

IN-DEPTH: DATA PROCESSING

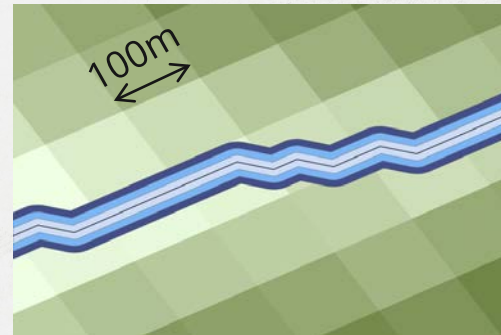
March 23, 2015

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PREPARING INPUTS

SPATIAL INPUT LAYERS

- Have **all** data in the **same projected** coordinate system
- Check the units
- Use an appropriate resolution for your goals
 - Overall detail needed
 - Interaction between layers
 - Speed/memory

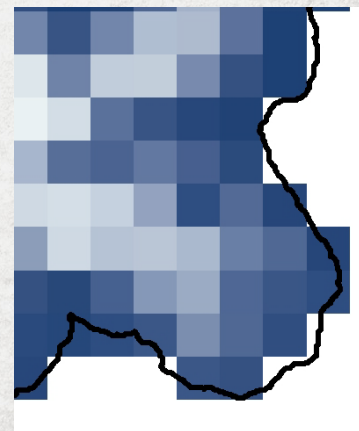


Stream buffers
← or
threat distance

Resampling the DEM from 30m to 90m

Watershed	Resolution	Sediment Retention	Sediment Export
Guabas	90m	1,268,257	97,685
	30m	1,081,782	86,769
Fraile	90m	2,208,148	87,933
	30m	1,746,993	69,087

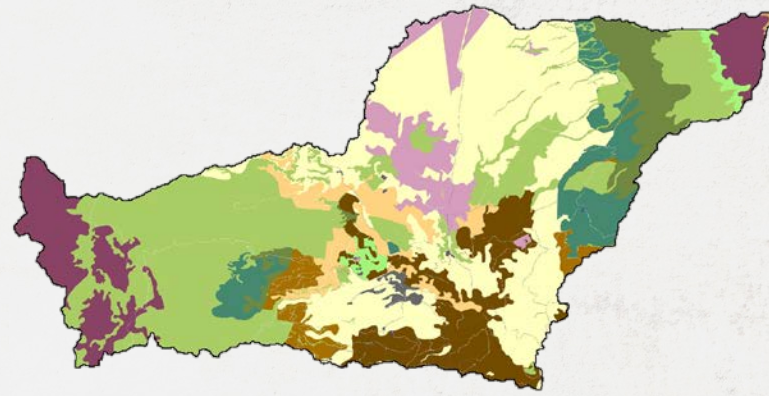
Resampling coarse layers



LAND USE

Does it capture the detail you need?

- *Habitat*: Is the species' habitat represented?
- *Carbon*: Forest age classes?
- *Nutrient/sediment*: Different fertilizer/erosion practices
- *Terrestrial*: Do you have differentiating model coefficients?



LULC classes

Bare rock	Grass
Bare soil	Native montane bunchgrass
Coffee	Shrub
Corn	Tea
Evergreen forest	Unpaved road
Forest	Urban
Forest plantation	Water
General agriculture	

SOILS

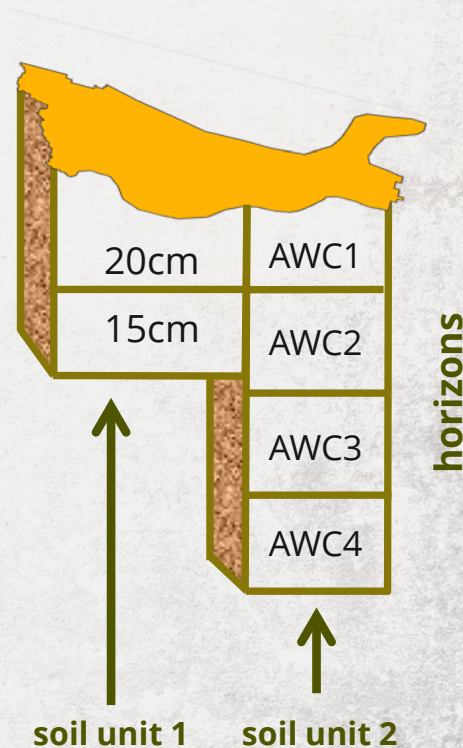
- If in the U.S., try USDA Soil Data Viewer
- If working with other soil databases...

Mapping unit



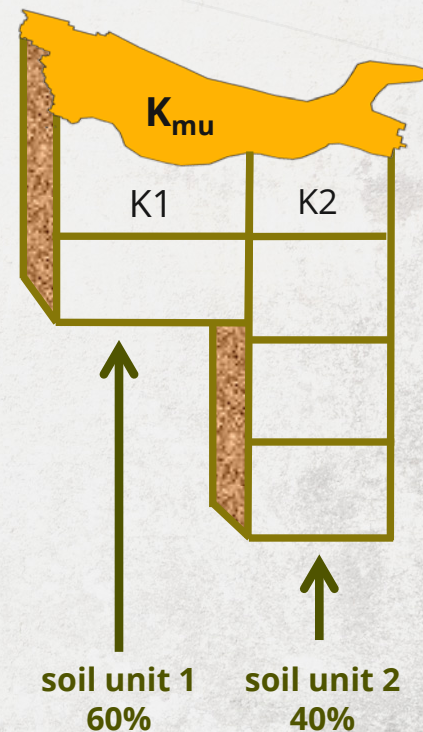
SOILS

- If in the U.S., try USDA Soil Data Viewer
- If working with other soil databases...
 - Soil depth: add up horizons or find max depth field
 - AWC: Sum of provided AWC values across horizons



SOILS

- If in the U.S., try USDA Soil Data Viewer
- If working with other soil databases...
 - Soil depth: add up horizons or find max depth field
 - AWC: Sum of provided AWC values across horizons
 - Erodibility: %sand/silt/clay/carbon in top horizon; use table to convert to K values
 - Mapping unit value
= weighted average across soil units



$$K_{mu} = (K1 * .6) + (K2 * .4)$$

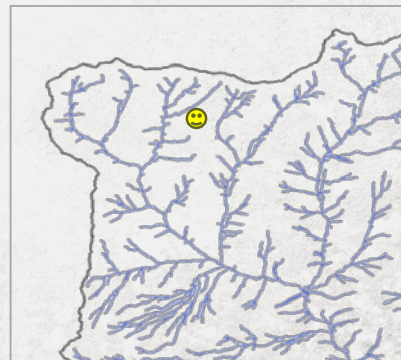
TOPOGRAPHY/HYDROLOGY

- Preparing the DEM: Mosaic, fill holes, fill sinks, burn streams
- If reprojecting, **don't** use Nearest Neighbor
- Verify watersheds and/or create with ArcHydro/ArcSWAT/AGWA/BASINS...
- Determine threshold flow accumulation:

Threshold = 10,000



Threshold = 100



ROUTEDEM

A nifty new InVEST tool that:

- Resolves flat areas
- Fills pits

DEM

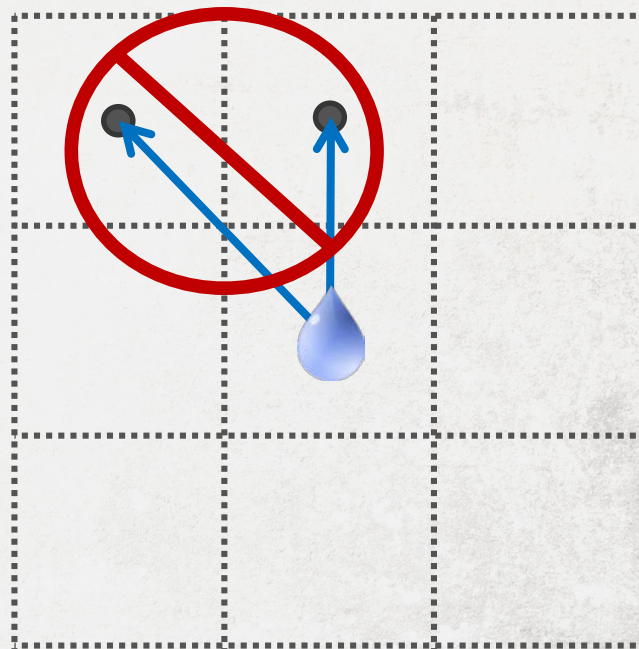


ROUTEDEM

A nifty new InVEST tool that:

- Resolves flat areas
- Fills pits
- D-Infinity flow direction

D-8

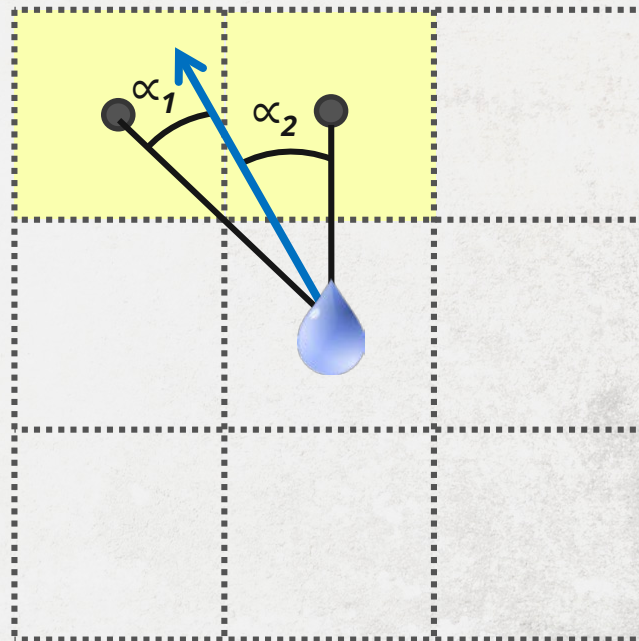


ROUTED_{DEM}

A nifty new InVEST tool that:

- Resolves flat areas
- Fills pits
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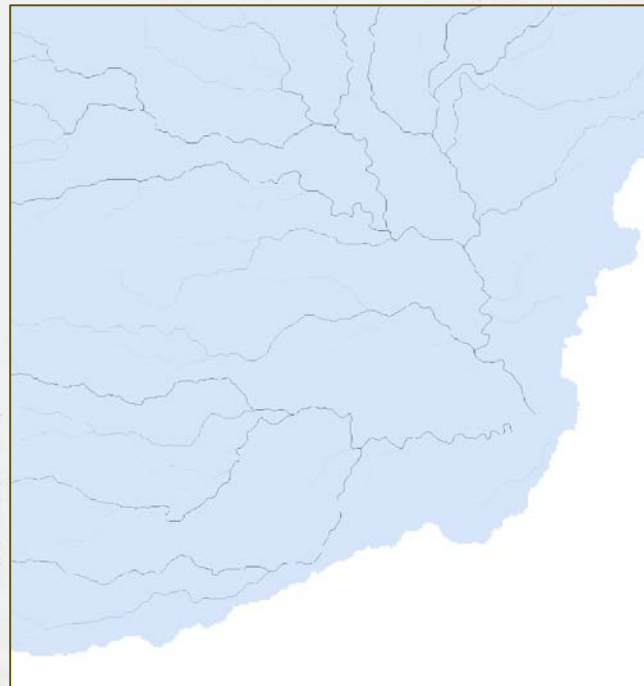
D-Infinity



Flow accumulation

A nifty new InVEST tool that:

- Resolves flat areas
- Fills pits
- D-Infinity flow direction
- Flow accumulation

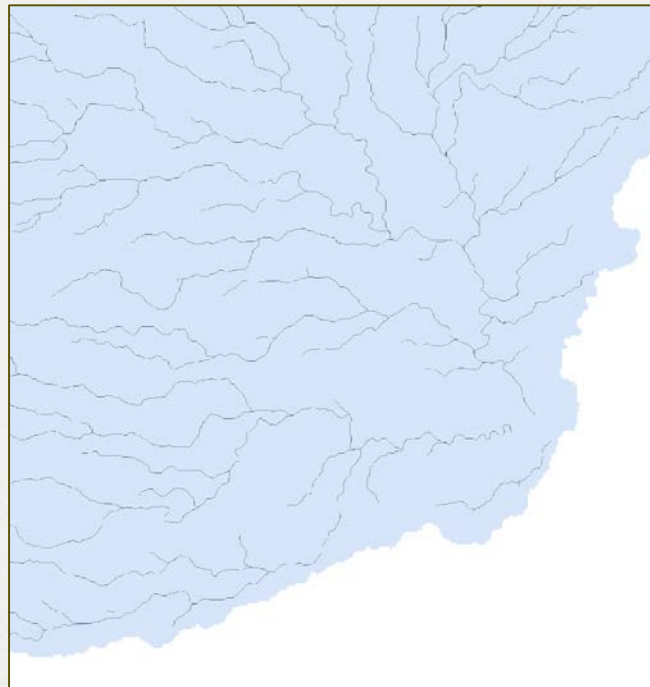


ROUTEDEM

Streams 10000

A nifty new InVEST tool that:

- Resolves flat areas
- Fills pits
- D-Infinity flow direction
- Flow accumulation
- (Multiple) stream definition

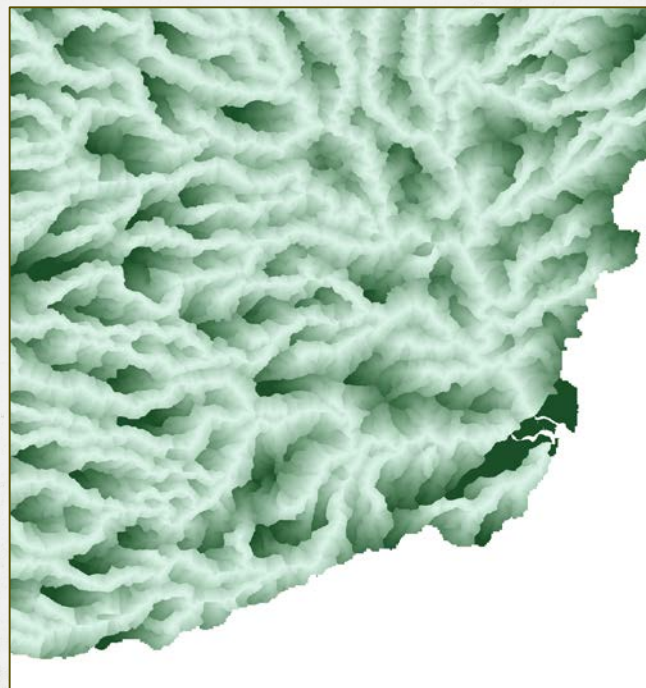


ROUTED

Distance to stream

A nifty new InVEST tool that:

- Resolves flat areas
- Fills pits
- D-Infinity flow direction
- Flow accumulation
- (Multiple) stream definition
- Distance to stream



Slope

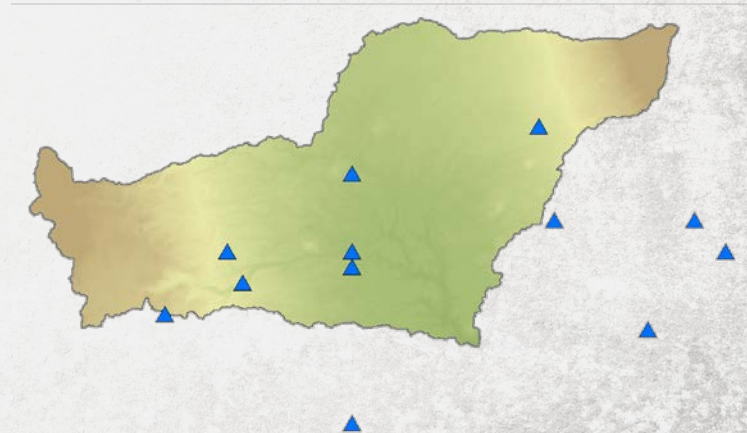
A nifty new InVEST tool that:

- Resolves flat areas
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- D-Infinity flow direction
- Flow accumulation
- (Multiple) stream definition
- Distance to stream
- Slope



CLIMATE

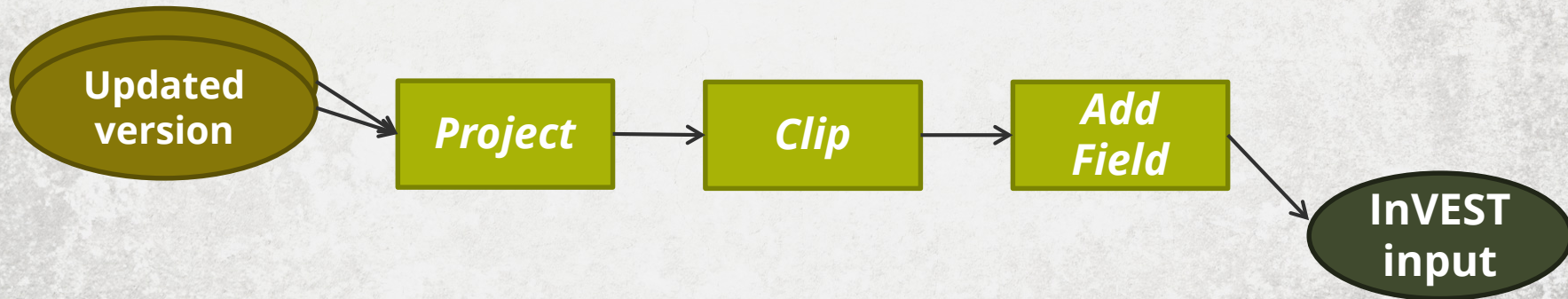
- Precipitation from weather stations, gridded local or global data, climate change scenarios
- Derivative layers: Potential ET, Actual ET, Rainfall erosivity
- Average over 10+ years
- If weather stations:
 - Best to have full coverage
 - Test out interpolation methods
 - Adjust for elevation?



