

Recommended Practices

The Nature Conservancy California (TNC CA) Remote Property Monitoring

Version 2020-09-16

This guidance document lives on a TNC Microsoft Teams site and is updated and improved periodically. These are the practices we share with our monitoring staff and contractors. It is not a set-in-stone set of procedures, but rough guidance in this emerging field.

POLICY GUIDANCE

It is important that land trusts, conservancy chapters, or other organizations responsible for establishing annual monitoring programs work within the Guidance from the LTA and within policies, standard operating procedures and other guidance when establishing their monitoring program and practices.

LAND TRUST ALLIANCE (LTA) GUIDANCE

The LTA *Land Trust Standards and Practices* (revised in 2017)

<http://s3.amazonaws.com/landtrustalliance.org/LandTrustStandardsandPractices.pdf>

provides some guidance on the role of remote monitoring for conservation easements. Guidance is shown in below. *Italicized text is our commentary within the guidance.*

Standard 11: Conservation Easement Stewardship

C. Conservation Easement Monitoring

1. Adopt a written policy and/or procedure for monitoring conservation easements that establishes consistent monitoring protocols and record-keeping
2. Monitor each conservation easement property at least once per calendar year
 - a. If the land trust uses aerial monitoring, conduct on-the-ground monitoring at least once every five years.
 - b. Promptly document the annual monitoring activities for each conservation easement

Standard 12: Fee Land Stewardship

C. Inspecting Land Trust Properties *(No specific guidance related to remote monitoring for fee lands)*

1. Determine the boundaries of land trust properties and physically mark them to the extent possible or necessary
2. Inspect properties at least once per calendar year for potential management problems and promptly document the inspection
3. Address management problems, including encroachments, trespass and other ownership challenges, in an appropriate and timely manner and document the actions taken.

TNC STANDARD OPERATING PROCEDURES

TNC's *Standard Operating Procedures* provide some guidance on the role of remote monitoring for both conservation easements and fee properties.

TNC Policies and Standard Operating Procedures (last checked for updates in July 2020)

Legal: Conservation Easements and Deed Restrictions (rev. June 2018)

III. Monitoring Compliance

B. Monitoring Frequency: Conservation Interests will be monitored at least once each calendar year beginning with the calendar year after the Conservation Interest was accepted or acquired. The first monitoring will occur no more than 15 months after the date the Conservation Interest was accepted or acquired. If a Conservation Interest is monitored aerially, on-the-ground monitoring must occur at least once every five years.

Conservation: Fee Land Management and Inspections (rev. October 2019)

III: Inspections

A. Responsibility and Frequency: Each Business Unit is responsible for inspecting each Fee Management Unit within its jurisdiction at least once every calendar year, and more frequently as circumstances warrant.

B. Methods: Each inspection must include a visual inspection, with on-the-ground physical inspections as the site warrants. Inspection methods may be tailored to the scale and accessibility of the subject Fee Management Unit (such as fly-over, drive-by, float-by, aerial photography, satellite imagery, remote sensing). Sources of any information gathered and used in the monitoring report from outside organizations - for example, aerial photos or government reports - must be clearly identified. Inspections may be made by staff or volunteers, partners or contractors as long as they are trained in the requirements of this SOP.

TNC LEGAL: FAQs and GUIDANCE

Excerpts from additional internal TNC best practices regarding monitoring and inspections provide additional guidance and framing for remote monitoring.

Frequently Asked Questions: Conservation Easement and Deed Restriction Standard Operating Procedure (Updated February 2020)

MONITORING COMPLIANCE

Are remote inspections still permitted for certain conservation interests or in certain circumstances? I see that the Optional Monitoring Situations section that was in the old SOP has been removed. That section permitted reviewing aerial

imagery as appropriate in place of ground surveys. I don't see any mention of remote inspections or aerial imagery in the new SOP. This option was quite useful for conservation interests that are particularly difficult to access.

The drafters of the new SOP removed specific references to how monitoring should be completed. It is up to the BU to decide on the best approach to monitoring – so if the BU determines aerial imagery is best based on the circumstances such as the size, accessibility, and uses of the property, then aerial/remote imagery will be acceptable. Note that aerial/remote imagery that wasn't produced specifically for monitoring of the property should meet the following standards:

- a. the monitor can identify the location of the property on or within the image from visible landmarks such as peaks, roads, water bodies, etc. or with an overlay of the boundary using GIS, and
- b. the "remote-sensing" images were taken within the calendar year for the monitoring report, and
- c. the source of the imagery and the date it was taken are noted in the report.

