah Charney
Beth Fenstermacher
John Mullin

Additional attendees:
Katherine Garcia for Jack Lash, Mass. Dept. of Conservation and Recreation
Peter Hoffman, DCR
Denise Morrissey, DCR

Introduction and presentation by Jack Ahern, UMass
Meeting mediation by John Mullin, UMass

Meeting called to order at 3pm by Jack Ahern.
Meeting Agenda:

1. (Re) Introductions
2. Review of Project Scope, Goals, and Schedule
3. Summary of Second Public Workshop (1/27/07)
4. Draft Report: comments, updates
5. Summary of Wildlife Tracking Data
5. Discussion / Evaluation of alternative crossing locations
6. Preparations for Final Public Workshop, Next Steps

Project Background and Goals
Jack Ahern re-introduced the project background and goals of the project. In 2004, the Federal Highway Administration (FHWA) awarded a Transportation, Community and System Preservation Program (TCSP)

grant to fund a feasibility study of a highway overpass for pedestrians and wildlife crossing Route 2 in Concord, Massachusetts. The project, initially proposed by the Walden Woods Project, is now managed by the Metropolitan Area Planning Council (MAPC), the Regional Planning Council for the Boston Metropolitan region. The MAPC has contracted with an interdisciplinary team of UMass Amherst faculty and graduate research assistants to examine the feasibility of establishing a wildlife and recreation overpass.

Project goals: To explore and analyze the feasibility of establishing a combined wildlife and pedestrian crossing of Mass. State Route 2 in Concord, MA. Jack Ahern placed emphasis on the following three main points of the study:

- Study area is pre-defined (Crosby's Corner to Sudbury River)
- Study is intended to study feasibility for combined wildlife and recreation uses
- The final report/recommendations will include a preferred alternative and options

1. Review and findings of the 2nd Public Workshop (Jan. 27, 2007)
39 present, including the Public, Advisory Board members, and Project Staff
Project presentation followed by break-out group discussions

Main Agenda: Presentation and Discussion of Alternative Locations:

1. Goose Pond/Bristers Hill
2. Railroad Underpass
3. Sudbury River
4. No-Build Alternative

The strengths/opportunities and weakness/threats decided upon at the Public Workshop for each site location were presented (see Minutes from 1/27/07 on Project Website).

2. Initial Draft Report:
Jack Ahern discussed the comments received from the First Draft of the Walden Passage Feasibility Study (March 16, 2007). There were many comments regarding data on Lincoln and on the wildlife data. New data on Lincoln and final results of wildlife monitoring have been acquired since the issuance of the first draft and will be added into the second draft.

Comments have been received to date from:
Delia Kay, Tom Gumbart, Buzz Constable, Angela Seaborg, Richard Forman, MAPC, and project staff.

Significant Comments:
Make clear that project should not pre-empt Crosby's Corner-Rte 2 improvement project; and Update report with new Lincoln Draft Open Space Plan.
New Data on Wildlife tracking will address many questions about wildlife species.

Responses

Delia Kaye wanted to re-iterate her comment that the report should better represent the concern Advisory Board members have regarding whether a combined wildlife/pedestrian passage can actually work.

3. Summary of Wildlife Tracking Data

Noah Charney from UMass presented research findings and tracking data collected since issuance of the first draft.

Introduction:

- Past wildlife crossing structures have been very effective (currently four mitigation tunnels exist in the study area)
- Combined human-wildlife crossing as an urban solution is promising
- Walden project holds great potential as high profile educational opportunity to raise awareness
- Walden project certainly has worthwhile cultural/recreational benefits

Our task:

Evaluate the direct benefits to wildlife within study area

The types of species that are considered likely to exist in the study area, and the type of passage structure they would be likely to use (based on literature review) were presented. The potential marginal benefit of adding another large crossing structure to the study area was discussed by looking at 3 scales and assessing the impacts of Route 2 as a barrier to wildlife:

The Scales of Wildlife Populations:
Metapopulation – increased connectivity for genetics, re-colonization, occur across broad areas and regions.
Population – breeding habitat for interacting populations, occur across small regions/neighborhoods.
Individual Species– access to habitat for individual species, occurs at a very local scale.

Noah presented a list of species and home range that has been compiled based on literature reviews. He also presented data on current tunnel usage. Coyote, striped skunk, and eastern mole are the species that are not currently using the tunnels (based on monitoring). Peter Hoffman, DCR, asked about who was collecting data. Delia Kaye responded that The Wildlife Passage Task Force, a team of trained volunteers, was collecting data. Noah indicated that the UMass team is very confident in the skills of the task force.

Noah discussed the three alternatives as they relate to connectivity:

-Sudbury River: To more fully understand wildlife presence and movement requires extending the study area upstream and downstream to the Great Meadows National Wildlife Refuge. There is a kind of bottleneck at the Rte 2 crossing due to the small arched bridge. Close to the river, the tunnels are being well used.

-Railroad: There is a potential for bottlenecks at the RR underpass and for trapping wildlife underneath the tunnel, especially if fencing is added to increase safety for pedestrians.

-Goose Pond: Some degree of connectivity for wildlife crossing of Route 2 exists in the eastern portion of the study area because of railroad underpass and Wildlife Tunnel A.

