# A Summary of the Panama City Crayfish, *Procambarus econfinae* Hobbs, 1942

Panama City Crayfish *(Photograph by Lisa A. Keppner)*

Prepared by: Edwin J. and Lisa A. Keppner

For: The Candidate Conservation Agreement with Assurances

October 2004

## Executive Summary

The Panama City Crayfish, *Procambarus* (*Leconticambarus*) *econfinae* was described in 1942 from two sites in a small area of Bay County, Florida. It was located at an additional site in 1986 and rediscovered in the year 2000. During 2000-2003, additional populations were located in about 33 square miles of Bay County bordered on the west by St. Andrew Bay, the north by the south shore of North Bay, the south by the north shore of East Bay, and the southeast and east by Callaway Creek and its tributaries. During 2003, the east and southeastern boundaries were better defined as Callaway Bayou and Callaway Creek, The northeastern boundary was extended eastward to the end of Nadine Drive in 2003, and the range was, therefore, extended to about 43-45 square miles.

The species is currently known from 801 of the approximately 2095 sampling locations in urban roadside ditches, power line easements, peoples yards, and on the St. Joe Company property within the known range of this species. The natural habitat appears to be depressions in flatwoods on hydric soils that have surface water during the wet season and are dry during the dry season. The water table in these soils remains near the surface under dry conditions. This species is a secondary burrower in appropriate hydric soils and appears to prefer those soil types that support herbaceous vegetation. Closed canopy forests and shrub areas, and those areas with a deep layer of ground litter or duff on hydric soils appear to be unsuitable habitat.

Little is known of the life history of the PCC beyond the incidental observations made during the surveys for the location of populations. The PCC has been listed as a Species of Special Concern since 1989 (facing a moderate risk of extinction in the future) by the Florida Fish and Wildlife Conservation Commission. The PCC is not listed by the U.S. Fish and Wildlife Service under the Endangered Species Act. Non-regulatory organizations that have assessed the status of the PCC include the Florida Natural Areas Inventory (globally imperiled and imperiled in Florida), the International Union for the Conservation of Nature (Endangered), and the American Fisheries Society (Endangered). The classifications are based on the small range, threats to survival, and absence of knowledge of distribution within its range.

The threats to the continued survival of the PCC include alteration of their habitat due to human activities associated with the conversion of habitat to residential, commercial, and industrial use. The maintenance of existing infrastructure and addition of new infrastructure required to support the growing human population within the range of the PCC also provides a threat to their survival. This includes alteration of its ditch habitat, storm water ditching, new roads, widening of existing roads, and, possibly, the use of pesticides and herbicides. Silviculture activities also pose a threat to the habitat for the PCC through ditching for drainage, bedding of pines, and controlling fire. Pollution may also pose a threat to the species, as well as harvesting of the species. Introduction of non-native crayfish is also a possible threat.

The Candidate Conservation Agreement with Assurances (CCAA) is a method provided in the U.S. Endangered Species Act to provide for the continued existence of a species in the absence of formal listing under the Endangered Species Act. Participants in the CCAA process that become signatories to the plan and will voluntarily agree to manage their lands to remove threats to the existence of the PCC will receive assurances that their conservation efforts will not result in future regulatory obligations in excess of those agree to at the time of their entrance into the CCAA.

**Introduction**. The following is a summary of the existing information regarding the Panama City Crayfish (PCC). The PCC is known only from a small area in Bay County, Florida and nowhere else on Earth. Franz and Franz (1990) provided a review of the crayfish fauna of Florida and stated that Florida has one of the richest crayfish faunas in North America with 50 species in six genera, provided a list of the species, and provided information regarding their regional distribution in the state.

**History and Taxonomy.** Dr. Horton Hobbs of the University of Florida surveyed northwest Florida for species of crayfish in 1938. Hobbs (1942) published the results of that survey in a large document that included a wealth of information regarding the species of crayfish in northwest Florida, their ranges, their migrations, and manner in which populations became isolated and evolved into new species. Descriptions of a number of new species of crayfish and redescriptions of other species were also included in this document. One of the new species described was *Procambarus econfinae* that he collected from two sites in a small area of Bay County, Florida. Hobbs (1988) provided the type locality for the PCC as flatwoods between the railroad and U.S. Highway 231 in Section 33, Township 3 south and Range 14 west.

Hobbs (1972) subdivided the species of crayfish in the genus *Procambarus* in North America into subgenera and placed *P. econfinae* in the subgenus *Leconticambarus*. The full scientific name of the species became *Procambarus* (*Leconticambarus*) *econfinae*, and the validity of the species has not been challenged taxonomically since its description. It is one of the few species of crayfish that has an accepted common name, the Panama City Crayfish.

There were no reports of this species from the time of Hobbs' collections in 1938 until about 1986 when Mr. Paul Moler of the then Florida Game and Freshwater Fish Commission collected this species near the junction of County Road 390 and County Road 389 in Bay County. It was about this time that the common name Panama City Crayfish was attached to this species and it was included in the first report by Deyrup and Franz (1974) and in the second report by Mansell (1994) of the rare and endangered biota of Florida. According to NatureServe (2003) the species was considered to be extinct until the collection by Moler, and the only known site (that of Moler).

**Description.** Some of the species of crayfish in the genus *Procambarus* are quite similar in appearance and are difficult, if not impossible, to separate from the other species based on the general appearance alone. However, the upper (dorsal) side of the PCC is brown with two black stripes down the abdomen, and the sides are lighter brown with rusty colored dots. They grow to about 3 inches long. Accurate identification of the species requires the examination of the external reproductive structures of the reproductively competent male. This is best achieved with the aid of a stereoscopic microscope. The first two pairs of the swimmerets on the underside of the abdomen of the male are modified for the transfer of sperm to the female during mating. It is the shape of the first pair of these structures that provides accurate identification to the species level. Further complicating the identification of the species, the males in the genus *Procambarus* alternate between sexually competent forms (Form I males) and sexually incompetent males (Form II males). It is the anatomy of the first pair of pleopods (swimmerets) of the Form I males that provides the best identification.

**History of Surveys for the PCC.** In 2000, curiosity regarding the possible extinction of this species led two members of the St. Andrew Bay Environmental Study Team (BEST) to conduct a preliminary, volunteer survey for this species at the previously recorded sites (Keppner and Keppner 2000). The purpose of the survey was to attempt to locate and examine the sites mentioned by

Hobbs and Moler. As stated above, Hobbs reported the species from two locations along and near Highway 231. The species was found at a site thought to be one of the original locations (type locality) now on Industrial Drive in Section 33, Township 3 south and Range 14 west as stated by Hobbs (1988). Hobbs' second site, as near as one can estimate, was on the east side of Highway 231 south of Bayou George, but it could not be located. The species was also collected at the Moler site south of County Road 390 on County Road 389.

The volunteer report was submitted to the U.S. Fish and Wildlife Service (FWS) and the Florida Fish and Wildlife Conservation Commission (FFWCC) in 2000. The rediscovery of the existence of the PCC led to a more extensive survey supported by a FWS grant to BEST. Both surveys were restricted to roadside ditches and power line easements primarily but yielded a number of new locations within the range of this species as proposed by Hobbs in 1942. The reports were submitted to the FWS and the FFWCC (Keppner and Keppner 2001 & 2002).

**St. Joe Company Survey.** A survey commissioned by the St. Joe Company during 2003-2004 on their land in Bay County within the known range of the PCC to attempt to define the eastern boundary of the range of this species and to locate additional populations of the PCC on St. Joe Company property. The survey was conducted on about 22.5 square miles of land owned by the St. Joe Company about 15 square miles of which is located within the known range of the PCC (Figure 1). Certain areas of the land on this property within the range of the PCC are being considered for inclusion in the Candidate Conservation Agreement with Assurances as the St. Joe Company's enrolled property.

The survey involved the sampling of 2060 locations, and the PCC was observed at 785 of the sampling locations (Figure 2). Each sampling location was recorded as latitude and longitude, the general habitat was described, and the soil type at the sampling location was obtained from soils maps of Bay County. A subjective estimate of population density at each positive sampling location was accomplished by counting the number of specimens captured in five sweeps of the net. Each sweep of the net was approximately five feet long when the size of the location permitted or less if the location was smaller than five feet in length. The sampling location was recorded as sparse if 1-2 specimens were collected, as moderate if 3-5 specimens were collected, and as abundant if more than five specimens were collected in the five sweeps of the net. Many factors serve to effect this method, therefore, it is subjective. Figure 3 shows the positive sampling locations and the relative abundance at each location. The following sections include the additional information obtained during the St. Joe Company survey.

**Distribution.** Hobbs' hypothesis in 1942 was that the boundary of the range of the PCC was St. Andrew Bay on the west and unsuitable, well-drained soils on the southwest; North Bay and a band of unsuitable, well-drained soils formed the northern boundary; and the north shore of East Bay was the southern boundary. These boundaries appear accurate based on collections of species of crayfish outside of these boundaries and the surveys conducted within these boundaries. It was the eastern boundary of the range of the PCC that Hobbs did not establish with certainty. Hobbs stated that the eastern boundary may be the brackish nature of the small creeks in this area and the marshy Wetappo Intracoastal Canal that prevented an eastward migration of the PCC.

Figure 1 shows one of the ways of depicting the known limits of the range and the known locations at which the PCC has been collected to date. Where the line is drawn on the map depends on one's goal for the total known range. The line shown includes about 43-45 square miles. Some of the positive locations for the PCC, as indicated on Figure 4, have been lost completely due to human

