I. Introduction
Geographic information science and technologies (geographic information systems, global positioning systems, visualization tools such as Google Earth) provide a powerful medium for generating, understanding and disseminating information about Colorado. These skills and technologies are becoming increasingly important for educating the workforce of the 21st C. The aim of the GIS in Higher Education Summit (held at Colorado State University, April 2009) was to discuss the role of GIScience on college and university campuses and to determine next steps in statewide communication and coordination of education activities and opportunities.

Three predominant themes arose from the discussion that could guide future efforts:
1) increasing networking opportunities between institutions, GIS instructors and researchers,
2) sharing ideas and resources (lessons and data) between instructors, and
3) identifying core competencies and skill sets.

Other issues included professional development, standardized GIS certificates, articulation plans between two- and four-year institutions, and development of a centralized location for spatial datasets on Colorado.

Efforts to address these issues include the following: 1) establishing a higher education listserv with a website that identifies GIS programs by institution across the state, 2) holding a Summit each semester to facilitate and track progress towards statewide education goals, 3) conducting a needs assessment to identify and prioritize gaps in critical datasets and to better understand the types of information and delivery mechanisms most useful for education and research. These higher education activities should be linked to on-going State GIS and IT discussions.

II. Need
Geospatial technology can be used to integrate information across all sectors – energy, water, food, biodiversity, recreation, and economic activity. Although most states in the country have some centralized, coordinated geospatial data/analysis center (often funded by state legislature, a directive of state government, or cooperation between universities and the private sector), geospatial activities in Colorado have been largely fragmented, duplicative, and un-coordinated. There are incipient plans in place to correct this situation. The Colorado GIS Advisory Council is part of a statewide IT initiative (that included elevating the state’s Information Officer to a cabinet position) to centralize and coordinate data standards, development and governance. A key aim of this activity is to identify the major stakeholders across the state, one of which is higher education. While there is a clear need to provide better statewide coordination, integration, and standardization of geospatial data in Colorado, there is also a clear need to
communicate and coordinate GIScience education activities to better meet the need of Colorado students and employers.

There are several reasons to meet this need. First, K-12 GIS education is laying the groundwork for the integration of GIS throughout the curriculum and raising students’ expectations that GIS will be part of higher education. For example, the recent acquisition of a district site license for ArcGIS in the Denver and Aurora public schools means that students are using GIS at an earlier age. In Fort Collins, Rocky Mountain High School offers a “Mapping Technologies” course. Second, the general consensus from industry representatives is that university graduates are not ready for GIS jobs. For example, GIS developers are coming out of computer science departments, lacking the fundamentals of spatial thinking, but excelling in programming and computer skills. Third, current education and training programs are too dependent upon a “cookbook” approach and need to develop ‘non-linear’ educational activities that include real life experiences (e.g., community mapping), internships (providing for connections to professionals), and advanced, hands-on exercises. Lastly, the integration of domain specialties with GIS skills is lacking. GIS is often taught separately and is not well integrated into the broader curriculum.

While numerous resources exist for GIScience education, the amount of material is overwhelming and represents a rather inchoate view of GIScience. However, efforts such as the Body of Knowledge (http://www.ucgis.org/priorities/education/modelcurriculaproject.asp) designed by the University Consortium for Geographic Information Science Education Committee and built upon the National Center for Geographic Information and Analysis (http://ncgia.ucsb.edu/education.php) core curriculum, provides a guideline for curriculum development, certificates, and course content. Additionally, there are numerous sources of online resources with a particular emphasis on introductory materials (e.g., The Geographer’s Craft, http://www.colorado.edu/geography/gcraft/contents.html; Education Portal, http://edcommunity.esri.com). Google Earth has demonstrated the ability to expand spatial thinking into all parts of the curriculum in both K-12 and higher education (http://www.google.com/educators/p_earth.html). This complicated landscape of a variety of geospatial resources is reflected in the variety of curriculums offered across the state and is difficult for both instructors and students to navigate. Understanding curriculums at different institutions would help with developing articulation agreements to ensure transferability and would assist students in identifying the type of program offered by different institutions (such as certificates, degree programs, special areas of emphasis in the courses).

The GIS job market is growing at an annual rate of 35% (US Dept of Labor Employment and Training Administration). It has been touted at the “megatechnology” of the 21st C (Wired, Marble). Colorado graduates need key skills to compete in the geospatial job market. These skills include not only fundamental abilities in reading, mathematics, writing and problem solving, but also technical and computer skills in programming, database management, modeling, statistics, and project management. The offering of certificates, programs, degrees and courses need to clearly identify in what ways they are meeting the needs of employers in business, industry, research, education, and science. Additionally, Colorado is a major hub of the geospatial industry; there are approximately 365 software firms in Fort Collins, many of which utilize GIS. Higher education has an opportunity to create stronger partnerships with these industries.
III. Solution
There are several approaches that higher education can take to meet the need to improve GIScience education in Colorado.

1. Improve networking opportunities.
   - Annual meeting at GIS in the Rockies (September 2009 – follow up discussion from Summit)
   - Annual spring summit (April 2010)
   - Listserv to discuss topical issues
   - Faculty exchanges for workshops, seminars
   - Virtual lectures by GIS researchers

2. Demonstrate statewide coordination.
   - The higher education GIS webpage identifies programs and courses by institution ([http://monsoon.nrel.colostate.edu/gishighered/](http://monsoon.nrel.colostate.edu/gishighered/)). Keeping this site updated is critical to providing information to interested students, parents, and other stakeholders. A further outcome of this activity would be the recognition of GIS ‘niches’ by institution and may provide a clearer marketing tool to students seeking GIS education.
   - Use the Body of Knowledge to assess our courses and curriculum. Link student learning with core competencies. Examine GIS certificates and ensure they fit with Body of Knowledge.
   - Coordinating and communicating about GIS Day across the state would build towards creating a coherent vision of GIS education. GIS Day could be hosted by different institutions to create another mechanism for sharing and learning about each other.
   - Articulation agreements between two- and four-year institutions. We need to get our administrators involved.

3. Resource sharing
   - Data development. CSU will explore the role of developing and providing value-added datasets for conservation planning and natural resource management. As a pilot study, we will build upon the successful model of COMaP, we will examine the feasibility of compiling, synthesizing, and disseminating key GIS data sources and add value by creating them in a standardized format. Key data sets for the state Colorado would provide the basis for many courses taught across the state as well as provide better information to natural resource managers and policy makers in moving towards a more sustainable Colorado.
   - Identifying and posting lessons on education sites (such as ESRI’s education clearinghouse)
   - Construction of a GIS Resource website to post information on GIS resources within the state.

IV. Benefits
These activities will start to address some of the key issues raised at the GIS in Higher Education Summit. An annual summit and meeting at GIS in the Rockies will create a forum for discussion and networking. These discussions will provide the basis for elevating GIS statewide as well as within our institutions to better situate ourselves for resources and recognition of the important contribution that GIS education can make. As the economic landscape changes, we need to ensure that we demonstrate to upper administration and state government the critical needs
that GiScience can fill. By coordinating our curriculums, we provide a service to students to identify the program the best meets their needs. This is not to say that curriculums need to be standardized or restricted in anyway – it is to define clearly what is in the curriculum and how the content aligns with acquiring core competencies. We also suggest a pilot project to demonstrate the utility of coordination through hosting through CSU value added data for natural resource management.