January 16, 2007

Beth Goldstein, Refuge Planner
U.S. Fish and Wildlife Service
300 Westgate Center Drive
Hadley, MA 01035-9589

Dear Ms. Goldstein:

Thank you for the opportunity to provide comments as you develop the Comprehensive Conservation Plan for the Silvio O. Conte National Fish and Wildlife Refuge. Defenders of Wildlife is a non-profit, public interest institution with over 500,000 members nationwide. Defenders has long been an advocate for the Refuge System and takes a special interest in the Refuge System planning process. We published the ***Citizen's Wildlife Refuge Planning Handbook*** to encourage the public to become more involved in refuge planning. Defenders also publishes an annual report on the state of the Refuge System, ***Refuges at Risk.*** This year's report featured the impacts global warming is having, and will have in the future, on the Silvio O. Conte National Fish and Wildlife Refuge.

We are generally supportive of the current management direction of the refuge. One of the most profound, looming issues facing the refuge, however, is global warming. Through the planning process, the Fish and Wildlife Service (FWS) has an opportunity to assess what is known about global warming and the species and ecosystems that depend on the refuge, what issues need further study, and how this information can be incorporated into management of the refuge. This assessment is a central and required element of refuge planning.

Through the comprehensive conservation planning (CCP) process, the FWS is required to identify and describe the "significant problems that may adversely affect the populations and habitats of fish, wildlife, and plants within the planning unit and the actions necessary to correct or mitigate such problems." 16 U.S.C. §668dd(e)(2)(E). In administering the refuge system, the FWS is also required to "ensure that the biological integrity, diversity, and environmental health of the System are maintained." 16 U.S.C. §668dd(a)(4)(B). As we will outline below, global climate change is a significant problem that will adversely affect wildlife and habitat and threaten the biological integrity, diversity, and environmental health of the refuge.

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The FWS is under specific guidance to address climate change in its management planning. Interior Secretarial Order 3226, issued January 19, 2001,states that

> Each bureau and office of the Department will consider and analyze potential climate change impacts when undertaking long-range planning exercises, when setting priorities for scientific research and investigations, when developing multi-year management plans, and/or when making major decisions regarding the potential utilization of resources under the Department's purview. Departmental activities covered by this Order include, but are not limited to… management plans and activities developed for public lands...

In addition, in May 2006, Congress passed House Concurrent Resolution 398 "expressing the sense of the Congress that the United States Fish and Wildlife Service should incorporate consideration of global warming and sea-level rise into the comprehensive conservation plans for coastal national wildlife refuges, and for other purposes." The resolution states that:

> (1) the United States Fish and Wildlife Service should incorporate consideration of the effects of global warming and sea-level rise into the comprehensive conservation plan for each coastal national wildlife refuge;
>
> (2) each such comprehensive conservation plan should address, with respect to the refuge concerned, how global warming and sea-level rise will affect--
>
> (A) the ecological integrity of the refuge;
> (B) the distribution, migration patterns, and abundance of fish, wildlife, and plant populations and related habitats of the refuge;
> (C) the archaeological and cultural values of the refuge;
> (D) such areas within the refuge that are suitable for use as administrative sites or visitor facilities; and
> (E) opportunities for compatible wildlife-dependent recreational uses of the refuge; and
>
> (3) the Director of the United Fish and Wildlife Service, in consultation with the United States Geological Survey, should conduct an assessment of the potential impacts of global warming and sea-level rise on coastal national wildlife refuges.

To assist the FWS in the identification of issues to address in the CCP, we have the following comments on how New England habitats, birds, reptiles, amphibians, and fish will be affected by climate change. We also include recommendations for management of the refuge based on these findings.

