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Largemouth Bass Abundance and Aquatic Vegetation in Florida Lakes: An Alternative Interpretation

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INTRODUCTION

Hoyer and Canfield (1996) examined relations among largemouth bass (*Micropterus salmoides*) abundance, aquatic macrophytes, and limnological characteristics in 56 Florida lakes. These authors reported that young-of-year (< 160 mm total length, TL) and subadult (160-240 mm TL) largemouth bass densities were only weakly associated with macrophyte abundance. However, adult (> 250 mm TL) density and biomass were weakly, but positively correlated to lake trophic status when accounting for the nutrients in the water column and the nutrients sequestered in aquatic macrophytes. These authors also found that largemouth bass growth to age-2 was weakly and inversely related to macrophyte abundance. Hoyer and Canfield (1996) concluded that macrophyte presence even at low levels (< 20-30% areal coverage), may not be needed to sustain viable largemouth bass populations in Florida lakes that are less than 300 hectares, exploitation of largemouth bass likely contributed to the large amount of variation in the data base, and the response of largemouth bass populations to macrophytes in small and large natural lakes, and reservoirs is variable.

In this paper, I present an alternative interpretation of the data presented by Hoyer and Canfield (1996). I have been involved in numerous studies in Florida, Texas, and Alabama that examined the relations among largemouth bass populations, aquatic plant abundance, and limnological characteristics (Shireman et al. 1984, Bettoli et al. 1992, Maceina et al. 1992, Bettoli et al. 1993, Maceina et al. 1994, Maceina et al. 1995, Maceina et al. 1996, Wrenn et al. 1996). Although other studies have been conducted on the response of largemouth bass populations to various levels of aquatic macrophytes, results have been mixed with negative, positive, and sometimes neutral impacts detected (reviewed by Maceina et al. 1994).

From my own observations, the size of the water body may influence the response of largemouth bass populations to aquatic vegetation. In our small experimental sport fishing ponds (< 5 hectares) at Auburn University, largemouth bass, bluegill (*Lepomis macrochirus*), redear (*L. macrochirus*), and grass crap (*Ctenopharygodon idella*) are the only fish species present. Aquatic macrophytes are limited by maintaining phytoplankton blooms that ranged in intensity from 40 to 60 mg/m^3 of chlorophyll *a* (hypereutrophic), and grass carp are stocked at high enough densities to prevent any macrophyte growth. These systems typically support 35 to 45 kg/ha of largemouth bass with sustained annual yields of about 15 kg/ha. These values are generally much higher than found in larger public water bodies (Jenkins 1982) and approach the maximum biomass observed by Hoyer and Canfield (1996). However, as lake and reservoir size increases, species diversity increases, biotic interactions become more complex, and environmental instability becomes greater in larger water bodies, particularly in reservoirs. The presence of submersed macrophytes favors the presence of certain fish species, especially fish from the family Centrarchidae (Bettoli et al. 1993), of which the largemouth bass is a member.

In this paper, I reanalyzed the data of Hoyer and Canfield (1996) to test the hypothesis that a lake size-aquatic macrophyte interaction was associated with largemouth bass populations in Florida lakes. Using the data presented by Hoyer and Canfield (1996) from 56 lakes, I separated the data base

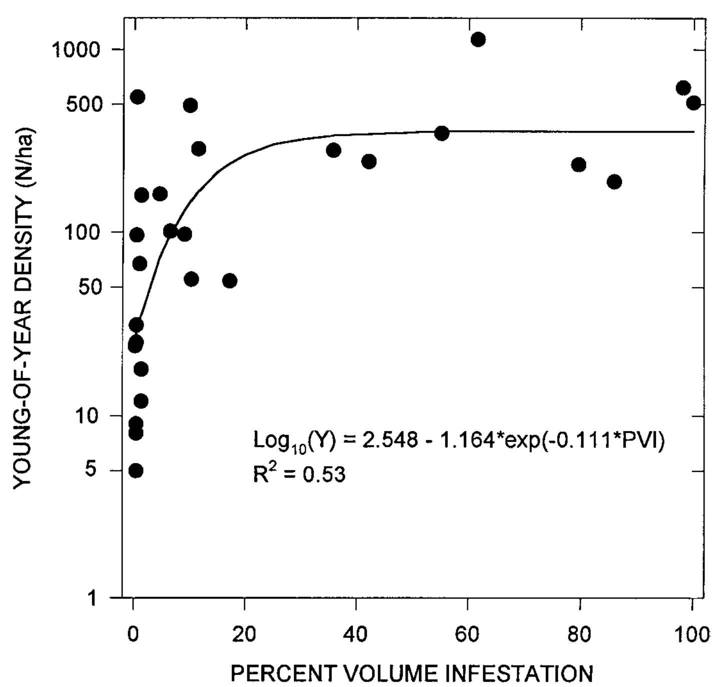

Figure 1. The relation between young-of-year largemouth bass density and percent volume infestation of aquatic plants in Florida lakes greater than 54 ha. Line represents least-squares non-linear regression.