Based on the review of data, Noah concluded that there is likely no threat at the metapopulation, population or individual level for many of the species identified in the area. The wildlife monitoring team is not concerned about deer, coyotes, skunks, molea at the metapopulation level in the study area and vicinity.
Peter Hoffman asked if Noah had the data from Mass fisheries about the density of deer? Jack Ahern answered that he has been in contact with Pat Huckery of FWS, and she will comment on all the wildlife data.

Moose might be physically blocked by the size of the existing tunnels. Moose can swim at the Sudbury River and can also use the railroad underpass.

But can moose get to the road because of urbanization, and do we want them there?

Three state listed species of herptiles are in the vicinity. However, we can't be sure about the herptiles because the roadkill, if any, is often cleaned up quickly. Matt Burne –there are priority habitats in the Walden area, and they should be included in the report. Noah responded that they have looked at the priority habitats, however, it does not appear that Route 2 impacts these habitats. Guy Bresnahan indicated that Mass Highway recently did the culverts on Rt. 2 and probably did an environmental study, he will provide UMass with the Environmental Impact Statement(s).

A concern was raised about how it is still not clear how high the benefit is for wildlife for any of the alternatives.

Guy Bresnahan asked if the former landfill site is ruled out? (Jack – No, Goose Pond location is just to the east of the landfill). He also asked if the study takes into account that there will be new signaling associated with the Crosby's Corner project, and if traffic data has been looked at. The UMass team will look at Crosby Corner plans (to be provided by Guy B).

4. Visualizations

Jack Ahern presented preliminary visualizations of the passage structures at each alternative location:

1. Sudbury River – New Route Bridge with above-water crossings on both sides
-this is on the high end as far as cost and wildlife benefit, but low in terms of human use (which may be good for wildlife).

2. Railroad Bridge
-there are concerns in terms if human connectivity, and how long will the trail follow the railroad track. There is concern that by adding a fence, a barrier for wildlife will be created, and potentially trap wildlife on the RR tracks.

Angela Seaborg suggested looking at creating a trail link to the Commuter Rail station in Concord center.

3. Goose Pond
-two alternative structures will be looked at for this location, curved and straight. Straight structure would be better according to Richard Forman.

Questions were raised regarding how would it be fertilized and watered? And how would you deal with stormwater? Jack Ahern answered that native plantings would be used, and fertilization and irrigation would not be required. Sergio Brena indicated that stormwater would be piped away through an internal drainage system, as with highway bridges.

5. Discussion of Evaluation Criteria

An updated version of the evaluation matrix was presented to the Board, and the Board was asked to comment.

DCR members raised several concerns:
-concern regarding additional pedestrians arriving at the Walden Pond State Reservation during the summer months, and if the evaluation considered this.
-Parking and walk in capacity—they try to police and monitor and keep in check.

-New pattern of use because people are shifted.
-Vehicles are left after hours, no way to tell if they are in the reservation or on the trail.
-They can't differentiate people who are just hiking through
-1,000 people limit is an environmental and ecological issue.
-Management challenge between public use and environmental issue.
-Summary of state park concern: it would impact operations greatly, and they would need more staff
(UMass will further review Walden Pond State Res. General Management Plan).

It was suggested that the goal of the project is not to bring people to Walden Pond, and the goal should be to bring people to Brister's Hill and away from the reservation. If the goal really is to get people into the places, then DCR feels they are "stuck in the middle" of Lincoln and Concord Trails, and the Bay Circuit Trail. Jack Ahern spoke for Alan French who was not able to attend (Bay Circuit Trail), that his alliance is in favor, in principle, of linking public/protected lands for the greater public good.

Highway Safety—Several members of the board raised concerns regarding the impacts of traffic queing into the study area, would there be impacts on wildlife crossing (noise, pollution, etc.).

Walden reservation access issue. The impact on trails at the reservation year round. Could be increase in use of trails and maintenance.

It was suggested that an additional criteria category be added:

Discuss environmental concerns.

Railroad could be a positive thing for surrounding neighborhoods, add trail connections on railroad underpass and connection to railroad depot.

Angela Seaborg asked if the option of rerouting 126 around park still an option. Should there be some reference to this option in the report?

Human use has not been adequately quantified, is it possible to look at human use year round?

Neighborhood impacts criteria—Delia Kaye added that there is potential for impacts to parking at Sandy Pond, the high school, and Brister's Hill neighborhood.

Delia also wanted to clarify her significant comment –there is still the question if a combined overpass will work, especially in the study area

Guy B. added that he does not think that we have made an overwhelming argument for the need of such a structure from the wildlife point of view—sees that there are good use of existing underpasses, and evidence that a structure of this type would be effective in this type of area. These things cost a lot to build and ultimately need to be more than a "pretty gateway". However, whether or not it gets built, this study will be important for other communities.

Is it feasible to just have a pedestrian crossing? Angela S. - Yes there is, and there will be pedestrian and bike access from Lincoln and Concord at the Crosby's Corner

Wildlife concern—if we put the money here, where is it being taken away from?

There is concern that this would be better suited somewhere else, what are the trade offs of money in the context of the entire state?

Finally, the board would like to see better clarification on exact locations in the Goose Pond area, and who owns the properties involved.

5. Final Comments:

- Pleased with increased data about wildlife data
- Impressed with the process
- Done a great job—a little stuck on the rare species thing—do a data release from Natural Heritage
- Good forum—getting stakeholder feedback
- The most welcome information was that existing culverts are used. And the sensitivity to environmental issues

Next Steps

Final Public Workshop Saturday June 2, 2-5 PM
Advisory Board members were invited to attend a Public Workshop on Saturday, June 2, from 2-5 pm at the Concord Middle School – Peabody Building Cafeteria.

