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Two New Mobile Apps for Rangeland Inventory and Monitoring by Landowners and Land Managers

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On the Ground

- Opportunities for rangeland inventory and monitoring have been transformed by innovations in both indicator and methods standardization and new technologies.
- These technologies make it easier to collect, store, access, and interpret inventory and monitoring data.
- The Land-Potential Knowledge System (LandPKS) platform and apps help users with little or no soils knowledge to describe their soil, and for those with little botanical knowledge to monitor key shifts in the relative dominance of plant structural groups.
- The system also allows users to easily share and compare their data with others.

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Rangeland inventory and monitoring have been transformed during the past 10 years by four major innovations.[1] The *first innovation* is the standardization of functional indicators of land health associated with the adoption of standard methods. The Bureau of Land Management's (BLM) recent adoption[2,3] of a subset of the methods used nationally since 2003 by the Natural Resource Conservation Service (NRCS)[4] has resulted in nearly nationwide coverage of the United States.

The *second innovation* in rangeland monitoring is associated with the vastly increased accessibility, ease of use, and quality of geospatial data and technologies. This allows land managers to leverage field data with geospatial information, improve landowner's understanding of landscape variability,[5] and take advantage of the increasing amount of knowledge and information available through state-and-transition models.[6] The availability of free geospatial data, in combination with standardized indicators and spatially explicit analysis methods, increasingly allows independent datasets to be combined and used to address previously unforeseen questions across scales, including those that were virtually impossible to answer in the past due to the resource limitations of individual projects and programs working in isolation.

The *third innovation* is the development of tools for collecting data electronically in the field. These have evolved from hardware-specific programs written for personal data assistants and enhanced GPS devices to tools that work on a broad variety of tablet personal computers and mobile devices, because they are based on widely available software.[7,8]

The *fourth innovation* is the rise of mobile communication technologies and tools. These, together with cloud-based data storage, integration, analysis, and retrieval, make the near-instantaneous interpretation of inventory and monitoring data possible.

Our purpose in this paper is to review the status of two new mobile apps (LandInfo and LandCover) that are part of a larger "Land-Potential Knowledge System" (LandPKS) that is being developed to capitalize on these four innovations in order to provide the knowledge and information needed to make land use and land management decisions at individual field, pasture, or ecological site scales. Our paper focuses specifically on opportunities to use these apps to support inventory and monitoring by landowners and land managers.

Land-Potential Knowledge System Overview

The global LandPKS is being developed as an open-source suite of mobile phone apps connected to cloud-based global databases and models.[9,10] Goals of LandPKS include providing tools for 1) collecting, storing, accessing, and sharing local and scientific data, information, and knowledge, and 2) selecting and interpreting management- and policy-relevant information to support decision-making.

The initial components of LandPKS (LandInfo and LandCover) simplify the process of collecting 1) the basic soil and topographic information necessary to determine land potential (LandInfo), 2) vegetation cover data necessary to inventory and monitor major changes in plant community composition and wind and water erosion risk (LandCover), and 3) to interpret them in the context of soil and climate (LandInfo[i]). All entries are uniquely identified by their location and user-defined plot name. Both LandInfo and LandCover can be used on the website, and downloaded together as the free "LandPKS" app from the Google Play and Apple App stores. The website also includes a user guide.

LandInfo

LandInfo was designed to make it as simple as possible for individuals with little or no soils training to collect the geo-tagged information necessary to identify a soil type and access land potential information. This is the foundation for LandPKS. The information collected with LandInfo is consistent or compatible with that required by the BLM Assessment, Inventory, and Monitoring (AIM[ii]) program and the NRCS National Resources Inventory (NRI[iii]) (Fig. 1). LandInfo is also designed to be used by other apps and systems that lack a soil component, but could benefit from soil and topographic information. For example, seed companies could use this information to target specific seed mixes to specific soil and climate combinations, with the location-based climate information also provided by LandInfo. (See Fig. 2).

LandInfo currently includes screens for basic land cover types, slope classes, slope shape, presence of surface salts and vertical cracking, and soil texture by depth. Slope class may be selected from a set of drawings, or measured using an embedded clinometer, while instructional video clips support soil texture determination.

Most importantly, LandInfo guides non-soil scientists through the process of determining soil texture, which is one of the most important determinants of land potential, especially in water-limited rangelands. Differences in soil texture can result in up to 10X differences in potential plant-available water holding capacity, and up to 1,000X differences in potential infiltration capacity.[11]

[i] See https://landpotential.org.

[ii] For more on AIM see http://aim.landscapetoolbox.org/.

[iii] For more on NRI see http://www.nrisurvey.org/nrcs/Grazingland/2016/.

Soil texture is selected using one of three options: a drop-down menu of slope classes, a text-based key, or a series of embedded videos showing, for example, the creation of a ribbon. While using this tool during workshops, we have observed that working through the key appears to increase the consistency of soil texture determinations among participants, while the embedded videos (which largely follow the recommendations of Joly and colleagues[12] for botanical keys) increase the confidence of those with little or no training in successfully identifying soil texture. We have also found that using the key has caused some of the more experienced co-authors to take a more systematic and consistent approach to hand texturing. The value of keys for plant identification has been supported since Richard Waller first developed one (image-based) in 1689, a model which Lamarck then applied using text in 1778,[13] and keys are widely promoted for soil identification by the NRCS (soil survey manual) and many introductory soil classes. Coarse rock fragment content is recorded by matching observations to one of a set of standard diagrams. Soil depth is recorded if the bedrock is encountered. Observers are encouraged to indicate the depth at which they stopped digging, and whether this was because they encountered bedrock or because they simply did not wish to dig any deeper.

LandInfo data are saved on the phone until cellular or wireless data access is detected, resulting in automatic upload to cloud-based servers. Plant-available water holding capacity for the soil profile is calculated on the server from texture and rock content based on a pedotransfer function and returned to the phone, along with local climate information (which can also be accessed as soon as the app is opened by clicking on the cloud button at the top of the opening screen). The time required depends on data connection and server speeds, but is generally well under 5 minutes. Future feedback to the user will include ecological site identification, relative potential productivity for a variety of crops and forages, and potential for wind and water erosion (which can be refined for current conditions using data derived from field measurements using the LandCover app).

LandCover

The LandCover app replicates the paper data forms provided for the "Stick method" in the "Monitoring Rangeland Health" manual (Figs. 3–4).[14,15] This method[iv] was designed to rapidly generate indicators that are as consistent as possible with those yielded by the standard BLM AIM and NRCS NRI methods,[16] but with less effort and detail, and with less need for training and expertise (Fig. 3). A 1-meter (or 1 yard) stick, constructed from any material, is used to make all measurements. All of the following measurements except for plant density and dominant species on the plot are recorded on the app by selecting from a

[iv] For more on the "stick method" see http://jornada.nmsu.edu/monit-assess/manuals/StickMethod.