Additionally, remote imagery must be copied, printed or otherwise stored as part of the monitoring report, and the location of the property should be depicted within the imagery.

Guidance for Fee Inspection Reports (Updated February 2020)

REQUIRED FIELDS

1. Description of how the visual inspection was conducted. The description should identify the type of inspection – on the ground or other methods tailored to the scale and accessibility of the Fee Management Unit (fly-over, drive-by, float-by, aerial photography, satellite imagery, remote sensing). *

**Sources for any information gathered and used in the inspection report from outside agencies (for example, aerial photos or government reports) must be clearly identified.*

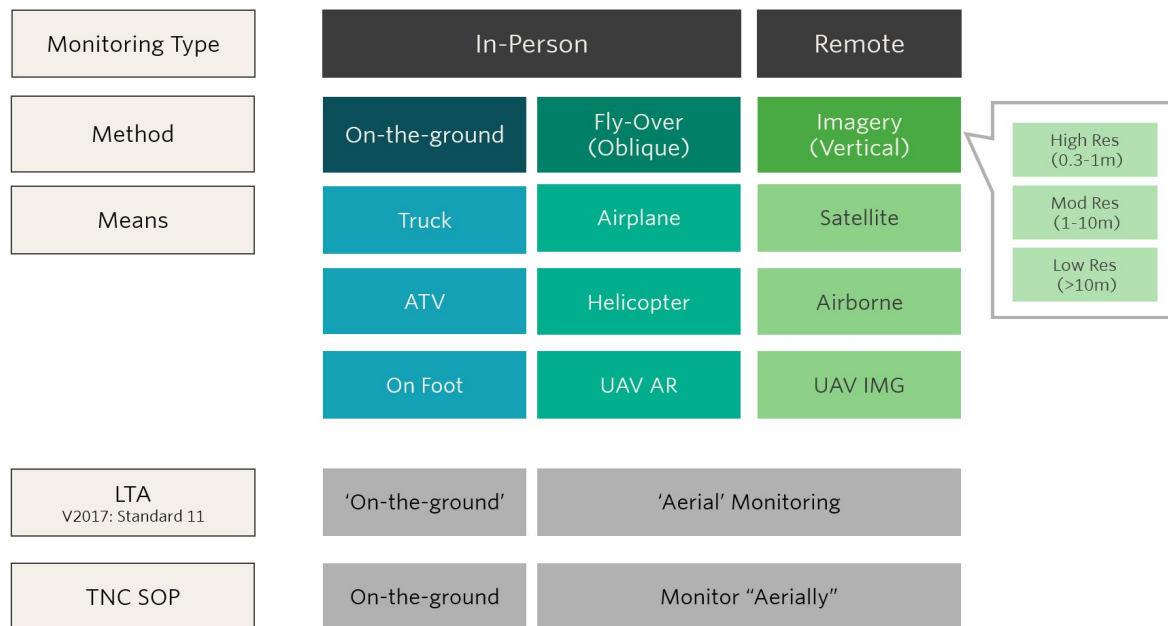
2. Photography, as warranted, to document the conservation values and condition of the property, including any changes or concerns caused by natural events or human uses and any management problems or ownership challenges. Photography should be appropriate for the scale of the site, keyed to a location map, or otherwise clearly geo-referenced in the report. For photographs not taken by the Inspector, include clear identification of sources and receipts for purchased photographic images.

REMOTE PROPERTY MONITORING DEFINITIONS

CONCEPTS

Below, is a conceptual graphic to establish some terms that need to be defined:

- One purpose of this graphic is to demonstrate the support of LTA and TNC SOPs and guidance for remote monitoring.
- As documented in the Policy Guidance in Monitoring Guidance above the LTA states "If the land trust uses aerial monitoring..."
- Aerial monitoring is understood to include both in-person flyovers and visual or computational review of previously captured remote imagery.



Graphic demonstrating the support of LTA and TNC SOPs and guidance for remote monitoring

DEFINITIONS For the purposes of this project:

In-Person Monitoring: In-person monitoring means the monitor is present in real time. They may be 'on the ground' or may be observing the property by 'fly-over' from an aircraft (including viewing from an airplane window or viewing a UAV camera view on a screen or through goggles.). In-person monitoring is typically documented by taking photos with a phone, tablet or digital camera. The imagery captured in these cases is for documentation and their later viewing is not the primary activity conducted to complete monitoring.