A press release and posters have been forwarded to Board members to distribute to their respective organizations, newsletters, email lists and listserves. The press release was also sent to local and regional newspapers.

Second Draft Report:
June 15 – A Second Draft will be distributed to the Advisory Board, in addition the report will be posted on the website and be available to the public at libraries and municipal offices.
June 15-July 15 – Comment Period on the Second Draft Report

Final Report
August 1

Meeting Minutes by Beth Fenstermacher and Lee Jennings, UMass

Appendix E:
Minutes of Public Workshops

Public Workshop Minutes
Walden Woods Project – Public Workshop
October 21, 2006, 2-5 pm
Concord-Carlisle High School, Concord, Massachusetts

Agenda
This first public workshop focused on introducing the project and identifying issues and opportunities for the study to address.
2:15-2:30 Meeting Introduction
2:30-3:15 Break out into discussion teams
3:15-4:30 Team presentations of critical concerns, overall group discussion of location criteria and overall responses to the project

Introduction and Project Background Presented by Jack Ahern, UMass
Wildlife Biology presentation by Paige Warren, UMass
Cultural Significance presentation by Ethan Carr, UMass
Meeting mediation by John Mullin, UMass
Meeting called to order at 2:15 pm by Jack Ahern

Project Background and Goals
Jack Ahern introduced the project background. In 2004, the Federal Highway Administration (FHWA) awarded a Transportation, Community and System Preservation Program (TCSP) grant to fund a feasibility study of a highway overpass for pedestrians and wildlife crossing Route 2 in Concord, Massachusetts. The feasibility study, initially proposed by the Walden Woods Project, is now managed by the Metropolitan Area Planning Council (MAPC), the Regional Planning Council for the Boston Metropolitan region. The MAPC has contracted with an interdisciplinary team from UMass Amherst to examine the feasibility of establishing a wildlife and recreation overpass within a defined study area from Crosby's Corner to the Sudbury River, centered on State Route 2 in Concord MA.

Project goals: To explore and analyze the feasibility of establishing a combined wildlife and pedestrian crossing of Mass. State Route 2 in Concord, MA.

The study will examine the proposed crossing from neighborhood to national perspectives and consider associated benefits and impacts on:

- transportation
- wildlife movement
- community/neighborhood issues, concerns and opportunities
- recreational use
- the economy of the host communities and the region

In summary, there are multiple perspectives that willl be considered on this project: wildlife, vehicular and pedestrian safety, community issues, and access and aesthetics.

Dr. Paige Warren, a Research Professor of Wildlife Biology at UMass, presented the importance of connectivity for wildlife. She discussed the importance of wildlife corridors for movement and the types of animals and reptiles that can be expected to be present in the study area.

Dr. Ethan Carr, a Cultural Landscape Professor at UMass, presented the importance of this study as it pertains to the Cultural Landscape of Concord and the larger metropolitan region. He presented the significant cultural sites located in and around the study area.

Team Discussions: Critical Criteria to be Addressed

Attendees were formed into four teams. Each team was asked to list out all the critical criteria that should be addressed with this study. Following a 20 minute discussion, each team was asked to choose their top three criteria. One representative from each team presented the top three criteria to the entire room. Based upon the top three criteria from each team, the priority issues to be addressed in the study are:

- an opportunity to showcase an innovative approach to crossing design
- an important educational opportunity
- potential local economic benefits
- Compatibility of Wildlife and Pedestrian Crossing—is this feasible?
- Cost/benefit analysis—Trade offs. Why this is needed—impact on other existing highway projects?
- Where are people and animals currently moving ? —scale, location and distribution
- Connection to existing trails and railway
- Community factors (needs, concerns, etc.)

*The UMass team will take these priorities into consideration, as well as all other criteria presented but not listed herein, for the scope of the feasibility study.

Group Discussion - Location

Following team presentations, all attendees were asked to provide some location priorities and criteria for determining alternative locations for the passage structure. The major points are listed below:

<u>Location priorities</u>

- Brister's Hill/Town Forest/Landfill (suitable to meet needs for both pedestrians and wildlife)
- At highest existing land in the study area
- Use the existing railroad track underpass
- Avoid wetlands
- Avoid intersections
- T station as access point

<u>Criteria</u>

- Consider the project in Landscape context
- Local and regional context
- Human comfort
- Parking
- Safety of access points
- Sensitivity to existing residents in relation to human use
- Open space connectivity
- Connections form town center to town center
- Inconvenient to Walden Pond
- Existing trails
- Desire lines (look at different users – cultural, recreational, etc.)
- Compatibility of uses for humans and wildlife
- Wildlife needs (which species) where are they trying and failing to cross?
- New active recreation placement (CCHS playing fields)
- Cost
- Structural
- Minimize takings, private ownership
- Times of Use (for pedestrians and wildlife)

Open Discussion
During the open floor discussion, the following concerns were raised:

Members of the Mass. Department of Conservation and Recreation were present at the meeting. They voiced concerns over the management of the new passage and accessibility. There is a concern over the passage increasing visitation to the Walden Woods State Reservation and Walden Pond and whether the existing DCR management plan will be consulted and considered in the location determination as well as the design process. The DCR notified the UMass staff that there are significant limits to expandability.

Local residents also asked the team to consider the timeliness of the project, and the changing political climate and population shifts in the town. In addition, there could be a shift in attitude towards wildlife movement. Progress is very important for the success of this project.

