Preliminary Study of the Spatial Distribution Patterns of Largemouth Bass and Its Relation to Water Chemistry Along With a Prediction of The Species Using Maxent Model

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Abstract: - The main theme of this study was to determine how chemical water quality affects the distribution and abundance of largemouth bass (*Micropterus salmoides*), as an invasive species, in the Korean waterbodies. The abundance of largemouth bass was analyzed in relation to the trophic compositions and chemical tolerance. This analysis showed that the abundance of the largemouth bass was largely determined by trophic compositions, chemical conditions and the stream size and also dominated in the clear water (low turbid water), based on chlorophyll-a in the waterbodies. The high abundance of the largemouth bass occurred in the stagnant waters rather than the running waters, indicating a preference on the waterbodies with longer water residence time. We also applied the Maximum Entropy model (Maxent) to show the distributions of the species and tried to predict the future distribution in the watersheds.

Keywords: - Elevation, Largemouth Bass, Maxent, Nutrients, South Korea, Trophic Guild

1 Introduction

Exotic species is a major threat to freshwater ecosystems and biodiversity [1, 2]. The largemouth bass is an exotic species and it is widely distributed in the Korean water body as well as all over the world. In Korea, it was first introduced as an exotic species in 1963 [3] in Han, Nakdong and Geum rivers. Largemouth bass has a serious impact on native fish fauna. It threat fish populations, freshwater fishery and aquatic to littoral environments. Largemouth bass has strong predatory performance that's why it is well established in the waterbody.

Each species has a specific optimal, sub-optimal, or lethal tolerance range in terms of water quality parameters. Chemical parameters such as organic matter pollutant (i.e., BOD and COD) or nutrients (N, P) are the key factors that control fish tolerance in the waterbodies in geographic regions [4]. In addition, fish tolerance may also be associated with biological factors such as predation [5]. The abundance of largemouth bass greatly affected by the regional fish fauna. The physical, hydrological and chemical parameters of a waterbody greatly influence the regional distribution of a fish species [6].

The exotic species are increasing management priorities for governments worldwide owing to their potential to cause severe ecological and economic impacts. In order to efficiently manage exotic species, predictive tools are needed to prioritize locations where they are

likely to become established and where their impacts will be most severe [7]. Maximum - entropy model (Maxent) has been widely used for the predictions of species distribution [8].

In this preliminary research, we determined how largemouth bass tolerate water quality parameters and distributed in the Korean waterbody on the basis of waterbody morphology, habitat parameters and Ecological indicator.

2 Materials and Methods

2.1 Sampling period and sites

We collected the largemouth bass from 72 samples sites in the Geum river watershed in 2012 (Fig. 1) and also analyzed the chemical parameters from these points by using ascorbic acid method and gas filter chromatography [9, 10].

2.2 Sampling gears and sampling methods

Fish assemblages were sampled with overnight sets of fyke nets (FN), gill nets (GN), trammel nets (TN). Minnow traps (MT), and casting nets (CN) and kick nets (KN) were conducted in the daytime in littoral zones of the Geum river. All types of habitats such as littoral, sub-littoral and limnetic zones were included for the fish sampling. The sampling gears such as trammel net (50 m long and 1.0 m high, mesh size 12 ×12 mm), gill net (50 m long and 2 m high, mesh size 45 × 45 mm), fyke net (20 m long and 2.4 m high, mesh size: 5 × 5 mm), casting nets (mesh size: 7 × 7 mm), kick nets (mesh size: 4 × 4 mm), and minnow trap (0.6 m long and 0.3 m high, 4 mm mesh size) were used in the open water at different depths, in the profundal and the littoral zone. A casting net and kick net was used in nearshore as well as offshore waters of Geum River. Fyke net, gill net, trammel net, and minnow trap was done along the shoreline using a small boat. We sampled at the littoral zone with 0.5 – 1 m in water depth using casting net (38.5 m^2 capturing area) and kick net (1.6 m^2 capturing area). Casting net was mainly used in the open water around the littoral area and kick net was used at the shallow region with hydrophytes and water weeds. At each sampling location, sampling distance was 200 m and the sampling time elapsed was 60 minutes according to the quantitative sampling method [11].

