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Narrator: ECOSYSTEMS ARE A COMPLEX WEBOF SPECIES INTERACTING EACH ONE DEPENDENT UPON ANOTHER.

STUART DAVIES INVESTIGATES THE WORLD’S MOST DIVERSE ECOSYSTEM -- TROPICAL RAINFORESTS. THROUGH A WORLD WIDE TREE CENSUS HE HOPES TO DISCOVER HOW SUCH A WIDE RANGE OF SPECIES ALL COMPETING FOR THE SAME RESOURCES CAN CO-EXIST.

IN YELLOWSTONE NATIONAL PARK ROBERT CRABTREE AND HIS TEAM OF SCIENTISTS SEEK TO UNTANGLE THE CASCADING EFFECTS IN THE ECOSYSTEM WHEN THE TOP PREDATOR -- THE WOLF -- IS REMOVED AND YEARS LATER RETURNED TO THE PARK. BY LOOKING AT THE DELICATE BALANCE
BETWEEN DIFFERENT SPECIES
BOTH SCIENTISTS HOPE TO
LEARN
HOW TO MANAGE AND PRESERVE
THESE ECOSYSTEMS
AND OTHERS WORLDWIDE.

IN PANAMA, ON BARRO
COLORADO ISLAND
AN ECOLOGICALPreserve
CREATED THROUGH THE MAKING
OF THE PANAMA CANAL
STUART DAVIES HOPES TO
UNCOVER
SOME OF THE MYSTERIES OF A
COMPLEX ECOSYSTEM --
THE RAINFOREST.

Man: I'M THE DIRECTOR
OF THE CENTER FOR TROPICAL
FOREST SCIENCE
WHICH IS A GROUP WHO
STUDY THE RAINFORESTS OF THE
WORLD.
AND WE WORK TOGETHER AS ONE
VERY LARGE NETWORK
TO TRY TO UNDERSTAND HOW
RAINFORESTS FUNCTION
AND HOW THEY'RE GONNA
CHANGE IN THE FUTURE.

Narrator: TROPICAL RAINFORESTS
ARE BELIEVED TO BE THE OLDEST TERRESTRIAL ECOSYSTEMS ON EARTH. THEY ARE HOME TO OVER 5 MILLION KNOWN SPECIES OF PLANTS, ANIMALS, AND INSECTS WITH MILLIONS MORE YET TO BE DISCOVERED.

AND TREES PLAY AN ESSENTIAL ROLE IN THE DIVERSITY OF THESE INTRICATE ECOSYSTEMS.

Dr. Davies: ONE FAMOUS ECOLOGIST SAID TREES IN TROPICAL RAINFORESTS ARE LIKE -- HE CALLED THEM THE ECOSYSTEM ENGINEERS. WHAT HE MEANT BY THAT IS THAT THEY PROVIDE THE HABITAT ON WHICH ALL THESE OTHER ORGANISMS DEPEND.

SO MONKEYS THAT LIVE UP IN CANOPIES OF TREES GO EXTINCT IF YOU TAKE THE TREES AWAY. ANTS AND TERMITES -- THEY'RE GONNA BE ABSENT IF THE TREES DISAPPEAR. TREES CREATE THE STRUCTURE IN FORESTS AND THEREFORE THEY'RE
CENTRAL TO THIS WHOLE ECOSYSTEM.

Narrator: ALTHOUGH RAINFORESTS CURRENTLY COVER ONLY 6% OF THE PLANET THEY ARE HOME TO OVER HALF OF THE EARTH'S PLANT AND ANIMAL SPECIES. Dr. Davies: THE KEY QUESTION WE'RE STILL TRYING TO FIGURE OUT IS WHY TROPICAL RAINFORESTS HAVE THIS EXTRAORDINARY DIVERSITY AND HOW IT CONTINUES TO BE MAINTAINED.

