Proposal to reintroduce eelgrass (*Vallisneria americana*) into Volusia Blue Spring

Species introductions are now recognized as one of the most important ways by which humans affect ecosystems, both positively and negatively, and this species of eelgrass would benefit the ecosystem within Blue Spring for many reasons (Strayer, 2003). Introduction of *Vallisneria americana* into Blue Spring would allow for a new and abundant habitat for invertebrates. Eelgrass offers food, shelter, and essential nursery areas to many species that are produced within, or migrate to, eelgrass. *Vallisneria americana* produces tall leaves that provide refuge for juvenile fish, small species of finfish, and benthic invertebrates (e.g. amphipods, insect larvae, snails) (Hill, 2002).

In addition to the protective features of eelgrass, it also serves to dampen the effects of strong currents for fish and invertebrates, while also preventing scouring of bottom areas. These epiphytic organisms are important contributors to the food webs in their ecosystem. Organisms graze on the eelgrass directly, such as manatees (*Trichechus manatus*) and cooters (*Pseudemys* sp.), and the death of the epiphytes provides a detrital carbon source to the food web (Hill, 2002).

Reproduction and Life Cycle

*Vallisneria americana* is a dioecious, perennial, aquatic macrophyte. It is stoloniferous and capable of extensive clonal growth; most individuals in a population remain vegetative. The female flowers of the plant remain attached to the parent plant by a long spiral peduncle (Fig. 1) and male inflorescences, containing many minute flowers (Fig. 2), open their sheaths and release their flowers as small "boats" which rise to the surface. Male flowers are left to float on the water due to surface tension riding water currents. Pollen is kept dry through this process and pollination is effected by wave action which moves male flowers to contact female flowers and pollination takes place (Doust, 1991).

Due to the way the flowers are pollinated, we would recommend having at least one population of eelgrass near the boil but not in the boil. This strategy should maximize reproductive potential; when plants begin to flower the slow movement of the water from the
boil to the river should carry along the male flowers and hopefully pollinate those female flowers that are down the run as well as possibly pollinate those near the boil.

*Vallisneria americana* begins rapid growth around June. By mid-summer, the aboveground biomass in most ecosystems has reached its peak and growth slows somewhat in response to higher water temperature; however, Blue Spring has a consistent temperature year round, so there will be less variability in growth rates. During winter, growth is slowed considerably. On average, individual shoots of eelgrass do not live for more than two years. (Cornell, 2010)

### Habitat

*Vallisneria americana* requires certain conditions to maximize survival and reproduction, such as specific depth requirements, substrate composition, thermal requirements, and sufficient light exposure. The depth requirement for *V. americana* ranges between 0.2 meters and 3 meters (Korshgen and Green, 2006). *Vallisneria americana* tubers can be observed in the wild at depths from 10 to 20 cm in silty clay substrate and at depths of 5 to 15 cm in sand (Rybicki and Carter, 1986). Under laboratory conditions, survival of planted seeds was 90% when burial depth was 10 cm or less, but seed mortality was 100% when they were buried in substrate 25 cm or greater (Rybicki and Carter, 1986). Jarvis and Moore (2008) found that sediment composition of ≤ 3% organic content and > 40% sand enhanced the germination and growth of *V. americana* seeds under laboratory conditions. Overall, however, there exists considerable variability in the sediment composition that supports growth and reproduction for *V. americana*.
The recommended light requirements for *V. americana* range between 20.4 - 78.3 µmol m\(^{-2}\)s\(^{-1}\) for maximum photosynthetic rates (Boustany *et al.*, 2010). Between these two extremes, *V. americana* reproduces at an increasing rate (Kurtz *et al.*, 2003). The thermal requirements for *V. americana* are relatively distinct. In water temperatures below 20°C, growth is severely restricted. In water temperatures above 50°C, plants become limp and disintegrate. Therefore, the ideal temperature range is between 20°C and 36°C (68°F - 96.8°F) (Korshgen and Green, 2006). Blue spring meets these temperature requirements by remaining 22°C (72°F) throughout the year (Scott *et al.*, 2002).

*Potential threats to the restoration*

Volusia Blue Spring contains threats to the success of project. The biggest threat to *V. americana* that is present in the spring is the manatee. A manatee can eat from six to eight hours a day (Van Meter, 1989) and sea grass cores taken in grazed and ungrazed areas of Hobe Sound, FL, indicated that manatees can reduce shoot densities to half the density of ungrazed sea grass beds (Lefebvre *et al*. 2000). Volusia Blue Spring hosts large numbers of manatees in the colder months due to the constant temperature of the spring (Wetlands Solutions, Inc., 2009). Grass carp (*Ctenopharyngodon idella*) and turtles also pose a threat to *V. Americana* in the spring. Grass carp have been known to eat eelgrass and they can eat as much as 25% of their body weight per day, at least for hydrilla, *Hydrilla verticillata* (Shireman and Maceina 1981). *Pseudemys* sp. (cooters) strictly feed on aquatic vegetation, unlike the other turtles in that occur in the spring (Wetlands Solutions, Inc., 2009; Bjorndal *et al*. 1997). Although their diet is strictly herbivorous, depending on the season or drought conditions, they can go days, weeks, or months without eating (Buhlmann *et al.*, 2008). Red eared sliders (*Trachemys scripta elegans*) also will eat aquatic vegetation such as *V. americana*, although it is not their preferred diet. They primarily feed on small fish, insects and tadpoles (Cagle, 1950). These turtles may not be a big threat, but they can cause damage to the restoration project depending on the condition of the spring.

