TECHNOLOGY REVIEW AND RECOMMENDATIONS

FOR

ILLINOIS NATURAL AREAS INVENTORY UPDATE PROJECT

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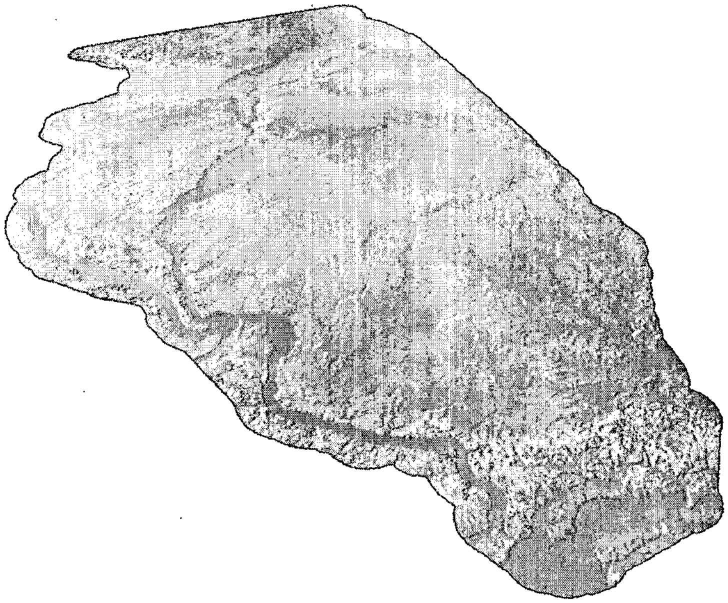
6/30/2005



Equipment Recommendation Summary

Equipment Recommendations

The following table summaries hardware/software* equipment recommendations for the Illinois Natural Area Inventory (INAI) update project.

Hardware item	Recommendation	Cost
Field Computer	Panasonic Toughbook CF -18	$5,000
Office Computer	Dell Precision 670	$2,000
Office Server	Dell PowerEdge 800	$5,500
Office / Field Printer	HP LaserJet 1022	$199
GPS Receiver	Thales MobileMapper	$1,595
Digital Camera	Ricoh / Olympus (See note pg 18)	$1,150 / $700
Digital Video Camera	Canon ZR400 / Samsung SC M105S (See note pg. 21)	$450 / $500
Digital Voice Recorder	Included with others	$0
Office Scanner	HP ScanJet 8250	$800
Office Plotter	Hp DesignJet 500	$3,500

*Software recommendations are detailed on page 26

Field Computer

Business Requirements

The INAI update project will support six field ecologists, located across the state, which may include remote areas without access to broadband internet service or reliable cell phone service. In addition, the field staff will work in their offices, analyzing various spatial data.

Data entry operations should be streamlined for manual entry and ideally completed while the ecologists are in the field.

Technical Requirements

A mobile lightweight computer is required that can survive in daily field use. Computers falling in to this category are commonly referred to as "ruggedized". Additional technical requirements include:

- Ability to use screen in various lighting conditions
- Long battery life (or availability of extra battery
- Weatherproof
- Shockproof
- Tablet style data entry
- Keyboard style data entry
- Network connection (office use)
- Modem (land line connection)
- Compatible with GPS receiver
- Compatible with digital camera
- Ability to run ArcGIS and MS Office applications
- System OS Windows XP or later

Products Reviewed

Based on the business and technical requirements, the following tablet PC computers were reviewed for use on the INAI project.

Manufacturer: *Hewlett Packard*
Model: *TR3000*
Ruggedized: *yes*
Price: *$1200*
Weight: *7lbs.*
Screen: *8" (approx.)*
Operating System: *Windows XP Tablet Edition*

Comments: *This tablet has recently been discontinued by HP. New systems are still being sold and are completely supported by HP. The unit is weatherproof, but not warranted against total submersion in liquid. The weight of the tablet seems heavy given that some tablets twice the size weigh in at ~4lbs. The unit does not come with a built in keyboard although one could be attached with the available USB ports.*

Status: ***Rejected***
Reason: *Concern over discontinuation of product line, heavy weight of unit, and lack of integrated keyboard*

Manufacturer: *Itronix*
Model: *GoBook Tablet*
Ruggedized: *yes*
Price: *Starting at $2700*
Weight: *3.7lbs.*
Screen: *10" (approx.)*
Operating System: *Windows XP Tablet Edition*

Comments: *The Itronix tablet is fully weatherproof. It is build to operating in a driving rain without any problems and conforms to most military specifications. The weight of the unit is very good at less than 4lbs. Like the HP tablet, the Itronix does not have a built in keyboard. The tablet comes with a 3 year warranty.*

Status: ***Rejected***
Reason: *Lack of integrated keyboard and concern with Itronix not being a mainstream vendor of computer equipment.*

Manufacturer: *Panasonic*
Model: *Toughbook CF - 18*
Ruggedized: *yes*
Price: *Starting at $3200 (as configured for the project will be $4500-$5000)*
Weight: *4.2lbs.*
Screen: *10" (approx.)*
Operating System: *Windows XP Tablet Edition*

Comments: The CF-18 tablet has been rated as "best of breed" by several different reviews. Panasonic is an established vendor with over 70% of the ruggedized computer market. The CF-18 has battery life of over 7 hours. The unit is fully ruggedized and like the Itronix, conforms to military operating specifications. The CF-18 has a full keyboard that can be folded flat against the back of the computer when operating in tablet mode.

Status: ***Recommended***
Reason: *The Panasonic Toughbook line is the proven leader in field computing solutions. The CF- 18 is lightweight and meets or exceeds all of the requirements for the INAI update project.*

Recommendation: Panasonic Toughbook CF-18 tablet computer

Office Computer

Business Requirements

The project will support two to three office staff located at Lincoln Land Community College (LLCC). It is anticipated that two of these positions will be GIS analysts working on extensive spatial data sets and requiring high-end PC desktop workstations.

The office computer should also be capable of running typical computers applications including word processing, spreadsheets, databases, etc. Scanning software may also be used on these computers.

Technical Requirements

The desktop workstation should be capable of running ArcGIS 9.x and working with large raster datasets. This will require additional RAM memory and adequate fixed storage space. The desktop units should meet or exceed the following requirements:

- 2.8 ghz processor
- 80GB Hard Disk
- 1GB RAM
- 64mb video card
- USB 2.0 slots available
- 19" Monitor or larger (flat LCD preferred)
- Ethernet network card
- Windows XP Professional Operating System
- Warranty (3yr minimum)

Manufacturer: *HP*
Model: *xw4300*
Price: *$2000 (price may vary slightly depending on current market)*
Processor: *3.0 MHz Intel*
Hard disk: *160 GB*
RAM: *1 GB*
Video: *64MB*
Monitor: *19" LCD*
Ethernet: *yes*
OS: *Windows XP Professional*
Warranty: *3 year*

Comments: *The HP workstation was reviewed to cost compare the Dell workstation.*

Status: ***Rejected***
Reason: *LLCC does not use HP computers. This unit was reviewed for cost comparison against the Dell PC to make sure that Dell was not abnormally high on cost.*

Manufacturer: *Dell*
Model: *Precision 670*
Price: *$2000 (price may vary slightly depending on current market)*
Processor: *3.0 MHz Intel*
Hard disk: *160 GB*
RAM: *1 GB*
Video: *64MB*
Monitor: *19" LCD*
Ethernet: *yes*
OS: *Windows XP Professional*
Warranty: *3 years*

Comments: *LLCC uses Dell PCs. Dell has a good track record of reliable workstation level computers. They are one of the leading manufacturers.*

Status: ***Recommended***
Reason: *LLCC uses Dell computers and this system meets or exceeds all project requirements. Selection will help the project in that LLCC staff will have experience in working on these types of systems.*

Recommendation: Dell Precision 670 or similar Dell configuration.

Office Server

Business Requirements

It is anticipated that a server class computer will be needed in support of the office GIS workstations. This server will be used for file storage, file backup, file transfer (with field ecologists), and possible application serving. Hardware should be able to perform all of the above activates.

Data storage requirements for state-wide datasets are estimated to be very large. Server storage space should be adequate to handle these data sets.

Technical Requirements

The office server should be a PC based unit running Microsoft's Windows 2003 Server operating system. In addition, the server unit should meet or exceed the following requirements:

- 2.8 ghz processor
- 800gb Hard Disk or greater
- 2GB RAM
- 64mb video card
- USB 2.0 slots available
- 17" Monitor or larger (flat LCD preferred)
- Ethernet network card
- Windows 2003 Server Operating System
- Warranty (3yr minimum)

Manufacturer: *HP*
Model: *ProLiant ML 110*
Price: *$4000 (price may vary slightly depending on current market)*
Processor: *3.0 MHz Intel*
Hard disk: *584 GB*
RAM: *2 GB*
Video: *32MB*
Monitor: *15" LCD ($75 purchased separately)*
Ethernet: *yes*
OS: *Windows 2003 Server*
Warranty: *3 year*

Comments: *The HP server was reviewed to cost compare the Dell server. Total disk storage < 600GB..*

Status: ***Rejected***
Reason: *LLCC does not use HP computers. This unit was reviewed for cost comparison against the Dell Server to make sure that Dell was not abnormally high on cost. Available disk space lower than required*

Manufacturer: *Dell*
Model: *PowerEdge 800*
Price: *$5500 (price may vary slightly depending on current market)*
Processor: *2.8 MHz Intel*
Hard disk: *900 GB*
RAM: *2 GB*
Video: *32MB*
Monitor: *15" LCD (separate purchase)*
Ethernet: *yes*
OS: *Windows 2003 Server*
Warranty: *3 years*

Comments: *LLCC uses Dell servers. Dell has a good track record of reliable server level computers. They are one of the leading manufacturers.*

Status: ***Recommended***
Reason: *LLCC uses Dell computers and this system meets or exceeds all project requirements. Selection will help the project in that LLCC staff will have experience in working on these types of systems.*

Recommendation: Dell PowerEdge 800 or similar Dell configuration.

Office Printer

Business Requirements

The INAI update project will support six field ecologists, located across the state, and at least three main office positions. All locations require the ability to print information from the computer. Information printed must have the flexibility of being taken in to the field without inks fading or running if paper get wet.

Printer should operate efficiently and have a low cost of ownership for toner and supplies. Toner changes and other routine maintenance should be able to be performed by general users.

Technical Requirements

Ideally, all printers would have the ability to print color as well as black/white (b/w). Unfortunately the cost of ownership is still quite high (> 7.4 cents per copy) for color laser printers and the inkjet models available do not meet the business requirements of field use.

In addition, all printers should be able to perform the following:

- Minimum of 12 pages per minute (ppm) for black/white
- Compatible with Windows XP
- Compatible with ArcGIS
- USB Connection to computer
- Available manual paper feed, including envelopes and labels
- Printing resolution of 600dpi or better

Manufacturer: *Dell*
Model: *1700 Laser Printer*
Speed: *25ppm*
Price: *$150*
Resolution: *1200x1200dpi*
Toner life: *Over 3000 sheets*

Comments: *The 1700 is a quality entry level b/w laser printer. It meets or exceeds all of the requirements outlined. The manual paper feed is capable of handling paper weights up to 43lbs.*

Status: ***rejected***
Reason: *LLCC uses HP printing equipment. Dell does not actually manufacture their printers. They are made by others and sold under the Dell brand.*

Manufacturer: *Brother*
Model: *HL-5140*
Speed: *21ppm*
Price: *$199*
Resolution: *2400x600dpi*
Toner life: *not available*

Comments: *Brother has been an entry level printer for many years. The speed of the printer is slightly slower than the Dell, but still well above the project requirements. The price of the 5140 is a little higher than the Dell.*

Status: ***Rejected***
Reason: *Price is too high and resolution is not as fine as other models reviewed.*

Manufacturer: *HP*
Model: *LaserJet 1022*
Speed: *19ppm*
Price: *$199*
Resolution: *1200dpi*
Toner life: *not available*

Comments: *HP is an industry leader in printer technology and produces some of the most reliable units. The 1022 is not their entry level printer, but is comparable in price to the other reviewed printers. The printer supports manual duplexing via the printer driver.*

Status: ***recommended***
Reason: LLCC has an existing relationship with HP and their printers. HP is the industry leader in printing technology. .

Manufacturer: *Samsung*
Model: *ML- 1740*
Speed: *17ppm*
Price: *$90*
Resolution: *600x600dpi*
Toner life: *1,000 pages*

Comments: *Samsung is an entry level vendor in the laser printer market. This printer is designed for low level usage and appears to have a lifespan of approximately 15,000 pages. The delivered toner cartridge is only good for 1,000 pages.*

Status: ***Rejected***
Reason: *Concern that the unit will not be durable enough to last for the duration of the project.*

Recommendation: HP LaserJet 1022 or similar HP model.

GPS Receiver

Business Requirements

GPS receivers will be used for a variety of tasks on the INAI project. Two main tasks will be performed on a regular basis, the delineation of community boundaries and the location of individual spots in the field. Additional tasks include general navigation and waypoint identification. The GPS unit should be able to be used with or without the PC.

Technical Requirements

All GPS units should be able to perform the following:

- Accuracy within 5 meters
- Good battery life
- Communication with Panasonic CF -18 (NEMA protocol)
- Integration to ArcGIS for data entry
- Weatherproof
- Usable in various lighting conditions

Manufacturer: *Trimble*
Model: *Pathfinder Pocket receiver*
Accuracy: *2-5 meters*
Price: *$515*
Communications: *NMEA*
Weatherproof: *yes*

Comments: *Trimble is a leader in professional GPS equipment. Typically their products are much more expensive than consumer GPS units. The Pathfinder unit would require a cable between the unit and the tablet PC. There is no on unit display screen.*

Status: ***Rejected***
Reason: *GPS receiver should not need a cable to function and relay data to the tablet PC. Additionally this unit has no display screen.*

Manufacturer: *Geneq Inc.*
Model: *SX Blue*
Accuracy: *< 1 meter*
Price: $1,995
Communications: *NMEA (bluetooth)*
Weatherproof: *yes*

Comments: *The SX Blue is a rugged bluetooth unit. It would link nicely to the tablet PC's and has low power requirements so it should run for a long time. The unit weighs approximately ½ lb. There is no on-screen display for the unit.*

Status: ***Rejected***
Reason: *No on-screen display*

Manufacturer: USGlobablSat (Rayming)
Model: *BT-338*
Accuracy: *10 meters*
Price: *$180*
Communications: *NMEA*
Weatherproof: *yes*

Comments: *Rayming produces a quality unit that is field proven. This unit does not have a screen on the unit and does not meet the 5 meter accuracy requirement.*

Status: ***Rejected***
Reason: *See comments above.*

Manufacturer: *Garmin*
Model: *GPSMAP60*
Accuracy: *~3 meters (with WAAS)*
Price: *$325*
Communications: *NMEA*
Weatherproof: *yes*

Comments: *The Garmin unit is the only one reviewed that has an on-unit display screen. This unit will deliver the needed accuracy only if WAAS signal is available. The unit would require the use of a cable to connect to the tablet PC.*

Status: ***Rejected***
Reason: *GPS receiver should not need a cable to function and relay data to the tablet PC.*

Manufacturer: *Thales*
Model: *MobileMapper*
Accuracy: *2-3 meters*

Price: *$1595*
Communications: *NMEA*
Weatherproof: *yes*

Comments: *The Thales unit is expensive when compared to the other units reviewed. However it is also the only unit that meets or exceeds all of the business and technical requirements. It has an on-screen display and is capable of communication via Bluetooth (wireless).*

Status: ***Recommended***
Reason: *This is the only GPS unit reviewed that meets the INAI project requirements.*

Recommendation: Thales MobileMapper GPS

Digital Camera

Business Requirements

The INAI project will require field ecologists to document various features and conditions. Photos of the site are an invaluable resource for future reference.

Photographers should not be required to manually index photos. Ideally, photos will be located by GPS coordinates of the photographer at the time photo was taken. Zoom capabilities should allow for close-up photos as well as panoramic views. Camera should be self contained and not require additional lens to function.

Technical Requirements

All digital camera units should have the following minimum features:

- Work with standard batteries
- Built-in flash
- Ability to focus at 4 feet
- Picture storage on non-volatile media (i.e. storage card or CD)
- Weatherproof
- Ability to locate photo position with GPS

Manufacturer: *Ricoh*
Model: *Pro G3*
Focus: *~12" – infinity (camera has a macro mode that advertises 1cm)*
Resolution: *3.4 megapixels*
Data Storage: *SD memory card*
Price: *$1150 ($850 w/o GPS-Link)*
Communications: *bluetooth*
Weatherproof: *yes (with additional case $25)*

Comments: *The Ricoh is a point and shoot camera with mid-range resolution capabilities. The camera comes with "GPS-Link" software that allows the camera to interface with ArcGIS to position the photo location.*

Status: ***Conditional Recommendation (see note at end of this section)***
Reason: *Although the Ricoh meets or exceeds all business and technical requirements it is very expensive compared to other cameras. Likely this is a result of paying for the extra features not needed by the project.*

Manufacturer: *Kodak*
Model: *EasyShare Z740*
Focus: *~4.7" – infinity*
Resolution: *5 megapixels*
Data Storage: *32mb internal + available SD memory card slot*
Price: *$380*
Communications: *USB cable (not real time)*
Weatherproof: *no*

Comments: *A good camera value for the price. Camera has many additional features. This camera is not weatherproof.*

Status: ***Rejected***
Reason: *Not weatherproof*

Manufacturer: *Canon*
Model: *A80*
Focus: *~2" – infinity*
Resolution: *3.9 megapixels*
Data Storage: *Compact Flash (CF) memory card slot*
Price: *$380*
Communications: *USB cable (not real time)*
Weatherproof: *yes (with case $160)*

Comments: *Superior image quality. This camera uses the larger CF type storage card and does not have as fast of "image save" times. Camera is only weatherproof with the addition of an expensive and bulky outer case.*

Status: ***Rejected***
Reason: *Bulk and price when combined with outer case.*

Manufacturer: *Pentax*
Model: *Optio 33WR*
Focus: *~1" – infinity*
Resolution: *3.2 megapixels*
Data Storage: *SD memory card slot*
Price: *$350*
Communications: *USB cable (not real time)*
Weatherproof: *yes, but not for underwater use*

Comments: *This camera has an odd size being almost square. The weather resistant properties of the camera are nice. No Bluetooth communications.*

Status: ***Rejected***
Reason: Need special driver and software to download pictures.

Manufacturer: *Olympus*
Model: *Stlyus 400*
Focus: *~2" – infinity*
Resolution: *4.0 megapixels*
Data Storage: *XD memory card slot*
Price: *$400*
Communications: *USB cable (not real time)*
Weatherproof: *yes*

Comments: *XD memory cards are not as common as SD (not compatible either) or CF cards. They are somewhat faster for reading and writing data. This may be overlooked though by the fact that the unit is water resistant and otherwise meets every requirement except the Bluetooth communications*

Status: ***Recommended***
Reason: *Overall best value for dollars. Proven vendor.*

Recommendation:

The Ricoh solution is the best overall solution if the budget will tolerate the purchase of six cameras at that price. The GPS-Link software is included in the price of the camera which otherwise will need to be purchased for $300 regardless of what camera is chosen.

The Olympus Stylus 400 is an alternative recommendation and would bring the cost (including GPS-Link) of each unit down in to the $750 range.

Digital Video Camera

Business Requirements

The INAI project will occasionally require field ecologists to record video documentation of various features and conditions. Videos of the site are an invaluable resource for future reference.

Video camera should function in a variety of lighting conditions. Zoom function should be as smooth as possible.

Technical Requirements

While waterproof video cameras are available on the market, this feature appears to be the domain of diving units. As such, these models tend to be very bulky. Other cameras offer the ability to take still shots, as a rule this functionality is limited and at much lower resolutions than true digital cameras. No attempt has been made to find the best unit to take still photos, although this functionality has not been strictly excluded from reviewed cameras.

DV cameras are not designed for operation at temperatures below freezing.

All digital video camera units should have the following minimum features:

- Minimum of 2 hour battery life
- Built in microphone
- Record to DV tape or direct to DVD
- LCD screen for recording and playback (in field)

Manufacturer: *Canon*
Model: *ZR400*
Battery life: *40 minutes*
Built-in microphone: *yes*
Data Storage: *Mini DV tape*
Price: *$450*

Comments: *Canon is an industry leader in image quality and image stabilization. Their ZR line of DV cameras are very popular and produce quality video. The included battery does not have a very long run time. Longer lasting batteries are available at extra cost. This camera has the ability to take still pictures.*

Status: ***Recommended***
Reason: *Superior image quality and stabilization.*

Manufacturer: *JVC*
Model: *GRDF430*
Battery life: *85 minutes*
Built-in microphone: *yes*
Data Storage: *Mini DV tape*
Price: *$400*

Comments: *The JVC camera is a mid-range product from a quality company. The battery run time of 85 minutes is double that of Canon's ZR400.This camera has the ability to take still pictures*

Status: ***Rejected***
Reason: *Battery run time is too short*

Manufacturer: *Sony*
Model: *HandyCam HC90*
Battery life: *70-90 minutes*
Built-in microphone: *yes*
Data Storage: *Mini DV tape*
Price: *$400*

Comments: *The Sony camera is smaller than the other units reviewed. Sony has a reputation for utilizing non-standard components. This is the case for the still image portion of the camera that uses the Sony memory stick.*

Status: ***Rejected***
Reason: *Battery run time is too short*

Manufacturer: *Sony*
Model: *HandyCam HC90*
Battery life: *70-90 minutes*
Built-in microphone: *yes*
Data Storage: *Mini DV tape*
Price: *$400*

Comments: *The Sony camera is smaller than the other units reviewed. Sony has a reputation for utilizing non-standard components. This is the case for the still image portion of the camera that uses the Sony memory stick.*

Status: ***Rejected***
Reason: *Battery run time is too short*

Manufacturer: *Samsung*
Model: *SC-M105S*
Battery life: *60 minutes*
Built-in microphone: *yes*
Data Storage: *Mini DV tape*
Price: *$500*

Comments: *This camera is much smaller than the other units reviewed, weighing in at a small 0.3 lbs. It also has the ability to record voice messages (8hrs).*

Status: ***Recommended***
Reason: *Battery run time is too short*

Recommendation:

None of the cameras reviewed met the technical requirement for battery runtime (2hours). This is likely because camera manufacturers include smaller battery packs with the camera to help keep costs down. Additional batteries, including those with longer runtimes can be purchased separately.

Both the Canon ZR400 and the Samsung SC-M105S are quality cameras that would work nicely for the INAI project. The Canon is a better product from a solely digital video standpoint. The Samsung is attractive due to its ability to record voice to the memory stick. Final recommendation will be on whether or not it is decided to include the voice recording in this device or keep it separate.

Digital Voice Recorder

Business Requirements

Field personnel require the ability to record voice notes at various times during the project. The recorder should be easy to operate. Ideally the unit should be operable by one hand.

Technical Requirements

The voice recorder should utilize digital technology.

All voice recorder units should have the following minimum features:

- Minimum of 2 hour recording time
- Built in microphone
- Record to mp3 format or similar industry standard format
- Ability to playback in the field

Manufacturer: *Panasonic*
Model: *Toughbook CF-18*
Recording time: *> 2 hours*
Built-in microphone: *yes*
Data Storage: *Hard disk of tablet computer*
Price: *included functionality in field computer*

Comments: *The tablet PC has the ability to record voice by way of microphone. A headset would be suggested so that the field staff would have hands free operation*

Status: ***Conditional Recommended***
Reason: *If this option is acceptable, it would eliminate the need for a separate device.*

Manufacturer: *Samsung*
Model: *SC-M105S*
Recording time: *8 hours*
Built-in microphone: *yes*
Data Storage: *Memory stick*
Price: *included functionality in video camera*

Comments: *The camera has the ability to record voice by way of a built-in microphone. It would require the field ecologist to carry the video camera when doing voice recording.*

Status: ***Conditional Recommended***
Reason: The selection of this option is based on the selection of the Samsung unit for video camera.

Manufacturer: *Olympus*
Model: *VN-1000*
Recording time: *1000 minutes*
Built-in microphone: *yes*
Data Storage: *Built-in flash memory*
Price: *$50*

Comments: *This is a stand-alone voice recorder. It has voice activation and a battery life of 30 hours. Data would need to be downloaded to the PC. Olympus is the industry leader in digital voice recording.*

Status: ***Rejected***
Reason: *This option would require the purchase of additional equipment.*

Recommendation:

Recommend that existing equipment be used for voice recording. No additional purchase or support would be needed.

Office Scanner

Business Requirements

The INAI office staff and field staff will have a need to scan documents or other data from time to time. .

Technical Requirements

Documents may range from printed text to color photos, to hand drawn diagrams. The scanner must be able to handle all of these scenarios.

The scanner should have the following minimum features:

- 24 bit color
- Document feeder
- Legal size document capable
- USB connection to PC

Manufacturer: *HP*
Model: *ScanJet 8250*
Color: *48 bit*
Document feeder: *yes*
Max page size: *8.5" x 14" (legal)*
Connection type: USB 2.0
Price: *$800*

Comments: *LLCC has experience with HP scanners.*

Status: ***Recommended***
Reason: *The scanner market is filled with vendors offering units that easily exceed the project requirements. LLCC has standardized on HP as a vendor for this technology. There is no compelling reason to not select an HP unit.*

Recommendation: HP ScanJet 8250 or similar HP unit.

Office Plotter

Business Requirements

The INAI office staff will have a need to plot map documents or other large format data from time to time. Content may be USGS topographic maps, aerial photos, custom maps or large blocks of text.

Technical Requirements

The plotter should have the following minimum features:

- 36" width capable
- Color and B/W
- Roll feed capable
- Network capable

Manufacturer: *HP*
Model: *DesignJet 500*
Color: *yes*
Roll feeder: *yes*
Max page size: *42" x 150' (roll)*
Connection type: Ethernet
Price: *$3500 approx.*

Comments: *LLCC has experience with HP plotters.*

Status: ***Recommended***
Reason: *HP is unquestionably the leader in the large format printer market. HP has a number of units that easily exceed the project requirements. LLCC has standardized on HP as a vendor for this technology. There is no compelling reason to not select an HP unit.*

Recommendation: HP DesignJet 500 or similar HP unit.

Software

Software Requirements

The software requirements for the INAI project are summarized below:

Software	Unit Cost (Approx.)	# Needed	Total Cost
MS Office Professional	$300	9	$2700
ArcGIS 9.x	$TBD	9	$TBD
ArcGIS Maint. / 3yr.	$TBD	9 x 3yr.= 27	$TBD
ArcGIS Spatial Analyst	$TBD	1 + maint.	$TBD
Anti-Virus Software	$40	9 x 3yrs. = 27	$1080
GPS Link[1]	$299	6	$1794
VB.net [2]	$100	1	$100
Grand Totals			$TBD

[1] GPS Link positions digital photos with GPS data.