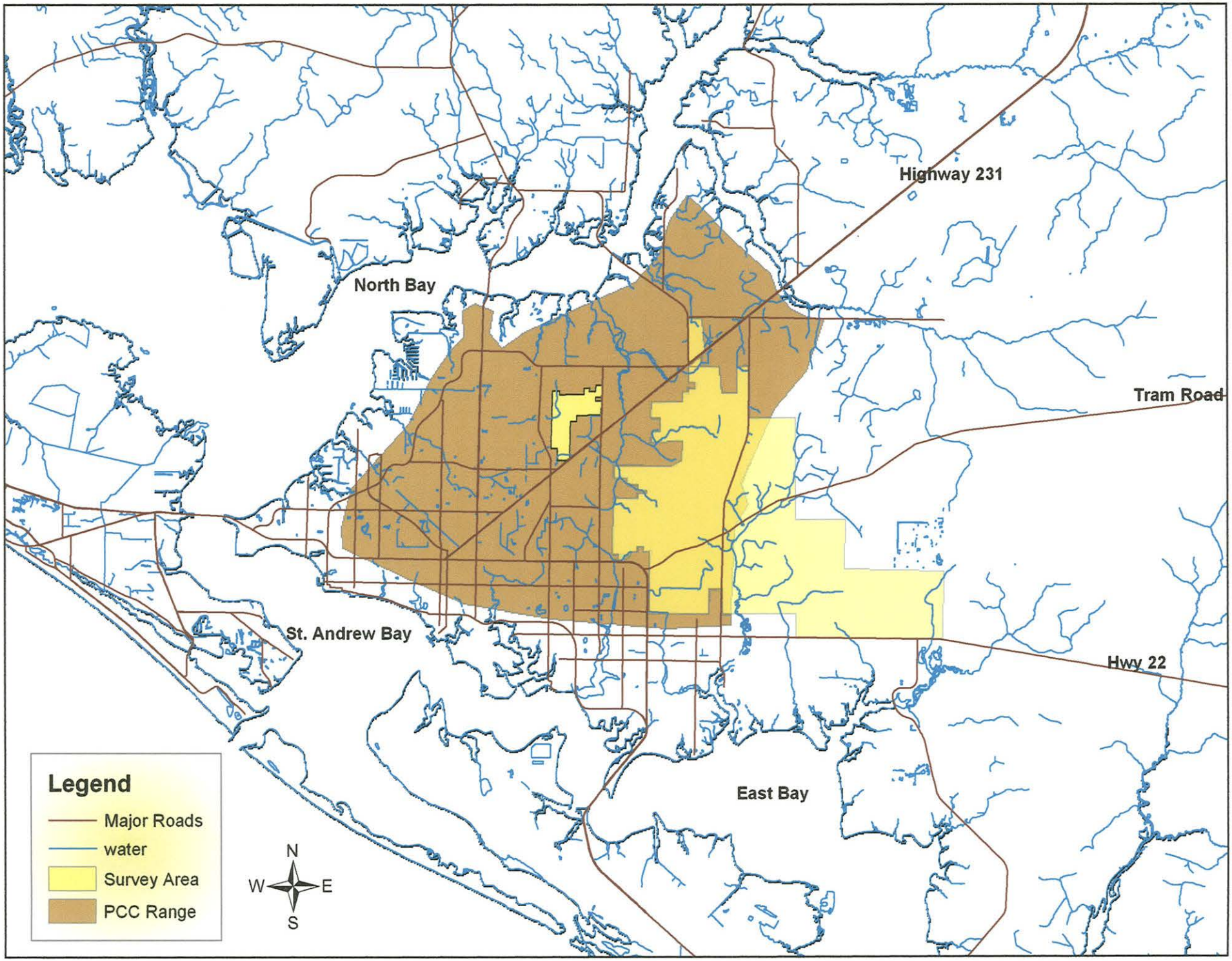
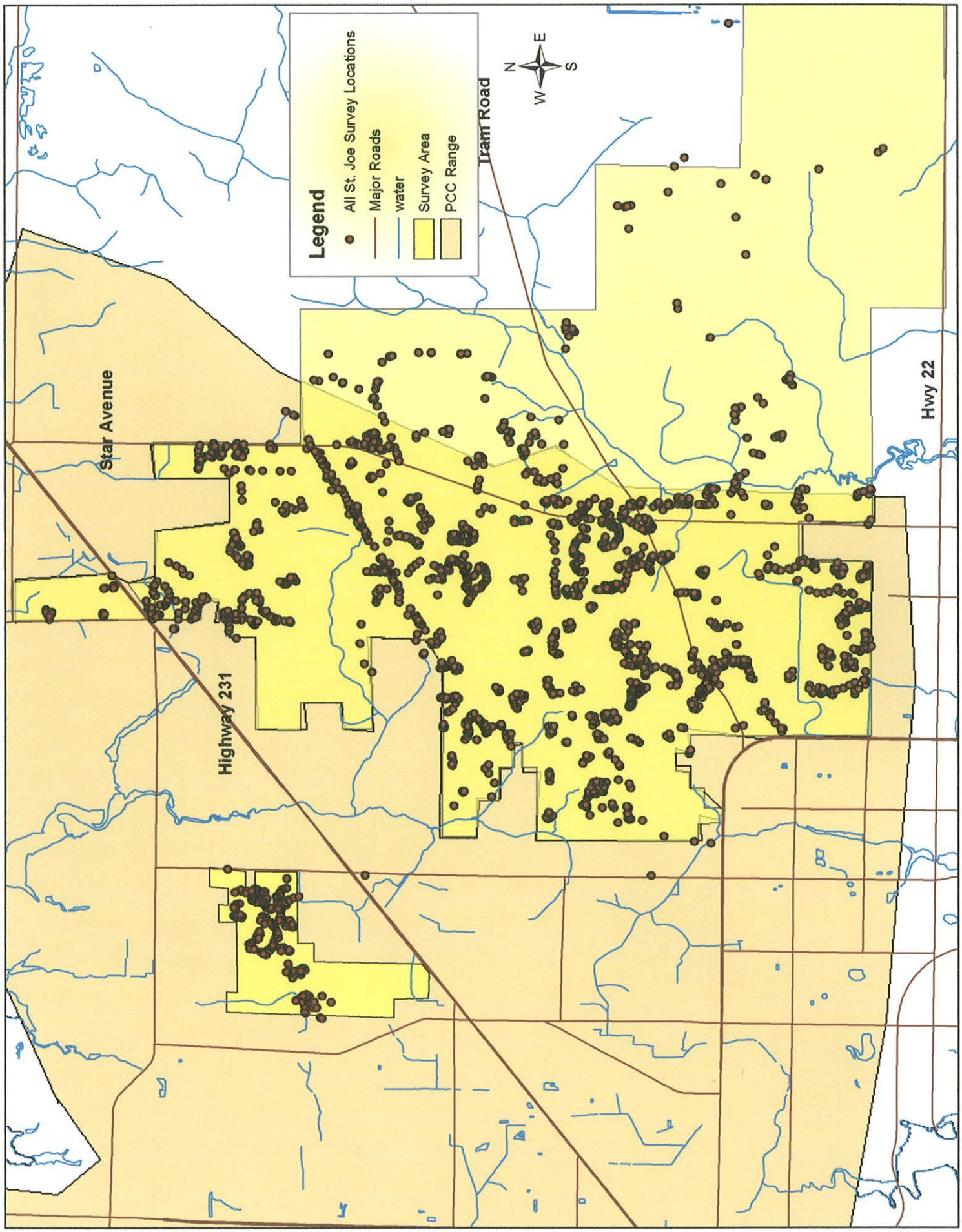
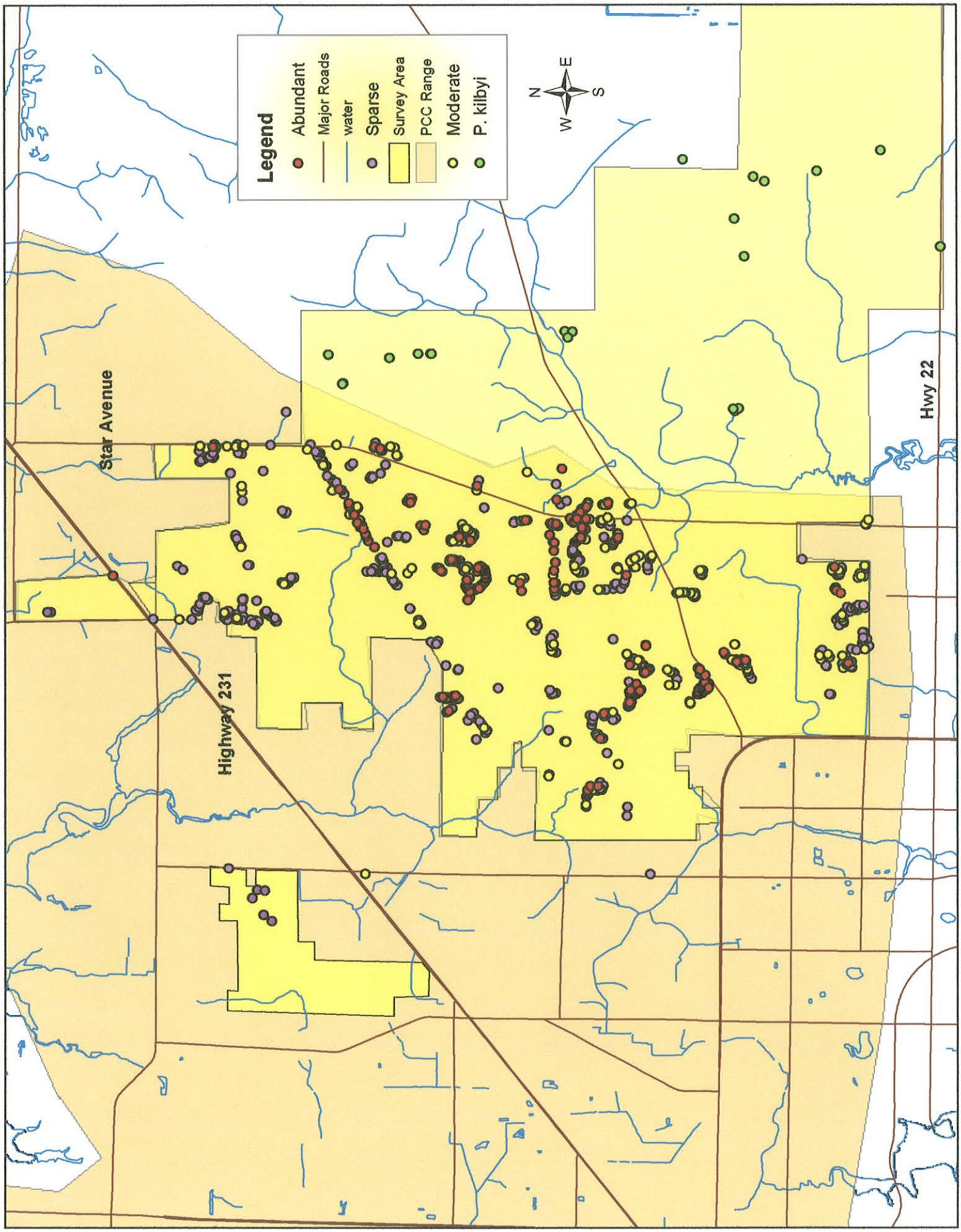



Figure 1. PCC Range and St. Joe Survey Areas

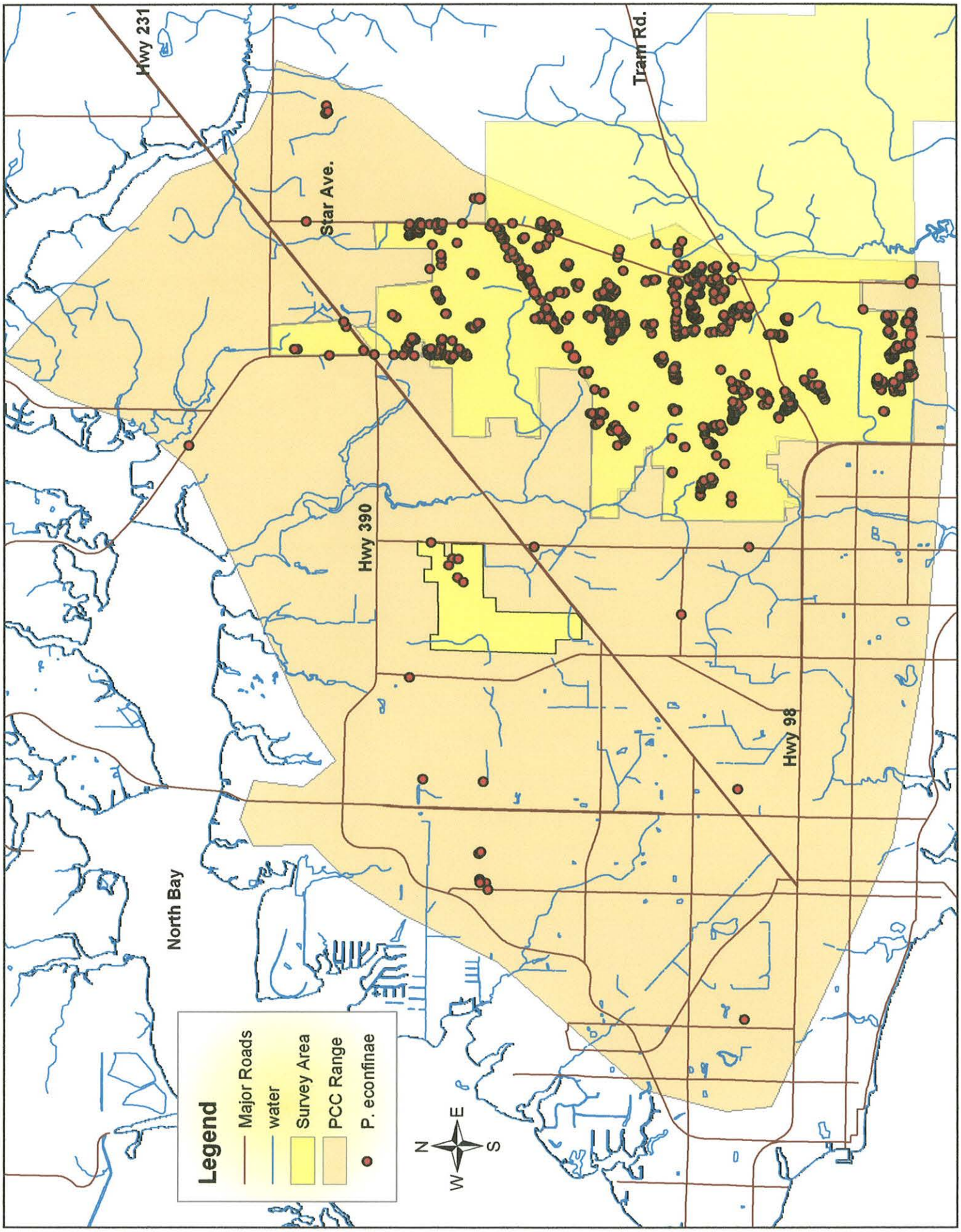
## Figure 2. Sampling Locations In St. Joe Survey Area



## Figure 3. PCC Sampling Locations by Abundance



## Figure 4. All Known PCC Locations



alteration, some are threatened by human alteration, a few have been permitted for loss or alteration, and some may have succumbed to the drought after they were surveyed.

