A Transportation Grid Beneficial for All Residents:

Greenways Interlaced with Cul-de-Sacs (GIC)

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Abstract

A neighborhood with a network of interconnected greenway trails, with cul-de-sacs extending inward from a circumferential ring road, enables residents to live in greater safety and health. Local government enjoys a lower crime rate, higher tax base, and no-cost public greenspace. When government regulations are supportive, developers can receive a healthy profit. The network design is well grounded in ecological science, providing corridors and habitat appropriate for a broad range of residents of various abilities, ages and species. The transportation system is flexible: for each trip, residents choose among convenient alternative transportation modes. With a few simple and inexpensive changes in design from the status quo of typical subdivisions or street grids, many benefits are created.

We briefly review the literature demonstrating the benefits of this design in places such as Village Homes, a neighborhood in Davis, California and Houten and Almere, cities in the Netherlands. We show that many of the goals espoused for Smart Growth and New Urbanism (such as a sense of safety and community, a place of beauty, and convenient public transportation) may be met more broadly and more deeply by the Greenways Interlaced with Cul-de-Sacs (GIC) plan, instead of a fully connected street grid.

Keywords

Cul-de-Sac, Superblock, Street Grid, Village Homes, Greenway, Reconciliation Ecology, Stormwater Management, Urban Trail, Kids' Rights, Seniors, Active Living by Design, Neighborhood, Community.

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Contents

Introduction

This paper demonstrates that a neighborhood of Greenways Interlaced with Cul-de-Sacs (GIC) has many advantages over neighborhoods of more conventional design, such as fully connected street grids. A diagram of GIC is shown in Fig. 1, with narrow residential roads extending inward from a circumferential ring road, and ending in cul-de-sacs. The ring road defines the boundaries of a "superblock", an urban block larger than normal. Within the superblock, greenways (shown in gray) form a contiguous network, with few (if any) street crossings. Houses or townhomes with relatively small yards are clustered around commonly held "pocket parks". Each residence faces a road on one side and a greenspace on the other side.

In Fig. 1, the neighborhood center of activity is marked with a star. All residents can access the neighborhood center over the greenway paths in less than 10 minutes by foot, bicycle or wheelchair. There is one transit stop at the neighborhood center, so buses do not meander through cul-de-sacs or stop at every street corner. The commercial district near the bottom of the figure is displayed as a rectangle with diagonal lines. The businesses serve pedestrian customers from the neighborhood and from public transit, as well as customers in motorized vehicles travelling the arterial road at the bottom of the figure.

Benefits

This paper explores the ways in which GIC promotes safety, community, health and prosperity for all residents. Residents young and old can enjoy a variety of safe,

interesting, easily accessible outdoor spaces for recreation and for daily commuting to school and work. Stormwater is managed in inexpensive, aesthetically pleasing and environmentally beneficial ways. Developers and homeowners enjoy premium appreciation and return on investment. The local government enjoys a lower crime rate, a higher tax base, no-cost, maintenance-free public greenspace, and less pavement to maintain.

Background

The roots of GIC design can be traced to the Garden Cities of Ebeneezer Howard. While many of the advantages of GIC have been well researched and documented, relatively few new communities are being built with a GIC layout. In "Designing Sustainable Communities", Corbett and Corbett (2000) describe many lessons learned from the Village Homes development, a primary example of GIC. Perhaps because there are so many innovations at Village Homes, the particular attributes of GIC may not stand out clearly in the literature. For instance, while Hirschhorn and Souza (2001) praise Village Homes extensively, they propose design requirements which would exclude GIC altogether, in favor of street grids. This paper highlights the ways in which a greenway network, interlaced with cul-de-sac roads, is essential in the successful design of places such as Village Homes, a subdivision in Davis, California, USA and Houten and Almere, cities in the Netherlands.

Opposition

Concerns are sometimes expressed about GIC regarding the difficulty of common area landscaping and maintenance, the desire to welcome guests at the front door, the

increased traffic on arterials, the inclement weather in some parts of the world, and the need for access by emergency vehicles. This paper addresses each of these objections, and finds silver linings in some of them.

Alternative Designs

Cul-de-sacs are controversial. Many suburban residents appreciate cul-de-sac streets as common areas where children can meet and play. When each lawn is too small for childrens' activities, then the street becomes a long, conveniently located playground with infrequent, local motorized traffic. However, the incomplete street grid discourages navigation by bus, bicycle or foot, and children are at risk of colliding with occasional motorized traffic. Cul-de-sacs without greenways are detrimental to all modes of transportation except private motorized vehicles, and thus detrimental to the many youth and elders who lack either a driver's license or a car.