The majority of participants recognized the significance of this project as precedent-setting.

Conclusion
At the conclusion of the meeting, meeting attendees were asked to present one thing they think UMass should do in this study:

- Know about what is happening at Crosby's Corner
- Be commended
- Focus on wildlife
- How will it benefit local people (present and future)?
- Work closely with stakeholders
- Contact land managers about wildlife issues
- Be aware of 126 rerouting
- 1 species = 1 vote
- Make it stunningly beautiful
- Think of culture and ecology
- Think of reality not the hypothetical
- Not solve one problem by creating another
- Think of connectivity of corridors
- Solve wildlife problems
- See as interesting opportunity
- Don't screw it up
- Address human use and impacts on wildlife
- Look at impact of larger area
- Look at impact of area around it
- Don't be afraid to say it won't work
- Look at Thoreau Amble
- Get better wildlife data
- Think of interactions in all other contexts to determine how it works
- Map all proposed and existing trails
- Not exacerbate problems at Walden Woods
- Consider areas that don't have as many variables
- Simplify

Next Steps
UMass will take public comments into consideration and integrate with the project outline/plan. A draft report will be submitted to the Advisory Board for review in late November. At the next Public Workshop to be held

in January, UMass will be presenting to the public the research findings as well as location alternatives and design ideas.

Next Public Workshop Meeting: Saturday, January 27, 2007, time and place TBA (snow date is Saturday February 3, 2007)

Please visit the project website for updates:
www.umass.edu/waldenpassage

Attendees:
Public: Dan Stimson, Steve Winter, Elissa Brown, Carol Dwyer, Cheri Geckler, Lydia Rogers, Harry Beyer, Barbara Lynn Davis, Lois Siegelman, Maureen O'Connell, Barbara Peskin, Henry Morr (sp?), Dinah Rowbotham, Susan Frey, Libby Herland, Tessa Hedleywhyt (sp?), Wendy Ingram, Joan Ferguson, Ken Bassett, Denise Morrissey, Peter Hoffman

Project Advisory Board Members Present: Nancy Nelson, Matt Burne, Dinny McIntyre, Buzz Constable

UMass Attendees: Jack Ahern, Ethan Carr, Beth Fenstermacher, Lee Jennings, Zenia Kotval, John Mullin and Paige Warren

Meeting Minutes by Beth Fenstermacher and Lee Jennings, UMass

Public Workshop Minutes
Walden Woods Project – Public Workshop 2: Alternatives
January 27, 2007, 2-5 pm
Lincoln Town Hall, Lincoln, Massachusetts

Agenda
This was the second of three workshops to be held as part of the Walden Passage Feasibility Study. This second workshop focused on presenting the findings of the study to date and presenting three proposed alternative locations that will be the focus of the study. The comments and questions raised by the public during this meeting will be used by the project team to help make a final decision on the preferred location for the passage structure that will be presented at the next public workshop (June 7, 2007) as well as in the final study report.

2:15-3:00 Introduction and presentation by UMass staff
1. Introduction: Personnel, Scope, Schedule
2. First Public Workshop Summary
3. Wildlife Issues (Paige Warren)
4. Engineering Issues (Sergio Brena)
5. Cultural Landscape Issues (Ethan Carr)
6. Process: Alternative Crossing Locations

3:00-4:00 Discussion: Break out into three teams to discuss location alternatives
4:00-4:45 Team presentations of overall group discussion and responses to the proposed location alternatives.

Introduction, Project Background, and Location Alternatives Presented by Jack Ahern, UMass
Meeting mediation by John Mullin, UMass
Meeting called to order at 2:15 pm by Jack Ahern

Project Background and Goals
Jack Ahern introduced the project background. In 2004, the Federal Highway Administration (FHWA) awarded a Transportation, Community and System Preservation Program (TCSP) grant to fund a feasibility study of a highway overpass for a recreational and wildlife crossing of Route 2 in Concord, Massachusetts. The feasibility study, initially proposed by the Walden Woods Project, is now managed by the Metropolitan Area Planning Council (MAPC), the Regional Planning Council for the Boston Metropolitan region. The MAPC has contracted with an interdisciplinary team from UMass Amherst to examine the feasibility of establishing a *combined wildlife-recreation passage* within a *pre-defined* study area: Crosby's Corner to the Sudbury River, centered on State Route 2 in Concord, MA. The study will consider alternatives and recommend a *preferred alternative*.

Project goals: To explore and analyze the feasibility of establishing a combined wildlife and pedestrian crossing of Mass. State Route 2 in Concord, MA. The study will examine the proposed crossing in neighborhood, town, region and national perspectives and consider associated benefits and impacts on:

transportation
wildlife movement
community/neighborhood issues, concerns and opportunities
recreational use
the economy of the host communities and the region

In summary, there are multiple perspectives that will be considered on this project: wildlife, vehicular and pedestrian safety, community issues, and access and aesthetics.

The three alternative locations that will be the focus of the study were presented:

Location 1: Brister's Hill area, adjacent to the Concord Landfill - this location would involve a combined recreational/wildlife overpass structure.

Location 2: Existing Railroad Underpass – this proposed location would include widening the existing underpass and using data from Rails-with-Trails movement to create a safe passage for humans and wildlife.

Location 3: Adjacent to Sudbury River – this proposed location would involve replacing the existing Sudbury River Route 2 bridge to allow for passage under Route 2, as well as to potentially include boardwalk structures for human passage.