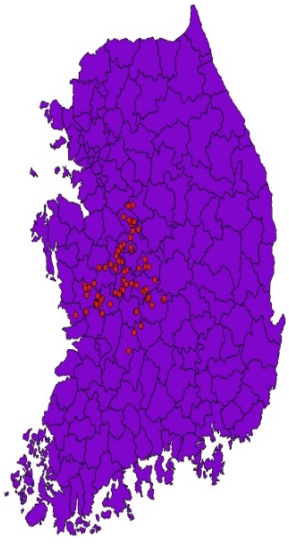
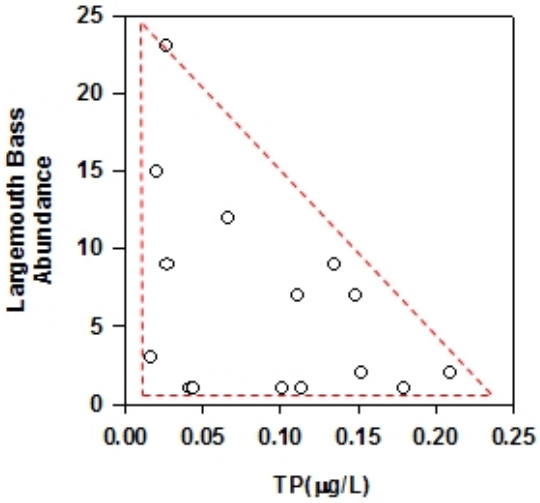


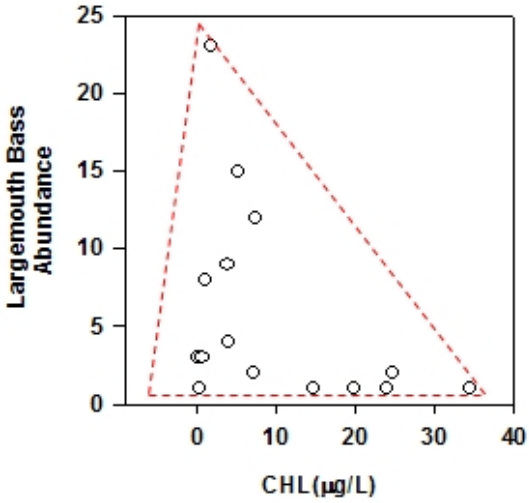
Figure 1. Largemouth bass occurrence points in Geum river watershed.

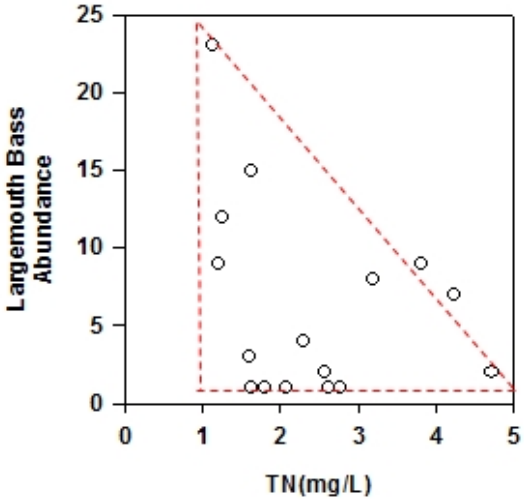
3 Results and Discussion

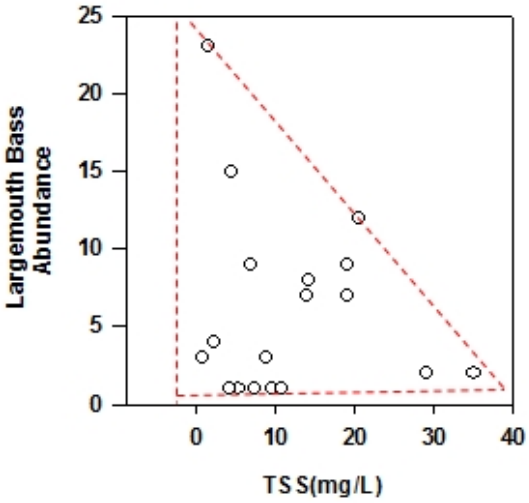
3.1 Chemical tolerance analysis of largemouth bass