Fully connected street grids with sidewalks were popular in the early 1900's and have seen a renaissance in New Urban design. While this approach supports bus routes, bicycling, and walking better than most cul-de-sac designs, the streets are not as safe for children to play in, because some motorists take high-speed shortcuts through the residential streets. This leaves many children in need of a parental chauffeur in order to engage in any activity such as soccer, baseball or football requiring more space than a single lawn. In many parts of the world including America, cyclists share the roads with motorized vehicles, at some risk to the cyclists. Pedestrians and cyclists must cross motorized traffic at every street corner, which can be dangerous especially for the young, elderly and differently abled. Some of these dangers can be reduced (at additional

expense) with measures such as speedbumps, curb extensions, wide bicycle lanes and flashing lights at pedestrian crossings.

Unlike simple cul-de-sacs, GIC supports all modes of transportation well. Unlike street grids, GIC offers children a rich choice of safe and interesting playspaces. For the young and for the elderly, street grids and simple cul-de-sacs tend to be inconvenient, if not dangerous. In contrast, GIC neighborhoods are safe, convenient and delightful. This may explain why they tend to command premium prices even though they do not cost more to build, when supportive regulations are in place.

Discussion

In this discussion section, we compare GIC to a street grid in more detail, describe the benefits and features of GIC, and answer various objections to GIC. For readers inspired by the many benefits of GIC, we outline some aspects of implementation.

GIC Detailed Diagram

Fig. 2 shows a detailed schematic of a hypothetical Greenways Interlaced with Cul-de-Sac (GIC) design, in an American subdivion of approximately 40 acres (16 hectares). With minor adjustments, the size might be 20 to 60 acres. In Fig. 2A, narrow residential roads (20 to 26 foot width, 6 to 8 meters) carry local motorized traffic. All through-traffic is confined to the arterial shown at bottom, or the ring road shown on the sides and top of the superblock.

In Fig. 2B, greenways shown in gray provide a contiguous, uninterrupted right-of-way for surface water and contiguous, uninterrupted paths for animals & people. There are few (if any) pedestrian street crossings or culverts within the entire residential superblock. Children, frogs, and other small creatures can roam the entire greenway network without ever seeing a car, much less crossing a street. When the paths are paved like sidewalks, wheelchair users can access the entire network including the neighborhood center without negotiating any curbcuts or crossing any streets. Beside the greenway paths, surface water creates attractive intermittent and/or permanent water features such as streams, ponds and waterfalls. Installation may be less expensive than stormdrains or soakage trenches, and the final result is a visual amenity.

Cul-de-sacs are essential components of the GIC design. If the residential roads were closed loops, then the interior of each loop would be isolated from the larger greenspace. Residents on the outside of a loop might live adjacent to greenways, but residents on the inside of a loop would not. Anyone living or visiting homes on the interior of a loop would need to cross the street, in order to access the greenspace or the town center. Stormwater within the loop would need to be managed onsite, or else flow through a culvert into the common greenspace. With a connected grid (multiple adjacent loops), these problems are compounded, greenspace is highly fragmented, and many street-crossings are created. With the cul-de-sacs of GIC, street crossings are eliminated for people, stormwater and animals.

In a temperate climate, each residence can be oriented along an east-west axis as in Village Homes, for optimal daylighting from glazing on the north and south walls, and passive solar heating and cooling. This is especially important in China, where Feng Sui encourages south-facing windows. In Fig. 2C, most residences face open space such as a road or park on the south side, to optimize solar exposure for winter heating. All residents live beside a greenspace. In Village Homes, all residents are less than 1 minute's walk from a small park (LGC, 2004).

In Fig. 2D, public transit is focused at the neighborhood center, providing one central stop (shown as a star) for all routes, and a meeting place for all residents. Residents can walk to the neighborhood center on greenway paths in less than 10 minutes. A vista terminated at the neighborhood center can provide an attractive destination, encouraging pedestrians as they approach the center, and making the distance appear smaller. Many residents find it more convenient to walk or bicycle to the neighborhood center, rather than driving. A commercial district with shops, offices and restaurants extends along the arterial.

In Fig. 2E, guest parking lots provide guests with direct access to greenway paths. Whether guests arrive by foot, bicycle, public transit, or private motorized vehicle, they arrive at each residence by way of the greenway path. So, every front door faces the greenway path, and back doors face the roads.

A GIC layout may create heavier traffic on arterials, compared to a fully connected street grid. This can be a positive attribute when commercial zones are concentrated along arterials. In Fig. 2F, arterial congestion can be minimized with one-way streets a block or two apart and traffic lights synchronized for a steady 25-30 mph flow. Cars can flow most efficiently through an area at 25-30 mph (Clark, 2001). The commercial establishments and downtown zones get more traffic and more customers, the residential zones get less traffic and quieter neighborhoods, and the vehicles passing through the 1-way arterials get synchronized traffic lights and smoothly flowing traffic.

While Fig. 2 shows straight lines for simplicity, the road/greenway pattern will vary based on the parcel shape and topography, and roads and greenways may be curved. The entire superblock is sized so that all residences are less than 0.5 mile (a 10 minute walk or 3 minute bike ride) from the town center, measured along the greenways. A maximum path length of 0.25 miles (a 5 minute walk) is likely to encourage even more walking.