On the Ground Monitoring: On the ground monitoring is a form of in-person monitoring where the monitor 'sets foot' on the property. This may include driving on the property as well.

Fly-Over Monitoring: Fly-over monitoring is a form in-person monitoring where the monitor views the property in real time from an aerial vehicle.

Remote Monitoring: Remote monitoring means that the property is monitored by reviewing relevant existing imagery or other remotely sensed data without being present in the field. Remote monitoring is typically conducted on a computer but could include review of analog/hardcopy images.

Aerial Monitoring: This is when monitoring is conducted from an 'off the ground' perspective, as opposed to an 'on-the-ground' perspective. This can include in-person fly-over monitoring or remote monitoring.

Combined (Augmented) Monitoring: Combined or augmented monitoring occurs when the monitor does both on-the-ground and aerial monitoring for the same monitoring year. Example A: The monitor plans to monitor the property remotely but sees something of interest or concern in the imagery. They choose to follow up with a field visit to document the remote finding. Example B: The monitor plans to monitor the property on the ground but sees an issue or finding that they would like to better document. They use remote imagery to better understand the nature and extent of the issue (maybe the timing using change indices within the year), and to fully document the issue. Combined or augmented monitoring is often the most effective technique to understand and document conditions and changes.

Aerial Imagery: Imagery captured from an aircraft (airplane, helicopter, UAV, other) IE Airborne imagery. This could be orthogonal imagery or oblique imagery (defined below).

Airborne Imagery: Imagery captured from an aircraft (airplane, helicopter, UAV, other)

Space Imagery: Imagery captured from a spacecraft (satellite, human spacecraft).

Orthogonal Imagery: Imagery captured with a camera angle approximately perpendicular to the Earth's surface. Commercial airborne and satellite imagery is often orthogonal imagery but is commonly acquired at angles that are up to 20 degrees or more off-nadir. Examples would include much of the imagery viewed in Lens, and ArcGIS. Google Earth has a mix of orthogonal and oblique imagery.

Oblique Imagery: Imagery captured with a camera angle significantly less than 90 degrees to the Earth's surface. Examples would include a picture taken in-person with a camera from an airplane or helicopter, a picture snapped from the International Space Station (ISS), or Bing Bird's Eye images.

Spatial Resolution: A measure of the finest level of ground detail captured in an image, or pixel size. Differing classification of low, moderate and high spatial resolution exist, and for clarity it is best to simply state the numerical value, such as "70 cm" or "3 meters". Some satellite imagery vendors refer to high-resolution as finer than 1 meter. Others refer to high-resolution as finer than 2 meters. Some academic groups refer to imagery finer than 1 meter as very high resolution, etc.

Spectral Resolution: The number and characteristics of spectral bands or wavelengths captured in an image (UCB).

Temporal Resolution: How frequently coverage of a particular area of the Earth is available, or the time period that characterizes a remote sensing system's ability to revisit and image a particular area (e.g., every day, every 4 days, every 2 weeks, etc.).

Continuous Imagery Capture: Imagery is captured continuously as the satellite orbits the Earth. This results in regularly re-occurring images for any particular land area on

Earth. MODIS, Landsat, Sentinel, PlanetScope are examples of continuous capture systems.

Tasking or On-Demand Imagery Capture: Imagery is captured only when a client orders and purchases a capture. This is the typical model of commercial high-res satellites, as well as aerial photography vendors. Airbus Pleiades and SPOT, Maxar WorldView, Planet SkySat Are examples of on-demand imaging satellites. Tasked imagery is captured in an on-demand system by a task request. A client asks the satellite to capture an image of a specific geography. Tasked imagery usually has a premium price.