Narrator: TO INVESTIGATE THE DIVERSITY OF THE RAINFOREST THE CENTER FOR TROPICAL FOREST SCIENCE OF THE SMITHSONIAN TROPICAL RESEARCH INSTITUTE HAS BEEN CONDUCTING A CENSUS OF RAINFOREST TREES. Dr. Davies: OUR BASIC RESEARCH PROGRAM IS TO STUDY LARGE PIECES OF FOREST. WE SET UP THESE RESEARCH PLOTS
WHICH ARE 50 HECTARES IN AREA, TYPICALLY --
SO THAT'S A KILOMETER BY HALF A KILOMETER --
IN WHICH WE STUDY EVERY SINGLE TREE SPECIES
THAT OCCURS IN THOSE AREAS.

WE DO IT ALL ONE BY ONE.
WE GO OUT
WE START AT THE CORNER OF THESE BIG PLOTS
AND WE TAG AND MAP AND MEASURE
EVERY TREE BIGGER THAN A CENTIMETER IN DIAMETER.
THAT'S AS BIG AS A LITTLE SAPLING IN YOUR GARDEN.
AND WE MONITOR EVERYTHING.
WE HAVE, IN SOME OF OUR RESEARCH PLOTS
MORE SPECIES OF TREES THAN THE WHOLE OF NORTH AMERICA OR THE WHOLE OF EUROPE.
THAT'S A PHENOMENAL NUMBER OF SPECIES --
1,000 SPECIES OR 1,200 SPECIES IN ONE PLOT.

Narrator: AT 17 FOREST-DYNAMICS PLOTS
THROUGHOUT LATIN AMERICA, AFRICA, AND ASIA, DAVIES’ PROJECT IN COLLABORATION WITH THE ARNOLD ARBORETUM OF HARVARD UNIVERSITY MAINTAINS AN ACTIVE DATABASE OF MORE THAN 3 MILLION TREES OF 6,000 SPECIES.

Dr. Davies: THIS IS A HUGE DATA SET, WHICH NO ONE ELSE //IN THE WORLD IS DOING THIS KIND OF RESEARCH. AND THE IDEA OF DOING IT RIGHT ACROSS THE WHOLE WORLD IS THAT THEN WE'LL BE ABLE TOCOME TO SOME GENERALIZATIONS ABOUT WHAT'S HAPPENING TO TROPICAL RAINFORESTS.

Narrator: BY STATISTICAL ANALYSIS OF A LARGE NUMBER OF INDIVIDUALS OVER A LONG PERIOD OF TIME THE TEAM CAN DETERMINE THE DYNAMICS OF FOREST GROWTH.

Dr. Davies: WHAT WE DO IS WE MONITOR THEM EVERY FIVE YEARS. WE GO AND REMEASURE ALL THE TREES.
THE IDEA IS TO TRY TO WORK OUT FOR HUNDREDS AND HUNDREDS OF SPECIES THEIR POPULATION BIOLOGY -- THAT IS, THE RATES WITH WHICH THEY GROW THE RATES THEY DIE AT -- TO TRY TO UNDERSTAND THE WHOLE BIOLOGY OF THE SPECIES.


Man: WHEN WE FIRST SET OUT TO PLOT IT TOOK 12 PEOPLE TWO YEARS TO TAG AND MEASURE AND IDENTIFY ALL OF THE PLANTS IN THE PLOT. AND ONE OF THE REMARKABLE THINGS WE FOUND WAS THAT EVEN THOUGH THIS IS A VERY WELL-STUDIED ISLAND THERE WERE SPECIES THAT WERE UNKNOWN TO SCIENCE RIGHT HERE ALREADY UNDER OUR NOSES --
SOME OF THEM GREAT BIG TREES THAT HAD NO SCIENTIFIC NAME WHICH WAS A BIG SURPRISE TO US.

Narrator: THROUGH THEIR EXPLORATION THE TEAM HAS DISCOVERED SOME UNUSUAL SPECIMENS. SO THIS IS ONE OF THOSE PUZZLING TRAITS OF TREES THAT WE'RE TRYING TO FIGURE OUT.