Alternative to GIC: Street Grid Diagram

Fig. 3 shows a diagram of a fully connected street grid. The residential roadways carry a mixture of local and through motorized traffic. Sidewalks, if any, place pedestrians beside motorized traffic, with street crossings at every intersection. Local arterials have less traffic than in the GIC example. Unless the residential density is very high, commercial establishments may need larger arterials for more traffic, so businesses tend to be located farther away from most residential areas. The “greenspace” is highly fragmented into individual front yards and back yards, many with fences. Individual building lots are shown in Fig. 3B. The lawns only appear connected to birds and other

species able to negotiate the fences. Only a few residents adjoin a larger greenspace (shown with dotted pattern). The only contiguous right-of-way is along the street, so stormwater is either buried, or channeled in a ditch beside motorized traffic. Public transit routes are scattered throughout the neighborhood. Because local buses may stop every block or two (bus stops are shown by stars in Fig. 3C), bus routes may tend to be slower than those with one centralized stop at each neighborhood center as in Fig. 2C.

GIC Benefits

GIC promotes safety, community, health and prosperity for all residents. Residents young and old can enjoy a variety of safe, interesting, easily accessible outdoor spaces for recreation and for daily commuting to school and work. Stormwater is managed in inexpensive, aesthetically pleasing and environmentally beneficial ways. Developers and homeowners enjoy premium appreciation and return on investment. The local government enjoys a lower crime rate, a higher tax base, no-cost maintenance-free public greenspace, and less pavement to maintain.

Safety and Community

Crime rates in Village Homes are ninety percent below those of other Davis neighborhoods, based on information from the local police department (Corbett and Corbett, 2004). The GIC design contributes to this effect, as does the ideal community size (approximately 500 residents) within well-defined physical boundaries (Corbett and Corbett 2000, p.139). The ring road provides a clear definition of the neighborhood's boundary. In Village Homes,

> "The average person knows 42 people in their neighborhood, compared to 17 by those in outlying areas. Residents spend 3.5 hours a week with friends in the neighborhood, compared to a vicinity average of 0.9 hrs./week. The average resident identifies 4.0 of their best friends living within the neighborhood, while the average is 0.4 for people living elsewhere in the vicinity." (LGC, 2004)

These statistics suggest that GIC contributes to a sense of community, which may help to reduce crime.

> "Several studies have found that crime and fear of crime are barriers to exercising and being physically active outdoors for women, particularly minority women… Likewise, parental concerns about safety curtail children's activity levels… Older adults are another vulnerable group. Numerous studies have found that older adults may restrict their activity because of concern about personal safety ." (TRB, 2005, p.164)

GIC may help to provide a convenient physical space and a supportive social structure in which to exercise safely.

> "Approximately 5,400 pedestrians and cyclists were killed in the United States in 2003, and an additional 116,000 were injured… Children and the elderly are the most vulnerable to pedestrian–automobile collisions—children in terms of injuries and older adults in terms of fatalities.. Most pedestrian–automobile collisions involving children happen in residential areas near a child's home… or on the journey to school" (TRB, 2005, 164-165)

> "Almere has proven to be a relatively safe city in terms of crashes, especially for the average cyclist. Almere is about twice as safe as the rest of the Netherlands in terms of crashes with fatalities and/or heavy injuries. For all vehicle/cycle crashes, Almere is 30% safer." (LEDA, 2000)

In a residential street grid, hazards to non-motorized traffic can be reduced (at additional expense) with traffic-calming devices, bike lanes, and cross-walk signage and signals at intersections. Within a GIC neighborhood, motorized hazards to non-motorized traffic are virtually eliminated at no cost, because there are no intersections and because bicycles are not required to share the roads with cars. While these are significant benefits, in the city of Almere they have found that there are still a few details to resolve for overall GIC safety. Even though bicyclists and pedestrians are very safe, there is a relatively high level of motorcycle crashes. "It is difficult to decide where motorcycles, mopeds and other motorised cycles belong on the cycle paths or on the roadways." (LEDA, 2000)

Health

Only 25% of Americans exercise enough to benefit their health (CDC, 2006). 20% of Americans walk, making walking the most common form of exercise (TRB, 2005, p.161-162). Some of the most widespread and growing health problems in America, such as obesity, diabetes, asthma, high blood pressure, and depression can be mitigated with simple, daily exercise. Even ADHD (Attention Deficit Hyperactivity Disorder) is mitigated by outdoor activity in nature (Louv, 2005). GIC promotes daily outdoor exercise in natural surroundings, at little or no cost. Walking downtown beside a

babbling brook is more fun and less stressful than walking downtown beside smoke-belching trucks and speeding cars.

