A Reptile and Amphibian Survey

of

The Tinmouth Channel Wildlife Management Area

in Tinmouth, Vermont

2003-2004

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Introduction

This is a revised and updated version of a report originally based on fieldwork done at the Tinmouth Channel Wildlife Management Area (TCWMA) in 2003. Revisions are based on three additional visits to the site during the 2004 field season. The scope of the 2003 fieldwork was to perform a herpetological survey of four parcels of Vermont state lands: the Roaring Brook Wildlife Management Area (WMA) in Vernon, the Narrows (WMA) in West Haven, Tinmouth Channel WMA in Tinmouth, and the Kulig-Spiegel addition to Bomoseen State Park in Hubbardton. The goals of the survey were to locate any rare, threatened, or endangered reptiles or amphibians that were using the parcel or might be using the parcel based on their location, habitat, and reports from adjacent areas. An additional goal was to determine and discuss any issues pertaining to the sustainability of their populations at those sites and recommend management strategies or additional survey work if warranted. Funding and hence effort during 2003 were limited, so the state lands and specific regions within some of the lands were prioritized. Approximately 50% of the time was spent at Roaring Brook WMA with the remaining time divided between the other three parcels. Only two visits were made to the TCWMA during 2003. This was not an adequate amount of time to locate the full spectrum of herptiles that might inhabit the site; so additional visits were scheduled for the 2004 field season. Three additional visits were made. This updated report covers all reptiles and amphibians (herptiles) located or suspected in the **Tinmouth Channel Wildlife Management Area** in both 2003 and 2004 (Table 1), paying particular attention to those with a Vermont State Heritage rank of S3 or lower. In addition, significant habitats and locations are noted and management suggestions given.

Methods

No one method will inventory the complete range of reptiles and amphibians occurring in an area. A combination of methods must be employed over a variety of seasons, but as a result of limited time, I used two of the most comprehensive of the methods: active searches and site checks. Visits were made on July 4, and July 11 in 2003 and on May 13, July 2, and October 12 in 2004. During the July 4 visit in 2003 and the July 2 visit in 2004, I was assisted by a team of students and counselors from Vermont Audubon. The help of all these additional eyes, ears, and hands was significant and paid for out of other sources. On July 11, 2003 two of my student employees visited the site without me. On May 13, 2004 I visited the site with two assistants and on October 12, 2004 I visited the site with one assistant. Over half of the WMA was surveyed at least once. We targeted sites that seemed the most likely to hold unusual species. Unusual reptile and amphibian species often require multiple visits to the same site to locate them. Consequently the species list (Table 1) for this parcel, although expanded from 2003, still may not be entirely complete.

An active search is a concentrated effort in a predetermined area to locate reptiles and amphibians by raking leaf litter, looking under rocks and logs, looking within rotten logs or under any items, natural or unnatural, that provide moist and shady retreats during the day. In addition, diurnally active species are searched for in appropriate microhabitat and identified if calling.

A site check is a less localized form of active search that includes time spent searching for and traveling between the best microhabitats. We targeted potential over-wintering pools for Wood Turtles and basking cover for snakes on the October visit.

In addition to the above methods, I used records from previous visits to the area and other contributions to the Vermont Reptile and Amphibian Database. As coordinator of the Vermont Reptile and Amphibian Atlas Project, all known records of Vermont herptiles current or historic are on a database on my computer. These records were accessed to check for all other records from the region and surrounding towns.

Results

All reptiles and amphibians located

Fifteen species of herptile were located in the WMA (Table 1): six species of frog; American Toad (*Bufo americanus*) Gray Treefrog (*Hyla versicolor*), Spring Peeper (*Pseudacris crucifer*), Green Frog (*Rana clamitans*), Pickerel Frog* (*Rana palustris*), Wood Frog (*Rana sylvatica*), five species of salamander; Spotted Salamander (*Ambystoma maculatum*), Northern Dusky Salamander (*Desmognathus fuscus*), Northern Two-lined Salamander (*Eurycea bislineata*), Eastern Newt (*Notophthalmus viridescens*), Eastern Red-backed Salamander (*Plethodon cinereus*), two species of snake; Milksnake (*Lampropeltis triangulum*), Common Gartersnake (*Thamnophis sirtalis*) and two species of turtle; Snapping Turtle (*Chelydra serpentina*) and Wood Turtle (*Glyptemys insculpta*). Four of these species were new additions for 2004: American Toad (S5), Northern Dusky Salamander (S4), Milksnake (S5) and Wood Turtle (S3). Three of these species were listed as probable after last year's survey, the other (Milksnake) as possible. The Pickerel Frog was documented from TCWMA prior to this survey in 1999 but was not located during these five visits. With the exception of the Wood Turtle, which is a special concern S3 species, all the species located are fairly common S4 & S5 species.

Reports in our database of additional species from surrounding areas

Reliable reports of additional species from the towns surrounding Tinmouth Channel include seven other species that may use this WMA (Table 1). Three of the four species that were listed as probable after the 2003 survey, were located. The fourth species, Painted Turtle (*Chrysemys picta*), I have downgraded to possible as a result of the lack of sightings and limited habitat.

There are seven species that I currently list as **possible**. They were reliably reported from surrounding towns but there is no additional evidence that they use this area other than the fact that it contains some habitat that may be suitable for them. Two of these are unusual. One **S2 species of special concern** that may be using this WMA is the **Four-toed Salamander (*Hemidactylium scutatum*)**. The swamp habitat along the Tinmouth Channel is a potential breeding habitat for this salamander. Although we did not find them in the time we spent at this WMA, this salamander is rare, secretive, and hard to find except during the spring breeding season. The **Blue-spotted Salamander (*Ambystoma laterale*, S3, SC)** also may breed in the wetlands within the Tinmouth Channel but we saw no evidence of this and it usually is fairly easy to find if abundant. It often is found breeding at the same time and in the same location as Four-toed Salamanders. Egg masses of a possible cross between the Blue-spotted Salamander and the Jefferson Salamander have previously been reported from Tinmouth and Pawlet, and a Blue-spotted Salamander specimen was collected in 1943 in Wallingford. Road searches in the area would help determine if either of these species were present. I am currently inclined to believe that neither of these two species are found here or are here only in very limited numbers.

Three S4 species: Northern Leopard Frog (*Rana pipiens*), Ring-necked Snake (*Diadophis punctatus*), and DeKay's Brownsnake (*Storeria dekayi*) may use the site. Of these, I think the Northern Leopard Frog is the least likely. The remaining two species now considered possible are the Red-bellied Snake (*Storeria occipitomaculata*) and the Painted Turtle (*Chrysemys picta*). Both are S5 species that are quite widely distributed in the state. The Red-bellied Snake seems most abundant at higher elevations and further north. The Painted Turtle may be using the abandoned beaver ponds but they are old and don't appear to hold a lot of food or emergent vegetation. We did not observe any basking but we did not use any turtle traps either.

It is not possible to prove the absence of small, secretive, seasonal, or rare species. It is still possible that species other than those mentioned above exist in low numbers in the area during certain seasons. However, it is unlikely that species not already discussed have significant populations within this WMA. A current list of all known Vermont species of reptiles and amphibians along with their protective status and state ranks is contained in Appendix A.

Sites visited

Over the course of the past two years we were able to make at least one visit to representative habitats within most of TCWMA. Over 1/2 the area was sampled and this included the sites I felt were most likely to reveal the diversity of herptiles using the WMA. Visits to the unsampled areas, or additional visits to the previously sampled areas at different times of the year, during different weather conditions, or using different methods could reveal additional species but I feel the area was adequately surveyed given funding realities.

This WMA does not include a high diversity of habitat types and hence its herptile diversity is understandably limited. What makes this area unique are its extensive lowland swamps bordering a low gradient stream without a road immediately along side it. In some places there is also connecting upland habitat (limited) that serves as the terrestrial habitat for both the amphibians and some of the reptiles in the area. Unfortunately, much of the upland habitat is not state-owned but on the private lands adjacent to the WMA. We did not locate any upland vernal pools on our visits but trapped water within the floodplain serves the same purpose of providing fish-free breeding. Egg-masses of pool-breeding species were found in two floodplain pools (Figure 1). A few old beaver ponds were discovered but there was no evidence of use by the more unusual herptiles. The fact that this land is not surrounded by development at this time is important and should be considered in efforts to maintain species within the parcel. On the map (Figure 1), I have shown the areas that we visited.