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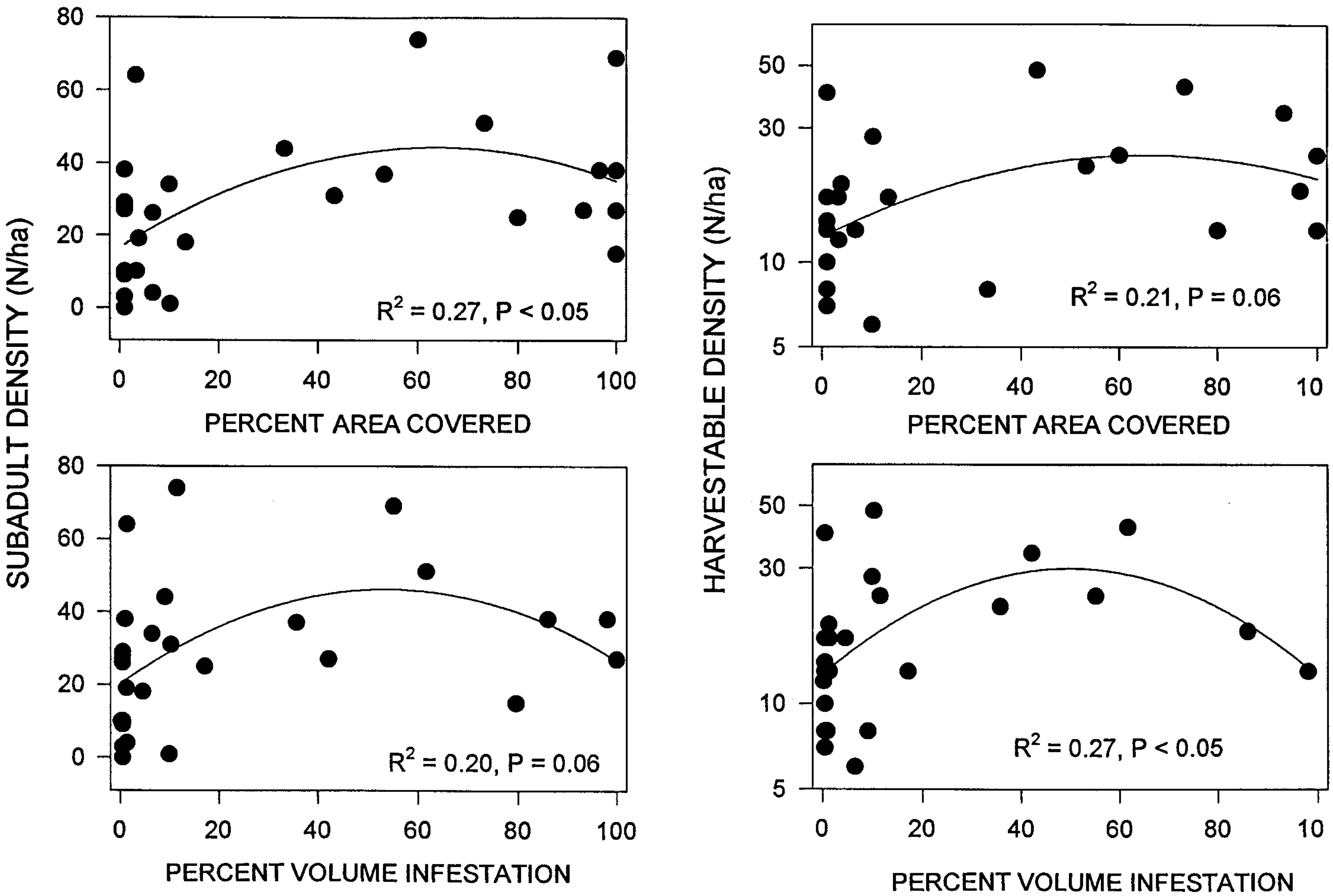

Figure 2. The relations between subadult and harvestable largemouth densities and percent area covered and percent volume infestation of aquatic plants in Florida lakes greater than 54 ha. Lines represent second-degree parabolic regressions.

into small (≤ 54 ha; N = 27) and large (≥ 55 ha; N = 29) lakes by taking the median of lake area. I also created another subset data base that included lakes in the upper 25% quantile in area, but sample size was reduced to 14 lakes. Hoyer and Canfield (1996) did not include lake size in their analyses, but did recognize that this variable and lake morphometry may also influence largemouth bass populations in Florida lakes.