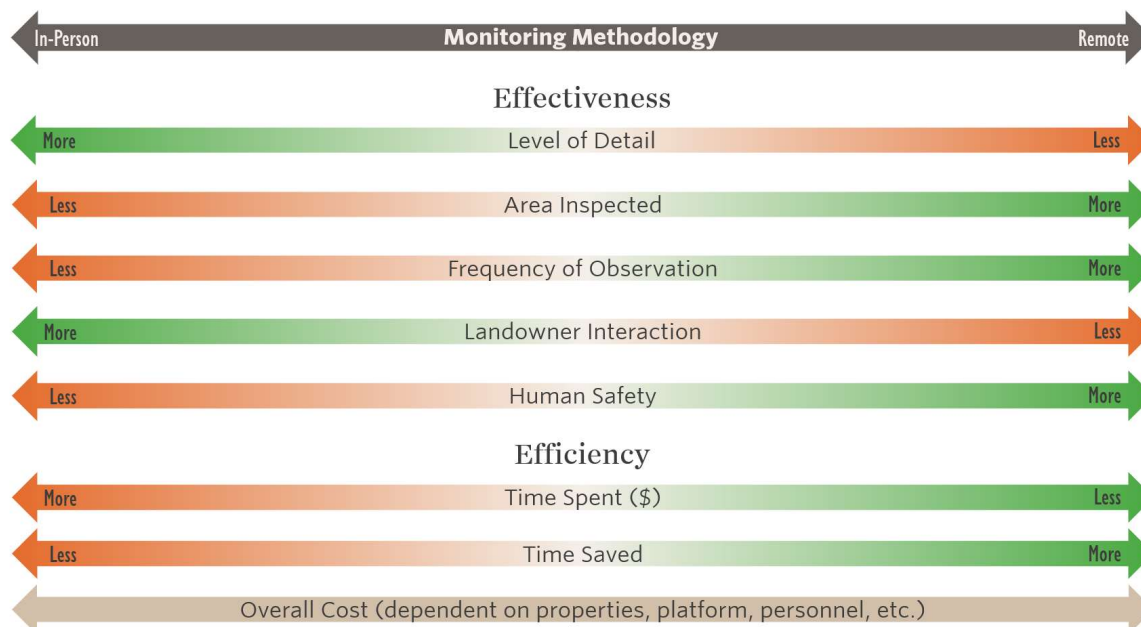
Archive Imagery: Imagery that is captured is typically archived by the satellite owner. This may be from a continuous capture system, or on-demand imagery that was already generated by a tasking order. For publicly owned satellites, users can access imagery archives in a variety of ways (Google Earth Engine is one example). For commercial imagery, users can purchase licenses to use archive imagery or subscribe to archive services. Commercial archive imagery typically has a reduced price compared to tasked imagery.

CONSIDERATIONS FOR REMOTE VS. IN-PERSON MONITORING

Differing organizations, TNC business units, monitoring teams, or individual have differing criteria, decision trees or processes for determining which properties should be remotely monitored vs field monitored.

Some of these characteristics may be inherent to the property, such as remoteness or size. Others may vary year to year, such as recent violations or catastrophic events, imagery availability, or pandemic shelter in place orders...

These are some slides we have used over the past several years to clarify and share the issues we are considering when making these determinations.