Discussion

Conservation of the most significant reptiles and amphibians located

The one unusual species that we located was the **Wood Turtle** (***Glyptemys insculpta,*** formerly ***Clemmys insculpta***) **an S3 species of special concern**. We located a single healthy male adult (carapace 180 mm straight line length) in what I suspect was its over-wintering pool (Figure 1) on our October 12th 2004 visit. We specifically targeted sections of the channel that had a faster current and some deeper pools at a time when Wood Turtles would be in or near their streams. These sites are fast and deep enough to prevent freezing, deliver dissolved oxygen, and provide some protection from ice scouring in the spring. On May 3, 2004 another Wood Turtle was photographed and reported to the Atlas Project from the same section of stream (apparently within 200 m). Photographs were detailed enough for us to see that this was a different adult. Both of these turtles had all four legs (removal of legs by raccoons or otters is often reported). Other Wood Turtles have been reliably reported from downstream of Tinmouth Channel in the Clarendon River in 1979 and 1994 and just south of this site in Baker Brook in 2001. I suspect others over-winter in the same section of brook. This species over-winters in streams under logs, in undercut banks, in root wads, downstream of large rocks, in muskrat tunnels, or in any area that provides some protection from ice scour and freezing. I suspect that these turtles are part of a larger population that survives in this area. A sustained effort concentrated on just this species would be required to estimate the size and sustainability of this population.

The **Wood Turtle** is too widely reported to get protection under the current state endangered species criteria. However, I personally believe that the S3 status is misleading and that Vermont is losing populations of this species and those remaining are becoming more isolated. Declines may not be realized for many years due to the long lives of the remaining adults in populations that are no longer producing young. Its relatively large range, habit of feeding on land, low reproductive rate, and its attractiveness as a pet put populations at risk. Mike Klemens (2000) points out that among the many threats worldwide to turtles, the primary threats to this species are habitat destruction, fragmentation, and illegal collection. I suspect that a population remains in TCWMA because the wide flat floodplain of this brook gives this species more room to feed without coming into contact with humans and their vehicles. The relatively sparse development and low density of traffic on the surrounding roads also helps to minimize mortality of this species at this site. Increased traffic and increased local development are potential threats to this species.

Populations of this species center on a moderate to low gradient home river. Although most activity is concentrated within 500 ft. of the streams, the Wood Turtle is known to travel up to 1,400 ft. from its home stream at another Vermont site (Steve Parren unpublished data) with ~95% of its activity within 1,000 ft. It will travel and feed in both forests and in pastures where it occasionally gets hit with equipment. This species also travels up tributaries of their home rivers to feed or lay their eggs. I believe that the section of the brook where the two turtles were found this year (Figure 1) is where part of the population over-winters, breeds, and feeds. Since this species travels extensively, it would benefit from protection of more of the adjacent uplands not only in the WMA but both upstream and downstream of the WMA. The downstream habitat appears more appropriate (larger stream and other records) and hence would be a higher priority than habitat upstream but this is based on limited information.

Boundaries of the WMA roughly follow the 1,100 ft. elevation contour. In some portions of the WMA this provides over 1,000 ft. of protected terrestrial habitat. However, in other areas the boundaries of the WMA come much closer to the brook itself. I recommend acquiring additional lands or working with adjacent landowners to prevent development and manage for this species to a distance of at least 1,000 ft. from the stream. This should protect most of the terrestrial habitat. Expanding the WMA or conservation easements east and west of this WMA **to the nearest roads** should protect almost all of the terrestrial habitat and would limit the amount of development and recreational use that could occur in the area. It would maintain a habitat mosaic that would benefit this and a wide variety of other game and non-game species.

The Wood Turtle is a long-lived, low-reproductive-capacity species. It lives up to 40 years in wild populations (Lovich et al. 1990) and does not breed until it reaches an age of ~14 years (Ernst et al. 1994). The removal or mortality of one or two breeding adults per year would be enough to eventually eliminate a population. Since this species is highly prized as a pet, its presence in an area should not be advertised beyond the local area. However, I believe that local education and the building of local support and protection efforts is valuable.

Since this turtle is diurnal and terrestrial, it is more easily encountered and caught by humans. These encounters frequently result in the removal of the turtle from the population. Consequently, increased recreational use of the area should not be encouraged from April through October. In one infamous study in Connecticut (Garber & Burger, 1995), two formerly protected areas were opened to recreational use (hiking and biking). The populations of Wood Turtles both entirely disappeared in a matter of only 10 years. It is assumed that this was a result of the slow removal of only a few breeding adults each year by recreational visitors.

Open land itself is not a deterrent to this species but if mowing is done during the active season (April-October), the mower should be set very high (6 inches or higher). The ideal would be to cut once a year in the late fall after the ground has frozen. At this time, the turtles should be at their overwintering sites in the brook. If logging takes place, the contractors should be informed about the turtles and asked to be on the lookout for them so as not to hit them with equipment. Winter logging or horse logging should minimize the chances of mortality.

All turtles likely to use this area (Wood, Snapping, and possibly Painted) seek out sunny moderately-well-drained loose soil without much vegetation other than scattered annuals to lay their eggs. The sun provides the heat necessary for the eggs to incubate in a reasonable amount of time. Dense plant roots can prevent development and hatching of eggs. Moisture is necessary but flooding or drying need to be avoided. The Wood Turtles may lay their eggs in the open portions of the nearby gravel pit, in the cemetery, on the road banks where the roads cross the channel, or perhaps in a naturally eroded bank. I did not find any natural egg-laying sites however. On the road bank around the culvert where Channel Road crosses the WMA, we found many Snapping Turtle eggs that had been dug up and eaten. We found no eggs of any other species though. It would be useful to know where the Wood Turtles nest. Egg-predation by skunks and raccoons can be as high as 100% in some years and can have a large impact on populations. Nesting habitat could be artificially created or if known, managed so as to limit disturbance and predation when they are still in the ground (May through October). Naturally eroding stream banks may be nesting areas and should not be stabilized.

Spring or fall surveys along portions of the stream that look like potential over-wintering sites should reveal other turtles. Radio-tracking a couple turtles from this population would reveal their feeding and nesting area, home range, and probably lead to other individuals. This information could prove helpful for protecting this population. I am unaware of any populations of Wood Turtles on public land in Vermont that are being monitored and protected. There is an opportunity at this site.

Conservation of other significant reptiles and amphibians that might use the area

The **Four-toed Salamander (S2, special concern)** was not found on the parcel but it is a secretive species that may use the wetlands along the brook and the adjacent uplands. It lays eggs under moss or in tussocks near the wetlands and migrates from nearby uplands where it feeds and overwinters. It is not known how far they migrate, but I recommend the same management suggestions for this species as I do for the Blue-spotted Salamander (see below): protection of wetlands and buffers, protection of adjacent wooded terrestrial habitat, and maintenance of the connections between the two. They appear to have a greater tolerance for low pH (acidic) breeding sites than other spring breeding salamanders. I do not believe that any significant populations of this species exist in the WMA.

Blue-spotted Salamanders (S3, special concern) are often found with Four-toed Salamanders. They are also a woodland species that may breed in pockets of water in the floodplain. They are usually fairly easy to find with an intensive active search effort or night-time road searches. We did not perform any night-time road searches in this area but we did perform active searches fairly widely. I doubt that any sizable populations of this species are using this WMA. If found, I recommend treating the **edge of the floodplain** as if it were the edge of a vernal pool, managing buffers and terrestrial habitat measured from that point. A minimum 30-m buffer (100 ft.) of uncut trees should be left beyond the high water line to conserve shade, absorb nutrients, slow or trap sediment, provide cover, and minimize direct mortality.

The need to maintain such buffer strips is clear but sometimes obscures the equally important concept of protecting foraging and overwintering habitat for the species that breed in those protected wetlands. Semlitsch (1998) reviewed travel distances of many amphibian species and determined that a protected distance of 164.3 m would include 95% of the salamander population using a given pond or wetland. This is clearly short, however, of the total distance traveled by Wood Frogs and Eastern Newts, and does not consider recolonization distances. Amphibians breeding in the pools may be coming from as far away as 400 meters. deMaynadier and Hunter (1995) recommend that no more than 25% of the basal area should be cut in a 100-m 2nd-tier buffer that extends beyond the no-cut zone around a pool or wetland. I recommend carefully managing a 600-ft. terrestrial-habitat zone, starting at the wetland edge.

Heavy equipment should be kept out of the wetlands and they should not be filled with debris. Fish should not be introduced into any pools, beaver ponds, or lakes that have significant breeding populations of spring breeding amphibians. The introduction of salmonids in the western US to high elevation lakes has been shown to be the cause of precipitous declines of both salamanders and frogs (Gillespie and Hero 1999).