I. The Refuge's Current and Predicted Climate Conditions

The Silvio O. Conte National Fish and Wildlife Refuge falls within four states, all of which have experienced climate change over the last 100 years. Average Connecticut temperatures increased almost 3 degrees Fahrenheit over that period, and precipitation increased by 20%. (USEPA 1997a). By 2100, Connecticut temperatures are predicted to increase by an additional 4 degrees Fahrenheit (all seasons) and precipitation is predicted to increase by an additional 10-20%, with slightly less change in spring and summer than the winter (USEPA 1997a). Over the last century, average Massachusetts temperatures increased 2 degrees Fahrenheit and precipitation increased up to 20% (USEPA 1997b). By 2100, Massachusetts winter and spring temperatures are likely to increase by an additional 4 degrees Fahrenheit, while summer and fall temperatures are predicted to increase by an additional 5 degrees Fahrenheit (USEPA 1997b). Massachusetts fall precipitation is expected to increase by 15%, winter precipitation is expected to increase by 20-60% and spring and summer precipitation is predicted to increase by 10% (USEPA 1997b). Average New Hampshire temperatures increased 2 degrees Fahrenheit over the last century, and precipitation decreased by up to 20% (USEPA 1997c). By 2100, temperatures could increase an additional 4 degrees Fahrenheit in the spring and 5 degrees in the other seasons (USEPA 1997c). While New Hampshire precipitation is not expected to change in the spring, fall and summer precipitation are predicted to increase approximately 10% while winter precipitation will likely increase 25-60% (USEPA 1997c). Over the last century, average Vermont temperatures increased approximately 0.4 degrees Fahrenheit and precipitation increased up to 5% (USEPA 1998). By 2100, Vermont temperatures could increase by an additional 4 degrees Fahrenheit in the spring and 5 degrees the other seasons (USEPA 1998). While spring precipitation in Vermont will likely change very little, the EPA predicts that summer and fall precipitation could increase by 10% and winter precipitation by 30% (USEPA 1998).

Overall, Northeastern winter snowfalls and periods of extreme cold are expected to decrease over the next 100 years, while heavy precipitation events and warming should continue to increase (Barron 2001). As described below, if climate change persists as expected throughout the refuge, much of the Connecticut River's ecosystem will be negatively affected.

II. The CCP should incorporate information on how New England habitats are affected by climate change

Hydrology

Precipitation and temperature are important to a river's flow since a major component of river basin hydrology involves snowpack and the timing of snow melt (Dudley et al 2005). Increased winter air temperatures and precipitation are already significantly affecting New England's rivers (Hodgkins et al 2003). Increased precipitation leads to increased amounts of snow falling during each storm, leaving larger snowpacks. Warmer spring temperatures increase river flow when rain melts the large snowpacks or falls on previously saturated soil (Hodgkins et al 2003). Earlier New

England springs have occurred the past 30 years, most likely due to temperature increase, and are blamed for earlier and faster snow melt of large quantities of snow (Hodgkins et al 2003). In fact, the period between the first and last days with snow on the ground decreased by 7 days over the past 50 years and has been linked to warming temperatures (Barron 2001).

Trees

The USDA predicts that the sugar maple, evergreen trees, and paper and yellow birches will be unable to survive the impending warmer New England climate and will be replaced by northern red oak and red maple (Abbott et al 2002). The U. S. National Assessment Synthesis Team (NAST) predicts that the mixed deciduous/ coniferous New England forest will be superseded by a temperate deciduous forest similar to the Mid-Atlantic (Abbott et al 2002, Wilensky 2006). Many trees will become sterile as warming temperatures make conditions unsuitable for reproduction and dying trees will become more susceptible to invasive pathogens (Abbott et al 2002). According to the U.S. Environmental Protection Agency (USEPA), some tree species may migrate north by approximately 200 miles to avoid the warmth (USEPA 2006).

Native wildlife species may be directly or indirectly impacted by the change in tree species through changing food, shelter, predator-prey relationships, pests, and disease; some wildlife species will adapt or migrate with the forest habitat, some will not (Arron 2001). Spruce and fir species with southern boundaries limited by summer heat and drought will likely be extirpated from New England (Iverson et al 2001). Spruce and fir trees are associated with a variety of specialized native flora and fauna, including moose and Bicknell's thrush, which could suffer as a result of climate change (Iverson et al 2001, Lambert et al 2004).

Clouds

Warmer air associated with climate change condenses at higher elevations than cooler air and may be a primary cause of ascending mountain cloud covers (Richardson et al 2003). The cloud base over the Appalachian Mountains is on the rise; the cloud-ceiling climbed an average of six meters per year since 1973, a total of approximately 180 meters (Richardson et al 2003). The deciduous and spruce-fir forest boundary is expected to endure the worst effects since the cloud ceiling in the Northern Appalachians likely controls the border between low- elevation deciduous and high- elevation coniferous forests (Richardson et al 2003). As broad- leafed deciduous trees, such as sugar maple and yellow birch, move up the mountains' slope towards the higher clouds, Richardson et al (2003) predict an upward shift in the deciduous-coniferous border.