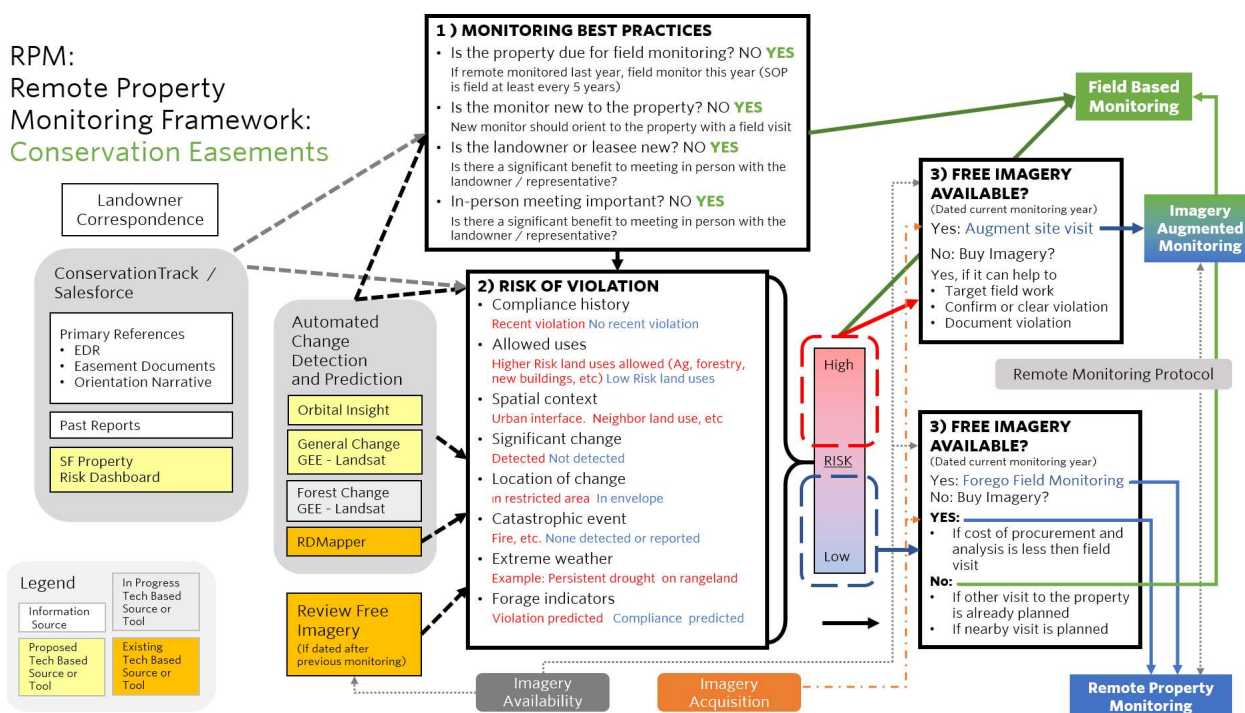


Some conceptual trade-offs for RPM vs. field monitoring (2020)

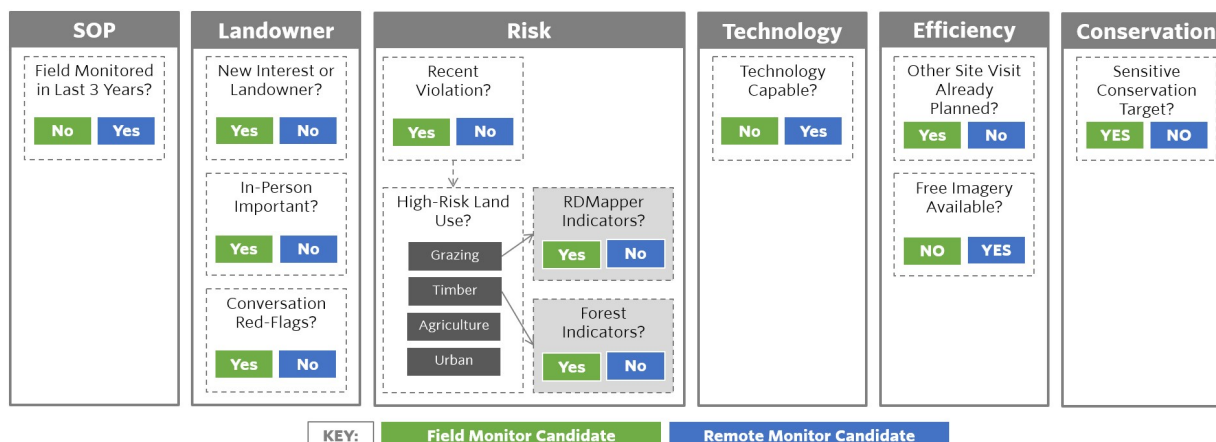
INHERENT CHARACTERISTICS	Suitability for RPM	Quality	<ul style="list-style-type: none"> Easement Terms Allowed Uses Property Characteristics Remoteness 	<ul style="list-style-type: none"> Ruggedness Road Density Landcover characteristics
		Efficiency	<ul style="list-style-type: none"> Field Travel Cost Estimate Field Monitoring Cost Estimate 	<ul style="list-style-type: none"> Remote Monitoring Cost Estimate Cost estimate of imagery (size of property)
	Risk of Violation		<ul style="list-style-type: none"> Easement Terms Allowed Uses 	<ul style="list-style-type: none"> Spatial Context Sensitivity of Targets
CHANGING CHARACTERISTICS	Annual Suitability for RPM	Quality (and SOPs)	<ul style="list-style-type: none"> Is the property due for field monitoring? NO YES If remote monitored last year, field monitor this year (SOP is field at least every 5 years) Is the monitor new to the property? NO YES New monitor should orient to the property with a field visit Is the landowner or lessee new? NO YES Is there a significant benefit to meeting in person with the landowner / representative? In-person meeting important? NO YES Is there a significant benefit to meeting in person with the landowner / representative? 	
		Efficiency	<ul style="list-style-type: none"> Other trips planned? Likelihood of free imagery (urban proximity) Free imagery available? 	
	Annual Risk of Violation		<ul style="list-style-type: none"> Landowner Communication Landowner Projects Recent Violation 	<ul style="list-style-type: none"> Significant Change Detected Catastrophic Event Forage Indicators

More considerations for RPM vs, field monitoring (2018)

RPM: Remote Property Monitoring Framework: Conservation Easements



CA hypothetical decision criteria and systems (2017)



CA hypothetical decision criteria (2016)

HOW-TO GUIDANCE

OVERVIEW

Remember that generally, monitoring can be considered an exercise in change detection, contextualization, and documentation. Changes for a property or its features may be detected visually, or with analytical or automated tools.

