Flying Safety: A GIS Perspective

BY: AIRPORT JUNKIES: KATE FERLAND, JOCELYN LAYTE, AND CHERYL HARTMAN
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Introduction

Flight training is about safety during an activity that can have serious consequences. Pilots have multiple concerns when they are flying an aircraft. This report presents two such concerns; awareness of the limitations of the aircraft in changing atmospheric conditions and vigilance in detecting and selecting emergency landing sites. Humboldt County's varied terrain and microclimates compound these challenges.

Density altitude is considered one the most important atmospheric factors affecting aircraft performance. Higher elevation airports on hot days dramatically impact the engine, propeller, and lift efficiency of an aircraft. Humboldt County's nine public airports range from an altitude of seven feet for Murray Field to Kneeland Airport at 2745 feet. During the summer months when the coastal airports stay relatively cool, the inland airports can experience temperatures above 100 F°. Density altitude at these inland airports can be thousands of feet above the actual airport elevation. We will use bar charts on a map of Humboldt County to illustrate these invisible atmospheric conditions.

Awareness of emergency landing sites is a pilot's responsibility. During flight, a pilot should be scanning for suitable areas if it should become necessary to land the aircraft. Certain parts of the coastal region have low lying farm areas, beaches and long stretches of roads that are suitable, but forested mountain areas and shorelines with cliffs present few emergency landing places. We will use the analyzing capabilities of ArcMap software from ESRI, Inc. to locate potentially acceptable landing sites.

1. Density Altitude

Pilots failing to consider the effects of density altitude is a major cause of aviation accidents. Many aviation experts believe that air density is the single most important factor affecting aircraft performance. It affects the lift generated by the wings and other airfoil surfaces. It effects the efficiency of propeller blades or rotors (which are airfoils). It effects the power output of the engine as the engine depends on oxygen intake. The engine output is reduced as the equivalent "dry air" density decreases and the engine produces even less power as moisture displaces oxygen in more humid conditions.

Density altitude is defined as pressure altitude corrected for temperature. Density altitude is given as a height above mean sea level. Basically, as temperature, altitude, and humidity increase, air density decreases. It's the altitude at which the airplane "feels" it is flying. The practical effects are that aircraft taking off from a "hot and high" airport are at a significant aerodynamic disadvantage. The aircraft will accelerate slower on takeoff, the aircraft will need to achieve a higher true airspeed to attain the same lift. This results in a longer takeoff roll and a higher true airspeed which must be maintained when airborne to avoid stalling. The aircraft will climb slower as the result of reduced power production and lift.

Methods

A dataset displaying California public use airports was obtained from the State of California, Department of Transportation, and Division of Aeronautics. A shape file for the Humboldt County Boundary was downloaded from the Humboldt County Planning Department GIS website. A shape file for California county boundaries was obtained from Cal-Atlas. Airport elevation figures were obtained from the AirNav web site (AirNav.com). Multiyear average monthly temperature data for the nine airports was obtained from the Western Regional Climate Center, the National Climatic Data Center, and the National Oceanic and Atmospheric Administration (NOAA). Humidity data for the Eureka area was obtained from WeatherSpark.com. Digital Elevation Model rasters were obtained from the National Elevation Dataset, United States Geological Survey (USGS). Qualification of the data, calculations, and preparation of the maps were performed in ArcMap version 10.2 (Esri, Inc.). Additional calculations were performed in Microsoft Excel 2007.

Data was chosen to represent average values and standard variations. Average high and low monthly temperatures were used. Because humidity has a relatively small influence on determining density altitude, 68% humidity was used for all calculations. The standard pressure at sea level was adjusted for temperature for the high and low average monthly temperatures. The decrease in pressure altitude was determined for each airport using the altitude air pressure calculator at altitude.org which gave the pressure in millimeters of mercury (mm Hg). This was converted to inches of mercury (in Hg). The dew point for each high and low temperature was calculated using the dew point calculator at calculator.net. Finally, the air temperature, extrapolated average station pressure, and average dew point was entered into the NOAA Density Altitude Calculator and the figures were entered into the attribute table for the airport point layer.