As a result of their moist permeable skin, amphibians absorb water and any substance that is dissolved in it, directly through their skin. Any species that feeds upon amphibians, such as herons, raccoons, and snakes, can then be affected by these chemicals as well. Although many **biocides** have been shown to be toxic to amphibians (Power et al. 1989), the short-term toxic effects of most chemicals (herbicides, pesticides, fungicides, etc.) have not been tested on amphibians. The long-term and/or sublethal effects are almost never tested prior to commercial use. Information regarding the effects of different biocides on amphibians and reptiles may be found at www.on.ec.gc.ca/herptox/.

A few general recommendations for protecting the habitat in and around wetlands follow. They are the same as for protecting habitat around vernal pools.

- Potential breeding pools along the margins of wetlands should be kept buffered (100 ft. no cut zone) and surrounding terrestrial habitat should be carefully managed.

- I recommend that woodlands within 600 feet of wetlands and known and potential breeding pools be managed as amphibian terrestrial habitat. In this zone (outside the buffer), woodlands can be managed for hardwoods, maximizing coarse woody debris and dense leaf litter. However, no more than 25% of the 600-foot radius outside the buffer around the pool should be in young or early successional growth. The rest should be 70 years old in moist areas and older in dry areas. This concentrates activity and disturbance in a relatively small area and leaves the majority of habitat undisturbed. This is a slightly different recommendation than that of deMaynadier and Hunter (1995) who recommend spreading a smaller impact over a wider area (remove no more than 25% of basal area). These two approaches could be looked at as two management options for any given site.

<u>Conservation of reptiles and amphibians in general</u>

There were really remarkably few terrestrial amphibians of any species in this area. Finding even the most common species such as Red-backed Salamander took some time. Red-backs are known to avoid floodplains, but even in the uplands, Red-backed Salamanders were concentrated in only three locations: a hemlock stand, in one sugarbush on the east side of the channel, and in a moist red-maple stand a few feet above flood level. I am not sure why this is the case. My guess would be that many of the deciduous trees were younger second growth and coarse woody debris and deciduous leaf litter were minimal. Other options are that many of the uplands consisted of glacial deposits that were too well drained or with too little organic matter to hold moisture. Another option is soil damage as a result of a history of heavy grazing. Lastly, a problem that I have read about, but not yet experienced, is introduced worms released by fisherman and gardeners depleting the leaf litter but I have no evidence to support that here.

The remaining S4 and S5 species found or possible will not be mentioned here individually (see Table 1), but they are still worthy of wise management in an effort to improve populations.

General amphibian microhabitat requirements

- breeding locations that hold water at least through July,

- coarse woody debris in adjacent forested areas,

- foliage height diversity in adjacent forested areas,

- canopy cover over breeding and foraging areas,

- deep deciduous leaf litter for moisture retention and feeding,
- cool and moist conditions.

General reptile microhabitat requirements

- coarse woody debris (standing and down),
- small open patches for basking, mixed with well shaded refugia for warm weather and feeding,
- undisturbed areas in and around wetlands for feeding and breeding,
- access to safe denning areas.

Many studies have examined the relationships between different timber management practices and amphibian richness and abundance (see review by deMaynadier and Hunter 1995). Most work supports the finding that amphibian richness and abundance decrease with clearcuts and similar shelter wood cuts (Ash 1988, Howard and Caschetta 1999, Petranka et al. 1993) but gradually return to pre-cut levels with time (60 to 120 years) **as long as source populations and travel corridors are maintained intact.** deMaynadier and Hunter (1998) also showed that these declines extend 25-35 m beyond the edges of the affected area cut. General recommendations for the maintenance of reptile and amphibian habitat relative to timber harvesting practices are listed below. They will benefit the common amphibian and reptile species that use this parcel.

<u>General forest management recommendations for reptiles and amphibians</u>

- Maintain large down trees (>2 per acre, 7 per hectare), dead standing trees (> 4 per acre), and a future supply consisting of older standing trees.
- Maintain standing trees with knotholes and dead branches.
- Within areas that are heavily cut, patches of older trees should be left in addition to the scattered mature trees.
- Maintain a thick layer of deciduous litter.
- Softwood plantations limit the number and diversity of amphibians (decreased coarse woody debris, decreased structural diversity, decreased hardwood leaf litter, increased acidity). In these situations maintaining pockets of hardwoods and leaving large debris on the ground would help to minimize the impact.
- Long rotations provide the old mature growth and dense forest cover amphibians prefer. As forests age they show increasing amphibian abundance up to an age of 60 to 70 years old in wet cool habitats and up to 120 years in warm, dry, lowland habitats (deMaynadier and Hunter 1995).
- Minimize compaction of the soil and direct mortality by keeping heavy equipment off the site when the ground is saturated. Winter logging or logging in late summer and early fall should help minimize this effect.
- Protect and maintain shrub cover in the forest and on forest edges (vertical complexity).
- Do not create ditches and ruts that will hold water only briefly. Amphibians often lay their eggs in these small patches of water, which dry too soon to permit the larvae to transform and leave. They should either be prevented or they should be deep and shaded enough to hold water through July.

The recommendations above are also included in the handout <u>Forest Management Practices for Vermont Reptiles and Amphibians</u>. I have included a copy (Appendix B).

Rarely is there a species of amphibian that benefits from large openings. A few species such as Spring Peepers, Pickerel Frogs, and American Toads will use small openings for at least part of the season. Most of our snakes will benefit from small openings.

Almost all herptiles will benefit from the protection and maintenance of **buffers for all streams and wetlands**. These buffers minimize siltation, absorb nutrients, maintain shade, maintain undisturbed soil, and deep leaf litter, provide patches of older growth as sources for recolonization, and provide movement corridors. Buffer strips should be widest where wetlands and streams are larger, where the intensity of harvest is greatest, where the surrounding terrain is steepest, or where rare, threatened, or endangered species are found.

Seepage areas

The management of seepage areas is sometimes overlooked but important to amphibians. They need to be kept shaded so that the moisture content will remain high and the mosses will continue to grow (Northern Dusky Salamanders lay their eggs under the moss). They don't need to be large to be significant; they may be only a few feet across as long as they stay moist. During periods of drought, seepage areas (along with stream beds and other wetland edges) become a very important refuge as a wide variety of other more terrestrial amphibian species will join the saturated soil salamanders (in this case Northern Dusky and Northern Two-lined Salamanders) in their moist hideouts. My recommendations for seepage areas in general are listed below.

- Maintain a 100 ft. wooded buffer (50 foot minimum) to keep the seeps well shaded and moist. The 100-ft. buffer will be most effective at preventing light penetration, intercepting sediment and nutrients, and providing future coarse woody debris.
- Minimize erosion and keep sediments and chemicals from draining into seepage areas and small streams.
- Nearby logging should be during dry or frozen ground conditions when erosion is minimized.
- Locate roads out of the buffer areas.
- Don't allow septic overflow, fertilizers, pesticides, herbicides, or equipment fluids to drain into the sites.
- Don't channelize, ditch or drain the area.
- Leave existing coarse woody debris but don't smother the sites with tops or branches.
- Leave rocks in place, don't remove them.
- Don't flood the areas by damming up the drainage.
- Remove invasive exotic vegetation (I did not see any at these sites).
- Keep livestock out.
- Keep logging equipment, ATVS, and other vehicles out of the buffer area.
- Locate trails so that foot traffic, bicycles, and sunlight are kept off the seepage areas.

Connectivity, fragmentation, roads, and development

The protected wetlands of the Tinmouth Channel primarily provide breeding areas and a moisture refuge in periods of drought for amphibians, which in turn provide food for some of the reptiles and many other species. The stream itself provides over-wintering sites, refuge sites, breeding habitat, and a movement corridor for the Wood Turtle. However, most of the year, the amphibians and reptiles are using the surrounding woodlands that in some cases is not included in the state lands. One of the reasons herptiles can persist in the area is the current connectivity of habitat types; herptiles can easily move between overwintering, breeding, and foraging grounds. They can move relatively freely through or around private lands, and the amount of direct road mortality is probably low. As mentioned earlier, as **development** increases on the private parcels adjacent to this parcel, so does the fragmentation of the habitat, making it more and more difficult for these species to move to and from their required habitats. Not only does increased development affect an individual herptile moving from one habitat type to another; it can also affect an entire population. As patches of suitable habitat are destroyed or broken into smaller and smaller pieces, local diminished populations die off, and recolonization and immigration (the ability of an existing population to "rescue" the declining or extinct population) decreases. As cited in Sjogren 1991, "the fragmentation process poses a twofold extinction threat at local and regional levels. In addition to the increased risk of extinction following the reduction in population size, increased isolation of the remaining populations beyond a critical degree is likely to increase the risks of local and regional extinction further" (Sjogren 1991, 144). Therefore, "reserves should include sets of interconnected local populations and vacant suitable habitats, or be located in groups so that connectivity is achieved" (Sjogren 1991, 144). The state should work to maintain connections within and allow for movement in and out of this parcel. **In particular it should be working to conserve adjacent uplands and maintaining connections to them.** This would establish an area large enough to contain the different habitats used during the annual movements of many of the species discussed here. Connections to additional protected lands outside of the usual range of these populations would allow for genetic exchange and recolonization over the long term.