DESIGNING WORKFLOWS

Build a **script** or a **workflow** that takes data from its raw form to InVEST-ready

- Document methods as you go
- Reproduce and share easily
- Easily plug in a new dataset later on

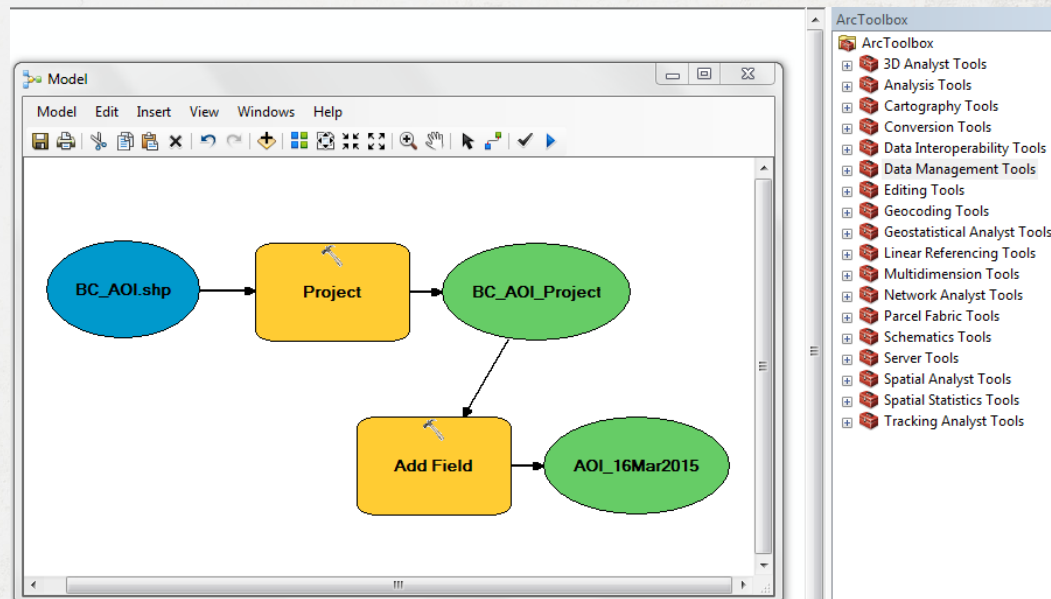


DESIGNING WORKFLOWS

Different options and technologies...

Desktop GIS:

- ArcGIS – ModelBuilder
- QGIS – Graphical Modeler



DESIGNING WORKFLOWS

...more options

Scripting languages:

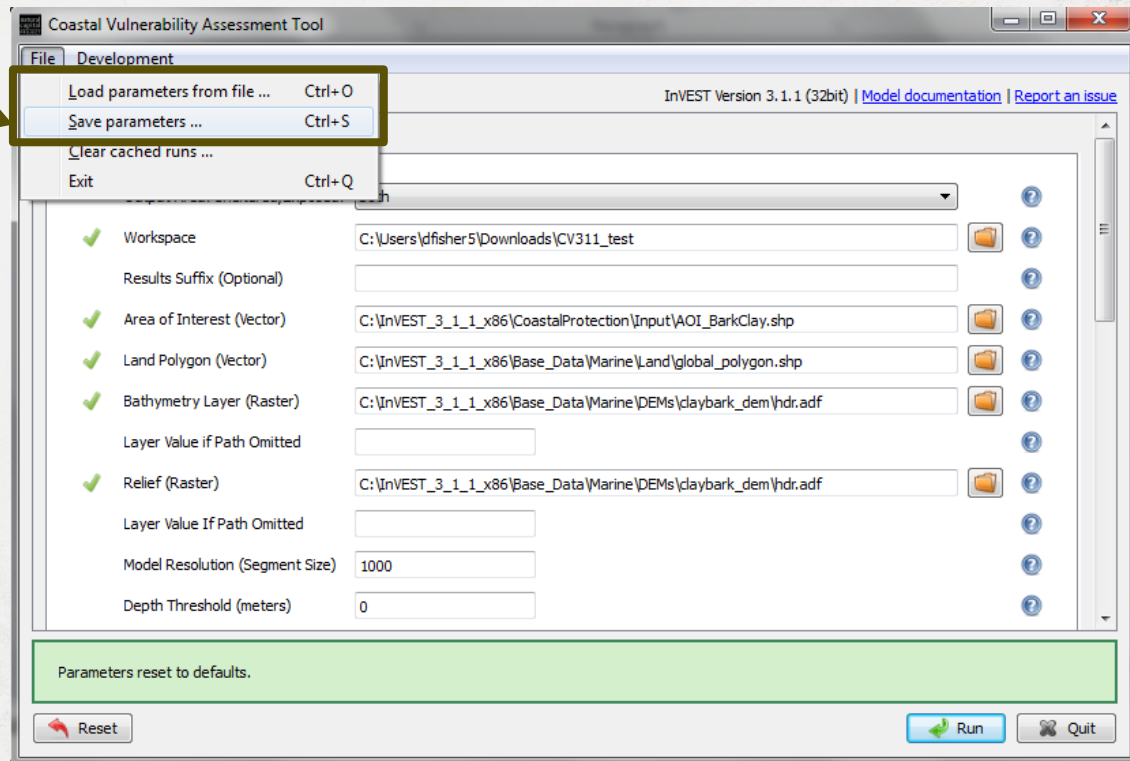
- Python
shapely, gdal, arcpy
- R
sp, rgdal, raster, rgeos

```
1 library(rgdal)
2 library(raster)
3 library(rgeos)
4 library(rasterVis)
5
6 setwd("C:/Users/dfisher5/Documents/WestCoastAquatic/CV/output/9Dec2014_310_
7
8 ce.whole <- raster("outputs/coastal_exposure/1_i_coastal_exposure.tif")
9
10 regions.shp <- readOGR(dsn="C:/Users/dfisher5/Documents/WestCoastAquatic/da
11 regions <- spTransform(regions.shp, CRS(projection(ce)))
12
13 ## clip output to bounds of WCA study region (can use subregions-sample.shp
14 ce <- mask(ce.whole, regions)
15
16 ## or use WCA breaks from Carla, 4 equal intervals with middle 2 as MED
17 vals <- getValues(ce)
18 summary(vals)
19 range <- max(vals, na.rm=T) - min(vals, na.rm=T)
20 p25 <- min(vals, na.rm=T) + range/4
21 p75 <- max(vals, na.rm=T) - range/4
22
23 ## make copy of raster before reclassing
24 ce.cat <- ce
25
26 lows <- which(vals <= p25)
27 ce.cat[lows] <- 1
28 meds <- which(vals > p25 & vals <= p75)
29 ce.cat[meds] <- 2
30 highs <- which(vals > p75)
31 ce.cat[highs] <- 3
32
33 ## extract cells in each region, do math
34 bark.ex <- unlist(extract(ce.cat, regions[1,]))
```


DESIGNING WORKFLOWS

Keep track of InVEST runs

- Store input parameters with model outputs
- Duplicate a past run, alter a single parameter



BATCH PROCESSING

Why? Many scenarios, sensitivity testing, uncertainty analysis...

Requirements:

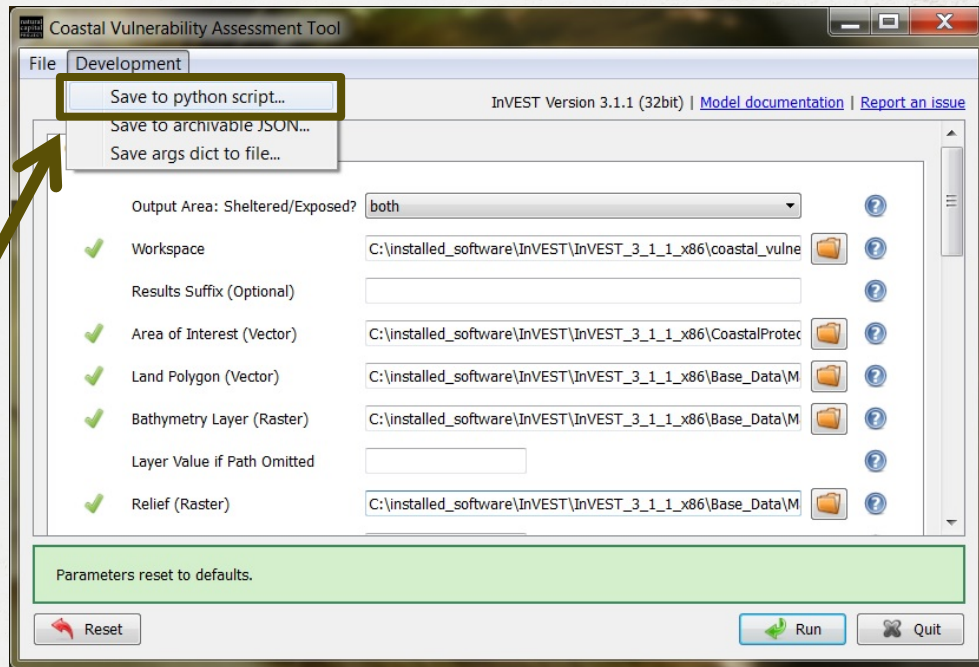
- Python programming skills
- Windows only, Python 2.7 only

How?

