Optimizing Transportation Networks Based on Ecological Suitability: An Innovative Approach to Integrating Non- Motorized Transportation Efficiency with Urban Ecology

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Highlight

Integrate transportation efficiency with ecological and sustainability concerns, where related research is rare

Focused on non-motorized transportation infrastructure alignment and design and reduction of ecological impacts

Analysis was conducted by combining Geographic Information Systems (GIS) and Space Syntax to facilitate the research

Provide a potential methodology for augmenting and improving existing non-motorized transportation networks that may be referenced by other researchers and planners

Motivation

With regional and local ecological priority areas increasingly impacted by urban development, the impacts of urban infrastructure, land use, and roads on biodiversity, natural communities, water resources, and landscape-scale green infrastructure is increasingly of concern.

However, research that attempts to integrate transportation efficiency with ecological and sustainability concerns is rare. In particular- research focused on non-motorized transportation infrastructure alignment and design and reduction of ecological impacts is hard to find.

To this end, the goal of this research is to identify a methodology for designing an improved non-motorized transportation network, which allows consideration of both transportation efficiency and ecological priorities in infrastructure network design.

Research Framework

◇ Research Hypothesis

If generate non-motorized route based on ecological suitability, can it also benefit urban transportation?

- Yes, let's make an positive hypothesis
- And we should consider how to make it positive

◇ Test Hypothesis

How to generate a applicable non-motorized network?

- Limited ecological impact
- High traffic attractiveness
- Limited construction cost

How to evaluate the benefits from the optimized non-motorized network?

- Compare to the existing transportation network
- Assess the service coverage
- Test the OD Matrix

Which tool is applicable for the research process?

Software Platform	Tools	Analysis
Geographic Information System	Raster Calculator	Ecological Suitability Map (Local)
	Cell Statistics	Ecological Suitability Map (Overall)
	Map Editor	Potential areas for commuters, visitors, and sportspeople
	Cost Connectivity	Potential New Routes
	Euclidean Distance	Proximity to existing transportation network
	OD Matrix	Least cost routes among multiple origins and destinations
	Service Area	Accessible coverage and service area that can be reached with time or distance impedance
Space Syntax	Axial Map	Linear assessment
	Depth Map	Depth assessment
	Segment Map	Integrity and connectivity assessment

Objectives

◇ Identify Applicable Non-motorized Network

To identify potential non-motorized routes for the optimized transportation network

- Identify ecological suitability map and traffic attractive map for calculation
- Using GIS to get the potential non-motorized routes that improve transportation efficiency with limited ecological impact

◇ Evaluate Transportation Efficiency

To assess how the optimized transportation network improved the transportaion efficiency

- Evaluation based on both quantitative research and transportation effiency analysis

Methodology and Application

◇ Identify Ecological Suitability Maps

Local scale

Using local data to create a tabular report that using five indexes, landscape, habitat, watershed, conservation and green space land with proper weighting for their subdivision based on expert scoring method.

Regional scale

Referenced CLIP project, the Critical Lands and Waters Identification Project, to show the ecologial suitability map from regioanl concern.

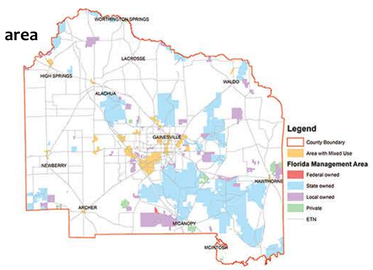
Overlay

Get the overall suitability map based on GIS, using both Cell Statisitcs Maximum approach (to protext all the ecological high priority area) and Average Approach (to maximum potential licaltion for non-motorized routes with limited ecological impact).

◇ Identify traffic demand area

To identify where additional transportation routes are needed based on the purposes of travel and the density of traffic attractions.

Typical areas were identifies based land use type for the purpose of Commuting, recreation, and education.



◇ Identify Applicable Nonmotorized Routes

Nonmotorized routes were produced based on the two ecological suitability map by calculating the ecological cost with Cost Connectivity tool.

Screening

- Identify the proximity to existing transportation network and potential traffic demand areas
- Analyze land suitability based on land use type (public accessibility and

◇ Comparative analysis

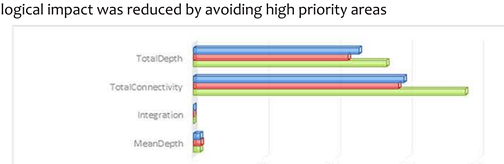
Topological comparison

Statistic: Topological relationship was increased by strengthen the depth, connectivity and integration

Visually: importance of each index was imcrease up to 2 levels

Ecological comparison

Ecological impact was reduced by avoiding high priority areas

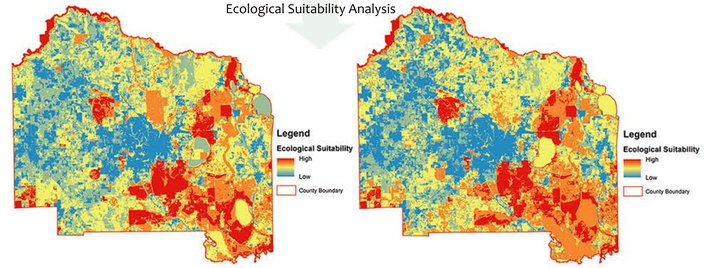


	MeanDepth	Integration	TotalConnectivity	TotalDepth
Road Network	18.97	0.42	588.78	463.36
Existing transportation Network	21.22	0.40	573.50	432.73
Optimized Transportation Network	19.26	0.44	760.33	540.09