Road mortality is a serious threat to a wide variety of wildlife, including herptiles, through direct mortality, migrational barriers, hydrologic disruption, pollution, construction impacts, spread of exotics, and increased human usage (Trombulak and Frissell, 2000). Much of the February 2000 issue of Conservation Biology is dedicated to the ecological effects of roads and a variety of websites have sprung up with useful bibliographies (see End of the Road: www.nrdc.org/publications). As traffic increases, so do the negative effects on local amphibian densities (Fahrig et al, 1995). Heine (1987) calculated that 26 cars per hour could reduce the survival rate of toads crossing roads to zero.

With increased road traffic and numbers of roads, the chances of road mortality are much greater. When road mortality pushes the total mortality beyond the production capability of the herptile populations, they disappear. Ideally, traffic on all roads adjacent to this parcel will remain limited and no new roads would be built. The greatest concentration of mortality takes place on wet, warm, and humid nights (all herptiles) and on sunny mornings after the first frosts of fall in late September and October (snakes). Since **Wood Turtles are diurnal and terrestrial, they could be crossing the roads anytime during the day from May through October but particularly while traveling to and from egg-laying sites.**

Although I did not identify any specific locations of concentrated crossing activity, I have included information on designs that could be useful as this area becomes more developed and traffic increases. Properly designed **tunnels and underpasses** built under roads can guide young and adult herptiles under roads. This involves the combined use of fencing or walls and underpasses for reptiles, amphibians, (Langton 1989) and some small to medium sized mammals. Underpasses have been very effective when carefully designed and strategically placed. They are expensive. The design that makes the most sense based on my experience and observations would be that used in Payne's Prairie in Florida (reptile wall and culverts). The continuous wall is a valuable addition to the design and it is aesthetically more pleasing than a fence.

For more information on the Payne's Prairie design, visit the website below and open the chapters on Tortoise Underpasses, Salamander tunnels, and Amphibian-Reptile wall and culverts.

Critter Crossings (Federal Highway Administration)
www.fhwa.dot.gov/environment/wildlifecrossings/index.htm

There is a large and growing body of literature on the impacts of roads on herptiles. I have attached a bibliography in Appendix C.

Other construction-related threats are **amphibian-breeding traps**. These can result when pools are created in gravel pits, construction sites, or road beds that hold water long enough to entice amphibians to breed but not long enough for the young to metamorphose. Even if these pools hold water through the time of metamorphosis, some of them are too frequently disturbed by vehicles to produce metamorphs. The drainage of man-made pools that are frequently disturbed (roadbeds) should be altered so that they do not gather any water in the spring. **Pools could also be created in areas that are not disturbed.** I don't suggest this as a method to replace significant pools but as a way to enhance amphibian breeding at disturbed sites such as old logging headers. If so, care should be taken to make sure they are deep enough to hold water through July of most years (>70 cm).

Sedimentation of streams from road construction also diminishes the abundance and diversity of salamanders present (Bury and Corn, 1988 and Corn and Bury, 1989) and the effects may last for many years. Among other effects, silt fills the spaces in stream beds where larval amphibians hide and feed.

Other options to minimize road impacts on herptiles in critical areas include signage to alert traffic to wildlife of all types and to ask drivers to avoid or assist wildlife crossing roads, lowered speed limits, speed control bumps, narrowing of roads, removal of blacktop, closing of roads after dark or on rainy evenings after dark, limiting the amount or type of vehicles (bicycles instead of cars), and hiring or training volunteers to act as conservation officers. Clearly, the impact on wildlife of building, improving, or relocating roads should be taken into consideration and the effects of increased traffic flow should also be taken into account.

Chemical use

Amphibians absorb any chemicals which are in the water (dew, ground water, streams etc.) around them. Minimize use of herbicides, pesticides, and other biocides. Almost none of these chemicals have been tested on our native herptiles. In some cases even the inactive ingredients (e.g., surfactants in Roundup) have been found to be deadly to amphibians. Indirect, long-term, and sublethal effects have almost never been tested before marketing.

General thoughts on conservation design for reptiles and amphibians

Most mobile species use a variety of community types over the course of the year and over the course of their lives. In addition, they need to be able to recolonize areas where populations have been eliminated due to drought, winterkill, disease, or anthropogenic forces. They need to be able to find alternative cover, food sources, breeding, or over wintering sites when natural disasters occur. Genetic diversity also needs to be maintained by allowing different populations to interact. Permeability is a term that I think should be used when thinking of the ability of a species to move comfortably across the landscape. Does the intended use leave the landscape permeable to the wide variety of species you wish to maintain? When details about the permeability of landscape uses are not known for many species, I believe that the safest and most logical way to proceed to maintain natural biodiversity is to maintain a network of interconnected sites where natural processes are allowed to occur. This network seems to exist within and between many of the parcels that make up the public and private lands in this valley. **Roads in the area such as North End Road, North East Road, and Rte. 140 will become more significant barriers as traffic on them increases.** Further development in the area (the building of new roads and structures, the increase of traffic, and clearing) could potentially impact a wide variety of herptile species, by direct road mortality, loss of habitat, and habitat fragmentation and alteration. Human uses don't need to be curtailed in the region but they should allow the regular movement of species. Efforts to maintain permeability and connectivity on surrounding lands should be considered necessary to maintain the biodiversity of this parcel over the long term. Working with land trusts and conservation organizations to obtain development rights on surrounding lands will help conserve its wildlife.

Summary

This site has been fairly well surveyed for overall herptile diversity. Significant populations of species at this WMA other than those found or listed as possible seems highly unlikely. With the exception of the Wood Turtle all of the species located were common and wide spread in the state. The **Wood Turtle (special concern, S3)** is now known to be using this WMA based on this year's two records and older records from surrounding areas. Two other unusual species may be using the site but it seems unlikely that there could be significant populations of them. They are the Four-toed Salamander (S2, special concern) and the Blue-spotted Salamander (S3, special concern). **Management for herptiles at this site should be focused on the Wood Turtle** and additional information on the size and habits of this population would be useful. A variety of specific recommendations are made above. Expansion of protected lands to include more of the adjacent uplands required for Wood Turtles and migratory amphibians is encouraged. Maintaining a large strip of protected uplands along the brook to the north of the WMA would help maintain habitat for the large movements of the Wood Turtles and to keep from fragmenting a larger population that probably extends downstream beyond the boundaries of this population. In addition, maintaining connections to surrounding habitat beyond the annual range of the local populations is also recommended to help maintain interconnected populations.

Appendices

Attached are: a printout of the current status and accepted names for reptiles and amphibians in Vermont (Appendix A), forest management recommendations for reptiles and amphibians (Appendix B), a bibliography of road impact literature (Appendix C), suggested resources for herptile identification, natural history, and management (Appendix D) and some photographs of the Wood Turtle and Milksnake found at this site (Appendix E).

Recommended management guides that include reptiles and amphibians

Management guides are just beginning to be available. All of the following include reptile and amphibian related information.

Biebighauser, T. 2002. A guide to creating vernal ponds. USDA Forest Service in cooperation with the Izaak Walton League of America. Morehead, Kentucky. 33 pp. (Call 606-784-6428 to order or find it on the web.)

Calhoun, A.J.K. and M. W. Klemens. 2002. Best Development Practices: Conserving pool-breeding amphibians in residential and commercial developments in the Northeastern United States. MCA Technical Paper No. 5, Metropolitan Conservation Alliance, Wildlife Conservation Society, Bronx, New York. 57 pp. (Call 914-925-9175 to order.)

deMaynadier, P. and M. Hunter. 1995. The relationship between forest management and amphibian ecology: a review of the North American literature. Environmental Reviews 3: 230-261.