Dr. Paige Warren, a Research Professor of Wildlife Biology at UMass, presented the importance of connectivity for wildlife. The study looks at the species that are considered to be present in the study area. Each species is being ranked on the likelihood of using a passage structure as well as the type of passage structure the species would use. Tracking data from Mass Audubon and a local volunteer group will be compiled and analyzed.

Sergio Brena, a Professor of Civil Engineering at UMass, presented the engineering concerns and criteria that will be looked at when determining the preferred location alternative. The study is looking at two potential crossing types, overpass and underpass. The crossing type affects engineering decisions and cost will be dependent on site features. Aspects considered will include: site grading, abutment location, soil conditions, aesthetics, type of vegetation to be supported, crossing width, and existence of intermediate supports.

Dr. Ethan Carr, a Cultural Landscape Professor at UMass, presented the importance of this study as it pertains to the Cultural Landscape of Concord and the larger metropolitan region. The study will look at cultural connectivity and potential for new interpretive experiences. Connections to existing trails will be examined, as well as the historical themes of Walden Woods and the many other important cultural resources of the area.

Comments and questions that were raised following the presentations included:

- look at Hanscom – Minuteman underpass for "lessons learned"
- consider looking at Native American trails (Concord Antiquarian)
- concerns over whether wildlife and humans can use the same structure
- what animals will be focused on being served by the passage structure?
- what is the driver for wildlife - demonstrate and identify the destinations wildlife will use
- show how the passage structure will work through presentation of data
- consider renaming project to lessen impact on Walden
- find a way to maximize opportunities and minimize impacts
- talk to MBTA to see if we can reverse their "anti- rails with trails" mentality
- Clarify what is meant by connectivity
- Look at existing Sudbury River trails

Break-out Group Discussions: Location Alternatives

Attendees were formed into three groups; each team was assigned to discuss a location alternative. Each team was asked to list out all the strengths and opportunities of each of their assigned location, as well as the weaknesses and threats associated with the location alternative and then rank the top strength and the top weakness. Following a 45 minute discussion, each team was asked to choose their top strength/opportunity and their top weakness/threat. One representative from each team presented the findings to the entire workshop. Based upon the presentations from each team, the top strengths and weaknesses for each location are as follows:

Location 1: Brister's Hill/Landfill area

Strengths/Opportunities:

- Reestablish Walden Woods as a larger reservation
- Buildable with respect to Route 2 (less due process)--does not require shutdown of Rt. 2
- Practicability
- Closest to Bay Circuit, Thoreau/Emerson Amble, Brister's
- Away from available parking (not too convenient)
- More available space on either side for wildlife—best amount of space for scale
- Creating more of a 'whole' complete cultural landscape by eliminating Route 2 cutting through.
- Model for other areas-most rich cultural/ecological landscape
- Best for pedestrian use
- Respects historic tradition
- Bicycle connection on Route 2
- Best for accomplishing all goals of project
- Good location for adjusting/lowering Route 2

Weaknesses/Threats

- Too far east for wildlife and people
- Wildlife (opening access to humans)
- Limited connections on North
- No parking
- Parking at cul-de-sac/residential area will increase
- Fragile ecosystem
- Limited benefits to wetland species (all upland in this area)
- Impacts of increased human use (Don't under estimate numbers)
- Impacts on existing residential neighborhoods

**Top Strength/opportunity:* Creating more of a 'whole' complete cultural landscape by eliminating/lessening presence of Route 2.

**Top Weakness/threat:* Negative impacts on fragile ecosystem and increased human use in area

Location 2: Railroad underpass

Strengths/opportunities

- Best for people—they are already walking there
- Wildlife is already there—deer, coyote, fox, moose
- Density of people—a strength for people, not for wildlife
- Parking might be available at high school
- There could be a train stop there
- Historic significance of Thoreau's 'Deep Cut Woods'
- It is in Walden Woods area
- It is not an overpass so there would not be issues with people throwing stuff from the highway
- Arena farms might be changing
- Bridge might be in need of repair
- Another access point to Walden Reservation that can be monitored
- Human/wildlife could be separated by tracks
- Good opportunity to track wildlife and people
- Could bring coyotes

Weakness/Threats

- People walking into Walden Reservation which has a carrying capacity

- Possibility that playing fields will be developed in the area.
- Parking at high school might not be possible
- MBTA regulations
- Safety along train tracks
- Can only be on the east side
- Some species might be less likely to use because of trains
- Hard to take land out of state reservation—how much would plan be on Walden Reservation land?
- Least opportunity for connectivity for wildlife
- Not very sexy or flashy—too pedestrian
- NW corner of Walden Reservation has 6 vernal pools (some sedge vernal pools)
- Wetlands might be impacted
- Town playing fields proposal only has a 100' buffer between Route 2 and the fields
- Bus depot relocation
- Coyotes—pet predation
- Increase movement of wildlife might increase wildlife disease issues—the site is close to school and neighborhoods

**Top Strength/opportunity*: 1. Railway was already identified as important for wildlife in Open Space and Recreation Plan (Concord 2004) 2. Easy to implement—existing structure/low cost.
**Top Weakness:* Regulatory issues - including MBTA, Mass Highway and that it might be built on state land

