

GIS 공간분석을 통한 남부 플로리다 Big Cyprus 분수계 보존서식지 보호

Using GIS Spatial Analysis to Protect Critical Habitats in the Big Cyprus Watershed, South Florida

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ABSTRACT: Big Cyprus watershed, which is located in the Southwestern Florida and covers Everglades National Park that has high proportions of endangered species' habitats, plays an important role for the entire Florida ecosystem. Due to the rapid urbanization and high population growth, however, the watershed has been continuously polluted and the current regional watershed plan is not created to accommodate the speed of growth. The purpose of this study is to suggest proper protection policies and strategies for the Big Cyprus watershed by employing the Inverse Distance Weighted interpolation tool in Geographic Information System. The findings show that conservation priorities should be given in the North and South portion of the watershed area, which are proven to be the most important aisle for the habitats in the Big Cyprus. The study concludes with policy suggestions that local environmental planners should concentrate for adopting their new watershed plan in the near future.

KEYWORDS: Policy Evaluation, Habitat Preservation, GIS, Watershed Plan, Florida

키 워 드: 정책평가, 서식지 보존, 지리공간시스템, 분수계 계획, 플로리다

1. Introduction

1.1 Background & Study Area

Big Cyprus watershed, which is located in the Southwestern Florida, plays a significant role in Florida ecosystem along with Everglades National Park. It covers about 6,397 km² of southern Florida west of the Everglades and south of the Caloosahatchee River (US Geological Survey; USGS, 2012). Six counties are included in the watershed, but Big Cyprus watershed mainly covers four counties in the southwestern region, which are Collier, Lee, Monroe, and Hendry. Specifically, Big Cypress Natural Preserve, which entails approximately 729,000 acres of connected wetlands and diverse landscapes, is a crucial place within the study area.

Study area also encompasses Collier Seminole State Park, Fakahatchee Strand Preserve State Park, Florida Panther National Wildlife Refuge, and Picayune Strand State Forest (National Audubon Society, 2012). The Big Cyprus and Corkscrew Swamps, which are lying south of the sandy flatland, include abundance of small and moderate cypress trees, pines, and hammock forests. Thus, the study area's strength and uniqueness derive from a vast amount of diverse ecological communities and biodiversity. High portion (nearly 29%; 35 out of 120) of Florida panther currently resides in the study area (National Park Services, 2015a). It is a critical habitat for a number of endangered species, such as Florida sand-hill crane, American crocodile, and feral hogs.

In order to establish conservation priorities (both

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conceptual and geographical) for the Big Cyprus watershed, this study recognizes and understands factual basis and strengths of the Big Cyprus watershed plan. A well-arranged factual basis may assist a community or an organization to understand their crucial resources, as well as define what and how they should conserve for the further protection (Brody, 2008).

Problem definition section addresses the major human-induced environmental impacts that may affect the watershed plan by citing several relevant literatures from the field of ecosystem management and environmental planning. Main problems of the study area will be defined in this section. Section 2 determines the type of species, habitats, functions, and processes that we should concentrate for goals and objectives. Section 3 describes the specific areas and ecological components within the Big Cyprus watershed, and it investigates where we should focus on in a regional watershed plan. Section 4 emphasizes the significant role of patches and corridors in maintaining the landscape mosaic and overall ecosystem through literature reviews and the analysis of the study area. In addition, it discusses the overall spatial configuration of landscape ecology principles, especially on corridors, which may enhance the connectivity and support metapopulations of key species within the watershed. Section 5 suggests two planning policies/strategies that may support the suggested goals and objectives.

1.2 Problem Definition & Research Question

Peck (1998) asserted that human-induced disturbances are included as a key component of ecosystems, and thus, it is hard to avoid affecting these systems. However, problems occur because the disturbances from human beings are typically larger than any other environmental impacts (Peck, 1998). To effectively manage and protect natural resources, community's role is important in coping with human impacts in ecosystem planning (Brody, 2008).

