Introduction:
Inundation is a critical parameter of wetland hydrologic performance. Many recent studies have adopted geospatial modeling to simulate wetland inundation dynamics, however, these models or methods are essentially theoretical predictions without comparisons to actual wetland conditions. Two data sources are currently used to define wetlands at the national level: the hydric soil footprints in the Soil Survey Geographic (SSURGO) database and the wetlands in the National Wetland Inventory (NWI). Although both datasets are not intended to be used for regulatory purposes, in fact, they have been widely used as management tools in wetland conservation programs. Little research has been done to compare the actual wetland inundation conditions with these two major national wetland datasets. Light Detection and Ranging (LiDAR) technology provides a new dataset source with accurate spatial parameters to help with wetland delineation and mapping.

In this study, LiDAR data were used to examine the effectiveness of theoretically-calculated hydrological depressions by using the real inundation conditions in playa wetlands. The study used geospatial analysis methods to discover the differences between the actual wetland inundation performance and the wetland information from the three datasets: the hydric soil footprints from the SSURGO data, the wetlands from the NWI data, and the depressions produced from LiDAR data. The degree to which the NWI, SSURGO, and LiDAR data predicted where ponding in playas will occur during the peak of the spring waterfowl migration was assessed. Wetland inundation and hydric vegetation coverage conditions were analyzed to examine the correlation of these three datasets with wetland inundation conditions. Evidence-based recommendations are provided to improve wetland mapping and guide wetland conservation programs.

Methods:
This study uses Annual Habitat Survey (AHS) data collected between 2004 and 2012 in the Rainwater Basin region of south-central Nebraska to examine differences between the actual inundation conditions and three datasets: the NWI, the SSURGO, and LiDAR-derived depressions. The AHS data are derived from color-infrared photography collected during flight surveys and field verification, when needed. The AHS documents spring habitat conditions in Rainwater Basin wetlands during the peak of spring waterfowl migration. The Annual Habitat Survey map two types of wetland information: inundation and hydric vegetation. This study used ArcGIS 10.1 to overlay and compare the hydric soil footprints in SSURGO data, the NWI data, and the LiDAR-derived depression layer with the AHS inundation and/or hydric vegetation layer(s).

Results:
The results show that current wetland inundated areas were well overlaid with these datasets. Over 99.9% actual inundated areas were located in the hydric soil footprints of SSURGO data, 67.9% of inundations were reflected in NWI data, and 87.3% inundations were captured by LiDAR-derived depressions. However, the hydrologic degradation of playa wetlands was not reflected in these datasets. In the SSURGO data, only 13.3% of hydric soil footprint areas were inundated and 26.6% of footprint areas were covered with hydric vegetation during this period. For playa wetlands identified in NWI data, only 30.7% were inundated during this period and 60.5% were covered by hydric vegetation. A significant portion of the playa wetlands were not functioning with either ponding water or supporting hydric vegetation during the peak of the waterfowl spring migration season in the Rainwater Basin.

Discussion:
This study used the ground-truthed AHS inundation data to verify wetland dataset effectiveness. The hydric soil footprints in the SSURGO data reflect historic conditions, so the current degraded wetland and watershed hydrology were not evident. This is consistent with prior research that indicated the total area of wetlands classified by the SSURGO dataset is greater than that of the NWI data. The results of this study and prior research suggest that the NWI data often underestimate the size of wetlands and tend to miss small or linear wetlands. Additionally, many man-made water features are counted as wetlands in the NWI data. These areas can only host runoff and their functions are not the same as natural depressional playa wetlands. We verified that actual inundation can be well captured by a LiDAR-derived layer. However, LiDAR data may not be accurate in some wetland areas due to water body reflection and dense vegetation. In addition, LiDAR data cannot capture some complex systems such as underground culverts and ditches. More research is needed to further examine the effectiveness of LiDAR data in wetland mapping.

