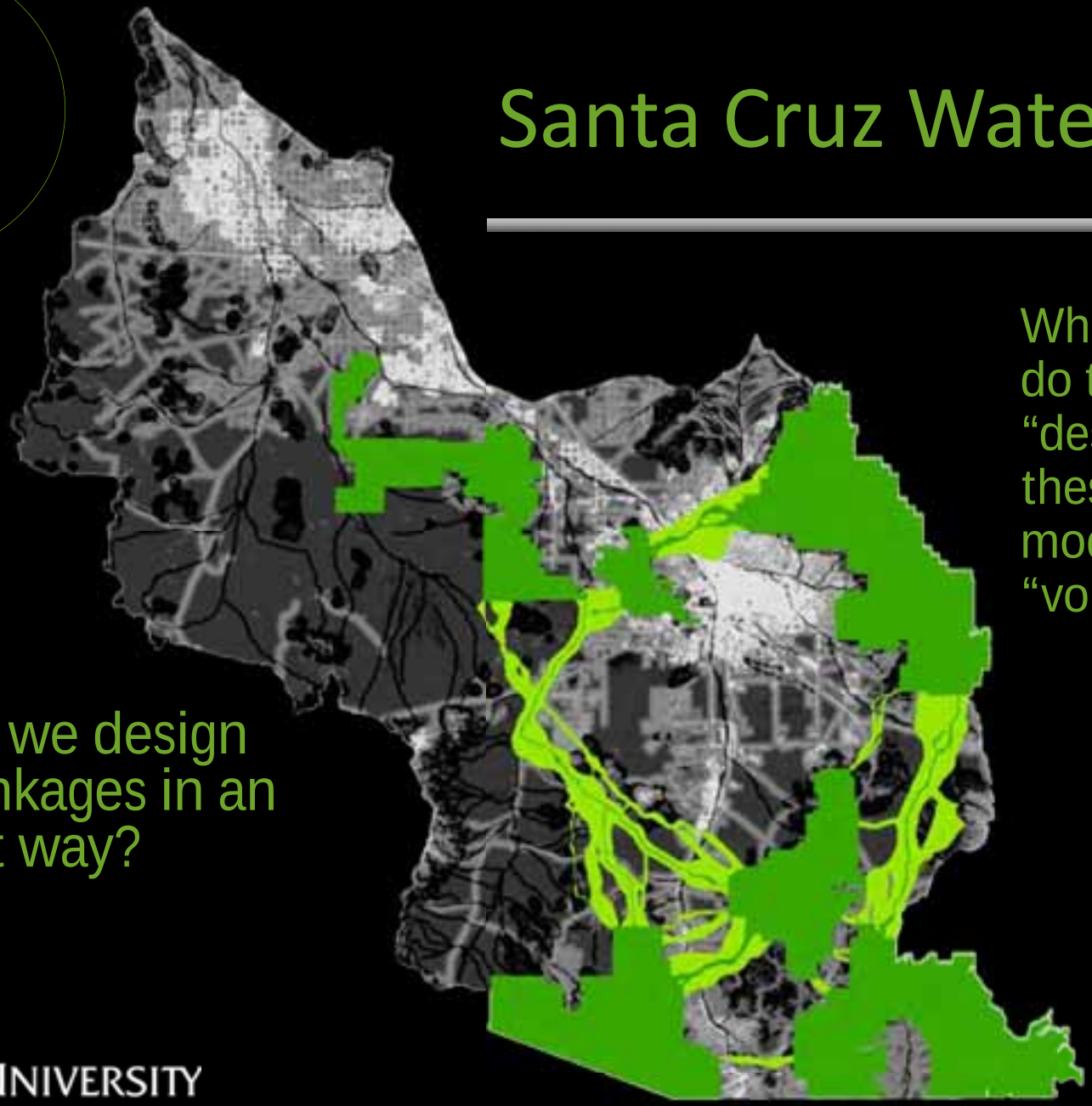
Employing an Automated Design Module (ADM) in Wildlife Corridor Design

Ryan M. Perkl, Ph.D.
Planning Degree Program
School of Landscape Architecture & Planning
The University of Arizona

Research Team:
Samuel Chambers,
Brandon Herman, Garrett Smith, Wanyi Song

THE UNIVERSITY OF ARIZONA

Santa Cruz Watershed

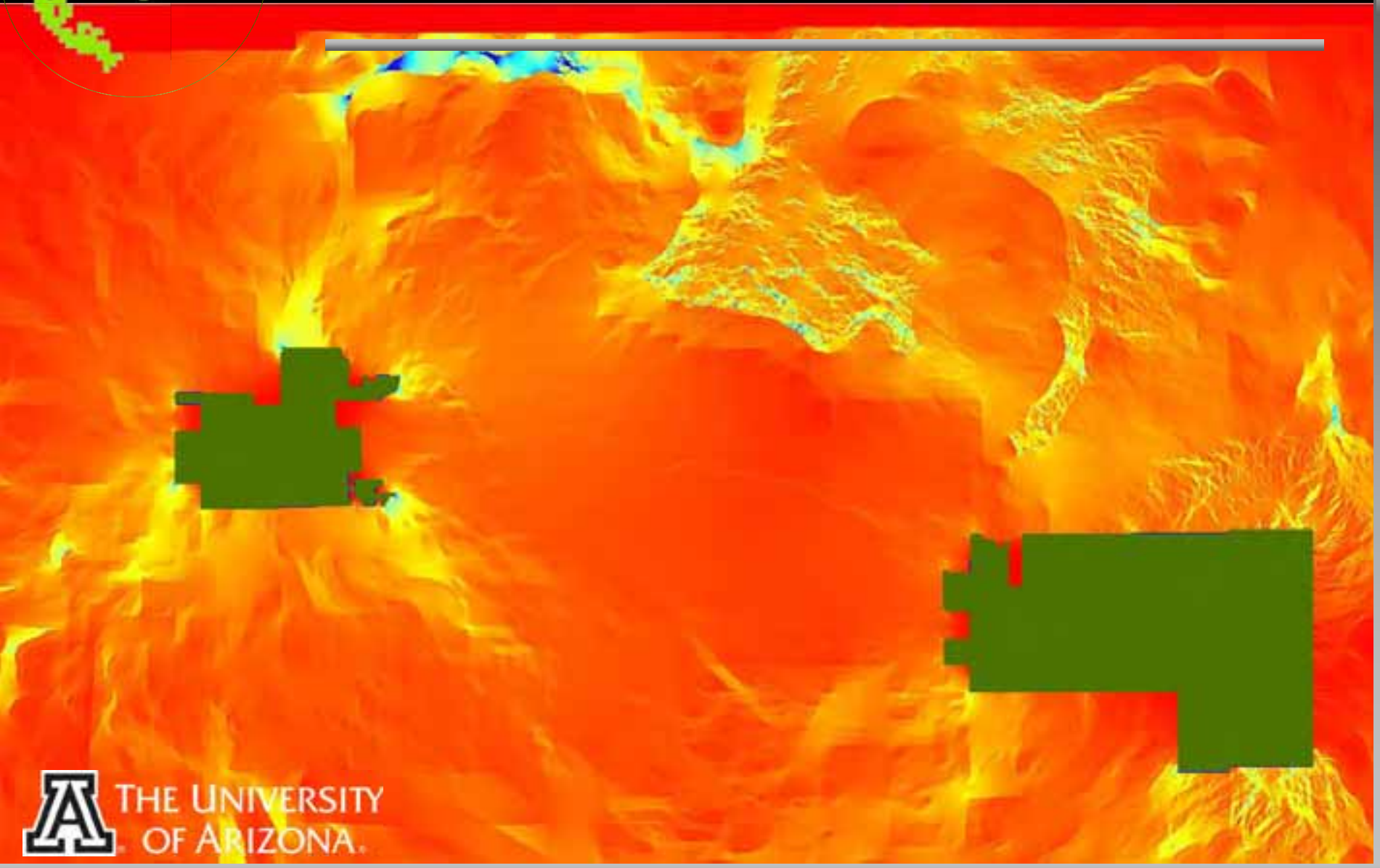


What can we do to "design" these modeled "voids"?

How do we design these linkages in an efficient way?