The distribution of largemouth bass was associated with water quality parameter and greatly affected by the nutrient and organic pollution (Fig. 2). The relative abundance of largemouth bass was decreased with increasing the concentration of nutrients (especially N and P), which are the key factor of chlorophyll production and it makes algal bloom. It indicates that largemouth bass does not live in a polluted area where bloom occurs. If the concentration of total suspended solid increases the abundance of largemouth bass decrease. Biological oxygen demand (BOD) and chemical oxygen demand (COD) are the main factors of organic matter pollution. The organic matter pollution has vice-versa effect to the abundance of largemouth bass in the waterbody. Due to the nutrient and organic pollution the water is turbid. The relationship of water quality parameter and largemouth bass abundance reported here support the view of high locating ability was reduced by the turbidity and advanced level of eutrophication has the reverse effect on bass predation [12]









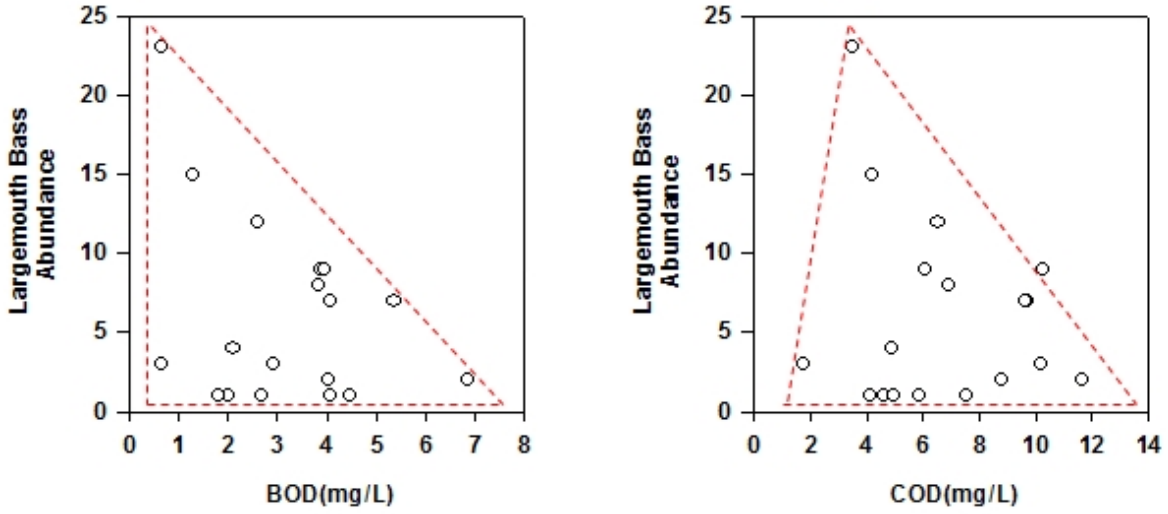


Figure 2. Relation of largemouth bass abundance with nutrients and organic matter pollution.

3.2 Trophic / tolerance preferences tests of largemouth bass

Trophic preferences of largemouth bass were analyzed by comparing omnivore, carnivore and insectivore species, and also, tolerance preferences were visualized by studying tolerant, intermediate and sensitive species (Fig. 3). Trophic guild and tolerance guild of fish are closely related to water quality parameters such as organic matter and nutrient (N, P) pollution [11]. As shown in Fig. 3, the relative abundance of largemouth bass were highest when the percentage of omnivore and insectivore species were centric level. The relationship of largemouth bass abundance and percentage of carnivore species were vice-versa because they have to compete for their food. It supports that the introduction of exotic fish into an established community may result in interspecific competition for food [13]**.** When the percentage of tolerant and intermediate species were lowest and highest, the largemouth bass abundance was lowest but the largemouth abundance was in top level while the percentage of tolerant and intermediate species are in middle position. The largemouth bass abundance was decreased with increasing the percentage of sensitive species.