Evink, G. 2002. National Cooperative Highway Research Program Synthesis 305, Interaction between roadways and wildlife ecology, A synthesis of highway practice. Transportation Research Board, Washington D.C. 78 pp. (Impacts of roads on herptiles and some conservation strategies. A big problem, good information. Order at 202-334-3213 or on the web.)

Flatebo, G., C. Foss, and S. Pelletier. 1999. Biodiversity in the forests of Maine: Guidelines for land management. University of Maine Cooperative Extension Bulletin #7147. C. Elliot editor, University of Maine Cooperative Extension, Orono, Maine. 168 pp. (Contact UME Extension Office at 207-581-3188.)

Kingsbury, B. and J. Gibson. 2002. Habitat management guidelines for amphibians and reptiles of the Midwest. Midwest Partners in Amphibian and Reptile Conservation (Midwest PARC). 57 pp. (Visit the PARC website for more information: www.parcplace.org.)

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Howard, J.H. and A.R. Caschetta. 1999. Effects of clearcutting on amphibian abundance in Western Maryland. Northeast Wildlife 54:35-43.

Klemens, M. 2000. Turtle Conservation. M. Klemens (ed.), Smithsonian Institution Press, Washington D.C., 334 pp.

Langton, T.E., 1989. Amphibians and Roads. Proceedings of the Toad Tunnel Conference, Rendsburg, Federal Republic of Germany, 7-8 January, 1989. ACO Polymer Products, Ltd. Shefford U.K. 202 pp.

Lovich, J.E., C.H. Ernst, and J.F. McBreen. 1990. Growth, maturity, and sexual dimorphism in the wood turtle, *Clemmys insculpta*. Canadian Journal of Zoology 68:672-677.

Petranka, J.W. 1998. Salamanders of the United States and Canada. Washington: Smithsonian Institution Press. 587 pp.

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Table 1. Reptiles and amphibians found or suspected on Tinmouth Channel WMA as a result of the 2003 and 2004 reptile and amphibian survey. The site was visited on two different days in 2003: July 4 and July 11, with one survey method used. It was visited on three different days in 2004: May 13, July 2, and October 12 using two survey methods. Additional records from visits in prior years are included.

Species Found

Common name	Scientific name	State Rank & Status
Amphibians		
Frogs		
American Toad **(new in '04)**	*Bufo americanus*	S5
Gray Treefrog	*Hyla versicolor*	S5
Spring Peeper	*Pseudacris crucifer*	S5
Green Frog	*Rana clamitans*	S5
Pickerel Frog (1999 only)	*Rana palustris*	S4
Wood Frog	*Rana sylvatica*	S5
Salamanders		
Spotted Salamander	*Ambystoma maculatum*	S5
Northern Dusky Salamander **(new in '04)**	*Desmognathus fuscus*	S4
Northern Two-lined Salamander	*Eurycea bislineata*	S5
Eastern Newt	*Notophthalmus viridescens*	S5
Eastern Red-backed Salamander	*Plethodon cinereus*	S5
Reptiles		
Snakes		
Common Gartersnake	*Thamnophis sirtalis*	S5
Milksnake **(new in '04)**	*Lampropeltis triangulum*	S5
Turtles		
Snapping Turtle	*Chelydra serpentina*	S5
Wood Turtle **(new in '04)**	*Glyptemys insculpta*	S3

Table 1. Continued.

Other Possible Species based on habitat, elevation, latitude, and other records from Tinmouth, and other towns in south-western Rutland County

Common name	Scientific name	State Rank & Status
Amphibians		
Frogs		
N. Leopard Frog (Possible)	*Rana pipiens*	S4
Salamanders		
Blue-spotted Salamander (Possible)	*Ambystoma laterale*	S3
Four-toed Salamander (Possible)	*Hemidactylium scutatum*	S2
Reptiles		
Snakes		
Ring-necked Snake (Possible)	*Diadophis punctatus*	S4
DeKay's Brownsnake (Possible)	*Storeria dekayi*	S4
Red-bellied Snake (Possible)	*Storeria occipitomaculata*	S5
Turtles		
Painted Turtle (Possible)	*Chrysemys picta*	S5

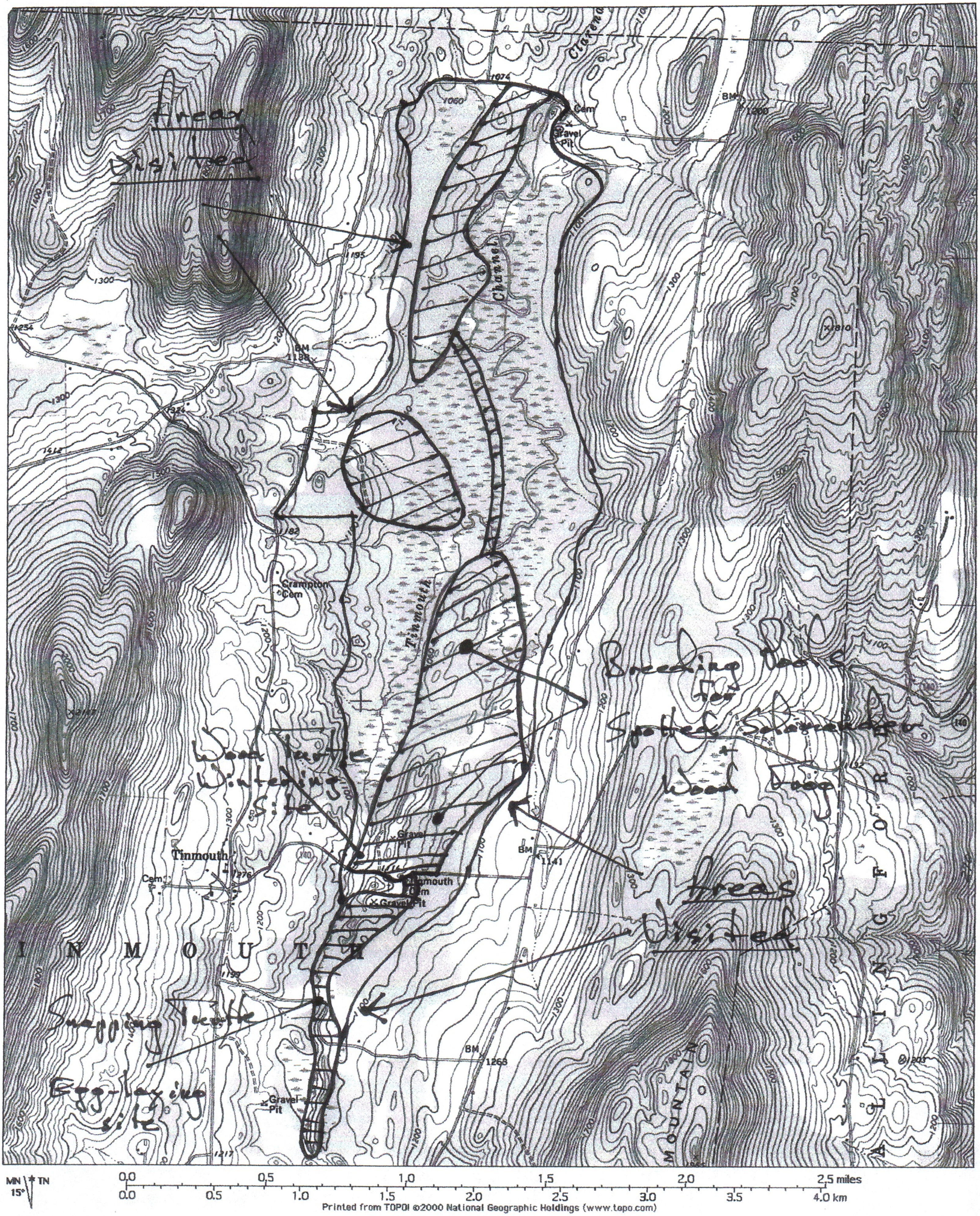

Figure 1. Sites visited within the Tinmouth Channel Wildlife Management Area.