IT HAS SPINES ON THE TRUNK THAT ARE QUITE SHARP AND THERE’S NO LIVING REASON THAT WE KNOW ABOUT FOR THIS THOUGH THERE MAY HAVE BEEN GIANT GROUND SLOTHS IN THIS FOREST THAT WOULD HAVE SHINNIED UP THIS TREE AND THIS WOULD HAVE BEEN A VERY PAINFUL EXPERIENCE.

BUT THIS IS NOT A TREE YOU WANT TO CUT DOWN TODAY WITHOUT SOME CAUTION, BECAUSE ITS SAP IS TOXIC. AND IF YOU GET IT IN YOUR EYES IT CAUSES THE CORNEAS TO MILK UP PERMANENTLY, SO YOU GO BLIND. THIS IS NOT SOMETHING YOU
SHOULD DO AT HOME.
[ LAUGHS ]

Narrator: THE MANY SPECIES OF TREES CREATE VARIED NICHERS FOR A DIVERSE ARRAY OF ANIMALS AND INSECTS EACH ONE ADAPTED TO ITS HOST.
Dr. Davies: THIS IS A PARTICULARLY INTERESTING KIND OF TREE BECAUSE IT HAS A VERY TIGHT SYMBIOSIS WITH ANTS.
ANTS ACTUALLY LIVE INSIDE THE STEMS OF THIS TREE AND THEY ACTUALLY DEFEND THE TREE FROM HERBIVORES.
THE PLANTS PROVIDEA VERY RICH SOURCE OF LIPID FOOD BODIES FOR THE ANTS IN RETURN FOR THIS DEFENSE.
WE'VE COME DOWNTO THE SIDE HERE.
YOU CAN SEE THE ANTS ARE GETTING AGITATED BY ME BREAKING THE LEAF.
BUT YOU CAN SEE THESE HOLES IN THE STEM.
THE ANTS COME IN AND OUT OF THE STEM.

SO THE WHOLE STEM IS HOLLOW.
THE ANTS WILL CONTINUE TO DEFEND THIS COLONY FROM A WIDE RANGE OF HERBIVORES, A WIDE RANGE OF INSECTS THAT WILL EAT THE LEAVES OF THE PLANT.

Narrator: THE RESEARCHERS EXPLORE HOW SO MANY DIFFERENT SPECIES ALL COMPETING FOR THE SAME RESOURCES CAN COEXIST. ONE WAY THE TREES HAVE ADAPTED IS THAT THEY BECOME SPECIALISTS, SURVIVING IN NICHE CONDITIONS. SPECIALIZATION IS ONE HYPOTHESIS FOR HOW DIVERSITY IS MAINTAINED.

WE'RE STANDING IN THE MIDDLE OF A FOREST GAP. IT'S THE RESULT OF THIS HUGE TREE HERE WHICH DIED. IT DIED STANDING. IT DROPPED ALL ITS BRANCHES. IT CLEARED A BIG OPENING IN THE UNDERSTORY KILLED SMALL TREES AND LEFT A BIG OPENING IN THE
CANOPY.
AND IN THAT OPENING
A RUSH OF TREES GERMINATES
AND ESTABLISHES.
AND WE CALL THOSE TREES --
THEY'RE VERY FAST-GROWING --
WE CALL THEM PIONEERS. THEY
PIONEER THE NEW GAP.
AND THEY'RE SPECIALISTS.
THEY DON'T OCCUR IN THE
UNDERSTORY.
THEY ONLY OCCUR IN THESE
GAPS.
SO THIS PROMOTES DIVERSITY
BECAUSE YOU HAVE SPECIES
SPECIALIZED TO THESE GAPS.
YOU HAVE SPECIES SPECIALIZED
TO THE DARK UNDERSTORY OF
THE FOREST.
AND IF WE LOOK AT A BIG
LANDSCAPE SCALE
THE FOREST IS A MOSAIC OF
TREES AND GAPS.

