FINAL REPORT

Recovery of pond-breeding amphibians at Warbler Woods Nature Preserve following fish removal

30 June 2004

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Grant #04-010W

Funded period: 1 July 2003 – 30 June 2004

INTRODUCTION

This report details on-going work at Warbler Woods Nature Preserve (WWNP), Coles County, Illinois, an 81.5 ha piece of land owned by L. Barrie Hunt. The overall project concerns the monitoring of amphibian populations that utilize four breeding ponds in the southeast portion of the property. Predatory fish previously inhabited two of these ponds. The fish populations were removed by January 2003, prior to the amphibian breeding seasons in 2003 and 2004. This report will illustrate the recovery of amphibians using the breeding ponds at WWNP and the increased recruitment observed for this community.

Study Site

Four ponds in the southeast section of WWNP (Figure 1) are labeled from East to West: A, B, C, and D. Ponds A and B are separated by a 5 m ridge of secondary deciduous forest and understory vegetation. Ponds B and C are separated by 80 m of old field that has been planted with seedlings of deciduous hardwoods in accordance with an existing IDNR restoration objective. Ponds C and D are separated by 280 m of primarily old field that also has been planted with seedlings of deciduous hardwoods. A small access road leading to a barn and an extension of deciduous forest ravine bisecting the old field also separate the latter two ponds.

Prior to the fish removal, Pond B contained a stable population of small *Ameiurus melas* (black bullhead catfish); Pond C contained a stable population of centrarchids (*Lepomis macrochirus* [bluegill], and *Lepomis cyanellus* [green sunfish]). All ponds have stable populations of a variety of invertebrate species (*e.g.*, snails, aquatic insects/larvae, *etc.*). All ponds permanently hold water except for Pond D that has gone dry in 3 of the past 5 years. Until mid-July 2001, the ravine upstream from Pond D had a laundry effluent line from the adjacent property draining into it. Although the effluent was re-directed away from the WWNP at that time, it may have suppressed amphibian populations in the same manner that fish limited amphibian reproductive success in ponds B and C.

Background & Objectives

In May 2000, drift fences and pitfall trap arrays were constructed around ponds A, B, C, and D (with coverage of 100 %, 75 %, 60 %, and 80 % of their circumferences, respectively) as a means of monitoring amphibian use at the ponds. Due to fluctuating water levels that damaged the fencing or other landscape features, the coverage was modified in 2001 to 87 %, 89 %, 44 % and 91 %, for ponds A, B, C, and D respectively. Buckets were inserted flush with the soil surface every 7.5 m on both sides of the fence. Initial data from this trapping effort was reported to IDNR at the end of FY2000-2001; in that report, I recommended application of Rotenone™ to ponds B and C in early December 2001. The basis for the recommendation was that: (1) all of the fish should be killed; (2) the smallest number of amphibians will be affected (most having begun to over-winter outside of the ponds by that time); and, (3) that all of the rotenone will be flushed out of the system prior to amphibian breeding activity at the ponds during Spring 2002.

Following that initial report and an IDNR management directive for WWNP, all fish were removed from ponds B (in January 2003) and C (in December 2001) by applying Rotenone™ with a combination of portable broadcast sprayers. Additionally, Rotenone™ was poured into small pools in the inflow channels at the south end of each pond to prevent juvenile fish escaping the effects of the poison by swimming "up-stream." Subsequent rains in the ensuing weeks flushed the poison from these ponds. A combination of visual surveys and baited minnow traps has not produced any observations of fish in either pond B or C since the Rotenone™ application.

The present report provides additional data to extend the understanding of the amphibian populations using the ponds at WWNP as breeding sites. I also report on the response of the amphibian community at ponds B and C to the fish removal. Lastly, I provide further recommendations to IDNR for the continued management of amphibians at WWNP.

MATERIALS & METHODS

This project is being conducted with assistance from Leroy Walston, a graduate student in my laboratory. He has been primarily responsible for conducting the monitoring effort at WWNP since the end of April 2003. The funds from the current grant period were used to provide a one-month salary to Mr. Walston during Summer 2004, and to purchase supplies necessary to maintain the integrity of the drift fences/pitfall trap arrays surrounding the four ponds at WWNP.