[2] VB.net is a programming language that will be needed for customization.

Methods for Interpreting Maps and Aerial Photographs to Identify Prairies, Savannas, Wetlands, and Selected Other Features with High Potential for Supporting Natural Areas

Prepared for
The Nature Conservancy

by John White *

June 2005

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INTRODUCTION

Scope of this Report

This report describes methods for interpreting maps and aerial photography to identify potential natural areas for the Illinois Natural Areas Inventory. The following kinds of features, termed *survey features*, are covered:

Prairie
Savanna
Wetland
Selected other features with high potential for supporting natural areas

The "selected other features" are *topo-edaphic features*, which are defined as unusual, extreme environments that have special *topographic* and *edaphic* (soil) characteristics. The following thirteen topo-edaphic features are discussed:

Acidic soil
Basic soil
Bedrock outcrop
Depression
Eroded area
Exposed slope
Gravel deposit
Open water
Organic soil
Saline soil
Sand deposit
Sheltered slope
Steep slope [1]

Searching for topo-edaphic features is a productive way to identify potential natural areas for the following reasons:

(1) Many natural communities can be identified on the basis of their characteristic topography and soils. Some rare and unusual natural communities occur on extreme environments such as excessively steep slopes.

[1] A fourteenth survey feature, *wetland*, can also be considered a topo-edaphic feature — but for the purposes of this report, it is treated separately.

(2) Extreme environments often are difficult or unprofitable to log or to clear for farming, so they generally have a relatively high potential for undisturbed conditions.

(3) As a general rule, native plants can out-compete exotic species in extreme environments, so these sites are more likely to have native vegetation.

(4) Many endangered and threatened plants and animals inhabit unusual environments.

(5) Topo-edaphic features can be identified without any detailed foreknowledge about a region's biology.

The presence of a topo-edaphic feature often indicates relatively high potential for undisturbed conditions or rare species, but not every occurrence of a topo-edaphic feature is automatically mapped and recorded as a survey site (*i.e.* a potential natural area). That is, the occurrence of a topo-edaphic feature (such as a gravel deposit or a depression) usually does not — in itself — call for mapping and tracking a survey site. But if a topo-edaphic feature occurs in combination with promising-looking vegetation, then the area should be selected as a survey site.

The potential for a natural area increases wherever two or more topo-edaphic features occur together. For instance, a *steep*, *exposed*, *gravel* slope (three different topo-edaphic features in combination) should be scrutinized on aerial photography; if the vegetation is grassy or if the tree cover is thin or discontinuous, then the site has relatively high potential for native prairie or savanna vegetation.

Format of this Report

This is the current edition of a draft set of methods that is continually being revised. The format of these methods and the instructions for drafting them are based on the premise that the methods will continue to be expanded, corrected, and otherwise improved and updated.

Beginning on page 7, methods for interpreting maps and aerial photos to identify each survey feature are presented under the following headings:

Definition and description
Natural communities
Geographic distribution
Topographic position
Map symbols
Soils
Shape
Size
Photographic tone and color
Photographic texture and pattern
Height

Relation to other features
Disturbance features
Additional notes

Not every topic in the above list is discussed for every survey feature. If a particular interpretation clue (such as *shape*) is not applicable or diagnostic, it is omitted. If two topics are most efficiently discussed at the same time, the topics and their headings are combined (for instance *map symbols and soils*).

Each of the above 14 topics is described below in the context of instructions about how to document the methods.

Definition and description

Provide a definition of the survey feature. If necessary or desired, elaborate with a more general description.

Natural communities

Name each natural community, community subclass, community class, or other group of communities that either comprises the survey feature or is commonly associated with it. Topo-edaphic features often do not have a close association with specific natural communities, but topo-edaphic features often have relatively undisturbed conditions and rare species.

Geographic distribution

Describe the geographic extent of the survey feature in general terms (*i.e.* by Natural Division); this will indicate in general where to search for the feature.

As appropriate, discuss the feature's distribution more specifically (*e.g.* "commonly clustered: where one occurrence is known, other examples of this feature are likely to be found nearby").

Topographic position

A survey feature may have a distinctive topographic position, indicated by the type of landform it occupies or by (a) the *slope position* (*e.g.* blufftop, base of slope, etc.), (b) *aspect* (direction it faces), and (c) *steepness* that it characteristically occupies.

Describe the feature's topographic position in as much detail as is useful for developing a search image for the feature. [2]

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[2] A *search image* is a set of criteria that is used to search for a survey feature.

Map symbols

A survey feature may be either clearly shown or indirectly indicated by a map symbol. If the feature is represented in some way by a symbol, explain how. For instance, topographic maps depict small quarries with crossed pickaxes or crossed shovels. Soil survey maps employ a number of symbols to indicate gravel deposits, rock outcrops, and the like.

Most of the photo-interpretation work to identify potential natural areas is done in conjunction with 7.5-minute U.S. Geological Survey maps (1:24,000-scale quadrangles). If the methods are based on 7.5-minute maps, it usually is not necessary to say so; but if the methods pertain to some other kind of map, specify the type of map.

Soils

If a survey feature is strongly associated with a certain kind of soil, then soil maps can be used to search for examples of the feature. Soil maps are useful even if a survey feature is not restricted to only one or a few soil series. Sometimes a feature is best developed on a certain soil series but it extends onto other soils; in such cases, soil maps can indicate areas with a high probability for the feature.

Soils that may have high potential for supporting certain survey features include organic soil, basic soil, acidic soil, gravel, and sand. If there appears to be any potential for a close relationship between soils and a certain survey feature, find out and document what the relationship is. Locate known occurrences of the survey feature on soil maps, and look for soil–vegetation relationships that would be helpful for finding more survey sites.

Shape

Shape refers to the overall configuration of a feature, as it is viewed on a map or an aerial photo.

If occurrences of a feature have a characteristic shape that can serve as a clue for finding the feature, describe the shape.

Size

Size refers to the areal (not aerial) extent or acreage of a feature. In this context, size does not refer to the stature of the vegetation.

Describe the feature's size in general terms; be specific if it has a characteristic size (*e.g.* "usually a fraction of an acre").

Photographic tone and color

Aerial photographs come in many forms that affect their appearance. Photos may be either black-and-white or in color. Both black-and-white and color photos may be either panchromatic or infrared. Panchromatic film is conventional film, which is sensitive to approximately the same light spectrum that is visible to the human eye. Infrared film records images of reflected near-infrared radiation, which is invisible to the unaided eye. Photos may be in the form of paper prints, transparencies, or electronic images; they may also be obtained at various seasons and at a wide range of scales. [3]

Each kind of photo has certain advantages as well as drawbacks. For example, color photos often allow an interpreter to see features that cannot be detected on black-and-white photos, but color photos usually have a significantly lower resolution than black-and-white photos. Color infrared film often increases the contrast among natural communities, but the colors are unfamiliar: living vegetation is red, for instance. A surveyor must examine several different kinds of photos to take advantage of the strengths of each.

Describe each kind of photo used to search for the survey feature. A general description such as "black-and-white photography" may suffice; or, be specific when desired: *e.g.* "1984, 1:40,000-scale, dormant-season, color infrared transparencies."

For each kind of photo, describe the gray tone or color of the feature. The photographic tone of a black-and-white photo is a shade of gray, which can vary between black and white. These tones can be loosely described as *black*, *dark gray*, *medium gray*, *light gray*, or *white*. Colors should be described simply, in terms that anyone is likely to understand (*e.g.* "bright purplish-red" rather than magenta).

Photographic texture and pattern

Texture refers to the appearance of unevenness or fine-scale surface variability of a feature when it is photographed from a distance. For the most part, texture is the result of the size and density of the individual plants that make up the vegetative cover. Texture is described as *coarse textured*, *medium textured*, *fine textured*, or *textureless*. Forests have a coarse texture, grasslands are fine textured, and shrubby areas are intermediate in texture. Sometimes additional qualifiers are in order (*e.g.* "the inner zone of the wetland is very fine textured").

Although *texture* resides near the lower limit of photographic resolution, *pattern* refers to the distribution of larger, readily discernable areas. If adjacent areas on an aerial photograph have distinctly different textures and tones or colors, then the contrasting areas appear as patches. The spatial arrangement of adjacent patches forms a *pattern*.

Some natural communities have obvious bands or zones within them, and these zones comprise a regular pattern. Other communities are homogenous (patternless), or they may be heterogenous and without a regular pattern. A feature's pattern or lack of pattern might be

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[3] Digital cameras do not record images on film, but many digital aerial photos are made by scanning a photograph that was originally recorded on film.

described in terms such as the following: "the community has an arc-like pattern of alternating ridges and swales," or "the feature has a uniform texture and is patternless."

Height

Height refers to how tall vegetation or some other feature is; it does not refer to the elevation of the ground that the feature occupies. The height of a feature on aerial photography can be examined with a stereoscope, or the height sometimes can be inferred from the length of the shadow that the feature casts. A stereoscope exaggerates the vertical dimension and makes it easier to see relative differences in height.

As appropriate, describe the height of the vegetation or other feature. Usually it is adequate to describe the height in general terms (*high*, *medium*, or *low*) — for example: "the forest is medium height but often has scattered taller trees emerging from the canopy."

Relation to other features

Natural communities and topo-edaphic features often occur in a certain position in relation to other communities or other natural features. For example some kinds of communities characteristically occur as small inclusions within larger ones.

Note this sort of information if it helps one recognize or evaluate the survey feature (*e.g.* "hill prairies near farmsteads have almost always been heavily degraded by livestock unless the prairie is isolated from the barnyard by a steep bluff").

Disturbance features

Use this section to discuss only those disturbances that affect the way in which the survey feature is identified on maps and aerial photos. Other procedures for detecting and evaluating disturbances are discussed in detail elsewhere in the set of methods that are being developed for updating the Illinois Natural Areas Inventory (INAI).

Additional notes

Use this section to record useful information that does not fit elsewhere.

Acknowledgment:

Barbara Schuler of Ecological Services reviewed a draft of this report.

PRAIRIE

Definition and description

White and Madany (1978) define the *prairie* community class as those natural communities dominated by grasses (or, locally, low shrubs) on mineral soil. They further state that "trees may be present, but less than 10% of the area has a tree canopy." This limit of 10% canopy coverage is unreasonably high: the majority of plant ecologists probably would classify a native grassland site as a savanna — not a prairie — even if it has as little as 5% tree coverage. Curtis (1959:331) adopted an arbitrary criterion of one tree per acre as the lower limit of tree density to distinguish savanna from prairie. [4]

Natural communities

The INAI classification recognizes six prairie subclasses:

- Prairie
- Sand prairie
- Gravel prairie
- Dolomite prairie
- Hill prairie
- Shrub prairie

There are a total of 23 prairie natural communities.

Geographic distribution

The chance of finding prairie on mesic soil is very slight; almost no prairie remains on mesic sites except along railroads and in cemeteries — but rare exceptions await discovery.

Prairies once occurred throughout Illinois, but extensive areas of the state were heavily wooded. If the region that is being inventoried is a formerly forested area, there is little likelihood of finding a prairie remnant. Wherever this is the case, one should adjust the survey methods so that most uncultivated open areas are passed over without a closer look (even though these same areas would be closely scrutinized in a former prairie region). Caution must be exercised, though, because prairies and prairie-like communities once occurred on special topo-edaphic situations (*e.g.* wetlands and dry, exposed sites) even in forested

[4] A square area that is about 210 feet on each side covers about an acre. A single tree standing in an acre of grassland covers 5% of the acre if the tree's crown is 53 feet in diameter.

regions. The very topo-edaphic features that allowed these natural grasslands to develop in a forested environment are the same conditions that may have allowed the prairies to persist to the present day. Consequently one must not automatically reject every uncultivated, grassy area in a forested region.

Topographic position

Prairies may occur on any topographic position, but they are most likely to have persisted on exposed south and west-facing slopes (this is especially true for hill prairies). In the Pecatonica River valley of Stephenson and Winnebago Counties, three of the highest quality prairie remnants are in a surprising topographic position: they are on north-facing hillsides where dolomite is at or very near the surface. It appears that glacial action or some other geological process has resulted in very thin glacial till on these north-facing slopes. The Natural Areas Inventory staff should be aware of the potential for prairies in such unusual topographic situations elsewhere in the state.

If a grassy patch is surrounded by cropland, it is more likely to have relatively high quality vegetation if it occurs on a topographic high (instead of in a low area), for the following reasons:

> A grassland in a low spot in farmland is likely to have been damaged by sediments and chemicals carried by runoff from the surrounding crops. Such an area is also likely to have suffered from past attempts to improve drainage, and it is likely to have even been plowed at least once in the past.
>
> In contrast, a grassy area on a high spot in a crop field is relatively immune to the damaging impacts of runoff (even though it is vulnerable to herbicide drift carried by wind). Such an area is also likely to have very thin or rocky soil, so it may have resisted any and all attempts at cultivation.

Soils

Prairies are most likely to persist on soil that is sandy, gravelly, rocky, shallow (to bedrock or some other subsurface feature that restricts the growth of roots and limits the movement of water), wet, excessively well drained, clayey, steep, or eroded. These sites are more likely to have escaped plowing, and they may not have suffered as much grazing damage as sites on less extreme environments. In addition, prairie vegetation is more likely to survive under such harsh conditions because it is less likely to have been invaded and replaced by woody vegetation or exotic herbaceous plants.

Soil maps use symbols to show bedrock outcrops in areas where the soil is so thin that the bedrock is not fully covered. Since prairie is more likely to persist on dry, exposed sites where the soil is quite shallow, soil maps can be used to help locate such areas. However, most bedrock crops out along watercourses and on the steep side-slopes of valleys, where running water has stripped away much of the soil. These particular areas are likely to be relatively moist and protected, so they are not promising places for prairie remnants.

The Natural Resources Conservation Service employs a *soil capability classification* system to designate soils that have limitations for farming and other uses because of shallow depth, low permeability, etc. Although many of these characteristics are the same ones that foster prairie remnants, the NRCS soil capability classes have not proven useful for searching for prairies because the correlation between the capability classes and the presence of prairies is not strong. It is better to take a more direct approach (*i.e.* searching for topo-edaphic features) — rather than trying to rely on the soil capability classification system. See the study by Alverson (1988) under *additional notes* (page 16) and in the Appendices (page 65).

Shape

Relatively undisturbed prairies often have irregular boundaries. On the other hand, straight boundaries often mean that the prairie has been fenced and then grazed to oblivion. Many prairie remnants persist in irregularly shaped patches that coincide with soil that cannot be cultivated, and they are surrounded by tillable ground. Almost without exception, these small, isolated, irregularly shaped grassy patches in cropland are not being pastured. However, one should not assume that this was always the situation: before World War II, a significant percentage of these areas were grazed because they were part of much larger pastures and haymeadows. Most of these big grasslands were plowed up after the war, when farmers shifted from horses to tractors. Since that time, there has no longer been as much demand for pasturage and hay on each farm, and tractors have been available to plow up areas that had proven too wet or rocky to cultivate with horse-drawn equipment.

In some other parts of the Midwest (outside of Illinois), native prairie haymeadows are still relatively common. In these regions, high quality prairies are more apt to have straight boundaries because they are treated in the same manner as other crop fields. Although this situation is unlikely to occur in Illinois, it would be a big mistake to overlook a prairie on an aerial photo because it is a rectangular haymeadow.

Shape can be used as an indicator of whether an opening in a forest is an abandoned field or a potential prairie. An old field is more apt to have straight edges and squarish corners; in contrast, a natural opening tends to have curved edges that may follow topographic contours. But shape alone cannot always be used to select or reject candidate sites, for three main reasons. (1) Not all artificial clearings are rectangular. (2) The rectilinear shape of a former field may gradually soften as woody plants encroach first on the most favorable spots along the borders; consequently an opening with a natural-appearing shape on an aerial photo may prove to be a former clearing if examined on older photos or during an on-site visit. (3) On droughty or infertile sites, former cropland or pasture may revert to grassland that has a significant complement of native species within several decades after farming ceases — if there is native prairie or savanna vegetation adjacent to the field.

Size

Prairies originally occurred in any size, from less than an acre to hundreds of square miles — but now prairies are likely to be small. The larger prairies are most likely to have been severely damaged by past grazing and even past cultivation, so they commonly have lower quality vegetation.

If a prairie is examined on a series of aerial photos (taken over the span of decades), the photos usually will show that the prairie has become smaller and smaller over time because of encroaching trees and shrubs. As the prairie diminishes, it shrinks faster and faster. The cause of this accelerated loss lies in an increasing perimeter/area ratio. As a prairie loses ground, its perimeter grows larger in proportion to its area. The increasing edge speeds up the rate at which trees and shrubs can close in on the prairie. The most invasive trees and shrubs spread by sending up sprouts from their roots. As the woody border and isolated thickets increase relative to the grassland, root-suckering woody plants grow evermore overwhelming. As the prairies shrink, they become more and more shaded and protected from the wind — which further abets the advance of trees and shrubs.

Photographic tone and color

Almost all native prairie grasses are warm-season species, which are green and actively growing during the warm summer season. Compared with cool-season species, the warm-season grasses break dormancy later in the spring, and they become dormant earlier in the fall. The major non-native grasses are cool-season species, which stay green during more of the year: they green up in early spring, and they remain green during the fall and most or all of the winter. However, cool-season grasses are stressed by hot, dry conditions, so they tend to "dry up" and may even turn brown during midsummer. These differences in seasonal growth patterns help distinguish prairie from non-native grassland on the basis of photographic tone or color.

Color infrared photography

Native grasses can be distinguished from exotic cool-season grasses on color infrared (CIR) aerial photographs taken during spring or fall. At these two times of year, the native, warm-season, prairie grasses are dormant (not green or photosynthesizing), but the exotic, cool-season, Eurasian grasses are green. Green herbaceous vegetation appears reddish or pinkish on color infrared photos. Dormant vegetation is not red but is variously dull-hued (grayish, greenish, or bluish). If a prairie is invaded by exotic grasses, it may be either a smooth blend or an uneven mix of gray and pink.

A grassland dominated by cool-season exotics has the same appearance as a native grassland if the green foliage is obscured by duff or a heavy thatch of dead grass from the previous growing seasons. This condition is especially characteristic of unmowed, ungrazed, and unburned stands of smooth brome (*Bromus inermis*) and, to a lesser extent, meadow fescue (*Festuca pratensis*). One must be careful not to screen out native prairies in northern Illinois that have been heavily invaded by exotic cool-season grasses. Many of these prairies are now dominated by smooth brome, Canada bluegrass (*Poa compressa*), and Kentucky bluegrass (*P. pratensis*), but they still have a high native species diversity and can recover with proper management.

Land dominated by dormant annual weeds such as foxtails (*Setaria*) and ragweeds (*Ambrosia*) may also be the same color as dormant prairie, but these weedy areas can usually be discriminated from prairie by some other clues (*e.g.* by their location in a barnlot or a fallow field).

See White (1981*a*, 1981*b*, 1982*a*, 1982*b*) for further notes about using color infrared aerial photography to identify, evaluate, and classify prairies.

Black-and-white panchromatic photography

Reese (1982) studied a series of black-and-white aerial photos of southwestern Missouri, taken between 1936 and 1980, to determine how well he could distinguish between native prairie and exotic grassland. He found that the optimum time for making the distinction was between July 1 and mid-September. Before July, prairie resembled exotic cool-season grass communities on this photography: "On photos taken before July 1, the grey tones of communities dominated by cool-season grass nearly matched the grey tones of native prairies." After mid-September, prairie grass once again resembled exotic grass on these black-and-white photos — even though prairie grasses actually develop a distinctive rusty or yellowish hue beginning in late September or early October.

Reese learned that the optimum time for recognizing prairies on these photos was between July 1 and mid-August (or more specifically, in early July, prior to haying), because so many prairies had been hayed by mid-August and were easy to confuse with cropland. The confusing effects of haying persisted through mid-September, when phenological changes made it even more difficult to distinguish native prairie from non-native grassland. Very little prairie is harvested for hay in Illinois, so haying should hardly be a limiting factor for identifying prairies in this state.

Color photography

Reese (1982) found that he could detect prairies in southwestern Missouri by examining true color (not color infrared) slides taken by the U.S. Department of Agriculture from very late June to mid-July during drought years. "Exceptional differentiation" between warm-season and cool-season grasslands stemmed from the fact that prairies had a dark green appearance unlike most other vegetation, and they were easily separated from brown, cool-season hayfields or pasturelands. Reese reported that this differentiation was "subtle to non-existent" on May to August photography during wetter years.

Photographic texture and pattern

Parallel lines or faint streaks in a prairie may indicate past cultivation or mowing. The lines are caused by furrows, ruts, gouges, or weedy vegetation growing along these soil disturbances. The lines may persist for many years after the disturbance, and they do not necessarily indicate that a prairie is too disturbed to qualify as a natural area. Mowing may have relatively little lasting effect on a prairie, but ruts from mowing in wet soil may persist for years. A prairie may partially recover from cultivation, especially if the soil is sandy and an adjacent prairie remnant can serve as a seed source for colonizing the disturbed area.

Relation to other features

Most wet prairies are found on the fringe of natural wetlands (usually sedge meadows).

In rare circumstances, a prairie remnant may persist in an odd piece of ground where a fence or stream cuts off access to a corner of a property.

A prairie next to a farmstead almost always has been destroyed by more than a century of grazing (beginning as soon as the farmstead was established (often before the Civil War). There are rare exceptions, such as Sass Prairie (Winnebago County); this prairie is adjacent to a farmstead but it persisted because it is on thin soil over dolomite, and there was no convenient and dependable source of water for livestock.

In prairie regions where most of the land is tillable, grasslands are now generally limited to relatively narrow strips along small streams. These grassy areas are remnants of larger pastures and haymeadows — which were often 40-acre (or larger) tracts of grass. After World War II, farming became completely mechanized (except in Amish neighborhoods) and horses were dispensed with. Cropland was expanded by whittling away the grassland until only the wettest, most flood-prone streamside corridors were left in grass. Now the grassland is often less than 200 feet across — instead of being a quarter-mile-wide pasture or haymeadow. On most farms, livestock are now concentrated and restricted to these moist lowlands along streams and ditches, and prairie vegetation has virtually no prospect of surviving in these circumstances.

One should pay particular attention to locations, land uses, or topographic situations that have proven to have a high likelihood for prairies. Schennum (1986) identified five such places in Iowa: (a) undrained pothole wetlands, (b) areas cut off from cropland by roads and railroads, (c) cemeteries, (d) prairie hayfields, and (e) steep slopes in stream-dissected landscapes. The presence of these kinds of factors can be used as part of a search image to identify potential prairies, but the absence of these factors should not be used as a criterion to screen out potential prairie sites.

In Woodson County, Kansas, Shortridge (1973) took note of the popular belief that prairie haymeadows occur mostly on steep slopes and on shallow, infertile, or rocky soils. To the contrary, he found that (a) haymeadows are generally distributed except on the stoniest soils (which cannot be mowed and are kept in pastureland), (b) the highest percentage of hay is on nearly level ground, and (c) more than 70 percent of the haymeadows could be cultivated. Although Kansas has much more prairie than Illinois, Shortridge's research provides a cautionary note: Do not assume too much about the potential (or lack of potential) for finding prairie in a highly cultivated landscape. Some surprises remain to be found!

Disturbance features

Pasturage by domestic livestock usually destroys a prairie within a matter of years. Native prairie grasses are not adopted to continual grazing pressure: they die out and are replaced by Eurasian cool-season grasses. Likewise the native prairie forbs are largely replaced by weedy species, most of which are not native to America.

Pasturage is so damaging to prairie that most pastures in prairie regions can be eliminated from consideration as potential prairie remnants except in unusual edaphic situations, including sandy soil, gravelly soil, and shallow soil over bedrock. On these extreme environments, light to moderate grazing can actually be responsible for maintaining a prairie by preventing it from growing up with trees and shrubs.

Reese (1982) provides the following discussion of how to assess the amount of exotic, cool-season invasion of prairie by examining color slides taken by the U.S. Department of Agriculture in southwestern Missouri:

> March or April color photography in any year may provide an indication of the amount of cool-season grass invasion in a native prairie. This is done by evaluating the amount of green on a potential site. Since warm-season grasses are still dormant at this time, the green hue represents either the cool-season grasses or early spring forbs. An abundance of either may indicate low quality prairie. These spring photos are potentially useful in identifying prairies when no other photography was suitable. The interpretive clues used with spring photos were the opposite of those used with summer photography. Light brown, vegetated sites (as opposed to light brown, plowed soil) with little or no green represented native prairie communities. Darker hues of brown were usually indicators of overgrazed prairie or old fields. Since cool-season grass invasion on prairies is common in west-southwest Missouri, it was frequently difficult to separate prairie from "improved" pasture using spring photos alone.
>
> Late June to mid-July drought year photography can also provide an index to the degree of cool-season grass invasion on native prairie. Noticeable areas of brown vegetation indicate poor dominance by warm-season grasses and may be disturbed and/or invaded sites. Conversely, a deep, homogeneous green hue may indicate overabundance of prairie grasses and low forb diversity. Maximum diversity of native flora is generally indicated by intermediate hues.

Recently plowed or mowed areas in a prairie are clear, bright, whitish areas, usually with sharp, straight edges. The mowed or plowed areas have a light tone because they reflect sunlight much better than standing grass reflects light.

Some apparent indicators of disturbance may actually be signs that a prairie has not been grazed recently and may be recovering. For example, a sand prairie that has a pine plantation probably has not been grazed since the trees were planted (nor has it been burned). A gravel prairie or dolomite prairie that has a gravel pit or mine may not have been grazed since the quarry was started (because quarry operators often do not want to contend with livestock).

Some of the brushiest-appearing potential prairies may be among the most natural because brush invasion is sometimes evidence of lack of disturbance from grazing. Or, the brush may simply be thorny and unpalatable species that have managed to invade a pasture.

Additional notes

Prairies have been nearly eliminated from Illinois, so all remnants that can be detected on aerial photography merit examination in the field. If this careful, conservative approach is applied, the potential prairies must eventually be examined from an airplane or (better yet) on the ground, but aerial photos are still useful for learning about past disturbances.

Prairies are often hard to detect on aerial photography. Chances of success are increased by applying these approaches:

> Use previously identified prairies as reference sites, to develop a detailed search image for finding more prairies in the local region.
>
> Be liberal when selecting survey sites, and be conservative when rejecting them.
>
> Use several different sets of photography to cross-check survey sites. This approach will help to (a) detect prairies that would otherwise be overlooked, (b) verify the accuracy of judgements made while screening sites, and (c) reduce the need for field surveys, either in the air or on the ground.