> "Humans can adapt to a wide range of environmental conditions, but the result of adaptation to inhospitable conditions is temporary or chronic stress… Noise has been implicated in such disorders as… hypertension, ulcers… migraine headaches, insomnia, colitis, and mental illness… (E)xposure to noise (both loud, sudden noise and lower-level, continuous noise such as city traffic noise) can cause such reactions as vasoconstriction, raised blood cholesterol levels, high blood pressure, and irregular heartbeat… (T)he risk of heart attack is higher when one or more of the previously mentioned symptoms of noise exposure is present." (Corbett & Corbett 2000, p.59)

In an extensive literature review, the Transportation Research Board of the Institute of Medicine of the National Academies found that

> "neighborhood characteristics, identified by both subjective and objective measures such as presence of sidewalks, enjoyable scenery, and seeing others exercising, are positively correlated with walking and total physical activity… positive perceptions about shade, scenery, traffic, people, safety, and walking incentive and comfort were positively correlated with numbers of walking trips to neighborhood commercial areas." (TRB, 2005, pp.150-158)

Walking downtown is convenient when it is nearly as fast as driving out and around the ring road in a car. When walking downtown to the transit stop or business center is pleasant exercise, then exercise may be incorporated in daily commutes. When children have safe access under the neighbors' watchful eyes to an entire neighborhood's greenway network that includes a series of interesting pocket parks, with no danger of getting hit by motor vehicles, then playing outside may be more appealing. When residents can exercise safely on greenway paths, they may drive to the gym less often but still exercise more. Residents who might find street intersections risky (such as the very young, the blind or those using a wheelchair or walker) can travel from home to the downtown shops and public transit center without crossing a street. Village Homes even has a recreation center with solar-heated swimming pool at the town center, for easy exercise and play without motorized vehicle use.

According to the Active Transportation website (2006),

> "over half of Americans would like to walk more for exercise or transportation. Specifically, 63 percent claimed they would like to walk more for errands, while 38 percent would like to walk to work more. People point out a number of reasons for not walking more:… High traffic speeds… Incomplete, poorly maintained or missing sidewalks… Lack of safe street crossings… Crime/personal safety concerns… Dirty or unattractive walking environment."

Provided that the Homeowners' Association maintains the greenway paths properly, then all of these objections are addressed successfully by GIC. Traffic and street crossings are

eliminated from the walking environment, crime is reduced, and the greenway paths are attractive.

The Quality Communities Interagency Task Force Report of New York (QCITF, 2001) noted that

> "Americans are walking much less than they used to… Walking dropped from 9.3 percent of all trips in 1977 to just 5.4 percent in 1995… metro areas where people walk less tend to be places where more people are overweight… The concept of quality communities clearly should incorporate a transportation network that is safe and comfortable for pedestrians and bicyclists of all ages. … Alternative transportation means, such as walkways and bicycle paths, are perceived to afford a higher quality of life in urban and adjacent areas."

GIC empowers residents to walk and bicycle as an integral part of their daily routines, safely isolated from motorized traffic. In an appropriately sized neighborhood (~500 residents), GIC may reduce crime by as much as 90%, enabling more women, children and elders to walk safely, and thus enjoy the health benefits of exercise.

Attractive Surface Water Management

Surface water, whether flowing in streams or standing in ponds, is a beautiful component of many natural landscapes. In a typical urban street grid, surface water is only visible when storm drains are clogged, or when someone has installed a self-contained water feature.

GIC provides a contiguous right-of-way in the greenspace which can be used simultaneously for stormwater management, recreation, habitat and aesthetic enjoyment. Building lots are graded so that rainwater flows from the roads and building rooftops into the greenspace. Depending on the climate, streams and ponds in the greenways may be intermittent or constant. Bioswales enable rainwater to soak slowly into the ground after each storm, recharging the groundwater while filtering out contaminants from the roads. In many areas, aquifer levels are declining, so it is important to recharge the groundwater when possible.

Surface water access is an essential component in urban habitat that supports wildlife such as frogs, salamanders, birds and fish. For many humans young and old, relaxing and playing beside a body of water is enjoyable. It is fun to splash or fish or watch the water ripples or search for salamanders. Sitting in a street staring at a storm drain simply does not have the same appeal.

Safe, Interesting, Accessible Outdoor Space Where Children Play

Children often enjoy activities which require more space than a single urban or suburban lawn. A street grid provides most children with three options: a single lawn, a busy street, or a distant park. GIC provides more options: a single lawn, an alley with slow local traffic, a greenway with water features, pocket parks each with their own unique attributes, and a larger central park. All of these options can be accessed safely on foot or bicycle without crossing any streets. Any children living within the entire superblock can meet one another to play, without crossing any streets.