This guidance focuses on visual observation and review of imagery. It may include high-spatial-resolution true-color imagery, and coarser true-color imagery or spectral indices such as vegetation indices.

This guidance is agnostic to remote imagery capture source (airborne, satellite) and image viewing platform (Lens, ArcGIS, Google Earth, etc.)

Preferred Prerequisites for Remote Property Monitoring

- (See Remote vs In-Person Monitoring section for consideration in determining preferred monitoring methods)
- The person conducting visual remote monitoring has monitored the property in-person in the past, or at least visited the property in-person.
- Imagery from previous years is available for comparison to current monitoring imagery.
- A property boundary GIS file is available and can be overlaid on imagery.

Prior to Visual Monitoring

Review documents:

- conservation easement deed and exhibits, including maps of easement use zones such as building envelopes
- Property baseline condition reports
- monitoring report from previous year(s), especially summary of findings

Communication with Landowner

- Verbal or written dialog regarding activities and changes on the property since the previous monitoring effort.
- Ensure discussion and understanding of changes occurring on the property, including information regarding the type, location, extent, timing and cause of changes on the property.

While Monitoring

Sources of Variability when Comparing Images

Differences when comparing two images of the same location but from a different date may not be due to real changes:

- Variations in image acquisition and processing can cause apparent differences in images or changes in features.
 - The time of day or season of image capture can vary from image to image, which can affect shadow lengths and azimuths.

- The angle of view of the image sensor can vary from image to image, which can affect the appearance of objects and features.
- The processing of the data to create an image can cause large changes in color, contrast, and general appearance.
- No geospatial dataset (image layer, property boundary layer, etc.) is perfectly registered to real world coordinates.
 - This may mean that imagery represents features that are not quite in the right location
 - This may mean that a property boundary is not represented in the right location
- No two geospatial datasets are perfectly co-registered to each other.
 - This may mean that two images are slightly shifted from each other, even if they are from the same source, such as Sentinel.
 - This may mean that an object or feature appears to move or change when comparing images, even if no change has occurred.

It is important to keep all these sources of variability in mind when visually interpreting and comparing imagery.

Zoom Scale

Observe the imagery at a zoom scale appropriate to the spatial resolution of the imagery and the scale of features you are observing. It is often most informative to view the images at different scales, zooming in and out as needed, to understand the context and the big picture while zoomed out, and the details of particular areas when zoomed in.

Image Comparisons

There are various ways to compare images. It is easiest with digital images and appropriate software that has functions often called swiping or flickering.

Entire Property

Once you are viewing imagery at an appropriate zoom scale, you can pan in an ordered pattern to ensure complete coverage.

For example, you could start at the NW corner, and pan east to the NE corner. Then move down one 'row' of imagery and pan back to the west.

Especially if this is the first time you are remotely monitoring a property, it is a useful practice to scour 'every square inch' of the property.

- This may help you to establish a visual 'baseline' of property features and characteristics.
- You may identify features or uses that you had never observed on the ground (we discovered a house on a property we had owned for 20 years!).

Property Boundaries

Important notes about boundaries:

- (redundant to 'Remember' above) The precise location of the property boundary may not be accurately represented by the geospatial layer.
- It is important to know the source of the property boundary layer and potential errors or inaccuracies of the layer. Layers generated from a modern survey are typically most accurate. Layers generated from old scanned plat or parcel maps may introduce significant error.
- Keep in mind that property fence lines are not always located at the property line.

Visually pan and follow the entire extent of the property boundary.

Look for evidence of encroachments / vectors of trespass

Roads, Trails, Fire Breaks

- Look for evidence of new roads or trails.
- Due to their linear nature, and surface material that is typically different than surroundings, they often stand out visually.
- Look for evidence of road or trail maintenance, repairs, upgrades.
- This might include the widening of the road or trail or widening specifically at a stream crossing for a culvert installation, for example.
- A change in feature color could imply a re-grading or resurfacing.