The following three assumptions can help guide the process of selecting and screening potential prairie areas:

> Almost all prairies (except some hill prairies, a few wet prairies, and a few other extraordinary cases) have had a significant history of grazing.
>
> If a prairie is on loamy, well-drained soil, it almost certainly has been grazed so much that the vegetation has been replaced by exotic, grazing-tolerant grasses.
>
> If a well-drained grassland is not periodically grazed, mowed, burned, or otherwise disturbed, it will grow up with woody plants. If a prairie has not yet grown up with shrubs and trees, it is either extremely wet or extremely dry — or it has been periodically disturbed to retard the invasion of woody vegetation.

These assumptions are not 100% fail-safe. But the exceptions are exceedingly rare and must be the result of highly unusual circumstances.

Additional information from the Farm Services Agency

Potential prairie areas may be indistinguishable from pasture or even cropland, especially on photography that has poor resolution. If an aerial photo is too blurry or washed out to determine whether a field might be prairie, is it possible to determine whether the tract is being actively farmed by information available at the Farm Services Agency (FSA). The boundaries of each crop field (*i.e.* "common land unit," or CLU) are marked on FSA aerial photos, and these CLUs are annotated with the acreage of cultivated land.

If a tract is delineated as a CLU, it is farmland — but beware that prairie remnants may occur as isolated patches within the cropland. According to FSA procedures, these uncultivated spots must be outlined on the photography to exclude them from the cultivated acreage — but these procedures are not always followed. The farmer has no economic advantage to point out the error because the FSA makes its price support and insurance payments on the basis of the acreage that is counted as cultivated. Consequently it is not safe to assume that there are no patches of prairie in a field that the Farm Services Agency says is entirely cultivated.

Notes about photographic resolution and film type

In a search for bunch-grass prairies in California, Dremann (1987) determined that the ideal scale for identifying the characteristic speckled pattern of bunch-grass hummocks on black-and-white photography is between 1:12,000 and 1:24,000. On clear 1:100,000 photos, he could find bunch-grass remnants as narrow as 60 meters.

When using 1:80,000-scale color infrared transparencies to find Iowa prairies, Schennum (1986) found that the resolution was so limiting that some significant prairies were overlooked. For example, a 5-acre prairie on a kame and a 17-acre prairie on a level till plain were missed during photo-interpretation. The 17-acre site was not found because the photo did not clearly show patches of prairie among large areas of exotic grasses. Schennum found it difficult to distinguish small prairies from meadows of Eurasian grass.

In a search for bluestem prairie in North Dakota with 1:65,000-scale color infrared transparencies, Heidel (1983, 1986) could identify 40-acre prairies with confidence. When two people independently interpreted the photos, selection of potential prairies smaller than 40 acres was not always consistent between interpreters. Certainty fell sharply with prairies smaller than 20 acres. One 10-acre prairie remnant in good condition was overlooked but later came to their attention. Mowed prairies in less-than-prime condition were especially difficult to identify.

A report by Reese (1982) noted that prairies smaller than about 15 acres can easily be overlooked on 1:7,920-scale ASCS black-and-white panchromatic photographs in Missouri. [5]

Heidel (1986) selected potential bluestem prairies in North Dakota with 1:65,000-scale color infrared photos and then double-checked the selections with larger-scale ASCS color slides in two counties. She concluded that (a) the slides provided information on land use that could not be seen on the infrared photos, (b) the slides generally corroborated the initial site selections from the color infrared (CIR) photos, but (c) the slides would be an inadequate substitute for CIR photos.

Reese (1982) quickly reviewed black-and-white ASCS photography to identify about 190 obvious potential prairies in a Missouri county, then used ASCS slides to find 130 more sites (mostly small and degraded). He concluded that most of the prairies could have been found with color slides alone, but using both sources increased accuracy and made an aerial survey to verify photo-interpretation unnecessary.

Techniques from other inventory projects

Reese (1982) provides an excellent discussion of the advantages of using various kinds of aerial photography, taken at different seasons, to identify prairies.

Heidel (1986) searched for bluestem prairie in North Dakota using color infrared photography supplemented by color photos. She used the following criteria: (1) presence of both warm-season and cool-season floristic components as indicated by colors, (2) a heterogeneous vegetation pattern, and (3) absence of disturbance features such as furrowing and bare earth. A conservative approach was used in screening sites, so the presence of a livestock pond did not automatically warrant rejection of a candidate prairie.

Meyer *et al.* (1980) found that 35-mm color infrared aerial photography was superior to color photography for distinguishing areas of native prairie from areas dominated by exotic grasses in a Minnesota preserve. They further determined, "Mid-May coverage was most useful for delineating disturbed areas with exotic (Eurasian) grass species, and late October was most useful for mapping different vegetation zones."

Schennum (1986) found that small-scale, low-resolution aerial photography made it difficult to distinguish prairies from meadows of Eurasian grass, especially patches of high quality prairie surrounded by brome or timothy.

Alverson (1988) conducted a search for native bunch-grass prairie remnants in the Willamette Valley farmland of Oregon, which has major ecological similarities to the Grand Prairie of Illinois. Alverson used county soil surveys, which are mapped on aerial photos,

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[5] The ASCS (Agricultural Stabilization and Conservation Service) is now known as the FSA (Farm Services Agency).

to find candidate sites. He searched for areas mapped as Stayton silt loam (a shallow, excessively drained type) because (a) these areas are unlikely to have ever been plowed, (b) native plants resist invasion by exotics under grazing on such dry soil, and (c) woody encroachment is slow.

Alverson also tried to use the Soil Conservation Service's soil capability classification to identify sites with high potential for prairie. Shallow, stony, Stayton silt loam is in Capability Class 6, and it supports most of the remaining prairie. Class 6 is the least suitable for cultivation, so Alverson thought that other Class 6 soils might have a high potential for native grassland remnants. However, he did not find a good correlation between the occurrence of native grasslands and the distribution of other Class 6 soils. One reason for this low correlation is that some soils are in Class 6 because they are wet, but these soils can be drained and cultivated. In addition to Stayton silt loam, another Class 6 soil is stony, but it does not appear to support much native grassland.

Kooser and McCance (1988) searched for prairies in unglaciated southeastern Ohio, where they occur on unusual edaphic situations such as past slumps, hilltop balds, and calcareous clay soils. They found that most such prairies are on soil units that are far too small to be mapped in soil reports. They also concluded that aerial photos are of limited use in finding these prairies, and they recommended an approach that is based on examining topographic maps for appropriate site conditions, then flying over these areas.

SAVANNA

Definition and description

From "Classification of Natural Communities in Illinois" (White and Madany 1978):

> Savannas are communities with a grassy groundcover and an average tree canopy cover less than 80% but greater than 10%. A savanna may have shrubby areas, and the tree canopy may locally be greater or less than the above limits. Savannas have soils that are transitional between forest and prairie, and they have distinctive plants and animals. These communities were maintained by fire in presettlement times. They were among the most widespread and characteristic communities in Illinois, but few high quality stands remain. Most remnants have obviously been changed. The least-disturbed remnants are on sandy land that still is frequently burned, and on the very driest slopes where woody encroachment has been slowest. Three savanna subclasses can be named in Illinois: *savanna, sand savanna*, and *barren*. Individual savanna communities are distinguished by soil moisture class.

According to the INAI's definition, a natural grassland with as much as 10% tree cover is defined as a prairie instead of a savanna. In practice this 10% limit has proven to be too high: most plant ecologists, if standing in a native grassland with 10% tree cover, probably would say that they were in a savanna, not a prairie.

Some vegetation classification systems recognize *woodland* as an intermediate between *forest* and *savanna*. Under the current scheme of the Illinois Natural Areas Inventory, areas that might otherwise have been classified as woodland fall into the savanna community class. During the initial stages of the Natural Areas Inventory, for the purposes of identifying potential natural areas, there probably is no good reason to distinguish woodlands from forests and savannas.

Perhaps more important to address is the question of *entitation* ("making entities"): in this instance, entitation consists of drawing boundary lines to separate patches of savanna from adjacent patches of prairie or forest. One person might decide to draw a single line around a large, heterogeneous area and call it all savanna; another person might decide to delineate treeless patches among the trees as prairie — and might even recognize dense patches of trees as small groves of forest within a matrix of savanna and prairie.

Natural communities

The INAI classification recognizes three savanna subclasses:

> Savanna
> Sand savanna
> Barren

There are a total of seven savanna natural communities.

Geographic distribution

Savannas occur throughout the prairie regions of Illinois and in localized areas in forested regions. Most of these savannas are highly degraded, though. The greatest concentration and highest potential for natural savanna remnants are in the state's sand regions.

Topographic position

Savannas can occur on any topographic position. Sand savannas are associated with sand plains, dunes, and beach ridges. Barrens occur mostly on steep, dry ridges and south to west-facing slopes.

Map symbols

Savannas are only partly wooded, and the trees are not uniformly distributed. This uneven, partial tree cover presents a challenge when cartographers depict savanna areas. On the U.S. Geological Survey's topographic maps, wooded areas with canopy coverage as low as 20% are depicted with green "woodland overprint." The USGS makes no distinction between closed-canopy forest and woodland that has as little as 20% cover. Consequently some savanna areas are mapped as solid green (the same as dense forest), and other savanna areas are depicted as treeless (without green overprint).

The extent and boundaries of a green wooded area on a topographic map can be interpreted only as a general indication of the extent and density of the woods. It is impossible for a map-maker to depict the variation in density of wooded areas — or to show the intricate and gradual boundaries a wooded tract that intergrades with open land. To address this variability and intergradation, the USGS employs the following guidelines (adapted from Thompson 1979:70–72):

> Many of the intricate vegetation patterns existing in nature cannot be depicted exactly by line drawings. It is therefore necessary in some places to omit less important scattered growth and to generalize complex outlines.
>
> Woods, brushwood, and scrub are mapped if the growth is thick enough to provide cover for troops or to impede foot travel. This condition is considered to exist if density of the vegetative cover is 20 percent or more. Growth that meets the minimum density requirement is estimated as follows: if the average open-space distance between the crowns is equal to the average crown diameter, the density of the vegetative cover is 20 percent.
>
> This criterion is not a hard-and-fast rule, however, because 20 percent crown density cannot be determined accurately if there are irregularly scattered trees and gradual transitions from the wooded to the cleared areas. Therefore, where such growth occurs, the minimum density requirement varies between 20 and 35

percent, and the woodland boundary is drawn where there is a noticeable change in density. A crown density of 35 percent exists if the average open space between the crowns is equal to one-half the average crown diameter.

Clearly defined woodland boundaries are plotted with standard accuracy, the same as any other well-defined planimetric feature. If there are gradual changes from wooded to cleared areas, the outlines are plotted to indicate the limits of growth meeting the minimum density requirement. If the growth occurs in intricate patterns, the outlines show the general shapes of the wooded areas. Outlines representing these ill-defined or irregular limits of vegetative cover are considered to be approximate because they do not necessarily represent lines that can be accurately identified on the ground. The outline of a tract of tall, dense timber represents the centerline of the bounding row of trees rather than the outside limits of the branches or the shadow line.

Woodland areas covering 1 acre or more are shown regardless of shape. This area requirement applies both to individual tracts of vegetation and to areas of one type within or adjoining another type. Narrow strips of vegetation and isolated tracts covering areas smaller than the specified minimum are shown only if they are considered to be landmarks. Accordingly, shelterbelts and small patches of trees in arid or semiarid regions are shown, whereas single rows of trees or bushes along fences, roads, or perennial streams are not mapped.

Woodland is not shown in light red "urban-tint" areas, but it is shown where appropriate in areas surrounded by urban tint if such areas are equivalent to or larger than the average city block.

Soils

Savannas occur on all types of soil, but natural remnants are most common on sand.

Shape

Savannas typically have an irregular configuration, roughly corresponding with the shape of the landform that the savanna occupies. A savanna's edges may be squared off by farming activities: the edges may be straight because of clearing, or the savanna may abruptly change to closed-canopy forest at a fenceline (the open-canopied savanna is on the more heavily pastured side of the fence).

Size

Savannas can cover hundreds of acres, but higher quality remnants are small.

Photographic tone and color

On dormant-season CIR photos of sand savannas, the most extreme environments (steep, south to west-facing slopes) have a distinctive, bright golden-brown color. This bright color probably is from sun reflecting from oak leaves that are lying on the ground or are retained by some trees throughout the winter. Whitish areas (bare sand) are common. Less extreme environments (flats and north-facing slopes) are darker and tend toward gray — because of shadows (on slopes), perhaps because of higher soil moisture, and possibly because of denser leaf litter.

Photographic texture and pattern

A savanna exhibits a pattern of coarse-textured trees among fine-textured grasses. Shrubby areas are intermediate in texture. The trees and shrubs are likely to be clumped, so that some areas have a solid canopy and other areas are grassy.

Height

Mature trees can be distinguished from thickets in a savanna by studying the length of shadows that are cast on the adjacent grass. A stereoscope can aid in discerning the height of woody plants.

Relation to other features

Savanna remnants occur most commonly along stream valleys in the prairie regions of Illinois, where they occupy a zone between forested valley slopes and level upland areas (former prairie). If the outer edge of the savanna (toward the former prairie) is in pasture rather than cropland, then the physiognomic transition from savanna to prairie is preserved. Pasturing will help maintain the open structure of the savanna.

Disturbance features

If a savanna is not grazed, burned, or mowed, it will grow up into a dense forest. Although grazing will help maintain the open vegetation structure of a savanna, this grazing usually destroys the herbaceous component and often encourages the invasion of shrubs. Grazing does not always have such a severe impact on sand savannas.

Additional notes

The basic approach for identifying prairies is adaptable to finding high quality savannas: search for openly wooded areas with a ground cover of warm-season grasses.

The crown coverage of an openly wooded area can sometimes be estimated with two rules of thumb. (1) If the average distance separating tree crowns is equal to the average diameter of the crowns, then the canopy cover is 20%. (2) If the average open space between tree crowns is equal to one-half of the average crown diameter, then the canopy cover is 35%.

Meyer *et al.* (1980) compared 35-mm color infrared aerial photos with color aerial photos taken at various times throughout the growing season, in order to test the effectiveness of film types and dates for distinguishing areas of native grass from areas dominated by exotic grasses in a Minnesota sand savanna. They concluded, "Of the types and dates of photography obtained on this area, the early September color infrared coverage provided the greatest visible range of plant species differences and conditions."

WETLAND

Definition and description

Wetlands are transitional between deep water and dry land. They usually are vegetated, and most of them are not permanently inundated. There are many definitions of wetlands; simply stated, one of the most widely used definitions says that wetlands are areas with (a) hydric soils, (b) hydrophytic vegetation, and (c) wetland hydrology. This definition depends on the definition of its three components; in general, it means that a wetland is a site with (a) soils that developed under wet conditions, (b) plants that are adapted to growing in wet soil or in water, and (c) conditions that cause the site to be saturated or inundated often enough to result in hydric soils and hydrophytic vegetation. A wetland may lack hydrophytic vegetation (the second criterion in the definition) if cultivation or disturbance by water keeps plants from becoming established or persisting.

The Illinois Natural Areas Inventory's classification (White and Madany 1978) defines wetlands in a much more limited way:

> The wetland community class includes natural communities that are flooded or have hydric soils and that have a vegetative cover. The subclasses (marsh, swamp, bog, fen, sedge meadow, panne, and seep and spring) are recognized mainly by differences in the vegetation.

The Natural Areas Inventory employs a limited definition of *hydric* soil, which is more poorly drained than *wet* and *wet-mesic* soil. [6] Consequently the Inventory does not classify natural communities such as wet prairie and wet-mesic floodplain forest as wetlands — even though these communities are legitimately defined as wetlands by regulatory agencies such as the U.S. Army Corps of Engineers. For the purposes of identifying and screening potential natural areas, a generalized and liberal definition of "wetland" should be applied — not the restrictive definition of the Natural Areas Inventory's community classification system.

Natural communities

All 20 of the natural communities in the Illinois Natural Areas Inventory's wetland community class are wetlands. In addition the wet and wet-mesic natural communities in the forest, savanna, and prairie community classes are wetlands. The poorly drained parts of flatwoods are also wetlands. In many ecological classification systems, ponds are classified as wetlands, but the Illinois Natural Areas Inventory places the pond natural community in a separate community class (along with lake communities).

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[6] The INAI defines a hydric soil in this manner: "Very poorly drained: Water is removed from the soil so slowly that the water table remains at or above the surface the greater part of the time."

Topographic position

Although water flows downhill, wetlands are not always limited to the lowest topographic position in a particular area. A seepage wetland will occur wherever a permanent, continuous supply of groundwater discharges across a broad area on a slope, and the water permanently saturates the soil farther down the slope. Wetlands are also common on the highest morainic ridges (although they occupy depressions on these ridges).

Map symbols and soils

Topographic maps

Wetlands are depicted on U.S. Geological Survey (USGS) topographic maps with a blue pattern of wetland symbols, which are stylized tussocks of emergent graminoid plants. [7] If a topographic map has green woodland overprint, wooded wetlands are shown by the blue wetland symbol overprinted with green. Wetlands that are not dominated by trees and shrubs (*i.e.* open wetlands such as marshes and sedge meadows) are shown with the wetland symbol alone. Because trees and shrubs in wooded wetlands are often thinly and irregularly distributed, the USGS must make difficult and arbitrary decisions about where to show the green woodland overprint in wetlands; see the discussion on pages 19 to 20.

Occasionally a swamp is indicated on a topographic map with solid green printed over solid blue, rather than with solid green printed over the blue wetland symbol. Such areas are supposed to be permanently flooded swamps, but this mapping convention is not used often and is not applied consistently.

Sometimes the presence of a non-forested wetland can be inferred while studying a topographic map even if there are no wetland symbols on the map. Such areas sometimes appear as non-wooded (white) patches in wooded (green) bottomlands. These areas may also be shown as depressions by contour lines.

Topographic maps are fairly accurate in showing the locations of the most obvious and best-developed wetlands, but these maps are far from complete in showing (a) smaller wetlands, (b) the full extent of individual wetlands, and (c) areas with wet-mesic or wet soil instead of hydric soil. [8] USGS cartographers map the most obvious, best developed wetlands, but

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[7] The USGS refers to this wetland symbol as a "marsh" symbol, which can cause confusion. Many classification systems (including that of the Illinois Natural Areas Inventory) define a *marsh* as a wetland dominated by graminoid vegetation; other wetlands, dominated by woody plants, are defined as *swamps* — not marshes. The USGS applies the "marsh" symbol to both graminoid wetlands (marshes) and wooded wetlands (swamps).

[8] In a survey in the Missouri Ozarks, Orzell (1984) found that not a single one out of 140 fens was depicted with wetland symbols on topographic maps. This is in part because of their small size, but cartographers probably overlooked the larger ones because these fens are usually on slopes, where wetlands are not normally expected.

their procedures do not call for mapping all areas that might be deemed wetlands. A wetland is a gradual transitional feature, and its boundaries must ultimately be arbitrary. One approach to mapping wetlands might result in recognizing 100 acres of wetland on a site, while another interpretation might encompass 200 acres. The guidelines used by the USGS are so restrictive that a topographic map is likely to show 50 acres or less of wetland on a site where other definitions would call for 100 to 200 or more acres.

As a general rule, topographic maps indicate wetlands that are permanently or semi-permanently flooded and are in obvious topographic depressions — but they do not show the majority of wetland areas, which are not so wet. The USGS is far more likely to omit wetland symbols in forested areas than in areas that are just as wet but are not forested. Cultivated wetlands (and even formerly cultivated wetlands) are likely to be shown as dry land on topographic maps even if they actually are wet. Some marshes that display obvious emergent vegetation on aerial photography are mapped as open water on topographic maps. Sometimes these maps mistakenly have wetland symbols in an area that is hardly wet or not at all wet.

Soil maps

Because wet ground has such a big impact on farming, soil maps often are very good at depicting wet spots in fields.

The Natural Resources Conservation Service (NRCS) is an important source of information about wetlands. The NRCS has classified all soils according to whether they meet the agency's definition of a hydric soil; the local NRCS office can be very helpful in identifying areas with wetland soils.

The NRCS numbers each soil series. Soil maps may or may not indicate wet soils with a capital W at the beginning of the number.

Hydric soils and non-hydric soils are not always distinguished from each other on soil maps. In some local situations the two kinds of soil may be mapped together as a "complex" in a single mapping unit. In other cases the hydric soils may simply be noted as "inclusions" within a mapping unit of non-hydric soils.

Soil maps may indicate small wet spots with a special symbol.

Information in the following statement by Johnston (1980) is about Wisconsin but probably applies as well to Illinois:

> Soil surveys are usually published at scales of 1:15,840 or 1:20,000, with a minimum map unit size of approximately 2 to 3 acres. Each soil mapping unit theoretically may have up to 25 percent inclusions of other soils; in reality this figure may be exceeded if the soils present are similar. Wetland inclusions which are smaller than the minimum map unit size are sometimes indicated by marsh or wet spot symbols.

Farm Service Agency maps

Wetlands are mapped for regulatory purposes by the USDA. These wetland maps are on file at each county office of the Farm Services Agency. [9] The Illinois Natural Areas Inventory staff can use these wetland delineations as supplemental information while examining the FSA maps to identify potential natural areas. Procedures that were used to prepare the USDA's wetland maps in Winnebago County are in the Appendices (page 102).

The FSA maps are handy because they integrate information from soil maps, National Wetlands Inventory maps, and local field experience. However, it is not uncommon to find an area on these maps that is delineated and classified as a wetland even though it obviously cannot be wet — such as a supposed wetland that is draped across the top of a ridge.

Other wetland maps

Many agencies have prepared wetland and floodplain maps, using various criteria and methods. One source of wetland maps is the National Wetlands Inventory; their wetland maps may be useful tools, but they should not be totally relied upon. Most of these maps are based on minimal fieldwork, so their accuracy is not always ensured.

Shape and size

Wetlands come in all sizes and shapes. However, a particular kind of wetland may have a diagnostic size or shape that is useful for identifying examples of it.

Photographic tone and color

The single most reliable and productive way to find wetlands is to interpret dormant-season color infrared aerial photography, supported by plenty of on-site investigations. Wetlands are most visible on photos taken in late winter or early spring — when leafy vegetation does not obscure the ground, and when wet areas are likely to be at their greatest extent. On infrared photography, wet soil is dark grayish, and standing water is inky black unless it is muddy or has an algal bloom or other aquatic plant cover. Most wetlands can also be detected on panchromatic aerial photos, but their boundaries are not as obvious as on infrared photos, and small wet spots are more likely to be overlooked — either because they do not show up or they cannot be reliably distinguished from other features such as clumps of bushes.

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[9] Older, outdated (but still useful) versions of these maps may be stored elsewhere in the same county USDA building, in the offices of the Soil and Water Conservation District or the Natural Resources Conservation Service.

A wetland that is covered with dense leafy vegetation may not be distinguishable from a non-wetland on the basis of color or tone alone because the vegetative canopy obscures the wet or flooded soil.

Photographic texture and pattern

Wetlands have a wide variety of signatures [10] that are readily apparent to photo-interpreters — for example: (a) the mottled and splotched pattern of marshes with clones of emergent herbaceous plants (cattails, bulrushes, sedges, etc.), and (b) the uniform, medium-dark tone and fine texture of sedge meadows and graminoid fens.

A wetland may display distinct zones on aerial photography; for example, there may be a central zone of open water ringed by a herbaceous zone and a border of shrubs. These zones usually are quite distinct on aerial photos, and they can be used as an aid for recognizing wetlands. In addition, to a certain extent, a wetland's quality may be evaluated on the basis of its zonation. Disturbances tend to disrupt zonation; in general a wetland with distinct zones is likely to be relatively undisturbed.

Moist spots in plowed fields usually have curved boundaries that correspond to the edges of wet depressions: they look like mud puddles. On very flat cultivated fields, the edges of wet areas are streaked because dark, wet soil extends out from the main body of wet ground along plow lines.

Grassy areas often occur in cropland as isolated spots or as promontories that extend into the field from an edge. These grassy areas usually are places that are too wet to cultivate, or they may be grass waterways that were planted to reduce soil erosion. Some wet spots in cropland are formed by the failure of subsurface tile lines. If the grassy area is relatively recent, it is not a significant wetland from the standpoint of the Natural Areas Inventory. New grassy areas (either grass waterways or recently abandoned farmland) characteristically have a sharp, clean boundary between the grass and the cultivated ground. On the other hand, long-established grassy wetlands in cropland commonly have a shrubby border between the grass and the crops. The presence of a shrubby border can be used as an indicator that the grassy area is not new and might be a remnant of native vegetation.

Relation to other features

If a wetland lies next to a railroad or road, one should consider whether the wetland has been created or enhanced by the roadbed. If the embankment is on the downslope side of a wetland, it may be impeding drainage enough to either create the wetland or to make an existing wetland wetter. This is especially true for wetlands that are isolated in farmland and are bordered by a railroad. Examination of old aerial photography may show that the wetland was once farmed. Clogging and failure of a ditch or drainage tile on the railroad right-of-

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[10] In this context, a *signature* refers to a characteristic appearance that allows a feature to be identified on aerial photography.

way — combined with the damming effect of the railroad embankment — may have allowed the wetland to develop.

Disturbance features

Wetlands can result from an artificial impoundment, which may or may not have been deliberate. Roads and railroad grades may impede surface drainage and create a wetland. Sometimes such artificial situations can be revealed by studying old aerial photos and learning that a wetland was created by some sort of disturbance in the past. Old photos may reveal signs of past cultivation or drainage efforts that are now undetectable or too obscure to recognize with certainty.

One of the most reliable indicators of a wetland or former wetland is the presence of a ditch.

Wetland vegetation in many areas recovers from disturbances or adjusts relatively quickly after being disturbed, so it may be difficult to detect past disturbances and their effects. Here are some disturbance features and clues to look for:

Linear features, which usually indicate past drainage and farming activities

Duck blinds and adjacent excavated open water (often bordered by a pile of spoil)

Sharp changes in vegetation patterns, caused by past cultivation, past clearing of woody vegetation, past manipulation of water levels, or differences in grazing history on either side of a fence

Dams, levees, and ditches in or around the wetland

Additional notes

This chapter discusses issues that pertain to wetlands in general. Techniques specifically for detecting and examining depressions (page 36) and organic soils (page 50) also apply to wetlands in general.

A way to infer the presence of small forested wetlands is to look for wet spots in adjacent fields. If the cropland has ephemeral ponds, then nearby forested areas on the same kind of soil or topography are likely to have ponds too. The forest may even be more likely to have wet areas because numerous wet spots may have kept it from being cleared.

Season of photography

Early spring aerial photos usually show wetlands at their greatest extent. This kind of photography also allows wet ground to be detected in forests because the forest floor is not obscured by a leafy canopy. However, herbaceous wetland vegetation is not well developed at this season because it is mostly dormant and the previous year's growth has generally matted down and decayed — or it has been washed away or covered by water.

See Cole and Fried (1981) for a discussion of the advantages and disadvantages of examining various types and seasons of photography to identify and classify wetlands.