Just as an “indicator species” can represent the health of an entire ecosystem, children can indicate the suitability of a particular place for human habitation. GIC can provide various amenities for children such as easy access to neighborhood friends and parks, interesting ecologies to explore, and edible landscaping in the greenways. A GIC community that is properly sized (500 people within each well-defined border, Corbett and Corbett, 2000, p.139) provides a safe space in which children are free to explore and play, without danger from motorized vehicles or strangers. For adolescents, the central transit stop provides a doorway to the wider world, without a parental chauffeur in the family car or a driver’s license. While these amenities can be particularly valuable to children, they may be enjoyed by residents of all ages.

Market Value

In order to implement GIC which is relatively unfamiliar, many developers require a superior return on investment as compensation for the risk of innovation. In Village Homes, investors realized a 30% annual Return On Investment, and in 1995 property values were 13% higher than comparable homes nearby (Hirschhorn and Souza, 2001, p.32). While this provides one very positive data point, there are relatively few examples of GIC in the US. While savy homebuyers may seek clustered housing or parks nearby, most homebuyers are probably not aware of the overall value of GIC, unless each developer provides educational marketing materials.

However, there are examples of property in America adjacent to greenspace, whose value has been well documented. One might infer from these studies that a GIC development,

where every residence is adjacent to greenspace, may command a premium price. Correll et al (1978) found that the average value adjacent to a greenbelt in Boulder, CO was 32% higher than a comparable property 3200 feet away. Nelson (1985) found that land adjacent to a greenbelt in Salem, OR was worth $1200/acre more than comparable land 1000 feet away from the greenbelt. Lacy (1990) found that homes in two Massacusetts subdivisions of clustered housing with permanently protected open space appreciated at an average annual rate of 22%, compared to a rate of 19.5% in two comparable, conventional subdivisions, even though the conventional subdivisions had significantly larger lots. Lutzenhiser and Netusil (2001) found that in 1990, properties in Portland, Oregon within 1500 feet of greenspace sold for more than $10,000 more than comparable properties farther away from greenspace.

A survey by the National Association of Realtors (2001) found that 60% of respondents felt that it was very important to be able to walk to a neighborhood park, and 57% would consider the proximity to greenspace in choosing one neighborhood over another. 42% were willing to pay $10,000 extra for a house near a greenspace, and 60% supported zoning changes to permit smaller lot sizes when combined with common greenspace.

These numbers represent an under-served market willing to pay a premium for a rare product. If the benefits of GIC ever become available to 40% or more of the population, then the premium price might lessen. In the meantime, however, these benefits are rare and desirable.

Americans may be familiar with some of the benefits provided by GIC, from their experience on vacation. For instance, Intrawest is well known for its pedestrian-friendly, walkable resorts in North America, where pedestrians enjoy shopping in the downtown commercial districts while still having easy access to outdoor activities. Condominiums in these developments command premium prices and sell very quickly.

Size Matters

This section discusses how GIC can be applied to developments of various sizes and densities, and how GIC offers appropriate amenities to residents both large and small.

Density and Size

The GIC design can be applied to developments of varying densities and sizes, from sparse suburbs to compact multi-family communities. While Village Homes has a relatively sparse density of 4 units per gross acre, 40% of the area is held in common as greenspace by the Homeowners' Association, and much of the residents' fresh produce is grown in edible landscaping. The footprint shown in Fig. 1 could support single family residences, or multifamily residences at higher densities. Condominium townhome developments are particularly amenable to a GIC layout, because existing practices already provide Homeowners' Associations to hold and manage common property. At various densities, GIC supports mixed-use development with retail at the town center, because residents naturally frequent the town center in the course of daily activities, and because through-traffic funnels through the business district, bringing additional customers. If a development is too dense for surface parking, then a car park can be located under a green roof which supports common greenspace on top, as in Greenwich

Millenium Village of London and Village Green Homes on Blueberry Lane in Portland, Oregon.

Two large developments with GIC attributes have been built in the Netherlands. Currently, Houten has a population of 40,000 and Almere has a population of 150,000. A greenway network provides easy, direct access throughout the area for "slow traffic", while motorized travel from one neighborhood to another is only possible on the ring road. Residential streets are shaped as loops, grids and cul-de-sacs.

In Houten,

> "The bicycle is the most popular form of transport... The most important route is therefore the main cycleway, which has been constructed at right angles to the railway line. It is located in a car-free, park-like zone with the Centre (near the station) at the middle. The route is 3.2 km long, and the path is wide and stands out clearly. Trees have been planted on the verges at either side. The fact that the houses look out onto the cycle route has created a kind of social control. Open cycle paths and footpaths lead from the residential areas onto the main cycle route.
>
> In some places, junctions with motor traffic are unavoidable, but here cyclists are given priority. And where large numbers of cyclists have to cross busy roads, such as the ring road, cycle tunnels have been built.
>
> The main cycle route forms the backbone of the slow traffic system. The ring road leads motor traffic neatly around Houten, which means that only local traffic is

found in the residential areas. Cars can access these districts via offshoots. If they want to go to another district they have to return to the ring road, which ensures that the residential areas are quiet and safe places in which to live.