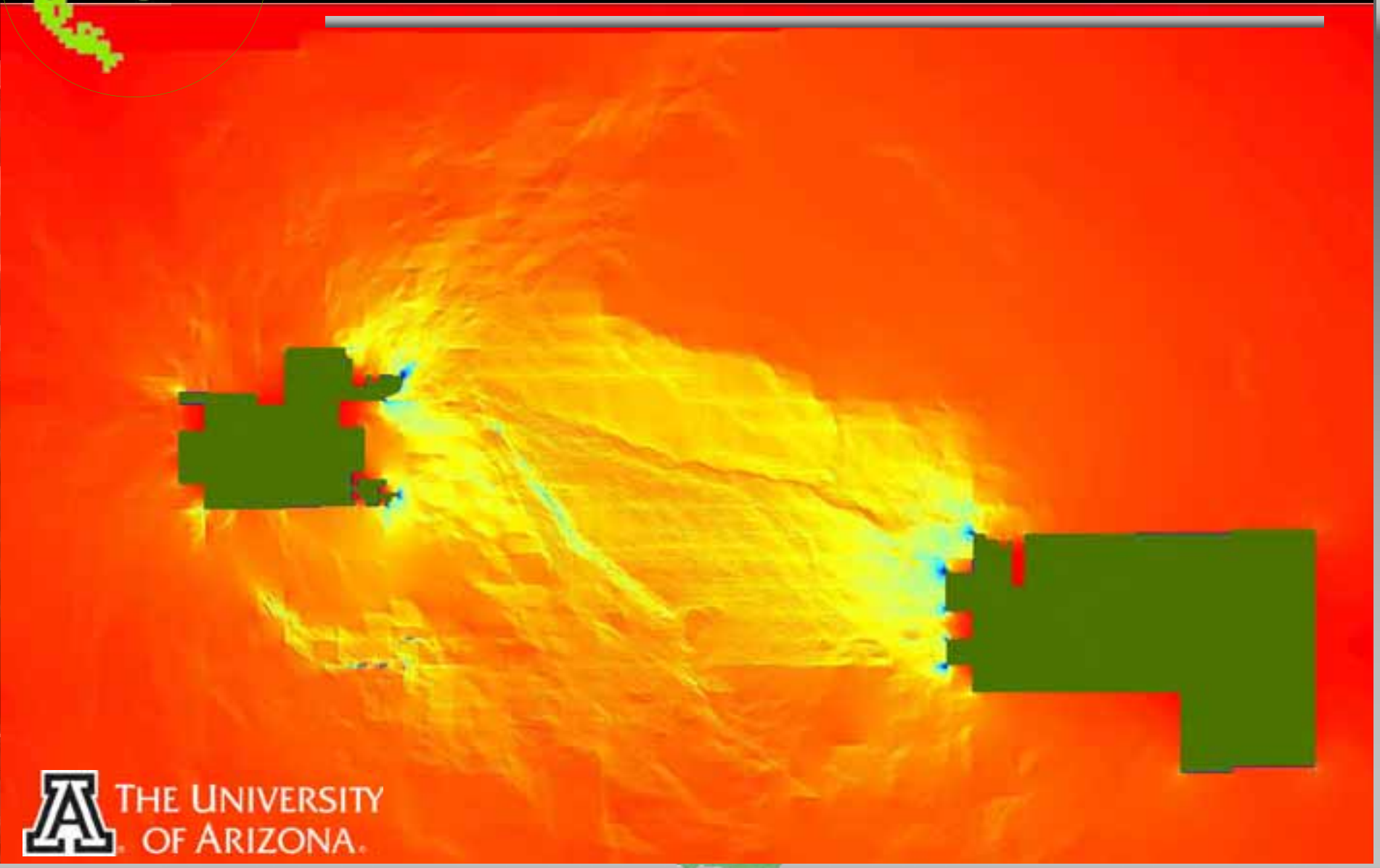
THE UNIVERSITY OF ARIZONA

Linkage Modeling



THE UNIVERSITY OF ARIZONA

Linkage Modeling



THE UNIVERSITY OF ARIZONA

More to Linkage Modeling

- A modeled corridor by itself is NOT a design, but rather a planning mechanism that can be consulted and used to guide decision making. It is a very helpful and necessary first step.

- Design requires attention to site specific characteristics, functions, and even qualitative variables such as aesthetics. These variables are not easily captured in corridor modeling and require additional refinement.

- What do we know about landscape patterns and their effect on connectivity? Can we borrow from other disciplines and integrate this knowledge into the design of modeled corridors to enhance how they function?

Meta-Analysis: Urban Linkages

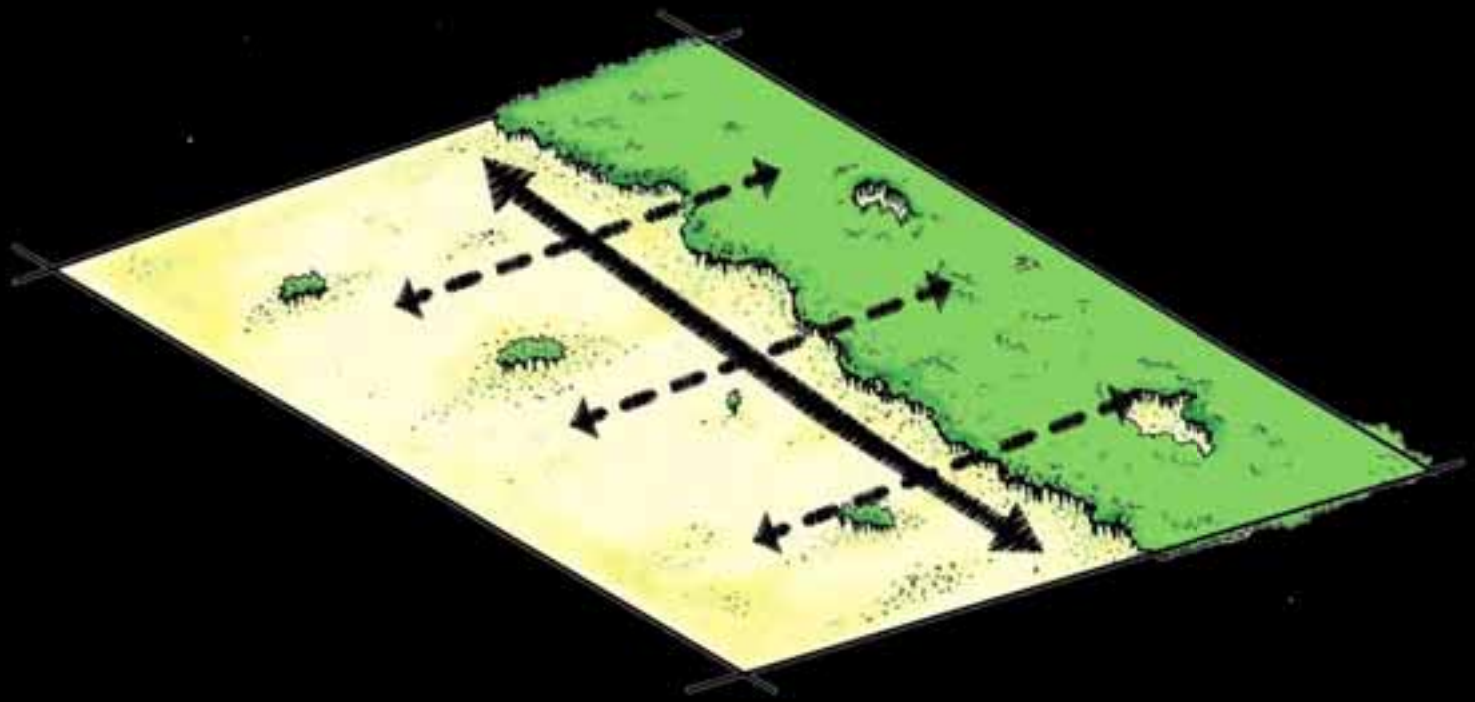
1. Urban stream corridors system, Sapporo, Japan. (Asakawa, et al_2004)
2. Trail development planning, South Okanogan and Similkameen. (Higgs_1997)
3. Land Value Impacts of the CCIC Project in Seoul, Korea. (Chang_Cervero_2005)
4. A proposal for a greenway, Winnipeg, Manitoba, Canada. (Coley_2004)
5. Influence of Land-Use Type on the Distribution of Uses along Urban River Greenways, Lansing and Battle Creek, Michigan, U.S. (Costa_2003)
6. An understanding of differences in environmental discourses in industrialized and developing countries, Istanbul Metropolitan Area, Turkey. (Erkil_2005)
7. The quality of greenways planning, northwest Indiana. (Flores_et al_2009)
8. Public space networks as a guide to sustainable urban development and social life, Mugla, Turkey. (Hepcan_et al_2006)
[illegible] systems in planning residential com- [illegible] (Imam_2006)
10. A comparative study of greenway projects, Chattanooga, Tennessee and Rockford, Illinois, U. S. (Mackenzie_2007)
11. Sumas Way recreational greenway design, Sumas Way Abbotsford, British Columbia. (Marples_2002)
12. Establishing greenways urbaris, Abbotsford, Canada. (Neil_Jonathan_2002)
13. A greenway proposal for the Onondaga Creek Corridor, Syracuse, New York. (Townsend_2000)
14. An evaluation of the Greater Vancouver Regional District's Regional Recreation Greenway Program, Canada. (Wonnell_2001)
15. Biodiversity in urban habitat patches, Birmingham, England. (Angelo_et al_2006)
16. Avian urban dwellers, Winnipeg, Manitoba, Canada. (Cowan_2007)
17. Habitat Use by Meso-Predators in a Corridor Environment, Northern Utah, U. S. (Prey_2006)
18. Traffic Volume Alters Elk Distribution and Highway Crossings in Arizona, U. S. (Gagnon_2007)
19. Designing suburban greenways to provide habitat for forest-breeding birds, Raleigh, Carolina, U. S. (Mason_et al_2007)
20. Wildlife conservation in urban greenways of the mid-southeastern United States. (Schiller_Horn_1997)
21. Mammalian nest predators respond to greenway width, landscape context and habitat structure, Carolina. (Rochlair_2003)
22. Ecological effects of roads: theory, analysis, management, and planning considerations, Florida, U.S. (Smith_2005)
*23. Planning wildlife corridors. (Wheeler_1994)
24. Making the connection, Indiana, U. S. (Dutton_2000)
25. International greenways, Minnesota, U. S. (Bailey_1999)
26. Comprehensive greenspace planning based on landscape ecology principles in compact Hangzhou, China. (Qu_Chen_2003)
27. Comprehensive concept planning of urban greening based on ecological principles, Beijing, China. (Li_et al_2005)
28. How to use roads in the creation of greenways, New Zealand. (Vias_Rosier_2003)
29. An approach for greenway suitability analysis, Prescott Valley, Arizona, U. S. (Miller_et al_1998)