Results

Density altitude computations for the nine airports ranged from a physically impossible -1104 below sea level figure at Murray Field during cool winter temperatures to +5061 at Dinsmore Airport during the hottest summer months. Actual airport elevation for these two airports is 7 feet and 2375 feet, respectively. The high and low temperature figures shown in the last two columns of Table 1 are averages and do not reflect density altitude figures for extremely cold or extremely hot days when the differences would be more extreme.

Table 1. Average temperatures and resulting density altitude for Humboldt County Airports.

Airport	Altitude Feet	AvLow	AvHigh	psiLow	psiHigh	inHg_32F	InHg_60F	DewPlow	DewPhigh	DAlowT	DAhighT
Arcata/Eureka	222	41	64	14.57	14.58	29.66	29.77	31.3	53.2	-815	695
Dinsmore	2375	27	90	13.40	13.54	27.28	27.65	17.9	78	1043	5061
Garberville	546	37	86	14.40	14.42	29.32	29.44	27.4	74.2	-705	2656
Hoopa	356	36	90	14.50	14.52	29.52	29.65	26.5	78	-1011	2709
Kneeland	2745	39	63	13.24	13.31	26.96	29.3	29.3	52.3	294	1167
Murray Field	7	41	64	14.69	14.69	29.91	31.2	31.3	53.2	-1104	-918
Rohnerville	393	42	73	14.49	14.50	29.5	29.61	32.2	61.8	-557	1520
Samoa	20	41	64	14.68	14.69	29.89	29.99	31.3	53.2	-330	443
Shelter Cove	73	46	70	14.66	14.66	29.85	29.93	36	58.9	-677	939