Houten has excellent train connections: a train leaves Houten for the city of Utrecht, which is just ten minutes away, and vice versa, every fifteen minutes. There are also good bus connections… There is an embankment between the ring road and the residential areas, to prevent noise pollution." (Houten municipal website, 2006)

In Almere,

"The goal is to make travel time in the inner city shorter by cycle than by car, and to facilitate direct cycle access between the various city sections.

Within the districts walking and cycling has been given priority in the spatial plan. The cycle paths radiate from the city centre. To reach the heart of each district the cyclist only has to travel a short, straight path that is exclusively used by 'slow' traffic.

Between districts, facilities have been located in such a way that they are easily accessible and within reasonable distances for slow traffic. Crossings with motorised traffic are grade separated, and are on average available every 400 metres. The separation is an important feature to which many benefits can be related. (LEDA, 2000)

Village Homes, Houten and Almere show that GIC design can be applied to projects of various sizes, from a neighborhood to a city.

Fig. 4 suggests some of the ways in which GIC superblocks can be adjoined with one another, to form larger communities. In Fig. 4A, two blocks share a common town center. In Fig. 4B, two blocks are located between a commercial strip development at the bottom of figure, and a greenspace at the top of figure used for agriculture, forestry or parkland. Ideally, greenway/roadway intersections are mediated with pedestrian tunnels or bridges, as in Houten and Almere. A pedestrian walkway under the roadway is especially appropriate where the greenway follows the course of a river through a culvert under the road.

Appropriate Scale for All Uses

A street grid provides one basic street pattern for all transportation uses, regardless of their scale. In contrast, GIC provides different transportation patterns at different spatial scales. In 10 minutes on residential roads, a car can travel 2 miles or more, while a pedestrian can only travel 0.5 mile or less. GIC design recognizes this difference in speed and scale, and requires motorized vehicles to travel farther (via the circumferential ring road) because they can travel faster.

In conservation biology, biodiversity is correlated with land area. Corridors between wildlife sanctuaries can increase biodiversity by increasing the effective land area

available to particular populations. Humans have defined the habitat of more than 90% of the livable surface of the Earth. The Earth is in the midst of a massive species extinction. Over the next few centuries, if we are to lose less than 90% of the species that existed before the Industrial Revolution, we will need to modify the land use in our inhabited/cultivated portion of the Earth, to be more compatible with our wild neighbors (Rosenzweig, 2003). GIC is one way to accomplish this. The basic GIC design is a contiguous network of greenways intelligently interspersed with a contiguous network of roads, with minimal intersections between the two networks. This design can be applied at many scales in order to enhance the survival of many species. Residents of GIC neighborhoods, particularly children who have grown up in GIC neighborhoods, may be especially well suited to accomplish this modification in human land use patterns. The GIC design embodies appropriate forms for various residents at various scales such as children, adults, elderly, motorized vehicles, bicycles, aquatic and terrestrial plants and animals. Appropriate design such as this is essential in the budding field of reconciliation ecology.

Objections to GIC

Common Area Maintenance

One objection to GIC is that wide swaths of pavement are easier to maintain than common greenspace. Village Homes has demonstrated that when GIC design is supported by well-formulated covenants, this will nourish a sense of community so that neighbors will adopt each pocket park as their own, taking the burden of landscape

development, maintenance and surveillance off the developer or local government. Homeowners own the greenway areas in common, so they develop a sense of community in the process of managing these areas. In Village Homes, much of the landscaping in each park was completed by the new residents, at minimal cost to the developers (Corbett and Corbett 2000). While the Homeowners' Association at Village Homes has a significant responsibility to maintain the common space, it also has significant sources of revenue in the form of rental income from commercial space at the neighborhood center.

Front Doors and Guest Parking

A challenge for GIC is that homeowners want guests to arrive at the front door, but the public side of the house with the front door faces the greenway. This challenge can be resolved with small guest parking lots with direct access to greenway paths, at intervals between houses. Directions for guests arriving by private vehicle might be, "Drive down Sycamore Lane, park in the third driveway on the left. Enter the trail and turn right. We're the third house on the right". The front door faces the greenway, for invited guests and for a public face to the passersby on the greenway. Of course, guests also have the option to arrive by public transit, and walk through the greenway network to the front door.

Arterial Traffic

With notable exceptions such as San Francisco and New York City, most residential areas in America are not dense enough to support a vibrant commercial district based solely on local residents. At lower densities, local neighborhood retail establishments depend on through-traffic for customers. While New Urbanism promotes mixed-use

development with small-scale, local retail, high customer volume is essential for most retail success.

Compared to a street grid, GIC increases arterial traffic through the commercial district. This is good for business. The through-traffic stays off residential streets, and this creates quieter, safer neighborhoods. Fig. 2D shows that arterial congestion can be minimized with one-way streets a block or two apart and traffic lights synchronized for a steady 25-30 mph flow along the arterial. Many downtown areas such as Eugene, Oregon and Ithaca, New York use this arterial pattern to support vibrant downtown commercial districts.