Narrator: SOME TREES ARE
SPECIALIZED
BY THE NUTRIENTS IN THE SOIL.
Dr. Hubbell: THIS SPECIES IS RARE.
THIS IS CASEARIA, AND IT ONLY
OCCURS
IN THIS LOCAL LITTLE AREA THAT
WE'RE IN
OF ABOUT 100 FEET BY 100 FEET. AND THERE ARE A COUPLE
HUNDRED INDIVIDUALS HERE BUT NOWHERE ELSE IN THE PLOT OR
VERY RARE IN THE REST OF THE PLOT. AND SO WE'RE TRYING TO
UNDERSTAND WHY THIS SPECIES LIKES THIS PARTICULAR PLACE IN THE
FOREST. AND ONE IDEA IS THAT THIS PARTICULAR SPECIES LIKES
HIGH-CALCIUM SOILS AND POOR-PHOSPHORUS SOILS. AND SO THIS IS
ONE AREA THAT HAS HIGH CALCIUM AND LOW PHOSPHORUS.
BUT OTHER SPECIES MAY NOT BE SO PARTICULAR. IN PARTICULAR,
THIS ONE -- FARAMEA -- GROWS EVERYWHERE AND SEEMS TO BE
INDIFFERENT TO THE VARIATION IN SOIL NUTRIENTS. SO IT'S MUCH
MORE COMMON. Narrator: UNLIKE IN TEMPERATE FORESTS RARE
SPECIES FAR OUTNUMBER THE COMMON SPECIES. THAT'S NOT ONE, BUT...
THERE YOU GO. OVER THERE. THIS DISTRIBUTION IS ESSENTIAL IN PROMOTING DIVERSITY. ON BARRO COLORADO ISLAND THE COMMON SPECIES ONLY ACCOUNT FOR 15% OF THE TOTAL TREE POPULATION COMPARED WITH AROUND 80% COMMON SPECIES IN A TYPICAL NEW ENGLAND FOREST.

ONE WAY TO INVESTIGATE HOW THIS DIVERSE COMPOSITION OF THE RAINFOREST IS PERPETUATED IS BY STUDYING THE SEEDS AND SEEDLINGS. Dr. Davies: THE SEEDLINGS ON THE GROUND IN A FOREST ARE THE NEXT GENERATION OF THE FOREST. AND SO WE HAVE A NUMBER OF STUDIES WHERE WE MAP VERY SMALL PATCHES OF THE FOREST TO MONITOR THESE LITTLE SEEDLINGS. Narrator: DIVIDING THE 50,000 SQUARE-METER PLOT INTO 1-METER-BY-1-METER SECTIONS.
THE RESEARCHERS GATHER DATA FOR EACH SEEDLING AND NOTE ANY CHANGES.
Dr. Davies: SO WE WANT TO KNOW IF THE SEEDLINGS HAVE THE SAME COMPOSITION OR THE SAME SPECIES DIVERSITY AS THE CANOPY. BECAUSE WE WANT TO UNDERSTAND HOW DOES THE DEVELOPMENT OF A FOREST OCCUR.
DETERMINA QUE LA PLANTA HA MUERTO.
Y AQUí SE PONE EL CóDIGO DE QUE ES MUERTA.
Narrator: THESE STUDIES HAVE LED TO HYPOTHESES ON HOW SO MANY RARE SPECIES CAN SURVIVE WITH SO FEW INDIVIDUALS.
OF THE 300 SPECIES IN THIS PLOT 15 TO 20 OF THEM ARE REPRESENTED BY A SINGLE INDIVIDUAL.

Dr. Davies: HOW DO THESE INDIVIDUAL SPECIES JUST WITH ONE TREE, HOW DO THEY SURVIVE? HOW DO THEY REPRODUCE?
THE TWO HYPOTHESES ABOUT
HOW RARE SPECIES GET MAINTAINED --
THE POLLINATORS MAY BE VERY MOBILE.
THEY MAY BE ABLE TO TRAVEL LARGE DISTANCES
TO FIND THEIR MATES
TO FIND INDIVIDUALS OF THE SAME SPECIES TO REPRODUCE.
THE SECOND ONE IS THAT THEY MAY BE SELF-FERTILE.
THAT MEANS THEY MAY JUST REPRODUCE THEMSELVES.
AND THEN THEY DON'T NEED ANY OTHER INDIVIDUALS NEARBY.