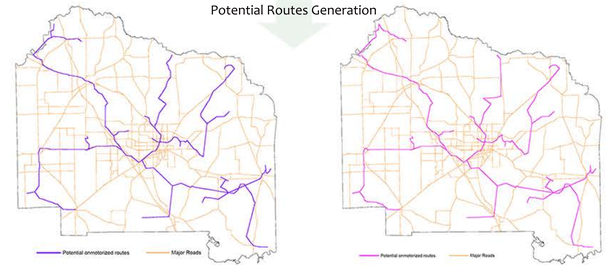
	MeanDepth	Integration	TotalConnectivity	TotalDepth
Road Network	17964.76	401.94	557577	438798
Existing transportation Network	25655.28	479.96	692817	523165
Optimized Transportation Network	26523.89	610.69	1046976	743710

Alachua County, FL

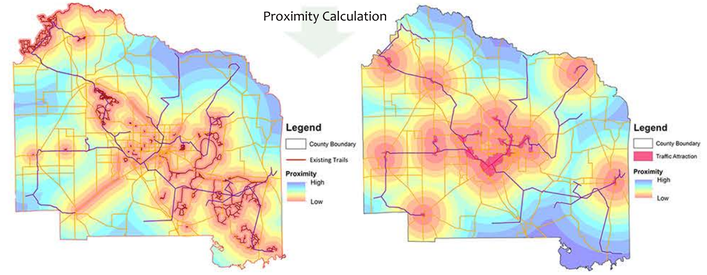
Ecological Suitability Analysis

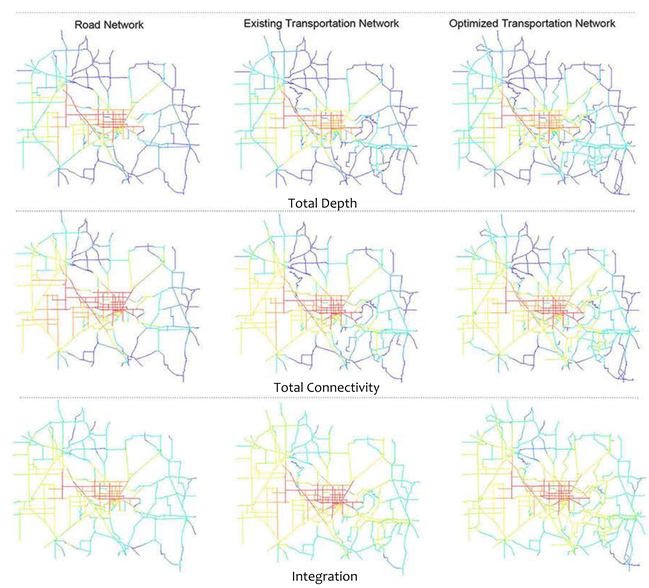


Potential Routes Generation



Proximity Calculation





◇ Service Efficiency

Network Analysis

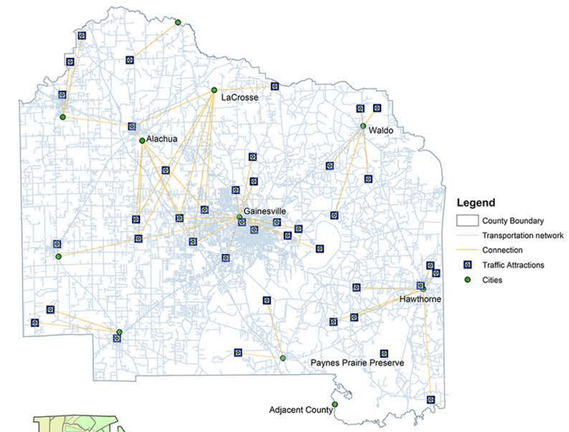
To assess the least cost route among multiple origins and destinations.
OD data from the entroids of cities and traffic attractions

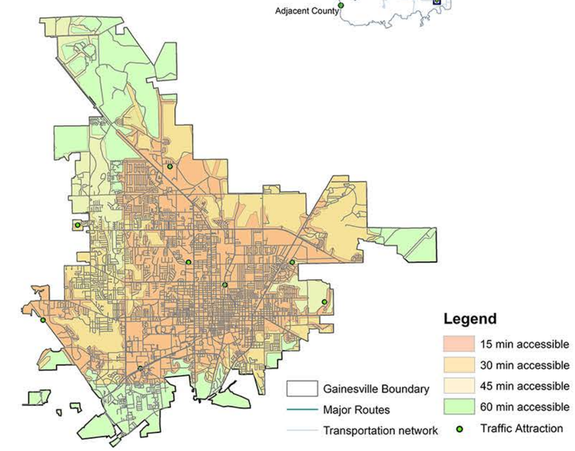
Service Coverage

To assess the accessible range inder limited travel time

Context Suitability

To double-check with the most updated existing condition





Conclusion

Consider both ecological priority and traffic demand can benefit both ecosystem and transportation efficiency in Alachua case

Ecological suitability is a feasible reference to select non-motorized lines to improve transportation efficiency considering accessibility, convenience, and travel time and distance

Non-motorized network can link open space and urban life while facilitate non-motorized travelers, in particular for intercity commuters.

Ecological concern should be a precautionary concern before the design process, as it can save ecological impact and construction while improve topolical relationship that benefits transportation efficiency

Context infomation is necessary to balance the right for both ecosystem and human, especially in built environment

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