Some Departments of Transportation are committed to street grids as efficient ways to move vehicles. However, in residential neighborhoods, the primary cargo is people. The primary purpose of a residential transportation system is to move people—not vehicles. A GIC transportation system moves people efficiently and safely, while enhancing their health and wellbeing. A GIC transportation system is flexible: if private motorized transportation becomes more expensive in the future, GIC residents can easily choose other transportation modes.

Weather

Clark (2001) in Michigan has expressed concern that GIC may be most appropriate in the sunny climate of California, where the weather supports outdoor activity year-round. While Houten and Almere in the Netherlands provide counterexamples, some of the best answers to this concern are the many university campuses in northern climates.

University students walk to class outdoors for most of the year, from Missoula, Montana to Boston, Massachusetts. Some campuses provide alternatives for the coldest weather, such as heated underground tunnels. However, students would probably revolt if they were forced to use these tunnels all year long, rather than walking outdoors in the summer sun. GIC provides options. Each resident can choose each day, for each trip, which transportation mode is most suitable.

In the winter snow, some GIC residents might walk and some might enjoy a cross-country ski jaunt downtown. In the snow or rain, other residents will drive their cars, rather than walking to the town center. They have a choice. GIC does not make a trip by private motorized vehicle impossible, or even difficult. The trip is simply a few minutes longer than it would have been, in a street grid.

Emergency Vehicle Access

A street grid provides predictable, accessible addresses for emergency responders. As with any cul-de-sac development, a GIC developer should educate the local emergency responders about access to all of the addresses in the development, and the street addresses should be named and numbered in an obvious manner. Village Homes has demonstrated a 90% reduction in crime rate, compared to surrounding neighborhoods. This reduction in crime rate may help to compensate for a slightly longer response time, on the rare occasions when police are called. GIC residents who exercise regularly in a natural setting, as an integral part of their daily routines, will enjoy many health benefits including lower blood pressure, lower cholesterol levels, and more regular heartbeats.

This improvement in health may help to compensate for a slightly longer response time, on the rare occasions when an ambulance is called.

Implementation

While GIC provides many benefits, it also can bring significant cost savings to developers. In Village Homes, the unlined surface system of bioswales was significantly less expensive to build than conventional storm drains would have been. Many of the new homebuyers were happy to help plan and landscape their very own pocket park. Because GIC provides many rare and sought-after benefits, a few press releases can generate a significant marketing presence. Approval for a new subdivision can go more smoothly and quickly, when the neighbors understand that much of the land will be maintained as public open space. While most developments are considered successful with at least 20% ROI (Return on Investment), Village Homes returned 30%.

The main barriers to implementing Village Homes were regulations, such as fire codes requiring wide streets and building codes requiring storm drains. Village Homes was only possible because 3 of the 5 City Council members supported the project throughout a 2-year series of regulatory exemptions. Fortunately, Judy Corbett, one of the founders of Village Homes, has established the Local Government Commission (www.lgc.org) to help municipalities adopt regulations which support developments similar to Village Homes. Conventional financing was also a challenge, because the project was in some ways unconventional. The primary risk to a developer is that unsupportive regulations could lengthen the construction time. If a developer can confirm that the local regulatory

environment is friendly to GIC and that financing is available, before purchasing land, then the risk of implementing GIC will be significantly reduced.

Incidentally, developers negotiating with a Fire Marshall for narrow streets and cul-de-sacs might consider complementary green building techniques. For example, many firefighters support the green practice of eliminating vinyl (PVC) from buildings, because the smoke from burning vinyl is extremely toxic.

The GIC layout is probably not more common because it is unfamiliar to many planners, developers and homebuyers. As more planners and developers embrace the unfamiliar, the myriad benefits of GIC will become available to more and more homebuyers. The first developers who adopt GIC may be those concerned about leaving a legacy, or interested in a better image within a community, or planning to live in the development themselves, or with other nonfinancial incentives to accept the challenges of the unfamiliar.

Of course, for local governments, GIC provides civic benefits for free. The homeowners buy greenspace in common and the Homeowners' Association maintains it. The role of local government is simply to permit GIC to exist, with appropriate codes for zoning and building. For instance, the codes need to permit "clustered development", with small individual lot sizes and minimal setbacks, combined with a share of a common greenspace. The building codes need to permit bioswales and other surfacewater management tools, to enable the developer to create a beautiful common space at an

affordable cost. And the codes must permit narrow street widths (20 to 26 ft, 6 to 8 meters) without sidewalks, so that more land is available for greenways with paths. Appropriate local regulations help to create public greenspace, lower crime, higher property values and healthier citizens, at no cost to the municipality.