RESULTS AND DISCUSSION

In large (> 54 ha) lakes, young-of-year largemouth bass density was positively correlated (r = 0.63, P < 0.01) to percent area coverage (PAC) and to percent volume infestation (PVI; Figure 1). However, in small lakes no relation (P > 0.5) was evident between young-of-year density and aquatic plants. The relation between young-of-year density and PVI was non-linear (Figure 1), a positive, asymptotic equation was fitted to the data, and, PVI explained 53% (R^2 = 0.53) of the variation in young-of-year density. This relation suggested that density reached an asymptote at about 350 young fish per hectare at a PVI value of around 35%. For all the data combined, Hoyer and Canfield (1996) found that PAC and PVI only accounted for less than 7% of the variation in young-of-year density.

Similarly for subadult largemouth bass density in large lakes, I computed positive correlations between this variable and PAC (r = 0.46, P < 0.05) and PVI (r=0.49, P < 0.05). No relations (P > 0.5) were detected between subadult density and plant abundance in small lakes. Subadult largemouth bass density appeared to peak at intermediate levels of plants then decline, and was best described by second-degree parabolic equations (Figure 2). For all sizes of lakes, Hoyer and Canfield (1996) found PAC and PVI only explained 8 to 11% of the variation in subadult largemouth bass density.

In larger lakes, I found that harvestable largemouth density also showed a weak, but parabolic relation to aquatic macrophytes (Figure 2). Although higher harvestable densities were observed at low levels of macrophytes, PVI values of 10 to 60% increased the probability of greater abundance of harvestable fish. In small lakes (≤ 54 ha), aquatic macrophytes were not related (P > 0.5) to harvestable density. Hoyer and Canfield (1996) found no relation between harvestable density and plant abundance when all the data were pooled.

Similar to the analysis conducted by Hoyer and Canfield (1996), I found no relation between harvestable biomass and plant abundance in larger lakes. Although density of harvestable fish was slightly higher at intermediate levels of plants

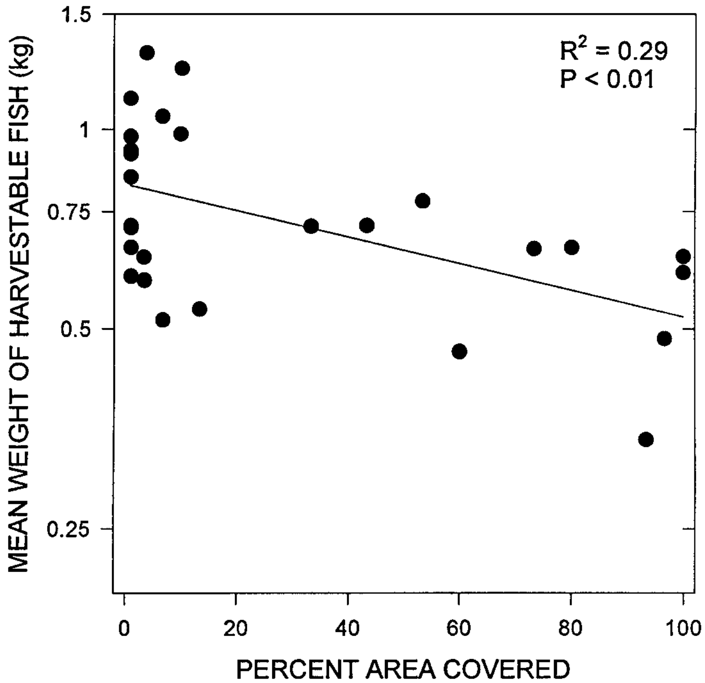

Figure 3. The relation between mean weight of harvestable largemouth bass and percent area covered of aquatic plants in Florida lakes greater than 54 ha.

(Figure 2), the mean weight of harvestable fish declined as PAC increased (Figure 3). Thus, harvestable biomass was unaffected by plant abundance even though density increased at intermediate plant abundances.