In December 2003, the fence array along the west side of pond C was extended by 30 m so that the coverage of that pond by the drift fence-pitfall traps has been increased to 67 %. These additional traps, plus all others around all ponds were checked on an alternate day basis from 13 March to 28 November 2003 and 2 March 2004 to the present (data included up through 10 June 2004). Individuals collected in the traps were measured (snout-vent length [SVL], total length [TL]), and toe-clipped to indicate their capture during a particular year (cohort-specific; Dodd and Cade 1998) and at a particular pond. During those periods when the traps were not monitored, all traps were sealed to prevent capture of any non-target organisms.

RESULTS

Table 1 lists the species of amphibians and reptiles that have been observed at WWNP since the beginning of the study (taxonomy follows Phillips et al. 1999). Three species have been added to the list since the most recent Final Report to IDNR (FY2001-02) – the blue racer (*Coluber constrictor foxii*), the eastern hognose snake (*Heterodon platirhinos*), and the northern redbelly snake (*Storeria o. occipitomaculata*) – bringing the total species count to 27 amphibians and reptiles for this site.

The relative abundance of two pond-breeding amphibian species has been up-graded since the last report on WWNP. *Pseudacris crucifer* should now be considered as "common" on this site – increased trapping success of individuals and regular breeding choruses in the early Spring indicate that this species is breeding regularly at WWNP ponds. Nearly 500 individuals were recorded since May 2000, which is unusual in that treefrogs can easily climb out of the pitfall traps. *Rana utricularia* should now be considered as "moderate" on this site – increased trapping success of subadults of this species indicates that the adult population, though small, is breeding in these ponds on an annual basis. Over 500 individuals (mostly subadults) have been trapped since the beginning of the study.

Table 2 lists mean body sizes for those species for which there are adequate data based on collection in pitfall traps, as well as the occurrence of recaptures. The general pattern across all ponds at WWNP is that populations of pond-breeding amphibians have grown since fish were removed (Figure 2). The pattern is least apparent at Pond D, but this pond having dried up in 2002 and 2003 can explain this exception. The additional figures (3-16) illustrate temporal patterns of use of the various species collected in the fence/trap arrays. Not all of the amphibian species found at WWNP are represented in these figures because some species are not conducive to the trapping regime used in this study (*e.g., Acris crepitans blanchardi*) or were caught in very low numbers (*e.g., Rana blairi*). Other species were never observed using the ponds but were seen in close proximity to them (*e.g., Eurycea cirrigera*). The following are comments on each of the species' usage patterns of the ponds since the beginning of the study.

Ambystoma texanum – I have previously reported that the adults of this species are most active at WWNP in March and April, with a metamorph emergence from ponds occurring in June. This species favored ponds A and D in 2000 and 2001 but has shown successful use of ponds B and C in the years following the fish removal (Figure 3). Of the 2205 adult and metamorph individuals observed at the site since May 2000, 167 (7.6 %) have been recaptured, usually at the same pond where they were first trapped. The increase in numbers of individuals recorded at ponds B and C in 2002 and thereafter might indicate that this species' ability to reproduce successfully was suppressed by the presence of predatory fish. Over the course of the study period, and especially since the fish were removed, this species has exhibited a positive population growth trajectory (Figure 4). The recruitment value for this species during 2003 (the only year during the funding period for which there is complete data) was 11.4 metamorphs emerging from the ponds per adult female trapped at the ponds.

Bufo a. americanus – I have previously reported that adult breeding activity of this species at WWNP ponds peaks in April and May, with most of the recent metamorphs leaving the ponds for terrestrial habitat in June. Most of the individuals of this species were observed at ponds A and B (Figure 5). Of the 3692 adult and metamorph individuals observed at the site since May 2000, 49 (1.3 %) have been recaptured, usually at the same pond where they were first trapped. The low recapture rate may reflect low survivorship experienced by the metamorph cohort for each year. The population trend for this species at WWNP is negative (Figure 6); only 10 % of the variance in the trend can be explained by the variable of time, however, indicating that other factors may be causing variation in the population size of *B. americanus*. The recruitment value for this species during 2003 (the only year during the funding period for which there is complete data) was 3.1 metamorphs emerging from the ponds per adult female trapped at the ponds.