Narrator: THE SCIENTISTS HAVE ALSO FORMED THEORIES ON WHY THE COMMON SPECIES ARE UNABLE TO TAKE OVER.
AND THE REASON IS THAT COMMON SPECIES WHEN THEY REPRODUCE SEEDLINGS -- THEY PRODUCE MORE SEEDLINGS THAN RARE SPECIES BUT THOSE COMMON SPECIES THE COMMON SEEDLINGS GET AFFECTED BY PATHOGENS AND PESTS AT A VERY HEAVY RATE.
YOU CAN IMAGINE A SPECIALIST
A PATHOGEN OR PREDATOR THAT LIKES A PARTICULAR SPECIES WILL COME INTO A LITTLE PATCH AND IT'LL EAT ALL THE SEEDLINGS. IT'LL KILL THEM ALL. AND WE CALL THIS DENSITY-DEPENDENT PROCESSES. THAT MEANS IF YOU'RE AT A HIGH-DENSITY YOU SUFFER VERY HIGH MORTALITY. YOU DIE MORE OFTEN THAN IF YOU'RE RARE. AND SO THIS BALANCES DIVERSITY.

Narrator: THERE ARE STILL MANY UNANSWERED QUESTIONS AS TO HOW TROPICAL RAINFORESTS MAINTAIN DIVERSITY. UNLOCKING THESE MYSTERIES BECOMES URGENT AS HUMANS IMPACT THESE ECOSYSTEMS. DUE TO DEFORESTATION RAINFORESTS NOW COVER LESS THAN HALF OF THE AREA.
They once occupied.
Dr. Davies: Over the last three decades
The loss of tropical rainforest has been significant.
And so if we don't understand the biology of these species in their natural habitats
I don't think we have any chance of understanding how they're gonna respond to human modifications of those habitats.

Narrator: While Davies is focused on understanding the diversity of tropical rainforests another team of scientists investigates an ecosystem centered in Yellowstone National Park where human attempts to manage its wildlife have changed the balance of species.
[ Wolves barking, howling ]

Robert Crabtree is the Chief Scientist
AND FOUNDER OF THE YELLOWSTONE ECOLOGICAL RESEARCH CENTER. CURRENTLY, HE IS INVESTIGATING THE CASCADING EFFECTS ON THE ECOSYSTEM AFTER THE TOP PREDATOR -- THE WOLF -- WAS REMOVED AND YEARS LATER RETURNED TO THE PARK.

[ WOLVES BARKING, HOWLING ]

Man: THE WOLF REINTRODUCTION IS INADVERTENTLY A WONDERFUL EXPERIMENTAL SETUP TO TRY TO UNDERSTAND HOW THE WOLF CAN HELP BRING BACK THE YELLOWSTONE SYSTEM INTO MORE OF A NATURAL AND UNMANAGED STATE TO PRESERVE IT FOR FUTURE GENERATIONS.

Narrator: YELLOWSTONE NATIONAL PARK WAS ESTABLISHED IN 1872 AFTER EXPLORERS DISCOVERED ITS EXTRAORDINARY HOT SPRINGS GEYSERS, AND OTHER GEOTHERMAL FEATURES.