Old aerial photography

Examination of old photography is an important step in screening wetland survey sites. A large proportion of vegetated wetlands that occur in farmland have been cultivated at least once in the past.

ACIDIC SOIL

Definition and description

This topo-edaphic feature is defined as soil that has a surface pH of 5.0 or lower; therefore it could be more precisely termed *highly acidic soil.* Most soils in Illinois are at least slightly acidic at the surface, with a pH lower than 7.0.

Most acidic soils are derived from sand, sandstone, or chert — but they can form on almost any parent material if the soil has been sufficiently weathered and leached so that the mineral bases are largely removed.

Natural communities

Bog community subclass
Acid gravel seep

Limited areas in various types of forests, prairies, and other natural communities have highly acidic soil and consequently harbor a distinctive biota — but these kinds of areas are not currently recognized as distinct comminutes in the Illinois Natural Areas Inventory's natural community classification system.

Geographic distribution and topographic position

Different kinds of acidic soils can be found on a wide variety of topographic positions in different regions. Ridgetops and steep upper slopes throughout the state are conducive to leaching and formation of acidic soils. Old glacial drift plains and bedrock hills in the southern half of the state are especially likely to have acidic soils.

Bogs have acidic peats. Another acidic wetland habitat consists of seeps emerging from gravel deposits in the Cretaceous Hills Section of the Coastal Plain Natural Division.

Map symbols and soils

The best way to begin the search for acidic soils is by reading soil survey reports and maps to locate soils with a pH of 5.0 or lower. This approach could be supplemented by reading geologic maps and geologic reports to find acidic substrates (*i.e.* most sands and sandstones, and many shales and siltstones). For instance topographic maps can be used in combination with geologic maps to find ridges underlain with sandstone and chert, which are most conducive to the formation of acidic soils. However, county soil survey reports generally provide good information about the distribution and characteristics of soils, so it may rarely prove necessary to resort to geologic maps to find parent materials that have formed acidic soils.

Shape and size

Shape and size usually are not useful clues for detecting acidic soil. Some occurrences of acidic soil have a distinctive shape and size because the extent of the soil corresponds to a natural community that has a distinctive shape and size (such as an acid gravel seep). However, in such instances, it is most expedient to focus on finding the community itself rather than the acidic soil.

Photographic tone, color, texture, and pattern

Photographic appearance usually does not provide useful clues for detecting acidic soil. Some occurrences of acidic soils have a distinctive appearance on aerial photography because the soil corresponds with a natural community that exhibits a distinctive tone, color, texture, or pattern (such as the appearance of dunes in a sand prairie). However, in such instances, it is most efficient to search for the community itself rather than the acidic soil.

BASIC SOIL

Definition and description

Any soil with a surface layer that has a *p*H higher than 7.0 should be considered basic. These soils have high levels of mineral bases such as calcium and magnesium. Bases increase soil fertility up to a point, but soils with high concentrations of bases are highly alkaline and are tolerated only by plant species with special physiological adaptations. Many of these plants are so rare that they are listed as endangered or threatened.

Sources of basic soils include base-rich materials such as limestone, dolomite, and calcareous glacial drift. Soils that develop from these substrates are basic unless the surface layers have been weathered and leached so much that the mineral bases have largely been removed. The accumulation of organic matter tends to make topsoil acidic rather than basic.

Basic substrates develop wherever groundwater percolates through base-rich glacial drift or other calcareous material and then discharges onto the surface and deposits calcium and magnesium carbonates. Tufa (*i.e.* travertine in spring runs), marl deposits, and other calcareous wetlands are extremely basic or alkaline habitats.

One category of basic soils consists of soils that are high in sodium. These are treated as a separate topo-edaphic feature, *saline soil.*

Natural communities

Limestone glade
Fen community subclass
Calcareous seep
Eroding bluff (in part)

Limited areas in forests, prairies, and other natural communities have basic soil and consequently have a distinctive biota — but these kinds of areas are not currently recognized as distinct communities in the Illinois Natural Areas Inventory's natural community classification system.

Geographic distribution

Basic soils can be found throughout the state, but they occur in very localized areas.

Map symbols and soils

Areas with basic soil can be identified by reading the descriptions in soil reports and finding the soils on soil maps.

Indirect approaches may be required to find basic soils whenever soil reports prove inadequate. The potential for basic soils may be inferred by examining geologic maps for calcareous substrates and then studying topographic maps to find sites that are likely to have one of two conditions: (a) the bases have not been largely removed from the surface by leaching, or (b) the bases have been concentrated at the surface by movement of groundwater and soil water. The first condition may occur on eroded slopes where fresh, unweathered glacial drift is continually exposed; the second situation may prevail in seepage areas and at the base of hills. It may be necessary to study topographic maps and aerial photos to find eroding areas and seepage areas in order to identify potential basic substrates.

Shape and size

Shape and size usually are not useful clues for detecting basic soil. Some occurrences of basic soils have a distinctive shape and size because the extent of the soil corresponds to a natural community that has a distinctive shape and size (such as a fen). However, in such instances, it is most expedient to focus on finding the community itself rather than the basic soil.

Photographic tone, color, texture, and pattern

Photographic appearance usually does not provide useful clues for detecting basic soil. Some occurrences of basic soil have a distinctive appearance on aerial photography because the soil corresponds with a natural community that exhibits a distinctive tone, color, texture, or pattern (such as a fen). However, in such instances, it is most efficient to look for the community itself rather than the basic soil.

Additional notes

Geological reports occasionally describe specific localities with highly basic or alkaline deposits such as marl and tufa.

Chinquapin oak (*Quercus muhlenbergii*) is a good indicator of basic soil because it is most abundant on calcareous substrates, and it is conspicuous. The crown of this tree is highly visible from the air (or from a distance on the ground) during the late summer because its leaves turn yellowish while the associated tree species are still green. With practice and adequate ground-truthing, it might (or might not) prove possible to distinguish chinquapin oaks on late summer aerial photography.

BEDROCK OUTCROP

Definition and description

A bedrock outcrop is a place where unweathered, consolidated rock is exposed at the earth's surface. The exposure may take the form of a cliff, ledge, overhang, knob, or level "pavement."

Wooded areas where bedrock is at or near the surface have a relatively high potential for supporting barrens vegetation (especially on south and west aspects).

A bedrock outcrop of any size is potential habitat for unusual plants, but larger outcrops are generally more likely to have species of interest. A few rare animal species are closely associated with bedrock outcrops; several more are loosely associated in the sense that they are most likely to be found in rugged, heavily timbered areas that have rock outcrops.

Natural communities

Barren community subclass
Glade community subclass
Cliff community subclass
Cave community class

Geographic distribution

Bedrock is deeply buried by glacial drift, alluvium, and other unconsolidated materials across most of Illinois, but bedrock does crop out along most perennial streams (at least in localized areas) and in rugged hill country.

Topographic position

In regions where bedrock is not deeply buried, areas of rugged, highly dissected topography and steep slopes have high potential for outcrops. Bedrock is most likely to be exposed wherever the slopes are steepest.

Map symbols and soils

Soil reports commonly mention rock outcroppings in their descriptions of soil series, and soil maps often show the location of outcrops with symbols. These maps may show small rock exposures that would not be located through any other means, but they commonly fail to show all the outcrops — especially in regions where bedrock commonly occurs at the surface. Most of the outcrops that are depicted on soil maps are in crop fields, and they are not significant to the Illinois Natural Areas Inventory.

Surficial geologic maps are also a good resource for finding rock exposures — but again, in regions where outcrops are common, many are omitted from the maps.

Shape

Bedrock outcrops occur in all shapes. Large outcrops may be elongated (*i.e.* significantly longer than wide) in approximately the same direction as topographic contours.

Size

Most outcrops are so small that they are not distinguishable on aerial photography. In forested areas, an outcrop will be difficult or impossible to distinguish (even on dormant-season photography) unless it is large enough to cause a gap in the tree canopy.

Photographic tone and color

Rocks are visible on aerial photos as light, highly reflective areas if they are large enough to detect and are not obscured by shadows and vegetation.

Natural rock outcrops and bare, dry soil usually are lighter toned on aerial photography than one might expect from their actual color.

Photographic texture and pattern

Exposed bedrock often is so highly reflective that the glare obscures any surface texture or pattern, and the outcrop appears as a homogeneous, light-toned area. A broad expanse of bedrock may have a pattern of rills that run downslope. Some outcrops display a rectilinear pattern of crevices that are eroded joints (cracks) in the bedrock.

Additional notes

A broad expanse of naturally exposed bedrock is a cliff or an overhang if it is vertical or nearly so. Or it is a glade if it is more moderately sloping. Methods for detecting steep slopes and glades are useful for finding bedrock outcrops.

Disturbed areas of bare sand, surface mines, and artificially bare areas of any kind can be mistaken for natural bedrock exposures.

DEPRESSION

Definition and description

Any valley or topographic low might be considered a depression; but, as defined here, a depression has a center that is lower than any and all of its sides. Even if one side of the depression is lower than the other sides, some part of the middle is the lowest. In other words, it is a "closed depression."

Depressions typically are small, basin-like features. They usually are shallow but sometimes are deep, and they usually have gentle sides but sometimes are steep-walled.

Depressions are of interest when they contain wetlands or have an unusual microclimate. They may have bedrock outcrops.

Depressions commonly have a special microclimate because they are especially moist and humid. They are also sites for cold air drainage, so they may form frost pockets that significantly shorten the annual growing season. Depressions may provide the long-term, stable, cool and moist microclimate that northern species require in order to persist far south of their normal range.

Natural depressions have many origins: (a) sinkholes formed by the dissolution or collapse of bedrock in areas underlain by caves, (b) swales between beach ridges, (c) isolated low spots caused by the irregular erosion and deposition of sand dunes, (d) oxbows and meander scars resulting from shifting stream channels, (e) shallow basins formed by irregular deposition of glacial end moraines and ground moraines, and (f) deep glacial potholes that formed when huge blocks of ice were trapped in glacial drift as a glacier melted.

In some regions, rare plant species occur in temporary ponds that form during wet years in crop fields (especially in sandy soil); wet depressions in plowed cropland are of interest in these regions. The rare Illinois chorus frog breeds in flooded depressions in farmland in sand areas along the Illinois River.

Natural communities

Cave entrances often are in sinkholes.

Ponds and wetland natural communities commonly occur in depressions.

A wide variety of herbaceous and wooded natural communities may occupy the slopes of depressions — but they often appear to be no different from the same kind of community on slopes than are not in depressions.

Geographic distribution

Northeastern Illinois was glaciated more recently than any other part of the state, and it has the most glacial depressions. Over the millennia after a glacier has retreated, small stream channels erode headward, cut into glacial depressions, and destroy them. Or, if the depressions are not drained in this manner, they may become filled with sediment. Consequently depressions on glacial moraines are generally more common on more recently glaciated landscapes.

Topographic position

Most depressions occur on level or nearly level ground. They are rare or absent on steeply sloping terrain. Many depressions are on lowlands (floodplains and outwash plains), but many are on uplands. In fact, in glaciated regions, depressions tend to be concentrated on broad, flat watershed divides that have not been dissected by headward erosion of streams.

Map symbols and soils

Depressions can be seen on topographic maps if they are deep enough to cut across at least one contour line. Closed depressions are shown with hatchured contour lines. The hatchures or tick-marks point downslope into the depression, and they make it easy to quickly distinguish a depression from a hill.

A depression often is so shallow that it is not intersected by any contour lines; or, it may appear as a swale or ravine with an outlet because one side is too low to intersect the contour line that would otherwise completely encircle it. Even if contour lines fail to depict them, depressions may be indicated on topographic maps by wetland symbols (most wetlands are in basins that have no surface outlet or such a poor outlet that drainage is impeded).

Closed depressions are characteristic of karst topography, or sinkhole plains that develop over carbonate rocks (limestone and dolomite). Small, shallow sinkholes are common in such situations, but a large percentage of them fall entirely within one contour interval and therefore do not appear on topographic maps (see Angel *et al.* 2004).

Soil maps sometimes show closed depressions with special symbols, and they often show small wet spots in depressions with wetland symbols. Surficial geologic maps do not necessarily show any more depressions than are shown on soil maps and topographic maps, but they indicate geologic materials that tend to form depressions (carbonate rocks, alluvium, and sand).

Shape

Natural depressions commonly have rounded edges.

Size

Natural depressions can be any size, up to a square mile or more for lake basins.

Photographic tone, color, texture, and pattern

Depressions exhibit the photographic tone, color, texture, and pattern of the natural communities that occupy them.

Additional notes

Cropland

On aerial photography, most uncultivated patches in cropland are likely to be wet depressions. If a crop field is cultivated and bare of crops, any depression usually is apparent because the soil is relatively moist and dark in comparison with the higher, better-drained parts of the field. If the field is in crops, a wet depression will show up as a spot with a thin crop cover, or none at all.

Mine subsidence

In regions that are underlain by subsurface coal mines, many depressions are the result of subsidence of the earth above a mined-out area. Mine subsidence does not always create a depression: if the subsidence is on a slope, the angle of the slope may steepen or flatten without forming a closed depression.

If a mine subsides beneath a floodplain, the result will be one or more wet or water-filled depressions. These artificial depressions may appear to be natural wetlands except that their shape and distribution often reveal their origin: they may be squarish in outline, and they may be arrayed in a grid-like pattern.

ERODED AREA

Definition and description

An eroded area is defined as an area where erosion has exposed the underlying earth, and the vegetation is very sparse. The earth may be eroding by running water, or it may be slumping by gravity.

Most erosion is initiated by unnatural disturbances such as cultivation or pasturage of livestock, but areas of naturally active erosion exist where the slope is very steep and vegetation does not hold the soil well. Normally an eroding slope will stabilize and revegetate after a period of time — but erosion will remain active if continual disturbance or an extreme environment keeps plants from reestablishing, or if the slope is kept over-steepened by some agent such as a meandering stream. Another significant kind of active erosion consists of blowouts, where a dune has lost its soil-binding vegetation and wind is removing the sand.

Although stream channels usually have little or no vegetation, they are not included in the definition of the *eroded area* survey feature.

Natural communities

Glacial drift hill prairie
Eroding bluff
Sand prairie (blowout)

Geographic distribution

Eroded areas are concentrated near streams.

Topographic position

Eroded areas can be sought by inspecting topographic maps for exceptionally steep slopes, particularly where a stream flows against the base of a hill.

Map symbols and soils

Although steep slopes and dunes can be detected on topographic maps, eroded slopes usually do not have a distinctive appearance on these maps. Occasionally a heavily gullied hillside has a crenelated pattern of contour lines, but usually the contour lines are generalized and too far apart to depict the small irregularities that characterize a severely eroded surface.

Modern soil survey maps show steep, erosion-prone slopes with symbols (for example, a capital G may indicate a 30 to 60 percent slope).

Modern soil maps also denote eroded soils (for example, a number 2 at the end of the mapping symbol often indicates an eroded soil). Soil surveys usually show eroded areas in places where topsoil has been stripped away but subsoil remains in place. In contrast, rare species and unusual vegetation are most likely to occur on sites that are so heavily eroded that all the soil has been removed down to the raw, unaltered parent material. Such severely eroded areas often are not classified as soils in soil survey reports. In such instances the soil maps may show the areas of exceptional erosion with a symbol.

The U.S. Department of Agriculture classifies individual crop fields as "highly erodible land" if the field meets certain criteria with regard to soil texture, slope steepness, and slope length. The formula that is used to identify highly erodible farmland identifies far more land than what would fit the definition of the *eroded area* survey feature. Therefore the USDA program to map highly erodible land cannot be used by the Illinois Natural Areas Inventory to help identify eroded areas.

Shape

Eroding bluffs often appear to be crescent-shaped when viewed on aerial photography. Blowouts in sand may be broadly rounded or crescentic. Gullies may display a branching, dendritic shape.

Size

Most eroded areas are small, much less than an acre in horizontal extent. The apparent size of an eroding bluff on an aerial photo will vary, depending on the position of the bluff in relation to the camera. If the bluff faces toward the camera, it will appear to be relatively large. If the bluff faces away from the camera, it will look smaller or may even be invisible. [11]

Photographic tone and color

Bare exposures of eroded earth usually have a light tone. This is true on either black-and-white or color photos, and it is true on both panchromatic and infrared film.

The best way to spot areas of active erosion is to use aerial photos in conjunction with topographic maps: look for the characteristic whitish signature of bare earth on an aerial photo, then check the corresponding topographic map to see whether the site is a steep slope or dune that might be eroding.

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[11] In vertical aerial photography, the camera points straight down from the airplane, so the center of the photo is directly below the camera. Therefore one might assume that a bluff that faces toward the center of the photo also faces toward the camera — but this is no longer a safe assumption since the advent and proliferation of DOQQs (digital orthophoto quarter-quads). In this format of photography, a single photograph is divided into quarters and is made into four separate images. The position of the camera is above one of the corners of each of the four quarter-quads (for instance, the camera's position is above the northeast corner of the southwest quarter-quad).

Photographic texture and pattern

Bare, eroded earth is often so highly reflective that the glare obscures any surface texture or pattern, and the eroded area appears as a homogeneous, light-toned patch.

Relation to other features

Eroded areas that are of interest to the Illinois Natural Areas Inventory are most likely to be immediately adjacent to stream channels, or in sand dune fields.

Disturbance features

Grazing by livestock can initiate erosion or cause a naturally eroding area to expand.

Additional notes

Eroded areas often are too small to be detected reliably — even on large-scale aerial photography — because they are obscured by shadows that are cast by surrounding vegetation or adjacent slopes. Or the eroded areas simply may not show up in contrast with the adjacent vegetation.

Blowouts in sand dunes are easy to find with maps and aerial photos: locate sand areas by using geologic maps or soil maps, then look on aerial photos for bright white areas of exposed sand. Blowouts usually are at the crest of dunes, and they normally are rounded. Because many native sand-inhabiting plants are ready colonizers of adjacent disturbed sites, even artificially exposed and eroded sand in abandoned cropland may harbor rare plant species.

EXPOSED SLOPE

Definition and description

Exposed slopes are elevated areas that are subjected to the drying effects of sun and wind. They also receive the full erosive forces of rainfall, wind, and freeze-thaw cycles. Such sites may harbor barrens and rare species that require open conditions with dry or eroded soil and sparse vegetative cover.

The most exposed slopes are high ridges and bluff lines that face south, southwest, or west. These areas receive the direct rays of the afternoon sun, during the warmest part of the day. On such slopes, more of the sun's energy is spent warming and drying the soil rather than evaporating the morning dew or frost, which has already dissipated by the afternoon.

The amount of soil moisture on an exposed slope is limited by several factors. Because the slope is on a topographic high, little or no water flows onto it from higher, adjacent slopes. If the slope is steep, much of the precipitation runs off quickly instead of percolating into the soil. Prominent ridges and bluff lines often are made of erosion-resistant bedrock, which decreases their capacity to absorb and hold moisture. The relatively low productivity and thin vegetation in exposed habitats results in the buildup of less leaf litter and soil organic matter, which further limits the moisture-holding capacity of the soil.

High ridges and bluffs lining broad river valleys are exposed to the drying effects of wind, especially if they are perpendicular to the prevailing westerly or southerly winds. For example, the high bluffs on the east wall of the Mississippi River valley feel the effect of desiccating winds unimpeded by hills or trees to the west. In the past, such dry slopes were prone to relatively frequent fires, and they supported extensive areas with hill prairies and open woodland vegetation.

Natural communities

Xeric upland forest
Dry upland forest
Prairie community class, especially the hill prairie community subclass
Cliff community subclass
Glade community subclass
Barren community subclass

Geographic distribution

Exposed slopes occur in regions of rugged topography, mostly along stream valleys and in non-glaciated hill country.

Topographic position

Locating exposed slopes is mostly a simple matter of examining topographic maps to find the requisite aspect, elevation, and steepness.

Map symbols

Exposed slopes are on high, steep to nearly level, south to west-facing landforms. Contour lines on topographic maps show where these slopes are.

Soils

The presence of exposed slopes can sometimes be detected or inferred by the occurrence of certain kinds of soils. For instance Hamburg silt typically occurs on exposed slopes. But exposed slopes are easy to see on topographic maps, so it is not necessary or desirable to use soil maps to find them.

Shape

Exposed slopes usually have a rounded outline, or they are commonly elongated parallel to topographic contours.

Size

An exposed slope can be any size, up to 100 acres or more. The largest such areas are likely to be of the most interest to the Natural Areas Inventory. Small areas are not likely to have significant ecological features.

Photographic tone, color, texture, and pattern

An exposed slope may be evident on aerial photography from the appearance of its vegetation. Hill prairies, glades, and barrens occur on exposed slopes; these communities typically stand out in contrast to the surrounding forest. If the photographic tone, color, or texture of the vegetation on an exposed slope does not look any different from that of the surrounding area, then the environment on the slope probably is not extreme enough to support a natural community that is of interest to the Natural Areas Inventory.

Disturbance features

In the extreme environment of an exposed slope, vegetation is relatively slow to recover from disturbances. If the trees on an exposed slope are cleared for pasture or cropland, and if this clearing is later allowed to revert to woods, the growth of trees on the most exposed slope will be slower than on the surrounding area. As woody plants grow up and obscure evidence of past clearing (such as straight edges on the clearing), the area will gradually take on the appearance of a natural opening in the woods. Depending on the local circumstances, the old clearing may even develop significant native vegetation.

Additional notes

During the first half of the 20th century, cattle were pastured in the woods much more often than at present. The woods also burned more often in the past. As a consequence of this grazing and burning, wooded areas were generally more open. Prairie openings, glades, barrens, and open woodland areas on exposed slopes were larger and better developed then. In general these early successional communities are most distinct on the earliest photography, and they become less and less apparent on more recent photos. Most such areas are more densely wooded now, and they do not show up as well — if at all — on new photography.

GRAVEL DEPOSIT

Definition and description

In the U.S. Department of Agriculture's classification system, *gravel* is defined as a soil particle that is between 2 mm and 75 mm (about 3 inches) in diameter.

A gravel deposit is defined here as an area where enough gravel is concentrated at the surface to have a significant ecological effect — even though the soil is likely to be an admixture of gravel plus finer-textured particles (sand, silt, and clay). Gravel influences the environment in the following ways:

(1) Gravel increases a soil's permeability and lowers its water-holding capacity, so gravelly soils are often droughty.

(2) Gravelly soils are strongly influenced by the mineralogy of the gravel particles: they may be alkaline (from limestone) or acidic (from chert).

(3) Gravelly sites are often not very productive in terms of vegetation, so they tend to have thin soil and a relatively sparse plant cover. These conditions provide habitat for species that would not otherwise occur in the local area — such as sun-loving annual plants, and animals that require a coarse-textured, well-drained substrate for some part of their life cycle.

(4) Groundwater can move relatively quickly through gravel. A seepy, springy area may occur where a buried gravel bed comes to the surface on the side or base of a hill.

Some supposed "gravel prairies" are on glacial till that has relatively little gravel mixed in a matrix of silt, clay, and sand. In these situations, surface erosion has removed finer textured soil particles, leaving the larger gravel particles as a residual lag deposit on the surface.

Natural communities

Gravel prairie
Gravel hill prairie
Fen community subclass
Seep and spring community subclass, particularly the acid gravel seep natural community

Geographic distribution

Gravel deposits are most common in glaciated regions, where they were deposited by glacial meltwaters. They also occur in localized areas in non-glaciated regions — either as residuum from weathering of bedrock, or as ancient shore and river deposits (such as in the Cretaceous Hills Natural Division).

Topographic position

Gravel deposits can range from high points (*e.g.* kames and eskers) to low areas (outwash plains and valley trains).

Map symbols and soils

Gravel deposits are mapped on some surficial geologic maps.

Soil reports describe gravelly or stony soil series or phases, and soil maps often show some (but not all) gravelly areas with symbols.

Kames, kame terraces, and eskers are gravel deposits that are likely to be described in geologic reports.

Shape

A practiced eye may be able to detect the shape of some gravel deposits (such as kames) on topographic maps. The following steps are suggested as a way to identify gravel deposits on the basis of their three-dimensional shape: (1) find a gravel deposit by using an information source such as a report about a natural area, (2) determine whether the deposit is expressed as a distinctive landform, and, if it is distinctive, (3) search for nearby, similar-appearing features on topographic maps.

Size

Gravel deposits usually are small — often less than 10 acres or even a single acre. The smallest gravel deposits do not have enough influence on the environment to be ecologically significant from the standpoint of the Illinois Natural Areas Inventory.

Photographic tone, color, texture, and pattern

If gravel deposits are already known in the inventory area, it may be useful to examine aerial photographs and topographic maps to see how these sites appear — and then search for similar-appearing features in the vicinity.

Relation to other features

Gravel deposits often occur in association with sand deposits.

Disturbance features

The presence of gravel mines is a clue that more gravel deposits may be in the vicinity. Even mined-out hillsides — particularly where mines have been abandoned — may be worth checking (especially in former prairie areas) because native vegetation may persist on the fringe of the quarry.

OPEN WATER

Definition and description

Open water is defined as a body of water that is not vegetated. The water may be either flowing or standing still.

Natural communities

Stream community class
Lake community class

Map symbols

Water is shown in blue on U.S. Geological Survey topographic maps. On a photo-revised edition of a topographic map, a body of water is shown with purple ink if it is a new feature or has a new shape.

Standing water

A permanent body of open, standing water is depicted on USGS maps by a light blue tint encircled by a solid blue line. The shoreline corresponds to what the USGS considers to be the normal water level. If an elevation figure is given for the water's surface, it is intended to indicate the normal water level, and it corresponds to the elevation of the blue shoreline.

USGS mapping conventions call for intermittent ponds to be symbolized with light blue diagonal hatching surrounded by a dashed blue line. Although most natural ponds in Illinois are intermittent rather than perennial, the USGS rarely uses the symbology for intermittent bodies of water. Instead almost all water bodies are mapped with the solid blue outline and light blue screened tint that is supposed to be reserved for perennial waters.

Soil maps employ special symbols for ponds, and these maps often use different symbols to distinguish natural ponds from artificial ponds.

Flowing water

The USGS symbol for a perennial stream is a solid blue line if the water-filled channel is 40 feet wide or less. Or, for a large stream, a broad blue area is enclosed by a pair of blue lines. The symbol for an intermittent stream is a series of short blue line segments alternating with sets of three blue dots. These mapping symbols cannot be relied upon entirely: small perennial streams may be shown as intermittent, and intermittent streams are frequently shown as perennial.

The USGS depicts streams as they appear under normal conditions, not during floods or droughts. The configuration and position of stream channels shift over time, and a map can show only how the stream appeared when the information was gathered and aerial photos were taken in order to prepare the map.

The USGS does not strive for accuracy and precision when showing the intricate meanders of small intermittent streams. Instead the course of the stream is generalized.

The USGS employs a small, square symbol to depict small buildings. If this symbol exaggerates the size of a building so much that it would overlap with an adjacent stream channel, the position of the stream is moved on the map so that the symbols do not overlap.