Appendix A

Current Status and Accepted Names of Vermont Reptiles and Amphibians

Reptiles and Amphibians of Vermont
Accepted Name, State Rank, and State Status, as of November 2003

Common Name	Scientific Name	State Rank	State Status
Amphibians	**Amphibia (Class)**		
Salamanders	**Caudata (Order)**		
Jefferson Salamander	*Ambystoma jeffersonianum*	S 2	SC
Blue-spotted Salamander	*Ambystoma laterale*	S 3	SC
Spotted Salamander	*Ambystoma maculatum*	S 5	
Northern Dusky Salamander	*Desmognathus fuscus*	S 4	
Northern Two-lined Salamander	*Eurycea bislineata*	S 5	
Spring Salamander	*Gyrinophilus porphyriticus*	S 4	
Four-toed Salamander	*Hemidactylium scutatum*	S 2	SC
Mudpuppy	*Necturus maculosus*	S 2	SC
Eastern Newt	*Notophthalmus viridescens*	S 5	
Eastern Red-backed Salamander	*Plethodon cinereus*	S 5	
Frogs (including toads)	**Anura (Order)**		
American Toad	*Bufo americanus*	S 5	
Fowler's Toad	*Bufo fowleri*	S 1	SC
Gray Treefrog	*Hyla versicolor*	S 5	
Spring Peeper	*Pseudacris crucifer*	S 5	
Western Chorus Frog	*Pseudacris triseriata*	S 1	E
American Bullfrog	*Rana catesbeiana*	S 5	
Green Frog	*Rana clamitans*	S 5	
Pickerel Frog	*Rana palustris*	S 4	
Northern Leopard Frog	*Rana pipiens*	S 4	
Mink Frog	*Rana septentrionalis*	S 4	
Wood Frog	*Rana sylvatica*	S 5	
Reptiles	**Reptilia (Class)**		
Turtles	**Testudines (Order)**		
Spiny Softshell	*Apalone spinifera*	S 1	T
Snapping Turtle	*Chelydra serpentina*	S 5	
Painted Turtle	*Chrysemys picta*	S 5	
Spotted Turtle	*Clemmys guttata*	S 1	E
Wood Turtle	*Glyptemys insculpta*	S 3	SC
Northern Map Turtle	*Graptemys geographica*	S 3	SC
Stinkpot	*Sternotherus odoratus*	S 2	SC
Lizards and Snakes	**Squamata (Order)**		
Lizards	**Lacertilia (Suborder)**		
Common Five-lined Skink	*Eumeces fasciatus*	S 1	E
Snakes	**Serpentes (Suborder)**		
Eastern Racer	*Coluber constrictor*	S 1	SC, PT
Timber Rattlesnake	*Crotalus horridus*	S 1	E
Ring-necked Snake	*Diadophis punctatus*	S 4	
Eastern Ratsnake	*Elaphe alleghaniensis*	S 2	SC, PT
Milksnake	*Lampropeltis triangulum*	S 5	
Northern Watersnake	*Nerodia sipedon*	S 3	
Smooth Greensnake	*Opheodrys vernalis*	S 4	
DeKay's Brownsnake	*Storeria dekayi*	S 4	
Red-bellied Snake	*Storeria occipitomaculata*	S 5	
Eastern Ribbonsnake	*Thamnophis sauritus*	S 2	SC
Common Gartersnake	*Thamnophis sirtalis*	S 5	

Hypothetical Species

Salamanders

Allegheny Mountain Dusky Salamander — *Desmognathus ochrophaeus*

One specimen of a juvenile from central Vermont may be of this species. Otherwise, the distribution of this species is believed to have an eastern boundary of the Hudson River and Lake Champlain. No populations have been located.

Northern Slimy Salamander — *Plethodon glutinosus*

Specimens labeled from Caledonia County in Vermont at the Carnegie Museum in Pittsburgh have long been questioned. They are believed to be mislabeled. No populations have been located.

Marbled Salamander — *Ambystoma opacum*

One historic photo of this species is labeled Vermont and an historic field record from Fair Haven is from a credible source. A population of this species may eventually be located in southern Vermont, most likely along the Connecticut River drainage. No populations have been located.

Turtles

Eastern Box Turtle — *Terrapene carolina*

The occasional reports of single adult animals are assumed to be released pets. Reports near the southern Connecticut River Valley could possibly be native turtles. No populations have been located.

Blanding's Turtle — *Emydoidea blandingii*

Widely disjunct populations of this species suggest that populations could potentially exist in Vermont. One well-documented record could be a released pet. No populations have been located.

Explanation of Legal Status & Information Ranks

State Status: As per the Vermont Endangered Species Law

- E: Endangered--In immediate danger of becoming extirpated in the state.
- T: Threatened--High possibility of becoming endangered in the near future.

Information Categories: Not established by law

- PE: Proposed for endangered.
- PT: Proposed for threatened.
- SC: Special Concern--rare; status should be watched.

State Ranks of Plants, Animals, and Natural Communities

State ranks are assigned by the Nongame & Natural Heritage Program based on the best available information. They are not established by law. Ranks are reviewed annually.

- S1: Very rare, generally only 1 to 5 populations believed to occur in the state and/or some factor(s) making it especially vulnerable to extirpation.
- S2: Rare, generally 6 to 20 populations believed to occur in the state and/or some factor(s) making it vulnerable to extirpation.
- S3: Uncommon, but believed to be more than 20 populations in the state and/or there is some threat to it.
- S4: Apparently secure in the state, often with more than 100 populations.
- S5: Demonstrably secure in the state.

Appendix B

Forestry Practices for Reptiles and Amphibians

Forest Management Practices
for
Vermont Reptiles and Amphibians

Most amphibians spend the majority of their lives away from water in the surrounding woods. The wetlands, vernal pools, and ponds are critical for breeding of most species but the forests are also critical for the foraging and wintering of those species. Some local amphibians migrate 300 meters or more from wintering and foraging areas to breeding ponds. Most snakes, some turtles, and Vermont's only lizard spend the majority of their lives away from water. Hence management of wetlands and the surrounding woods both have an impact on reptiles and amphibians. Some species of larger snakes and most land turtles require many years to reach breeding age. Direct mortality or removal of breeding adults can have a devastating impact on a population.

Specific management plans for rare, threatened, or endangered species

Learn to recognize Vermont's rare, threatened, and endangered species.

(habitat in which they are found should be managed specifically for them)

(contact the Vermont Non-game and Natural Heritage Program, they will be interested in the distribution information and may be able to make specific management suggestions)

General

Maintain large down trees (2 per acre, 7 per hectare), dead standing trees, and a future supply consisting of older standing trees.

Maintain standing trees with knotholes and dead branches.

Within areas that are heavily cut, patches of older trees should be left in addition to the scattered mature trees.

Maintain a thick layer of deciduous litter.

Softwood plantations limit the number and diversity of amphibians.

(decreased coarse woody debris, decreased structural diversity, decreased hardwood leaf litter, increased acidity)

(in these situations maintaining pockets of hardwoods and leaving large debris on the ground would help to minimize the impact)

Long rotations provide the old mature growth and dense forest cover amphibians prefer.

(as forests age they show increasing amphibian abundance up to an age of 60 to 70 years old in wet cool habitats and up to 120 years in warm, dry, lowland habitats)

Minimize compaction of the soil and direct mortality by keeping heavy equipment off the site when the ground is saturated.

(winter logging or logging in late summer and early fall conditions should help minimize this effect)

Protect and maintain shrub cover in the forest and on forest edges.

Openings

Maintain a natural pattern of forest cover with small forest breaks.

Large clear-cuts regularly show fewer amphibians than adjacent older growth.

(successive short rotation clear-cuts showed the lowest abundance of amphibians)

(natural disasters such as diseases and storms seem to have less of an effect on amphibian abundance as clear-cuts, probably because of the amount of coarse woody debris left behind)

(large clear-cuts seem to block the movements of some amphibian species)

Small upland meadows with nearby woods provide partial habitat requirements for some snake species.

In small upland meadows exposed rock piles, sawdust piles, and coarse woody debris can provide good habitat for snakes.

Wetland areas

Maintain the ability of swamps, vernal, and semipermanent pools to hold water.

Do not create ditches and ruts that will hold water only briefly. Amphibians often lay their eggs in these small patches of water which dry too soon to permit the larvae to transform and leave. They should either be prevented or they should be deep and shaded enough to hold water through July.

Streams, ponds, and vernal pools should be kept shaded and silt should be kept out.

(among other effects, silt fills the spaces in stream beds where the larval amphibians hide and feed)

(direct sun may speed the rate of evaporation in vernal pools)

Equipment and logs should be kept out of vernal pools and other wetlands.

(small amounts of coarse woody debris or single trees that fall into a wetland are not harmful but vernal pools should not be filled with debris)

Buffer strips should be maintained around all water bodies including streams, ponds, and vernal pools.