AS AMERICA'S FIRST AND STILL ONE OF ITS MOST
POPULAR NATIONAL PARKS
MUCH OF ITS ORIGINAL
ECOSYSTEM HAS BEEN
PRESERVED.
Dr. Crabtree: IT REALLY WAS
ABOUT DRAWING A BIG BOX
AROUND THE GEOTHERMAL
RESOURCES OF THE PARK.
AND OF COURSE A WONDERFUL
WINDBALL FROM THAT
WAS THE PROTECTION OF
PRE-COLUMBIAN CONDITIONS.
ALL THE SPECIES AND ALL THE
WONDERFUL HABITATS
THAT ARE NOT REPRESENTED IN
OTHER AREAS OF NORTH
AMERICA
WERE PROTECTED BY THE
ORIGINAL CREATION
OF YELLOWSTONE NATIONAL
PARK.
GO BACK UP AND SEE MORE OF
THE ACTIVE FIRES.
Narrator: HOWEVER PRISTINE THE
PARK MAY APPEAR
IN FACT, HUMAN EFFORTS TO
MANAGE THE PARK
HAVE HAD DRAMATIC EFFECTS
ON THE HEALTH OF ITS PLANTS
AND ANIMALS.
Dr. Crabtree: IN MANAGING AND
PROTECTING THIS PARK
MANY THINGS HAD TO HAPPEN. AND ACTUALLY, WHEN IT WAS MADE A PARK THERE WAS ALREADY SOME BIG IMPACTS TO THE PARK. FUR TRAPPING HAD OCCURRED. ELK AND DEER WERE BEING POACHED. AND THE PARK ACTUALLY FORMED BY BRINGING IN THE MILITARY TO HELP PROTECT IT. AND THEN SOON AFTER THAT THEY MOVED INTO A PHASE OF TRYING TO MANIPULATE IT TO GET IT BACK TO A HEALTHY STATE WHICH INCLUDED THE REMOVAL AND ERADICATION OF PREDATORS. THEY WERE THOUGHT TO HAVE BEEN BAD AT THAT POINT.

Narrator: IRONICALLY, WHILE STRIVING TO PRESERVE THE ANIMALS AND LANDSCAPE HUMANS IMPLEMENTED CHANGES THAT AFFECTED THE HEALTH OF THE ECOSYSTEM. IN 1926 PARK RANGERS EXTERMINATED THE WOLF POPULATION
TRIGGERING A CASCADE EFFECT.

IN THE FOLLOWING YEARS, THE ELK POPULATION SOARED SERIOUSLY IMPACTING OTHER SPECIES. THE ELK CONSUMED MUCH OF THE VEGETATION IN THE LAMAR VALLEY AN AREA IN THE NORTH OF THE PARK AND MANY SPECIES THAT DEPENDED ON THIS VEGETATION SUCH AS BEAVERS, GREW SCARCE.

TO COMBAT THIS PROBLEM DIFFERENT METHODS WERE ADOPTED OVER THE YEARS TO CONTROL THE ELK POPULATION INCLUDING TRAPPING AND KILLING THEM. FINALLY, IN A CONTROVERSIAL MOVE TO RESTORE THE PARK'S NATURAL CONDITIONS WOLVES WERE BROUGHT BACK INTO YELLOWSTONE AFTER A 70-YEAR ABSENCE.

Dr. Crabtree: IN 1995 AND 1996 AFTER 20 YEARS OF EFFORT BY A
LOT OF ORGANIZATIONS WOLVES CAPTURED AS SOCIAL GROUPS IN CANADA WERE TRANSPORTED DOWN, ACCLIMATED IN PENS AND RELEASED. THE FUNDAMENTAL QUESTION IS IS THE WOLF GONNA FIT RIGHT BACK INTO THE NICHE IT ONCE HAD OR HAVE THINGS CHANGED SUBSTANTIALLY ENOUGH TO WHERE THEIR NEW NICHE IS ACTUALLY DIFFERENT THAN WHAT IT WAS AT THE TURN OF THE CENTURY?

Narrator: SCIENTISTS HOPED THAT AS THE TOP PREDATOR IN THE FOOD CHAIN THE WOLF WOULD CONTROL THE POPULATION OF ELK AND OTHER HERBIVORES AND, THEREFORE, THE VEGETATION THAT THESE ANIMALS FEED ON SUCH AS WILLOWS, WOULD BE ABLE TO SURVIVE. SINCE THE RETURN OF THE WOLF THE ELK POPULATION HAS DRastically DECREASEd FROM 20,000 IN THE 1990s TO
FEWER THAN 10,000 TODAY.

NOW CRABTREE AND HIS TEAM HOPE TO DISCOVER WHAT EFFECT THE WOLF HAS ON THE PLANT LIFE. SPECIFICALLY, THEY'RE EXAMINING RIPARIAN SYSTEMS -- THE AREAS ALONG STREAMS, RIVERS, AND LAKES.