- Export script from a model
- Lots of Python libraries to install

Details here:

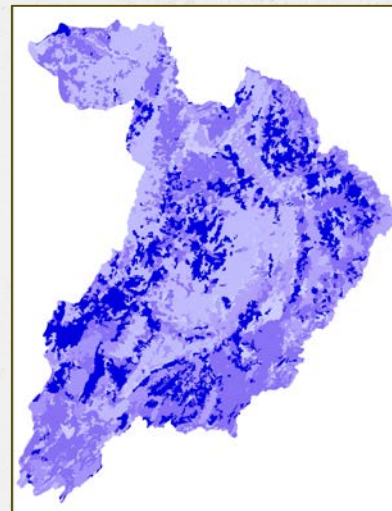
<https://code.google.com/p/invest-natcap/wiki/ScriptingInVESTOnWindows>



INTERPRETING OUTPUTS

SCRUTINIZING RESULTS

- No areas of missing data
- Spatial pattern makes sense
- Model limitations – how do they affect your interpretation?
- Uncertainty in inputs
- Output values look like they're in the right ballpark...



Threshold	Sensitivity	Specificity	TSS	AUC
0.00	1.00	0.00	1.00	0.87
0.01	1.00	0.00	1.00	
0.02	1.00	0.00	1.00	
0.03	1.00	0.00	1.00	
0.04	1.00	0.00	1.00	
0.05	1.00	0.00	1.00	
0.06	1.00	0.00	1.00	
0.07	1.00	0.00	1.00	
0.08	1.00	0.02	0.98	
0.09	1.00	0.03	0.98	
0.10	1.00	0.03	0.98	
0.11	1.00	0.03	0.98	
0.12	1.00	0.03	0.98	
0.13	1.00	0.04	0.96	
0.14	1.00	0.05	0.95	
0.15	1.00	0.05	0.95	
0.16	0.95	0.08	0.95	
0.17	0.95	0.10	0.94	
0.18	0.95	0.12	0.93	
0.19	0.95	0.12	0.93	
0.20	0.95	0.12	0.93	

CALIBRATION

Inputs (like climate):

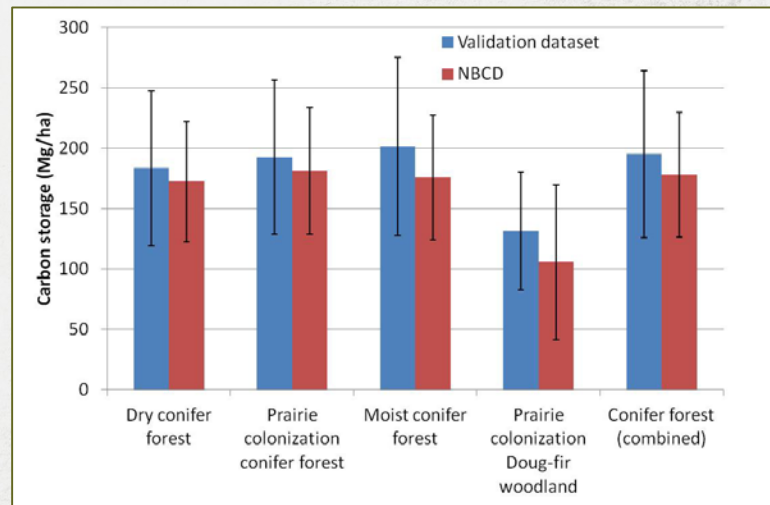
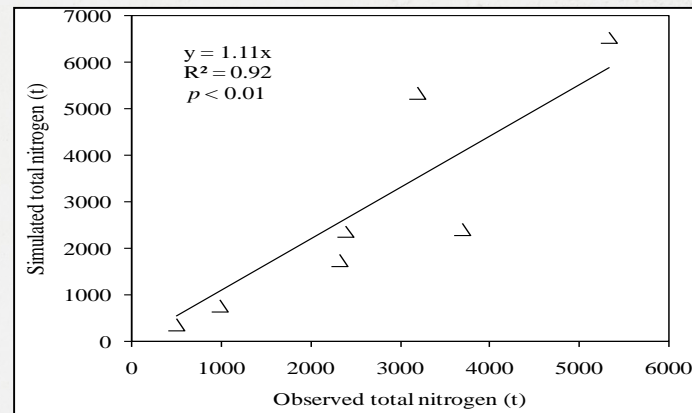
- Average over at least 10 years if possible
- Match time period with observations of services

Observed data (stream flow etc)

- Averaged over same 10+ years
- Match units with InVEST outputs

Do calibration before valuation

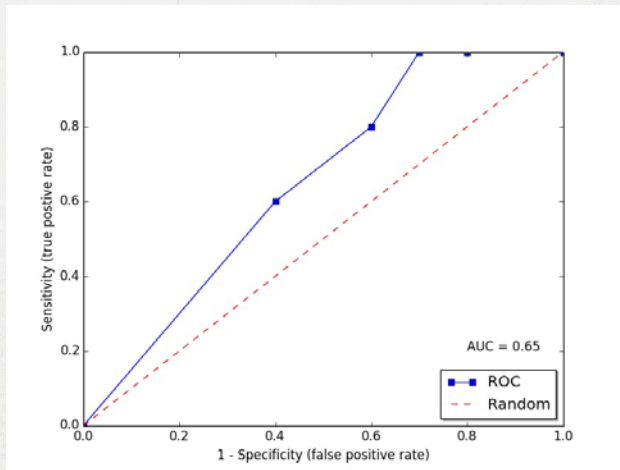
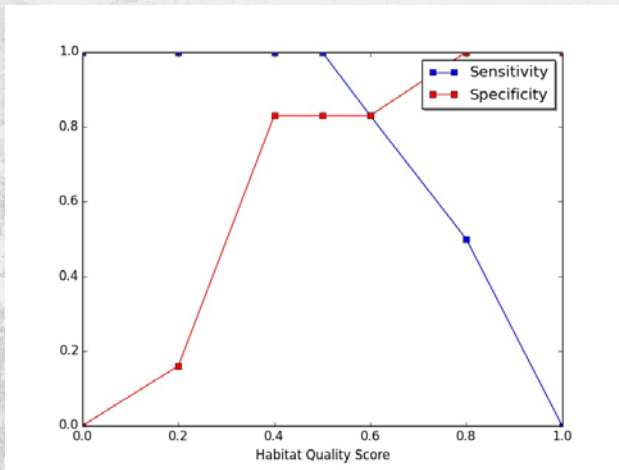
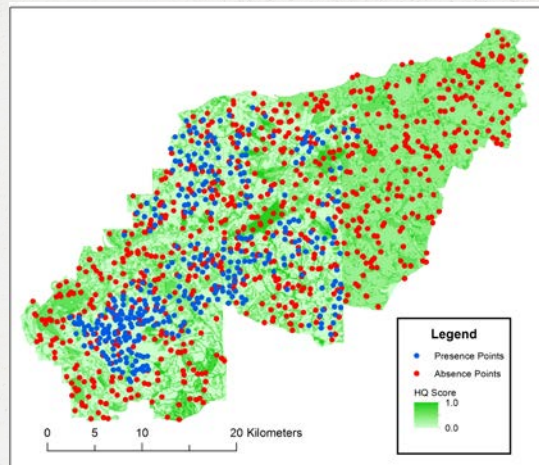
Nitrogen loading, Hainan, China