When only analyzing data from lakes in the upper 25% quantile in size (>116 ha), all the relations reported earlier improved including the association between harvestable largemouth bass biomass and plant abundance, even though sample size was smaller (Figure 4). Plant volume explained 74% of the variation in young-of-year density in lakes larger that 116 hectares. The relation was non-linear and was similar in response to that illustrated in Figure 1. Whereas in lakes greater than 55 ha, macrophytes only explained 20 to 27% of the variation in subadult and harvestable density, by only including lakes greater than 116 ha, aquatic plants accounted for 50 to 60% of the variation in these population parameters (Figure 4). Similar parabolic relations were evident, and highest subadult and harvestable densities and harvestable biomass were evident at intermediate levels of plant coverage. In addition, mean weight of harvestable largemouth bass showed a stronger association to PAC in lakes larger than 116 ha than in the subset of lakes that were greater than 55 ha (Figures 3 and 4).

In lakes larger than 116 ha, largemouth bass age-1 and age-2 growth rates showed a stronger inverse relation to PAC than in smaller lakes (Figure 5). For age-2 fish, growth was not related to macrophyte abundance in lakes less than 117 ha. Age-1 and age-2 fish comprise subadult largemouth bass and densities of these size fish were greater at higher macrophyte levels. This suggested that growth was more density-dependent than macrophyte influenced in lakes larger than 116 ha. In lakes less than 117 ha, chlorophyll *a* showed a greater association with growth rates than to macrophyte abundance. Untransformed, single, or double $\log_{10}$ transformed correlations between age-1 and age-2 growth rates and chlorophyll *a* concentrations ranged from 0.40 to 0.68 ($P < 0.05$) in lakes 55-116 ha and in lakes less than 55 ha in size. However for the entire set of lakes, Hoyer and Canfield (1996) reported PAC and chlorophyll *a* were inversely related ($r = -0.53$, $P < 0.01$). Typically in Florida lakes, as macrophyte abundance increases, algal biomass declines (Canfield et al. 1983). Thus, identification of whether macrophytes or algal biomass were better indirectly related to largemouth bass growth rates could not be determined.

Finally, the analyses conducted by Hoyer and Canfield (1996) attempted to examine the trophic state response of largemouth bass by including phosphorus and nitrogen sequestered in plants and adding these nutrients to those in the water column, then predicting an adjusted chlorophyll *a* concentration and trophic state. This approach permits a true analysis of trophic state associations, but masks the influence of aquatic plants on largemouth bass population characteristics.

In lakes greater than 54 and 116 ha, the relations between adjusted chlorophyll *a* to largemouth bass population characteristics were either non-existent or much weaker than those described by PAC or PVI alone. The inclusion of open-water algal biomass or chlorophyll *a* to these models that used PAC and PVI as independent variables did not significantly explain any additional variation in density or biomass of the different size categories of largemouth bass. Thus, aquatic plants appeared to influence largemouth bass populations in Florida lakes larger than 54 ha.

My analyses have shown that some levels of aquatic plants may enhance or at least provide recruitment stability to largemouth bass populations in Florida lakes. Although a great deal of variation was evident in the data, I also showed an increased probability of higher harvestable density and biomass of largemouth bass at intermediated levels of aquatic plants in lakes greater than 116 ha. This may be partially attributable to greater reproductive success. In Lake Conroe (8,100 ha), Texas, the density of age-1 largemouth bass declined from about 100 fish/ha when submersed vegetation covered 30-44% of the reservoir to about 20 fish/ha when vegetation was completely removed (Bettoli et al. 1992). This corresponded to a decline in catch rates in the fishery (Klussmann et al. 1988). In Guntersville Reservoir (28,000 ha), Alabama, young-of-year largemouth bass densities averaged 350 fish/ha in submersed vegetation compared to 24 fish/ha in unvegetated habitats during two years when flushing rates were high (Maceina et al. 1994). The formation of strong and weak year classes in Guntersville Reservoir was primarily related to flushing rates (Wrenn et al. 1996), and aquatic plants augmented largemouth bass recruitment when environmental conditions were poor in unvegetated littoral habitats. The densities of young fish in these two reservoirs were similar in range to those reported from these Florida lakes. Production of 25 or less age-0 largemouth bass per ha will likely not sustain a viable fishery. This occurred in 31% of the large (> 54 ha) Florida lakes sampled by Hoyer and Canfield (1996) and was associated with low PAC and PVI values of less than 7 and 2%, respectively.