THE UNIVERSITY OF ARIZONA

Meta-Analysis: Landscape Pattern

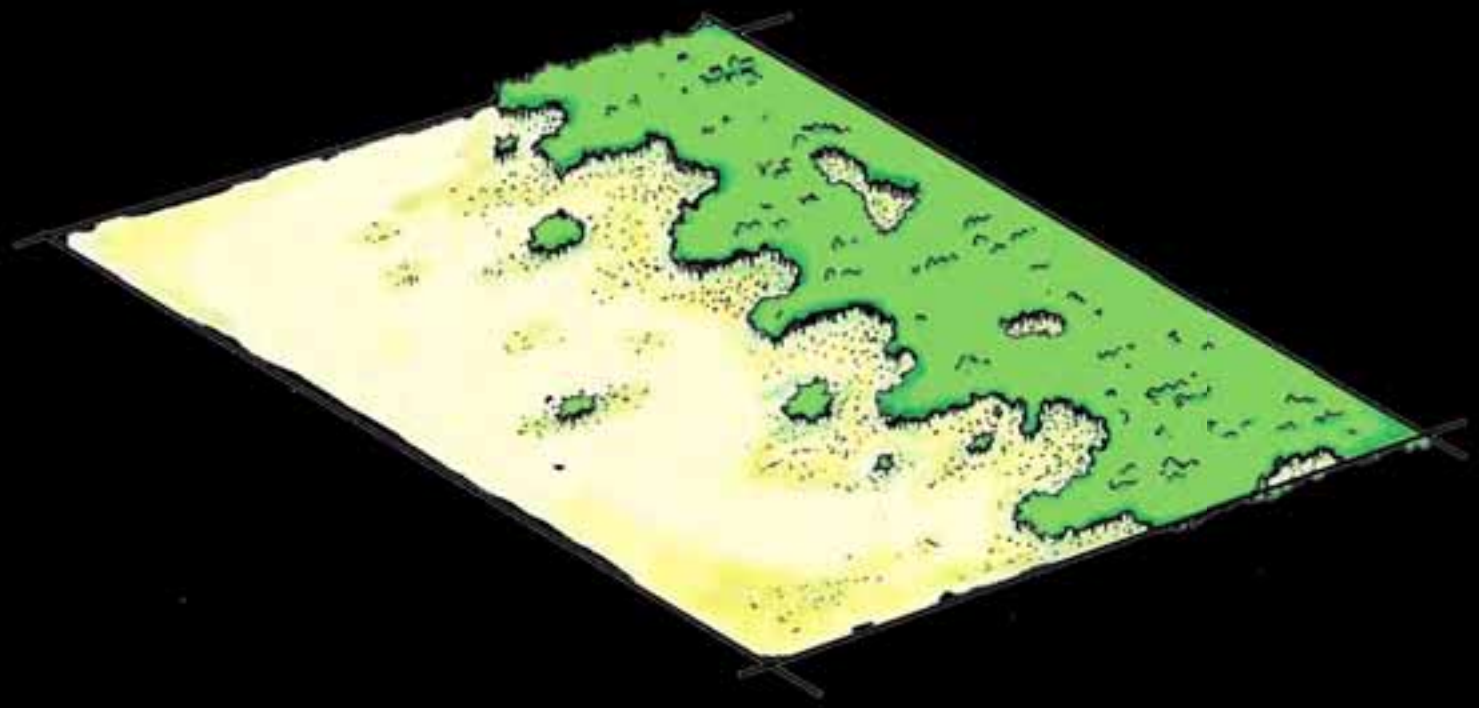
THE UNIVERSITY OF ARIZONA

Edge Conditions



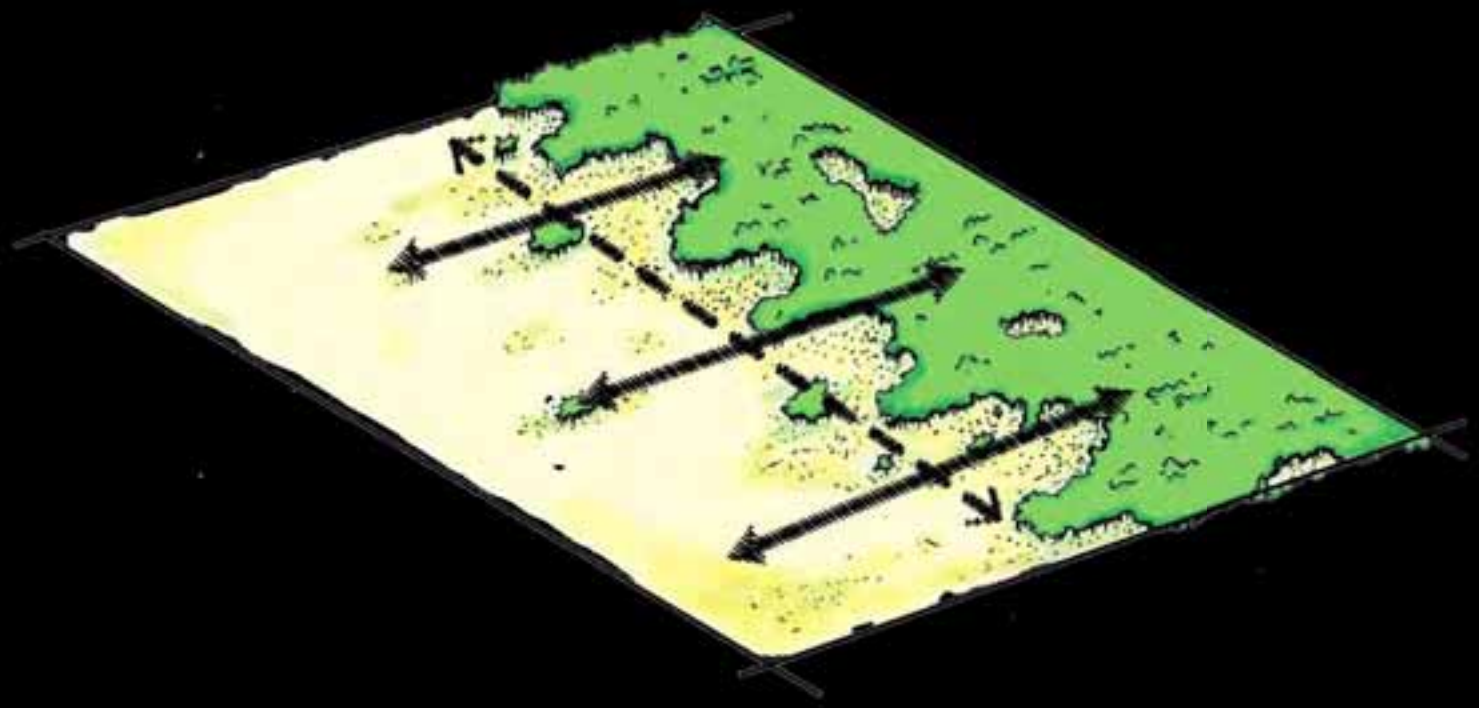
THE UNIVERSITY OF ARIZONA

Edge Conditions



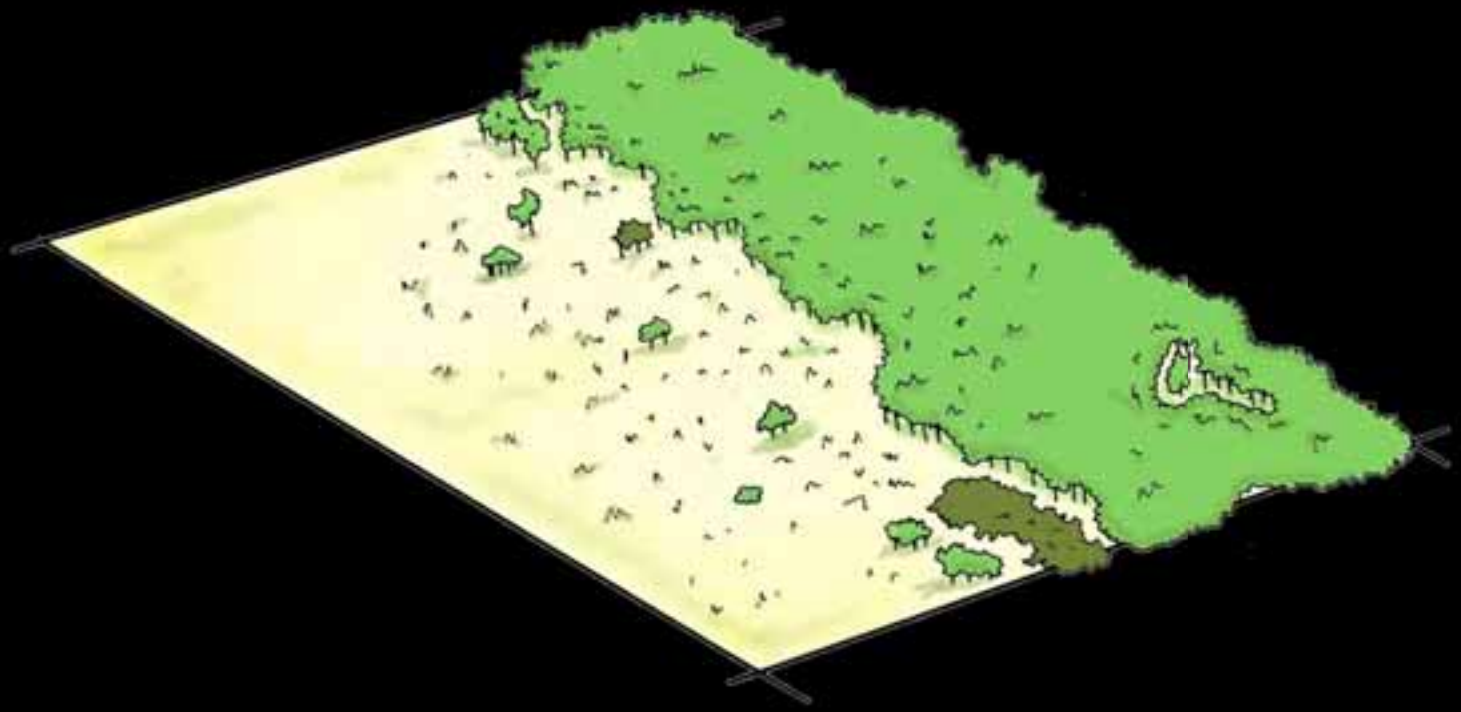
THE UNIVERSITY OF ARIZONA

Edge Conditions



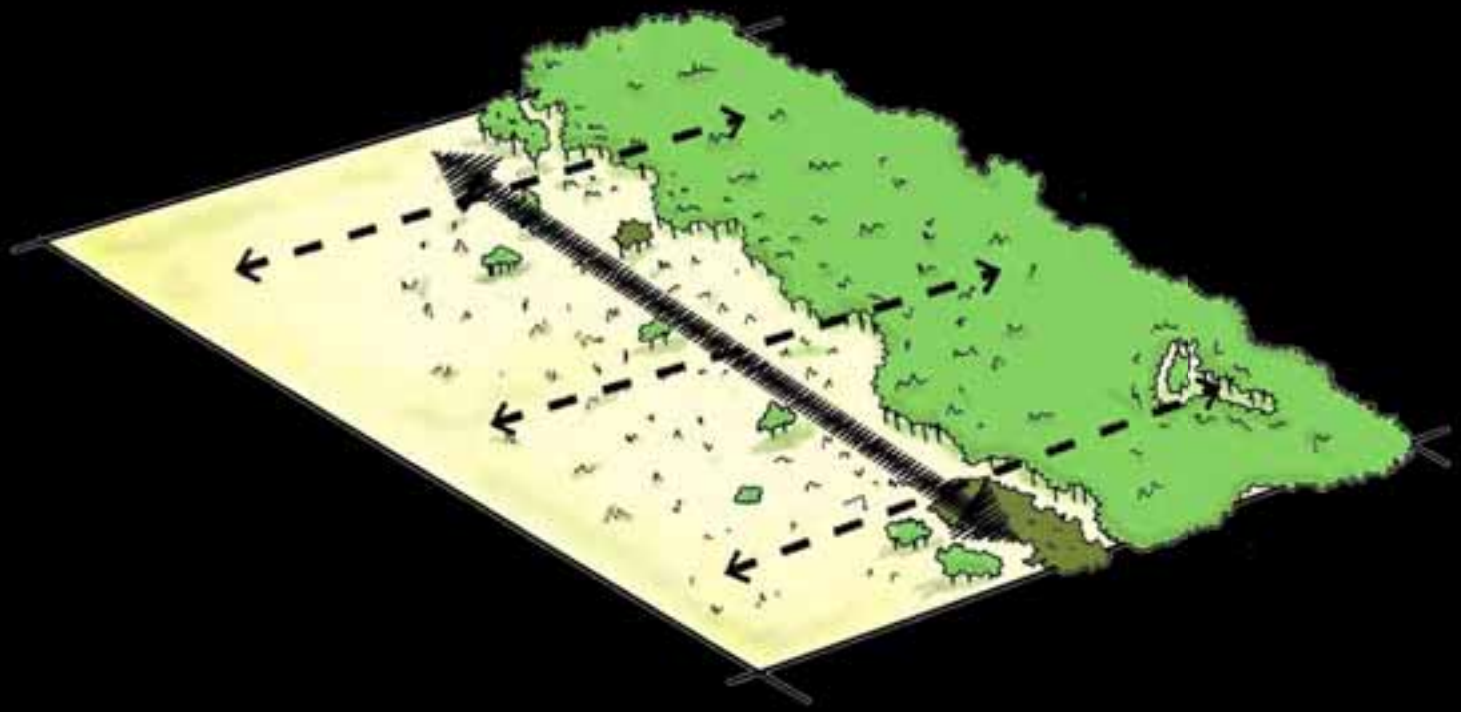
THE UNIVERSITY OF ARIZONA

Edge Conditions and Ecotones



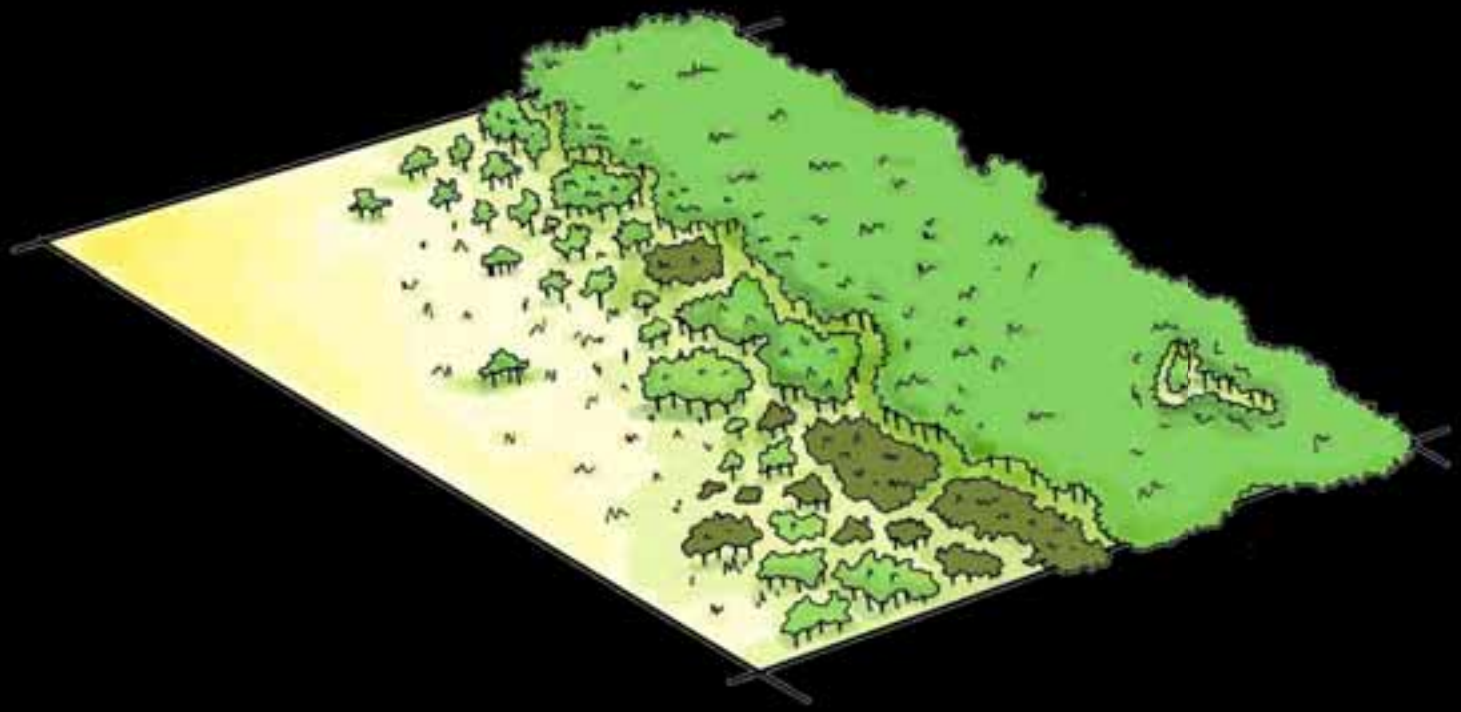
THE UNIVERSITY OF ARIZONA

Edge Conditions and Ecotones



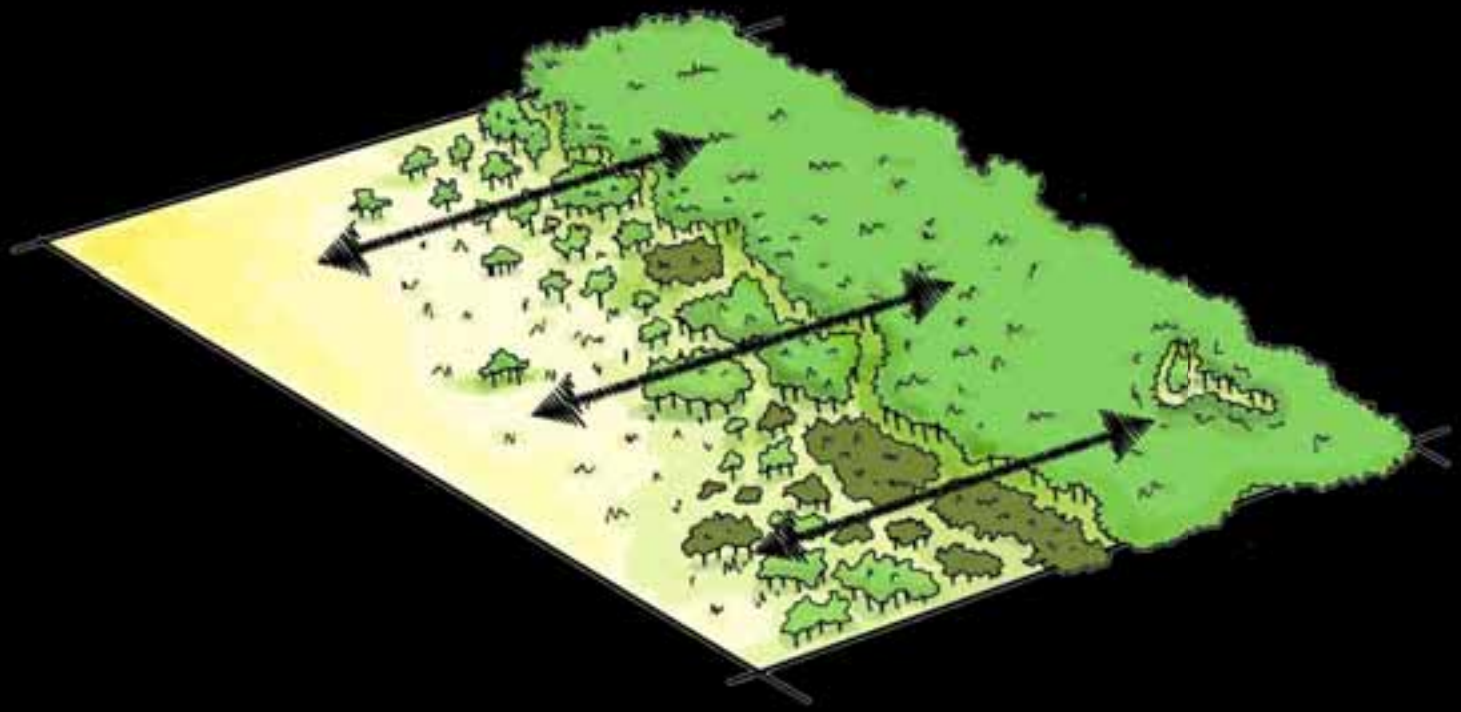
THE UNIVERSITY OF ARIZONA

Edge Conditions and Ecotones



THE UNIVERSITY OF ARIZONA

Edge Conditions and Ecotones



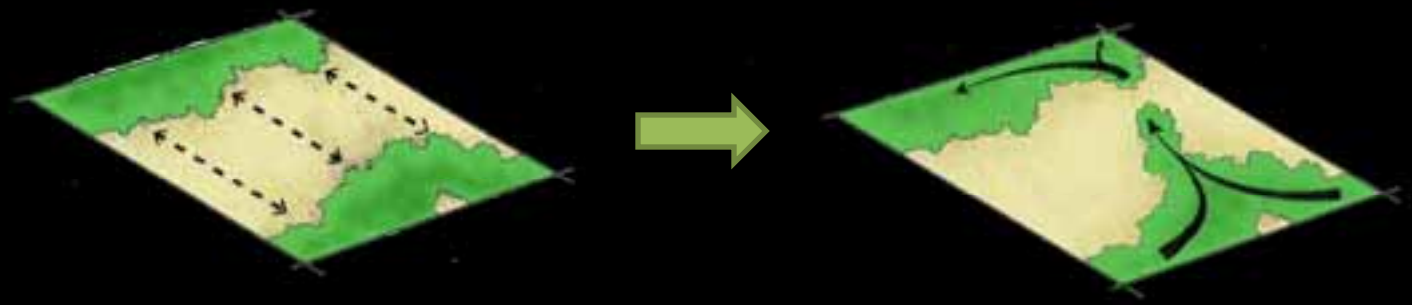