Where a contour line crosses a stream, the line (which is called a "contour crossing") shows the elevation of the water's surface, not the stream bottom.

Photographic tone and color

The tone or color of water on an aerial photo is a function of its turbidity. Clear water is very dark-toned, and muddy water is lighter. On color infrared (CIR) photos, perfectly clear water is inky black because water is highly absorbent of infrared radiation; consequently little of the infrared spectrum is reflected back to the camera to be recorded on film. Turbid water is light-colored on CIR photos because suspended sediments reflect some of the infrared radiation back to the film. The more turbid the water, the lighter the color on CIR photography. Muddy water ranges from dark gray to turquoise to milky white (the muddiest). These ranges in reflectance are also displayed by black-and-white infrared photos, but they are expressed as gray tones (from black to white) rather than colors.

On conventional panchromatic, black-and-white or color aerial photography, the same relationship between turbidity and photographic tone or color holds true, but the range in gray tones or colors is smaller and the differences are more subtle than with infrared film. As a result, compared to infrared photography, it is somewhat more difficult to distinguish clear water from muddy water on panchromatic black-and-white or natural color photography.

Water that is reflecting light from its surface (because of the angle of the sun in relation to the camera) is whitish on black-and-white photos, silvery on true color photos, and very light-colored (turquoise-blue to silver) on CIR photos. If the water acts like a mirror and reflects the sun directly into the camera, the water will glare in the aerial photo. Often sunlight glints off waves and registers as a distinctive ripple pattern on aerial photos. These glaring reflections can be used to help spot small ponds that might otherwise be overlooked. Because the reflection is caused by the sun's rays glancing directly into the camera, the ponds exhibit glare on only a small part of a photo (usually near one edge). A single pond may appear in a sequence of photos taken along a flight line, but the pond will glare into the camera in only one photo (if at all); as the airplane continues its flight and the angle between the sun, the pond, and the camera changes, the camera will no longer be in the right position to receive a direct reflection of sunlight from the pond.

Photographic texture and pattern

Water has a smooth surface unless it exhibits the ripple pattern of waves from wind. In rare circumstances, the surface of a stream is roughed by rapids.

Additional notes

Turbid water flowing into a clear lake appears as a light-toned plume. The contrast in the turbidity of two streams is often quite evident at and immediately below their confluence.

ORGANIC SOIL

Definition and description

Organic soils consist of peat and muck. Peat is comprised of dead plant material that is partly decayed but still has individual plant parts distinguishable as roots, stems, etc. The organic matter in muck has decayed so much that individual plant structures are no longer apparent. Peat often has a fibrous, spongy consistency, while muck may be fluid or pasty. In modern terminology, organic soils (both peat and muck) are known as histosols.

Peat and muck are rare in the relatively warm climate of Illinois because dead plants normally decay quickly and rather completely. For an organic soil to build up from accumulated vegetable matter, the environment must be unfavorable for normal biological decomposition. Decay is retarded in certain extreme environments, where conditions are too acidic, too alkaline, or too low in oxygen to support normal decomposition rates. Such conditions occur in acidic bogs and seeps, in alkaline fens and seeps, and in stagnant, permanently flooded areas where water lacks dissolved oxygen.

Natural communities

Marsh (in part)
Bog community subclass
Fen community subclass
Sedge meadow
Seep and spring community subclass

Geographic distribution

Cold conditions retard biological decay, so almost all peat and muck deposits are in northern Illinois. Sizeable peat beds have been found as far south as the Sangamon River valley, and extremely limited areas of muck may be found even in farthest southern Illinois.

Topographic position

Organic soils occur in topographic lows, often in depressions.

Map symbols

Topographic maps do not employ symbols to depict organic soils. But since organic soils are in wetlands, wetland symbols can serve as a guide to sites that may have organic soil.

Soils

Organic soils can be located on soil maps. The oldest soil reports give simple names to these soils (*e.g.* "deep peat"); but modern soil taxonomy uses names such as Houghton muck. Some soil types are predominantly mineral soil, but they have small inclusions of organic soils. These soils are not called peat or muck, so one must read the soil descriptions (or perhaps consult with a professional soil scientist) to identify them.

Soil reports do not necessarily point out every place with organic soils, so extra efforts are necessary to find all the organic substrates that might support rare plants and unusual natural communities.

Shape

Shape is not a strong indicator of organic soils, but an area of organic soil will have a distinctive shape if it occurs in a natural community that has a distinctive configuration. For instance the rounded shape (along with other characteristics) that are indicative of seeps) can be used to identify sites with organic soil. However, in such circumstances, it probably would be more efficient to search directly for seeps rather than focusing the effort on organic soils alone.

Size

Organic soils can occupy any size of area, up to hundreds or thousands of acres.

Photographic tone, color, texture, and pattern

On aerial photography, areas of organic soil exhibit the appearance of the natural community that occurs on it.

Disturbance features

Peat deposits are sometimes mined. Both peat and muck are often damaged by draining and tillage. Sometimes a deposit of peat or muck will be farmed — all except for the lowest, wettest spot in the center, which usually is covered with weedy vegetation and has a ditch running through it. On dormant-season aerial photography, the weedy patch usually is whitish (consisting of dead reed canary grass, giant foxtail, giant ragweed, etc.).

Additional notes

Organic soils are limited to wetlands, so any method that reveals wetlands may lead to organic soils.

Geological reports sometimes mention peat. A few reports specifically address peat as an economic resource and provide extensive descriptions and locality information. Many peat deposits described in publications are now destroyed, either because they were mined for their economic value or because they were drained to convert them to a more profitable use. As soon as a peatland has been drained and is farmed, the organic matter begins to oxidize much more rapidly, and the peat begins to disappear.

Geological reports routinely mention buried peat that has been exposed in a streambank or excavation. These peat deposits are the remains of wetlands that existed at an earlier time and in a different climate. Such peat deposits are of great interest to scientists because of the information they contain about the region's past, but no unusual vegetation is known to occur on an outcrop of ancient peat. (Leaves, wood, and seeds of some State-listed endangered and threatened species can be identified in peat, but these plants have been dead for thousands of years.)

Paleontologists and soil scientists are likely to be good sources of leads to peat deposits, and local residents often are interested in peaty areas. A potentially productive way to find peat is to read local histories and to talk with farmers and local history buffs. These sources may refer to "old peat bogs" and "peat swamps." Peatlands and mucky seeps often preserve fossils such as snail shells and bones of Pleistocene mammals that became mired in the wetland. Newspaper accounts of fossil discoveries and local lore about old bone deposits may lead to organic soils.

SALINE SOIL

Definition and description

Saline soils have a build-up of sodium chloride and other mineral salts. Saline soils provide habitat for plants and animals that either require or tolerate high concentrations of mineral salts.

Natural communities

Brackish marsh
Southern flatwoods?

It needs to be determined whether saline soils are a component of the southern flatwoods natural community. Also unanswered: Do any "claypan prairies" in the Southern Till Plain have a distinctive biota because of saline soils?

Geographic distribution and topographic position

Saline soils are known from two major kinds of landforms in Illinois: valleys and till plains. Salt springs and saline wetlands occur in a few, widely scattered valleys where salty groundwater discharges on the surface. Sodium-rich soils also occur in localized areas of the Southern Till Plain Natural Division, where they are known as "slick spots" or "scalds."

Salt springs usually have little or no distinctive salt-tolerant (halophytic) vegetation. Only one sizable natural area with wet saline soils is known in Illinois, where salty groundwater emerges in a series of seeps and springs to form a brackish marsh along the Illinois River in La Salle County.

Soils

In the modern soil taxonomy, high-sodium soils are known as Natralbolls, Natraqualfs, and Natrudalfs; examples are the Piasa and Huey series. They are discussed in the newer county soil survey reports and in *Soils of Illinois* (Fehrenbacher *et al.* 1984).

Photographic tone, color, texture, and pattern

It may prove possible to identify saline areas by the appearance of the vegetation on aerial photography. To test whether this approach will work, it will be necessary to study photos of some known examples of saline soils. If the areas display a distinctive tone, color, texture, or pattern, then it will be possible to use the photographic signature to search for additional sites.

Additional notes

Saline soils can be discovered by employing many of the same approaches that are productive for finding organic soils: scanning geologic reports, gleaning old histories (for references to salt springs and salt wells), and interviewing farmers.

Human activities are creating new habitats for "salt-loving" plants, or halophytes. In southern Illinois, oil and gas fields are being colonized by halophytes where briny water has been spilled on the ground or pumped into holding ponds. For the ambitious biologist, any maps or photos that lead to highways, stockpiles of road de-icing salt, stock ponds, and petroleum wells may be rich sources of leads to saline soils. The Illinois Natural Areas Inventory, however, is focused on natural habitats.

SAND DEPOSIT

Definition and description

Sand deposits are areas with nearly pure sand. These areas include soils that are formally classified as *sand* (*e.g. sand, fine sand, loamy sand,* etc.) — not but not soils that have a significant proportion of silt and clay in addition to sand (*e.g. sandy loam, sandy clay loam,* etc.).

Natural communities

Sand forest community subclass
Sand prairie community subclass
Sand savanna community subclass
Sand seep

Geographic distribution and topographic position

The majority of Illinois' sand areas are either in glacial outwash plains along rivers, or in broad lowlands such as ancient lake beds. Some extensive sand deposits are recognized as distinct natural divisions or sections. One should not overlook smaller sand deposits that occur throughout the state: (a) alluvial sands along streams of any size, (b) wind-deposited sands on uplands directly adjoining bottomland sand deposits, (c) residual sands derived from the disintegration of underlying sandstone bedrock, and (d) sandy shores of lakes and ponds.

Sandy deposits are often associated with low ridges that were formed by floods and wave action. Low, linear rises in the floodplains of streams (known as fluvial ridges) are at least somewhat sandy. Ancient beach ridges on the plain bordering Lake Michigan are made of sand and gravel.

Very limited areas of sand occupy blufftops adjacent to sandy floodplains. This sand has been blown onto the upland by the prevailing winds, so it characteristically occurs on the east side of streams.

Small deposits of pure, coarse sand can be found at the base of St. Peter sandstone outcrops in northern Illinois. The massive cliff-forming Caseyville sandstone in the Greater Shawnee Hills weathers so slowly that it does not result in significant sandy deposits.

Map symbols

Fluvial ridges and beach ridges often do not show up on topographic maps because they have so little vertical relief that they do not intersect even a single topographic contour elevation.

A sandy area may be detected on a topographic map if dunes are present. Dunes vary in form from region to region across Illinois. The appearance of a dune on a topographic map also depends on the contour interval, the scale of the map, and the precision of the cartography. Dunes usually are subtle topographic features, so they may not be immediately obvious on topographic maps. Any prominent rise in a sandy plain is likely to be a dune even if it does not have the crescent shape commonly associated with dunes. The best way to see what a dune looks like on a topographic map is to find out where a dune is, and then look at it on a topographic map. With this knowledge in mind, the minimum extent of the surrounding sand area can be determined by looking for similar topographic features in the vicinity.

The U.S. Geological Survey has sometimes employed special symbols to depict sand deposits. The symbol for "sand areas" is a pattern of brown stipples, reminiscent of sand grains. The symbol for "dune areas" is similar to the symbol for sand areas, except that the stipples are aggregated to represent piles of sand. These two kinds of symbols may appear on some on the older 15-minute topographic map series, but probably all sand plains and sand dunes on modern 7.5-minute maps are shown with contour lines instead of stippling.

Soil maps may prove to be an entirely adequate resource for finding sand deposits, but surficial geologic maps may also be consulted to find sand deposits as well as sandstone that disintegrates to loose sand.

Soils

Soil reports can serve as the primary source of information about specific locations of sand deposits. In these reports, the purest, coarsest sand deposits are classified simply as *sand* (rather than *loamy sand* or *sandy loam*, for example). These pure sands may have the highest potential for natural areas and rare species, particularly if the sands are deep and well-drained. Loamier and finer textured sands also have good potential, especially if they are poorly drained.

Shape and size

The sand deposits in a region may have a distinctive shape and size. If so, these characteristics can be used to search for more examples in the vicinity.

Photographic tone and color

Dry, exposed sand is white on aerial photography, regardless of whether the photos are black-and-white or color, and whether they are panchromatic or infrared. Moist soil is darker; the wetter the sand, the darker it will appear on photography. Bare sand in blowouts on dunes is glaringly white.

Sandy ridges are much more obvious on aerial photography if the soil is exposed by cultivation instead of covered with vegetation. Bare, dry, sandy soil on plowed ridges contrasts sharply with the loamier, moister soil in plowed swales between ridges.

Photographic texture and pattern

Natural communities that occur on sand often have a distinctive appearance on aerial photography. The texture and pattern of vegetation in sand prairies, sand savannas, and sand forests can be used to help determine the extent of sand deposits.

Relation to other features

Sand deposits often occur in association with gravel deposits.

Although the Illinois Natural Areas Inventory usually is not interested in sandy areas that are being cultivated, it can be useful to study aerial photography to determine the distribution pattern of sand deposits that are exposed in cropland next to a potential natural area. After learning how the sand deposits are arrayed in a crop field, one can use this information to infer where sand deposits occur in adjacent wildland — making it possible to detect subtle differences in the appearance of the adjacent natural vegetation that is growing on sand. This approach is especially likely to work if one can find places where a sand deposit obviously extends from the cropland into the immediately adjacent wildland.

Disturbance features

Vegetative cover on dry sandy areas is fragile, and it is slow to recover after it has been damaged. Aerial photos of dune fields often display the white scars of off-road vehicles (ORVs).

Blowouts can get started only where the plant cover has been broken, exposing sand to the action of wind. ORVs and overgrazing by livestock can result in blowouts.

SHELTERED SLOPE

Definition and description

A sheltered slopes is an area with high humidity and a moderated microclimate. Compared with its surroundings, such slopes remain relatively cool and moist throughout the growing season. In some circumstances, the sheltering effect of the surrounding land apparently keeps an area from becoming too cold in winter. Sheltered slopes provide habitat for a number of rare species that either are disjunct or are at the very edge of their range — such as relict northern plants that require cool, wet conditions, and southern species that cannot survive extremely low temperatures.

The most sheltered slopes are canyons, north-facing bluffs, and deep, steep-walled ravines and sinkholes that lie in shadows for most of the day. Such landforms are protected from wind and sun, and they do not experience the temperature extremes of more exposed situations. Water flows onto these topographic lows, so they usually are quite moist and humid.

An algific talus slope is an extreme type of sheltered slope; these cold-traps are habitat to three endangered species of plants in Illinois as well as the Iowa Pleistocene snail, which was known only as an Ice-Age fossil until it was discovered still living on algific talus slopes. This natural community was not recognized by the original classification system of the Illinois Natural Areas Inventory (White and Madany 1978).

Natural communities

Mesic upland forest (in part)
Cliff community subclass (in part)
Algific talus slope
Cave community class (entrance)

Geographic distribution

Sheltered slopes occur in regions of relatively high topographic relief.

Topographic position

Sheltered slopes are easily detected on topographic maps by looking for landforms with the requisite steepness, aspect, and configuration.

Photographic tone and color

Sheltered slopes may lie in deep shadows. The shadows may make the slopes more obvious on aerial photos, or they may completely obscure them.

Additional notes

Many of the clues for locating steep slopes and depressions can be used to help find sheltered slopes.

STEEP SLOPE

Definition and description

Steep slopes are defined as vertical, nearly vertical, or extremely steep slopes. They usually are either bedrock cliffs or bluffs in glacial drift. They may be loosely defined as slopes greater than 30 degrees, which is approximately 60 percent. The most significant slopes are steeper than 30 degrees, but a steep hillside (say, with a 30-degree slope overall) often has segments that are much steeper.

The degree of development (steepness and areal extent) that is significant to the Illinois Natural Areas Inventory will depend on regional circumstances: one should visit several of the steepest and largest slopes in the region and then decide what other slopes need to be selected from maps and photos, based on what appears to be ecologically significant for the region.

Steep slopes are of interest because they are likely to correspond with one of several other topo-edaphic features — namely bedrock outcrops, depressions, eroding areas, exposed slopes, and sheltered slopes. Steep slopes may also be associated with acidic soils, basic soils, gravel deposits, organic soils (in fens and seeps), sand deposits, springs, and wetlands (seeps).

Natural communities

Hill prairie community subclass
Glade community subclass
Cliff community subclass
Fen community subclass (in part)
Seep and spring community subclass

Geographic distribution

Steep slopes are likely to be found in stream valleys, in areas with bedrock outcrops, in dune fields, and on sinkhole plains.

Map symbols

Topographic maps should be the first resource for locating steep slopes. The closer the contour lines, the steeper the slope. The contour interval of a map will determine how close together the contour lines are, so it is important to determine the contour interval. The same hillside has twice as many contour lines on a map with a 10-foot contour interval as it has on a map with a 20-foot contour interval; unless one reads the legend on the map, one might assume that a hillside is relatively steep simply because it is on a map that has a small contour interval. Relatively large contour intervals (20 feet) are commonly used on maps of the hillier sections of Illinois, and 5-foot contour intervals are commonly used for flatlands. Because of this difference, relatively minor slopes in central Illinois may look steep on topographic maps, and major slopes in southern Illinois may not look especially precipitous.

Vertical or overhanging slopes should have contour lines that overlap, but topographic maps tend not to show them in this manner; instead, they usually are shown as very steep slopes with closely set contour lines that do not overlap. This is caused by the limitations of the machine that reads stereo aerial photos and plots topographic contours.

If a topographic map does show a vertical or nearly vertical slope, it is done in one of two ways. The converging contour lines may be broken so that they do not touch or overlap. Or, if the contour lines are not "feathered" in this manner, then the lines coalesce to form a single "carrying contour" that represents a vertical or overhanging hillside.

Soils

Modern soil maps indicate the steepness of each mapping unit according to a more-or-less standardized classification. For example, in one county soil report (and for a certain soil series), an "E" slope may be 12 to 25 percent, and an "F" slope may be 15 to 50 percent. Although soil maps can provide leads to steep slopes, they cannot be relied upon entirely: these maps are generalized, and they often are not entirely accurate on a site-specific basis.

Soil maps are limited because they are intended to show the average steepness of a soil mapping unit rather than the exact steepness of every segment of a slope. Sometimes, though, these maps employ a special symbol to indicate small areas with abrupt slopes that are not apparent on topographic maps.

Shape and size

When viewed on an aerial photograph, a slope will appear to be more or less steep, and more or less extensive — depending on whether the slope faces toward or away from the camera. A slope will look relatively broad and gentle if it faces toward the camera. On the other hand, the steepness of a hillside is exaggerated if it faces away from the camera. [12]

When a pair of aerial photos is viewed in three dimensions under a stereoscope, the lenses magnify the image. In addition to magnifying in the horizontal plane, the stereoscope exaggerates the vertical dimension, making hills look higher and slopes look steeper than they actually are. In the subdued topography of Illinois, this vertical exaggeration is helpful for spotting steep slopes, but one must be mindful that the slopes are not as steep as they appear to be under a stereoscope.

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[12] Facing "toward the camera" is not always the same as facing toward the center of an aerial photo. See the discussion in the footnote on page 40.

Photographic tone and color

Steep slopes (particularly north-facing slopes) may show up on aerial photography as shadowed areas if the angle of the sun is low enough. Steep, dry, exposed, south to west-facing slopes may be relatively light-toned and thinly vegetated on aerial photos.

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APPENDICES

These materials provide additional information about how to identify and evaluate survey features. All these materials are cited in the methods section of this report. Many of the papers have been abridged, and some have been edited slightly.

Alverson, E.R. 1988. Use of a county soil survey to locate remnants of native grassland in the Willamette Valley, Oregon. Abstract of a paper presented at the Fifteenth Annual Natural Areas Conference, State University of New York, Syracuse.

The upland grassland and oak savannah ecosystems that dominated the Willamette Valley prior to Euro-American settlement have been almost completely eliminated by the combined agencies of intensive agriculture, domestic livestock grazing, and fire suppression. The few remnants known have typically been located in the course of rare plant studies, or by road-oriented searches. A more systematic effort to locate native grassland remnants in Marion County, an area where previous surveys had been unsuccessful, was conducted in 1987.

Localities were targeted for ground searches by referring to specific mapping units in the Marion County Soil Survey. Specifically, it was predicted that sites mapped as Stayton silt loam, a shallow, excessively drained soil type generally unsuitable for agriculture, would be less likely to have been plowed.

Twenty-three different tracts were visited in 4 days of field work; 16 of these sites harbored at least some native grassland vegetation. Five new populations of three threatened plant species were located; two populations each for *Aster curtus* and *Erigeron decumbens*, and one population of *Lomatium bradshawii*. None of these species had been collected in Marion County since 1920. One site of particular significance was identified, harboring colonies of *E. decumbens* and *L. bradshawii*, a high quality *Festuca rubra* grassland, and floristically interesting vernal pool habitats.

Under the proper circumstances, this soil survey method provides a useful and efficient means of locating biologically significant tracts in an otherwise unpromising landscape.

Note: Alverson's paper is supposed to have been submitted for publication, but it has not been located. The following text [13] supplements the information in his abstract:

Ed Alverson (Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331; 503/754-4106) talked with me about his Marion County Survey. I

[13] From: White, J. 1988. Willamette Valley grasslands — Conversation with Edward Alverson. Unpublished memo. The Nature Conservancy, Arlington, Virginia.

took the following notes over the phone, and Ed later provided more information and clarification in a letter.

Ed chose Stayton silt loam for surveying instead of any uncultivated grassland on the soil survey map's aerial photos because this soil series had the highest likelihood of supporting native grassland. Ed originally came to this conclusion by finding a good grassland along a road and realizing that is was Stayton silt loam.

Stayton silt loam is a rocky, shallow soil. It has native grassland for the following reasons: (1) it is less likely to have been cultivated in the past, (2) grazing is not so damaging because natives can still out-compete the exotics in rocky seepage channels that are vernally moist and summer dry, and (3) there is less woody encroachment on these sites. In contrast, a deep soil would most likely be cultivated, or it would be severely damaged by grazing, or it would have been colonized by woody plants after fire suppression.

Ed noted a characteristic pattern of shrubs on the native grasslands, tied to edaphic conditions. The shrubs tend to be on the higher ground because the low ground is too wet during some part of the year. Shrubs are not present on heavily grazed sites, and neither are they on recently fallowed fields (though they eventually colonize abandoned fields).

Ed couldn't see the texture of the bunch-grasses on the aerial photos in the soil survey because of the low quality of the photographic reproductions.

Much of the Willamette Valley is planted to grass-seed crops. These crop fields are easily distinguished from native grasslands because they have such a uniform texture. A European strain of red fescue is commonly planted. It is a sod-former, unlike the native bunch grass ecotype of *Festuca rubra* that is native to the Willamette Valley. This is causing concern about the long-term maintenance of native grassland preserves because they may become genetically swamped.

On dry sites, disturbed grasslands are occupied by winter annuals (several species of *Bromus* and other low grasses). On deeper soils, both the introduced and native grasses are perennial C-3 species. [14] *Festuca arundinacea* is one of the commonest of the exotic cool-season grasses.

Ed has tried to use the SCS soil capability classes in his survey work. Class 6 is the least suitable for cultivation, and it includes the Stayton silt loam. He thought perhaps other soils in this capability class would likewise be not so apt to be cultivated and might support native grasslands, but he hasn't found this to be the case. In Marion County, another soil series was in Class 6 but didn't have the close correlation with native grasslands. In a second county that he surveyed after Marion County, he didn't find a close correlation between a low capability class (*e.g.* Class 6) and lack of cultivation. One reason for this low correlation is that some of the Class 6 soils are in low, wet areas; but even these soils can be cultivated if

[14] Editor's note: A C-3 species is a "cool-season" species.

they are artificially drained. The other Class 6 soil in Marion County that didn't seem to support a lot of native grassland was stony, like Stayton silt loam.

Ed doesn't know of any native haymeadows in the Willamette Valley. Perhaps the bunch-grasses don't lend themselves well to this kind of farming.

Many of the native grasslands have been damaged by pasture improvement (introduction of exotic species). Because the Willamette Valley grasslands did not evolve under the pressure of large herbivores, the grasses don't seem to be preadapted to grazing. Consequently, exotics replace the natives under grazing pressure.

Note: The following paragraph is from a July 25, 1988 letter from Alverson to White, which follows up on the phone conversation:

After we talked on the phone, I was taken to a haymeadow in which *Deschampsia caespitosa* is dominant over sizable patches. The *Deschampsia* patches were left standing so the seed could be harvested later on. Turns out that the man who was mowing the hay is the father of a fellow who wants to try to "recreate" an area of Valley grassland on some of the family farmland. The point of this is that at least one of the dominant native grassland species does tolerate haying; I couldn't really tell if this was virgin grassland or "improved pasture" into which the *Deschampsia* had been able to invade. However, there were few other native species associated with the *Deschampsia*. In the Willamette Valley, *Deschampsia caespitosa* commonly grows quite tall (4 to 6 feet tall), so it is one exception to the general idea that the native grasses (such as *Festuca rubra*) were not suited to haying because of their short stature.

Cole, N.B., and E. Fried. 1981. ***Technical Manual: Freshwater Wetlands Inventory.*** **New York State Department of Environmental Conservation.**

Following are excerpts from this manual:

Sources of Information

Air photos

The main source of information for the inventory was unrectified black-and-white panchromatic aerial photography at a scale of 1:24,000, or one inch equal to 2,000 feet. The photos were vertical rather than oblique views, printed on double weight paper with a matte finish to reduce glare.

The bulk of the photos used by the inventory were those taken for the Office of Planning Services' Land Use and Natural Resources Inventory (LUNR). Most of these photos were flown in Spring, 1968. A few test areas were flown in 1967 and a few areas were flown in 1969 to fill in gaps that occurred in the 1968 coverage.

The LUNR photos were chosen for the inventory because they provided the most nearly uniform coverage of the state that was available. Uniformity is very important if the inventory is to provide a base of information to which future investigators can compare current conditions, and if the inventory is to be reasonably comparable from one section of the state to another.

Summer photos

Air photos with appropriate summer dates were not available for the whole state, but were used where they could be found. Twelve whole counties and parts of ten others were interpreted on summer photos.

Summer photos for most areas were borrowed from the Agricultural Stabilization and Conservation Service (ASCS) office. They were black-and-white panchromatic photos at a scale of 1:20,000, printed on glossy paper. Photo dates ranged from 1960 to 1976, with the bulk of the photographs falling in the early to middle 1960's.

Photo quality and limitations

The inventory was designed to use air photos as its main source of information. In brief, the use of air photos provides a practical means of doing an extensive inventory in a reasonable amount of time. The pilot project showed that wetlands could be identified on black-and-white air photos. When combined with field checking to provide ground truth to standardize interpretation and identify anomalies, an air photo survey using covertypes designed to be identified on air photos can be quite accurate.