Hyla chrysoscelis x *versicolor* – The population status of this species at WWNP ponds is difficult to assess because treefrogs can easily avoid being trapped in a drift fence-pitfall array. No individuals were trapped at any of the ponds in 2002 and 2004 (Figure 7). Of the 217 individuals captured since the pitfalls were installed, only 1 (0.5 %) has been recaptured. The trajectory for this population is positive, however, and numbers of trapped individuals were particularly high in 2003 (Figure 8). It should also be noted that the coefficient of determination associated with this trend line is low ($r^2 = 0.09$), indicating that factors other than time may be causing variation in the population size of gray treefrogs. All individuals caught during that year were recent metamorphs; as such, a recruitment value for this species cannot be calculated.

Pseudacris crucifer – The population trend for this species at WWNP is difficult to assess because, as a group, treefrogs can easily escape from pitfall traps and climb over drift fences. Nevertheless, breeding choruses have been heard regularly, and the species seems to be increasing in numbers, especially at Pond B (Figure 9). Of the 405 individuals caught since May 2000, 3 (0.7 %) have been recaptured. The population trend for this species at WWNP is positive (Figure 10); only 20 % of the variance in the trend can be explained by the variable of time, however, indicating that other factors may be causing variation in the population size of *P. crucifer*. Recruitment for this species in 2003 was 53 metamorphs emerging from WWNP ponds per adult female entering the ponds to breed. This value is likely an over-estimate because the pitfall traps are not ideal for catching adult treefrogs.

Rana catesbeiana – This species is a generalist with individuals being active between March and November. The peak metamorph emergence period from WWNP ponds occurs from late-August to September. Furthermore, bullfrogs do not appear to favor any particular pond (Figure 11) – their low numbers at Pond D can be explained by the fact that the large adults are not easily trapped in the pitfalls, and that this pond has gone dry in 2 of the past three years. Because *R. catesbeiana* larvae require a full year of development before metamorphosis to a subadult, all larvae die when the pond dries. The relatively low numbers reported for 2004 reflect the fact that most metamorphs of this species have yet to emerge from the ponds this year (and thus, have not been trapped). For this same reason (prolonged larval period with overlapping generations), recruitment for this species cannot be calculated. Of the 469 adult and metamorph individuals collected, 22 (4.7 %) have been recaptured, usually at the same pond where they were first trapped. The *R. catesbeiana* population appears to be stable (Figure 12) and virtually none of the variation in population densities between years can be ascribed to the passage of time. Perhaps because of its large size, this species does not appear to have been negatively effected by the presence of fish in ponds B and C. Futhermore, this species has been previously reported to coexist with fish in permanent water bodies (Sexton and Phillips 1986).

Rana sylvatica – I have previously reported that adults of this species exhibit a peak of breeding activity at the ponds during March, with a metamorph emergence from ponds occurring in June. Prior to 2004, most of that activity was observed at pond D, but the numbers of individuals using ponds A and C increased this year (Figure 13). A lower level of activity at Pond D in 2003 may reflect that pond having gone dry early in the Summer of that year. Of the 513 adult and metamorph individuals captured since May 2000, 6 (1.2 %) have been recaptured. There may be some trap by-pass in this species because of its relatively large size. The population trend for *R. sylvatica* is positive, with 51 % of the variation in the number of individuals trapped being attributable to changes in year (Figure 14). Excepting the low numbers of individuals caught in 2003 (when Pond D dried up), the population appears to be steadily increasing at all ponds following the removal of fish. There were no metamorphs collected during their emergence from any of the ponds in 2003, so a recruitment value for this species during that period cannot be calculated.

Rana utricularia – This species was relatively rare at WWNP during the first two years of the trapping effort. The peak in breeding activity at WWNP occurs from April to mid-May, with subadult emergence from the ponds occurring during late June and July. The number of individuals trapped for this species has increased, but only in ponds A, B, and D (Figure 15). No individuals have been recorded at Pond C since the beginning of the study – even though the species is known to tolerate old field habitats (Phillips *et al.* 1999), it has not dispersed to that pond from the nearest source population (Pond B). Of the 623 individuals that have been trapped since May 2000, only 7 (1.1 %) have been recaptured, suggesting either high subadult mortality, or a larger population (especially of adults) than can be determined using the present pitfall trap system. No adults were caught during 2003, so recruitment during that time period cannot be calculated. The population trends for this species appears to be increasing (Figure 16), a phenomenon that should be supported once this year's metamorphs start emerging at the end of June. The removal of fish from Pond B appears to have contributed to a larger number of individuals trapped at that pond.