THE UNIVERSITY OF ARIZONA

Meta-Analysis: Landscape Pattern

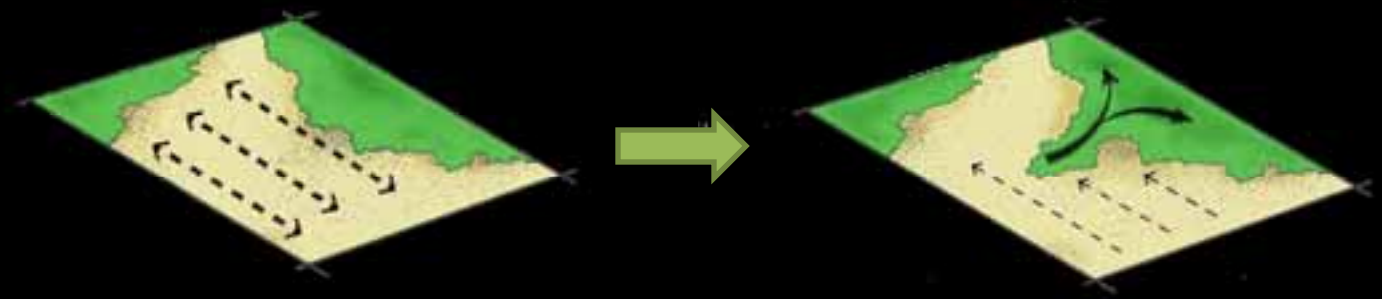
Fragmented Condition:

Designed Condition to Enhance Connectivity:

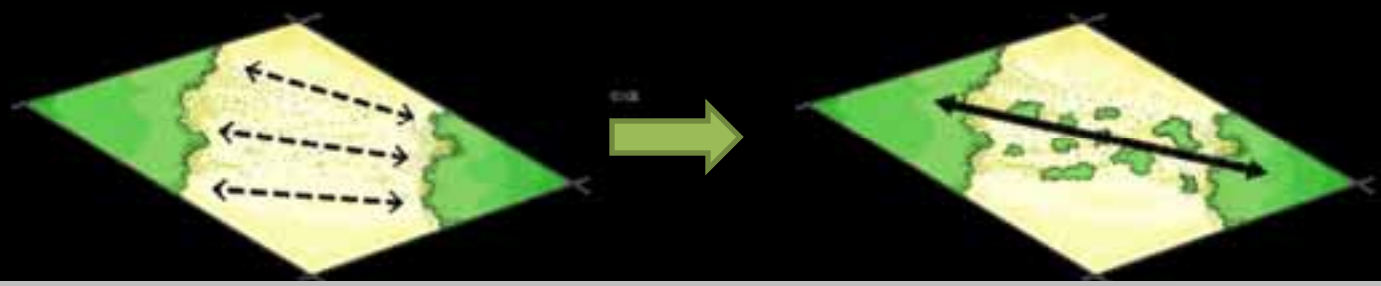
Extensions:



Gap Fences:



Stepping Stones:



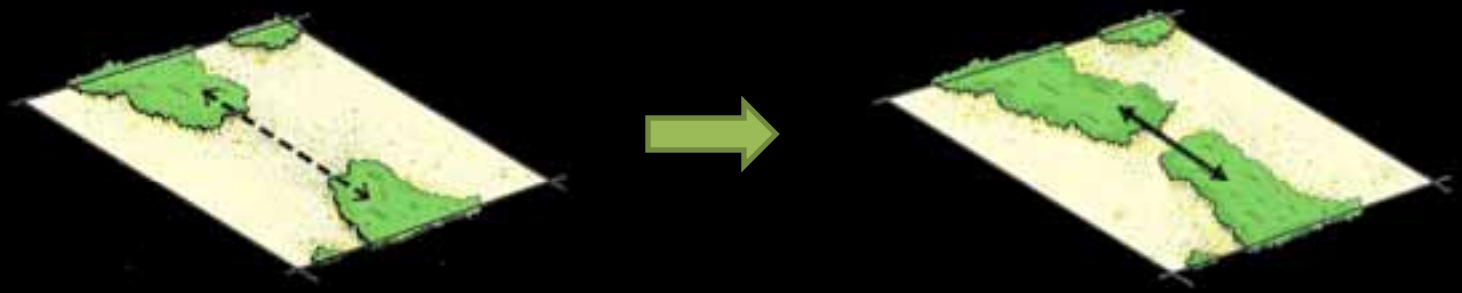
THE UNIVERSITY OF ARIZONA.

Meta-Analysis: Landscape Pattern

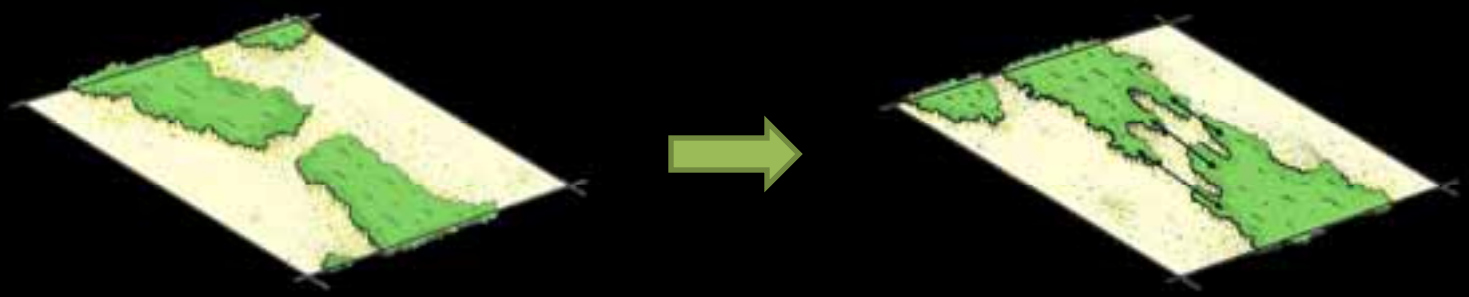
Fragmented Condition:

Designed Condition to Enhance Connectivity:

Cap Termini:



Cap Fingers:



Ball & Socket:

THE UNIVERSITY OF ARIZONA.

A Way Forward: GeoDesign


Large trees
Medium trees/Large shrub
Shrub/Small trees
THE UNIVERSITY
OF ARIZONA

Pattern Integration


THE UNIVERSITY