Air photos of any scale and type (*e.g.* black-and-white, true color, color infrared) impose certain limitations on the information an inventory can gather. As compared to information solely from on-ground surveys, air photos also introduce a whole set of variables which affect the apparent covertype or outline of the wetland.

The quality of an air photo is affected by many factors, such as atmospheric conditions, time of day, altitude, tilt, direction of flight of the plane, and the kind of film used. The printing process is also important and affects the sharpness, contrast, and, for this inventory, the wide array of gray tones that comprise the final black-and-white photo.

In air photo interpretation, vegetative covertypes are largely recognized by their tonal qualities, as well as by their patterns. If photos are either too light or too dark, it makes recognition of the covertypes and of wetlands more difficult. It also makes it hard to recognize the relative wetness of areas.

Sharpness and contrast are important because details of texture and changes in tone from one spot to another are useful clues to identifying wetlands and their covertypes. For some scattered parts of the state the photos were so fuzzy and nearly a monotone gray that it was hard to interpret them with accuracy. For others the photos had excellent resolution and were so sharp that the white lines painted on the roads could be seen.

In some areas, photo quality was not a problem, but the time of year of the photos was. In the Adirondacks, April photos were difficult to interpret because snow cover in many areas obscured the ground conditions. On the other hand, parts of Erie County were photographed near the end of May when a heavy leaf cover was beginning to form and it was difficult to see through the crowns of deciduous trees and shrubs to determine conditions on the ground.

An air photo is a "line of sight" image; that is, it records the first reflective surface which the light rays encounter. It cannot, except by inference, give information about soil or substrate chemistry, about conifer understory, or for this inventory about vegetation below the surface of the water.

Spring vs. summer photos

Most interpretation was done on spring photos. Spring photos are not considered ideal for interpreting many kinds of wetland vegetation, although they are best for delineating the maximum extent of wetlands. The advantage of spring photos for the inventory was that in wooded areas the leafy canopy of deciduous trees and shrubs had for the most part not yet come out, which made recognition of deciduous and shrub swamps much easier than on summer photos. The inventory covertypes were based on vegetation, but many of the air photo clues to recognizing wetlands also involved a darker gray tone due to saturated soil or due to seasonal flooding. At times there was a spectral reflectance (i.e. a glare or sparkle effect) from standing water. These clues visible on spring photos were especially helpful in differentiating deciduous or coniferous tree or shrub swamps from surrounding dry woods or brushlands.

Researchers have suggested that late summer or very early fall photography is best for delineating certain types of wetland vegetation (Larson, 1973). Many kinds of wetland vegetation for instance, duckweed (Lemna spp.) and other floating aquatic plants, are not yet apparent in the spring. Also, high water levels may cover areas of emergent vegetation or wet meadows. For this reason, where available, summer photos were used to check areas of open water. The best photo dates for interpreting summer vegetation, in particular the floating aquatics such as pond lilies, varied from one part of the state to another. The seasonal photo dates for which summer aquatic vegetation could be expected to appear in are July 1 to September 30 for most of the state. However, the summer photos available from the ASCS did not always fall within these guidelines, and in other areas no summer photos were obtainable. For that reason, much of the state has no summer interpretation.

Other problems arising from the use of summer photos included the fact that they were taken over a wide span of years. Some were taken as much as 8 years earlier, while others were taken later than the spring photos of the same area. Apparent changes were sometimes due to vegetative succession or were alterations by man or beaver rather than strictly seasonal differences.

The fact that the summer photos were at a slightly different scale (1:20,000 rather than 1:24,000) from the spring photos did not cause any serious problems, but the glare from the glossy finish on the photos caused eye strain for the interpreters.

Air Photo Interpretation

Summer interpretation

Summer interpretation was done primarily to detect such covertypes as floating vegetation (covertype 8) and submerged vegetation (covertype 13) that develop during the growing season. Other covertypes, such as wet meadow (1) and emergent vegetation (5), were found where the water level had gone down since the spring. Mudflats (14) were sometimes found on late summer as well as spring photos, especially around reservoirs.

Some changes did not represent seasonal differences. The dates of spring and summer photos were as much as eight years apart and actual long term changes may have occurred during the intervening years. This is especially true where there is evidence of beaver or human influence on the wetland, such as flooding or draining. These changes represent a major problem with summer data included in the inventory.

Covertypes

The covertypes and air photo clues for their recognition which are set forth in the following pages were written by Charles Gardner, 1976. These are the covertypes as they were finally defined and were used for the bulk of the inventory.

Covertype number 1: Wet meadow

The vegetation consists of sedges, rushes, coarse grasses, and sometimes cattails. The soil is usually saturated with water. Vegetation tends to grow in clumps or tussocks. Cattails, if present, tend to grow between these clumps.

In agricultural areas, wet meadow is usually a cleared, uncultivated parcel; often it is pastured. If the land is pastured, the clumps are more visually pronounced due to trampling by livestock. Wet meadows may occur within or at the edges of hayfields and may be mowed, depending upon the degree of wetness. Old beaver meadows and floodplains also contain wet meadow vegetation.

Standing water is often present during wet periods.

Tone.—A wet meadow on panchromatic photography runs from white (high reflectance) to a dark gray tone. The beaver meadow–floodplain areas are usually light toned areas, whereas the wet meadows in agricultural areas vary greatly in tone.

Slope.—Slope of wet meadows varies. Pastured wet meadow areas are frequently found on slight slopes. These areas are a result of hillside seeps. The other wet meadow areas are usually depressed in relation to the surrounding land. In broad expanses of wet meadows in depressed areas the terrain is level.

Apparent texture.—The apparent texture of a wet meadow is usually coarse as a result of the vegetation growing in tussocks. Broad expanses can have a smooth texture that may be confused with broad expanses of emergents.

Other clues.—Livestock tend to have definite paths around wet meadows. Since wet meadow vegetation is not usually grazed by livestock, it will grow higher than surrounding grazed areas.

Light toned areas upstream from broken beaver dams, if depressed, are usually wet meadow grasses. Light toned areas along streams or on gravel bars within the streams or rivers suggest wet meadow vegetation (usually reed canary grass).

Covertype number 8: Floating vegetation

Floating wetlands vegetation may be free floating, such as duckweed, or rooted with floating leaves such as pondweed or water lilies. Floating vegetation is usually not visible on spring photography.

Tone.—Tone will be light and very bright white due to spectral reflection of the sun's rays from the surface of the floating vegetation. The more water mixed in with the vegetation the more mottled the appearance of this covertype will be. The tone can be very light due to total spectral reflection. The greater the angle of incidence of the sun's rays, the greater the spectral reflectance will be.

Slope.—Level. Usually in depressed areas that are filled with water.

Apparent texture.—Texture of these areas is usually smooth if the vegetation is dense. The more water that is intermixed the more mottled the appearance becomes.

Other clues.—Free floating vegetation (duckweed) will usually occur on the leeward side of lakes and ponds. Floating leaved vegetation usually occurs around the shores of water bodies and along the banks of large rivers.

Covertype number 12: Flooded conifers

This covertype consists of live coniferous trees (American larch is also included in this category) greater than 15 feet in height. Some of the coniferous trees most commonly found in wetlands are: black spruce, hemlock, white cedar, red spruce, balsam fir, and American larch. Flooded conifers usually grow in hummocky terrain. The trees tend to grow out of the drier hummocks with pockets of water forming between the hummocks.

Tone.—Flooded conifers generally have a dark tone unless spectral reflectance from standing water underneath causes them to have a light tone. Spectral reflectance occurs most often on photos taken in the early morning or the late afternoon and at the edges of the aerial photographs.

Cedar swamps have a lighter tone than the other flooded conifers. Cedars are easily recognized by their conical shape.

Slope.—Slope of flooded conifers is usually level. Conifers will grow on hillside seeps and are considered to be flooded in these instances.

Apparent texture.—Most flooded conifers become stunted (core samples from black spruce of 2.5 to 3 inches dbh in the Adirondacks showed that these trees were approximately 45 years old) with a few erratics growing larger. The stunted conifers combined with their distinct crown pattern and the fact that they grow on hummocks produces a rough texture on the air photos.

Other clues.—Smooth distinct boundary. Balsam fir and occasionally other species may grow quite tall even though they are wet.

Dremann, C.C. 1987. Relic bunchgrass prairies surveyed by aerial photos.
***Restoration & Management Notes* 5:86–87.**

Less than 1 percent of original bunchgrass prairies, (*Stipa pulchra*, primarily), remains in California. Although there are well-known areas such as the Jepson Prairie, no statewide, systematic mapping exists and the locations and extent of the remaining relic stands are largely unknown to conservationists and researchers.

Bunchgrass hummocks form a speckled pattern that can be seen on black-and-white aerial photos taken at an altitude of 3050 m. Bunchgrass can even be distinguished from European annual grasses, which have a smooth, felt-like appearance in the photos. Ideal photo scale is between 1:12,000 and 1:24,000, but clear photos even at 1:100,000 can pick up bunchgrass swaths as little as 60-m wide.

Investigators should begin with photos of known prairies to become familiar with the characteristic hummock pattern. Other important points are:

Clarity of photos is critical — time of year is not critical, though bunchgrass does stand out more clearly in January and February and between July and September.

Within 8 km of the coast, the general wind-sweeping of vegetation makes spotting more difficult, but constant field checking and a photo scale of 1:12,000 make it possible.

Sedges in low areas can be mistaken for bunchgrass, but their location in low areas and their darker color help distinguish them.

Interestingly, aerial photos can also be used to estimate when prairie disappeared in unplowed areas. Bunchgrass may disappear through overgrazing, but their hummocks are still visible on photos and may take up to 25 years to disappear completely.

Further details will appear in the upcoming publication *Grasses of California: Stipa pulchra.*

Heidel, B. 1983. Red River Valley prairie inventory in North Dakota. Unpublished report. North Dakota Natural Heritage Inventory, Bismarck.

Following are excerpts from this paper. More complete information on the project is in Heidel (1986).

Methods

Potential native prairie sites were located through use of color infrared aerial transparencies of the U.S. Fish and Wildlife Service, flown as part of the National Wetlands Inventory. The photos were taken on at least three different dates between April and June over the years 1979–1981, at a scale of 1:65,000 (about one inch to the mile). This accommodates replicable site identification down to at least 40 acres.

Sites were identified on the 9" X 9" transparencies with use of a stereoscope and a light table, and mapped directly onto the nine county maps. An initial evaluation and note was made as to whether the site was likely to be grazed, mowed, or idle.

The full set of transparencies was double-checked between the two people working on site identification. After all the work with transparencies was completed, a duplicate set of county maps with identified sites was prepared, as well as site lists for each county.

Conclusions

Color infrared aerial photo-interpretation made extensive coverage feasible for relatively little time and project expense. The two primary drawbacks were unsuitability for consistent detection of potential prairie sites smaller than 40 acres, and potential omissions among less-than-prime mowed prairies. Ground surveys revealed that it was sometimes the case that among two neighboring grassland tracts in apparently similar over-grazed condition, only one site was mapped from aerial photos.

Heidel, B. 1986. Bluestem prairie inventory in the Red River Valley, North Dakota. Pages 160–162 *in* G.K. Clambey and R.H. Pemble (editors). *The Prairie: Past, Present and Future — Proceedings of the Ninth North American Prairie Conference.* Tri-College University Center for Environmental Studies, Fargo, North Dakota.

Following are excerpts from this paper:

Abstract.—A bluestem prairie inventory was conducted in the Red River Valley of North Dakota during 1982–1983. Potential bluestem prairie remnants were identified through photo-interpretation of aerial color infrared transparencies, and the 809 potential remnant sites were field-checked and evaluated. Five sites representing a total area of less than 1.2 square km (0.5 square mile) were identified as possessing healthy bluestem prairie. Nineteen more sites contained bluestem prairie which was degraded and/or predominantly composed of other prairie types on less arable land including sand prairie, mixed grass prairie, low prairie, and alkaline meadow. This signifies a state bluestem prairie habitat loss of 10,000-fold magnitude.

The Red River Valley plain spans 10 counties in eastern North Dakota. It extends into Minnesota, Manitoba, and the far northeastern corner of South Dakota, marking the southern lobe of glacial Lake Agassiz.

Preliminary evaluations of six previously reported bluestem prairie sites in the Red River Valley of North Dakota were conducted in the summer of 1982. Additional potential bluestem prairie sites were sought in the winter of 1982 through use of aerial color infrared transparencies at the scale of 1:65,000, photographed by the U.S. Fish and Wildlife Service in the National Wetland Inventory. They were photographed in early-season flights from April to May, between 1979 to 1981. Potential bluestem prairie sites were identified from the color infrared transparencies with use of a stereoscope. Site boundaries were recorded directly onto county maps at the scale of 1:125,000. Site identification was based on presence of dual warm season/cool season floristic components as indicated by colors, on presence of ground pattern heterogeneity, and on absence of agricultural features such as furrowing and bare earth. A conservative approach was taken in the identification process with marginal areas included. For example, stockponds did not automatically warrant site exclusion.

From the known prairie sites, it was determined that prairie remnants could be identified with reasonable certainty down to 16 ha in size, with certainty dropping off sharply below 8 ha. A total of 809 sites were identified and mapped.

As further check, the sites identified in two of the counties, totaling 270, were evaluated against 1981 color aerial slides of the Agricultural Stabilization and Conservation Service photographed in the latter part of the 1981 growing season. The color slides provide information on land use that was, in some cases not discernible on the color infrared transparencies. This added step generally corroborated the initial site identification, but was judged to be an inadequate substitute.

The 809 sites were ground-checked mainly between April and June 1983 in a reconnaissance to determine whether they were likely to represent native prairie remnants. Their species dominants, probable condition, and current utilization were noted.

Eighty-two sites were identified in the first screening as potentially warranting intensive evaluation. They were revisited between July 25 and August 14, 1983. Among the sites revisited were the six previously reported prairie sites. Among the 76 new sites, two were plowed under between the time of the initial evaluation and the revisit. Excluded from consideration were the blocks of native grassland that are not bluestem prairie and which have persisted in alkaline upwellings and in the Sheyenne Sandhills.

Intensive site evaluations were actually completed for only 24 sites which were confirmed as meeting the criteria of being at least co-dominated by native grass species in the presence of Kentucky bluegrass (*Poa pratensis*). They also showed no signs of plowing, seeding, or heavy grazing.

A total of five sites represented healthy bluestem prairie having native species dominance and relatively high species diversity. Together they total 110 ha, less than 1.2 km in a 13,000-km area. They ranged from 7 to 44 ha. Nineteen more sites, totaling roughly 1,000 ha, were either degraded bluestem prairie or very localized bluestem prairie within drier, wetter, or more halophytic prairie types.

The documented net area results are not exhaustive because the methods employed were not suited to identification of sites smaller than 8 ha. This shortcoming has already been demonstrated in the form of a 4-ha prairie remnant in good condition that subsequently came to our attention. However, there is the perceived scarcity of remnants in very small sites such as railroad rights-of-way and cemeteries. While the preceding totals are incomplete, they are interpreted as representing the great majority of remaining bluestem prairie area.

Some sites among the 785 others represent photo-interpretation errors, including planted watercourses and stubble fields. Of the remainder, almost 80% were grazed and less than 10% were hayed. They had highly degraded native grassland, seeded native grassland, or non-native grassland.

Johnston, C.A. [*Ca.* 1980.] Wetland mapping using existing information sources. Pages 290–305 *in*: C.B. DeWitt and E. Soloway (editors). *Wetlands Ecology, Values, and Impacts: Proceedings of the Waubesa Conference on Wetlands* [1977]. Institute for Environmental Studies, University of Wisconsin, Madison.

Following are excerpts from the paper:

Abstract

A great deal of wetland information can be gleaned from existing data sources, providing they are properly interpreted. Air photos, soil maps, and other source materials were used to map wetland vegetation, soils, and water regimes in study sites representative of different wetland types and conditions throughout Wisconsin. Ancillary surveys of various types (*e.g.*, topographic maps, land cover inventories) augmented the basic data sources. Air photos were also used to interpret adjacent land uses which might affect wetland quality. Historical air photos and references provided important clues about past wetland disturbances. Maps generated by these techniques can be helpful in identifying, delineating, evaluating, and managing wetlands.

Introduction

The problem and the need

The recent upsurge in support for wetland protection has uncovered the need for accurate wetland maps. Provisions for wetland mapping have been included in several of the recent Wisconsin wetland protection bills because existing resource maps are considered inadequate for inventory or regulatory purposes. To satisfy these needs, it is necessary to:

(a) Locate the wetlands of the state.

(b) Delineate upland-wetland boundaries.

(c) Inventory various wetland components (e.g., vegetation, wildlife, soils).

(d) Determine the quality of the wetlands.

The objective of this paper is to show that existing sources of data can provide much of this information, providing they are properly interpreted and manipulated. Not only can good results be obtained, but maps prepared from existing information would cost significantly less than those prepared from new aerial photography or by field work.

Hazards in information

Wisconsin has an abundance of existing data sources which can provide information pertinent to wetlands, many of which are listed in the *Inventory of Wisconsin Land Resources Data.* Not all of these information sources are accurate, however. Figure 1, based on Figures 26, 27, and 28 in *The Vegetation of Wisconsin* serves to illustrate. These three maps, all of the civil township of Plum lake (Vilas County), show areas of swamp conifers as mapped by three different agencies at three different times and for three different purposes. On the basis of these maps it could be concluded that wetland acreage is increasing with time, as the area of wetland mapped increases from top to bottom. In addition, it appears that the wetlands in this area are moving around! Figure 2 compares the differences in wetland location among the three maps: the lack of agreement between the maps is evidenced by the paucity of cross-hatched areas. Curtis (1959) believed the "slight differences in the location of conifer swamps on the three maps are apparently due to differences in interpretation by the three sets of surveyors and are not believed to represent actual vegetational changes." Another factor which undoubtedly influenced map accuracy was the improvement in cartographic materials and surveying techniques. Surveyors for the Public Land Survey had virtually no other maps to work from, and had to rely completely on field observations as they traversed the land. Surveyors for the Forestry Inventory, on the other hand, could work with air photos and accurate base maps. In any case, it is clear that comparisons of the three sets of wetland data would not give meaningful results.

The above example is not meant to imply that existing wetland maps are worthless; it only emphasizes the importance of knowing the capabilities and limitations of existing data sources.

Methods

Eight sites representative of different wetland types and conditions throughout the state were selected for study. Each study site had an area of 6 to 12 sections, which included upland as well as wetland. Air photos and soil maps were used as the primary data sources for mapping the wetlands in the study areas. Other maps and data sources pertinent to these wetlands were collected and examined. The following sections discuss the specific information sources and the results obtained with them.

Air Photos

The value of panchromatic (black-and-white) air photos in wetland mapping has been well established. Although other film types are somewhat better suited for detailed mapping of wetland vegetation, black-and-white air photos have been used for decades and therefore provide a historical record. Air photos of Wisconsin were taken as early as 1936. Interpretation of these older air photos can give important information on past water regimes, land uses which may have affected wetlands, and ecological succession.

The Agricultural Stabilization and Conservation Service (ASCS) has produced the most air photos for the state. In 1970, their standard photo scale for contact prints was changed from

1:20,000 to 1:40,000. The 1:40,000 photos have very good resolution, but are not as satisfactory as the 1:20,000 photos for stereoscopic interpretation because differences in relief are not as apparent. The smaller scale also makes it more difficult to outline small features on the contact prints.

The only color infrared aerial photography available for much of Wisconsin is the RB-57 photography flown by NASA. These photos have comparatively small scales, 1:60,000 or 1:120,000, but provided a great deal of wetland information when studied stereoscopically. Their small scale made it impossible to draft directly over the photo, so a larger scale base map (preferably photographic) had to be used in conjunction with the air photos for mapping.

Vegetation

The *Interim Classification of Wetlands and Aquatic Habitats of the United States* was used to classify wetland vegetation on maps prepared for this study. For the most part this system worked very well, although some difficulties were encountered in distinguishing certain vegetative types. For example, it was difficult to distinguish bog birch (a deciduous shrub) from ericaceous evergreen shrubs, such as leatherleaf. This distinction is not a critical one, since these shrubs fill a similar ecological niche.

Tamaracks were occasionally mapped as deciduous trees on the black-and-white air photos. This problem could be alleviated by using infrared photos, consulting the Wisconsin Land Inventory, and/or by being familiar with local wetland ecology.

Emergent vegetation in lakes (such as bulrush) was difficult to detect on air photos because each plant stem occupies a minute area, the plants were widely spaced, and there was poor tonal contrast between the plants and the surrounding water. Such areas were easier to distinguish on color infrared photography.

Submerged aquatic vegetation (e.g. pondweeds, milfoil) could not be consistently identified on black-and-white photos. Interpretation success was a function of plant development and water turbidity.

The time of year when air photos are taken influences the detail of vegetation mapping possible. Photos taken in early May were best for palustrine sites, because tonal contrasts permitted easy differentiation of grasses and sedges from forbs, and shallow fresh marshes from wet meadows. Emergent lacustrine and riverine vegetation was only visible on photos taken during mid- to late summer, after the plants had fully developed.

Gross changes in species composition were determined by comparing older air photos with new ones. For example, a sequence of air photos showed that shrubs have been progressively invading the eastern edge of Upper Mud Lake Marsh in Madison.

Wildlife

A skilled air photo interpreter can make certain inferences about wetland wildlife habitat after examining air photos, but very few species can actually be identified. Beaver dams are easily detected, although a census of beaver population is impossible using air photos alone. Muskrat lodges are usually visible on 1:20,000 scale photos, but bank dens are not. Deer trails show up distinctively on open organic soil areas.

Water regimes

The *Interim Classification of Wetlands* includes several categories of water regimes based on duration of flooding (seasonally flooded, saturated, permanently flooded, etc.). Theoretically, an experienced air photo interpreter could examine a series of air photos and infer the average hydrologic condition of the wetland. Although different degrees of flooding could be detected on each set of air photos for the various study sites, comparison of conditions shown on a series of air photos often confused the issue rather than clarifying it. Water levels appeared to fluctuate without cause. This is not altogether surprising when one considers the number of factors which affect water levels: amount and intensity of precipitation, amount of run-off from adjacent slopes, size of the watershed draining into the wetland, interaction with ground water, season of the year, amount of snow accumulation prior to the spring thaw, hydraulic conductivity of the soil, and human intervention. On the basis of this study, I feel that more research is needed into this important aspect of wetland ecology before these water regime classes can be applied.

Land use impacts

Land uses in and adjacent to wetlands have an impact on wetland quality. Rather than trying to identify specific factors which have degraded a wetland, many naturalists identify the resultant "disturbance vegetation." Such species cannot be identified on black-and-white air photos, but many of the actual disturbances can. Identification of disturbance vegetation and identification of the actual disturbance are both valid tools in assessing wetland quality, the only difference being that one looks at effect while the other looks at cause. The major drawback to the latter approach is the lack of research on the effects of various land uses on wetlands.

Past and present land use in the eight wetland study sites was analyzed using the air photo techniques described in Hardy *et al.* (1970). The following are some of the findings.

Agricultural use.—Agricultural features which can be distinguished on air photos include cropland, pasture, marsh, hayfields, drainage ditches, muck farms, and cranberry farms. Evidence of wetland cultivation often persists long after the practice has been abandoned, so frequent air photo flights are not essential.

In the Nine Springs Valley, disturbance vegetation mapped by Bedford et al. (1974) correlated very well with areas of past cultivation identified on 1950 air photos.

Logging.—Wetlands were logged in two of the study areas. Lowland forests on islands in the Mississippi which were clear-cut around 1938 appear to have recovered from the disturbance. Coniferous swamps near Sturgeon Bay (Door County) were logged at about the same time, but the regrowth is composed of deciduous trees.

Urban encroachment.—The most striking impacts to wetlands occur in urban areas. Many of the wetlands around Madison have been filled. These areas can easily be identified from soil maps and old air photos. Channelization of streams such as Nine Springs Creek is also obvious. Dredged areas are evident where palustrine wetlands have been disturbed but are more difficult to detect in lacustrine or riverine systems. An exception is the spring 1968 dredging of Upper Mud Lake near Madison, where the dredge barge and spoil lagoon are readily visible on ASCS air photos.

Fire.—Fire scars were found only on the 1968 air photos for the Madison area. These photos were taken in May while wetland vegetation was emerging, which is the best time to detect fire scars. Most marsh fires occur in the spring because of the abundant dry plant litter from the previous year. Also, marshes which burn at other times of the year become rapidly recolonized with new plant growth. The severity of the burns (i.e. whether peat layers were destroyed) could not be determined.

Soil maps

The type of soil present in any area varies with those environmental conditions that affect soil formation. Soils, therefore, can provide a record of the past. For wetland mapping, this has the advantage that wet soils can be identified even after the wetland vegetation has been disturbed or destroyed. Soils respond very slowly to environmental change, however, so wet soils which have been artificially drained for agriculture cannot be distinguished from wetland areas.

Although soil information does not readily become outdated, some discrepancies may occur where cut and fill operations have destroyed the original soil, or where the soils have been inundated by impoundments. Field work for "modern" detailed soil maps was done as much as 30 years ago in some areas of Wisconsin, during which time substantial soil modification can take place in disturbed areas.

Soil surveys are usually published at scales of 1:15,840 or 1:20,000, with a minimum map unit size of approximately 2 to 3 acres. Each soil mapping unit theoretically may have up to 25 percent inclusions of other soils; in reality this figure may be exceeded if the soils present are similar. Wetland inclusions which are smaller than the minimum map unit size are sometimes indicated by marsh or wet spot symbols.

Soil criteria are commonly used in wetland definitions. The most recent Wisconsin wetland protection bills, partially define wetlands as ". . . areas with soils of the type identified on soil maps as histosols (peat and muck) or as mineral soils that are *somewhat poorly drained*, *poorly drained*, or *very poorly drained*, or as *wet alluvial lands*, *marsh*, or *water* . . . ." While this definition is clearcut and relatively simple to use, it is too simplistic to adequately separate wetlands from uplands. A primary deficiency lies in the fact that many somewhat poorly drained soils are not, and never were, wetlands. Seven of the eight study areas had detailed soil maps. I compared these with wetland maps I had prepared by air photo interpretation, and found only two areas of somewhat poorly drained soils which might be considered wetlands. One was an area of Au Gres sand in Oneida County, supporting a fairly tall but scattered black spruce stand. The other area was in a cloverleaf of the Park Street – South Beltline interchange south of Madison, where surface drainage patterns had been drastically altered.