Intra- & Inter-annual Patterns

Assessments of relative abundance for each of the species (Table 1) are based on numbers seen &/or heard throughout the study, and in comparisons with densities observed at WWNP in years previous to the funding period and sites other than WWNP. It should be reiterated, however, that these assessments are subjective, and that not all species of amphibians are conducive to the trapping regime outlined in this study. In a previous report, I described most of the amphibian breeding activity as being concentrated around ponds A and B. This pattern appears to have been upheld in 2003-2004†– there are at least three possible reasons to explain the lower numbers of amphibians caught at ponds C and D (two or more may be synergistic in their effects): 1. Pond D dried up in 2003, thereby depriving amphibians of habitat necessary for reproduction; 2. Pond C is relatively isolated from the other ponds, so subadult individuals are less likely to disperse there; and; 3. Pond C has the least amount of forested area surrounding the pond, a habitat upon which the amphibians might depend as adults for shelter, migratory cues, or prey (Rothermel and Semlitsch 2002).

The breeding phenology for the amphibian species encountered at WWNP ponds appears to follow patterns that are typical for these species at this latitude. The difference in the timing of peak reproductive activity likely reduces competition for resources amongst the larvae of the various species (Faragher and Jaeger 1998). As the community is presently structured, larvae representing the greatest number of species are present from late April until late June. Only larvae of *A. texanum, P. crucifer* and *R. sylvatica* are present in large numbers during the early weeks of the breeding season (March to early April).

Of the species using the WWNP ponds for breeding activity, the population *Bufo americanus* appears to be of greatest concern. I am not alarmed by the trend exhibited by this species (Figure 6), however, because the larvae in 2004 have not completed their metamorphosis and left the ponds where they could be trapped. I expect that the numbers for all species that breed later in the activity season will increase dramatically as the year progresses. Of those species exhibiting positive population growth trends, the rates of growth appear to be most positive following the removal of fish from ponds B and C in 2002 (*e.g.*, Figures 4, 8, 10, 14, and 16). As the populations continue to respond to the absence of fish in ponds B and C, it will be interesting to determine each of the ponds' carrying capacity for the amphibian community as well as the competitive interactions occurring between species inhabiting the same pond.

STATUS & RECOMMENDATIONS

Of the species that I listed as "rare" or "very rare" (Table 1), I do not believe that IDNR should be concerned about the population status of any of them because these species all have large populations elsewhere in their geographic distribution &/or do not rely on the ponds as breeding habitat (*e.g., Eurycea cirrigera*). Furthermore, with the exception of *Bufo woodhousei fowleri*, these particular species happen to be at or near a boundary of their geographic distribution. In such instances, populations are often smaller in size &/or more transient in nature (Gilpin 1987, Goodman 1987, Sjˆgren 1991). I suggest continued monitoring of amphibians at all four of the ponds at WWNP to following the population responses to fish removal from ponds B and C (and comparison of the communities at those ponds to those never having fish present). Long-term monitoring not only assures that management objectives for WWNP are being met, but will also provide a valuable data set that contributes to the understanding of changes in amphibian populations (Semlitsch *et al.*, 1996).

Phillips et al. (1999) caution that isolated populations of *Rana sylvatica* may be more susceptible to extinction than similar populations of other frog species. Based on the increasing numbers of *R. sylvatica* recorded at WWNP (especially at Pond A in 2004), I think that the population at this site will be sustaining. Similarly, the population of *Ambystoma texanum* appears to be stable – especially as evidenced by the increasing numbers of individuals observed at ponds B and C following removal of the fish. Less can be said about the slight increases seen in the two treefrog populations (*Hyla chrysoscelis* x *versicolor* and *Pseudacris crucifer*) because these species are not easily trapped using the described experimental design. The three species that appear to be the least stable (judging from the currently-available data) – *Bufo americanus, Rana catesbeiana*, and *R. utricularia* – will likely show strong recruitment again in 2004. Their low numbers thus far in 2004 are attributable to being species that breed/mature later in the year. Species that breed earlier in the activity season (*A. texanum, P. crucifer*, and *R. sylvatica*) use some of the same resources from the aquatic habitat that larvae of other amphibians will require later in the season. Thus, it is also possible that competition for limited resources favors those species breeding early in the year (Wilbur 1972), and might contribute to the noticeable decline of *Bufo americanus* at the WWNP ponds.