In our study area, several human impacts are continuously threatening the natural environment system of the Big Cyprus watershed. First of all, the rapid growth of the city of Naples, which is located in the west part of the watershed, is jeopardizing the wetlands. As shown in Figure 1, west side of the watershed is intruded by the expansion of city

boundary. Currently, the suburban sprawl around Naples tends to increase, and this may cause habitat fragmentation and habitat loss of our watershed. As Noss (1983) indicated, habitat fragmentation can be a huge threat to biodiversity. Moreover, rapid urbanization may disrupt small patches of habitat and cut the connectivity and existing corridors, which are considered to be crucial landscape elements for the natural systems (Brody, 2008). It also increases impervious surfaces of watersheds, which triggers future flooding.



Figure 1. Satellite image of suburban sprawl of the city of Naples, FL (USGS, 2012)

Second, as Brody (2008) mentioned, human impacts, such as population growth and extensive road construction may interrupt the entire ecosystem. Specifically, these two impacts mainly cause the fragmentation of habitats. Figure 2 shows the projected population growth and major roads around the Big Cyprus watersheds. Population projection estimated the growth of year 2020 (blue), 2040 (yellow), and 2060 (red). Because of the suburban sprawl of Naples, you may observe that the population of the region close to the city of Naples continuously grows until 2040, following the major roads. Additionally, it is estimated that the population of the north part of the watershed may increase significantly.

Since the population growth can induce more road constructions, it may catalyze the habitat divisions and craft existing patches much smaller. This explains Perlman, D. L. et al.(2005) argument that urban land uses break up

native habitats into discontinuous patches. In sum, these human-induced impacts may influence problematic risks to endanger species, especially for the Florida panther, by dissecting patches and disrupting corridors. "Subdividing habitats related to a metapopulation into the small levels may reduce its size and survival" (Brody, 2008, p.85).

Third, increasing sugar plantations and cattle grazing in this watershed region may degrade the water quality by indiscriminate uses of fertilizers, herbicides, and pesticides. Rapid urbanization near the watersheds increases impervious surface, and this may even deteriorate the water quality. Water quality is an important factor for the healthy ecosystem, since it substantially affects the plants, animals, fishes, and human populations. Rapidly growing suburban regions and other existing areas' water usage (for irrigation or drinking) near the watershed may cause desiccation problems to flora and fauna, as well as aquatic organisms.

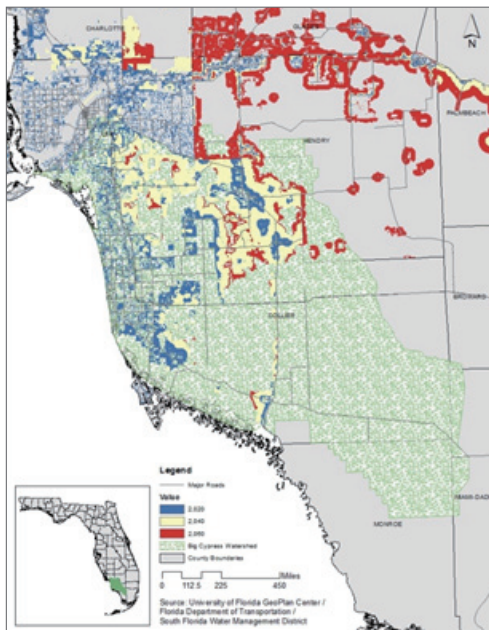


Figure 2. Projected population growth and major roads nearby the big cyprus watershed

2. Goals & Objectives in Current Plans

In this section, specific goals and objectives are listed based on the problems which the Big Cypress watershed should emphasize for the future healthy ecosystem. Goals and objectives in here mainly referred to the 'Galveston Bay Plan (1994),' and 'Comprehensive Everglades Restoration Plan (2001).'

Priority Problem 1: Rapid population growth and massive road constructions threaten endangered species and disrupt their habitats by causing fragmentation.

Goal 1: Conserve, restore, and protect endangered species to enhance biodiversity.

Objective: Define the habitat of endangered species, especially for the Florida panther, and discover suitable locations for eco-bridges to protect from road kills.

Objective: Improve the connectivity of Florida panther habitats.

Objective: Discover the important habitats for endangered species and add the information in the Southwest Florida Land Use and Management Plan within two years.

Priority Problem 2: Rapid suburban sprawl of Naples disrupts the watershed and ecosystem.

Goal 2: Reduce the impact from urbanization on the natural environment.

Objective: Provide incentives to private landowners in the watershed to avoid developments.

Objective: Create a boundary to prevent massive commercial and residential development.