Higher clouds could inhibit spruce and fir trees from scavenging water directly from the clouds (Ananthaswamy 2003). Montane amphibians that rely on the moisture accumulated when scavenged water drips down to the forest floor could be negatively affected when this water becomes unavailable (Ananthaswamy 2003). Richardson et al (2003) predict amphibian repercussions in the Appalachian Mountains similar to the die-offs in Costa Rica that were associated with increased cloud-base height.

III. The CCP should incorporate information on how birds are affected by climate change

The breeding range of songbirds, including some flycatchers, swallows, and warblers, may migrate north out of Vermont in search of cooler temperatures. This could have large impacts on the local forests since these birds eat gypsy moths and other forest pests (Wilensky 2006).

Bicknell's Thrush

Alpine species that depend heavily on cooler habitats, such as the Bicknell's thrush, may be the first affected by a warmer climate. The Bicknell's thrush is one of the rarest and most threatened birds, with less than 40,000 remaining within its estimated breeding ground (Doran 2006). The birds spend their summers in cool areas including high elevations in New England and winter in four Caribbean Islands, all of which are at risk due to deforestation (Doran 2006).

There is growing concern that the species has been eliminated from historic coastal locations in Canada and low mountains in the United States (Atwood et al 1996, Lambert et al 2004). In response, Atwood et al (1996) collected data in Massachusetts, New Hampshire, New York, and Vermont during 1992-1995 breeding seasons and concluded that restricted breeding distribution and habitat requirements (mainly balsam fir and red spruce) make Bicknell's thrush especially vulnerable to habitat loss and degradation. Balsam firs are moving up mountains towards cooler temperatures. According to the USDA, the current area covered by balsam firs may be reduced by 96% if global surface temperature rises 1.6-6.3% by 2100, as predicted by the EPA (Doran 2006). Lambert et al (2004) predict that a 3 degree Celsius July temperature increase (predicted to occur prior to 2100) could result in an 88%- 98% loss of United States Bicknell's thrush breeding habitat, with extirpations of the bird from Catskill Mountains, southern Adirondacks, the Green Mountains, the mountains of western Maine and up to 144 mountains in New Hampshire. In fact, an increase of just 1 degree Celsius could cause a dramatic reduction in suitable Bicknell's thrush habitat (Lambert et al 2004).

Warming temperatures could cause many species once restricted to lower elevations to encroach on higher elevations known to sustain Bicknell's thrush. In particular, Swainson's thrush, a possible competitor to Bicknell's thrush, is predicted to migrate upslope with impending lower elevation warming (Lambert et al 2005). The exotic balsam woolly adelgid, which has already decimated balsam fir in the Southern Appalachians, is currently controlled by New England's cold winter temperatures, but is likely to move northward as the climate warms (Lambert et al 2005).

Further research is needed in reference to the status and ecology of Bicknell's thrush, the extent of competition by Swanson's thrush, and possible habitat loss caused by balsam woolly adelgid (Atwood et al 1996, Lambert et al 2004). Lambert et al (2004) propose experimental manipulations of high- elevation forests so that management options that could counteract or delay climate change effects can be identified.

Black-Throated Blue Warbler

Black- throated blue warblers are migratory birds that breed within Northeast forest interiors, including the Connecticut River watershed. Rodenhouse (1992) studied a population of breeding black-throated blue warblers in nearby Hubbard Brook Experimental Forest within the White Mountains National Forest between 1982 and 1985. Direct negative effects to the warbler population may occur if rainfall increases greater than 10% of the 1992 mean as predicted (Rodenhouse 1992).

Sillett et al (2000) quantified warbler demographics again in the Hubbard Brook Experimental Forest, New Hampshire between 1986 and 1998 and suggest that black-throated blue warbler survival and fecundity correlate with climate patterns. Adult survival and fecundity was higher in La Niña years and lower in El Niño years (Sillett et al 2000). Sillett et al (2000) hypothesize that fecundity is limited by the availability of food, which decreased in New Hampshire during El Niño Southern Oscillation (ENSO). In addition, fledglings weighed less during El Niño than El Niña years (Sillett et al 2000).

El Niño affected both overwintering and breeding areas since El Niño was associated with low annual recruitment of juveniles and yearlings in both Jamaica and New Hampshire (Sillett et al 2000).