3.3 Relative abundance of largemouth bass in relation to stream physical parameters

The distribution of largemouth bass greatly affected by the stream width and order, and elevation (Fig. 4). The largemouth bass abundance increased with increasing the stream width and order. It strongly agreed that largemouth bass prefers to live in downstream rather than upstream and middle stream. While the elevation increased, the percentage of largemouth bass decreased. It strongly indicates that largemouth bass does not like to stay in the high current velocity region (upstream). Most probably they like to stay in stagnant water rather than running water.

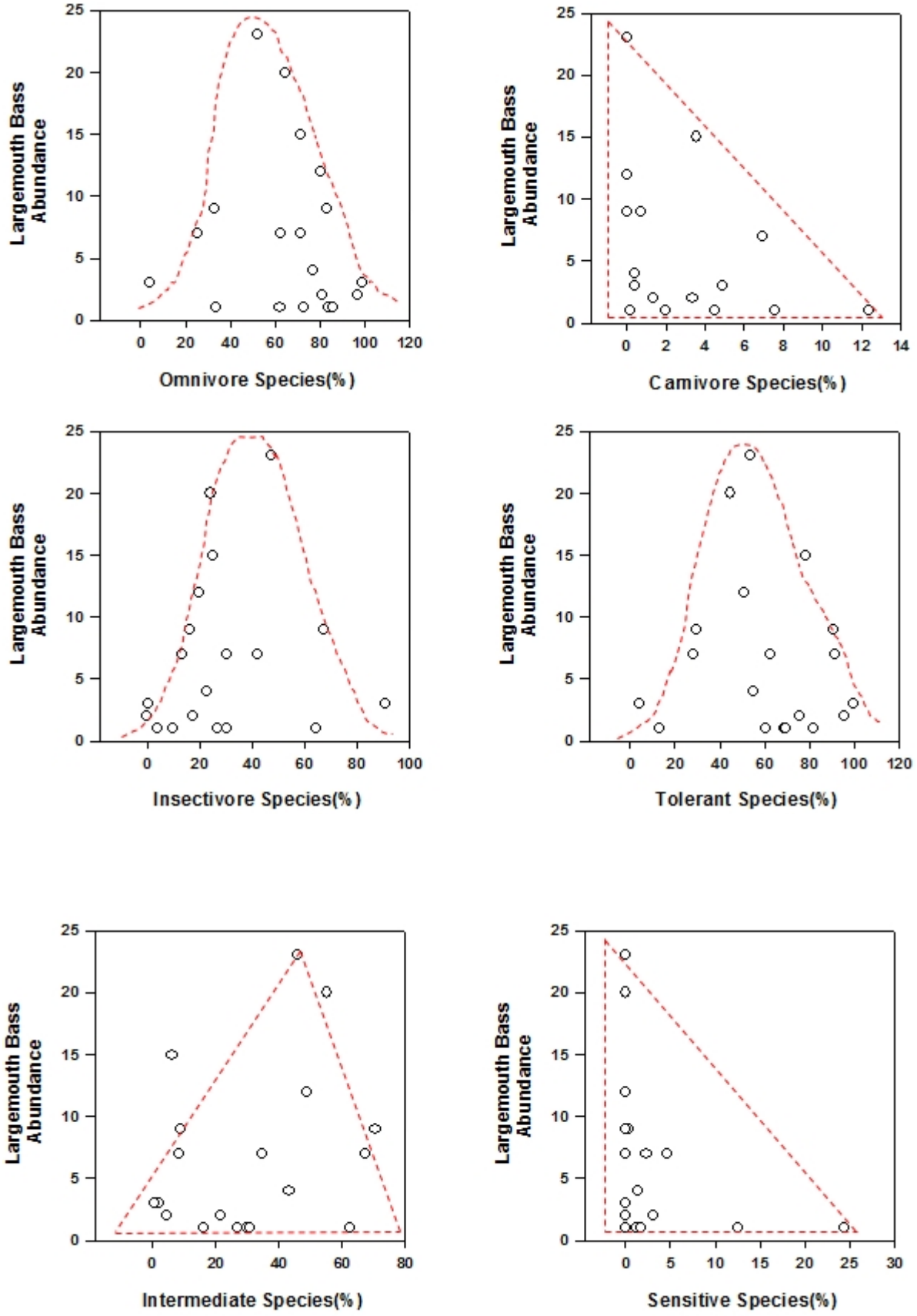


Figure 3. Trophic gradients of largemouth bass with an omnivore, carnivore, and insectivore species (%) and tolerance gradients of largemouth bass with tolerant, intermediate, and sensitive species (%).

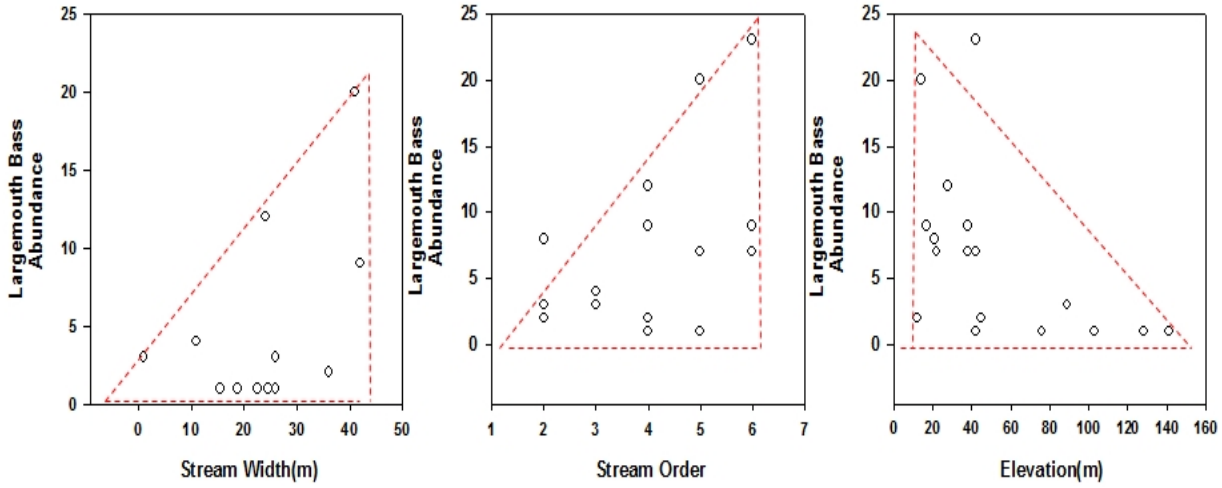


Figure 4. Relation of largemouth with stream width and order, and elevation.

3.4 Prediction of largemouth bass by maxent model

The water quality parameter affect the distribution of largemouth bass. In Maxent model, the area under curve value is 0.578 (Fig. 5) which indicates that this model does not fit. The future distribution of largemouth Bass is shown in Fig. 6.