Soils information has also been used to generate a figure of 9,200,000 acres for the original wetland acreage in Wisconsin. Somewhat poorly drained soils were included in this calculation, and they constitute 40 percent of the total figure. While these soils would all be considered wet in the sense that they are unsuitable for septic tanks and have wetness limitations for farming, not all of them originally supported wetland vegetation (F. Hole, personal communication, June 1977). This is borne out by Figures 4, 5, and 6. Marathon and Clark counties have over 50 percent of their soils classified as "wet" (somewhat poorly drained, poorly drained, and very poorly drained), and 70 to 89 percent of those wet soils are in agriculture (Figures 4 and 5). If all of those wet soils were originally wetlands, substantial drainage must have taken place to permit such heavy agricultural use. However, Figure 6 shows that of the 78 townships in Clark and Marathon counties, only four townships showed major wetland losses. The high percentage of wet soils reported is due to extensive areas of somewhat poorly drained Withee and related soils which originally supported northern mesic forest. [15]

It is therefore concluded that the original wetland acreage in Wisconsin is much less than 9 million acres, but probably more than the original land survey estimate of 5,000,000 acres.

Another common misconception is that all soils which are artificially drained were originally wetlands. Some drainage occurs on land which is too wet for optimum crop yields, but too dry to support wetland vegetation.

USGS maps

Several kinds of U.S. Geological Survey maps are available for Wisconsin, although their utility for wetland mapping varies. The 1:48,000-scale maps do not have topographic contours, and are largely outdated. The 1:62,500 maps provide good cultural and topographic information, but the scale is too small for them to be used as base maps. The 1:24,000 quadrangles also show good cultural and topographic information, and are at an acceptable scale for base maps. Advance manuscript copies of unpublished 1:24,000 topo-

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[15] Editor's note: "Somewhat poorly drained" equates to *wet-mesic* in the natural community classification system of the Illinois Natural Areas Inventory. Natural communities with wet-mesic soil are not in the INAI's Wetland community class, but they are classified wetlands in many classification systems. Johnston is applying a more conservative definition for wetlands.

graphic maps can be ordered for about 15 percent of the state, but they do not show as much detail as the published maps. A new USGS product, the orthophotoquad, provides an excellent base map for delineating wetlands, but lacks some of the cultural details of the topographic maps.

USGS maps show within limits the location and extent of wetlands, as well as gross vegetation differences ("marsh," "wooded marsh," and "submerged marsh"). The USGS definitions of wetlands are very general (USGS, 1971), so some variation occurs between maps. The USGS concept of wetland tends to be somewhat conservative. Drier wetlands, especially those that have been cultivated, tend to be mapped as upland, and aquatic wetlands tend to be mapped as open water. For example, Upper Mud Lake Marsh is shown as dry land on the 1:24,000 Madison East quad, while Red Cedar Lake in Jefferson County (which is primarily a large deep fresh marsh) is shown as open water. Wetlands which had been cultivated, even wet croplands which had been abandoned and were reverting to wetlands again, were mapped as upland on USGS maps. The USGS also seemed to be very conservative in its use of the "wooded marsh" classification. Floodplain forests along the Mississippi and Wisconsin rivers were usually mapped as "upland," as were the wooded ridge-and-swale complexes near Sturgeon Bay. The "wooded marsh" category was generally restricted to wooded wetlands with organic soils.

Any map which shows cultural features is likely to become outdated in a short time. Since wetlands are subject to human influence, wetlands mapped on older USGS quadrangles may have been modified since the time of map publication. Some USGS maps date back to the 1940's and substantial wetland changes have taken place in the interim.

Despite their deficiencies, USGS topographic maps are often the best maps available which show wetlands. Many counties use USGS maps as wetland maps for their Shoreland Zoning Ordinances.

USGS maps have the advantage for land use regulation that they are widely known and readily available to the general public. However, after examining the USGS maps for all of my study sites, I feel that these maps do not represent wetlands accurately enough to be used alone for inventory or regulatory purposes.

Kooser, J.G., and R.M. McCance. 1988. ***Heritage Program Field Staff Training.*** **Ohio Division of Natural Areas and Preserves, Columbus.**

Following is an excerpt from this manual:

Prairies occur only infrequently in the study area. Those that do exist typically appear on areas of past slumps, on balds on top of hills, and on areas of calcareous clay soils. There are no true, black-soil prairies in this territory. It is quite difficult to separate prairie communities from other grasslands on ASCS aerial photos. Soil maps have helped identify potential prairie areas in other states. In the glaciated portion of Ohio, most edaphic prairies are on soil units far too small to be mapped. Aerial photos are of limited use in finding prairies in southeastern Ohio. These are best found by examining topographic maps for appropriate habitat, then flying over these areas.

Meyer, M., M. Heitlinger, and P. Grumstrup. 1980. ***Monitoring and Mapping Natural Area Grassland Vegetation with Small Format Aerial Photography.*** **Institute of Agriculture, Forestry and Home Economics, University of Minnesota, St. Paul.**

Following are excerpts from the paper:

Abstract

Sequential spring-to-fall color and color infrared 35-mm vertical aerial photography, at a variety of scales, was flown of two of The Nature Conservancy's natural grassland tracts in Minnesota. The objective was to develop a cost-effective means of gathering information necessary to making management decisions and studying the effects of management practices such as prescribed burning. Color infrared proved to be superior to color, even in late October, and a film scale of 1:18,000 was determined to be an optimum compromise between minimum required detail and maximum area coverage per frame. Mid-May coverage was most useful for delineating disturbed areas with exotic (Eurasian) grass species, and late October was most useful for mapping different vegetation zones. The 35-mm technique proved to be both economical and technically effective.

Study area locations, descriptions

Schaefer Prairie.—This is a 160-ac (64 ha) tract in McLeod County which included about 100 ac (40 ha) of virgin (unplowed) grassland. Other cover types present are riverine woods (mostly green ash and box-elder), sandbar willow and reed canary grass floodplain, and old field last cultivated about 1966, and 30 ac (12 ha) presently cultivated but scheduled for prairie restoration.

The Helen Allison Savanna.—This tract is located in Anoka County. It consists of about 55 ac (22 ha) of northern pine and bur oak savanna—about 30 ac (12 ha) of which were formerly cleared and cultivated and ultimately planted in part to jack pine (recently removed).

Results

Schaefer Prairie.—Plants native to Eurasia are undesirable in New World natural areas; hence, a technique of monitoring undesirable exotic species is necessary to evaluate and improve the effectiveness of natural area management programs. In order to realize the economics of relatively small scale aerial photo coverage, however, the differentiation between native and exotic species would have to be on the basis of relatively gross differences in growth stage, expressed as color differences on the imagery, rather than on the basis of specific plant morphological characteristic differences. As a result of the overflight series, it was found that very good native/exotic species differentiation was possible with a relatively small photo scale (1:18,000)—in particular, with the color infrared 35-mm vertical photography. A summary of the results of the study follows:

(1) The exotic (Eurasian) cool season grasses reach peak-of-green earlier in the growing season than the warm season native grasses and, as a consequence, the exotics are green while the native grasses are still relatively dormant.

(2) During the remainder of the summer, there is difficulty distinguishing between native and exotic grasses, since both tend to develop, and maintain, a green-stage level not easily differentiated on the photography.

(3) Some time between September 4 and October 26, 1975 (the two last dates of photography), the cool season exotics went into dormancy and became distinguishable from the (still) green native grass species. On the average, early October is probably a suitable time to obtain this natural/exotic differentiation.

(4) At no time did the differences between the cool season exotic species and the warm season native grass species show up as well on color photography as on color infrared.

(5) Of the two times during the season (May and October) during which the exotic/native grass species differentiation was accomplished with CIR, the October imagery was deemed to be superior.

(6) A relatively high degree of differentiation between various native plant species was attained—particularly with late season photography.

(7) The CIR photography was also extremely sensitive to moisture differences such as current water levels and location of high-water lines.

(8) Past disturbances of historical significance were detectable—e.g., an old pioneer road and wheel marks of farm machinery in some of the previous cropped areas.

Allison Savanna.—The savanna has much drier, more sparse vegetation than Schaefer Prairie, due to the sandy substratum. Of the types and dates of photography obtained on this area, the early September color infrared coverage provided the greatest visible range of plant species differences and conditions.

Relative costs.—It is difficult to compare costs between this aerial photographic method and more conventional ground methods because it is not possible (financially or technically) to accomplish some of the tasks on the ground that are possible with the aerial photographs. In general, it was found that the quality of species identification, mapping and analysis accomplishable with the 35-mm aerial photography cost in the neighborhood of under $1.50 per acre. This cost figure included the following: (a) salary for flight planning, (b) aircraft rental and pilot, (c) salary of the photographer, and (d) film purchase, developing, printing.

Conclusion

Color infrared 35-mm vertical aerial photography was shown to be both useful and cost-effective for vegetation mapping and monitoring of tall-grass prairie and oak savanna. Disturbance sites supporting exotic grasses were clearly seen in May photography at scales up to 1:25,000. Vegetation zones such as emergent aquatic, cordgrass and bluestem prairie were distinguishable on 1:18,000-scale photography taken in late October.

Orzell, S.L. 1983. Natural area inventory of fens in selected southeastern Missouri counties: Part I. *Missouriensis* 4:113–119.

Here are excerpts from this article:

The following is a summary of my masters thesis research, which was a study to inventory, botanize, and classify fens (formerly calcareous wet meadows) of natural area significance from four southeastern Missouri counties: Reynolds, Madison, Shannon, and St. Francois. A fen is defined as a natural community of relatively firm, well decomposed, sapric, mucky peat or gravelly marl constantly saturated by cold calcareous groundwater at or just below the surface, and supporting a distinct calciphilous flora.

With the exception of some previous natural area surveys, fens remained largely undetected features of the Salem Plateau. A combination of survey techniques included aerial surveillance, examination of ASCS aerial photographs, USGS topographic quadrangles, USDA-SCS pedologic surveys, geologic surveys, hydrogeologic investigations, herbarium records, and interviews with local residents. All were evaluated and their effectiveness judged in developing an integrated systematic approach to locating fens.

Aerial surveillance was the most efficient tool. Late winter or early spring flights were most effective, when fens could be relatively easily spotted with some previous flight experience. Small seepage areas were more pronounced, not being obscured by leaf canopies of the surrounding forest. Seep-springs often appeared as darkened patches or emerald green due to watercress (*Nasturtium officinale*). Another aerial technique used to distinguish fens was the contrast exhibited by cool-season versus warm-season grasses. Native warm-season grasses were still dormant, whereas the exotic cool-season grasses cast a greenish hue. This variation was vital in discerning fens from fields converted to "improved" pastures.

Even in some old clearings, dominated by warm-season grasses, which might superficially resemble fen vegetation, one could employ certain flying tactics. The aircraft was tilted so as to give directed view of the site. If the area was a fen rather than an old field, a sparkling glare would be produced on a sunny day. This glare resulted from reflections of seep runs, that appeared much pronounced as a result of reduced evapotranspiration rates in late winter.

Some species inhabiting fens could be identified from the air with experience. Distinctive growth forms, coloration, and other features of certain species were sometimes recognized from the plane. Dense green stands of sweet flag (*Acorus calamus*) were noticeable. Stunted wiry clumps of alder (*Alnus serrulata*) usually signified a fen. Patchy whitened bark of sycamore (*Platanus occidentalis*) along a fen border was striking against surrounding earthy tones. Young green stems of willow (*Salix*) in crowded stands often identified a wetland. Tawny brown stalks of cattails (*Typha*), although characteristic of a wide range of disturbed wetlands, were apparent when forming dense beds. Generally, fens appeared as dark-tone images with free surface water visible between relatively homogeneously colored graminoids.

In addition to recognition of new fen sites, the aerial survey provided for determination of artificial disturbance. Vegetation on heavily grazed fens appeared stunted or denuded due to foraging pressure. Ungrazed fens had a more vigorous, stratified appearance.

Tonal variation and uniformity (texture) were important criteria for detecting fens on ASCS aerial photos. Dark grey tones of irregular configuration usually denoted wet soils with sedge dominants. In contrast, agricultural areas, developments, bare areas, or excavations appeared as sharply whitened tones. As a general rule, lighter tones indicated well-drained soils and darker tones, poorly drained soils.

Uniformity of texture were also utilized to locate potential fen sites. A closely patterned or mottled texture usually indicated a fen site. This textural distinction is the result of a mosaic of fen plant communities. In contrast, old fields were lighter toned and characteristically harbored numerous small scattered trees. Junipers, typical of old fields or well-drained substrates, appeared dark and well defined.

A few fens displayed a peculiar splotched appearance. Prominent lightly colored blotches frequently were contrasted against a deep homogeneous gray tone. Later upon field examination, these fens were found to contain a series of mounds, possibly of archaeological significance.

Aerial photos were also useful in detecting disturbance. If a fen occurred within the confines of a sharply delineated field, it was suspected as pastureland. In some cases, livestock trails (thin, white lines), stock-trampled areas (white splotches with radiating lines), barns, feeding bunks, or even occasionally grazing animals could be seen on some photos. Rows of parallel lines usually indicated past cultivation attempts or mowing, induced by machinery. Even more noticeable were drainage ditches.

When a potential fen site was identified with a significant forest buffer, it usually proved to be little disturbed. A combination of various textured, dark tonal qualities and an irregular boundary were the best clues in locating fens on black-and-white prints.

Topographic maps of the 7.5-minute series and 15-minute maps of the study area were examined. While 7.5-minute series quadrangles are generally precise in depicting wetlands, seepage associated with fens is never illustrated. Fens in the study area are too small to be represented by conventional wetland symbolism. Quadrangles were advantageous in detection of potential fen regions. They were less valuable in predicting precisely where new fens might be discovered during early phases of the study, prior to recognition of hydrogeologic parameters.

Initially, potential fen terrain was assessed from quadrangles by identifying valleys with permanent streams, irregular green-white (forest-opening) overlay, and the presence of springs. But this criterion had pitfalls. Perennial streams were not always represented on smaller critical tributaries. In a few situations, openings on a quadrangle represented fens. On others, even irregularly shaped openings were later determined as old artificial clearings. Sometimes an isolated green patch in a field proved to be a fen; or, conversely, an isolated woodlot. Lastly, even though all fens have some kind of spring flow, not all springs harbor fens; thereby the mere presence of springs on a topographic map was not sufficient to discern whether fens might be present.

Once in the field, 7.5-minute quadrangles were rather useful for predicting new fen localities. The first step was to calculate the elevation of plotted fens on a given quadrangle. Secondly, through close scrutiny of other features (topographic position, valley width, stream order, slope relief), one could compile a list of similar features. Remaining valleys on that quadrangle could be scanned for similar conditions. Faulting, fracturing, jointing, and other geologic phenomena necessitated examination of each individual quadrangle.

Hydrogeologic modes of fen occurrences were of importance in further refining inventory methods and developed as the inventory progressed. Fens are predominantly located in upper reaches of gaining streams characteristic of deeply dissected basins where there is thick residuum derived from Potosi and/or Eminence Dolomite (Upper Cambrian strata) overlying uplands and valley sideslopes. Deeply weathered residuum derived from these dolomites is presumed acting as an unconsolidated aquifer and responsible for formation of seep-springs nurturing fens. Furthermore, gaining streams in watersheds of relatively small extent on first or second stream drainage orders were most productive.

Along interrupted streams which are most pronounced in slightly dissected basins, fens were infrequent and restricted to gaining reaches. Losing reaches generally lack stream terraces, harbor subsurface conduits which drain surface water, and have greater surface–to–groundwater depths, all detrimental to fen formation.

Topographic position, slope, valley width, and sensitivity to flooding were also important factors. Fens were encountered either at the toe of the slope or base of stream terraces located along the lateral valley walls. In some cases, fens occupied shallow depressions between colluvial slopes and alluvial soils. If fens occurred on side slopes, they were usually gently sloping but could in rare cases be steeply sloping. Hanging fens on steep slopes are the exception rather than the rule.

Valley width is of consequence as it relates to flood frequency. Broad valleys that are subject to backwater flooding immediately upstream from narrows or "shut-ins" [16] rarely harbored fens. Major drainages with broad flat floodplains and narrow bluff-lined corridors lacked fens, except along former stream terraces that are no longer subject to frequent floods. Extremely narrow valleys, subject to flash flooding, never produced fens. Valleys of medium width, with relatively small drainage areas and with sustained base flow that rarely flooded, were most productive.

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[16] Editor's note: A shut-in is a gorge-like narrow segment of a stream valley. The valley is narrower at a shut-in because the stream cuts through highly resistant bedrock along this reach. The valley is broader both above and below the shut-in.

Compilation of available information accounted for 16% of all located fen sites. Herbarium label data were helpful in relocating fens where Steyermark had collected specimens. Soil and geologic map visibility depended primarily upon mapping scale and availability. Of particular value were leads given by area root diggers, timber cutters, and persons who harvest hay.

If the inventory would have relied solely on accumulating available information and literature sources, 84% of all the fens would have been missed. Nineteen new qualifying fens, 20 new notable fens, and 101 new nonqualifying fens would have been overlooked. This clearly demonstrates that new inventory methodology (examining topographic maps, aerial photos, aerial surveillance, and hydrogeologic criteria) is superior to previous inventory methods.

Reese, G.A. 1982. Identification of Missouri prairie communities using aerial photography. ***Natural Areas Journal*** **2:14–16.**

Examination of aerial photography is a proven and efficient technique to identify areas of potential natural quality. Among the most useful and readily available aerial photographs are those contracted by the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service (ASCS). [17] This photography was initiated in the late 1930's and has continued to the present. Prior to 1979 (in Missouri), aerial photography was flown approximately every 7 years yielding conventional black-and-white prints. Beginning in 1979, additional photography has been contracted twice yearly to provide color 35-mm transparency coverage.

Both types of photography have been used successfully to identify remnant prairie communities in a natural areas inventory of four west-southwestern Missouri counties. However, repeatedly accurate identification of prairie communities is limited to photography obtained during specific times and/or under specific conditions. The objectives of this paper are to (1) discuss the photo interpretive techniques used to identify prairies and to (2) identify flights which were found to be particularly effective in locating prairies. Potential exists for applying these techniques to prairie inventories in areas outside of west-southwest Missouri.

Reliable identification from photos of prairie communities is a consequence of the season of growth, or phenology, of prairie grasses. Much of Missouri's native prairie has been either plowed for row crops or converted to "improved" cool-season haymeadows or pastures. These cool-season grasses have their optimum growth in the spring and fall and are virtually dormant during the hot summer season. However, native prairie grasses are warm-season active, breaking dormancy or germinating later in the spring and entering dormancy earlier in the fall than the cool-season species. This difference in season of optimum growth of the grasses is the key in differentiating prairies from "improved" cool-season hay land or pasture.

Examination of black-and-white aerial photographs dating from 1936 through 1980 has shown that the most effective flight dates to make this differentiation for west-southwest Missouri occur between the first of July and mid-August. On photos taken before July 1, the grey tones of communities dominated by cool-season grass nearly matched the grey tones of native prairies. On photos taken between mid-August and mid-September, many prairies had been hayed and were easily confused with cropland. [18] After mid-September, prairie once again resembled cool-season communities on the photographs, despite their characteristic rust color which is apparent from the ground. The optimum flight date for

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[17] Editor's note: The ASCS is now the FSA (Farm Services Agency).

[18] Editor's note: Haying of native prairie is nearly non-existent in Illinois, so this issue is of almost no concern to the Illinois Natural Areas Inventory.

identifying prairies from black-and-white photos appears to be early in the month of July, prior to haying. Prairies dominated by cordgrass (Spartina pectinata) were less reliably located because they may be hayed more than once a year and appear as cropland after haying. There is no optimum flight date for identification of this wet prairie community type.

Summer photographs of certain crops (e.g. corn or milo) may be confused with the dark tones characteristic of prairies. The interpreter must look for clues on the photograph to eliminate these areas. On ASCS photographs, acreages are frequently calculated for croplands but not for hay or pasture lands. The ASCS farm record may also indicate if a crop has been planted. Plow lines are usually evident on cropland, while hay or pasture land has a homogeneous, smooth texture. Old fields dominated by foxtail grasses (*Setaria* spp.) share the dark tone of the prairie communities but usually have a blotchy appearance which is not characteristic of good quality prairie.

Comparisons of the same area on two or more separate flights is an effective method of eliminating questionable sites. Particularly good comparisons can be made between black-and-white photography and the ASCS color slides. These color slides are usually more current than the black-and-white photography, though of lower quality. Poor resolution, low contrast, and tilt distortion are frequently characteristic of the color slides. They are taken once in the spring (for wheat) and again in the summer (for grain crops) and both may be useful in identifying prairie. [19] The flight date and conditions on that day play an important part in their usefulness.

Examination of flights ranging from March through August, in both wet and dry years, showed that very late June to mid-July photography in a drought year (i.e., 1980) provided exceptional differentiation of cool-season versus warm-season communities. Prairies have a dark green "signature" unlike most other types of vegetation. They are easily separated from the brown, cool-season hay or pasture lands. This differentiation is subtle to non-existent in wetter years (i.e. 1979 or 1981) on May to August photography.

March or April color photography in any year may provide an indication of the amount of cool-season grass invasion in a native prairie. This is done by evaluating the amount of green on a potential site. Since warm-season grasses are still dormant at this time, the green hue represents either the cool-season grasses or early spring forbs. An abundance of either may indicate low quality prairie. These spring photos are potentially useful in identifying prairies when no other photography was suitable. The interpretive clues used with spring photos were the opposite of those used with summer photography. Light brown, vegetated sites (as opposed to light brown, plowed soil) with little or no green represented native prairie communities. Darker hues of brown were usually indicators of overgrazed prairie or

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[19] Editor's note: In Illinois there was normally on only one flight per year in each county. This program of taking slides each year has been supplanted by annual high-altitude digital photography, but the old sets of slides are still available for viewing at the Farm Services Agency.

old fields. Since cool-season grass invasion on prairies is common in west-southwest Missouri, it was frequently difficult to separate prairie from "improved" pasture using spring photos alone.

Late June to mid-July drought year photography can also provide an index to the degree of cool-season grass invasion on native prairie. Noticeable areas of brown vegetation indicate poor dominance by warm-season grasses and may be disturbed and/or invaded sites. Conversely, a deep, homogeneous green hue may indicate overabundance of prairie grasses and low forb diversity. Maximum diversity of native flora is generally indicated by intermediate hues.

The value of color photography in prairie inventories is readily apparent using one Missouri county as an example. Use of black-and-white photography only in Vernon County, Missouri, led to the identification of nearly 190 potential prairies ranging from 3 to 1,300 acres. This total was considered conservative in that only obvious sites were mapped. Subsequent examination of summer (1980) color slides yielded an additional 130 prairies. These usually included sites which were partially seeded to or invaded by cool-season grasses, grazed prairies (especially with woody invasion), or prairies smaller than about 15 acres which were easily overlooked on the black-and-white photographs. Similar results were obtained in the other three counties inventoried. While it is felt that most of these prairie could have been identified using the color slides alone, cross-checking between the two sources helped ensure accuracy and eliminated the need for an aerial survey to verify the photo interpretation.

A particularly effective method of both checking accuracy and aiding in the identification of prairie communities is to map all known prairies prior to a search. One should become familiar with the appearance of these prairies. As a county is progressively inventoried, these prairies should become readily apparent. They may subsequently be used as reference sites or training samples for selecting other potential prairies in the same area on photographs or slides.

Reese, G. 1988. Recon survey method: Prairie in Missouri. Unpublished memo. Michigan Natural Features Inventory, Lansing.

In the prairie rich areas of Missouri, aerial photography has proved to be an effective tool for identifying prairie remnants. However, in comparatively poor density areas (i.e., northern Missouri), no prairies may be presently known that can be used as references for the identification of additional occurrences. In such cases, it has proven effective to fly systematic autumn aerial surveys in a four-seater aircraft, to identify relict prairies by the distinctive golden hue of warm-season grasses.

The most cost effective method of conducting these surveys is to use two observers, on opposite sides of the plane, who must each scan a two-mile wide band of land as the plane flies at low speed (85–90 knots). Altitude should be sufficiently low to allow for detection of small tracts, yet high enough to see over the canopies of any trees. Approximately 1500 feet above sea level (roughly 900 feet above the ground) has proven to be effective. Direction of flight is important because the gold hue shows up best when viewed from the direction of the sun. However, it is not always practical to view from this direction since the plane must follow predetermined transects across the region (e.g., county) being surveyed. It is feasible to get the pilot to circle suspected prairies and verify hue while passing to the south of them. In general, north-south lines were best since both observers could observed perpendicular to the sun's rays (assuming a mid-day flight).

Because cemeteries sometimes have prairie remnants, it proved helpful to prepare for a flight by marking all cemeteries within a flight area onto a map showing flight lines. In Missouri, county highway maps were used for this. Each observer was given such a map, while the pilot had a map with the flight lines drawn, the direction of flight indicated on each line and the lines numbered by order of their completion.

Schennum, W.C. 1986. A comprehensive survey for prairie remnants in Iowa: Methods and preliminary results. Pages 163–168 *in*: G.K. Clambey and R.H. Pemble (editors). *The Prairie: Past, Present and Future — Proceedings of the Ninth North American Prairie Conference*. Tri-College University Center for Environmental Studies, Fargo, North Dakota.

Following are excerpts from this paper:

Abstract.—The Iowa Natural Areas Inventory (INAI) has located and gathered basic ecological data on Iowa's western Loess Hills prairies, several northeast Iowa hill prairies, and large black-soil prairies. Examination of infrared aerial photographs taken during cool seasons provides the most comprehensive survey for potential prairie sites. On these photos, potential prairies are gray (duff accumulation) while Eurasian grass meadows are pink (photosynthetic activity). Reports based on direct field examination were solicited from county conservation boards and county assessors' offices. The latter have records of prairies granted property tax exemptions through Iowa's "Slough Bill." Thirty-four previously undocumented prairies have been reported by county conservation boards and 15 by the tax assessors. Hundreds of undocumented potential prairies have been located on the infrared photographs. The most common locations found to have potential prairies are the following: (1) undrained pothole wetlands, (2) areas cut off from croplands by roads and railroads, (3) cemeteries, (4) prairie hayfields, and, especially, (5) steep slopes in stream-dissected landscapes.

Methods

Infrared (IR) photo analysis provides the most comprehensive means for locating prairie remnants, as well as related communities such as savannas and sedge meadows. Rolls of color infrared transparencies were examined using a specialized light table and microscope.

Potential prairie sites are identified on the IR photos by their color. Because the flight periods for the photos were during cool seasons, especially in spring, potential prairies, dominated by warm season grasses, appear gray from the accumulation of duff. In contrast, cool season grass meadows appear pink or red from active photosynthesis during spring (or fall). Prairies invaded by cool season grasses show both pink and gray tones, with the percentage dependent on degree of disturbance.

Each potential prairie was outlined on a topographic map and described as follows: topographic location, size, surrounding land use, and site features. A hypothetical example is "T98N R40W S14 NE4NE4, 10 acres on a long narrow west-facing slope above river, cropland to east and west, pasture north and south, high quality prairie potential (solid gray tones)." All written records were filed by county for future field inspection by INAI staff or pre-screening by county-level naturalists.