These findings confirm that watershed-level hydrologic restoration and within-wetland restoration is crucial to recover the inundation conditions of playa wetlands. The majority of the playa wetlands had no inundated water or hydric vegetation during the spring bird migration season over the 8-year study period. The current inundation condition is a result of landscape-level land use changes and wetland modification post-settlement. The natural process of playa wetlands has been dramatically shifted to an agricultural-dominated hydrologic process that has caused the degradation of historical hydric soil footprints. Playa wetland hydrology has been significantly altered at the watershed scale and within the wetlands.
Introduction:
Digital Elevation Models (DEMs) are the most critical datasets to the success of surface hydrologic modeling applications. These datasets can be used to produce critical topographic and hydrologic derivatives, such as slope, aspect and flow accumulation. The accuracy of derived hydrological features is largely dependent on the quality and resolution of DEMs. However, the DEMs typically derived from airborne LiDAR only reflect the topographic features on the ground and are therefore explicitly topographic DEMs. Such LiDAR-derived topographic DEMs are, in some cases, not suitable to use for hydrologic modeling. For example, ground features such as bridges and roads over drainage structures may be modeled as “digital dams” in a topographic DEM, affecting the modeled drainage passage and flow accumulation over the land surface. The problem becomes more acute for hydrologic features derived at the local scale. For instance, it was found that the LiDAR-derived surface flows could spill erratically in the wrong location if flow barriers were not removed from the elevation data.

The major objective of this paper is to propose a method for developing LiDAR-derived hydrologic DEMs, which includes collecting data on drainage structures (i.e., culverts and bridges), and the preprocessing and burning of the drainage structures. This method was demonstrated in a study area where surface runoff contributes to several wetlands. Based on the case study, a data model for a drainage structure dataset to be used for hydrologic burning is proposed. The hypothesis is that hydrologic burning of drainage structures such as culverts can result in differences in simulated surface water derivatives.

Methods:
To create the drainage structure dataset, the geographic coordinates of inlets and outlets of culverts and/or center points of the edges of bridges were collected using a GPS unit along with their corresponding geometrical parameters (i.e., diameter of the culvert pipe, bridge span and depth to bottom). The data were stored as vector point features. However, the point data are not directly applicable for burning LiDAR-derived DEMs since roads or bridges present significant width or spans. The point features must be converted into linear features before the burning process. In this study, the collected paired feature points were assigned with the same Structure IDs (e.g., 1, 2, 3, …, etc.) then converted to line features. This process can be implemented using the Points to Line tool of ArcToolbox in ArcGIS 10.

The linear drainage structure features can be burned into the DEMs using different approaches. In this study, the elevation of DEM grids corresponding to the drainage structures were reduced using specialized GIS tools, such as DEM Reconditioning in the ArcGIS Hydrology toolbox. The DEM Reconditioning tool was developed based on the AGREE algorithm which drops the elevation of the DEM cells corresponding to user-defined buffers of drainage structures. The elevation drop and the number of cells for the stream buffer were determined based on the collected geometrical attributes of depth to bottom and culvert diameter and bridge span over the river channels. The number of cells (stream buffer) is equal to the rounded value of the half culvert diameter divided by the cell size of the DEM. If the diameter is smaller than the cell size, the number of cells for the stream buffer was assigned as 1.

The proposed method to burn drainage structures in the LiDAR-derived topographic DEMs was applied to a case study in Nebraska. Differences between the simulated catchment size, drainage lines, and depression storage volumes were compared.

Results:
The modeling results shown in the case study confirmed the hypothesis that burning hydraulic structures, such as road culverts, can affect hydrologic modeling using LiDAR-derived DEMs. The simulation conducted in Figure 1 shows that the catchment size can be affected by incorporating the culverts into the LiDAR-derived topographic DEMs. The simulated drainage lines aligned well with the locations of the culverts that were burned into the LiDAR-derived topographic DEMs. The topographic DEMs (without culverts burnt) resulted in drainage lines with incorrect placement, because the process of filling sinks caused by road obstruction tends to create continuous surface flow spilling over the roads at the wrong locations or rerouted erratically along the road ditches. DEMs without burning culverts resulted in more depressions, most of which were bounded by roads.

Figure 1. One study site showing the topographic (LiDAR) DEM on the left and the Hydrologic (LiDAR corrected with culverts) DEM on the right. The top inset map shows a digital dam error caused by the roadway and the bottom inset illustrates a local scale drainage line error.