VALIDATION

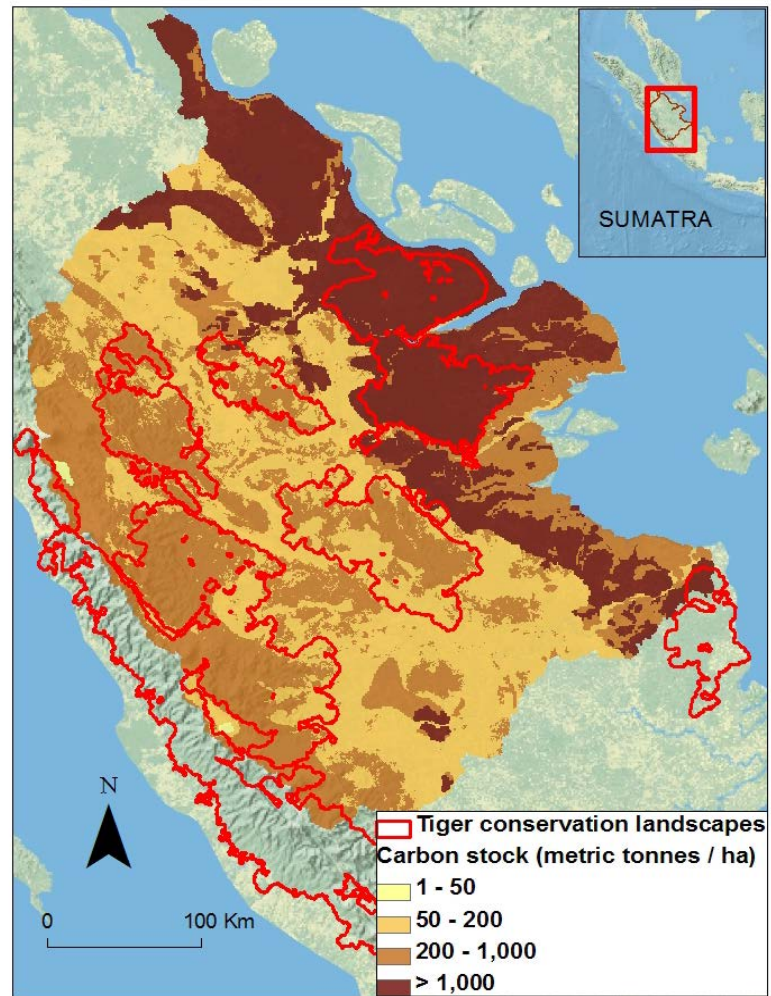
Comparing model outputs with observed data

- Field data, stream gauge data, etc.
- Regressions, Receiver Operator Curves (ROC)

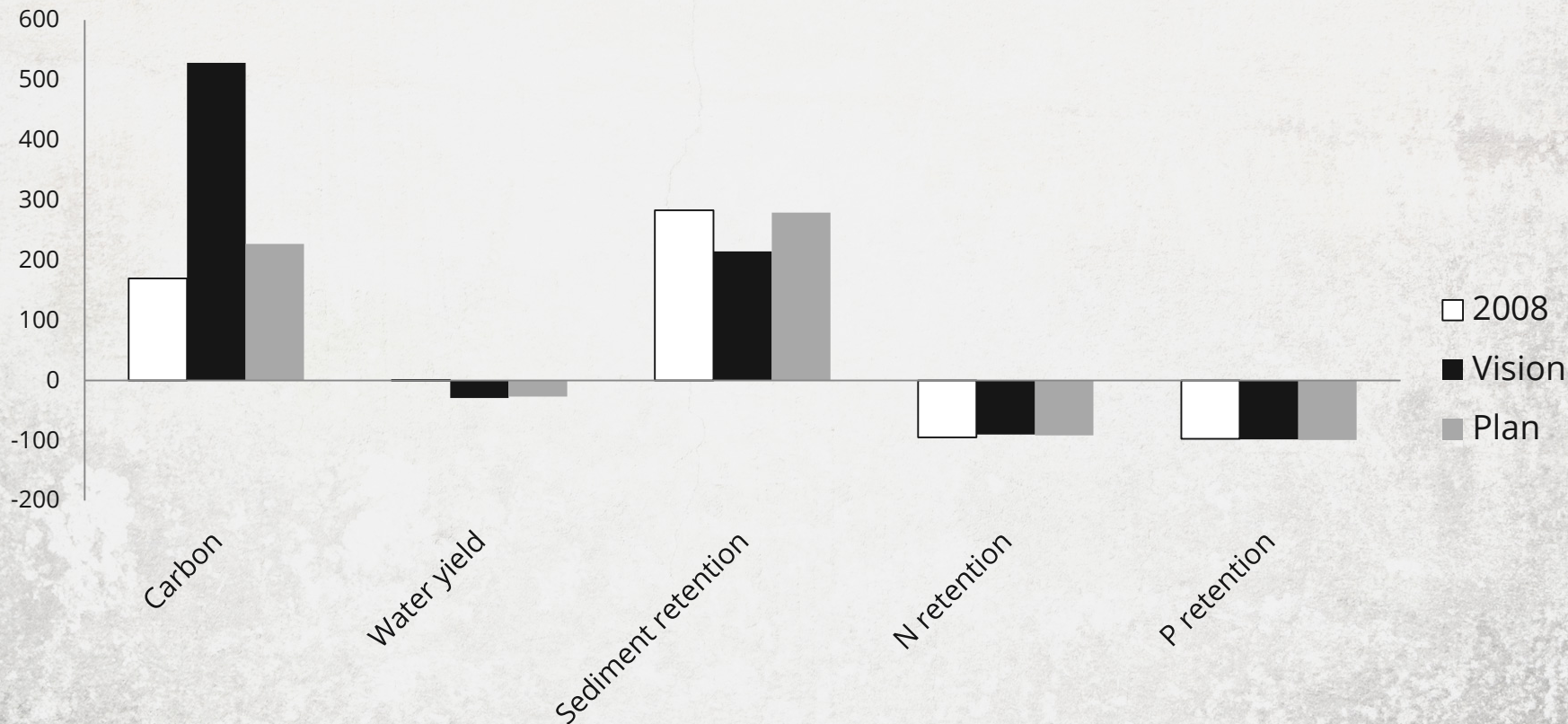


VISUALIZING RESULTS - OVERLAY WITH OTHER DATA

Carbon stock
+ tiger habitat



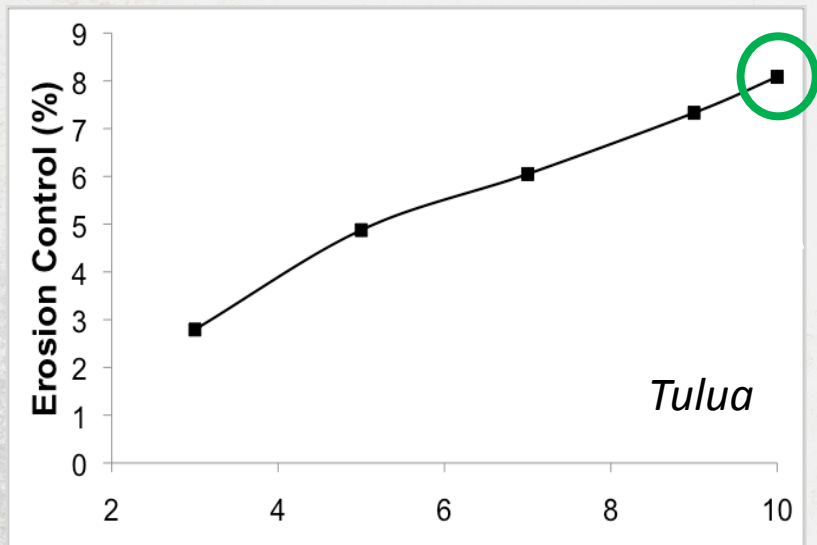
Services provided within tiger habitat versus outside



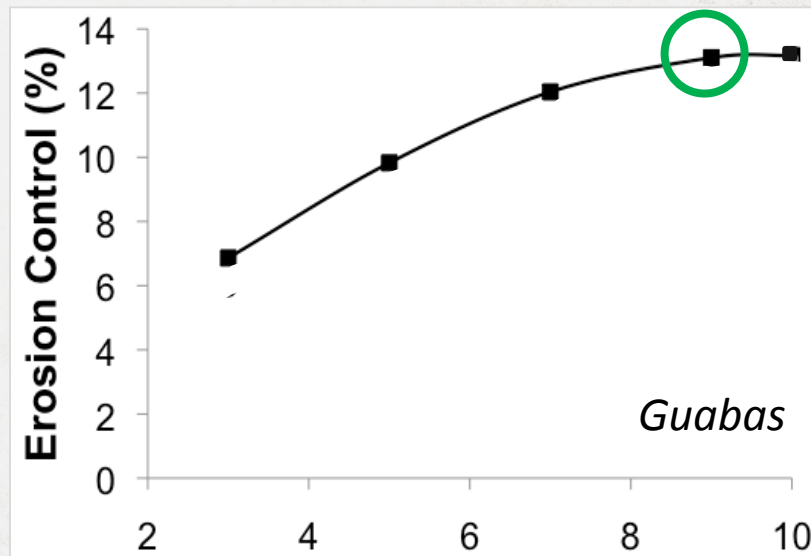
COMPARE CHANGE

Percent change can be very useful...