The surveys conducted to date indicate that the southeastern and eastern boundary of the range of the PCC is Callaway Bayou and Callaway Creek and its tributaries rather than Wetappo Creek. This is based on the existence of another species of crayfish that occupies essentially the same habitat as the PCC east of Callaway Bayou and Callaway Creek and its tributaries. This is a more common and widespread species of crayfish, *Procambarus kilbyi*. The boundary on the northeast has not been established but may be the unsuitable, well-drained soils located in this area between Bayou George Creek and Callaway Creek headwaters. Unpublished records of sampling north of North Bay and north of West Bay (along Highway 388 and Highway 2300,) the length of Highway 388 from Highway 77 to Highway 231, the length of Highway 20 across the county, and north along Highway 231 north of Bayou George yielded species of crayfish different from the PCC.

**Sampling Locations.** The known surveys for the PCC to date including the St. Joe survey resulted in 801 individual known sampling locations that were positive for the presence of the PCC. However, not every possible habitat for the PCC has been surveyed within this species known range. Additional positive locations undoubtedly exist in the urbanized areas and rural areas within the range and the St. Joe survey area.

A "sampling location" is defined for this discussion as a place where sampling occurred and a sampling location is a place where the PCC was found. There may be a number of positive sampling locations in a small area of habitat to delineate the area of the particular habitat that was supporting the PCC at the time of sampling. This includes the ditch habitats of the urban areas and the more natural habitats in the St. Joe Company survey area. The St. Joe Company survey indicates that the portion of the survey area within the range of the PCC is a large population of the PCC interconnected by the hydric soils that support the habitat of this species. Therefore, it is more difficult to delineate specific areas of occurrence as a specific site for management purposes. If one examines the sampling locations on the St. Joe Company property, one can arbitrarily delineate areas of occurrence in a number of ways.

The records of occurrence of this species in the ditches in the urban area represent a varying number of sampling locations within a length of ditch. Which of these ditches are interconnected and which are not, was not determined. As a result each ditch sampling location is an individual record of occurrence even if the population may be interconnected with another through varying lengths of ditches. However, the sampling locations are, for the most part, sufficiently distant from one another to justify them as individual records of occurrence. Figure 4 shows all known sampling locations for this species. There are about 31 known ditch locations for this species in the urban area. Some of the urban area locations have been altered and possibly lost and some have been lost.

**Habitat.** Hobbs (1942) categorized the species of crayfish in northwestern Florida in a number of ways. One way was by their burrowing habits. Primary burrowers are almost entirely restricted to their burrows. These burrows can be deep and extensive with a number of side chambers. Secondary burrowers occupy burrows when surface water is absent but are normally in the surface water when it is present. Their burrows are usually rather straight burrows to the water table, but a side chamber may occasionally be present. Tertiary burrowers are species of rather permanent water bodies and dig a burrow only during droughts or occasionally during the breeding season. Hobbs (1975) discussed certain morphological characters of three classes of burrowers.

Hobbs (1942) believed the PCC to be a secondary burrower in flatwoods depressions where surface water is present during the rainy season and the water table, though subsurface, remains high during the dry season. Observations to date appear to support this statement. The recent surveys were directed at soil types rather than vegetative habitat types. Hydric soils including those mentioned by Hobbs (1942) were marked on a soil map of Bay County, and those soil types were examined where possible. The PCC appears to prefer certain hydric soils that support herbaceous vegetation rather than forested or shrub dominated areas growing on the same type of soil. Plants observed in PCC habitat include a variety of wetland herbs and forbs including redroot, beakrushes, panic grasses, pitcher plants, sundews, butterworts, lilies, and other broad leaved and narrow leaved species. When encountered in dense titi swamps, the PCC were associated with ponded areas open to the sun with some herbaceous vegetation. The densest populations observed to date occurred in open areas almost or entirely without woody vegetation and an abundance of herbaceous vegetation. The sparsest populations occurred in small open areas with shrubs or trees with closed canopies or in furrows between bedded pine plantation rows before closure of the canopy.

The best examples of the supposed natural habitat observed included a flatwoods depression with a central cypress dominated pond around which a fire recently occurred within an area of planted pine trees. The fire opened up the canopy allowing the sun to reach the ground. This has resulted in a variety of herbaceous plants in the shallow water adjacent to the pond and extending out from the pond. PCC were very abundant in the shallow surface water among the dense herbaceous vegetation extending from the pond. They were sparse at the edge of the pond itself where the water was deeper and the emergent herbaceous vegetation was sparse. The permanent, deep water in the pond was dominated by another species of crayfish adapted to permanent water (a tertiary burrower).

Another area where the this species was extremely abundant during each visit is a large area of hydric soils where the bedded pines had failed to grow or survive and was dominated by herbaceous vegetation with a dense carpet of creeping rush (*Juncus repens*) in the standing water between the furrows produced when the area was planted with pine trees. The Gulf Power Company power line right-of-ways also support good populations of this species and dense populations of the PCC in the appropriate soil types. Gulf Power manages these right-of-ways to control the growth of woody vegetation while maintaining the herbaceous vegetation apparently conducive to the PCC.

This species has been rarely observed in small open areas in dense titi and St. John's-wort swamps, but when so observed the canopy was open at least to a degree and herbaceous vegetation was present. The PCC has also been rarely found in appropriate soils with heavy ground litter of pine needles or leaves. Roadside ditches with sloping sides (swales) are also habitat for the PCC whereas box-cut ditches do not appear to be habitat for this species. This species is most abundant in those swales that are dominated by herbaceous vegetation. Many of the best ditches, so to speak, are dominated by the non-native torpedograss (*Panicum repens*) while others such as those along Star Avenue support a variety of native species.

The soil types that support the habitats of this species are hydric soils that are seasonally inundated and maintain a relatively high water table when not inundated. Table 1 lists the soil types from which the PCC was collected during all of the above referenced surveys from Duffee et al. (1983).

**Table 1. Soil Types Supporting the PCC within the Known Range**

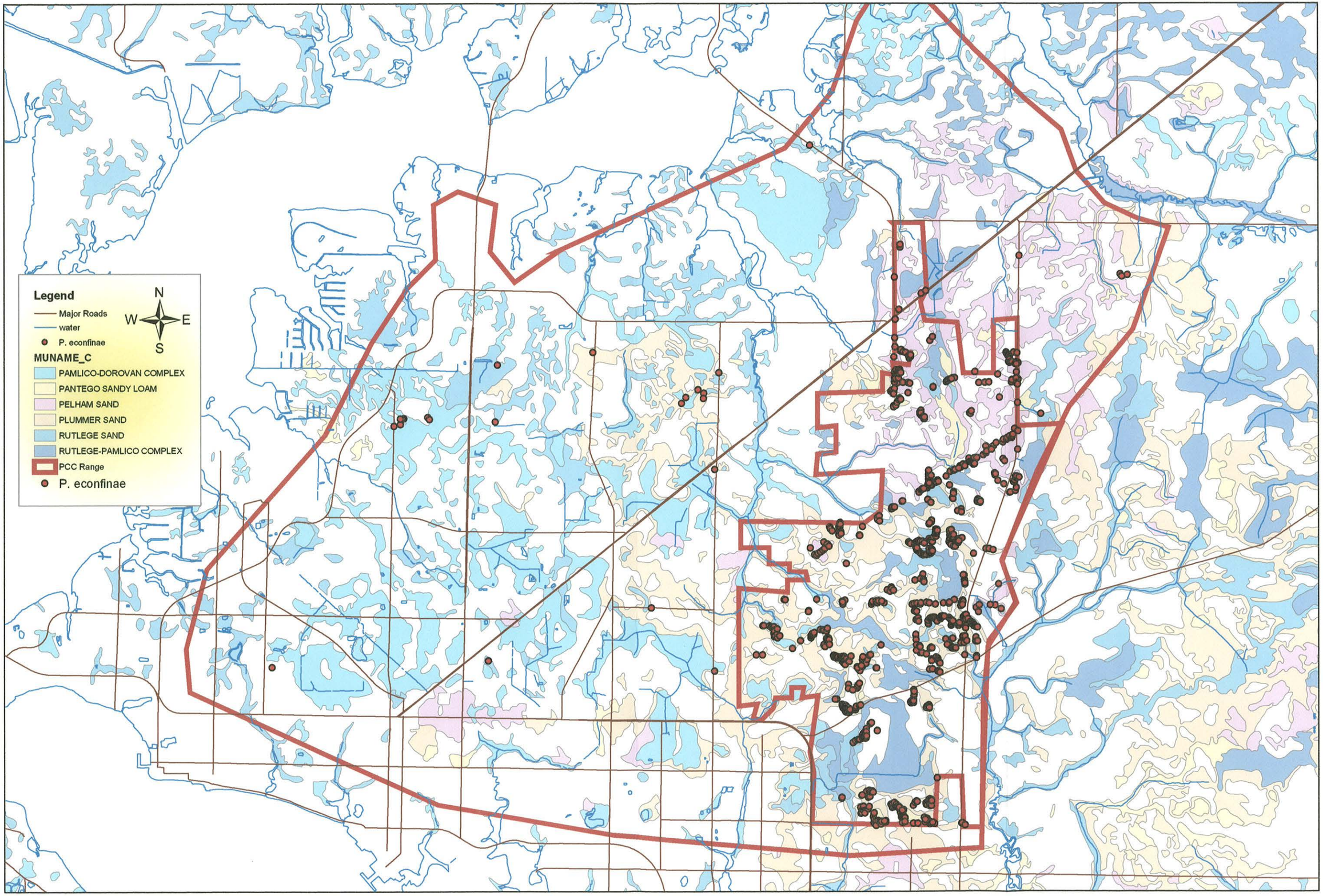
| Soil # | Soil Name | Characteristics |
|---|---|---|
| 1 | Albany Sand | Somewhat poorly drained along defined drainageways and on areas leading to lower wet areas, water table at depth of 18-30 inches for 1-3 months. |
| 12 | Leefield Sand | Somewhat poorly drained nearly level soil in wet areas along drainageways in flatwoods. Water table at 18-30 inches for about 3-4 months. Irregularly ponded. |
| 13 | Leon Fine Sand | Poorly drained, nearly level soil in flatwoods, water table within a depth of 10 inches for up to 4 months each year, 10-40 inches the remainder of year. |
| 22* | Pamlico-Dorovan Complex | Very poorly drained, depressional areas along low gradient drainages, ponded after flooding for 4-8 months, water table at 10 inches each year. |
| 29* | Rutlege Sand | Very poorly drained, level to slightly depressional areas along drainages, ponded 4-6 months, water table at or near surface 4-6 months each year. |
| 31 | Osier Fine Sand | Poorly drained, nearly level or slight depressions and flatwoods slopes, ponded 2-4 months, water table within 10 inches 3-6 months each year. |
| 32* | Plummer Sand | Poorly drained, low-lying areas and poorly defined drainages, ponded for brief periods, water table within 10 inches 3-6 months each year. |
| 33* | Pelham Sand | Poorly drained, slight depression, flats along poorly defined drains, brief periods of flooding, water table within 15 inches 3-6 months each year. |
| 36 | Alapaha Loamy Sand | Poorly drained, nearly level in wet depressions along poorly defined drainageways in flatwoods. Water table less than 15 inches for 3-6 months, brief flooding when water table is high. |
| 39* | Pantego Sandy Loam | Very poorly drained in wet depressions and poorly defined drainageways in flatwoods and moderately well defined drainageways in uplands. Water table at less than 15 inches for 3-6 months, depressional areas ponded for 1-3 months. |
| 51* | Rutlege-Pamlico Complex | Very poorly drained, frequently flooded, drainage ways and wide depressional areas, flooded about 3-6 months each year, water table within about 20 inches of surface. |

* = considered "core soils"

Core soils are those soil types that supported the PCC during the drought and during the normal dry seasons (Figure 5). The locations in Albany sand and other less hydric soil types are in ditches or in small depressions in these soil types. They are not considered to be core soils at this time, because return visits to a few of these locations, after the initial observations of the PCC at the locations with surface water, revealed the absence of surface water and absence of burrows.