Increasingly, aquatic plant and fishery managers are working together to solve complex aquatic resource problems

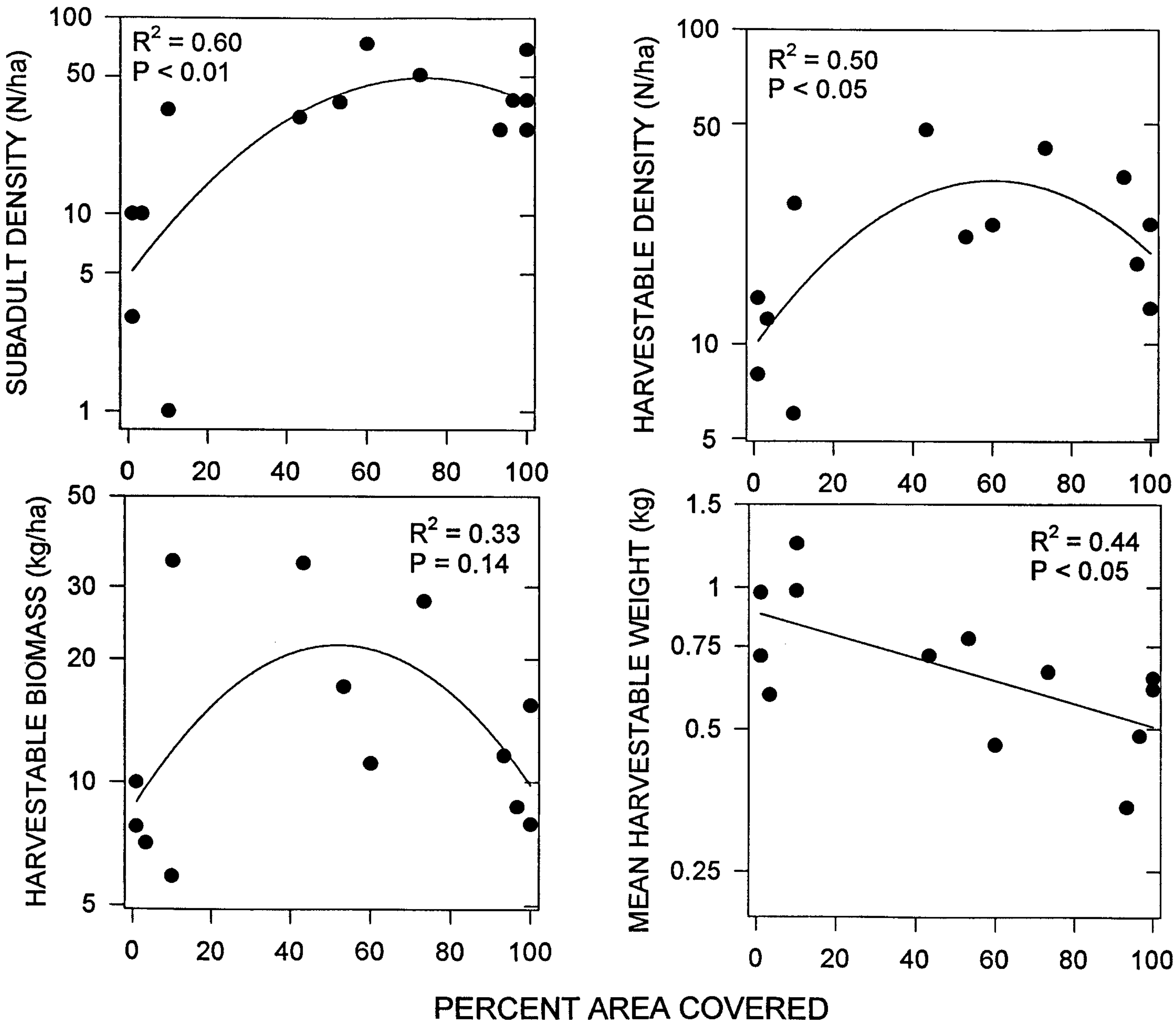

Figure 4. Relations between largemouth bass subadult density, adult density, adult biomass and mean harvestable weight, and percent area covered of aquatic plants in Florida lakes greater than 116 ha. Lines represent second-degree parabolic or linear regressions.

and conflicts that in many instances involves more than management of largemouth bass. From this analysis and other investigations, the results of research on aquatic plant-largemouth bass population interactions conducted in different size water bodies, including reservoirs, are not transferrable or at least must be viewed with caution. Realization that a water body size-aquatic plant-largemouth bass interaction may exist hopefully will lead to further investigations to verify and refine our understanding of these relations. Finally, aquatic plant and fishery managers should recognize and in some instances (see U.S. Army Corps of Engineers 1994) already have acknowledge lake size when controlling excessive aquatic macrophytes where largemouth bass fishery concerns need to be addressed.