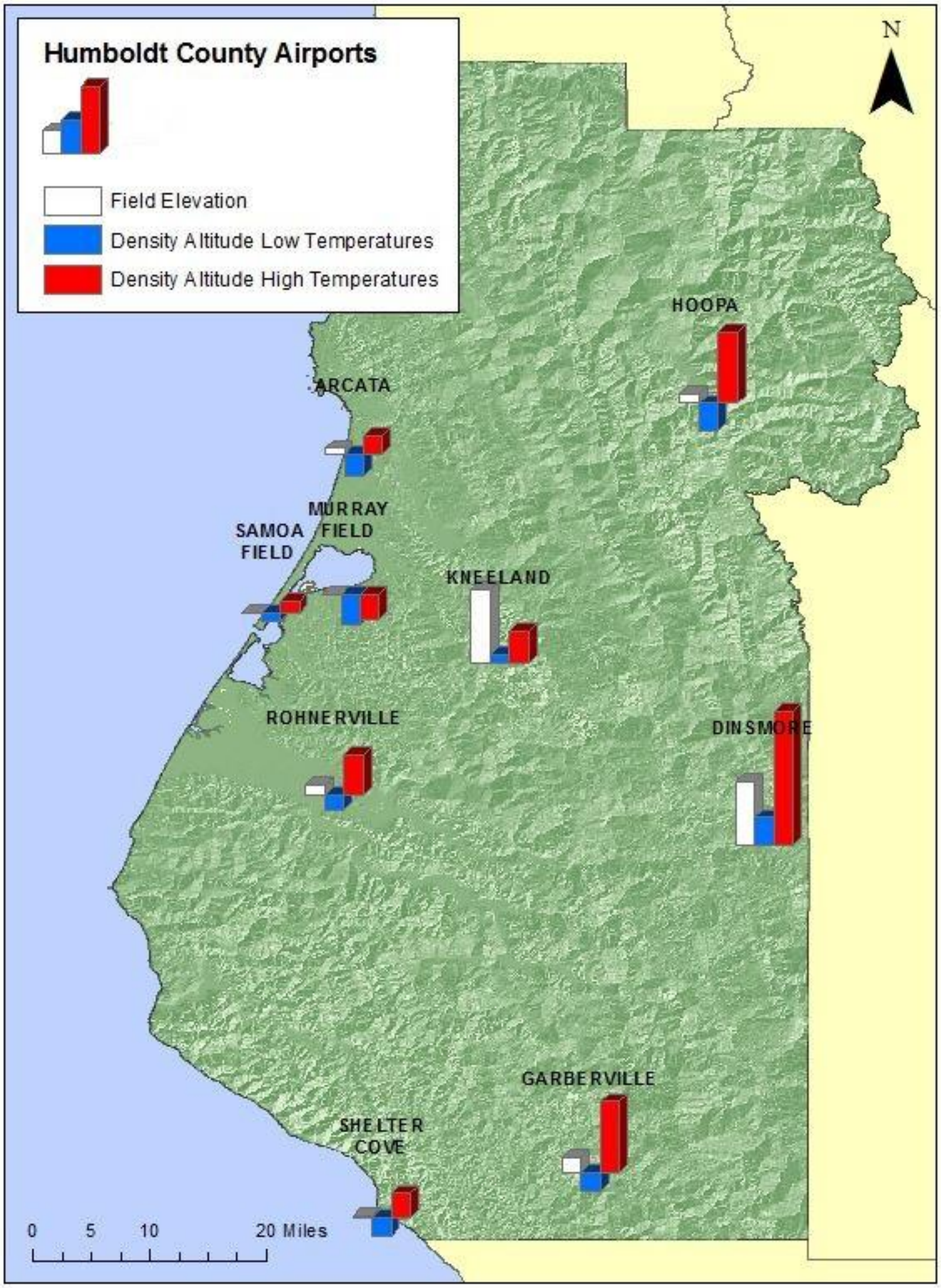

Figure 2. Actual airport elevation and average low and high temperature density altitude figures for Humboldt County Airports. Notice that the near-sea-level airports show negative density altitude numbers (below sea level) during cooler temperatures while inland airports show more than double the actual field elevation altitudes.

3. Emergency Landing Sites

Emergency landing sites are something that should be on a pilot's radar at all times and it becomes imperative in unfamiliar and mountainous terrain. Humboldt County has flat areas around the coast that include long beaches and farm land, but most of the county is forested, steep, or developed which present limited landing opportunities in the case of an emergency. ArcMap will be used for the analysis of potential sites based on slope steepness, vegetation type, development, minimum ground roll distance, and distance from a designated flight path. Murray Field outside of Eureka will be the hub from where eight flight paths will stem from because of its central location and accessibility to general aviation pilots. Ground roll distances will be based on the Cessna 172 because of its popularity and abundance in general aviation.

Methods

The "extract by mask" tool used to crop the Humboldt county DEM and NLCD to the Humboldt county outline. The DEM was then converted to a slope raster where values of 5% and under equaled 1 and values over 5% equal 0. The NLCD was reclassified to have open areas equal 1, and non-open areas equal 0. Open areas that could be landed included barren land, shrub/scrub, herbaceous, hay/pasture, cultivated crops, and emergent herbaceous wetlands. Non-open areas included open water, developed open space, development with low, medium, and high intensity, deciduous, evergreen, and mixed forests, and woody wetlands. These two rasters were multiplied with the "raster calculator" tool to produce areas that were open and under a 5% slope.

Airport data was uploaded to the county outline and a polyline shape file was created to make flight paths between the airports. Spokes were created from Murray field to the eight additional airports in the county. A one mile buffer was made around each spoke. The "extract by mask" tool used to crop the combined slope and land cover raster to the buffered flight paths.

The size of the site must also be considered when finding a site. The Cessna 172 Pilot's Operating Handbook was used to find the minimum ground roll distance for a short field landing.