A large area of Plummer sand was observed in the St. Joe survey area at which the substrate was a brown, "soupy" material and the PCC was absent throughout the large area of this substrate. The area was almost free of woody vegetation and the herbaceous layer was dominated by Walter's sedge (*Carex walteriana* = *striata*). One would have expected the PCC to be abundant in this area; however, the few sampling locations that yielded this species were at the edges of the area in a different type of substrate within the same soil type. The "soupy" consistency of the substrate may have some deleterious effect on the ability of the species to burrow and maintain the opening of the burrow to the surface. Other restricting conditions may also be present that are not conducive to the PCC.

Fig 5 Core Soils and PCC Locations



In summary, observations support the idea that the PCC prefers certain hydric soils that are conducive to their burrowing during the dry season, and that they prefer open areas with little to no woody vegetation and an abundance of herbaceous vegetation. The PCC has been observed in hydric soils in roadside ditches and swales, hydric soils in flatwoods, savannahs, in people's yards, and along power line right-of-ways. Of course there are exceptions to the general rule.

**Drought**. The 2000 through 2002 surveys were conducted during a rather severe drought that began about 1998. The St. Joe Company survey was conducted during a period of normal to greater than normal rainfall in parts of the range of the PCC that commenced in the spring of 2003. One could consider the results of the drought survey to have identified most core habitat types or those habitats in which the species survives under the adverse conditions of drought. The St. Joe Company survey could be considered as identifying those habitats occupied under average to better than average conditions regarding presence and duration of surface water and depth to the water table. The core habitat appears to be the key to the long-term survival of the PCC, because drought will return, and the populations that are now occupying marginal habitat will again be reduced or lost until the end of the drought. This was observed during the St. Joe Company survey as the high water of the summer receded and the water table fell in certain non-core habitats and soils.

**Life History.** The life history of this species is not well known. The surveys conducted to date were limited to finding locations where the PCC lives and attempting to generally characterize those habitats. Quantitative studies of population densities and the life history were not part of the surveys. As a result, there is only anecdotal information regarding breeding seasons, seasonal occurrence of juveniles, dispersal of adults and juveniles, fecundity, and population density in relationship to normal seasonal surface water fluctuations.

***Reproduction.*** Hobbs (1942) stated that he observed females with eggs in June 1938 and collected a female with young from a burrow in June 1938. A male was present in the same burrow with this female. He stated that this was the only species that he had collected in which a female with young was accompanied by a male. Keppner and Keppner (2002) reported recovering a female with eggs from a burrow in March of 2002. A female with young was taken from a burrow in early in September of 2003 and another female that was in berry was netted from surface water at the end of September 2003. These observations indicate that the PCC can produce young, at least, between March through September. However, based on the netting of juveniles, the PCC appears to be able to produce young from March through December under suitable conditions. Juveniles about the size that leave the female swimmerets (from 15-25 mm in length) were collected a number of times in December 2003 during the St. Joe Company survey. However, the number of juveniles encountered decreased from September through December (seasonal dry period). The number of juveniles and the population density in general was reduced again during the normal, seasonal dry conditions experienced from April through May based on previously visited locations with surface water presentt.

***Food Habits.*** Information specific to food habits of the PCC and related species was not located. Momot (1995) discussed the role of crayfish in aquatic ecosystems and their food habits. Crayfish have been referred to as scavengers, but are principally detritivores/herbivores and can be keystone predators according to Momot. Observations on PCC held in aquaria indicate that they are detritivores and herbivores. Specimens were offered dead minnows, but avoided them in favor of processing the substrate for particles of prepared fish food and the fresh aquatic vegetation that was also provided as a food source.

***Dispersal of Juveniles.*** During the heavy rains that occurred at the beginning of the St. Company survey, juveniles (from 15-25 mm in length) were observed being carried by sheet flow across various soil types and habitats along the power lines and in ditches along the dirt roads in the survey area. Juveniles were netted in depressions in the dirt roads in a variety of soil types both hydric and non-hydric. It is possible that the roadside ditches serve as conduits for dispersal though dry soils and the periods of heavy rains also carry juveniles from one area to another to colonize favorable habitats or become trapped and die in unfavorable habitats after the surface water recedes.

***Seasonal Dry Periods.*** The area within the range of the PCC experiences seasonal dry periods in the spring and fall. One such dry period occurred during April to June of 2004 during the St. Joe Company survey. Locations were revisited that supported moderate to abundant populations of the PCC when surface water was present. These revisited locations were dry with very few large burrows at the edge of and just below the high water mark. Burrows the size of which one would expect juveniles to construct were not observed, and excavation of the substrate did not yield juveniles of this species. The fate of the numerous juveniles that were present during the first visits to the locations is not known with certainty. Predation may have played a role as discussed below. The indication is that the abundance of the PCC at any site varies with the season and rainfall.

***Predation.*** It was observed at the revisited locations discussed above that there was an abundance of scat from an unknown animal not observed previously in the vicinity of these dried locations. The scat consisted almost entirely of crayfish exoskeletal parts (Figure 6). It is hypothesized that as the surface water receded, the crayfish were concentrated and became easy prey for predators such as raccoons and wading birds. The adult crayfish appeared to have burrowed before the surface water receded appreciably. These large burrows located near the high water mark that contained adults may serve as the source for rebuilding the population in the habitat when surface water returns.

***Burrows.*** The burrows excavated by the PCC are straight to somewhat angled and reach the water table. Adults were recovered during the drought surveys at a depth of at least 30 inches. Two adult specimens were retrieved from a single burrow during the surveys aside from the females with eggs or juveniles. Side chambers were not noticed in the burrows dug during the surveys. The chimney of the PCC burrows is constructed of distinct mud balls (Figure 7). These chimneys can be washed flat by rain and become difficult to observe in dense vegetation. Adults were returned to their burrows that were excavated by hand during the St. Joe Company survey and two were revisited after return of the specimens to their burrows. In both instances, there were mud balls at the opening of the burrow indicating that the individuals had survived.

**Associated Species of Crayfish.** The present and past surveys for the PCC included the netting of flowing water ditches as well as still water pools in hydric soils and surface water wherever encountered regardless of soil type. They did not include permanent standing bodies of water (lakes and ponds) or large creeks and streams or portions of creeks that were influenced by the tide. Burrows were dug to obtain specimens in areas without surface water. Two other species of crayfish were collected within the range of the PCC during the cited surveys as well as outside of the range of this species. *Procambarus* (*Hagenides*) *rogersi* intergrades (no common name), a primary burrower, was collected from a variety of soil types and survives in the more well drained soils as well as at the edges of PCC habitat. *Procambarus* (*Ortmannicus*) *pycnogonopodus* (no common name) is a widespread tertiary burrower and inhabits more permanent water bodies and flowing water. A few specimens of the PCC were collected a few times in flowing water ditches or standing water that

Figure 6. Scat from a predator with crayfish parts.

Figure 7. PCC Burrows.

also contained *P. pycnogonopodus*.

**Associated Species of Protected Vascular Plants.** A number of species of vascular plants listed as threatened or endangered by the State of Florida were observed occupying the habitats of the PCC. Table 2 is a list of the plants observed in association with PCC habitat during the surveys.

**Table 6. Species of Listed Plants from the Survey Area.**

| Family | Species | Common Name | State | Federal | FNAI |
|---|---|---|---|---|---|
| Amaryllidaceae | *Hymenocallis henryae* | Henry's Spiderlily | E | n/a | S2 |
| Asteraceae | *Verbesina chapmanii* | Chapman's Crownbeard | T | n/a | S3 |
| Droseraceae | *Drosera intermedia* | Water Sundew | T | n/a | S3 |
| Gentianaceae | *Gentiana pennelliana* | Wiregrass Gentian | E | n/a | S3 |
| Lentibulariaceae | *Pinguicula planifolia* | Chapman's Butterwort | T | n/a | n/a |
| Liliaceae | *Lilium catesbaei* | Pine Lily | T | n/a | n/a |
| Orchidaceae | *Platanthera nivea* | Snowy Orchid | T | n/a | n/a |
| Orchidaceae | *Pogonia ophioglossoides* | Rose Pogonia | T | n/a | n/a |
| Poaceae | *Dichanthelium nudicaule* | Naked Stemmed Panic Grass | T | n/a | S3 |
| Sarraceniaiceae | *Sarracenia psittacina* | Parrot Pitcherplant | T | n/a | n/a |
| Sarraceniaceae | *Sarracenia purpurea* | Purple Pitcherplant | T | n/a | n/a |

**Protection of Rare Species.** The State of Florida maintains a list of species of plants and animals that are in need of, and meet the criteria established for protection. The FFWCC lists species of animals considered deserving of protection as Endangered, Threatened, and Species of Special Concern. The PCC has been listed as a Species of Special Concern since 1989, but a management plan was not written for the species until recently.

The FWS is the federal agency responsible for rare species in the United States. The Endangered Species Act provides the authority to list and protect species that meet the criteria of the Act. The two regulatory listings under the law are Endangered and Threatened. The FWS also maintains a list of Candidate (C) species and species of management concern (MC) as well as other designations. The latter two categories do not have official status under the law but provide for methods to react to concern for rare species before official listing under the Act occurs. A CCAA is one of those methods. The PCC is currently listed as MC, but meets all the criteria for a ranking of Candidate and probably for inclusion as Threatened or Endangered under the Act.

The Florida Natural Areas Inventory (FNAI) maintains inventories and tracking lists of the species of rare plants and animals in Florida and tracks those species listed by the state and federal governments. In addition, FNAI ranks and tracks rare species according to their own criteria. The FNAI rankings include a global rank and a state rank. The PCC is ranked by FNAI (2002) as G1 (imperiled globally) and S1 (imperiled in Florida). Hipes et al. (2000) provided a summary of the knowledge of the PCC through the year 2000.

NatureServe (2003) provided the following additional information: *Procambarus (L.) econfinae* is given a National Conservation Status Rank of N1 (endangered in the nation), International Union for the Conservation of Nature (IUCN) lists the species as endangered, and the American Fisheries Society lists this species as endangered (Taylor et al., 1996).

**Reclassification of the PCC.** In August 2001, a petition was submitted to the FFWCC to reclassify the PCC from a Species of Special Concern to Threatened. The petition was accepted, and a Biological Status Report (2002) was prepared by the Commission staff. This report was based on

the then known information. Following acceptance of this report, a management plan (FFWCC, 2003) for the PCC was drafted and circulated for public comment. A Public Notice was published in the Florida Administrative weekly with a comment period ending on February 10, 2003. The management plan identified the PCC as meeting two of the criteria of Endangered as well as other criteria for Threatened based on the then available information. Subsequent information has expanded the range of this species to meet the threatened criterion. The management plan relies heavily on the completion of a Candidate Conservation Agreement with Assurances that would provide the means to protect this species from extinction.

The FFWCC Commissioners delayed action on the acceptance of the management plan until May of 2003 then further delayed a decision to November 2003 at which time the Commissioners further delayed action on the petition to an unknown date after November 2004. The management plan was signed by the Executive Director of the FFWCC, and those elements of the management plan within the Executive Directors authority to implement are available for implemetation. The information gathered during 2002 for the FWS and the by the St. Joe Company was not available at the time of preparation of the management plan.