Buildings, Infrastructure, and Development Envelopes

- If you have a geospatial layer of conservation easement development envelopes or other easement zones, this can be very helpful for review of conditions and changes.
- Look for new buildings and structures.
- Review characteristics of existing structures.
- A change in feature color or texture of existing structures could imply replacement or re-roofing.

Grazing, Agriculture and Forestry

High-temporal resolution imagery (Sentinel, Landsat, MODIS, etc.) can often be more useful for monitoring changes than high-spatial resolution imagery for land uses at a landscape scale.

Examples:

- The extent and timing of a timber harvest can be observed and documented using a standard vegetation index like the Normalized Difference Vegetation Index (NDVI) over multiple dates.
- Relative productivity and utilization of rangelands can be estimated or predicted using similar NDVI or other vegetation indices. Review our approach here (<https://www.scienceforconservation.org/science-in-action/monitoring-rangelands-from-above>)

Natural Systems and Catastrophic Events

Similarly, high-temporal resolution imagery can be very effective for observing and documenting changes to natural systems and catastrophic events including fire, flooding, landslides, invasive species and other ephemeral or developing situations.

DOCUMENTING YOUR OBSERVATIONS

Key Points (for CE monitoring): This is compliance monitoring. It is fundamentally a change detection exercise, in relation to the terms of the easement.

- Compare the current-year conditions to evidence of conditions from past years.
- Describe changes you observe in relation to easement terms.
- Document places you visually inspected where you did not observe changes related to the easement terms. This is equally important as documenting changes.
- Make clear, articulate notes about what you observe. Don't assume the reader/reviewer knows the context.
 - If your observation is based on a comparison of two image dates, mention that it is a COMPARISON.
 - If your observation is based on a vegetation index, or other derived image, mention to the reviewer what image they are viewing.
- Explain why you are interpreting an image the way you are. What are the visual clues that you observed to inform your conclusion?
- We've collected some good examples of documenting remote monitoring observations; see the Files tab at the top of this page, in the "examples" folder.

GUIDANCE from Lynn Lozier (TNC CA Monitoring & Oversight Program Director): August 2019

Having now reviewed several RPM (reports) pdfs, and returned all of them for revisions/tweaks, I want to point out to you what needs to be in these so that they meet our internal and external standards for a monitoring report. Hopefully this guidance will save us time and avoid the need for a lot of revisions.

This is compliance monitoring:

It needs to address the easement's terms and assess compliance with them, both in your choice of images and in your comments in the "Description" about them in the note. That means looking to see if something has changed or is not right. Include enough images to show that you looked carefully across the property, and especially around infrastructure. By way of description, you want to be able to say things like, "no new structures were detected outside of the ranch area"... that kind of thing.

Make sure the reader knows what and where they are looking:

When you use an image, make sure that your text makes it clear to the reader what it is they are looking at. (e.g. "the dense green area in the upper right is the beginning of the riparian corridor"). Remember that they are not going to

see the larger context. So, if you know it is a road because you saw it more clearly farther to the west, *say so* if it isn't obvious within the framing for that Observation in the pdf.

Explain why you are interpreting the image the way you are:

If you are saying that the appearance of the grassland is consistent with the RDM standards, *you need to say why*. Whether it has the same visual signature (which you describe) as where you saw it on the ground near the property entrance, or if it appears the same in the imagery for a comparable nearby property that you did measure on-site. You have to make the case.

About ecological observations/comparisons:

A few of you have included comparisons of the same location from 2019 and also from an earlier year to show changes in vegetation density or amount of water. This is fine, but requires more complete explanation including; what layer are they seeing, what the colors mean, and what it is that differs between the two years. As with other kinds of images, readers do not see the surrounding area, so explain carefully anything that is not extremely obvious within the framing for that Observation in the pdf.

GUIDANCE FOR NEW PROPERTIES

Imagery as part of baseline documentation

- Consider capturing high spatial resolution imagery as part of the baseline documentation for a new property acquisition.
- For small properties, UAVs can serve as a good source for baseline imagery.

Evaluation of easement terms in the age of remote monitoring

- We reviewed an easement template list of permitted and prohibited uses in relation to our experience using remote imagery.
- We identified terms that we think are able to be monitored using which imagery.

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