Return on Investment



Total budget (US\$ millions)

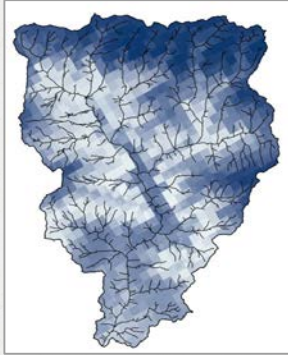
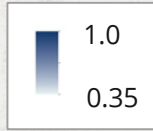


Total budget (US\$ millions)

RANK ACROSS MULTIPLE SERVICES

Biodiversity

Normalized



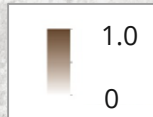
$\times 1$

+

=

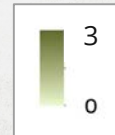
Carbon

Normalized



$\times 2$

Total Relative ES provision



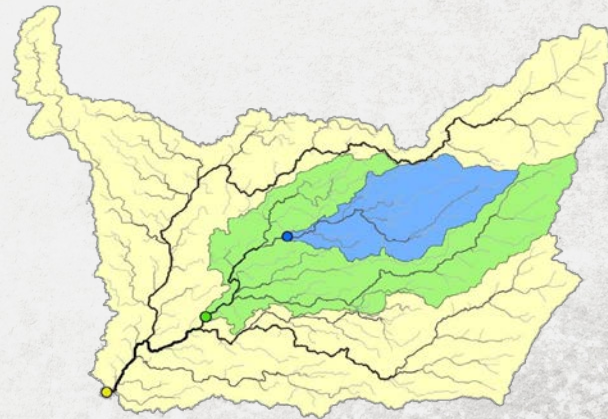
AGGREGATING RESULTS

- Can aggregate within countries, administrative zones, land cover classes... *Zonal Statistics*
- Do the results cover the whole area of interest?

Serviceshed: *A specific area that provides a service to a group of people*

- Hydrology: watershed
- Pollination: foraging range
- Recreation: travel distance

**If servicesheds overlap,
total service > supply**



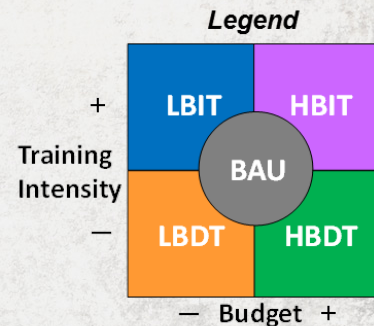
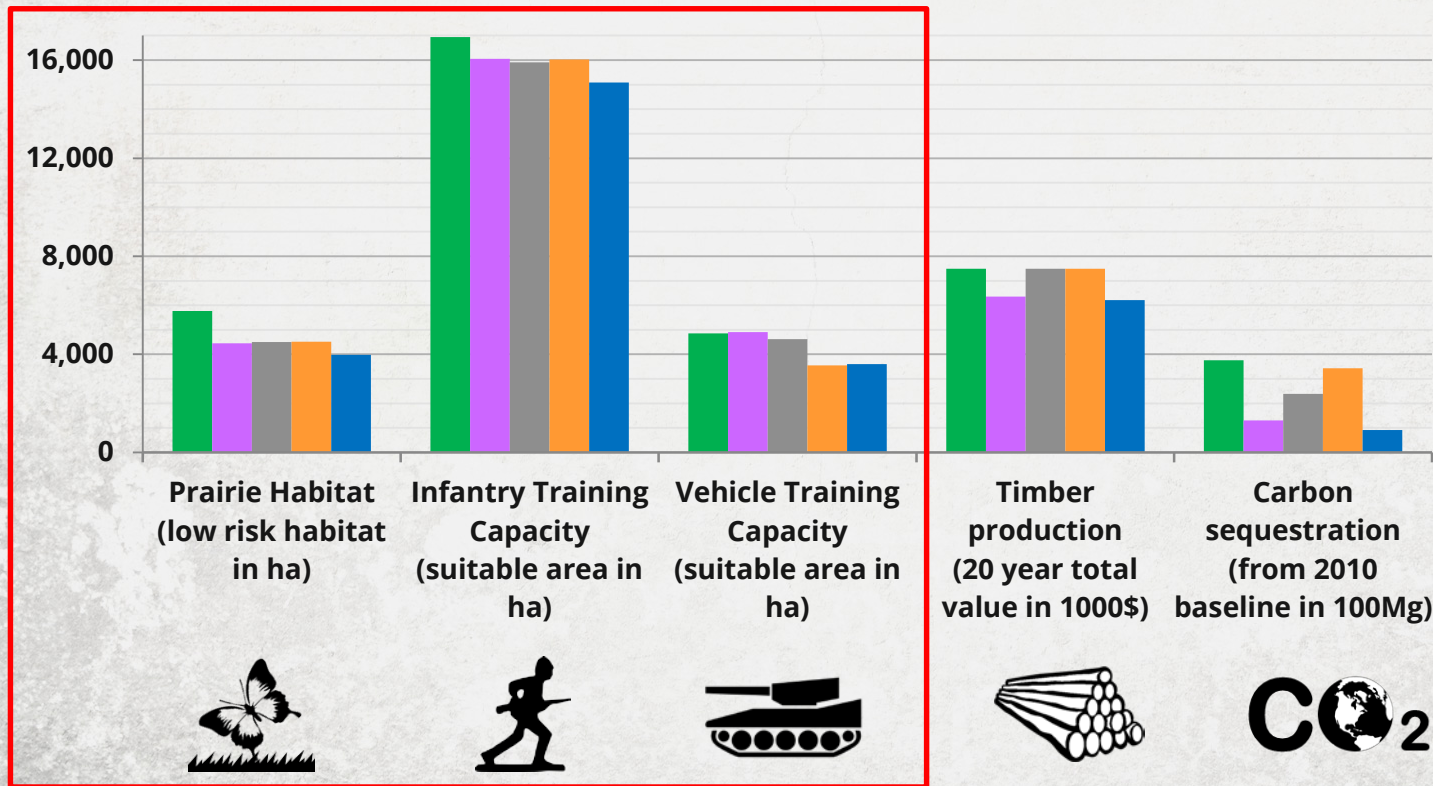
AGGREGATING RESULTS

TABLE

Ecosystem Service	Infantry Training Capacity	Vehicle Training Capacity	Puget Sound Prairie Sustainability	Timber Production	Carbon Sequestration
Measure Management Scenarios	Suitable area (1000 ha)	Suitable area (1000 ha)	Low-risk habitat (1000 ha)	Net present value (1M \$)	Biomass (1000 Mg)
High Budget- Decreased Training	16.9 (7%)	4.86 (5%)	5.77 (28%)	74.9 (0%)	375 (57%)
High Budget- Increased Training	16.0 (1%)	4.90 (6%)	4.45 (-1%)	63.6 (-15%)	130 (-46%)
Business-As-Usual	15.9 (0%)	4.62 (0%)	4.51 (0%)	74.9 (0%)	239 (0%)
Low Budget- Decreased Training	16.0 (1%)	3.55 (-23%)	4.52 (0%)	74.9 (0%)	343 (44%)
Low Budget-Increased Training	15.1 (-5%)	3.60 (-22%)	3.98 (-12%)	62.1 (-17%)	92 (-62%)