Location 3: Sudbury River
Strengths/Opportunities
- Can be built—existing structure needs to be rebuilt
- Good for wildlife traffic along river (Low and high water stages)
- Better for wildlife because not as desirable for people
- Types of species that may use make it compelling
- Cannot get to Walden Reservation
- Opportunity for river type wildlife
- Look at Concord Open Space Plan
- Could be additional site as it has to be rebuilt
- Traffic calming on river
- River Access/ area not normally used
- Accelerate bridge repair
- Landbank (across river) site could be accessed
- Wetlands/floodplain regulation
- Connect to new potential trails
- Making people aware of the river and wildlife
- Alliance with hospital to open up pedestrian access

Weaknesses/Threats
- Furthest away from existing trails and cultural assets
- Northward connection is weak (bad for people)
- Can't get to Walden Pond
- Very wet (need to be all board walk)
- No place for parking
- Doesn't connect to anything on the southern side
- Would violate existing conservation ordinances
- Difficult to achieve pedestrian access—not good for people
- Increased speed on river

- Eastern Mountain Lion
- Movement on Rt. 2 and traffic management
- Archeological Site
- Bike path through wetland
- Pedestrian/ Recreation use in Wetland area

**Top Strength/opportunity:* Opportunity for riverine wildlife
**Top Weakness:* Not amenable (attractive) for pedestrian/receational use

The points discussed in the individual group meetings will be considered by the UMass team during the decision making process for the preferred alternative.

Conclusion
At the conclusion of the meeting, meeting attendees were asked to provide final comments/thoughts based on the presentations and discussions generated during the meeting:

- Project has to be innovative/attractive in order to get funding
- Need a plan to illustrate how animals and humans will coexist
- Sudbury River site does not show the best corridor connections – need to demonstrate animal movement
- Overpass in Brister's Hill most likely of the three alternatives to get federal funding – overpass could have a profound influence on rest of the country
- Think big regarding opportunities
- Brister's Hill is best location based on trail connections
- Watch for overburdening Walden State Reservation (regarding parking)
- Wildlife should be number 1 priority
- Work with Mass. Fish & Wildlife Service
- Be more specific regarding usage and plan (e.g. parking)
- Be careful of unintended consequences
- Provide more facts and figures regarding safety issues, wildlife/human use, etc.
- Be careful of cultural significance, make sure funds are used correctly
- Consider that railroad and Sudbury River bridge will likely be rebuilt anyway, therefore focus on Brister's Hill as an additional passage and as an aside push for widening of the underpasses when rebuilding the underpasses
- Provide data regarding whether the wildlife and humans will use the same structure
- Focus on only one preferred alternative, don't plan for "fallbacks"
- Take advantage of existing infrastructure, piggyback on other projects

Next Steps
UMass will take public comments into consideration when determining the preferred alternative that will be presented in the final study report. Draft report sections will be submitted to the Advisory Board for review in early March. At the next Public Workshop to be held in June, UMass will be presenting to the public the research findings as well as the preferred location and design.

Next Public Workshop Meeting: Saturday, June 2, 2007, 2-5 pm, Concord Middle School – Peabody Building, 1231 Old Marlboro Road, Concord, MA

Please visit the project website for updates:
www.umass.edu/waldenpassage

Attendees:
Public: Virginia Bennett, Steve Winter, Tony Centore, Harry Beyer, Joe Wheeler, Jonathan Keyes, Brad Stoler,

Julia Pugh, Dagmar Guthke, Lois Siegelman, Patty Hecht, John Colman, Kurt Tramposch, Tom DeNormandie, Jane Layton, Joan Ferguson, Tim Oldfield, Linda McMillan, Sue Klem, Kathryn Garcia, Avram Kality, Peter Speert, Diana Abrashkin, Denise Morrissey

Project Advisory Board Members Present: Kathi Anderson, Matt Burne, Buzz Constable, Delia Kaye, Jack Lash, Dinny McIntyre, Nancy Nelson,

UMass attendees: Jack Ahern, Sergio Brena, Ethan Carr, Beth Fenstermacher, Lee Jennings, Zenia Kotval, John Mullin and Paige Warren

Meeting Minutes by Beth Fenstermacher and Lee Jennings, UMass

Public Workshop Minutes
Walden Passage Feasibility Study
Public Workshop 3: Recommendations
June 2, 2007, 2-5 pm
Concord Peabody Middle School, Concord, Massachusetts

Agenda
This was the final of three workshops held as part of the Walden Passage Feasibility Study. This final workshop focused on presenting the findings of the study to date and presenting the preferred alternative that will be recommended in the study. The comments and questions raised by the public during this meeting will be considered by the project team in drafting the final recommendations for the project report.

Workshop Agenda:
1. Introduction: Personnel, Scope, Schedule
2. Project Review (Scope, Goals, Schedule, Study Area)
3. Summary of Wildlife Monitoring/Tracking (Noah Charney)
4. Alternative Crossing Locations
5. Discussion of Preferred Alternative
6. Next Steps, Opportunities for Comment

Introduction, Project Review, and Location Alternatives Presented by Jack Ahern, UMass
Meeting mediation by John Mullin, UMass
Meeting called to order at 2:15 pm by Jack Ahern

Project Review
Jack Ahern introduced the project background. In 2004, the Federal Highway Administration (FHWA) awarded a Transportation, Community and System Preservation Program (TCSP) grant to fund a feasibility study of a highway overpass for a recreational and wildlife crossing of Route 2 in Concord, Massachusetts. The feasibility study, initially proposed by the Walden Woods Project, is now managed by the Metropolitan Area Planning Council (MAPC), the Regional Planning Council for the Boston Metropolitan region. The MAPC has contracted with an interdisciplinary team from UMass Amherst to examine the feasibility of establishing a combined wildlife-recreation passage within a pre-defined study area: Crosby's Corner to the Sudbury River centered on State Route 2 in Concord, MA. The study will consider alternatives and recommend a preferred alternative.