El Niños and La Niñas create variability in weather throughout the United States and are expected to increase in severity with climate change. Past ENSO events can provide insight into how future climate change could affect local ecosystems. Sillett et al (2000) predict that future climate change could elevate black- throated blue warbler population extinction rates, especially in small populations.

Impacts of climate change can not be predicted without fully understanding the major factors affecting breeding and survival. Rodenhouse (1992) recommend that biologists monitor the relationships between black-throated blue warbler breeding and climate with studies lasting 15-30 years.

Gray Jay

Gray jays are opportunistic feeders that breed and winter within the Connecticut River watershed, mainly in Silvio O. Conte NFWR’s Victory Basin. Climate change is contributing to decreased gray jay reproductive success, especially in their southern range which includes New England (Waite et al 2006). To compensate for both breeding during the cold northern winter and young hatching prior to spring thaws, adults collect and cache enough food in the summer to sustain them and their young throughout the year. They rely on freezing winter temperatures to keep the food fresh until spring (American Bird Conservancy 2006). “Hoard rot”, or food spoiling prematurely, is likely due to warmer conditions. As a result, adults do not have enough food for their young and breeding success is reduced (Waite et al 2006). Waite et al (2006) also point out that a warm, prolonged autumn prior to their winter breeding season can delay the commencement of breeding and negatively impact reproductive success.

IV. The CCP should incorporate information on how reptiles and amphibians are affected by climate change

Turtles

Painted turtles, a species with temperature-dependent sex determination (TSD), can be found throughout most of North America, including the Silvio O. Conte NFWR. Janzen (1994) studied a painted turtle population in Illinois (latitude similar to Connecticut) and found that offspring sex ratio is directly correlated with July air temperature. The study validates concerns that climate change will affect painted turtles since a four degree Celsius increase in mean temperature could eliminate the production of male offspring (Janzen 1994). Genetic and behavioral data suggest that painted turtles will be unable to evolve quickly enough to keep up with rapid global warming (Janzen 1994). Similar effects are likely in other turtle species, since most species lack sex chromosomes and possess TSD (Mitchell et al 2003).

Turtles are long- lived and take a long time to reach sexual maturity. Because of this life history, climate change, along with other habitat stressors, could drastically affect turtles before the negative results are noticeable. Actions to lessen the impacts of global warming should be taken as soon as possible. Painted turtles are more abundant than the threatened species with TSD residing in the Sivio O. Conte NFWR and could be used as indicator species. Biologists should perform field studies checking painted turtle population size and gender ratios to determine if and when ecological problems are occurring so they can be renovated before it is too late.

Mink Frog

The mink frog, whose southern limit is at the highest latitude of any North American anuran, is a water-dwelling species with overland movement usually restricted to periods during nocturnal precipitation (Hedeen 1986). Mink frogs live in the Silvio O. Conte NFWR, including the Nulhegan Basin Division in Vermont (Lambert 2001). Females deposit eggs in cold water, sometimes immediately following ice break up. Embryo survival rates are lower when the eggs are laid in warmer water with inadequate oxygen diffusion since embryos in the center of the egg mass do not receive adequate oxygen and die (Hedeen 1986). Mink frogs may be more susceptible to warming temperatures, due to decreased embryo survival, than other amphibian species in the region and are expected to show local declines if warming continues (Gibbs et al 2001).

Red-Backed Salamander

Although many other factors are contributing to their decline, most amphibians should adapt to Northeast climate change (Gibbs et al 2001). Some species change their breeding patterns accordingly, while others morph (Gibbs et al 2001, Gibbs et al 2006). The red- backed salamander has two primary morphotypes, striped and unstriped. The unstriped morph is more closely associated with warmer, drier climates. Unstriped experience higher mortality in cooler sites, retreat from the ground surface earlier in the fall, and have lower standard metabolic rates than the striped morph, allowing them to be more active in warmer weather (Gibbs et al 2006). Combinations of forest disturbance and regional warming have likely caused a shift in the species' range morph frequencies over the last century.

Red- backed salamanders can serve as an indicator species and help detect changes in ambient temperature that affect amphibians (Gibbs et al 2006). Biologists could determine which salamander morph is more prominent in different areas of the refuge. The data could then be used to determine where mink frogs and other temperature- sensitive species living in the corresponding ranges could benefit from management.