OF ARIZONA

What About Automation?

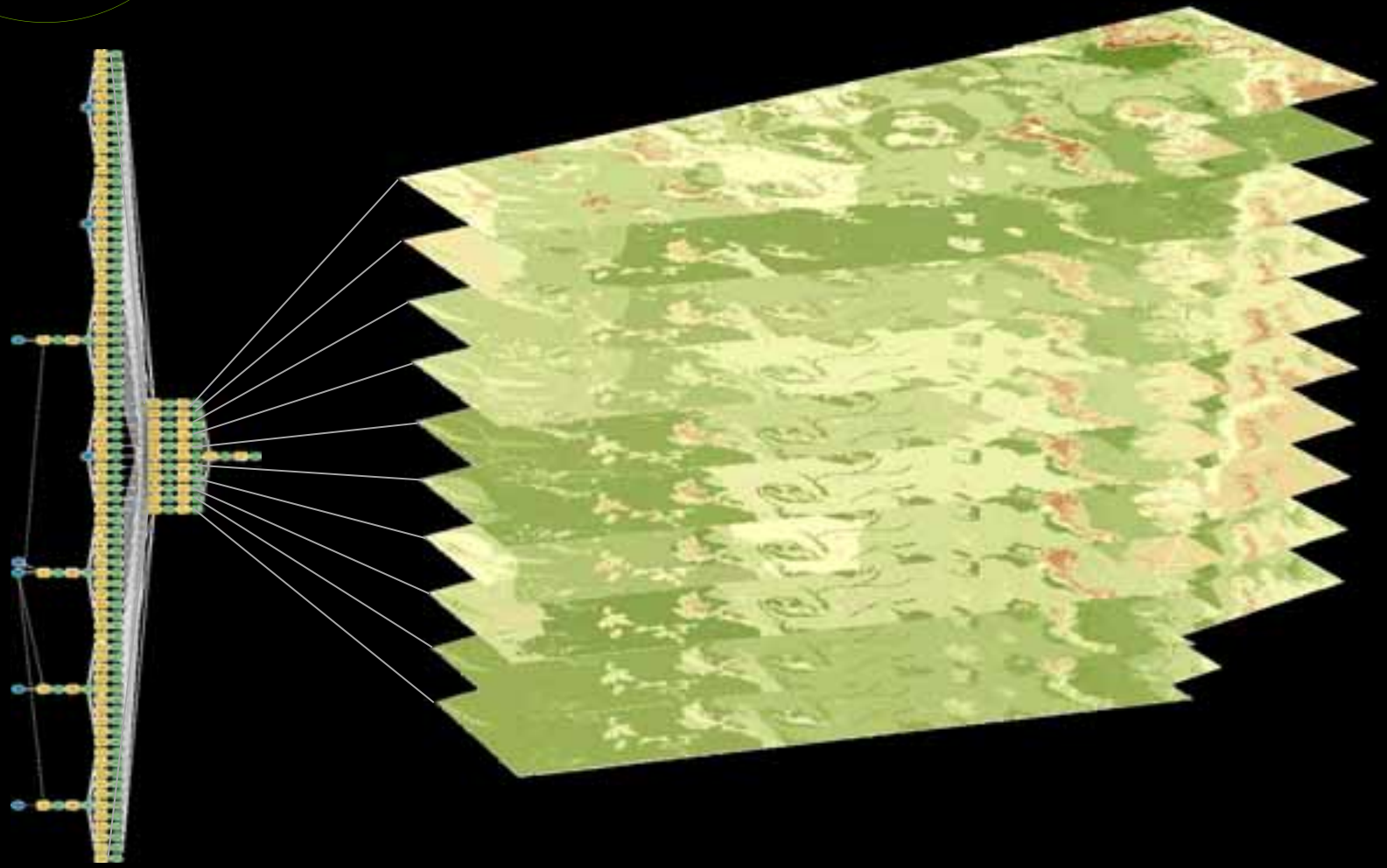
- Here, we illustrate the development of an Automated Design Module (ADM).
- Utilizes landscape characteristics to develop capability surfaces for native vegetation.
- Vegetation requirements are parameterized per focal species requirements and modeled corridor characteristics.
- The module generates vegetation density, heterogeneity, and aspects of pattern such as linearity and cohesion per user defined criteria.
- Corridor outputs are then populated with suitable vegetation arranged in spatial patterns which promote connectivity, mitigate edge effects of surrounding land uses, and promote desired landscape patterns.