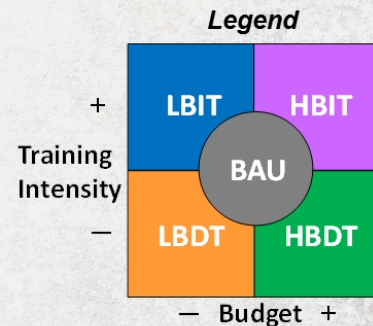
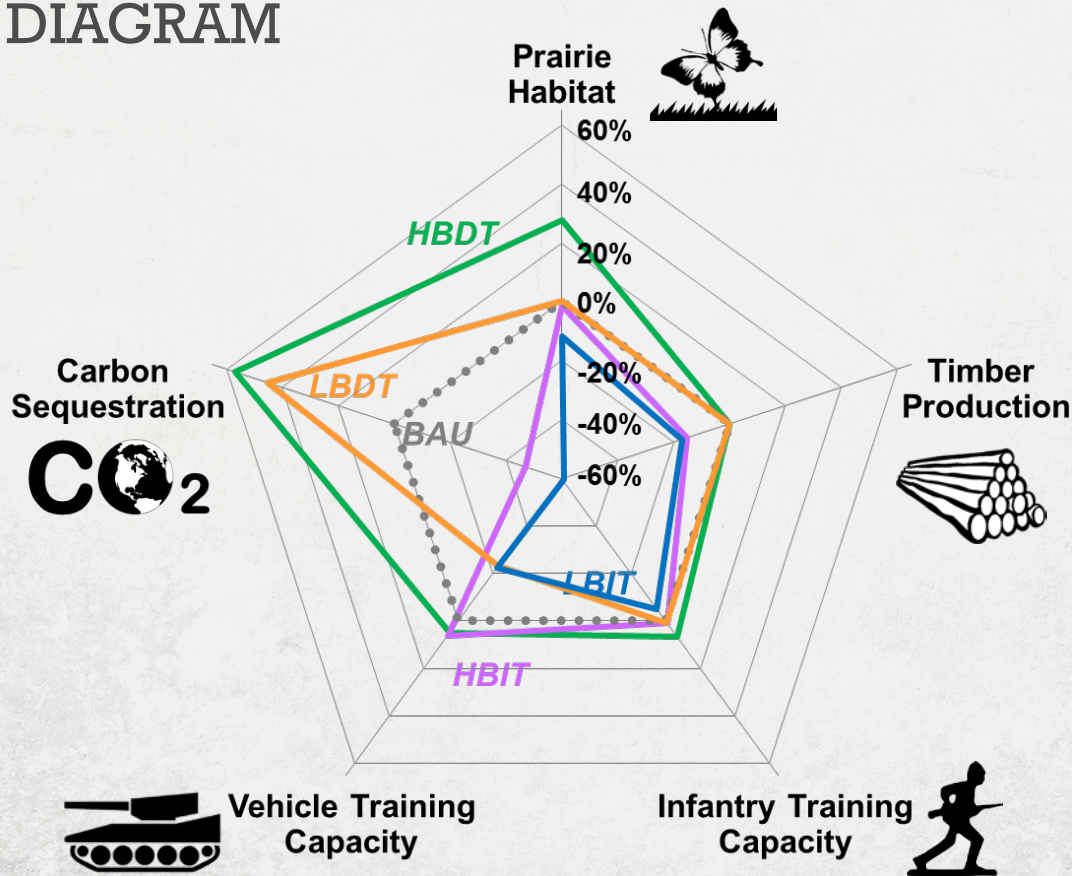
AGGREGATING RESULTS

BAR CHART



AGGREGATING RESULTS

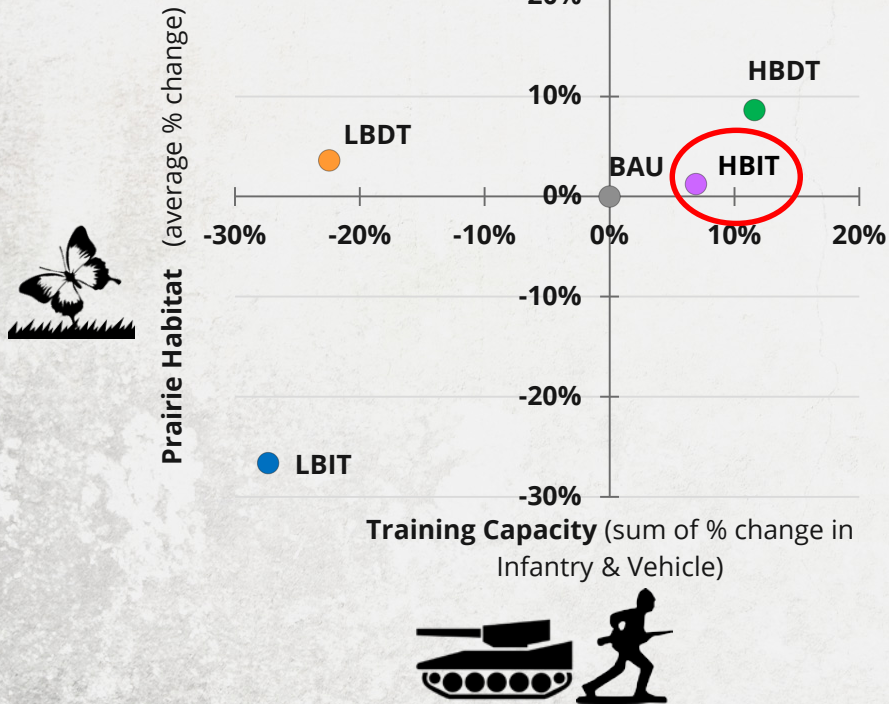
SPIDER DIAGRAM



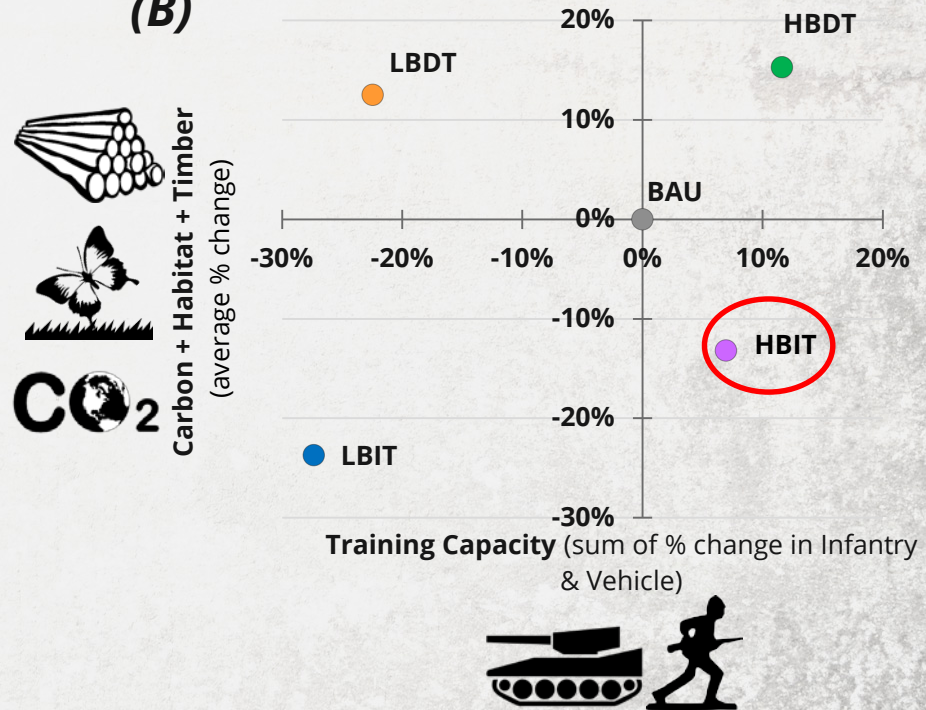
AGGREGATING RESULTS

TRADEOFF PLOT

(A)



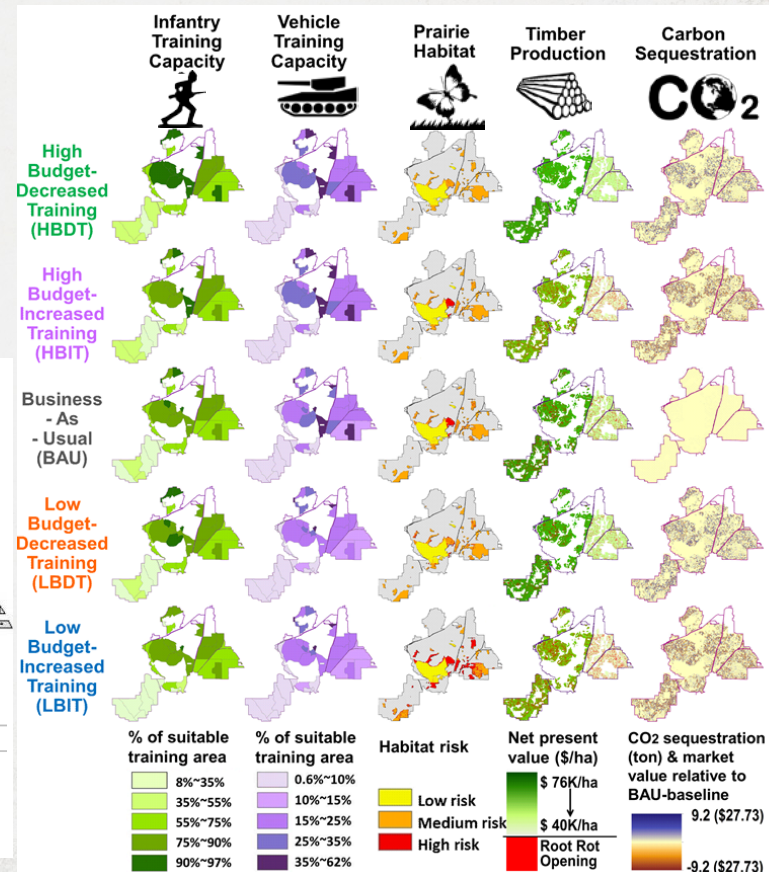
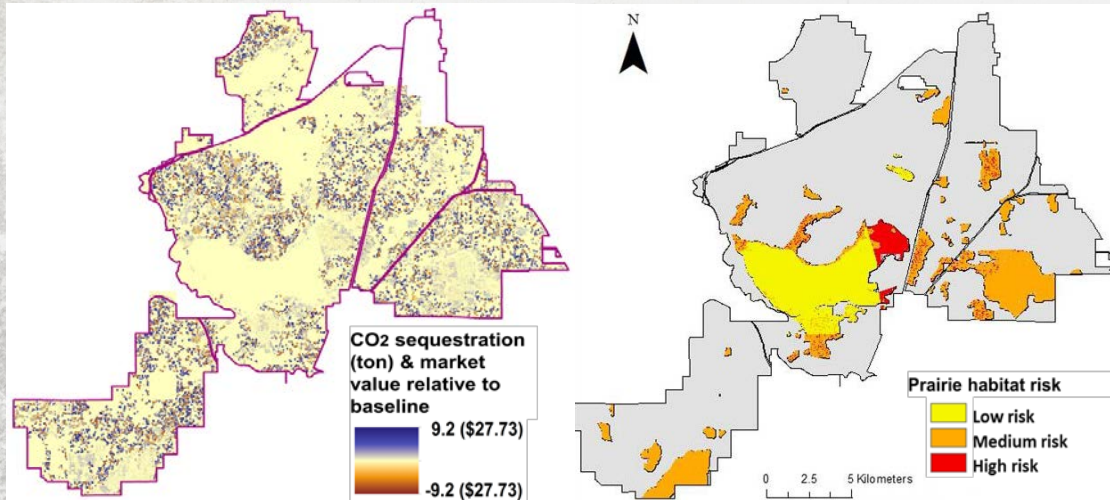
(B)