V. The CCP should incorporate information on how fish are affected by climate change

It is likely that recent fish depletions, initially caused by overfishing, could be amplified and prolonged by climate change (Rose 2005). A warming climate could reduce cold water fish habitat necessary for shortnose sturgeon, Atlantic salmon, brook trout and rainbow trout survival (Dudley et al 2005, Jenkins et al 1993, Wilensky 2006). Not all areas are expected to cool or warm equally and not all species may be impacted equally. Some species will die-off while others might move upstream to water that is 6-8 degrees Fahrenheit cooler (Abbott et al 2002).

Shortnose sturgeon

Shortnose sturgeon, an estuarine dweller that swims upstream to spawn in cold, fresh waters, once plentiful in eastern coastal rivers, is now found in just 16 of them. The Connecticut River population of this slow-to reproduce bottom- feeder is currently stable; a changing seasonal stream flow pattern linked to early melting of the mountain snowpack that feeds the river could change that. Earlier snow melt means that by late summer, the snow has finished melting and stream flows are significantly reduced. Reduced flow leads to low dissolved oxygen (D.O.) levels, a condition to which juvenile sturgeon new to life in the river are especially susceptible, since young shortnose sturgeon are more sensitive than adults to low D.O. levels (Jenkins et al 1993).

Shortnose sturgeon are also affected by flooding induced by climate change. Eutrophication, often caused by runoff, occurs when water bodies receive excess nutrients that stimulate excessive plant growth and can negatively affect shortnose sturgeon habitat (Campbell et al 2004). Efforts to reduce the input of nutrients to the Connecticut River will be especially important with climate change.

Atlantic Salmon

One of Silvio O. Conte NFWR's main goals has been to restore Atlantic salmon to the Connecticut River (MFH 2005). Atlantic salmon, once common in the Northeast, were extirpated from the Connecticut River at least 150 years ago (Hendry et al 2003). Recent restorations of Atlantic salmon to the Connecticut and Merrimack Rivers, the salmons' natural southern limits, have been unsuccessful with low return rates (Letcher et al 2003, USFWS 1999).

Atlantic salmon require cool, well- oxygenated water that is typically found in streams with moderate to steep gradients (Jacobsen et al 2000). Earlier spring snowmelts resulting in higher winter and spring stream flows, lower summer and fall stream flows, and lower D.O. could cause Atlantic salmon to no longer find the Connecticut River hospitable. Warmer Maine winters increased difficulties for Atlantic salmon populations and, in fact, many Atlantic salmon may have already migrated northward out of Maine due to rising temperatures (Committee on Atlantic Salmon in Maine 2004, Jacobsen et al 2000). Although challenging, rehabilitating salmon in Maine may be feasible since Maine once supported much larger populations (Committee on Atlantic Salmon in Maine 2004).

The continued existence of Atlantic salmon is increasingly threatened (Klemetsen et al 2003) and requires human attention. It is questionable whether salmon restoration to the Connecticut River is the best management option since scientists already suspect that warming is too great to successfully restore Atlantic salmon to parts of Maine. More research is required to determine how Atlantic salmon will respond to future climate change and whether acquiring and protecting suitable northern habitat could be more beneficial than restoration in its historic southern range.

VI. The CCP should incorporate information on how endangered and threatened species could be affected in the future

Silvio O. Conte NFWR provides unique habitat for federally endangered and threatened species, including the piping plover, American bald eagle, shortnose sturgeon, Puritan tiger beetle, dwarf wedge mussel, small whorled pogonia, Jesup's milkvetch, Robbins' cinquefoil, and Northern bulrush. All of the species are considered rare, with 20 or less known occurrences in the Connecticut River Watershed, and may require extensive management for continued survival.

The majority of the endangered and threatened species exist exclusively or almost exclusively within the Connecticut River Watershed. Puritan tiger beetles can only be found in two sites, one of which is a sandy riverine beach along the Connecticut River (CTDEP 2000, USFWS n.d.). The dwarf wedge mussel only exists in 17 river or stream sites within Atlantic states, three of which are in the Connecticut River Watershed. (NYDEC n.d., USFWS n.d.). The small whorled pogonia exists in three main population centers and inhabits upland mixed deciduous or mixed deciduous/coniferous forests in two known sites within the Connecticut River watershed, one in Connecticut and one in Massachusetts (USEPA 1994, USFWS n.d.). Jesup's milkvetch plants can only be found in calcareous bedrock outcrops in three sites along the Connecticut River watershed (USFWS n.d.). Robbin's cinquefoil plants only exist in two populations within the alpine zone of New Hampshire's White Mountains (USFWS n.d.). Northeastern bulrush can be found in approximately 40 populations in seven eastern states, twelve of which are within the Connecticut River Watershed (USFWS n.d.).