Records of prairie remnants confirmed by field sightings were garnered from two directly solicited sources and by reports from residents interested in prairie throughout the state.

These reports confirmed or added to the IR analysis records. Iowa has an extensive system of county conservation boards; 98 of the state's 99 counties have such boards and many are actively interested in the identification and protection of prairie remnants. Records of prairies, specifically those owned by the boards themselves, were sought through an article in the monthly statewide county conservation board newsletter. The second directly solicited source was a prairie record form sent to all 99 county tax assessors. Through Iowa's 'Slough Bill,' landowners are allowed to remove native prairies from the property tax rolls each year by registering their prairie tract with the county assessor. Sites are confirmed as prairies by county officials able to identify prairie.

Results and discussion

Thirty-four previously undocumented prairies were reported through the canvass of county conservation boards; 15 new prairies registered on the Slough Bill were reported by county tax assessors. Over 200 additional prairies are known from a variety of secondary sources, including state scientists, wildlife biologists, county conservationists, and knowledgeable local residents. The infrared analysis identified over 1,000 potential prairie sites. However, over 80% of these sites have not been field checked for quality, so as yet an estimate of the true total number of newly discovered prairies is not available.

The combination of the IR photos, other secondary source searches, and the field work completed to date illustrates that all methods of searching are needed to conduct a truly comprehensive prairie inventory, as the IR analysis by itself does not guarantee a complete or up-to-date record. One problem with the infrared technique is that it cannot clearly distinguish prairies from unmowed brome fields. The latter accumulate heavy duff loads which obscure the new photosynthesizing growth in spring and so appear the same gray color as prairies on the IR photos. For small sites, the low resolution capacity of the IR (due to the small scale of the photo—at least two whole townships per frame) also makes it difficult to distinguish prairies from Eurasian grass meadows.

Small size and resolution problems cause prairies to be overlooked on IR photos. For example, despite an intensive IR search of Waterman Township in O'Brien County in northwest Iowa, a 5-acre (2-ha) gravel kame prairie was completely overlooked. It was discovered while looking at numerous other larger areas of lesser quality that were identified by IR analysis. Similarly, a 17-acre (6.9-ha) level black-soil prairie in nearby Buena Vista County was overlooked on the photos (fortunately, it was known from a county board report). Areas of high quality prairie on the site were overlooked because the resolution of the IR photo did not clearly distinguish the prairie patches within large areas dominated by brome and timothy.

Far more important than these problems is the fact that even 1978 and 1980 photos are out of date. Land use changes are so rapid that a number of prairies identified in these photos may now be destroyed or degraded. Field checks of IR-identified areas verify this fact. For example, a 40-acre (16.2-ha) prairie pothole complex in Palo Alto County in northwest Iowa was drained and plowed in 1982. Several pastured prairies on hillsides in northwest Iowa appeared covered with prairie grass duff in the photos, but 1984 field checks showed that many of these areas had now been over-grazed and some were completely destroyed by aerial spraying for thistle control. However, if only 10% of the total number of recorded prairies prove to be of high quality, the time spent in IR photo analysis is justified. Covering the same area using aerial surveys would be far more expensive, and complete reliance on ground survey reports would exclude sites which are remote or in areas lacking local naturalists.

The best justification for the value of IR analysis comes from secondary source field reports and INAI staff field checks. To date, IR-identification has been reinforced for many sites by these two corroborative methods, and several of these sites have proven to be high diversity, high quality prairies, not simply prairie grass stands devoid of prairie indicator forbs. For example, both the steep hillside limestone prairie in Cerro Gordo County, largest of its type known in Iowa, and the largest and highest quality bur oak savanna–prairie complex known in the state (in Clay County) were noted in the IR analysis as areas of potentially high quality prairie (or savanna) communities. This was verified by reports from county conservation board officers in both counties during the time of the IR analysis and by subsequent field checks in the 1984 growing season.

In many cases, IR analysis also discovered previously unknown prairies of high quality. For example, a 50-acre (20.2-ha) prairie–pothole complex was discovered in the IR analysis of Cerro Gordo County. Isolated along dirt roads in a heavily farmed area, this prairie had been completely unknown. In fact, upon completion of the 1984 field season, 15 new IR-identified sites were shown to be high quality prairies and an additional 20 previously undocumented IR-identified sites corroborated by secondary reports were shown to be of high quality.

Shortridge, J.R. 1973. Prairie hay in Woodson County, Kansas: A crop anomaly. *Geographical Review* 63:533–552.

Following are excerpts from this article:

Prairie hay is a crop anomaly in the humid, relatively flat region of southeastern Kansas, yet it ranks behind only wheat, soybeans, and sorghums in acreage. In Woodson County, the center of the production area, more land is occupied by prairie hay than by any of these crops; in fact, almost a third of the total acreage harvested there is in native grasses. This paper will explore the persistence of the relic crop in the rural landscape of Woodson County.

Soils and slope considerations

Little direct work has been done on the Woodson County hay industry. Two general physical surveys by the state agricultural experiment station and one master's thesis on the transition from cropping to grazing in this area exhaust the literature. All three studies suggest that at least partial correlations exist between the characteristics of the land and the distribution of hay. Hay was thought to be concentrated on steep slopes, on thin, rocky soils, and on claypan areas in the county. During my field work in the summers of 1967 and 1972, when I interviewed approximately a hundred local people both in and out of the hay business, I also found that these opinions were widely held. Physical factors were the first ones mentioned when the location of prairie hay was discussed. To examine the relationship between the location of prairie hay and the physical characteristics of the land, the prairie hayfields in the study area were field mapped with the aid of aerial photographs from the local office of the United States Agricultural Stabilization and Conservation Service. The results were then compared with published data on soil type, generalized soil groupings, and slope.

Soil type

In Table II the areas of hay are compared with various soil types, which are listed in order of increasing hay percentages. The low figure for the Bates stony loam is attributable to sandstone and shale fragments on the soil surface. The abundance of stones prevents the use of mowers and causes the soil to be used almost entirely for pasture. The other six soils in the table have extremely similar percentages in hay; even a small increase or decrease in hayed area could move a soil type from one end of the list to the other.

The physical characteristics of the six soils vary greatly, despite the similar hay percentages. The Bates types, for example are relatively infertile, for they have only a thin layer of topsoil and they lack organic material. The Parsons and Woodson silt loams do not have these liabilities but suffer instead from claypans 10 to 12 inches below the surface. The pans form an effective barrier to moisture penetration and thus produce a "shallow" soil that waterlogs easily after rains and lacks moisture during moderately dry periods.

Regardless of their differences the Parsons, Woodson, and Bates soils are well suited to hay production. Prairie grasses, being native to the region, are better adapted than most introduced crops both to infertile soils and to alternating wet-and-dry cycles. Thus, the correlation between prairie hay and poor soil appears correct, but it does little to explain the extreme concentration in Woodson County. The soil types involved are widely distributed throughout eastern Kansas.

Another problem with a facile correlation between hay and low-grade soils is the presence of significant numbers of prairie hayfields on the Labette silt loam and the Summit silty clay loam — the two best upland soils in the county. The topsoils of both average a respectable 14 inches in depth, and they are inherently fertile, neutral in reaction, and free from claypans. Thus, hay has a general distribution on the various soils of Woodson County. It is precluded only on the rock-strewn surface of the Bates stony loam.

Slope

In field interviews slope was mentioned frequently as a reason for the localization of hay in Woodson County. The rationale was simple. Hay would be found on moderately sloping land — land gentle enough to be mowed yet too steep to be cultivated. When acreages of slope classes are compared with acreages of hay, however, the results indicate that contrary to popular belief slope is not a primary factor in the distribution of prairie hay. The highest percentage of hay is found where it was least expected: on nearly level ground. The 17.0 percent figure for the steepest slope category is probably a partial substantiation of the popular hypothesis, but the conjecture still cannot be considered proved because hay is abundant in all slope classes.

It is strange that the majority of people I interviewed believed that prairie hay was concentrated in Woodson County because of physical factors. Even farmers who admitted that their own hay land would be suitable for other crops made the claim. Apparently a lore has grown up analogous to the one that ascribes the existence of the nearby Flint Hills grazing region to rocky soil. Walter M. Kollmorgen and David S. Simonett identified the misconceptions of the Flint Hills belief, and a similar noncorrespondence of land use and physical conditions seems to exist for prairie hay. The Woodson County assessor estimates that more than 70 percent of the local hay meadows could be cultivated.

Capital requirements

Hay is also favored in real estate taxes. The county officially regards all prairie hayfields as native pasture for tax evaluation. The prairie hay (native pasture) assessment is 79 percent of the tame pasture and upland cultivated categories and only 50 percent of the bottomland cultivated category. Hay growers thus enjoy sizable tax advantages over those who graze sown grasses and over those who cultivate the soil.

Pasture conservation

Grazed pastures tend to become weedy after several years of heavy use, for cattle eat the more desirable, usually more nutritious species and leave the less desirable ones. The nutritious grasses thus suffer a loss of vigor that lowers their ability to compete, and they are gradually replaced.

The only way to restore weedy pastures to full stock-carrying capacity is to remove the livestock. Many farmers in Woodson County have found an efficient way to utilize the restoration period: they simply convert the idle pastures into hayfields. Since only one hay crop is taken annually, in late July or early August, ample time exists for grass growth before and after cutting. The first hay crop is of rather poor quality owing to weediness, but subsequent ones improve. After 5 years or so, the original prairie vegetation is fully restored. Some of the farmers use this method irregularly and only on their most abused pastures. Others follow a regular cycle and have as much land in hay as in pasture and alternate haying with grazing. The pastures can be grazed more heavily than is normally recommended, since they will be idle half of the time. Overall, the result of this simple system is beautiful pastureland, large hay crops, and no idle land. Thus pasture conservation explains in part the wide variation in the size of total operations of the small hay producers.

U.S. Department of Agriculture. 1989. Procedures for the wetland inventory of Winnebago County, Illinois.

Editor's note: The following text describes the procedures that were used to map wetlands on aerial photography in the USDA office in Winnebago County. This is an edited copy of the instructions, which are on file with the Winnebago County Soil and Water Conservation District in Rockford.

Step One:

Wetlands on the National Wetlands Inventory (NWI) map are transferred to the SCS base map. If it appears that the wetland is still present, the area is outlined in black, and a red checkmark is placed next to the site.

Note: The red checkmark signifies that the site is identified on the U.S. Fish and Wildlife Service's NWI map.

Step Two:

Soils in the identified sites are then checked with the county's hydric soils list. If the soil is on the list or has hydric inclusions, place a green checkmark next to the site.

Note: The green checkmark signifies that the site has an identified hydric soil or hydric inclusion.

Step Three:

Review the soils map for other hydric soils that have the same types of ground cover, or possible wetland areas based on hydric soils and soils with hydric inclusions. If areas are found, outline them in black and put a green checkmark only.

Note: Areas with only a green checkmark and no red checkmark mean that they were not on the NWI maps.

Step Four:

The base map with identified sites is now compared to the ASCS compliance slides. Look for the following:

A. Do the identified sites show up consistently? If irregularities show up, record the year in blue next to the site.

B. Have sites been farmed? If irregularities show up, record the year in blue next to the site.

C. If sites were forested, are the trees still there? If not, when were the stumps removed? If irregularities show up, record the year in blue next to the site.

D. Once the ASCS slides have been reviewed, the base map is marked with the correct FSA wetland symbol.

Note: A green checkmark with a slash will be used to document soils with hydric inclusions only.

Other assumptions to consider as of 12-21-89:

Small rivers, creeks, ditches, or drainageways that are wetlands will not be marked on the base maps. Note: When a non-cropped area associated with any of the above is wide enough to circle, it will be delineated on the base map and correctly marked with a "W." These areas may be wetlands.

Narrow fence rows (75 feet or less in width) will not be marked.

Any mined areas that appear on the NWI maps and are under some restoration or mitigation plan will be marked as wetlands. All other mined land appearing on NWI and not under a plan will be marked as "AW."

Any area that is on a NWI map and is not located on hydric soils or soils with hydric inclusions, but that does appear three or more out of five years on ASCS slides will be marked. These areas will not have a green checkmark.

All pastureland areas that have soil types which are hydric will be considered wetland. These areas will have a green checkmark and will be marked with a "W." Wet pastures will be determined to be wetlands, and they may be farmed under natural conditions regardless of the natural vegetation. Woody vegetation cannot be cleared from a site to make it farmable.

Farmed wetlands: If an area in a cropland field appears to have severe crop stress due to wetness, and this evidence appears on a majority of the years of ASCS slides, the area will be marked "FW." However, if there is local knowledge that the area has been drained prior to 12-23-85 by ditches or tiles, and the ditches or tiles are at an elevation or grade below the bottom of the area in question, the area will be marked "PC." If there is not sufficient local knowledge to determine the extent of the drainage of the site in question, the site will be marked "FW" and any drainage will be further documented at the time of the wetland determination.

W = Wetland
PC = Prior converted
FW = Farmed wetland
AW = Artificial wetland

White, J. 1981*a*. Color infrared photos of the Loess Hills in Iowa. Unpublished memo. The Nature Conservancy, Arlington, Virginia.

These are notes on interpreting 1:80,000 color infrared transparencies of spring photography.

The native prairies look gray-green. Other grasslands are red.

Orchards on ridges are prominent.

Grazing trails are apparent only if very large. Eroded, bare slopes are conspicuous.

Resolution is not as good as with ASCS photos. Even with magnification, detail cannot be seen as well as with conventional-altitude black-white panchromatic prints.

These April photos show deciduous trees with leaves. Cedars are very dark red. Brush appears as very fine textured features.

Sharp changes in vegetation often are apparent across fences. Shifts in tone and color are generally gradual on slopes — a response to soil moisture and grazing intensity.

White, J. 1981*b*. Iowa Loess Hills survey — Interpretation of infrared aerial photographs. Unpublished memo. The Nature Conservancy, Arlington, Virginia.

The Iowa Geological Survey's color-infrared transparencies (1:80,000 scale) of the Loess Hills proved very useful for identifying prairies because they are current, they have adequate resolution, and they are excellent for discriminating prairie from other vegetation types, including other grasslands.

This type of color infrared film records part of the visible spectrum as well as near-infrared wavelengths. Green light is recorded as blue; red wavelengths are recorded as green; and infrared radiation is red on this film. Since healthy vegetation is highly reflective of infrared light, green plants appear as red on this film. The following paragraphs describe the appearance of various vegetation and cover types on these infrared photos, which were taken in early spring (April 1980).

Green, growing (photosynthesizing) grass or other herbs.—Red or pink. Bright, solid red fields usually are winter wheat, which is the main crop growing in early spring. Golf courses, lawns, and well-maintained cemeteries are red. Green (growing) grass that (1) is closely cropped by livestock, or (2) is mixed with dead grass (duff), or (3) is just beginning to green up is pink, instead of red on the photos.

Prairie.—Blue-green to olive green. Native prairie (dominated by warm-season grasses) is dormant in early spring, so it is not pinkish. A light blue-green tone indicates thin vegetation (grazed, or very dry); darker-toned prairie has thicker vegetation (taller grass). Grazed prairie that has been invaded by brome grass, bluegrass, and other exotic or native cool-season grasses is pinkish because it has green, photosynthesizing plants. Former prairie that has been completely replaced by exotic forage grasses because of prolonged heavy grazing or because of disking and seeding is pink. The lower slopes and draws in rolling, pastured prairie are usually pink. In the most heavily grazed prairie, the pink extends rather far up the slope; blue-green prairie persists only on the hilltops in these situations.

Deciduous forest and thickets.—Dark gray-green. Individual open-grown trees are dark spots. Brush (such as clones of dogwood invading a prairie) is finer-textured than forest.

Evergreen trees (conifers).—Red. Red cedars (junipers) are the commonest evergreens and are exceptionally dark red.

Bare soil.—Usually blue-green, ranging from light to dark. Wet soil is dark; very dry soil is light. Mud is blackish. Bare sand (river bars, dunes) is whitish. Plowed ground shows lines and rectilinear shapes and boundaries. Fields with cornstalks or bean stubble are lighter than bare soil.

Roads, quarries, urban areas.—Light-toned, highly reflective.

Water.—Usually dark blue-black (inky). Clear water is darkest. Muddy water is lighter because of reflection by suspended sediments. Water that is reflecting light from the surface (because of the angle of the sun in relation to the camera) is turquoise-blue to silver.

Fire.—Smoke and flames are colored much as in conventional color photos. Prairie or other tall vegetation that has been consumed by fire is black.

White, J. 1982*a*. Niobrara Valley Preserve, Nebraska — Interpretation of color infrared aerial photographs (description and interpretation of 230-mm transparencies). Unpublished memo. The Nature Conservancy, Arlington, Virginia.

Following is an excerpt from this memo:

I made the following notes while quickly scanning all the false color infrared aerial photo transparencies on file at Niobrara Valley Preserve. The transparencies are 1:20,000 scale, 9-inch square photos taken with a Wild RC-8 UAG lens, 550 nm yellow filter, on Kodak 2443 film. (The photos have "10,000-AG" in the lower right of the first frame of each flight line. Does this mean 10,000 feet above ground? The plane had a radar altimeter.) Photo 1-1 was taken at 11:35 a.m., July 11, 1982; all the photos were taken on or very near this day.

Ground resolution is about 2 to 4 feet. Smaller objects can be resolved if they are especially contrasting. For example, the paired tracks of wheeled vehicles are easily resolved.

Plants with light green or highly reflective leaves appear to be bright pink on the photos instead of dark red. Examples include smooth sumac and wild grape. In the other extreme, bur oak has very dark green leaves, not especially reflective; these are dark red on the photos. I believe that living plants under stress may be more pink or lavender.

The sandhills prairie is generally a mottled gray-green. The prairie must have been predominantly dormant when the photos were taken. This gray-green color varies from light to dark, depending on how dense the vegetation is. Grazed areas or places where the vegetation is especially thin such as on the tops of dunes are lighter because there is less leaf material, so that more of the sandy soil shows through. Areas that have been protected from grazing or that have denser dormant grass are darker gray-green. The prairie is speckled with pink or red spots. Many of the pink areas are depressions among the dunes that apparently have grass that has greened up. Other red or pink areas are shrub thickets. Sumac thickets appear to be bright pink. Snowberry thickets probably are about the same but a bit darker. Plum thickets are dark reddish and have a definite roughened texture because the plants are bigger.

Much of the sandhills prairie has a pebbly texture. This is especially true in areas that are grazed so much that the canopy cover is not dense and continuous, but even denser areas have a very fine pebbly appearance. The pebbles are on the scale of 1 m or less, and I suspect that they are mostly bunches of grass.

The two evergreens are ponderosa pine and eastern red cedar (a juniper). On one photo where I compared pines and junipers, the two could be separated to a certain degree on the basis of color. The junipers are light chocolate brown, and the pines are more reddish. Elsewhere, I believe that this distinction does not hold true. In general, the pines are taller, with larger crowns; the crowns have a somewhat more roughened texture because the limbs of the individual tree crowns are more distinct and consequently make more shadows among the crowns. In contrast, the cedar crowns are more dense and even, fine-textured. The pines generally have a more rounded crown; old cedars may also have rounded crowns, though they are somewhat more conical in general. The shape of the crown is distinguished better by looking at the shadows cast by the crowns rather than by looking at the crowns themselves. However, the shadows on these photos are not very large and distinct because the angle of the sun is relatively high.

Pines out in a savanna often appear to have a more reddish cast than ones on canyon slopes, but I think that this may be largely from shadows rather than a difference in absorbtivity of the foliage.

If something is partly obscured by the overhanging canopy of a tree, the hidden feature may be visible on the adjacent photo because of the different camera angle.

Recently plowed, unvegetated ground (bare soil) is gray-green. Moist areas are darker; dry areas are whitish. Sandy or gravelly soil is highly reflective and whitish.

Grain bins, metal roofs, and other silvery surfaces are silvery.

Hay bales are straw-colored, yellowish with a tint of gray-green, usually; they can also be silvery or dull gray.

Cattle are sometimes apparent on the photos. They look like elongate fly-specks. Some are straw-colored, some are dark.

Prairie dog mounds are white speckles. They vary from 1–2 mm across (actual size on the photos) to so small that they may not even be visible on the photos.

White, J. 1982*b*. Notes on interpretation of color infrared aerial photos to find prairies in Iowa. Unpublished report. The Nature Conservancy, Arlington, Virginia.

These observations were made while searching for prairies on aerial photos. The photos were 1:80,000 color infrared aerial transparencies from late fall and early spring flights.

Cropland

Freshly plowed or disked soil is darker than soil that has not be recently cultivated. Freshly turned soil is moist, so it is dark. (Soil cultivated several days before the photo was made has had time to dry on the surface.) Newly plowed ground appears as dark "green" — a sort of "greenstone" green (not a true green, but the most nearly green color of any colors on the photos.

Moist ground (bare soil, unvegetated) is darker than dry ground. Dry ground is whitish. Moist spots in plowed fields usually have curved boundaries, corresponding to the edges of wet depressions: they look like mud-puddles. On very flat ground, the wet areas are streaked because of furrows in the fields: the dark wet ground extends out from the main body of wet ground along plow lines.

Much (approximately 10% or 20%) of the cropland has a pinkish cast from growing vegetation in both November and April photos. This is from weeds — probably a lot of spring ephemeral annuals such as mustards and annual grasses or broad-leafed weeds in the fall.

Winter wheat has a very dark or bright-red color. Also, it is rather dense and occasionally shows the pattern of the seed drill. That is, there are sharp edges or curved areas where the drill stopped or turned. In contrast, weeds show more variability according to topography and soil moisture. The pink color of weeds is fainter in the higher, drier, more eroded areas. This same color pattern is apparent to a lesser extent with wheat.

The strip-like pattern of rows of corn in fields of partly harvested and partly unharvested corn can be detected in some fields from November photography.

Burned cornfields (after harvesting) have a characteristic color and pattern. The burned areas are blackish, and these blackish areas extend down rows in a jagged pattern like the teeth of a comb. This is because the fire extends farther down some rows of corn stalks than others.

Pastures and cool-season grasses

If a pasture is bright pink or red in the draws, this is Kentucky bluegrass. The pasture is so heavily grazed that, if the knobs show prairie grass, then it is probably just prairie grass with very few forbs. Such pastures can generally be assumed to be so heavily grazed that they would not recover to a natural species composition within the foreseeable future.

If a pasture has a pinkish cast throughout, then one should suspect that it is just dominated by closely-grazed bluegrass. The pasture is pinkish instead of reddish because there is not very much photosynthetic material. That is, the pasture is so closely cropped that there is little green grass. Instead there is bare ground, dead grass stems, or dead unpalatable herbs.

If a pasture is close-cropped, it is light pink, but not a duffy pink. The lightness is caused by the lack of photosynthetic material — not by the presence of much prairie grass. The distinction can be made by looking for the clear, clean appearance of close-cropped grass. It does not have the texture and mottling or three-dimensional quality of taller grass.

Close-cropped grass has a lighter appearance than taller grass. The difference in height from grazing is most obvious when observed on either side of a fence that separates grazed pasture from ungrazed pasture.

Even during the growing season for cool-season grasses, cool-season grasses can appear dormant if the photosynthesizing leaves are covered by a thatch of dead leaves from the previous growing season. These grasses have not been grazed, burned, or mowed to remove the dead material. This situation is most apparent with smooth brome and tall fescue in grass waterways and on road rights-of-way.

Pink color in wet bottomlands or barn lots is usually annual weeds such as ragweeds and lamb's quarters. These same species are brown and dormant and give a "prairie" signature early in the growing season before they have started to grow.

Big round bales of hay have the appearance of small pimples in pastures. Though these bales are very large, they look very small on the photos.

Hay bales have a pinkish or whitish cast. I would have expected no pinkish cast from them, but they certainly were pink on some photos.

Round puffs, individual or coalescing, very light pink in color, are bales of hay that have been broken open. These can be inferred by their location, often in close-cropped pastures, near an entrance road or lane and often near a stock pond.

Prairies

Prairie should show tonal mottling in response to soil moisture. Close-cropped pasture is smoother, lighter. It doesn't have texture or "body."

One should look for vegetation patterns that correspond with edaphic situations. In grazed pastureland, pink tongues of cool-season grasses often extend down the ridgetops. On the steepest side-slopes and knobs, light blue-green areas are prairie. On the most heavily grazed pasture, the prairie is limited to small round patches on knolls, if at all present.

A fairly common pattern in pastures is to have a pink stream bottom, olive-green slopes (prairie), and pink (or cultivated) ridgetops. Grazed pastures with prairie grass appear to be common; these probably have potential for only partial recovery. We need to check some of them in the field in the summer, especially ones that have a known history of grazing and recovery from grazing. I suspect that they will have lost much plant species diversity.

I suspect that prairie grass may be perhaps lighter blue-green than weeds, which are darker.

We found many potential prairie remnants on steep slopes and odd corners of properties. A typical situation is a steep, eroded hillside in a corner of a property tract, isolated by a stream. The uncultivated land is too steep and small to be economically cultivated, and it is too isolated and small to be grazed. Consequently it is idle land and appears to be prairie. We found many of these potential prairie remnants (perhaps a big majority) on soil series 179 and 993 in Warren County on E and F slopes.

Small prairie tracts often have small bare spots in them, which are the sides of ravines where erosion is cutting small scarps.

I suspect that some of the brushiest-appearing potential prairies will be some of the most natural because brush invasion can sometimes be evidence of lack of disturbance from grazing. Other times, the brush may just mean that thorny shrubs have invaded a pasture.

Hayden Prairie (a big nature preserve) is very obvious on the November 1980 photography.

We saw but did not mark many small, good-appearing possible prairie patches in brushy pastures. These areas are far less than an acre, and careful searching shows that they are rather numerous. They may not even be prairie, but most likely many of them are stands of prairie grass that have become reestablished in pastures that have not been grazed for several years.

Burned prairie is blackish, with a green tinge. Dense grass produces a darker tone after it has burned than does less dense grass. I interpret this to mean that the charcoal or ashes produced by the burning grass is denser in areas that had denser vegetation. Burned prairie has an irregular, curvilinear edge cause by the advancing front of the fire.

Many of the transparencies show an obvious shift in exposure from one side of the transparency to the other. One side is light (over-exposed or, perhaps, underdeveloped) and the other side is much darker (greener). This causes some problem in interpretation because one must be aware of the exposure shift. A prairie may appear quite pale if it is on the left side of a transparency, but the same prairie may have a rather dark greenish cast if it is on the right side of the next transparency.

Wetlands and water

Areas of emergent wetland vegetation appear whitish in November. I interpret this to be dense stands of dormant herbs.

Ponds range from bright, light turquoise blue, to dark, dull turquoise blue-green, to dark, inky blue-black. I suspect that the light colored ones are the most turbid. These are relatively rare, as are clear black ones. Ponds are silvery white when they reflect the sun. Wave patterns often can be seen in the reflected sunlight.