There are two additional reasons not to be concerned about the variable population sizes of some species utilizing WWNP ponds (as is suggested by Figures 8, 10, 12, and 16). First, more amphibians have been recaptured during the period funded by this award than in any previous year of study at WWNP. Most dramatically, smallmouth salamanders are being recaptured as they exit the breeding ponds (Table 2). This indicates that their survivorship during the critical breeding period is higher than in previous years (*e.g.*, see previous IDNR reports for 2002 data), perhaps due to the removal of fish from the site. Second, although estimates of recruitment could not be calculated for all species (due to features of their natural history), *R. sylvatica, B. americanus*, and *P. crucifer* all exhibited positive recruitment during the study period. The adults are more than replacing themselves with new individuals during the breeding season, which allows for some mortality between the juvenile and adult stages. In particular, even though the *B. americanus* population trajectory is negative (Figure 6), the estimated recruitment for this species is 3.1 metamorphs produced per female entering the ponds. I predict that continued assessment of this population (showing recruitment in the 2004 activity season) will reveal its sustained use of the WWNP ponds.

I continue to believe that the steps taken between 2001 and 2003 (re-directing the laundry effluent, and removing fish from ponds B and C) have contributed to the increased population sizes for species utilizing the breeding ponds at WWNP. I suggest that any continued monitoring efforts direct particular attention those species found in low numbers at ponds previously occupied by fish (*e.g.*, *Rana utricularia* never having been observed at Pond C). The possible dispersal or increased population sizes at these ponds would confirm the idea that predatory fish were inhibiting the success of these species at ponds B and C. Furthermore, as the populations of these species increase at these two ponds, associated changes in the structure of their respective amphibian communities should be observed.

Additional Management Efforts

If all management objectives for WWNP are to be met (including the restoration of the biotic community to pre-settlement levels of diversity), I recommend that IDNR consider the translocation of one or more pond-breeding salamander species to one of the WWNP ponds. Both *Ambystoma maculatum* (spotted salamander) and *A. tigrinum* (tiger salamander) were historically present in the Charleston and Hutton townships of Coles County. The geographic ranges of these species include east-central Illinois, but neither species has been recorded in Coles County since 1971. These species are suggested for repatriation because they are early-season breeders and, as such, the larvae resulting from their reproductive effort would not be competing with those of only a few other species that use the WWNP ponds (see above).

Any translocation effort should involve only one species during a given time interval (as opposed to more than one simultaneously), and occur at only one pond at WWNP. A source population should be identified as close to WWNP as possible, and egg masses or larvae should be repatriated to one of the ponds (as opposed to subadult or adult individuals) because individuals are known to return to their natal ponds based on having imprinted on the topography and water chemistry where they develop as larvae (Weyrauch and Amon 2002). Translocation efforts involving either salamanders (Weyrauch and Amon 2002) or frogs (Cooke and Oldham 1995) have succeeded in similar habitats. Although the translocated species of salamander may compete for resources in the WWNP pond, previous studies have shown that the presence of *A. maculatum* or *A. tigrinum* can have a stabilizing effect on amphibian community structure in breeding ponds (Wilbur 1972).

Should a repatriation of either *A. maculatum* or *A. tigrinum* be undertaken at WWNP, I would recommend continued monitoring of all amphibian species using the breeding ponds. In this manner, the effects of the repatriated species can be assessed throughout the establishment period. It is likely that a repatriated species will not become established without several translocation events, possibly occurring over multiple years. As such, the responses of the resident amphibians should be monitored during and following all such translocations.

Acknowledgments – I thank J. Florey, D. Foster, S. Klueh, M. Sikich, and especially L. Walston for their assistance with maintaining the drift fence/pitfall trap arrays and monitoring the arrays to collect amphibians. I am grateful to IDNR for partially offsetting the funding for this project. I am also indebted to R. Szafoni for advice, and to L.B. Hunt for granting permission to conduct research on his property.