(these strips minimize siltation, maintain shade, maintain undisturbed soil and deep leaf litter, provide patches of older growth as sources for recolonization, and provide movement corridors)

(the width of uncut buffer strips should be a minimum of 30 meters, with a wider zone of up to 100 meters where cutting and its impacts are limited)

(deMaynadier and Hunter suggest no more than 25% of the basal area should be cut in this second tier buffer)

(buffer strips should be widest where streams are larger, where the intensity of harvest is greatest, where the surrounding terrain is steepest, or where rare, threatened, or endangered species are found)

Equipment should be kept out of forested seepage areas.

Forest cover over seepage areas should be maintained.

Chemicals

Amphibians absorb any chemicals which are in the water (dew, ground water, streams etc.) around them.

(minimize use of herbicides, pesticides, etc.)

(one study suggests that CaCl spread on roads to minimize dust may be a barrier to amphibian movement)

Roads

Minimize the number of roads, size of roads, and the amount of traffic on roads.

(a rural paved road in upstate New York killed between 50 and 100 percent of migrating amphibians breeding near it)

Permanent roads should be planned not to intercept the annual movements of reptiles and amphibians between breeding, foraging and wintering habitats.

Other Species

Allow only moderate grazing after the breeding season.

Keep livestock out of the riparian zone and away from vernal pools and ponds.

If livestock need access to a pond or a lake, limit it. Maintain as much naturally vegetated shoreline as possible.

Don't introduce fish in streams and ponds where they were not previously found.

(many fish feed on amphibian eggs and larvae, and absence of predacious fish is a primary requisite of vernal pool breeders)

Open areas with dense annual or shrubby growth near water bodies or on the edge of woods provide foraging areas for some species

open areas that are to be kept open should be cut high and either not raked or raked by hand, (direct mortality should be minimized) these areas could be cut after the ground is frozen and before the first snows (reptiles and amphibians would no longer be active)

General amphibian microhabitat requirements include;

breeding locations that hold water at least through July,
coarse woody debris in adjacent forested areas,
foliage height diversity in adjacent forested areas,
canopy cover over breeding and foraging areas,
deep deciduous leaf litter for moisture retention and feeding,
cool and moist conditions.

General reptile microhabitat requirements include;

coarse woody debris (standing and down),
small open patches for basking, mixed with well shaded refugia for warm weather and feeding,
undisturbed areas in and around wetlands for feeding and breeding,
access to safe denning areas.

Many of the above ideas were taken from a recent review of the literature regarding amphibians and forest management. This review includes an extensive bibliography that might be of interest.

deMaynadier, P. and M. Hunter. 1995. The relationship between forest management and amphibian ecology: a review of the North American literature. Environmental Reviews 3: 230-261.

Additional suggestions for this list were provided by the author (J. Andrews), P. Bartelt, S. Droege, S. Jackson, L. Raw, and R. Waldick.

James Andrews, 7/96
Format #2

Appendix C

A Bibliography of the Literature Dealing with Reptiles, Amphibians, and Roads

THE EFFECTS OF ROADS ON REPTILES AND AMPHIBIANS - BIBLIOGRAPHY

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Boarman, W., M. Sazaki, and W. Jennings. 1997. The effect of roads, barrier fences, and culverts on desert tortoise populations in California, USA. *In* J. van Abbema (ed.), Proceedings of the New York Turtle & Tortoise Society: conservation, restoration, and management of tortoises and turtles – an international conference, pp. 54-58. New York, July 1993.

Bugbee, R. 1945. A note on the mortality of snakes on highway in western Kansas. Transactions of the Kansas Academy of Sciences 47: 373-374.

Bunnell, J. and R. Zampella. 1999. Acid water anuran pond communities along a regional forest to agro-urban ecotone. Copeia 3:614-637.

Burke, V. and J. Gibbons. 1995. Terrestrial buffer zones and wetland conservation: a case study of freshwater turtles in a Carolina bay. Conservation Biology 9:1365-1369.

Campbell, H. 1956. Snakes found dead on the roads of New Mexico. Copeia 1956:124-125.

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INTERNET RESOURCES

Government Sites

US Department of Agriculture. Forest Service, San Dimas Technology and Development Center, and Utah State University. Wildlife Crossing Toolkit.
http://www.wildlifecrossings.info/beta2.htm

US Department of Transportation, Federal Highway Administration
Critter Crossing: Linking Habitats and Reducing Roadkills.
www.fhwa.dot.gov/environment/wildlifecrossings/main.htm
www.fhwa.dot.gov/environment/wildlifecrossings/amphibin.htm
www.fhwa.dot.gov/environment/wildlifecrossings/tortoise.htm
www.fhwa.dot.gov/environment/wildlifecrossings/salamand.htm
Keeping it Simple: Easy Ways to Help Wildlife Along Roads
http://www.fhwa.dot.gov/environment/wildlifeprotection/index.cfm

US Geological Survey. Paynes Prairie Ecopassage Project.
www.fcsc.usgs.gov/Amphibians_and_Reptiles/Paynes_Prairie_Project/paynes_prairie_project.html

Private Sites

Berryman Institute. Wildlife and Highways: Seeking solutions to an ecological and socio-economic dilemma.
http://gulliover.trb.org/publications/nchrp/nchrp_syn_305.pdf

Center for Transportation and the Environment
Searchable Database of Wildlife Ecology Literature and Web Sites.
http://itre.ncsu.edu/cte/wildlife.htm
Wildlife, Fisheries, and Transportation Web Gateway.
http://www.itre.ncsu.edu/cte/gateway/home.html
http://www.itre.ncsu.edu/cte/gateway/links.html
International Conference on Ecology and Transportation.
http://www.itre.ncsu.edu/cte/icoet/index.html
Evaluation of a Wildlife Underpass on Vermont State Highways 289 in Essex, Vermont
http://utre.ncsu.edu/cte/icoet/downloads/Posters.pdf
Wildlife Crossing Structures Field Course
http://itre.ncsu.edu/cte/gateway/banff_index.html

Converge: Where Transportation and the Environment Meet. Wildlife, Fisheries, Ecosystems.
http://www.converge.ncsu.edu/topics/topics_display.asp?topic_ref=21

Defenders of Wildlife. Habitat and Highways Campaign.
www.defenders.org/habitat/highways/
www.defenders.org/habitat/highways/new/sub/library/laurie's%20bridge%20paper.pdf

Eco Network Europe. Cost 341 – Habitat Fragmentation caused by Transportation Infrastructure.
www.cordis.lu/cost-transport/src/cost-341.htm

Natural Resource Defense Council. The End of the Road – Bibliography.
http://www.nrdc.org/land/forests/roads/refer.asp

Surface Transportation Policy Project
www.tea3.org

Wildland Center for Preventing Roads
http://www.wildlandscpr.org/databases/biblionotes/toads.html

World Bank. Roads and the Environment Handbook.
http://www.worldbank.org/transport/publicat/reh/toc.htm

Specific Articles

Wildlife Habitat Connectivity Across European Highways
http://www.international.fhwa.dot.gov

Twinning of the Trans Canada Highway: Highway Service Center: Parks Canada Agency
http://www.hsctch-twinning.ca/Environental/inex.htm

Interaction Between Roadways and Wildlife Ecology: A Synthesis of Highway Practice
National Cooperative Highway Research Program (NCHRP): synthesis 305
http://gulliver.trb.org/publications/nchrp/nchrp_syn_305.pdf

Appendix D

Additional Resources on Reptiles and Amphibians

Useful Sources of Information on New England Reptiles and Amphibians

Identification. A few good field guides to reptiles and amphibians exist. These help you identify herptiles but do not give you life history information. One that is easy to find, and up to date is:

Conant, R., and J.T. Collins. 1998. A field guide to reptiles and amphibians of eastern and central North America. Third Edition, expanded, Houghton Mifflin Company, Boston Massachusetts 616 pp.

Natural History. These guides focus less on identification and more on natural history, local distribution, and conservation.

DeGraaf, R.M., and D.D. Rudis. 1983. Amphibians and reptiles of New England. The University of Massachusetts Press, Amherst, Massachusetts 85 pp.

Harding, J.H. 1997. Amphibians and reptiles of the Great Lakes Region. The University of Michigan Press, Ann Arbor, Michigan 378 pp. (All our species are included.)

Hulse, A., C. J. McCoy, and E. Censky. 2001. Amphibian and reptiles of Pennsylvania and the Northeast. Cornell University Press, Ithaca, New York 419 pp. (Most of our species are included.)