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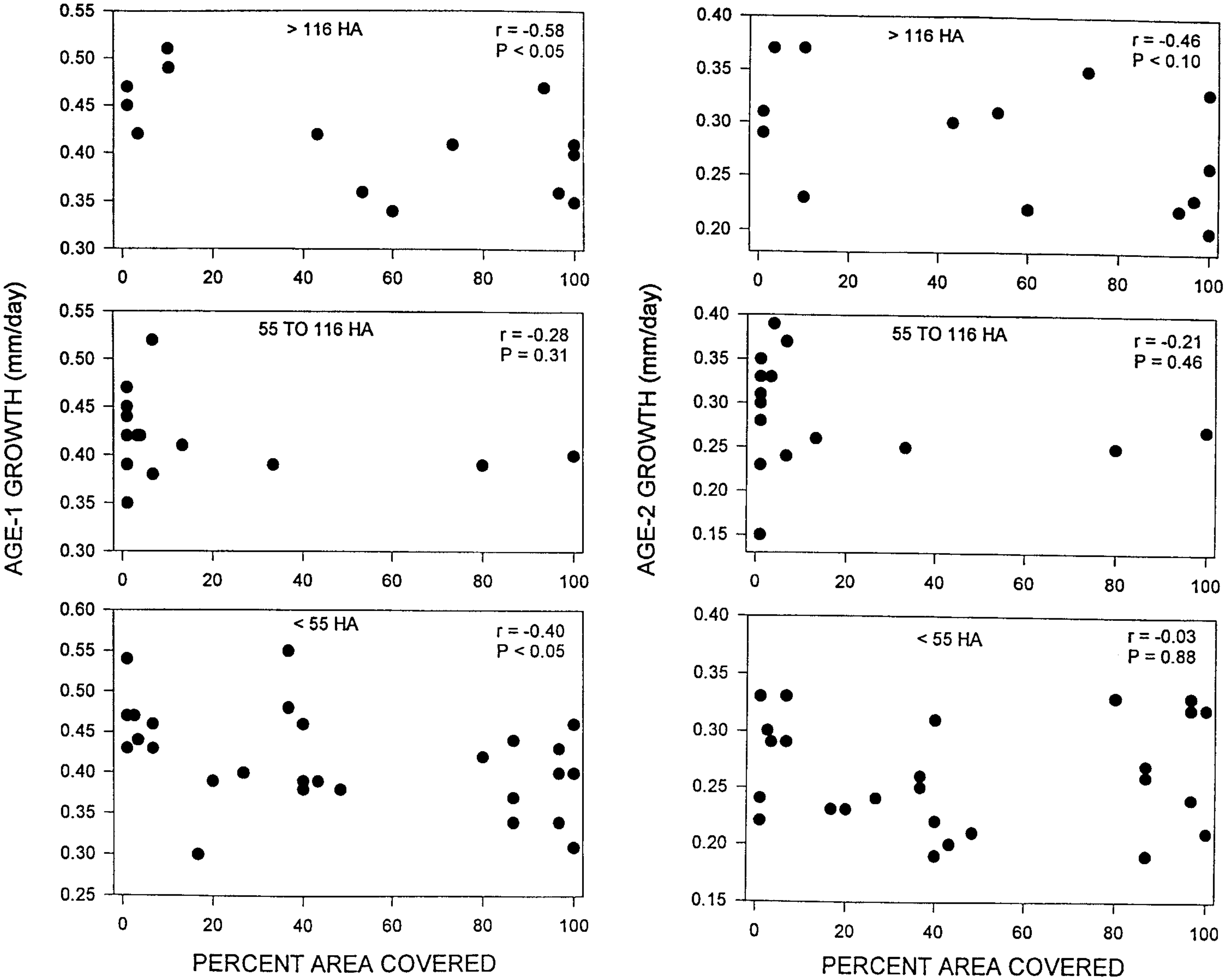

Figure 5. Average daily age-1 and age-2 growth rates of largemouth bass plotted against percent area covered of aquatic plants in Florida lakes that ranged in area from 2 to 54, 55 to 116, and 117 to 271 ha.

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