Native Vegetation Library

Species: Blue Palo Verde, *Parkinsonia florida*
Size: 15’
Elevation: 0 – 4,000’
Soil: Well drained, alkaline
Aspect: Full sun
Slope: Bottomland
Hydrology: Drought Tolerant, prefers riparian edge
Min Temp: 18f

Common Name	Scientific Name	Size	Elevation	Soil	Aspect	Slope	Hydrology	Temp (threshold)
Trees								
blue palo verde	***Parkinsonia florida***	**15ft**	**0 - 4,000ft**	**well drained, alkaline**	**full sun**	**bottomland**	**drought tollerant, prefers riparian edge habitat**	**18F**
velvet mequite	*Prosopis velutina*	30ft	0 - 4,800ft	well drained, alkaline, deep soil	full sun	all	prefers deep water table	10F
whitethorn acacia	*Acacia constricta*	18ft	0 - 4,500ft	sandy, caliche type, sandy loam, limestone soil	full sun	all	arid	10F
cat claw acacia	*Acacia greggii*	10ft	0 - 5,000ft	sandy, caliche type, sandy loam, limestone soil	full sun	all	arid	0F
ironwood	*Olneya tesota*	30ft	0 - 2,300ft	sandy/gravely soil	full sun	bottomland	arid	20F
Shrubs								
creosote	*Larrea tridentata*	8ft	0 - 4,000ft	sandy, sandy loam, medium loam, caliche type	full sun - part shade	bottomland - med slope	arid	0F
triangleleaf bursage	*Ambrosia deltoidea*	3ft	1,000 - 3,000ft	sandy, sandy loam, alkaline	full sun	all	arid	18F
Cacti								
saguaro	*Carnegiea gigantea*	50ft	0 - 4, 000ft	sandy, sandy loam, alkaline	full sun - part shade. Southern slopes at higher elevation	all	arid	20F
[illegible] chollia	*Cylindropuntia acanthocarpa*	9ft	0 - 3,500ft	sandy, well drained	full sun	all	arid	10F
[illegible]nn pickley	*Opuntia engelmannii*	5ft	1,000 - 6,500ft	all	full sun - part shade	all	arid	10F
[illegible]el	*Ferocactus wislizeni*	8ft	0 - 5,000ft	sandy or gravelly	full sun - part shade	all	arid	10f

Landscape Capability Models: Native Vegetation



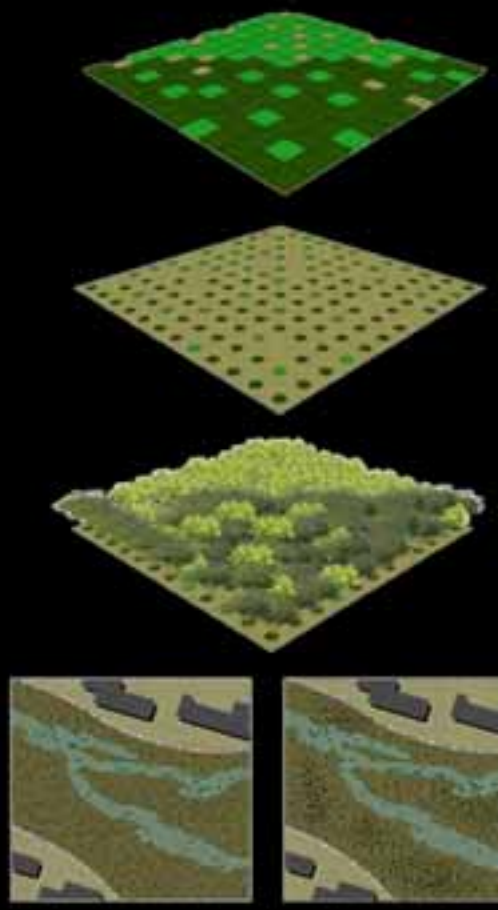
THE UNIVERSITY OF ARIZONA

Pattern Generators & Rules-Based Design Filters

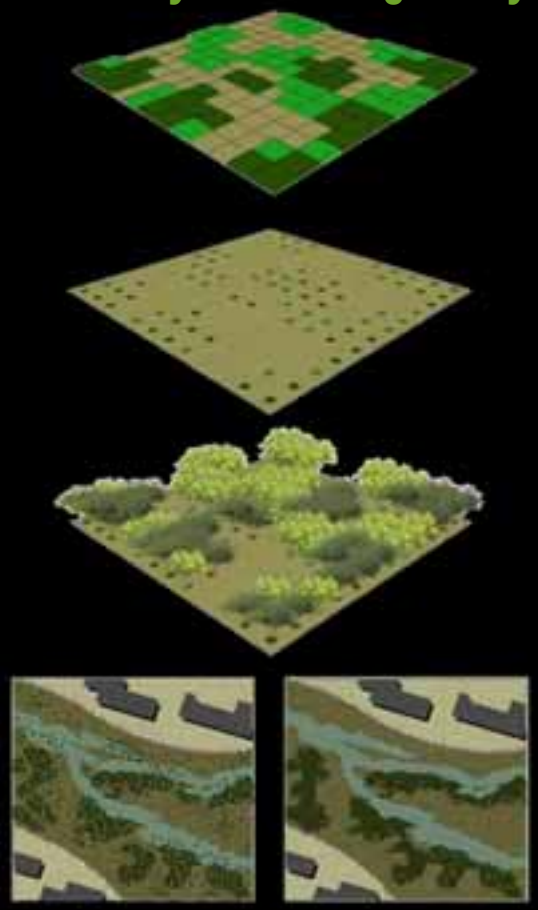
THE UNIVERSITY OF ARIZONA

Pattern Generators & Design Filters

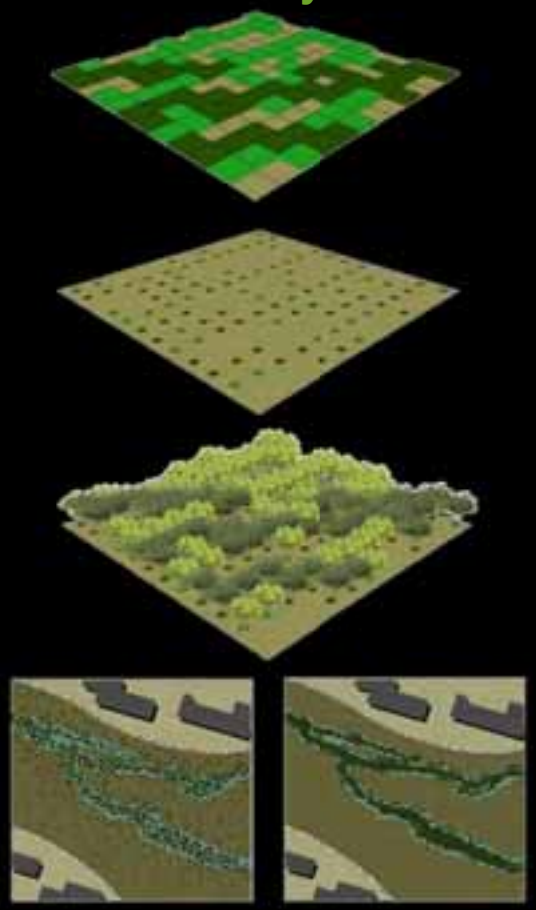
Cohesion:



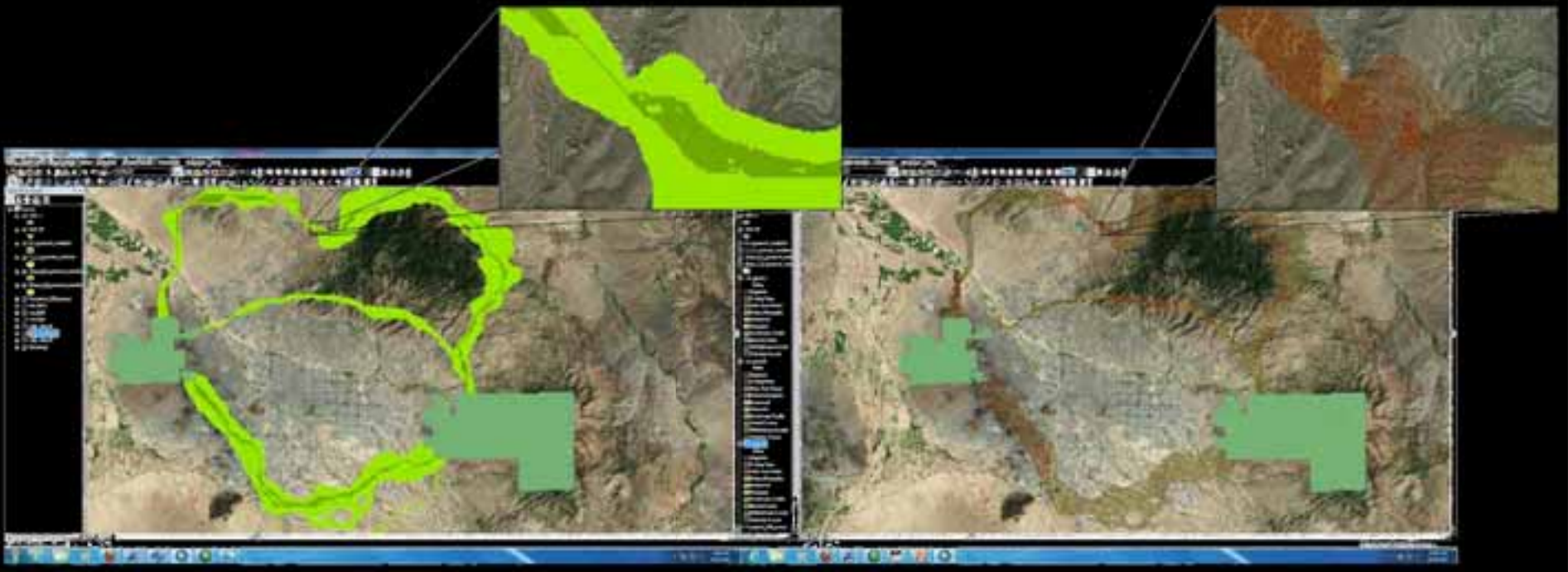
Density & Heterogeneity:



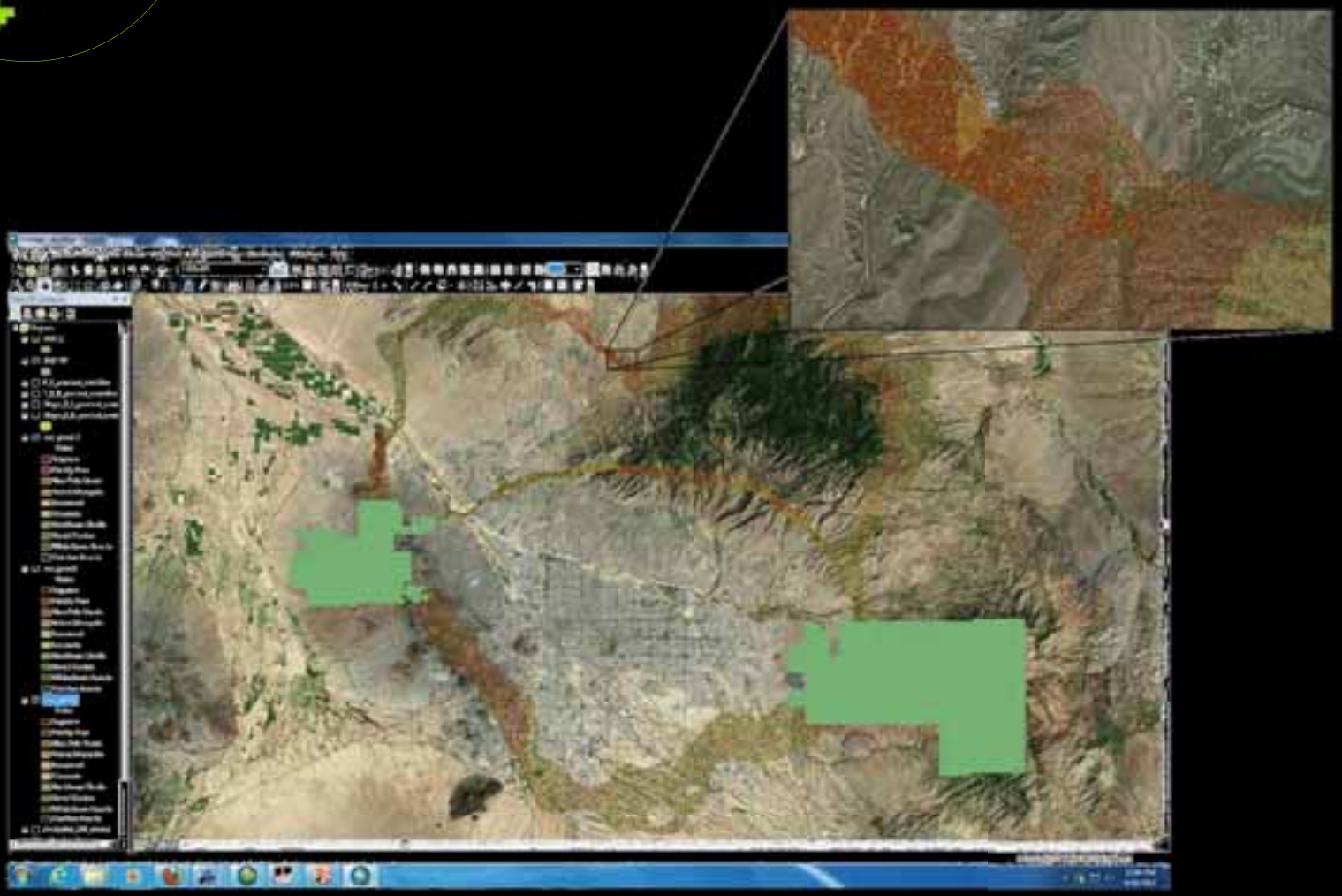
Linearity:



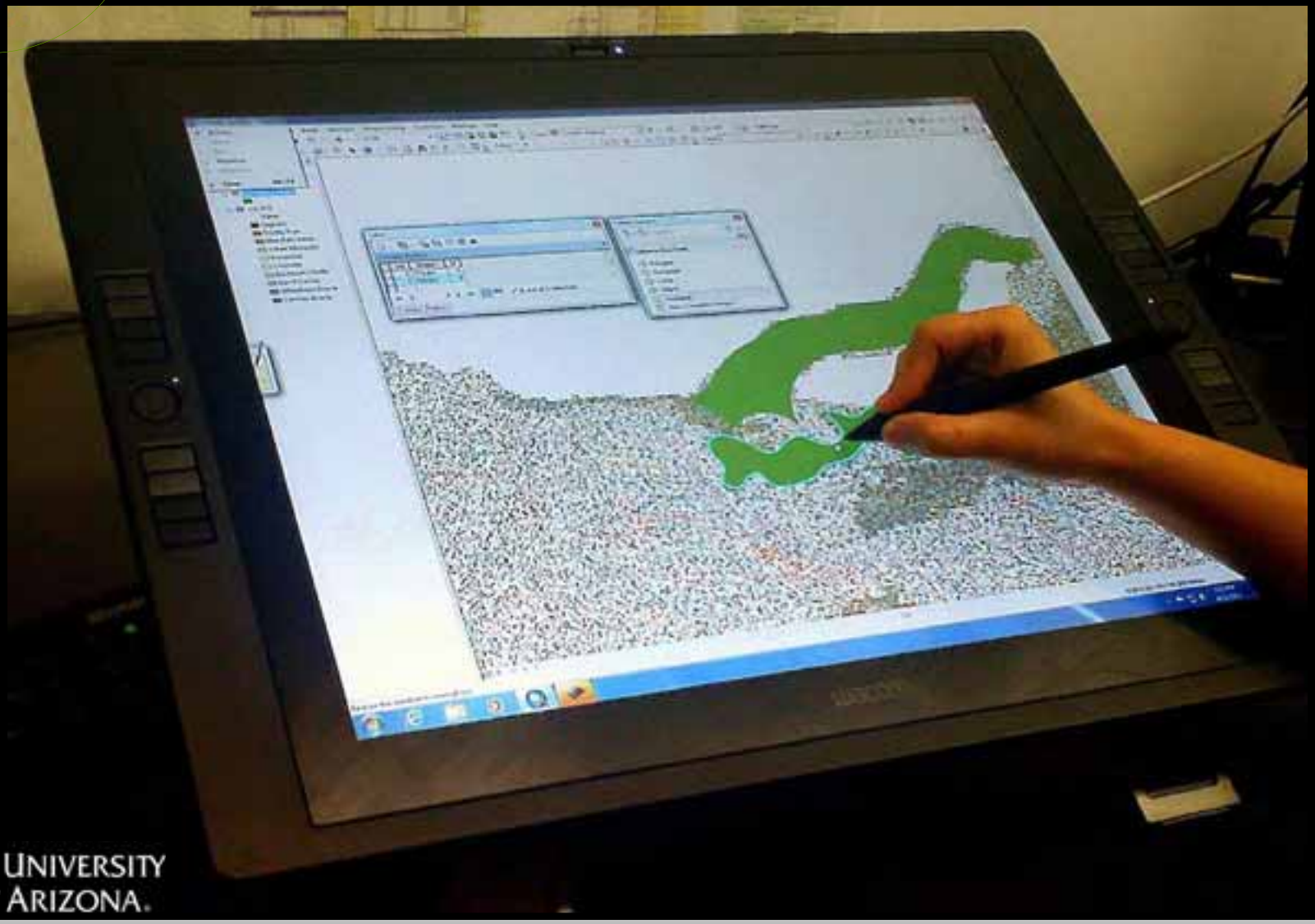
Current Vs. Proposed



Corridor Interior Populated

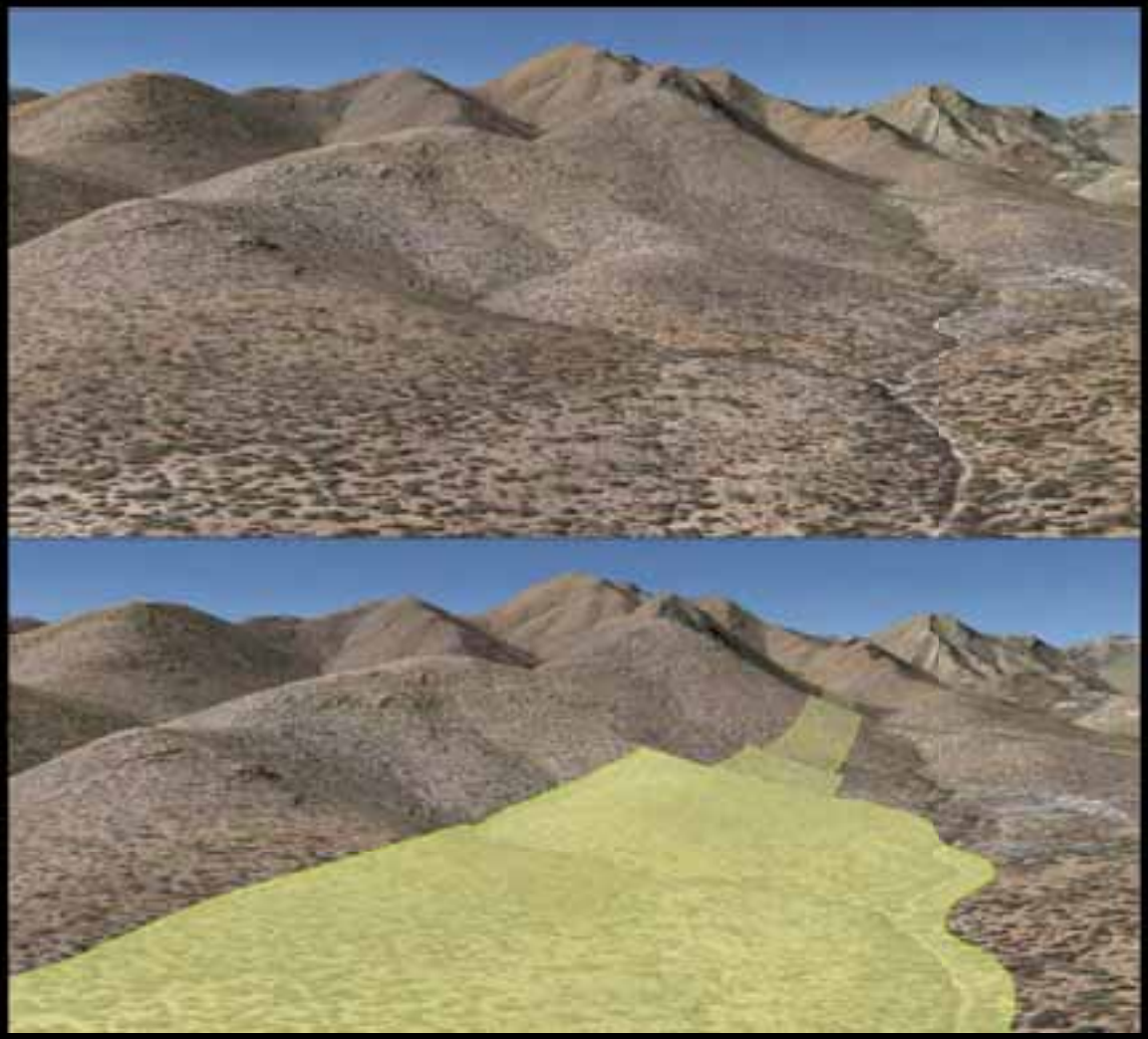


Pattern Integration and Editing



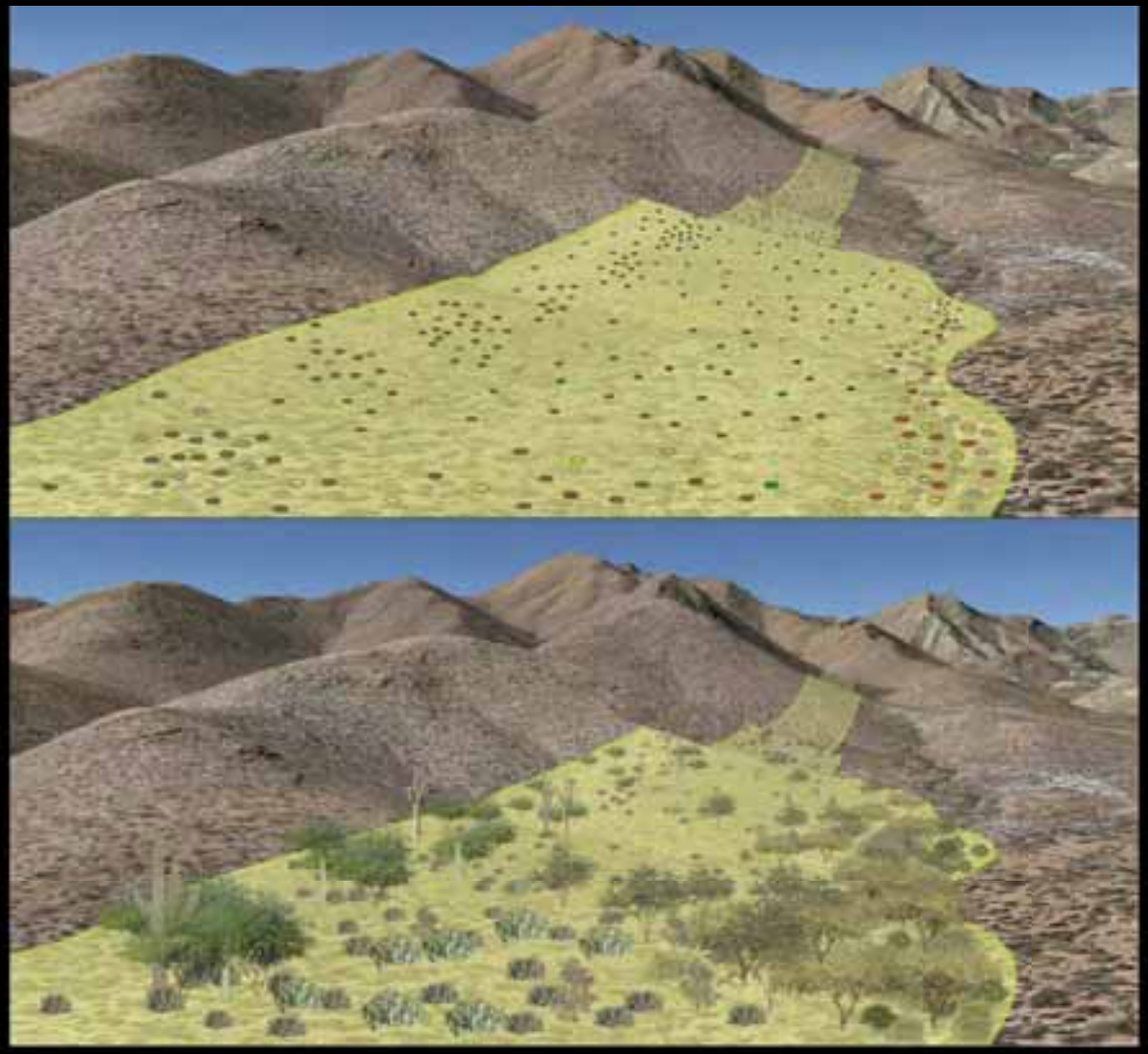
THE UNIVERSITY OF ARIZONA

Traditional Corridor Design?



THE UNIVERSITY OF ARIZONA

Improved Corridor Design?



THE UNIVERSITY OF ARIZONA

Closing Thoughts

- We need to do a better job translating science into terms and concepts that land use planners and designers can readily integrate and implement.

- Modeled corridor outputs require additional specificity within urban landscapes in order to be implemented, thus, more detailed planning and design is needed to fill in the voids of modeled corridors and guide decision making towards implementation.

- We need better ways to design large swaths of the landscape (i.e. modeled corridors) through maximizing efficiency, integrating data as the foundation upon which designs are based to increase function, and through integrating patterns known to enhance connectivity. We believe tools such as ADM may help.

Thank You

Ryan M. Perkl, Ph.D.

rperkl@email.arizona.edu

Research Team:

Samuel Chambers

Brandon Herman

Garrett Smith

Wanyi Song

THE UNIVERSITY OF ARIZONA

Citations

Baldwin, R. F., R. M. Perkl, S. C. Trombulak, and W. B. Burwell III. 2010. Modeling Ecoregional Connectivity in T. S.C., and B. R.F., editors. Landscape-scale Conservation Planning. Springer-Verlag, New York, NY. USA.

Baldwin, R. F., A. J. K. Calhoun, and P. G. deMaynadier. 2006. The significance of hydroperiod and stand maturity for pool-breeding amphibians in forested landscapes. Canadian Journal of Zoology-Revue Canadienne De Zoologie **84**:1604-1615.

Haddad, N. M., and J. J. Tewksburry. 2006. Impacts of corridors on populations and communities. Pages pp. 390-415 in K. R. Crooks, and M. Sanjayan, editors. Connectivity Conservation. Cambridge University Press, Cambridge, UK.

Majka, D., J. Jenness, and P. Beier. 2007. CorridorDesigner: ArcGIS tools for designing and evaluating corridors.

McRae, B. H., and P. Beier. 2007. Circuit theory predicts gene flow in plant and animal populations. Proceedings of the National Academy of Sciences of the United States of America **104**:19885-19890.

Perkl, R. M., and R. F. Baldwin. 2010. Connections between GAP Status 1 lands.

Theobald, D. M. 2006a. Exploring the functional connectivity of landscapes using landscape networks. Conservation Biology Series-Cambridge. **14**:416.

Theobald, D. M. 2006a. Exploring functional connectivity of landscapes using landscale networks. Pages pp. 416-443 in C. M. Sanjayan, editor. Connectivity Conservation. Cambridge University Press, Cambridge, UK.

Theobald, D. M., N. J. B., and S. M.R. 2006b. FunConn v1 user's manual: ArcGIS tools for functional connectivity modeling. Colorado State University, Natural Resources Ecology Lab, Fort Collins, CO.

Urban, D., and T. Keitt. 2001. Landscape connectivity: A graph-theoretic perspective. Ecology **82**:1205-1218.

Woolmer, G., S. C. Trombulak, J. C. Ray, P. J. Doran, M. G. Anderson, R. F. Baldwin, A. Morgan, and E. W. Sanderson. 2008. Rescaling the Human Footprint: A tool for conservation planning at an ecoregional scale. Landscape and Urban Planning **87**:42-53.

Citations

Bazelet, C. and M. Samways "Relative importance of management vs. design for implementation of large-scale ecological networks." Landscape Ecology **26**(3): 341-353.

Craig, L. (1999). "Optimizing wildlife habitat mitigation with a habitat defragmentation algorithm." Forest Ecology and Management **120**(1-3): 245-251.

DeStefano, S., A. X. Esparza, et al. (2009). Wildlife Corridors and Developed Landscapes. The Planner's Guide to Natural Resource Conservation, Springer New York**:** 85-102.

Drielsma, M., G. Manion, et al. (2007). "The spatial links tool: Automated mapping of habitat linkages in variegated landscapes." Ecological Modelling **200**(3-4): 403-411.

Forman, R. T. T. (1995). Land mosaics : the ecology of landscapes and regions. Cambridge [England]; New York, Cambridge University Press.

Horskins, K., P. Mather, et al. (2006). "Corridors and connectivity: when use and function do not equate." Landscape Ecology **21**(5): 641-655.

Linehan, J., M. Gross, et al. (1995). "Greenway planning: developing a landscape ecological network approach." Landscape and Urban Planning **33**(1-3): 179-193.

Olson, D. H. and K. M. Burnett (2009). "Design and management of linkage areas across headwater drainages to conserve biodiversity in forest ecosystems." Forest Ecology and Management **258, Supplement**(0): S117-S126.

Pinto, N. and T. Keitt (2009). "Beyond the least-cost path: evaluating corridor redundancy using a graph-theoretic approach." Landscape Ecology **24**(2): 253-266.