Habitat for these threatened and endangered species needs to be maintained and restored. In addition, more research needs to be conducted on the specific environmental requirements of these species and how they will react to climate changes (Campbell et al 2004, Noss 2001). Few model studies have been performed with populations that are unique to the Connecticut River Watershed. The most vulnerable life- stages of these populations should be clarified so future management plans can focus on the stages in need of human intervention (Hoffman 2003).

Climate change will increase the threats that ecosystems are currently facing due to non-climate stressors (Noss 2001). Several of the threatened and endangered species, once plentiful in the watershed, declined due to non-climate stressors:

- The Puritan tiger beetle likely declined along the Connecticut River due to inundation and disturbance of its shoreline habitat from dam construction, riverbank stabilization and human recreational activities (CTDEP 2000). More research is necessary to determine the most efficient ways to alleviate river flow problems. Decreasing land available for recreational use along with increased enforcement could also help alleviate the non-climate stressors.

- River dams and channels throughout the dwarf wedge mussel's range resulted in the elimination of formerly occupied habitat (USFWS n.d). Dwarf wedge mussels are sensitive to pesticides, chlorine, potassium, zinc, copper, cadmium, and possibly low levels of calcium (NYDEC n.d., USFWS n.d.). Water pollution, including sediments and chemicals from adjacent construction, agricultural, and forestry activities degrade mussel habitat and have substantial impacts on mussel populations (NYDEC n.d., USFWS n.d.). Before mussel populations can be sustained and/or increased, further research projects involving their habitat requirements as well as appropriate ways to alleviate river flow problems are necessary (NYDEC n.d.). Non-climate stressors, including nutrient run-off, should be decreased (Hannah et al 2005).

- Jesup's milkvetch, small whorled pogonia and Robbins' cinquefoil were previously decimated, partly due to collecting and/or trampling by hikers and boaters (USEPA 1994, USFWS n.d). Rules limiting human access to refuge areas that harbor these plants as well as increased enforcement could prevent future plant taking and trampling.

After researching various species' habitat needs and possible reactions to climate change, some species with limited dispersal activities may need to be transported to suitable habitat and/or additional populations may need to be established (Galley et al 2004, Hulme 2005). Populations should be spaced widely apart so that if a devastating weather event occurs, population loss may be less than if the entire refuge's population was struck simultaneously (Galley et al 2004). If establishing a new population for a particular species is the best management option, the highest altitude or most northern part of its range should be used to help combat the predicted warming New England climate (Galley et al 2004). Species translocation should be used only in extreme situations since unpredictable consequences could occur (Hulme 2005).

VII. Recommendations

Defenders urges the FWS to include the above information in the description of the refuge's resources and resource challenges within the CCP and in the "affected environment" section of the accompanying environmental impact statement. In addition, we have the following recommendations to be included in the CCP.

<u>The refuge should conduct research and monitoring and encourage partners (universities, other government agencies) to conduct research on the ongoing and emerging ecosystem changes wrought by global warming</u>.

Though there is overwhelming scientific consensus that the earth is warming and that the primary cause of this warming is human-caused increases in greenhouse gas emissions, much less is understood about the complex effects global warming will have on ecosystems and wildlife. We believe the National Wildlife Refuge System, and Silvio O. Conte NFWR in particular, should develop a comprehensive research and monitoring program to function as an early warning system for climate-induced changes. As the steward of the Connecticut River Watershed, the FWS has a unique role and opportunity to integrate research and monitoring throughout the local ecosystem, with a particular focus on birds, fish, reptiles, amphibians, and endangered and threatened species.

Indicator species should be identified and studied since they can give early warning signs that an ecosystem is being affected, either negatively or positively (Hoffman 2003). Indicator species existing in Silvio O. Conte NFWR include painted turtles and red-backed salamanders. River flows can sometimes be used as climatic indicators to help determine if the local area is experiencing the effects of climate change (Hodgkins et al 2003).