Results

START	DESTINATION	Airport ID	LANDING SITES
Murray Field	Arcata Airport	EKA to ACV	64
Murray Field	Dinsmore Airport	EKA to D63	37
Murray Field	Samoa Field	EKA to O33	25
Murray Field	Garberville Airport	EKA to O16	69
Murray Field	Hoopa Airport	EKA to O21	37
Murray Field	Kneeland Airport	EKA to O19	24
Murray Field	Rohnerville Airport	EKA to FOT	24
Murray Field	Shelter Cove	EKA to OQ5	44

Table 2. Summary of Landing sites between Murray Field and destination airports.

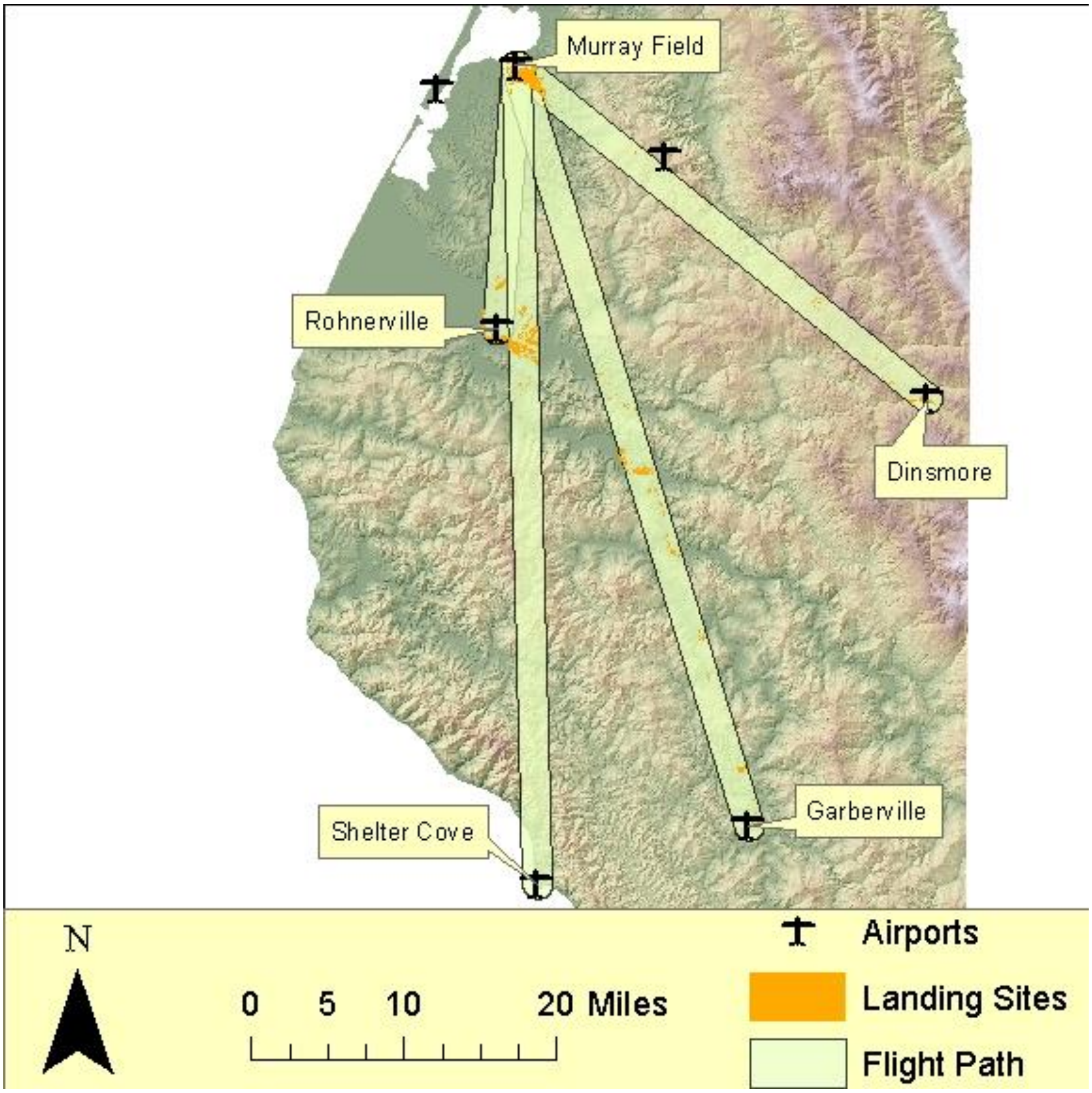

Figure 2. Map showing flight paths and potential landing sites for Southern Humboldt County.