Recently, a petition was been submitted to the FFWCC to delist the PCC. Delisting removes the protective measures provided by the formal listing by the state as Endangered, Threatened, or a Species of Special Concern. Delisting at the state level, however, does not preclude the listing of a species by the FWS under the Endangered Species Act. To date, a petition for listing of the PCC under the Endangered Species Act has not been received by the FWS. A Candidate Conservation Agreement with Assurances (CCAA) exercise is underway to reduce or eliminate the necessity of listing the PCC under the Endangered Species Act through the provision of sufficient guarantees of survival of the species. Regulatory benefits accrue to those who participate and sign the final CCAA agreement. However, the successful completion of the CCAA does not assure that this species will not be listed under the Endangered Species Act in the future.

**Threats.** A part of the process of listing a species by the state and/or federal government and the CCAA process is the examination of the threats that exist to the survival of a species, the PCC in this case. Taylor et al. (1996) evaluated the species of crayfish in the United States regarding their susceptibility to decline in populations and/or extinction and stated that species of crayfish are susceptible to destruction, degradation, or alteration of habitat; chemical pollution: over exploitation; and introduction of non-indigenous species. Gilpin and Soule (1986) provide an interesting discussion on some aspects of species extinction that may be applicable to the PCC. They stated that small natural range size is implicated as a factor underpinning potential or realized imperilment.

Bay County has been growing at a steady and fairly rapid rate for the past 20 years and is currently poised for rapid development of the remainder of the known range of the PCC. The threats to the continued survival of the PCC are primarily human activities. The known locations of populations of the PCC, as stated above, are primarily in roadside ditches, power line right-of-ways, openings in land used for silviculture, and home owners' yards. Figure 8 is an aerial photograph from 1941 of the area from east of Highway 77 eastward to east of the current Transmitter Road (not present in 1941). The known locations for the PCC are included on the map. Figure 9 is a 2003 aerial photograph of the same area with the same PCC locations. Changes in the extent of development are demonstrated.

The examination of threats to the PCC is, by necessity, a negative activity. However, the PCC has survived with certain activities, and those activities that have allowed survival for extended periods

**Figure 8. Central Bay County, 1941 with Current PCC Sites**

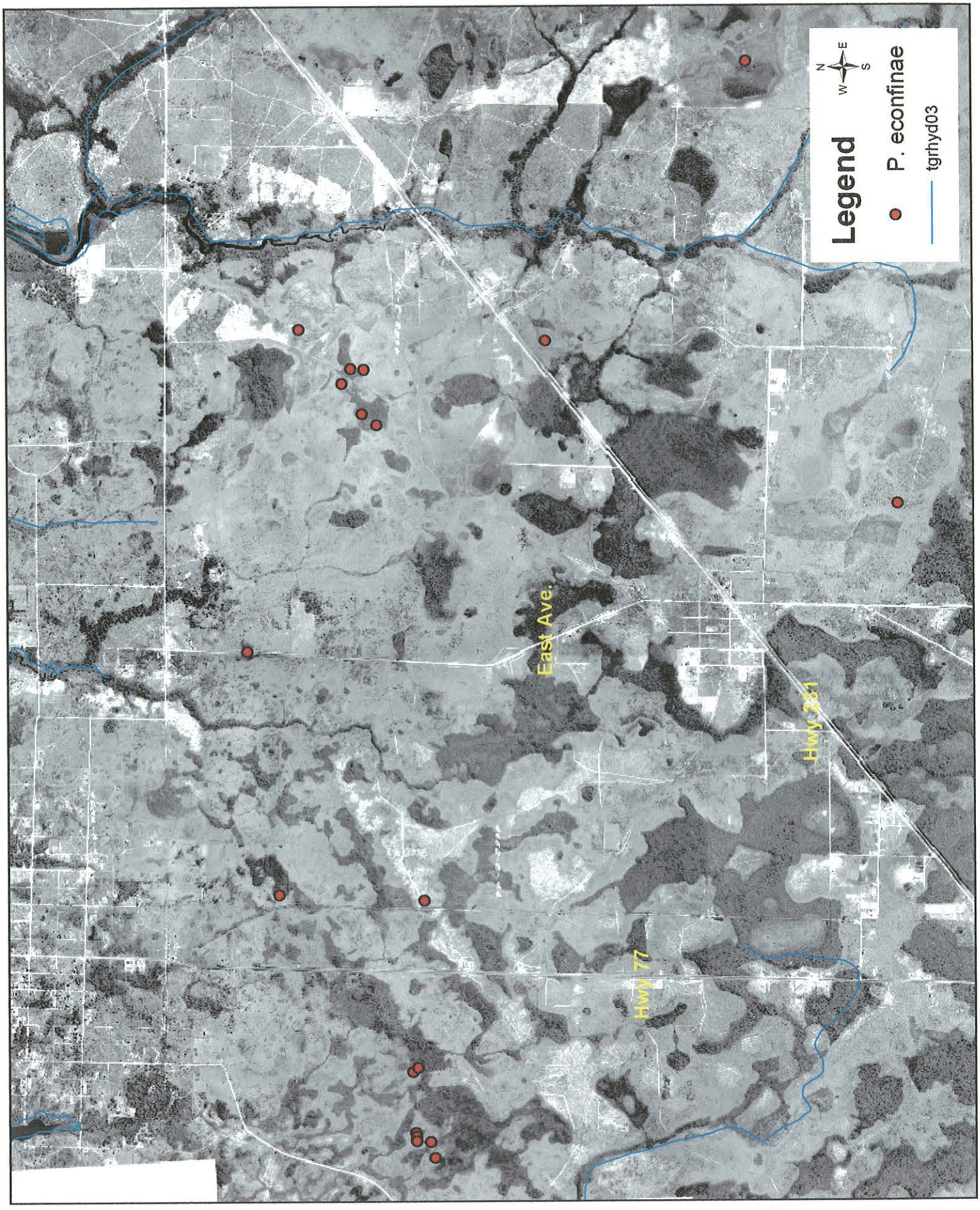
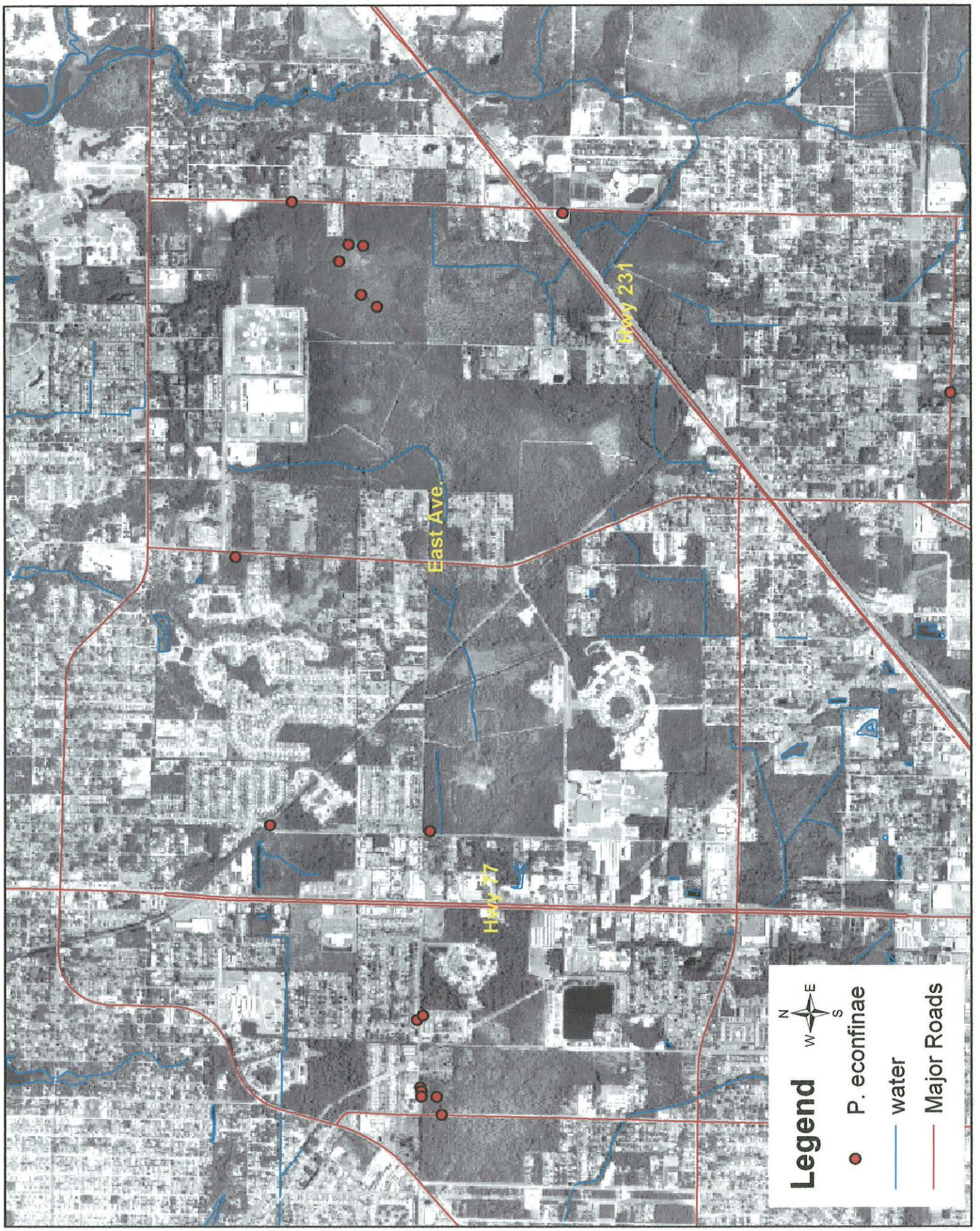


**Figure 9. Central Bay County, 2003 with Current PCC Locations**



of time are to be noted. For example, the maintenance of the swales at the Moler site and adjacent sites on Highway 389 are an example. The maintenance of populations on power line right-of-ways is another example. However, field observations on sites previously visited indicate that alteration of habitat may be increasing as the human population increases even in these areas of long-term survival such as the Highway 389 site and along some power line right-of-ways.

*1. **Roadside Ditches***. The PCC probably survives in some roadside ditches due to their gently sloping sides (swale) and the control of woody vegetation. Continued survival in these known habitats will depend on the maintenance activities and construction activities in these ditches. Alterations of the slopes of these ditches by digging of deep trenches and the use of heavy equipment that may crush or compact and plug burrows are threats to survival in these habitats. Underground utility lines placed in these ditches can also alter and may destroy habitat in the absence of mitigating actions.

*2. **Silviculture Land***. The necessary control of fire on land used to grow pine trees and near residential areas has allowed the hydric soils preferred by the PCC to become overgrown with pine trees, titi, species of St. John's-wort, and other woody vegetation that shade the herbaceous layer and, in many instances, eliminate it upon closure of the canopy. The bedding of pines by plowing furrows in wetter soil types may serve to artificially drain the area, lower the water table during dry seasons, crush crayfish in surface water or compact burrows destroying their underground structure, and pine needles and litter can become quite deep on the forest floor. The dense, closed canopy of the maturing pines and/or the overgrowth of shrubs in wet areas eliminate the herbaceous layer of vegetation. It is obvious, however, that there has been survival of the PCC in those areas of hydric soils that remain open until the next tree harvest. However, the PCC is considered to be sparse in these areas. Other activities such as roller chopping may have the same effects as bedding in terms of mechanical disturbance and adverse impacts to the PCC.

*3. **Land Use Changes***. Development for a growing human population within the range of the PCC provides a number of threats to the survival of the species. Direct alteration of habitat for residential, commercial, or industrial development eliminates the populations at the altered sites. Infrastructure needs also change habitat. Widening existing roads and the construction of new roads through PCC habitat may eliminate a large number of existing populations. The Metropolitan Planning Organization for Bay County has plans to widen Star Avenue and Transmitter Road and construct a new road through about the center of the PCC habitat between Transmitter Road and Star Avenue from Highway 231 to about Tram Road. Corridor selection for a road from Highway 231 south to Highway 98 east of Star Avenue is underway. The westernmost corridor for this road has been selected, and it appears that it will impinge on the populations along the eastern boundary of the range of the PCC.