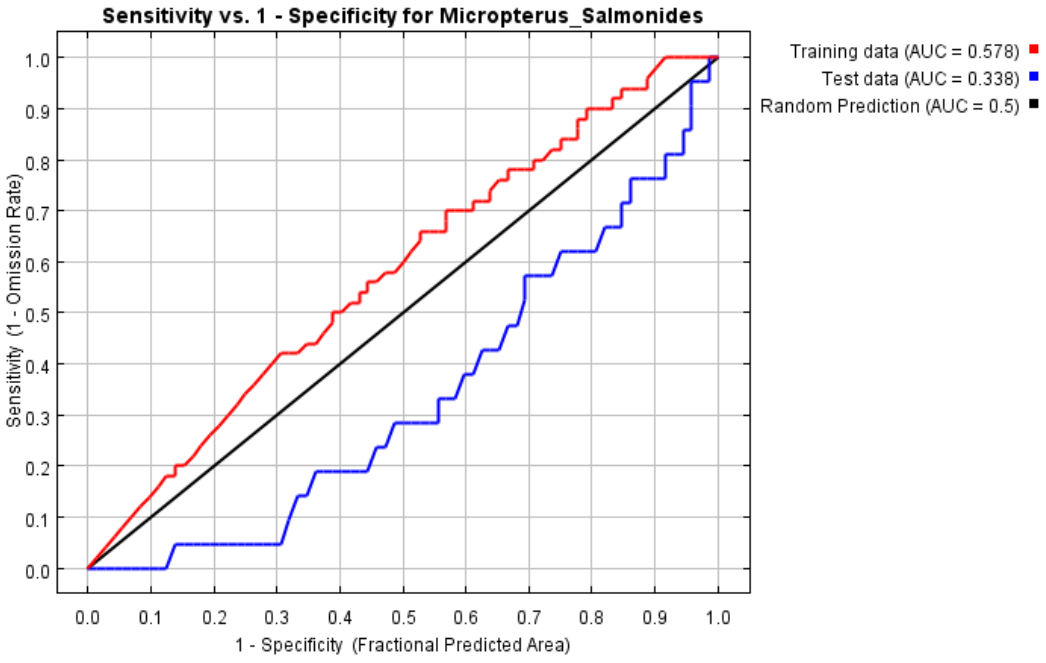


Figure 5. The Receiver operating characteristics curve

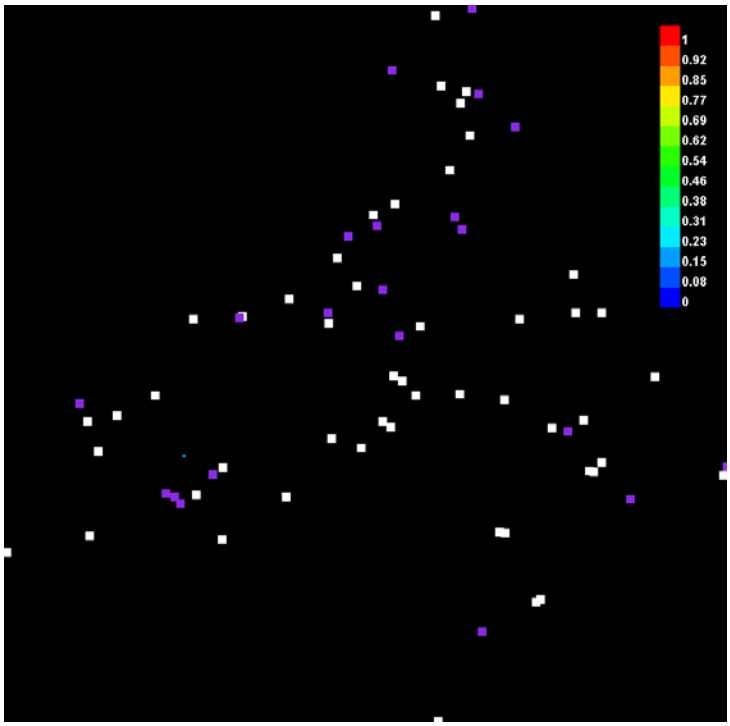


Figure 6. Prediction of largemouth bass distribution: Dot color shows present locations and Violet color shows future locations.

4 Conclusions

The preliminary research suggests that the distribution of largemouth is closely related to nutrient and organic pollution along with physical factors (stream width and order, and elevation). The other fish species also affect the presence or absence of largemouth bass in the water body. This preliminary study provides some baseline information about the relationship of largemouth bass with water quality parameter, the morphology of river, other fish species and MaxEnt model which could be more helpful for further research up to a standard level.

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