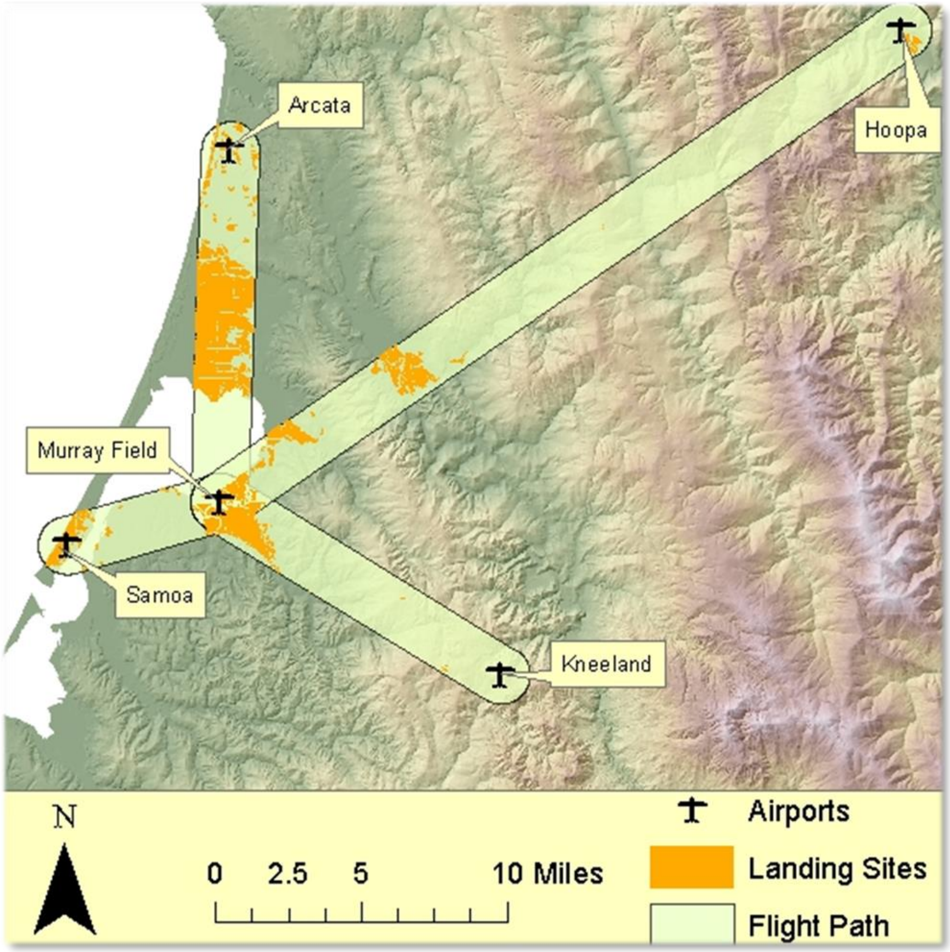

Figure 3. Map showing flight paths and potential landing sites for Northern Humboldt County.

Conclusion

As stated on Esri.com, a geographic information system (GIS) lets us visualize, question, analyze, and interpret data to understand relationships, patterns, and trends. The maps in this report do all of these things for density altitude and emergency landing sites, issues that are usually not the subject of a GIS map. Any pilot looking at these maps would gain new insights and flight safety awareness while flying in Humboldt County and could extend this understanding to other coastal and mountainous areas.

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