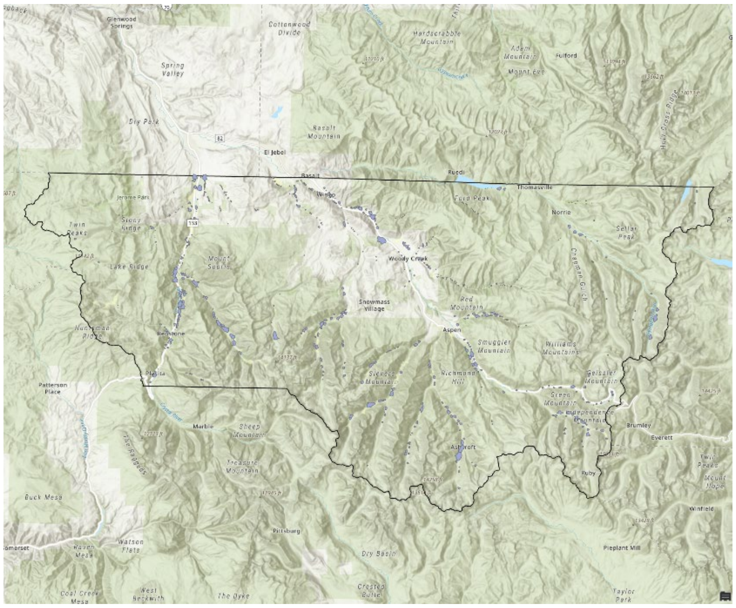
Pitkin County Alluvial Fan Mapping



Tags: Pitkin County

Summary

The metadata provides a summary, description, methods, credits, and extent of the item. Datasets included in this project are geodatabases containing polygon feature classes of mapped alluvial fans and high-angle fans: Pitkin County Alluvial Fans (Pitkin_AlluvialFans) and Pitkin County High-Angle Fans (HighAngleFans_Aprons_Talus).

The description section highlights the crucial role of lidar-based technology in mapping alluvial fans and other high-angle fans. This advancement in the field significantly improves mapping precision, which is essential because mapping fan landforms has many implications. Its application in areas at risk of geologic hazards is particularly noteworthy, as the benefits of this technology extend to various stakeholders, including cities, counties, landowners, and other constituents.

Description

Alluvial and high-angle fans are complex landforms shaped by frequent natural processes that may pose significant hazards, including debris flows, mudflows, and/or flooding. In response to developing wildfire-ready watersheds and overall preparedness for postwildfire hazards, there is an urgent need to map areas at risk of geologic hazards. With the continued development of new technologies and the acquisition of higher-resolution digital elevation data, lidar-based technology allows researchers to map fan landforms more precisely to alert cities, counties, landowners, and other stakeholders to areas potentially at risk following a fire event. This study uses high-resolution lidar imagery to compile, map, and define known and previously unrecognized fans.

In this study, the Colorado Geological Survey (CGS) provides the lidar-based mapping of alluvial and high-angle fans in Pitkin County. “HighAngleFans_Aprons_Talus” include debris-flow fans and other unconventional fan landforms (further discussion below).

Alluvial Fans:

The alluvial fan dataset is intended to capture conventional alluvial fan landforms. According to the American Geosciences Institute, alluvial fans are defined as “… a low, outspread, relatively flat to gently sloping mass of loose rock material, shaped like an open fan or a segment of a cone, deposited by a stream (especially in a semiarid region) at the place where it issues from a narrow mountain valley upon a plain or broad valley, or where a tributary stream is near or at its junction with the mainstream, or wherever a constriction in a valley abruptly ceases, or the gradient of the stream suddenly decreases; it is steepest near the mouth of the valley where its apex points upstream, and it slopes gently and convexly outward with gradually decreasing gradient.” Debris flows, or mudflows, are significant hazards associated with alluvial fans. Debris-flow fans with mean slopes of 20° or less are included in the alluvial fan dataset and are not differentiated from flood-deposited alluvial fans with similar mean slopes. The alluvial fans are mapped in Pitkin County.

High-Angle Fans:

The high-angle fans dataset is intended to capture conventional fan landforms with slopes generally exceeding 20° and unconventional fan landforms. These may include debris-flow fans, comingled cones, or aprons of colluvium/talus, alluvium, debris, and other high-angle fan landforms with mean slopes greater than 20°. Like alluvial fans, the high-angle debris-flow fans are mapped downslope from a channel outlet. However, these channels may be steeper and shorter than those that produce conventional alluvial fans. Colluvium and talus may chiefly comprise fan landforms that do not issue from a channel. High-angle fans may have irregular shapes that differ from traditional fan shapes. High-angle debris flow and unconventional fans can pose significant risks, especially in post-fire conditions. The high-angle fans are mapped in Pitkin County HighAngleFans_Aprons_Talus¡

Methods: Alluvial fans were digitized from 1-m (3.3 ft) resolution lidar-derived products (e.g., DEM, slope) and high-resolution aerial imagery obtained from the Colorado Water Conservation Board and Department of Natural Resources (https://coloradohazardmapping.com/lidarDownload) and collected by Merrick-Surdex Joint Venture, LLP and Merrick & Co. from 5/28/2020 to 10/19/2020. High-resolution aerial imagery was also used to aid in digitizing fans, with sources including Esri's World Imagery and Google Earth. This study intends to identify and map the extent of fan landforms. This includes interpretations where anthropogenic activities have modified the fans (e.g., roadcuts, housing developments, etc.). The methods of identifying fans from the available lidar imagery consist of the following steps:

- Generate lidar-derived products, such as hill-shaded imagery, 2- to 5-ft contour lines, and slope maps.
- Examine the lidar-derived maps at different scales with high-resolution aerial imagery.
- Review channel lines derived from ArcGIS hydrology tools, the DOGAMI Debris Flow Hazard ArcPRO Toolbox (https://pubs.oregon.gov/dogami/sp/SP-53/p-SP-53.htm)*, and/or from NHDPlus High Resolution (https://www.usgs.gov/national-hydrography/nhdplus-high-resolution).
- Digitize fan polygons: Identify and map fan-shaped landforms downslope from stream channels and the fan's estimated apex.
    - Definitions used for defining and mapping fans include:
        - The fan polygon has a mean slope of 20° or less for alluvial fans and greater than 20° for high-angle fans.
        - The apex is identified as the point at the outlet of a basin where the gradient rapidly decreases, confinement rapidly decreases, and sediment deposition occurs on an alluvial plain. A convolution filter generated using focal statistics on the slope map in ArcGIS helps identify the transition from a steep slope with a confined stream channel to an area with an unconfined alluvial fan. <insert info on threshold value used in convolution filter; county specific>
        - The distal extent/edge of the fan is where the fan approaches a creek/river or a slope less than <threshold value for the toe of the fan; county specific> degrees. The extent of the alluvial fans was limited to the most recent depositional features/landforms and contours, and

may not encompass the entire fan feature. Anthropogenic activities (e.g., roadcuts, earthwork activities, and housing developments) may influence the placement of the distal edge.

- The mean slope of individual fan polygons was calculated using Zonal Statistics as a Table from the Spatial Analyst toolbox in ArcGIS Pro using the lidar-derived slope maps as the input parameter.
    - Mean values on polygons may be artificially over-steepened owing to anthropogenic modification or heavy incision by stream channels within the fan polygon boundaries.
- Map scale is 1:24,000. Therefore, fan polygons with an area less than 2000 m2 are excluded from these datasets.

Talus cones, colluvial wedges, and other similar landforms were differentiated from alluvial fans and high-angle debris-flow fans that are deposited by floodwaters and debris-flow events by:

- Fan angle: talus cones and colluvial wedges tend to have higher slopes due to greater internal friction angles. Fans with slopes
    - greater than 35°, and
    - lack of a source stream.
- Rocky texture appearance in imagery. While debris-flow deposits may have higher proportions of coarser sediment, colluvial wedges and talus cones tend to comprise cobbles and boulders that appear coarser in imagery.

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It should be noted that occasionally, the mapper or author may have mapped geomorphic features that other professionals may classify as another type to capture alluvial and high-angle fans.

Field-checking:

Field-checking focused on landforms accessible by road and in areas with human activity and ongoing or future development. These landforms are the most likely areas to pose a hazard if they undergo geologic processes. Field-checking may not be thorough. Landforms that have been field-verified are recorded in the dataset. Notes regarding field observations may be included.

Quality Control and Quality Assurance (QA/QC)

Ten percent of the initially digitized fan polygons were randomly selected and reviewed by a different mapper. The location of the fan apex, the fan shape, and the distal edge were closely examined. Furthermore, any alterations to the fans caused by anthropogenic activities were noted. The supporting maps for the review included the stream flowlines, the catchment map, the slope map, and the convolutional filter separating the steep slope with the confined stream channel from the alluvial plain. If necessary, the fan polygons were adjusted based on the feedback from the review. A second, different mapper conducted another round of cross-mapper review.

*DOGAMI Debris Flow Hazard ArcPRO Toolbox (https://pubs.oregon.gov/dogami/sp/SP-53/p-SP-53.htm). The CGS developed two Python-scripted toolboxes based on DOGAMI's hazards generator toolbox to obtain base maps, initiation and transport, basins, and channel transport potential based on channel confinement and gradient. Refer to the DOGAMI Protocol.for.Channelized.Debris.Flow.Susceptibility.Mapping.

Credits

Colorado Geological Survey, Colorado School of Mines, Colorado Water Conservation Board (CWCB)

Use limitations

This study did not map other geologic hazards such as landslides, hydrocompaction, subsidence, sinkholes, and rockfall. Mapping is designed to be used at a scale of 1:24,000. The product is not intended to provide site-specific analysis; instead, the product should be used to identify the possible presence of natural hazards and what site-specific analysis may be necessary. Changes in the edges of the mapped alluvial fans should be expected with detailed site-specific work. The accuracy of the mapped alluvial fan is based, in part, on the mapper’s interpretation, current lidar imagery at the time of mapping, observations of alluvial fans during field checks (if performed), and landform definitions provided in the methodology section. Given these parameters, while the dataset is as detailed as possible at the time of mapping, it may not be complete with recent or unknown changes to deposition and erosion. Revisions to these mapped alluvial fans should be expected to vary.

Alluvial fans were digitized at a greater scale than 1:24,000, as much as 1:500 in places. However, this dataset is not intended for site-specific analysis; therefore, viewing or using the dataset at scales greater than 1:24,000 is not recommended and should be done at the user's own risk and discretion. To align with the STATEMAP Program 1:24,000 guidance and with our recommended usage, fans with areas less than 2,000 sq-m are converted to points.

The lidar dataset was obtained from the Colorado Water Conservation Board and Department of Natural Resources (https://coloradohazardmapping.com/lidarDownload). Lidar used for mapping Pitkin County was collected by Merrick-Surdex Joint Venture, LLP and Merrick & Co. from 5/28/2020 to 10/19/2020. Alluvial fans were digitized using the lidar-derived products and methods described above.

Scale Range

Maximum (zoomed in) 1:5,000

Minimum (zoomed out) 1:150,000,000