AGGREGATING RESULTS

DETAIL MAP

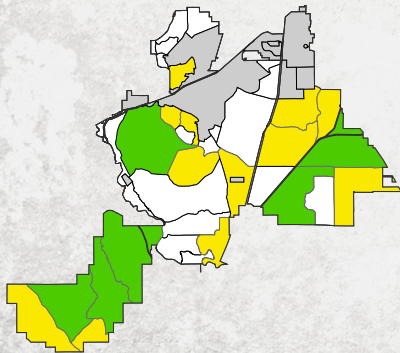
- Direct map outputs from InVEST
- Provides spatial distribution of absolute biophysical or economic values for user defined GIS units



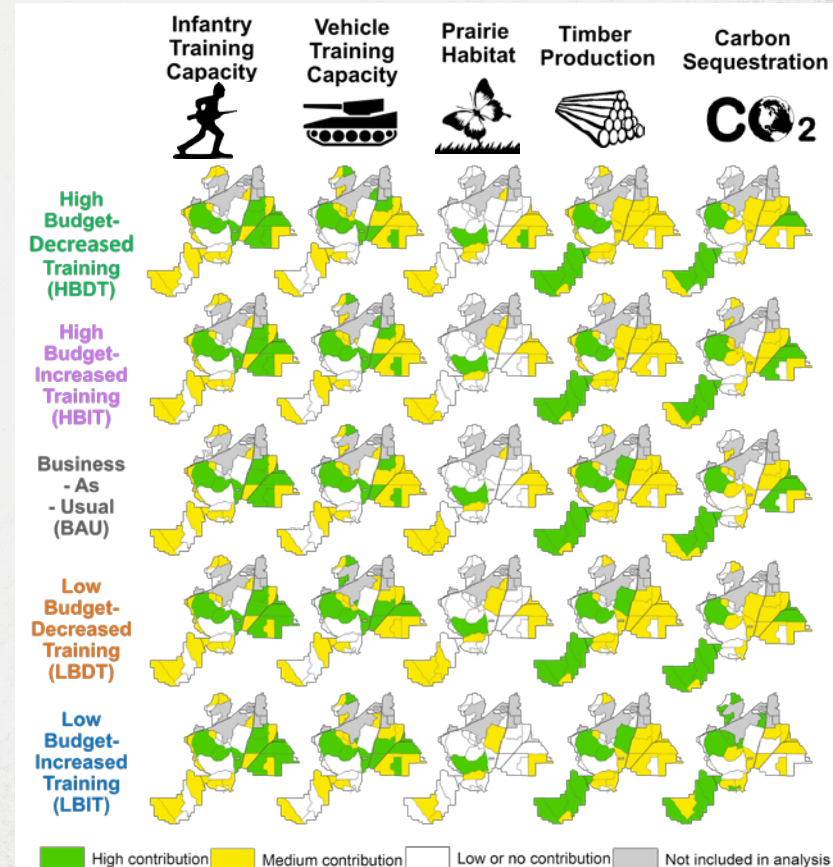
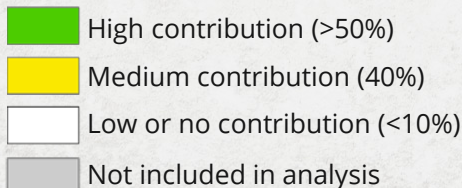
AGGREGATING RESULTS

MANAGEMENT UNIT MAP

- Aggregate pixel-based value to meaningful management unit (e.g., training area, sub-watershed)
- May convert to consistent measures for comparison across services (e.g., relative contribution of each training area to total provision of each service)



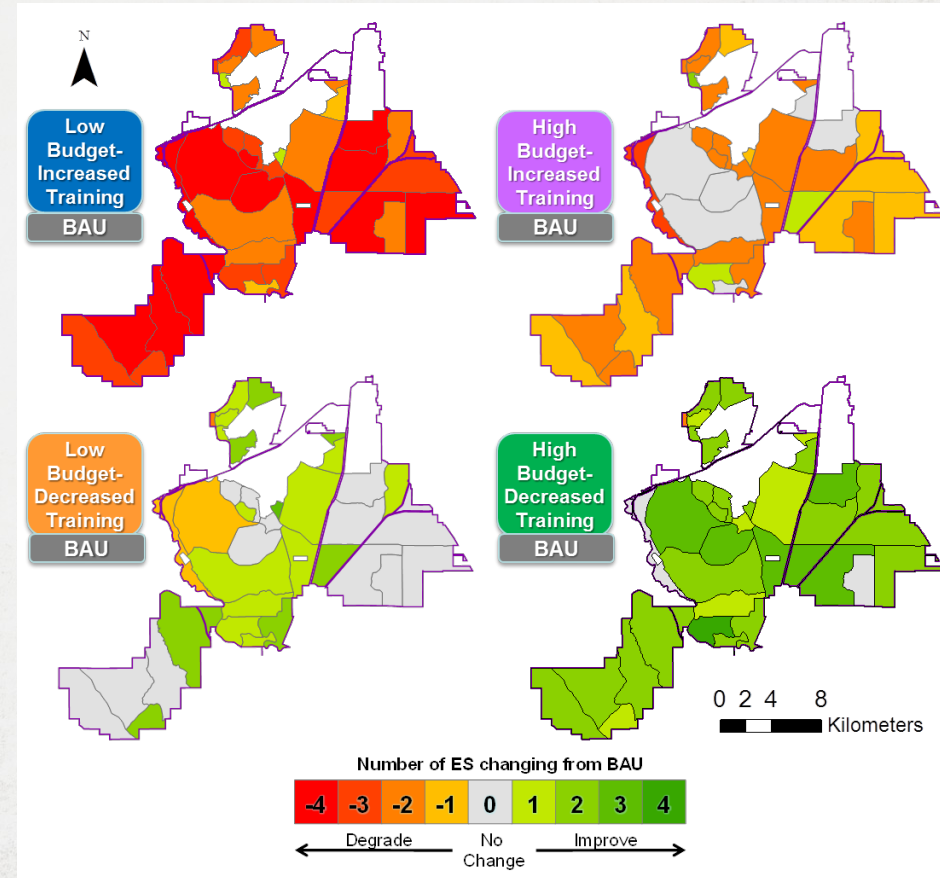
Carbon sequestration per training area



AGGREGATING RESULTS

CHANGE MAP

- Visualize changes across scenarios
 - Biophysical/economic value per pixel
 - Biophysical/economic value per management unit
 - Number of services improved/degraded
- Highlight general trend of changes across scenarios and areas requiring more attention in resource management and monitoring



RESOURCES

InVEST User Guide:

<http://naturalcapitalproject.org/download.html>

NatCap User forum:

<http://forums.naturalcapitalproject.org/>

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RTFM!



natural capital PROJECT

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integrated valuation of ecosystem services and tradeoffs

Natural Capital = Earth's lands, waters and their biodiversity

Ecosystem Services = The stream of vital benefits flowing from natural capital to people

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QUESTIONS?

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