Hunter, M.L., A. Calhoun, and M. McCullough (eds.). 1999. Maine amphibians and reptiles. The University of Maine Press, Orono, Maine 272 pp. (This edition includes a CD of local frog calls. Call 207-866-0573 to order.)

Klemens, M.K. 1993. Amphibians and reptiles of Connecticut and adjacent regions. State Geological and Natural History Survey of Connecticut, Bulletin No. 112 318 pp. (Unfortunately this is currently out of print.)

Tyning, T.F. 1990. A guide to amphibians and reptiles. Little, Brown and Company. Boston Massachusetts 400 pp.

Calls. A very useful tool to help you learn the calls of frogs and toads is:

Eliot, L. 2004. The calls of frogs and toads. Stackpole Books. Mechanicsburg, Pennsylvania. (call 1-800-732-3669 to order)

Websites. Many useful sites exist. Some provide more reliable information than others. A few reliable sites, some with many links to other resources are:

Amphibiaweb (an excellent source of information on amphibians)
http://elib.cs.berkeley.edu/aw/

North American Amphibian Monitoring Program (NAAMP)
http://www.pwrc.usgs.gov/naamp

FrogWeb
http://frogweb.nbii.gov/

Society for the Study of Amphibians and Reptiles (SSAR)
http://www.ssarherps.org/

The snakes of Massachusetts (a downloadable guide that includes all our local snakes)
http://www.umass.edu/nrec/fish_wildlife_biodiversity/fish_wildlife_online_docs.html

Management Information. Management guides are just beginning to be available. All of these include reptile and amphibian related information.

Biebighauser, T. 2002. A guide to creating vernal ponds. USDA Forest Service in cooperation with the Izaak Walton League of America. Morehead, Kentucky. 33 pp. (Call 606-784-6428 to order or find it on the web.)

Calhoun, A.J.K. and M. W. Klemens. 2002. Best Development Practices: Conserving pool-breeding amphibians in residential and commercial developments in the Northeastern United States. MCA Technical Paper No. 5, Metropolitan Conservation Alliance, Wildlife Conservation Society, Bronx, New York. 57 pp. (Call 924-925-9175 to order.)

Evink, G. 2002. National Cooperative Highway Research Program Synthesis 305, Interaction between roadways and wildlife ecology, A synthesis of highway practice. Transportation Research Board, Washington D.C. 78 pp. (Impacts of roads on herptiles and some conservation strategies. A big problem, good information. Order at 202-334-3213 or on the web.)

Flatebo, G., C. Foss, and S. Pelletier. 1999. Biodiversity in the forests of Maine: Guidelines for land management. University of Maine Cooperative Extension Bulletin #7147. C. Elliot editor, University of Maine Cooperative Extension, Orono, Maine. 168 pp. (Contact UME Extension Office at 207-581-3188.)

Kingsbury, B. and J. Gibson. 2002. Habitat management guidelines for amphibians and reptiles of the Midwest. Midwest Partners in Amphibian and Reptile Conservation (Midwest PARC). 57 pp. (Visit the PARC website for more information: www.parcplace.org.)

Additional Reading on Reptiles and Amphibians

<u>Amphibians</u>

Bishop, S.C. 1941 (June). The salamanders of New York. New York State Museum bulletin No. 324. The University of the State of New York, Albany, New York 365 pp. (This book is currently out of print, but contains excellent information on Vermont's salamanders.)

Bishop, S.C. 1994. Handbook of salamanders: The salamanders of the United States, of Canada, and of lower California. Comstock Publishing Associates, A Division of Cornell University Press, Ithaca, New York 555 pp. (A reprint of an old classic. It does not contain as much information on each species as The Salamanders of New York.)

Dickerson, M.C. 1969. The frog book: North American toads and frogs, with a study of the habits and life histories of those of the northeastern states. Dover Publications, Inc., New York 253 pp. (A reprint of an old classic. Still excellent information but some of it is outdated. No newer comprehensive works on frogs are available.)

Epple, A.O. 1983. The amphibians of New England. Down East Books, Camden, Maine 138 pp. (A good book for the beginner but without plates or photos.)

Petranka, J.W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, DC 587 pp. (The most current source for detailed information on salamanders.)

Pfingsten, R.A. and F.L. Downs. 1989. Salamanders of Ohio. Bulletin of the Ohio Biological Survey Vol. 7, No. 2. College of Biological Sciences, The Ohio State University, Columbus, Ohio 315 pp, 29 plates. (This contains detailed information on the many species of salamander that we share with Ohio.)

Wright, A.H. and A.A. Wright. 1995. Handbook of frogs and toads of the United States and Canada. Comstock Publishing Associates, A Division of Cornell University Press, Ithaca, New York 640 pp. (A reprint of an old classic. No newer comprehensive works on frogs are available.)

<u>Reptiles</u>

Carr, A. 1995. Handbook of turtles: The turtles of the United States, Canada, and Baja California. Comstock Publishing Associates, A Division of Cornell University Press, Ithaca, New York 542 pp. (A reprint of an old classic.)

Ernst, C.H. and R.W. Barbour. 1989. Snakes of eastern North America. George Mason University Press, Fairfax, Virginia. 282 pp. (An excellent source for detailed information.)

Ernst, C. H., and E. Ernst. 2003. Snakes of the United States and Canada. Smithsonian Institution Press, Washington D.C. 668 pp. (The latest and most complete source for snakes.)

Ernst, C.H., J.E. Lovich, and R.W. Barbour. 1994. Turtles of the United States and Canada. Smithsonian Institution Press, Washington D. C. 578 pp. (The best current source for detailed information.)

Klauber, L.M. 1982. Rattlesnakes: their habits, life histories, & influence on mankind, abridged edition. University of California Press, Berkeley and Los Angeles, California 350 pp. (An edited reprint of an old classic.)

Klemens, M. (ed.) 2000. Turtle conservation. Smithsonian Institution Press. Washington 334 pp. (A current discussion of conservation challenges.)

Mitchell, J.C. 1994. The reptiles of Virginia. Smithsonian Institution Press, Washington 352 pp. (This book provides excellent information on the species of reptile that we share with Virginia; most of our species are found in this book.)

Smith, H.M. 1995. Handbook of lizards: lizards of the United States and Canada. Comstock Publishing Associates, A Division of Cornell University Press, Ithaca, New York 557 pp. (A reprint of an old classic.)

Tennant, A. 2003. Snakes of North America: eastern and central regions. Lone Star Books, Lanham, Maryland. 605 pp. (One of a two excellent new snake resources.)

Wright, A.H. and A.A. Wright. 1994. Handbook of snakes of the United States and Canada, volumes 1 and 2. Comstock Publishing Associates, A Division of Cornell University Press, Ithaca, New York 1105 pp. (A reprint of an old classic.)

<u>Texts</u>

Duellman, W.E. and L. Trueb. 1994. Biology of amphibians. The Johns Hopkins University Press, Baltimore, Maryland 670 pp. (The standard text for amphibians.)

Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L-A. C. Hayek, and M.S. Foster. 1994. Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution Press, Washington 364 pp. (Useful information for researchers.)

Mitchell, J.C. 2000. Amphibian monitoring methods and field guide. Smithsonian National Zoological Park's Conservation & Research Center, Front Royal, Virginia 56 pp. (Very accessible, designed for citizen scientists.)

Stebbins, R.C. and N.W. Cohen. 1995. A natural history of amphibians. Princeton University Press, Princeton, New Jersey 316 pp. (Lots of interesting information in an accessible and easy to read format.)

West, L. and W.P. Leonard. 1997. How to photograph reptiles & amphibians. Stackpole Books, Mechanicsburg, Pennsylvania 118 pp.

Zug, G.R. 1993. Herpetology: an introductory biology of amphibians and reptiles. Academic Press, A Division of Harcourt Brace & Company, San Diego, California 527 pp. (A standard text.)

Novels

Phillips, K. 1994. Tracking the vanishing frogs: an ecological mystery. St. Martin's Press, New York 244 pp. (A good background read on amphibian decline.)

Other Regional Atlases

Bider, J.R. and S. Matte. 1996. The atlas of amphibians and reptiles of Quebec. St. Lawrence Valley Natural History Society and Ministere de l'Environnement et de la Faune du Quebec, Direction de la faune et des habitats, Quebec 106 pp.

Taylor, J. 1993. The amphibians and reptiles of New Hampshire with keys to larval, immature and adult forms. Nongame and Endangered Wildlife Program, New Hampshire Fish and Game Department, Concord, New Hampshire 71 pp. (Contains some simple and useful keys).

Appendix E

Photos of the Wood Turtle and Milksnake