Objective: Regulate and modify the land use plan.

Priority Problem 3: Discriminate use of fertilizers and rapid urbanization degrade the overall water quality of the Big Cyprus watershed.

Goal 3: Enhance ecological values of the watershed.

Objective: Improve hydrological functions of the watershed and protect wetlands.

Objective: Improve water quality and water flow within five.

3. Specific Areas & Ecological Components in a Regional Watershed Plan

Because the Big Cypress watershed includes a large area with various land covers, it is difficult to protect the entire watershed and its components. Therefore, this paper concentrated on specific areas and species, as well as ecological components to effectively create a regional watershed plan.

First, one of the major goals of this study is to protect and conserve endanger species. To be specific, we will

focus on protecting the habitat of Florida panther. Identifying the habitats of Florida panthers is crucial and habitat fragmentation is a huge threat to their survival, which substantially disconnects the connectivity (Brody, 2008). The U.S. Fish and Wildlife Service created 'Florida panther focus areas' in 2006 by using GIS (Figure 3).

In this map, most of our watershed region encompasses primary focus areas, which is represented as green. Some parts in the northern region are included as secondary focus areas within the watershed (red). We could discover from the existing map that the watershed plays a significant role for the protection of Florida panthers' habitat. However, most watershed regions are included as a primary or a secondary focus zone. It is not practical to protect the entire region. Therefore, we looked at the mortality of Florida panther to specify the focus area. This data was obtained from the Florida Fish and Wildlife Conservation Commission (FFWCC), and it shows panthers' mortality from 1972 to 2010. Since the original attribute table showed all kinds of mortality causes, we exported unknown deaths and intraspecific aggression deaths into the separate shapefiles, which are represented as yellow and blue, respectively (Figure 3). Dark red dots show where Florida panthers killed mostly because of human disturbances. As shown in the figure, Florida panthers are mostly killed by road-kills close to major and minor roads. Specifically, State Road 29, Country Road 846, and Interstate 75 are the roads where panthers frequently killed by car accidents. Thus, the areas near these roads need to be protected. Eliminating these three roads can be the best way to thoroughly connect the habitat of Florida panthers. However, since these roads' functions are important in the southwestern Florida region, we need an alternative method to protect Florida panthers from human impacts.

To incorporate wildlife conservation into the regional watershed planning and increase the connectivity of corridors, we suggest to construct a number of 'eco-bridges' or tunnels/elevated bridges in these roads in order to allow Florida panthers' movement more safely. In addition, some road kills are occurred near the City of Naples. This indicates that it is necessary to focus on this area to prevent future deaths of Florida panthers. If we do not regulate the suburban sprawl, future developments may split adjacent patches much

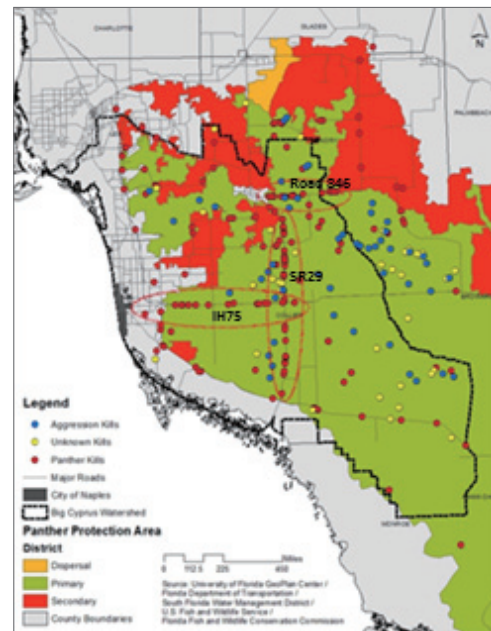


Figure 3. Florida panther focus area & road kills (US fish & wildlife service, 2006)

smaller and dissect the connectivity of wildlife.