Volusia Blue Spring is a big attraction to tourists, and the presence of large numbers of tourists (average = 812 visitors day\(^{-1}\), range = 0 - 6140 visitors day\(^{-1}\), Wetlands Solutions, 2006) is another possible threat to *V. americana*. High traffic areas in the run may prevent *V. americana* from growing. Visitors are unaware of the impact they have on the delicate vegetation
that is present. Since *V. americana* would have to be present along the bank areas, tourists will have to be informed not to climb or brush against those areas to preserve the restoration efforts.

**Scale of Reintroduction**

We support the attempt at *V. americana* restoration in Volusia Blue Spring, but if the initial attempts are unsuccessful, we would advise forgoing the continuation of the reintroduction in Volusia Blue Spring run. Based on available funding, we propose two options. One, we suggest small scale tests on three sites mentioned later in proposal, to determine propagation and success of *V. americana*. If such attempts prove to be successful in any of the three sites, then we recommend continuation on the successful sites of the restoration effort on a larger scale. A second option would be to forgo small-scale tests and do a full-scale restoration of *V. americana* at the three sites (again mentioned later in this proposal). If initial test sites fail or the full restoration fails, we advise that this restoration project be put on hold or dismissed in favor of other restoration activity needed in Blue Spring State Park.

**Restoration Strategy**

A strong strategy for re-establishing *V. americana* into Volusia Blue Spring will be to establish small founder colonies. By focusing on excluding herbivores and allowing time for the new beds to establish themselves, these initial founder beds may well serve as a source for natural population establishment throughout the spring (Dick and Smart, 1999). These initial colonies should consist of transplanted mature individuals; seeds in *Vallisneria* tend to germinate less well than adult plants when implanted in sediment (Ke and Li, 2006) and with the flowing current of Volusia Blue Spring, we would expect free floating seeds to have a very low chance of implanting in the sediment. As manatees pose the largest threat to these initial colonies, strong enclosures mounted at strategic times of the year will be vital. Mortality rates in *V. americana* colonies exposed to manatee herbivory in Kings Bay Florida were 100% for recently planted propagules; the manatees were apt to tear out all parts of the plant. However in established beds, manatees tended to graze on above ground foliage while leaving the plant intact in the sediment (Hauxwell and Osenburg, 2004). Hauxwell and Osenburg (2004) also suggested that survival of colonies was highly variable and that the most effective restoration strategies will establish multiple sites for founder colony implantation. This strategy allows for a higher chance that
colonies will experience favorable site-specific factors like low competition and herbivory, and favorable light, sediment, and disturbance conditions (Hauxwell et al., 2004)

Based on the suggestions of previous restoration studies of *V. Americana*, we suggest the following strategy. At least three colonies should be planted: one just upstream from the small spring inlet, one in the area downstream of the swim dock, and one across from the swim dock (Fig. 3). This separation of colonies will allow, if the plants become established, for higher reproductive success as flowers can flow downstream to other patches for fertilization.

Enclosures should be constructed from simple materials. We suggest 1.5 m² enclosures. We suggest utilizing four agricultural T-posts driven into the substrate at the corners of a 1.5m² square, wrapped with galvanized steel agricultural fencing (approximately 20ft of fencing per enclosure). The height of the T-posts and the fencing used will vary with water depth, but the posts should be driven deeply into the substrate as to minimize the chance of any damage that may be inflicted by passing manatees. The fencing should be fixed to the T-posts using heavy duty T-post clips. The spacing of the mesh in the fencing should not exceed 2x3 inches in order to exclude other herbivorous species, besides manatees, that may graze upon the propagules. These enclosures should contain at least 50-100 propagules each. The propagules should be adult transplants, not seeds. Ideally, transplants should come from a local source, such as the Wekiwa River, Rock Spring, or perhaps even the St. Johns River near Blue Spring. Maintaining genetic diversity is usually one of the goals of macrophyte restoration (Fonseca et al., 1998; Williams and Orth, 1998; Rhode and Duffy, 2004), so we encourage collection of material from multiple sites. The individuals should be planted 10-20 cm deep and immediately surrounded by enclosures. These colonies should be established during the summer, in July for optimum light exposure.
Figure 3. Map of Volusia Blue Spring showing potential restoration sites for *V. Americana*.

**Monitoring**

Once the *V. americana* restoration has been implemented, it will be necessary to monitor the population(s). A count of the initial number *V. americana* sprigs and repeated counts of the number of sprigs every month would allow managers to track population changes. This monitoring should be done until managers can conclude that the population is viable and that the *V. americana* restoration has been successful. If it seems the restoration is a success, monitoring can be extended to every two months, then every three months, etc. If it seems that the restoration is not working, depending on the severity of population decline, it may be best to change the approach of restoration or abandon the project all together. Furthermore, if the populations are declining, it would be beneficial to know why – whether it is due to predation, or insufficient habitat conditions. Possibly, these conditions can be adjusted to benefit the *V. americana*. 
Literature cited