While GIC is easiest to implement in a new development, it can be retrofitted in an existing street grid or cul-de-sac pattern by a developer or political authority with the power to close streets and establish new right-of-ways through existing yards. For example, Fig. 5 shows the street grid from Fig. 3B, converted to GIC. Streets are shown in black, public greenways are shown in gray. This conversion requires minimal changes in infrastructure: in this example, minor changes in pavement were made, and no houses were demolished. GIC conversions such as this would increase the walkability of many existing neighborhoods, and their usefulness for all ages, even though the storm drains are not daylighted and the front doors do not face the greenways.

Conclusion

Most new subdivisions provide adequate places for people to live. Neotraditional communities with street grids often provide better places for people to live. GIC communities can provide great places for people and wildlife to live in excellent health, safety and happiness. Creating a GIC neighborhood need not cost extra money, when local regulations support the process.

The GIC design demonstrates concretely to children that their elders have made space for Nature and for children, while still meeting their own needs as adults. This is the essence

of sustainability, to fulfill our own needs while supporting the ability of future generations to meet their needs. The needs of children are addressed by GIC in important ways where street grids fail, such as safe and easy opportunities to play in interesting, varied, extensive and beautiful outdoor spaces. Children raised in GIC neighborhoods may be well prepared to integrate more and more of their wild neighbors into the fabric of human land use, helping them avoid extinction.

The GIC design also provides the elderly with amenities such as safe, daily access to walking paths, public transit, neighborhood shops, natural settings and neighbors of all ages.

Cul-de-sacs are essential components of the GIC design. While cul-de-sacs without greenways have serious drawbacks, greenways interlaced with cul-de-sacs have significant advantages over traditional street grids.

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Figure Captions

Fig. 1 Greenways Interlaced with Cul-de-Sacs (GIC).

Narrow residential roads end in cul-de-sacs. A network of paths extends throughout the greenways shown in gray. Neighborhood center is marked with a star. Commercial mixed-use district near bottom of figure is displayed as a rectangle with diagonal lines. Arterial road is at bottom of figure.

Fig. 2 Greenways Interlaced with Cul-de-Sacs (GIC), details.

A. Residential roads only carry local motorized traffic. Through-traffic is focused in arterial (at bottom of figure) with small, local commercial district (hashed rectangle at bottom of figure). Streets are narrow without sidewalks, leaving land available for greenways with paved paths.

B. Network of greenway paths beside surface water drainage.

Greenways shown in gray provide contiguous right-of-way for surface water and contiguous habitat for animals & people. A network of paved paths (thin black lines) extends throughout the greenways. There are few (if any) pedestrian street crossings or culverts within the entire neighborhood. Surface water creates attractive intermittent and/or permanent water features beside the paths. Many residents find it convenient to walk or bicycle to neighborhood center, rather than driving. Bicyclists and pedestrians entering the superblock have multiple entry points from the ring road onto the greenway path network.

C. All residents live adjacent to a small park. For optimal daylighting and passive solar heating in temperate climates, houses are oriented on an East-West axis, with a clear southern exposure not blocked by adjacent houses.

D. Public transit is focused at the town center, providing one central stop (shown as a star) for all routes, and a meeting place for all residents. Residents can walk to town center on greenways in less than 10 minutes. A vista terminated at town center can provide an attractive destination.

E. Guest Parking with greenway access is shown in black. The front door of each house faces the greenway, and guests arrive at the front door by way of the path.

F. Arterial congestion through the commercial area can be minimized with one-way streets a block apart, and synchronized traffic lights.

Note: The entire superblock is sized so that all residences are less than 0.5 mile from the town center, measured along the greenway paths. The size of each superblock is in the range of 20 to 60 acres—the hypothetical block shown is 40 acres.

Fig. 3 Fully Connected Street Grid

A. Residential roadways carry local and through motorized traffic. Sidewalks, if any, place pedestrians beside motorized traffic with street crossings at every intersection. Local arterials have less traffic. Unless the residential density is very high, commercial establishments need larger arterials for more traffic, so businesses are located away from many residential areas. (Commercial zone is off the map, not shown here).

B. “Greenspace” is highly fragmented. Individual lawns are of limited use for many species. Only a few homes adjoin a larger greenspace (shown with dotted pattern). The only contiguous right-of-way is along the street, so stormwater is either buried, or channeled in a ditch beside motorized traffic.

C. Public transit routes are scattered throughout the neighborhood. Buses stop every block or two (transit stops shown with stars).

Fig. 4 GIC Blocks can be adjacent to one another.

A. Superblocks sharing a common town center.

B. Superblocks adjoining a commercial strip development below and greenspace above. The commercial strip surrounds 2 one-way arterials, a block apart, with synchronized traffic signals. Greenway/roadway intersections are mediated with pedestrian tunnels or bridges, as in Houten and Almere.

Fig. 5 Street grid converted to GIC

The street grid from Fig. 3B has been converted to GIC. Streets are shown in black, public greenways are shown in gray, commercial buildings are marked with diagonal stripes.