Dr. Crabtree: RIPARIAN ECOSYSTEMS OFTEN ARE AREAS WHERE YOU SEE THE HIGHEST CONCENTRATION OF SPECIES OR BIODIVERSITY. WE CALL THEM HOT SPOTS. AND CERTAINLY IN A SEMI-ARID ECOSYSTEM LIKE THE YELLOWSTONE THEY REALLY DO DOMINATE THE LANDSCAPE.

Narrator: ALTHOUGH THESE RIPARIAN SYSTEMS ONLY COMPRIZE AROUND 1% OF THE PARK'S LAND AREA THEY PLAY A VITAL ROLE, PROVIDING FOOD OR HABITAT FOR OVER 70% OF THE SPECIES IN THE PARK. SO PROTECTING THESE SYSTEMS
IS ESSENTIAL TO MAINTAINING THE OVERALL HEALTH OF THE PARK’S ECOSYSTEM. SARAH UHL COORDINATES THE FIELD RESEARCH IN THE RIPARIAN ZONES. Woman: WE'RE WORKING IN A VERY COMPLEX SYSTEM AND WE'RE TRYING TO UNDERSTAND HOW THE INTRODUCTION OF WOLVES IS ONE FACTOR INTERACTING WITH A SUITE OF OTHER FACTORS TO CHANGE WILLOW AND OTHER RIPARIAN SHRUB POPULATIONS. MAYBE THIS ONE THAT WE'RE LOOKING AT IS ONE OF THESE DOTS. AND THEREFORE, WE NEED TO GO A LITTLE BIT MORE... WE DEFINITELY NEED TO GET AROUND. Narrator: CRABTREE HAS SET UP AROUND 90 PLOTS THROUGHOUT YELLOWSTONE. EVERY FOUR YEARS A TEAM OF FIELD BIOLOGISTS RETURNS TO EACH PLOT LOCATES EACH OF THE TREES AND SHRUBS ON THE PLOT... WHAT ELSE IS AROUND YOU?
...AND UPDATES THE MASTER
DATABASE
WITH THE CURRENT HEALTH OF
EACH PLANT.
Man: OUR DAILY ROUTINE
USUALLY INVOLVES GOING OUT
AND RELOCATING WILLOW PLOTS
THAT WERE CHARTED, MAPPED
AND STUDIED FOUR YEARS AGO,
IN 2002.
SO WE DO NEED TO GO ALL THE
WAY TO THE BANK THERE.
Man: THEN WE CAN SET OUT OUR
MEASUREMENTS FOR THE PLOT.
AND WE ACTUALLY TAKE OUR GPS
UNIT, OUR DATA SHEET
AND OUR MEASURING TOOLS
AND BASICALLY GO TO EACH
PLANT, INDIVIDUAL PLANT
AND TAKE ALL THE CRUCIAL
MEASUREMENTS.
AN AVERAGE HEIGHT OF 1.1
METERS.
Swenson: THEN WE'RE RECORDING
THE SPECIES.
WE'RE ALSO RECORDING
THE VARIOUS PHYSICAL
DIMENSIONS OF THE PLANT --
The length of its long axis,
the length of its shorter axis
its average height, its
MAXIMUM HEIGHT, THE DENSITY -- AS IN THE DENSITY OF STEMS ON THAT INDIVIDUAL PLANT. AND THEN WE START LOOKING AT THE BROWSE HISTORY ALONG AN INDIVIDUAL STEM THAT'S REPRESENTATIVE OF THE WHOLE PLANT. Narrator: BROWSE HISTORY REFERS TO HOW MUCH OF THE TREES AND PLANTS WERE EATEN BY VARIOUS HERBIVORES OVER TIME. Uhl: IF WE LOOK AT THIS LEADER YOU CAN SEE LITTLE CHOMP MARKS HERE THAT ARE OLD. AND THIS PROBABLY TOOK PLACE DURING LAST WINTER WHEN THE ELK WERE WINTERING OVER IN THE PARK AND NEEDED SOMETHING TO EAT AND CAME AND STOPPED RIGHT HERE. AND AFTER THE WILLOW IS MUNCHED LIKE THAT THE PLANT CAN'T SIMPLY GROW FROM THAT REGION OF DEAD TISSUE. IT NEEDS TO SPROUT AGAIN FROM WHERE IT WAS STILL ALIVE, BENEATH THE BROWSING.
AND THAT'S WHAT YOU'RE SEEING RIGHT HERE WITH THIS BROWER, REDDER STEM.
THAT IS ALL NEW GROWTH.
Narrator: IN ORDER TO SURVIVE THE WILLOW MUST GROW ABOVE THE BROWSING HEIGHT WHERE HERBIVORES SUCH AS ELK CAN NO LONGER REACH IT.