Project goals: To explore and analyze the feasibility of establishing a combined wildlife and pedestrian crossing of Mass. State Route 2 in Concord, MA. The study will examine the proposed crossing in neighborhood, town, region and national perspectives and consider associated benefits and impacts on: transportation; wildlife movement; community/neighborhood issues, concerns and opportunities; recreational use; the economy of the host communities and the region.

In summary, there are multiple perspectives that will be considered on this project: wildlife, vehicular and pedestrian safety, community issues, and access and aesthetics.

Summary of Wildlife Monitoring/Tracking
Noah Charney, Wildlife Biologist from UMass, presented the importance of connectivity for wildlife, and presented research findings and tracking data collected with assistance from the Wildlife Passage Task Force and Mass Audubon.

Introduction:

- Past wildlife crossing structures in the study area have been very effective (currently four mitigation tunnels exist in the study area)
- Combined human-wildlife crossing as an urban solution to highway-wildlife conflicts is promising
- Walden passage project holds great potential as high profile educational opportunity to raise awareness
- Walden project certainly has worthwhile cultural/recreational benefits

Our task:

Evaluate the direct benefits to wildlife within study area

The types of species known to, or likely to exist in the study area, and the type of passage structure they likely use were presented (based on literature review). The potential marginal benefit of adding another large crossing structure to the study area was discussed by looking at 3 scales and assessing the impacts of Route 2 as a barrier to wildlife:

3 Scales of Wildlife Populations:
Metapopulation – increased connectivity for genetics, re-colonization, occur across broad areas and regions.
Population – breeding habitat for interacting populations, occur across small regions/neighborhoods.
Individual Species– access to habitat for individual species, occurs at a very local scale.

Noah presented a list of species and home range that has been compiled based on literature reviews. He also presented data on current tunnel usage. Of the species that are likely to be abundant in the study area and are easy to discern via track beds or camera traps, coyote, striped skunk, and eastern mole are the ones not observed using the four mitigation tunnels. Only two rare species were previously identified in the study area (Mystic Valley Amphipod and Elderberry Long Horned Beetle). However, these species are no longer state listed and would not likely use or benefit from additional passage structures.

Noah also presented an example of innovative solutions for arboreal species: arbor or rope bridge over the passage structure.

There were no questions or comments raised by the public following Noah's presentation.

Location Alternatives:
The three alternative locations that are the focus of the study were presented along with the strengths/opportunities and weaknesses/threats that were compiled during the January public workshop were presented. Conceptual design visualizations of the passage structures were also presented.

Location 1: Adjacent to Sudbury River – this proposed location would involve replacing the existing Sudbury River Route 2 bridge to allow for passage under Route 2 on both sides of the river.

Location 2: Existing Railroad Underpass – this proposed location would include widening the existing underpass to provide a wildlife/pedestrian passage on one or both sides of the tracks with a fence or wall separation from the railroad tracks for safety. .

Location 3: Goose Pond area, adjacent to the Concord Landfill - this location would involve a combined recreational/wildlife overpass structure.

The evaluation matrix used to determine the preliminary preferred alternative was provided in a handout to the attendees (see attached). Location 3, Goose Pond, was presented as the preferred location, based on the following:

- Best meets the goals of the FHWA TCSP program in terms of "reducing community and environmental impacts";
- Significant potential to link Walden Pond and Walden Woods Area with other historic and cultural opportunities in Concord and Lincoln, including the Bay Circuit Trail, the Emerson-Thoreau Amble, and potential connections with Minute man National Historic Park;
- Potential to provide alternative Rte. 2 passage for other wildlife species;
- Minimal impact on Walden Pond State Reservation.

Jack Ahern emphasized that this recommendation is preliminary, and is open for discussion and comment. A map of existing connections to cultural resources and parking was presented. Additional assessment of parking in the area will be completed by UMass.

Based on the findings of the research and comments from previous Public Workshops and Advisory Board meetings, the following related recommendations for the Study Area will be presented in the study report:

1. Assure that a new crossing structure NOT be installed at the expense, or delay, of the Crosby's Corner Rte. 2 alignment project
2. Elevate the Rte. 2 roadbed when the existing Sudbury River bridge is rebuilt to enable flood stage passage on both sides of the river by large animals.
3. Provide safe pedestrian passage, separated from the RR tracks on one or both sides at the Fitchburg RR underpass when this structure is rebuilt.
4. Modify the jersey barriers on Rte. 2 to provide possibilities for wildlife crossing (over, under and in-between options exist)
5. Continue to monitor the existing tunnels and establish long-term monitoring for any new passages that are established or improved.
6. Continue to coordinate with the Walden Pond State Reservation to assure that crossings do not exacerbate existing challenges with capacity and access management to the reservation.

Discussion of the Preferred Location (John Mullin, mediator)
Location 3: Goose Pond was presented as the preferred location. However, it was emphasized that this recommendation is preliminary, and is open for discussion and comment. Should the responses from the public meeting and second draft indicate that this alternative is not-preferred; UMass will re-evaluate the preferred alternative. John Mullin stated that that a passage can strengthen connectivity for wildlife, although many species are crossing the highway successfully at the present. The floor was opened for comments/concerns over the preferred location.