Possible loss of existing sites has recently occurred. An example is the south side of Industrial Drive that had a population of PCC in the roadside ditch (type locality). This area was altered to store large pipe by placing fill in the area surveyed for the PCC south of the road. Another area lost that supported a large, dense population of this species was located north of the entrance road to the Bay County Jail Annex east of Nehi Road. Original sampling along the road and observation of an abundance of burrows during the first visit was replaced by a dredged pond and fill material placed over almost the entire habitat (Figures 10 and11). Figures 12 and 13 is the site along Jenks Avenue south of 26$^{th}$ Street on

Figure 10. County Jail Annex Road First Visit

Figure 11. County Jail Annex Second Visit

Figure 12. Jenks Ave and 26th Street Before.

Figure 13. Jenks Ave. and 26th Street After.

In summary, observations support the idea that the PCC prefers certain hydric soils that are conducive to their burrowing during the dry season, and that they prefer open areas with little to no woody vegetation and an abundance of herbaceous vegetation. The PCC has been observed in hydric soils in roadside ditches and swales, hydric soils in flatwoods, savannahs, in people's yards, and along power line right-of-ways. Of course there are exceptions to the general rule.

**Drought**. The 2000 through 2002 surveys were conducted during a rather severe drought that began about 1998. The St. Joe Company survey was conducted during a period of normal to greater than normal rainfall in parts of the range of the PCC that commenced in the spring of 2003. One could consider the results of the drought survey to have identified most core habitat types or those habitats in which the species survives under the adverse conditions of drought. The St. Joe Company survey could be considered as identifying those habitats occupied under average to better than average conditions regarding presence and duration of surface water and depth to the water table. The core habitat appears to be the key to the long-term survival of the PCC, because drought will return, and the populations that are now occupying marginal habitat will again be reduced or lost until the end of the drought. This was observed during the St. Joe Company survey as the high water of the summer receded and the water table fell in certain non-core habitats and soils.

**Life History.** The life history of this species is not well known. The surveys conducted to date were limited to finding locations where the PCC lives and attempting to generally characterize those habitats. Quantitative studies of population densities and the life history were not part of the surveys. As a result, there is only anecdotal information regarding breeding seasons, seasonal occurrence of juveniles, dispersal of adults and juveniles, fecundity, and population density in relationship to normal seasonal surface water fluctuations.

***Reproduction.*** Hobbs (1942) stated that he observed females with eggs in June 1938 and collected a female with young from a burrow in June 1938. A male was present in the same burrow with this female. He stated that this was the only species that he had collected in which a female with young was accompanied by a male. Keppner and Keppner (2002) reported recovering a female with eggs from a burrow in March of 2002. A female with young was taken from a burrow in early in September of 2003 and another female that was in berry was netted from surface water at the end of September 2003. These observations indicate that the PCC can produce young, at least, between March through September. However, based on the netting of juveniles, the PCC appears to be able to produce young from March through December under suitable conditions. Juveniles about the size that leave the female swimmerets (from 15-25 mm in length) were collected a number of times in December 2003 during the St. Joe Company survey. However, the number of juveniles encountered decreased from September through December (seasonal dry period). The number of juveniles and the population density in general was reduced again during the normal, seasonal dry conditions experienced from April through May based on previously visited locations with surface water presentt.

***Food Habits.*** Information specific to food habits of the PCC and related species was not located. Momot (1995) discussed the role of crayfish in aquatic ecosystems and their food habits. Crayfish have been referred to as scavengers, but are principally detritivores/herbivores and can be keystone predators according to Momot. Observations on PCC held in aquaria indicate that they are detritivores and herbivores. Specimens were offered dead minnows, but avoided them in favor of processing the substrate for particles of prepared fish food and the fresh aquatic vegetation that was also provided as a food source.

***Dispersal of Juveniles.*** During the heavy rains that occurred at the beginning of the St. Company survey, juveniles (from 15-25 mm in length) were observed being carried by sheet flow across various soil types and habitats along the power lines and in ditches along the dirt roads in the survey area. Juveniles were netted in depressions in the dirt roads in a variety of soil types both hydric and non-hydric. It is possible that the roadside ditches serve as conduits for dispersal though dry soils and the periods of heavy rains also carry juveniles from one area to another to colonize favorable habitats or become trapped and die in unfavorable habitats after the surface water recedes.

***Seasonal Dry Periods.*** The area within the range of the PCC experiences seasonal dry periods in the spring and fall. One such dry period occurred during April to June of 2004 during the St. Joe Company survey. Locations were revisited that supported moderate to abundant populations of the PCC when surface water was present. These revisited locations were dry with very few large burrows at the edge of and just below the high water mark. Burrows the size of which one would expect juveniles to construct were not observed, and excavation of the substrate did not yield juveniles of this species. The fate of the numerous juveniles that were present during the first visits to the locations is not known with certainty. Predation may have played a role as discussed below. The indication is that the abundance of the PCC at any site varies with the season and rainfall.

***Predation.*** It was observed at the revisited locations discussed above that there was an abundance of scat from an unknown animal not observed previously in the vicinity of these dried locations. The scat consisted almost entirely of crayfish exoskeletal parts (Figure 6). It is hypothesized that as the surface water receded, the crayfish were concentrated and became easy prey for predators such as raccoons and wading birds. The adult crayfish appeared to have burrowed before the surface water receded appreciably. These large burrows located near the high water mark that contained adults may serve as the source for rebuilding the population in the habitat when surface water returns.

***Burrows.*** The burrows excavated by the PCC are straight to somewhat angled and reach the water table. Adults were recovered during the drought surveys at a depth of at least 30 inches. Two adult specimens were retrieved from a single burrow during the surveys aside from the females with eggs or juveniles. Side chambers were not noticed in the burrows dug during the surveys. The chimney of the PCC burrows is constructed of distinct mud balls (Figure 7). These chimneys can be washed flat by rain and become difficult to observe in dense vegetation. Adults were returned to their burrows that were excavated by hand during the St. Joe Company survey and two were revisited after return of the specimens to their burrows. In both instances, there were mud balls at the opening of the burrow indicating that the individuals had survived.

**Associated Species of Crayfish.** The present and past surveys for the PCC included the netting of flowing water ditches as well as still water pools in hydric soils and surface water wherever encountered regardless of soil type. They did not include permanent standing bodies of water (lakes and ponds) or large creeks and streams or portions of creeks that were influenced by the tide. Burrows were dug to obtain specimens in areas without surface water. Two other species of crayfish were collected within the range of the PCC during the cited surveys as well as outside of the range of this species. *Procambarus* (*Hagenides*) *rogersi* intergrades (no common name), a primary burrower, was collected from a variety of soil types and survives in the more well drained soils as well as at the edges of PCC habitat. *Procambarus* (*Ortmannicus*) *pycnogonopodus* (no common name) is a widespread tertiary burrower and inhabits more permanent water bodies and flowing water. A few specimens of the PCC were collected a few times in flowing water ditches or standing water that

Figure 6. Scat from a predator with crayfish parts.

Figure 7. PCC Burrows.

also contained *P. pycnogonopodus*.

**Associated Species of Protected Vascular Plants.** A number of species of vascular plants listed as threatened or endangered by the State of Florida were observed occupying the habitats of the PCC. Table 2 is a list of the plants observed in association with PCC habitat during the surveys.

**Table 6. Species of Listed Plants from the Survey Area.**

| Family | Species | Common Name | State | Federal | FNAI |
|---|---|---|---|---|---|
| Amaryllidaceae | *Hymenocallis henryae* | Henry's Spiderlily | E | n/a | S2 |
| Asteraceae | *Verbesina chapmanii* | Chapman's Crownbeard | T | n/a | S3 |
| Droseraceae | *Drosera intermedia* | Water Sundew | T | n/a | S3 |
| Gentianaceae | *Gentiana pennelliana* | Wiregrass Gentian | E | n/a | S3 |
| Lentibulariaceae | *Pinguicula planifolia* | Chapman's Butterwort | T | n/a | n/a |
| Liliaceae | *Lilium catesbaei* | Pine Lily | T | n/a | n/a |
| Orchidaceae | *Platanthera nivea* | Snowy Orchid | T | n/a | n/a |
| Orchidaceae | *Pogonia ophioglossoides* | Rose Pogonia | T | n/a | n/a |
| Poaceae | *Dichanthelium nudicaule* | Naked Stemmed Panic Grass | T | n/a | S3 |
| Sarraceniaiceae | *Sarracenia psittacina* | Parrot Pitcherplant | T | n/a | n/a |
| Sarraceniaceae | *Sarracenia purpurea* | Purple Pitcherplant | T | n/a | n/a |

**Protection of Rare Species.** The State of Florida maintains a list of species of plants and animals that are in need of, and meet the criteria established for protection. The FFWCC lists species of animals considered deserving of protection as Endangered, Threatened, and Species of Special Concern. The PCC has been listed as a Species of Special Concern since 1989, but a management plan was not written for the species until recently.

The FWS is the federal agency responsible for rare species in the United States. The Endangered Species Act provides the authority to list and protect species that meet the criteria of the Act. The two regulatory listings under the law are Endangered and Threatened. The FWS also maintains a list of Candidate (C) species and species of management concern (MC) as well as other designations. The latter two categories do not have official status under the law but provide for methods to react to concern for rare species before official listing under the Act occurs. A CCAA is one of those methods. The PCC is currently listed as MC, but meets all the criteria for a ranking of Candidate and probably for inclusion as Threatened or Endangered under the Act.

The Florida Natural Areas Inventory (FNAI) maintains inventories and tracking lists of the species of rare plants and animals in Florida and tracks those species listed by the state and federal governments. In addition, FNAI ranks and tracks rare species according to their own criteria. The FNAI rankings include a global rank and a state rank. The PCC is ranked by FNAI (2002) as G1 (imperiled globally) and S1 (imperiled in Florida). Hipes et al. (2000) provided a summary of the knowledge of the PCC through the year 2000.

NatureServe (2003) provided the following additional information: *Procambarus (L.) econfinae* is given a National Conservation Status Rank of N1 (endangered in the nation), International Union for the Conservation of Nature (IUCN) lists the species as endangered, and the American Fisheries Society lists this species as endangered (Taylor et al., 1996).

**Reclassification of the PCC.** In August 2001, a petition was submitted to the FFWCC to reclassify the PCC from a Species of Special Concern to Threatened. The petition was accepted, and a Biological Status Report (2002) was prepared by the Commission staff. This report was based on

the then known information. Following acceptance of this report, a management plan (FFWCC, 2003) for the PCC was drafted and circulated for public comment. A Public Notice was published in the Florida Administrative weekly with a comment period ending on February 10, 2003. The management plan identified the PCC as meeting two of the criteria of Endangered as well as other criteria for Threatened based on the then available information. Subsequent information has expanded the range of this species to meet the threatened criterion. The management plan relies heavily on the completion of a Candidate Conservation Agreement with Assurances that would provide the means to protect this species from extinction.

The FFWCC Commissioners delayed action on the acceptance of the management plan until May of 2003 then further delayed a decision to November 2003 at which time the Commissioners further delayed action on the petition to an unknown date after November 2004. The management plan was signed by the Executive Director of the FFWCC, and those elements of the management plan within the Executive Directors authority to implement are available for implemetation. The information gathered during 2002 for the FWS and the by the St. Joe Company was not available at the time of preparation of the management plan.

Recently, a petition was been submitted to the FFWCC to delist the PCC. Delisting removes the protective measures provided by the formal listing by the state as Endangered, Threatened, or a Species of Special Concern. Delisting at the state level, however, does not preclude the listing of a species by the FWS under the Endangered Species Act. To date, a petition for listing of the PCC under the Endangered Species Act has not been received by the FWS. A Candidate Conservation Agreement with Assurances (CCAA) exercise is underway to reduce or eliminate the necessity of listing the PCC under the Endangered Species Act through the provision of sufficient guarantees of survival of the species. Regulatory benefits accrue to those who participate and sign the final CCAA agreement. However, the successful completion of the CCAA does not assure that this species will not be listed under the Endangered Species Act in the future.