Second, a regional watershed plan needs to highly focus on the city of Naples and nearby suburban areas. Big Cypress watershed not only supports diverse plants and wildlife, but also prevents urban runoffs and flooding by providing extensive functional wetlands. However, rapid urbanization, population growth, disruptive road construction and commercial development, and the increase of impervious surface may significantly impact the function of the wetlands. The USGS conducted a land cover trends survey of southern Florida coastal plain in 2009 and demonstrated that most of our watershed lies in wetlands. According to the Florida Natural Areas Inventory's Conservation Needs Assessment (2000), wetlands located in undeveloped areas, which may considerably conduct important role on preventing future flooding, are located near the Naples (Figure 4). National Park Services (2015b) modeled how the water should flow to achieve maintain healthy ecosystem in the future. Currently, the water flow of southern Florida have distorted because of sugar plantations and urbanization in coastal areas. To enable the water flow as Florida did in the past, we should emphasize the functions of wetlands in a regional watershed plan.

Third, one of ecological components that a regional watershed plan should emphasize is to preserve isolated

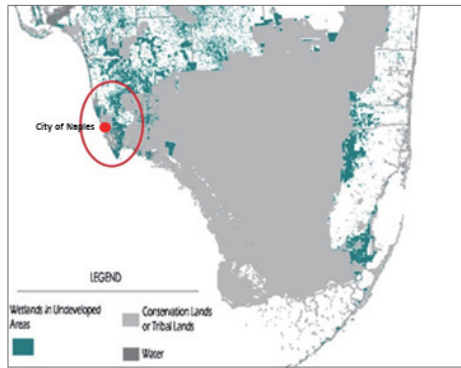


Figure 4. Wetlands in Undeveloped areas near naples

patches and to increase connectivity, Florida Natural Areas Inventory (2000) identified public lands and some private lands that have natural resource values and classified into three categories based on the protection status. Category 1 (green areas) indicates the highest protection and reserved for lands that are specifically and judiciously managed for biodiversity protection. Category 2 (yellow areas) shows lands that are generally managed for their natural values but that may incur additional uses such as habitat manipulation for game species and some recreation infrastructure. Finally, Category 3 (red areas) applies to lands maintained for multiple uses, including consumptive or recreational values, and not specifically dedicated to biodiversity conservation. Figure 5 illustrates the current conservation areas close to our watershed.

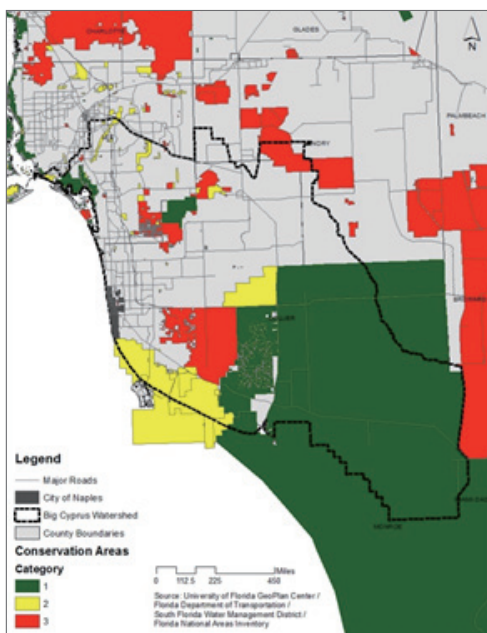


Figure 5. Managed conservation lands in florida

However, lands in the north part of the watershed were not classified by the Florida National Areas Inventory because they are included as private lands. Thus, this study used the Inverse Distance Weighted (IDW) interpolation tool to predict unknown lands' values at locations, based upon what is known. The basic concept of IDW is that features close together are more similar than features that are far away. Since the vector file converted to a raster file during the interpolation analysis, this study used mask tool only to consider the areas that are located inside the Big Cypress watershed boundary. Figure 6 shows the results of this analysis. Green areas are the high conservation regions, yellow areas represent the middle conservation sections, and red areas represent the low conservation sections. The major finding of this analysis is that the watershed is largely divided into two parts (north and south), by the red line that prolongs from the City of Naples to the northeast side of the watershed. Thus, it is encouraged that a regional watershed plan ought to concentrate on the areas where it divides the upper and the lower patches. Particularly, the findings argue that the areas, where SR-29 and I-75 intersects, may play a key role in connecting the north and the south regions. Hence, it will be an important corridor for wildlife. A plan should regulate human-induced disturbances in these highlighted areas to connect and maintain healthy ecosystem functions and processes.