Notes on comments raised during discussion:

-Alan French (Bay Circuit Trail Alliance): Exited about this project, the original intent of the Bay Circuit was to create a Greenbelt around the metropolitan area. There are currently 4000+ acres of open space in the vicinity of the trail, and linkage of open space is very important. He would like to see a project that mitigates the automobile's impact on the open space/trail network and how they can co-exist.
-Nancy Burnham (resident): Think about winter activities. Skiers, etc., currently use the RR underpass to cross Rte. 2. She thinks an overpass would be a tremendous benefit for winter recreation, keeping users from the RR tracks.
-Jane Herlacher (Lincoln resident): Get it on the agenda, don't let this opportunity pass. Likes the idea of

keeping people away from the Sudbury River and flood plain. Used to be opposed to the idea of this project, but now supports it. Would like to consider a separate wildlife structure.
-Delia Kaye (Town of Concord): Likes the idea of the project from the cultural standpoint, there's lots of potential. Thinks the arboreal bridge is a 'cool' idea. But, not sure of the wildlife value, concern of directing wildlife to downtown area, agrees with Sudbury River recommendation.
-Dinny McIntyre (Town of Concord): Crosby's Corner is at 75% design stage, and stuck over new underpass for Sandy Pond Road. Thinks the idea of overpass at Goose Pond would cover the need for underpass and would save a lot of money for Crosby's Corner project if it happens. As for design, hopes for rural/pedestrian design, not a wide paved trail/crosssing.
-Unknown (Lincoln resident): Concern that this is a "pie in the sky" idea since they've been waiting so long for Crosby's Corner. Only cares about the wildlife, thinks there are enough pedestrian paths.
-Jane H.: look at 20 to 40 vision plan for Rte. 2
-Patty Hecht (resident): talked at the selectman's meeting regarding the "scary" tunnel at Crosby's Corner, thinks this is a better alternative to look at (in combination with Crosby's Corner) for crossing Route 2. Concerned that its off the beaten path, where will people park if this is meant to be a destination?
-Allen F.: this is not meant to be a destination, and believes there is a big misconception over this. In the spirit of Thoreau, its part of the amble/saunter experience. Discussed that parking is not the priority when looking at such projects as the B.C. trail and this project.
(John Mullin response: this is complimentary, not an addition)
-Lydia Rogers: (Concord resident, Wildlife Passage Task Force) – parking is not an issue for Bay Circuit Trail; wants to keep proposed wildlife underpass at Crosby's Corner (doesn't think this should replace); what is the cost?
(John Mullin response: UMass is having talks regarding the cost/benefit analysis)
-Dinny M.: did we look at the hourglass shaped structure presented by Richard Forman?
(Jack Ahern response: once wildlife data indicated that this structure was not needed, we scaled back the design)
-Delia K.: Just do the wildlife crossing at Crosby's Corner, use this as a pedestrian crossing.
-Harry Beyer (Concord resident): NRC has just received funding to complete the Emerson-Thoreau Amble. What is the approximate width of structure? (Jack A.: 20')
-Matt Burne (Walden Woods Project): really pleased with the whole approach of this study. Surprised at how permeable Rte. 2 is to wildlife. Glad we now have data that shows the existing underpasses are working. Wants to reiterate the unique character of this internationally significant landscape, please do not do a generic pedestrian bridge.
-Jane Layton: Width of structure is a concern: animals may feel trapped, dogs chasing wildlife, etc. (John M. response: these designs are only for conceptualization purposes only)
-Avram Kality (Lincoln Resident): Likes the idea, preferred this location based on January workshop. Lincoln residents are concerned about the impacts of the Crosby's Corner, the entire process has impacted them a lot already. Would hate to have it delayed by even mentioning a connection to this project (Jack A. response: one of the top goals/recommendations is to not impact Crosby's Corner project in any way)
-Lydia R.: there is a big drive for people to cross Rte. 2, would like to see a structure so that people do not use the existing wildlife passages. They do not publicize these passages for the reason that they do not want people using them.

Conclusion
At the conclusion of the meeting, meeting attendees were asked to provide final advice to the UMass team:

- Go for all the grants
- Animals not people (3 people gave this comment)
- Look at all the options for money
- Think about stewardship, where will this connection bring people
- Go to it!
- Sort things out with the DCR, meet with them separately before presenting the final report

- Put announcement of draft report availability in local newspapers

Next Steps
The second Draft report will be submitted to the Advisory Board, be available in Concord and Lincoln public libraries and be posted on the web-site (www.umass.edu/waldenpassage) for review after June 15. Comments can be submitted via email at jfa@larp.umass.edu, or via postal mail:

Jack Ahern,
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Please visit the project website for updates:
www.umass.edu/waldenpassage

Attendees:
Public: Lydia Rogers, Steve Winter, Patty Hecht, Harry Beyer, Jane Layton, Jane Herlacher, Larry Kroin, Avram Kality, Diana Abrashkin, Nancy Burnham

Project Advisory Board Members Present: Matt Burne, Allen French, Delia Kaye, Dinny McIntyre

UMass attendees: Jack Ahern, Noah Charney, Scott Civjan, Beth Fenstermacher, Lee Jennings, Zenia Kotval, and John Mullin

Meeting Minutes by Beth Fenstermacher, UMass