**Threats.** A part of the process of listing a species by the state and/or federal government and the CCAA process is the examination of the threats that exist to the survival of a species, the PCC in this case. Taylor et al. (1996) evaluated the species of crayfish in the United States regarding their susceptibility to decline in populations and/or extinction and stated that species of crayfish are susceptible to destruction, degradation, or alteration of habitat; chemical pollution: over exploitation; and introduction of non-indigenous species. Gilpin and Soule (1986) provide an interesting discussion on some aspects of species extinction that may be applicable to the PCC. They stated that small natural range size is implicated as a factor underpinning potential or realized imperilment.

Bay County has been growing at a steady and fairly rapid rate for the past 20 years and is currently poised for rapid development of the remainder of the known range of the PCC. The threats to the continued survival of the PCC are primarily human activities. The known locations of populations of the PCC, as stated above, are primarily in roadside ditches, power line right-of-ways, openings in land used for silviculture, and home owners' yards. Figure 8 is an aerial photograph from 1941 of the area from east of Highway 77 eastward to east of the current Transmitter Road (not present in 1941). The known locations for the PCC are included on the map. Figure 9 is a 2003 aerial photograph of the same area with the same PCC locations. Changes in the extent of development are demonstrated.

The examination of threats to the PCC is, by necessity, a negative activity. However, the PCC has survived with certain activities, and those activities that have allowed survival for extended periods

**Figure 8. Central Bay County, 1941 with Current PCC Sites**

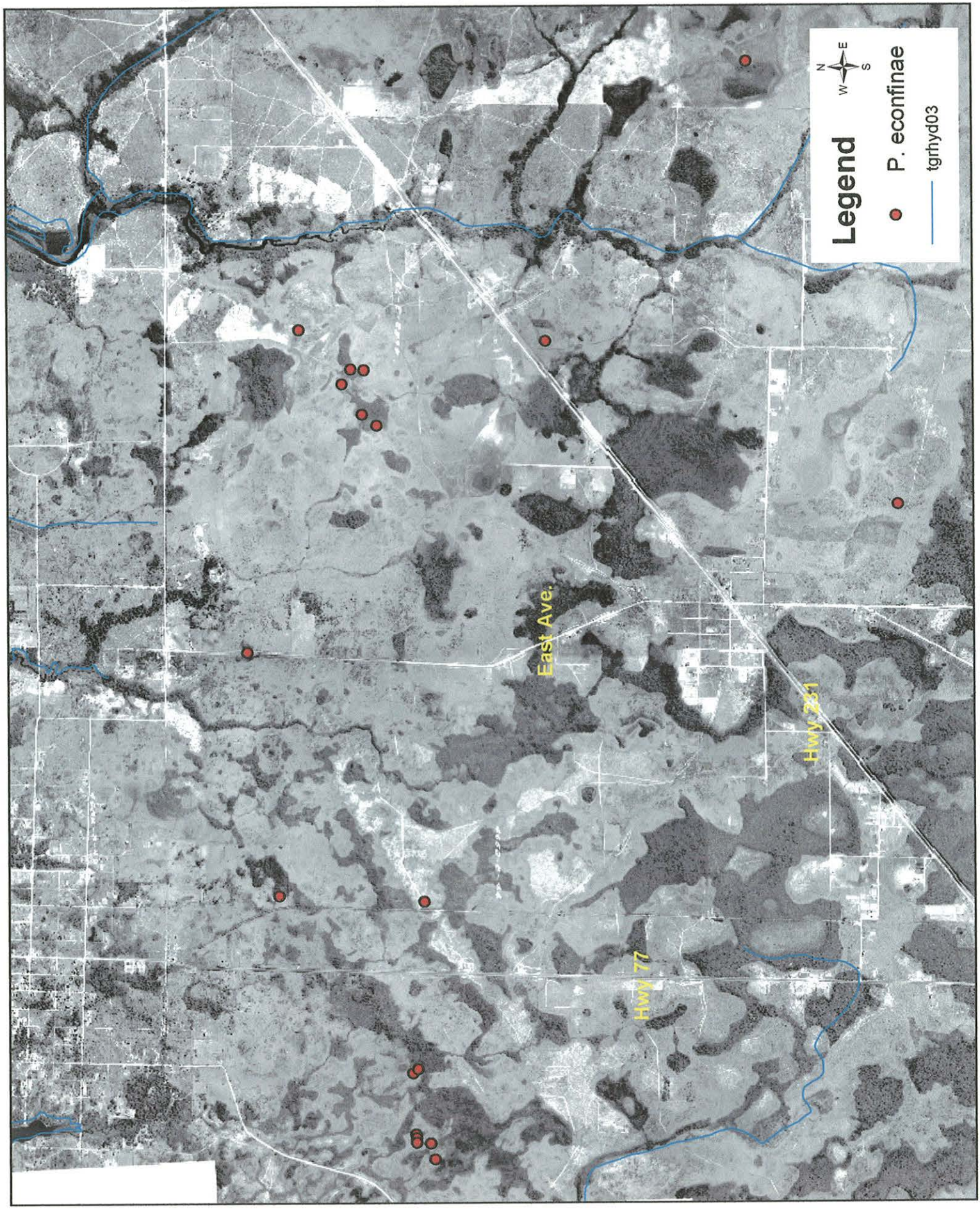
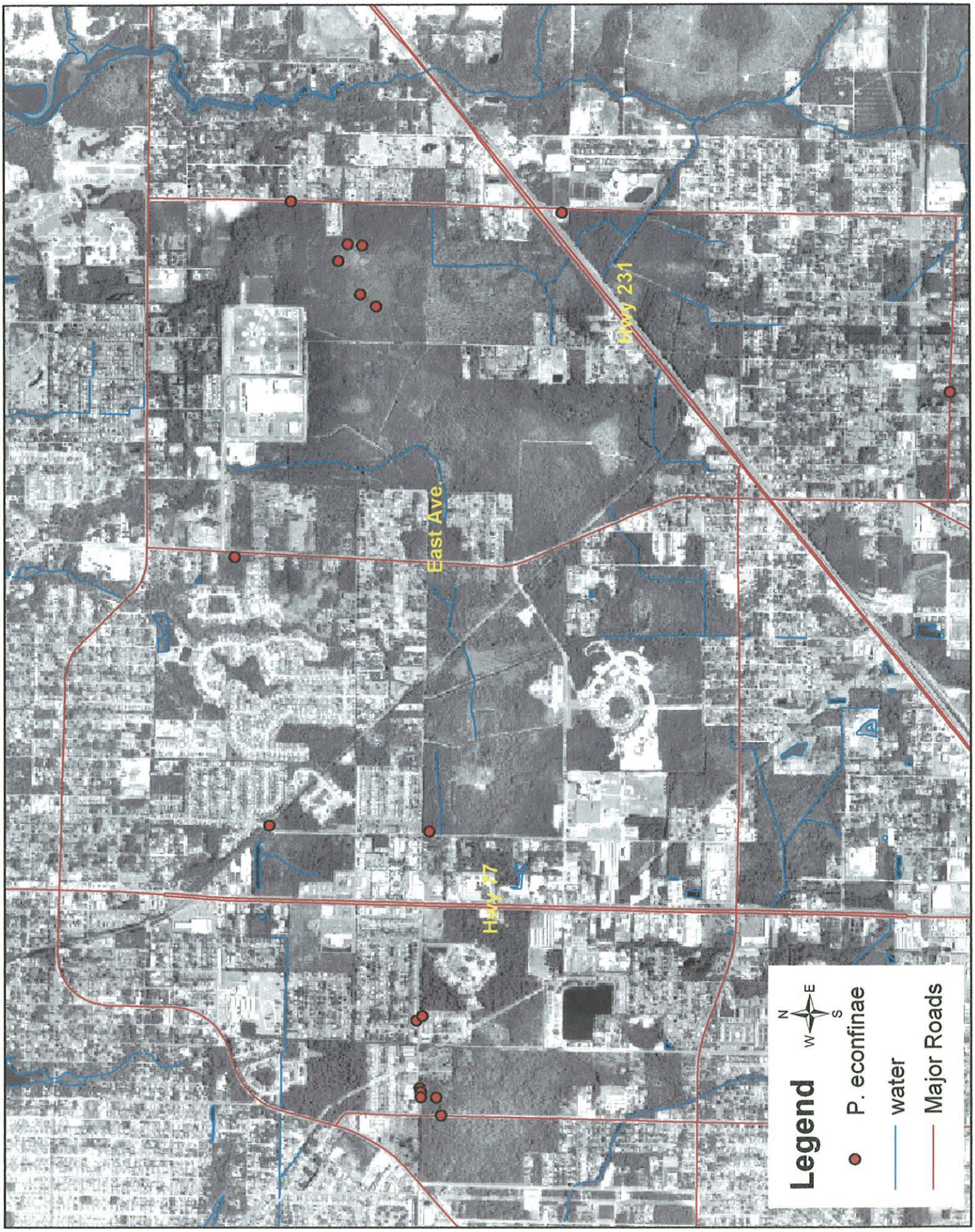


**Figure 9. Central Bay County, 2003 with Current PCC Locations**



of time are to be noted. For example, the maintenance of the swales at the Moler site and adjacent sites on Highway 389 are an example. The maintenance of populations on power line right-of-ways is another example. However, field observations on sites previously visited indicate that alteration of habitat may be increasing as the human population increases even in these areas of long-term survival such as the Highway 389 site and along some power line right-of-ways.

*1. **Roadside Ditches***. The PCC probably survives in some roadside ditches due to their gently sloping sides (swale) and the control of woody vegetation. Continued survival in these known habitats will depend on the maintenance activities and construction activities in these ditches. Alterations of the slopes of these ditches by digging of deep trenches and the use of heavy equipment that may crush or compact and plug burrows are threats to survival in these habitats. Underground utility lines placed in these ditches can also alter and may destroy habitat in the absence of mitigating actions.

*2. **Silviculture Land***. The necessary control of fire on land used to grow pine trees and near residential areas has allowed the hydric soils preferred by the PCC to become overgrown with pine trees, titi, species of St. John's-wort, and other woody vegetation that shade the herbaceous layer and, in many instances, eliminate it upon closure of the canopy. The bedding of pines by plowing furrows in wetter soil types may serve to artificially drain the area, lower the water table during dry seasons, crush crayfish in surface water or compact burrows destroying their underground structure, and pine needles and litter can become quite deep on the forest floor. The dense, closed canopy of the maturing pines and/or the overgrowth of shrubs in wet areas eliminate the herbaceous layer of vegetation. It is obvious, however, that there has been survival of the PCC in those areas of hydric soils that remain open until the next tree harvest. However, the PCC is considered to be sparse in these areas. Other activities such as roller chopping may have the same effects as bedding in terms of mechanical disturbance and adverse impacts to the PCC.

*3. **Land Use Changes***. Development for a growing human population within the range of the PCC provides a number of threats to the survival of the species. Direct alteration of habitat for residential, commercial, or industrial development eliminates the populations at the altered sites. Infrastructure needs also change habitat. Widening existing roads and the construction of new roads through PCC habitat may eliminate a large number of existing populations. The Metropolitan Planning Organization for Bay County has plans to widen Star Avenue and Transmitter Road and construct a new road through about the center of the PCC habitat between Transmitter Road and Star Avenue from Highway 231 to about Tram Road. Corridor selection for a road from Highway 231 south to Highway 98 east of Star Avenue is underway. The westernmost corridor for this road has been selected, and it appears that it will impinge on the populations along the eastern boundary of the range of the PCC.