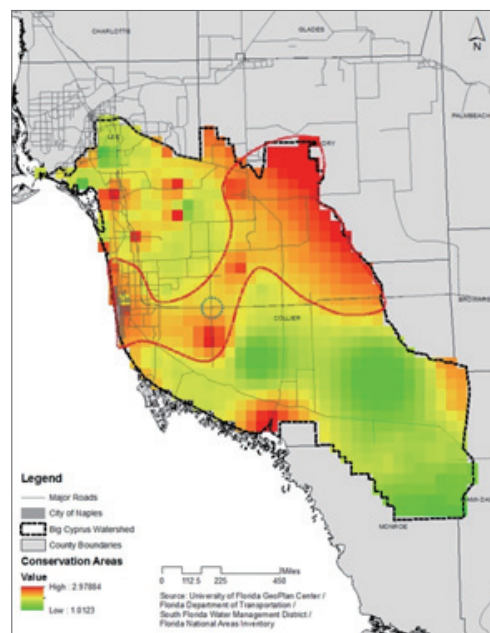


Figure 6. Conservation lands in raster f3ile

4. The Importance of Patches and Corridors

All of the landscape ecology principles are important to maintain the landscape mosaic and overall integrity of the ecosystem. However, the importance of each principle can be different depending on specific goals, objectives, and target areas of a plan. In this paper, the concept of patches and corridors are emphasized due to the selection of target areas and species. Large patches support larger populations and cover diverse species (Brody, 2008). Maintaining large patches is important to protect hydrological processes of watershed, provide essential habitats, and conserve overall ecosystems (Brody, 2008; Dramstead et al., 1996).

In modern society, however, habitats of wildlife increasingly emerge in scattered patches, which stand independently and connect the movement of natural systems (Brody, 2008). Many researchers stressed that the most important concept in the landscape ecology is to interconnect habitats, which may facilitate the movement of various species and dispersal (Brody, 2008; Noss, 1991; Peck, 1998). To enhance the capacity of connectivity, establishing landscape corridors is one of the most important and primary strategies (Peck, 1998). Damschen et al. (2006) discovered that habitat patches connected by corridors preserved more native plant species than isolated patches. In addition, "Corridors provide 'stepping-stones' to maintain species matrices intact and functioning as well as increase the movement of wildlife" (Brody, 2008, p.84). Thus, considering the concept of patches, corridors, and connectivity, which later form networks of landscape elements, is essential in maintaining the landscape mosaic.

Human impacts such as rapid urbanization, population growth, recreational activities, and sugar plantations may disrupt and fragment existing corridors. In this study, suburban sprawl of Naples is accelerating the corridor fragmentation. This study developed a map of potential habitats in our region based on the FFWCC's GIS data sets in order to show where the corridors fragmentation is happening in the watershed. Since FFWCC provided only a raster file for the potential habitat conservation areas (Figure 7), it had converted a raster file into a vector file and exported points by their richness level. Richness of potential

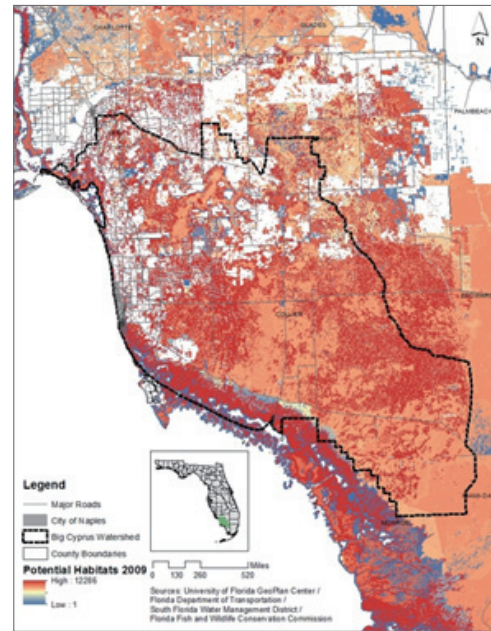


Figure 7. Potential habitat areas in 2009 (FFWCC, 2009)

habitat was classified from 1 to 10 by the FFWCC.

Figure 8 provides us clearly where the corridors dissection occurs. The findings show that the department should emphasize on connecting patches and corridors of north and south regions to maintain overall integrity of the ecosystem. In this step, it is highly recommended to use 'stepping stone connectivity' strategy to improve the movement of interior species between patches (Dramstead et al., 1996).