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Table 1. Species list of amphibians and reptiles observed at Warbler Woods Nature Preserve between May 2000 and June 2004. Qualitative assessments of abundance of amphibian species are provided based on trapping and other survey efforts. * = species for which sufficient data collected during funding period (2003-2004) exist to illustrate temporal or habitat usage patterns – see attached Figures. † = species abundance assessed from breeding choruses.

		Relative abundance
ORDER URODELA		
Family Ambystomatidae –	*Ambystoma texanum**	common
Family Plethodontidae –	*Eurycea cirrigera*	rare (not a pond-breeder)
ORDER ANURA		
Family Bufonidae –	*Bufo a. americanus**	common
	Bufo woodhousei fowleri	rare
Family Hylidae –	*Acris crepitans blanchardi*	common
	Hyla chrysoscelis x *versicolor* †	common (regularly heard)
	*Pseudacris crucifer**	common
	Pseudacris triseriata †	rare (few choruses heard)
Family Ranidae –	*Rana blairi*	very rare (only 2 seen)
	*Rana catesbeiana**	common
	Rana utricularia	moderate
	*Rana sylvatica**	common
ORDER CHELONIA		
Family Chelydridae –	*Chelydra serpentina*	

Table 1, continued.

Family Emydidae – *Terrapene c. carolina*

unidentified emydid (probably *Chrysemys* or *Trachemys*)

ORDER SQUAMATA

Family Scincidae – *Eumeces laticeps*

Family Colubridae – *Diadophis punctatus*

Coluber constrictor foxii

Elaphe o. obsoleta

Heterodon platirhinos

Lampropeltis c. calligaster

Lampropeltis t. triangulum

Nerodia s. sipedon

Opheodrys aestivus

Storeria dekayi wrightorum

Storeria o. occipitomaculata

Thamnophis s. sirtalis

Table 2. Mean adult body size (± 1 standard deviation) and number of recaptures of post-metamorphic amphibians trapped in drift fence-pitfall arrays around four ponds at Warbler Woods Nature Preserve between 13 March 2003 and 10 June 2004. Only those species for which sufficient data are available are listed. (SVL = snout vent length; n = sample size for SVL measurements).

			# of recaptures	
Species	SVL (mm)	n	2003	2004
Ambystoma texanum	58.8 ± 21.7	1740	24	116

Bufo a. americanus	58.1 ± 11.0	77	4	2
Hyla chrysoscelis (x *versicolor*)	45.0 ± 0.0	1*	1	0
Pseudacris crucifer	29.1 ± 2.4	41	1	0
Rana catesbeiana	38.9 ± 5.5†	205	7	0
Rana sylvatica	47.2 ± 13.5	53	0	3
Rana utricularia	56.8 ± 4.9	4*	6	0

* = many more young-of-the-year frogs caught during study period.

† = relatively small SVL value is attributable to number of 2nd-year metamorphs trapped during study period)

Figure 1. Diagram of Warbler Woods Nature Preserve, Coles County, Illinois, showing general habitat types and positions of ponds surveyed for amphibians from 15 May 2000 to 10 June 2004. [Scale: 1 cm = 78.7 m].

30 June 2004

Robert Szafoni, Natural Heritage Biologist
Illinois Dept. of Natural Resources
1660 West Polk Avenue
Charleston, IL 61920

Dear Bob:

Thank you and IDNR very much for helping offset the costs associated with conducting research on the herpetofauna of Illinois. I am pleased to include the enclosed Final Report for the portion of my study covered under the grant (#04-010W), "Recovery of pond-breeding amphibians at Warbler Woods Nature Preserve following fish removal." The report details the background of the project, and the information that was gathered during the grant period. I have also provided a few comparisons of this year's data with that collected in previous years.

Based on my understanding of the amphibian community at WWNP and IDNR management objectives for this site, I consider the previous years' removal of predatory fish from this site a success. Furthermore, I am recommending that IDNR and the Nature Preserves Commission consider the reintroduction of salamander species that have been historically present in Coles County, but not recorded at this site for over 30 years. This action will help increase biotic diversity at WWNP and restore the amphibian community at this site to pre-settlement conditions.

The Payment Request Form will be forwarded to your office under a separate cover by Christine Childress, grant accountant at EIU's Business Office. Please feel free to contact me should you have any questions concerning my report. Thanks again for your cooperation.

Cordially,

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Enclosures.