Long-term field studies and modeling are required to determine the impacts of global climate change (Wolters et al 2005). Change detected at individual divisions within Silvio O. Conte NFWR may not be enough to inform management decisions. A comprehensive program throughout New England will be able to discern population level changes in abundance or distribution. Regional coordination and data accumulation is necessary; the FWS should work closely with other agencies and stakeholders within New England, particularly the National Park Service, the Forest Service, universities, biogeographers, ecologists, local land-owners, and climate change scientists (Hannah 2003, Scott et al 2002). This will help fulfill the FWS requirement "to monitor the status and trends of fish, wildlife, and plants in each refuge". 16 U.S.C. §668dd.

<u>The refuge should include information about the effects of global warming on the refuge ecosystem in its environmental education and interpretation programs</u>.

Environmental education and interpretation are priority public uses of the refuge system and when compatible, support the refuge system's mission by building public understanding and support for wildlife conservation. According to the FWS General

Guidelines for Wildlife Dependent Recdreation (605 FW 1, *Service Manual*), recreational uses should provide "an opportunity to make visitors aware of resource issues, management plans, and how the refuge contributes to the Refuge System and Service mission." Silvio O. Conte NFWR already raises the public's awareness about important New England habitat issues through environmental education and interpretation programs. As described above, global warming poses a significant threat to the biological integrity and mission of the refuge. It is incumbent upon the FWS to ensure the public is informed about the climate-driven changes occurring to the wildlife they have come to enjoy and learn about at Silvio O. Conte NFWR. The FWS should develop brochures, interpretive panels, websites, and education programs that include the vulnerabilities of the Connecticut River Watershed's resources to climate change.

<u>The refuge should develop management actions to cope with climate-driven change</u>.

Through the planning process, the FWS is required to identify and describe: (1) significant problems that may adversely affect the ecological integrity or wilderness characteristics of the refuge and the actions necessary to correct or mitigate the problems; and (2) significant problems that may adversely affect the populations and habitats of fish, wildlife, and plants (including candidate, threatened, and endangered species) and the actions necessary to correct or mitigate the problems. (602 FW 3, *Service Manual*). Management actions and adaptive strategies should be flexible so adjustments can be made in response to unforeseen effects of climate change or rapid ecosystem alteration (Hulme 2005). Specifically, we recommend:

- The refuge should reexamine the feasibility and efficacy of the reintroduction of Atlantic salmon to the Connecticut River. It is questionable whether salmon restoration to the Connecticut River is the best management option since the Connecticut River is the southern boundary of the species' historic range. More research is required to determine how Atlantic salmon will respond to future climate change and whether acquiring and preserving suitable northern habitat could be more beneficial than restoration to its historic southern range.

- Upland and northern land should be preserved since suitable climate is likely to be sustained closer to the poles and in areas of high elevation (Galley et al 2004, Hoffman 2003). The creation of buffer zones could increase natural connectivity and accommodate migrating species (Hulme 2005, Noss 2001).

- The refuge should address non- climate stressors that could become particularly pronounced with climate change (Noss 2001). For example:
    - Dwarf wedge mussels, shortnose sturgeon and other aquatic life are negatively affected by excess nutrient run-off and eutrophication. As floods and nutrient run-off increase as expected with impending climate change, efforts to reduce watershed pollution will be increasingly important (Campbell et al 2004).
    - Shade trees should be planted along tributaries since they may mitigate problems associated with warmer water temperature.

- Management plans should focus on the needs of particular species as well as protect physical features, including flow patterns, water quality, and water quantity. In fact, managing the entire watershed, with the help of other agencies and stakeholders, would be ideal (Combes 2003).
- Warming temperatures could cause exotic species, such as the balsam woolly adelgid, once controlled by New England's cold winter temperatures, to encroach northward and to higher elevations. Increased measures will be necessary to prevent and control invasive pests (Combes 2003).

We hope this letter helps the FWS to identify and assess the significant problems facing the refuge as a result of global warming. These problems are extremely complex, and involve interactions throughout the refuge ecosystem and food chain. Understanding climate-driven changes in real-time will be essential to allow the FWS to adapt management strategies to conserve the wildlife resources the refuge was established to protect. The FWS should incorporate adaptive management strategies based on research and monitoring into the CCP that will help alleviate the effects of global warming.

We hope our comments have been helpful in the development of the Silvio O. Conte NFWR CCP and we look forward to participating in the planning process.

Sincerely,

Noah Matson

Noah Matson
Director, Federal Lands Program

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