To support metapopulations of key species within the watershed, we need to conserve the landscape mosaic through connectivity (Brody, 2008). Metapopulations are groups of spatially separated local populations which interact at some level (Levins, 1969; Brody, 2008). "The size of the habitat matrix, the degree of connection to other habitats, and the level of human disturbance to the habitat may significantly affect the existence of metapopulations" (Brody, 2008, p.85). Since a variety of human-induced disturbances such as a fast suburban sprawl near Naples, pavements, and recreational activities (off-road vehicles in National Preserve) are interrupting the connectivity of adjacent patches in the watershed, the role of patches and corridors are important to maintain biodiversity and metapopulations of key species.

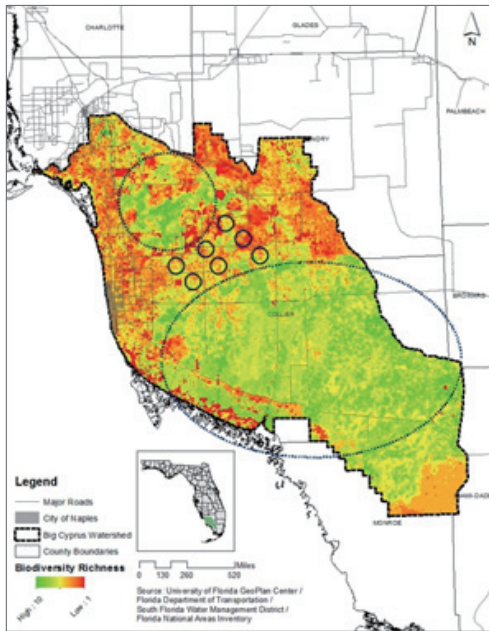


Figure 8. Potential habitat areas by richness

5. Conclusion

Florida emphasizes land use planning for local jurisdictions and ecological regions. To meet with the goals and objectives that this study suggested in the earlier section, two planning policies and strategies are suggested. Wondolleck and Yaffee (2000) pointed out that human impacts to biodiversity and habitat may positively affect the overall plan quality. Since the Big Cypress watershed is currently being menaced by various human-induced disturbances, the nearby jurisdictions should cooperate together and build strategies that may reduce various threats from future developments.

First of all, the main goal of this study is to conserve, restore, and protect endangered species to enhance biodiversity. In order to achieve this goal, the findings suggest that we need to focus on the habitat of Florida panthers and protect them from hazard risks. As it has been recommended in Section 4, SR-29, CR-846, and I-75 are the roads where panthers are frequently killed by car accidents. Specifically, the intersection of SR-29 and I-75 is discovered as crucial corridors, which connect the movement of Florida panthers from north to south. Thus,

constructing overpasses such as eco-bridges and eco-ducts may enhance their movement more safely. Moreover, conducting suitability analysis for the habitat of Florida panthers by using other specific indicators in GIS may also contribute on identifying the patterns of panthers' movement. When we look at the previous managed conservation lands that are determined by the Florida National Areas Inventory and the satellite image of Naples' suburban sprawl, we may readily discover that developments are rapidly destroying our watershed. Thus, watershed conservation shall be accomplished using incentives, land acquisitions, and land-use regulations. Figure 8 may support finding locations for land acquisition or places where it needs land-use regulations. In the end, these information should be updated to the Southwest Florida Land Use and Management Plan in order to effectively manage the future menaces and maintain healthy ecosystem.

Second, we need a concrete policies to conserve natural features of the wetland as well as the floodplain. Discriminate use of fertilizers and rapid urbanization degrade the overall water quality of the Big Cypress watershed. Wetland developments are disrupting the water flow on ecological features. Specifically, when massive development occurs near the suburban areas of Naples, it will be difficult to prevent severe damages from multiple hurricanes. To keep the function of wetlands and conserve natural features of the floodplain, several buffer zones should be placed in critical locations. Large-range buffers are recommended around wetlands in undeveloped areas near the City of Naples. Implementing these policies may balance the human impacts and valuable ecosystem. Finally, we highly suggest that a continuous monitoring process is essential to maintain the intricate ecological functions of the Big Cypress watershed.

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