Possible loss of existing sites has recently occurred. An example is the south side of Industrial Drive that had a population of PCC in the roadside ditch (type locality). This area was altered to store large pipe by placing fill in the area surveyed for the PCC south of the road. Another area lost that supported a large, dense population of this species was located north of the entrance road to the Bay County Jail Annex east of Nehi Road. Original sampling along the road and observation of an abundance of burrows during the first visit was replaced by a dredged pond and fill material placed over almost the entire habitat (Figures 10 and11). Figures 12 and 13 is the site along Jenks Avenue south of 26$^{th}$ Street on

Figure 10. County Jail Annex Road First Visit

Figure 11. County Jail Annex Second Visit

Figure 12. Jenks Ave and 26th Street Before.

Figure 13. Jenks Ave. and 26th Street After.

an earlier visit followed by a recent visit.

*4. **Pesticides, Herbicides, Fertilizers and other Pollutants**.* As development increases, the use of pesticides and herbicides may also increase. Increased development may reduce the use of fire and require the use of herbicides in its place. Holdich (2002) includes discussions in various chapters that address direct pesticide and herbicide impacts on crayfish, and the indirect affects of fertilizer. The extensive use of herbicides and fertilizer in the habitat of the PCC may interrupt the feeding patterns of the affected populations. Heavy use of fertilizers can result in algal blooms which can be detrimental to crayfish, particularly toxic blue-green algal blooms. Algal blooms, in general, may result in anoxic conditions in surface water that may be detrimental to crayfish. Runoff from roads into the ditches and the effect of heavy metals on crayfish are addressed to a degree in Holdich (2002).

The Gulf Power Company has recently agreed to restrict the use of the herbicide Garlon to control trees and shrubs along their power lines to spot treatments in the habitats of the PCC along their easements (pers. comm. FWS, 2004).

*5. **Vehicle Activity.*** Off road vehicles may have an adverse effect on the PCC directly by crushing individuals in surface water or compacting burrows and indirectly by altering the habitat. A large location for this species with a dense population on the power line easement running west of Nehi Road has been visited regularly for about 19 months. The number of vehicle tracks in the area has increased.

*6. **Harvest**.* Harvest of the PCC for bait for fishing has been observed a few times by the writers in the ditches along Star Avenue. Although the harvest of the PCC for bait does not appear to be extensive, this could become a concern should the other habitats and populations be negatively impacted.

*7. **Introduction of other Species**.* This possible detrimental activity has not been addressed for the PCC. However, the literature contains examples of the replacement of native species of crayfish by non-indigenous species. Examples of the interbreeding of separate species of crayfish, introduced or natural contact between different species of crayfish and effects of translocations of species of crayfish has not been located in the literature examined to date.

**Management Successes.** The FFWCC has been involved in at least two projects that involved successful completion of the proposed development activities while maintaining the PCC populations that were threatened by the activity. The first instance was the placement of a pipeline in a ditch along the east side of Highway 389. Adverse impacts to the PCC and its habitat were largely, if not completely, avoided by placing the pipeline at the eastern edge of the road right-of-way out of the ditch, using a filter cloth barrier to prevent siltation of the ditch during construction, and the prevention of equipment from driving in the ditch. Following completion of the project, the PCC were again found in the ditch. The second possible example is the development of a commercial business on the west side of Highway 389 in PCC habitat. Rather than placing fill material completely across the ditch, a culvert was placed that maintained connectivity, most of the integrity of the site, and avoided complete fragmentaton of the PCC site. This activity reduced the loss of the habitat to the fill placed. Again, the PCC was found in the ditch immediately after construction.

Additional projects occurring in PCC habitat include the placement of a pipeline along the power line easement from John Pitts road to Transmitter Road. This pipeline passes through the Nehi Road

power line site and other sites along the line. Mitigation measures have been taken to lessen the alteration of the PCC locations along this power line. Agreement has apparently also been reached with a developer at the locations on Jenks Avenue and 26th Street. The wetlands mitigation that is being required by the Florida Department of Environmental Protection apparently includes management of these areas for the PCC and placement of culverts in the ditches at the entrance areas. Recent observations at the development site indicate that the adverse impacts may be more severe than anticipated due to the clearing activity that extended through the ditch locations for this species. Survival of this population should be monitored.

In summary, the threats to this species are being realized. Efforts to reduce those threats on a case by case basis are being attempted. The solution appears to be the long range planning for survival of this species that can be provided by the CCAA process and/or listing by the FWS and reclassification to threatened or endangered by the FFWCC.

**Excerpts from the Florida Fish and Wildlife Conservation Commission Management Plan**

**Conservation Concepts.** The conservation goal is to ensure the long-term survival of the PCC in the wild. The conservation objective is to secure and maintain sites with PCC throughout the historic range of the species while simultaneously increasing the net number of known sites.

**Conservation Strategies.** The strategies to achieve this objective include the following potential activities.

*A. **Best Management Practices (BMPs).*** Develop BMPs for roadside ditches, infrastructure development, silvicultural practices, and habitat management activities that will occur in areas occupied or potentially occupied by the PCC.

*B. **Develop and/or Utilize Innovative Land-use Programs.*** Existing or newly developed programs may be used to encourage conservation of the PCC on private land. A number of existing programs could be reviewed for their applicability to the conservation of the PCC.

*C. **Protection of PCC Sites.*** Protection for some PCC sites may be achieved by purchase of the sites, purchase of easements, or a combination of such methods to preserve the sites.

*D. **PCC Working Group.*** A PCC working group could be established to promote communication between and among agencies, managers, biologists, and private landowners.

*E. **Outreach Program.*** An outreach program could be developed to inform private landowners and the general public of PCC conservation efforts and land-use incentive programs.

*F. **Continue Survey Work.*** Additional surveys could be conducted to identify other PCC inhabited sites within the known range and better establish the northeastern limit of the range of the PCC.

*G. **Monitoring Existing Sites.*** The presently known ditch sites should be re-visited immediately to determine the presence or absence of the PCC. Some of these sites have experienced work since their discovery. Any sites that have been lost could be noted. The existing sites could be visited on a regular basis to track the persistence or decline in the quality of the site and the existing population of PCC.

***H. Conduct Scientific Research on the PCC.*** Many aspects of the life history of the PCC are unknown or have only anecdotal comments. Research could be conducted to obtain more knowledge of the species to aid in its conservation. However, management action could be taken to ensure the survival of the PCC while the long-term scientific studies are being conducted.

1. Habitat Characteristics. The habitats occupied by the PCC could be described in detail, and the information used to establish the most significant habitat types for survival of the PCC. Included would be microhabitat studies to establish the species habitat requirements at a more definitive level, demographic studies, and a study of biophysical constraints on the species. It has been suggested that these studies be conducted before reintroduction to unoccupied habitats is attempted. This may not be feasible.

2. Assess Threats to Survival. Determine the threats to the survival of the PCC to better establish a plan for its survival.

3. Determine Effectiveness of BMPs. The effectiveness of the accepted BMPs at known sites could be closely evaluated in formal studies. The information obtained could be used to modify the BMPs to more effectively protect the PCC.

4. Evaluate Effectiveness of Survey Techniques. Sampling gear and methods could be evaluated to provide the most effective methods for surveys.

5. Population Biology. Investigate the fecundity, growth rate, natural mortality rate, and other aspects of the population biology of the PCC.

6. Develop Captive Rearing Techniques. If the ongoing surveys do not establish an acceptable number of sites supporting the PCC, acceptable potential sites for restoration and/or enhancement, or unoccupied sites for reintroduction, and captive rearing techniques could be developed if warranted.

***I. Reintroduction to Unoccupied Habitats.*** Reintroduction to suitable habitats without a population of the PCC or reintroduction to areas that have been restored or enhanced should be attempted. This attempt could be made prior to the completion of the population biology and biophysical restraints research. Recipient sites could be located or enhanced or restored sites with sparse populations could be tracked for re-establishment of the populations at a greater density.

***J. Monitor PCC Range-wide.*** All known sites and/or locations could be monitored for the continued presence of the PCC. Restored and/or enhanced sites could be monitored to track the increase or decline of the populations. A database could be necessary to document changes in known sites and the species on a range-wide basis.

## Literature Cited

Deyrup, M.P. and Franz, R. 1974. Rare and endangered biota of Florida. Volume IV. Invertebrates. University Press of Florida, Gainesville, FL.

Duffee, E.M., Baldwin, R.A., Lewis, D.L., and Warmack, W.B. 1984. Soil Survey of Bay County. USDA, Soil Conservation Service, Chipley, FL. 152 pp + maps.

Florida Fish and Wildlife Conservation Commission. 2002. Biological Assessment for the Panama City Crayfish. FFWCC, Tallahassee, Florida.

Florida Fish and Wildlife Conservation Commission. 2003. Management Plan Panama City Crayfish *Procambarus econfinae*. FFWCC, Tallahassee, Florida. 27 pp.

FFWCC Management Plan

Florida Natural Areas Inventory. 2002. Tracking list of rare, threatened, and endangered plants, animals, and natural communities of Florida. Florida State University, Tallahassee, Florida. 79 pp.

Franz, R. and Franz, S.E. 1990. A review of the Florida crayfish fauna, with comments on nomenclature, distribution, and conservation. Florida Scientist 53(4):286-296.

Gilpin, M.E. and Soule, M.E. 1986. Minimum viable populations: processes of species extinction. In: Soule, M.E. edit. Conservation Biology. The science of scarcity and diversity. Sinauer Associates, Inc. Sunderland, MA. pp.19-34.

Hipes, D., Jackson, D.R., NeSmith, K., Printiss, D., and Brandt, K. 2000. Field guide to the rare animals of Florida. Florida Natural Areas Inventory, Tallahassee, FL. Unnumbered.

Hobbs, H.H., Jr. 1942. The Crayfishes of Florida. Univ. Florida Press, Biol. Ser., 3(2): v-179.

Hobbs, H.H. Jr. 1972. The subgenera of the crayfish genus *Procambarus* (Decapoda: Astacidae)

Hobbs, H.H. Jr. In: Avault, J.W. Jr. edit. 1975. Adaptations and convergence in North American crayfishes. International Symposium of Freshwater Crayfish, Louisiana State Univ., Baton Rouge, LA. pp 541-551.

Hobbs, H.H. 1981. The crayfishes of Georgia. Smithsonian Contributions to Zoology, No. 318. 549 pp.

Hobbs, H.H, Jr. 1988. An Illustrated Checklist of the American Crayfishes (Decapoda: Astacidae, Cambaridae, and Parastacidae). Smithsonian Contrib. to Zoology, No. 480. 236 pp.

Holdich, D.M. (edit.). 2002. Biology of freshwater crayfish. Blackwell Science, Ltd., Ames, Iowa. 702 pp.

Keppner, Edwin J. and Keppner, Lisa A. 2000. A Preliminary Search for the Panama City Crayfish, *Procambarus* (*Leconticambarus*) *econfinae*. St. Andrew Bay Environmental Study Team report to the U.S. Fish and Wildlife Service, Panama City, Florida. 12 pp.

Keppner, Edwin J. and Keppner, Lisa A. 2001. A survey and conservation status of the Panama City Crayfish. Report to the U.S. Fish and Wildlife Service, Panama City, Florida, June 2001. 30 pp.

Keppner, L.A. and Keppner, E.J. 2002. Final report, extended survey for the Panama City Crayfish in Bay County, Florida. Report to the U.S. Fish and Wildlife Service, Panama City, FL. 18 pp +

maps.

Mansell, B.W. 1994. Panama City crayfish. Pages 187-189 in Deyrup, M.P. and Franz, R. editors. Rare and endangered biota of Florida. Vol. IV. Invertebrates. University Press of Florida, Gainesville, Florida.

Momot, W.T. 1995. Redefining the role of crayfish in aquatic systems. Reviews in Fisheries Science 3(1):33-63.

NatureServe. 2003. NatureServe explorer: An online encyclopedia of life web application. Version 1.8. NatureServe, Arlington, Virginia.

Taylor, C.A. et al. 1996. Conservation status of the United States and Canada. Fisheries 21(4):25-38.

U.S. Fish and Wildlife Service. 2004. Personal Communication with the Panama City Field Office regarding agreement with Gulf Power Company regarding the use of herbicides.