WELL, HERE WE HAVE A MUCH LARGER WILLOW. AND ITS GROWTH PATTERN OVER THE LAST FEW YEARS IS PRETTY DIFFERENT FROM WHAT WE WERE SEEING IN THE REST OF THE PLOT. HERE WE SEE THAT THE LAST FEW YEARS HAVE ACTUALLY NOT BEEN BROWSED. SO, FOR VEGETATED... ALL COVERED. 100% OVERALL.
Narrator: THE RESEARCH TEAM IS FINDING THAT THE WILLOW POPULATION IS STARTING TO RECOVER IN CERTAIN AREAS OF THE PARK.
Dr. Crabtree: IN PARTICULAR, WHERE THE WOLVES HAVE
YOU MIGHT SAY, FEAR IN THE ELK WHERE WOLVES CAN GO IN AND EFFECTIVELY KILL ELK ELK MIGHT NOT EVEN BE GOING DOWN INTO THOSE AREAS AND WILLOW IS ALLOWED TO GROW UP AND GET HIGH ENOUGH TO WHERE IT ESCAPES BROWSE HEIGHT FROM THE ELK. AND WE'RE SEEING THIS IN SEVERAL AREAS OF THE NORTHERN PART OF THE PARK.

Dr. Crabtree: THE MAJOR PART OF REMOTE SENSING FOR ECOLOGISTS AND THE GREATEST UTILITY IS THAT THEY TAKE DETAILED IMAGES AND DATA SETS OVER LARGE AREAS. RIPARIAN HABITATS ARE EXTENDED OVER LARGE AREAS THROUGH THE ENTIRE ECOSYSTEM AND WE SIMPLY DON'T HAVE THE MONEY OR THE LABOR FORCE TO GO OUT AND EXAMINE ALL THESE. BUT WE CAN INTENSIVELY LOOK AT REPRESENTATIVE SAMPLES OF THOSE RIPARIAN HABITATS AND THEN TURN TO OUR REMOTE-SENSING DATA THAT COVERS THE WHOLE ECOSYSTEM AND MAKE GREAT INFRINGEMENT OR EXTRAPOLATE OUR RESULTS TO THE WHOLE ECOSYSTEM ACCURATELY.

Narrator: ONE REMOTE-SENSING TOOL USED BY CRABTREE'S TEAM IS NASA'S AVIRIS HYPERSPECTRAL CAMERA.
Dr. Crabtree: YOU CAN THINK OF ONE OF THESE HYPERSPECTRAL CAMERAS AS ALMOST LIKE A BIOLOGICAL DNA FINGERPRINT OF THE LANDSCAPE.
AS YOU CAN SEE HERE IN THIS COLOR IMAGE WE'VE GOT LARGELY A BIG, GREEN, MARSHY RIPARIAN AREA THAT LOOKS A LOT THE SAME. IN A HYPERSPECTRAL IMAGE, THE SAME AREA HERE IS MUCH MORE THAN JUST A BIG, MARSHY, GREEN AREA WITH THE RIVER RUNNING THROUGH IT. IT'S COMPOSED OF MANY DIFFERENT KINDS OF HABITAT STRUCTURAL DIFFERENCES THAT'S APPARENT TO THE HYPERSPECTRAL CAMERA THAT YOU CANNOT SEE IN A SIMPLE COLOR IMAGE OF THE STUDY AREA.

Narrator: THE COLORS IN THE IMAGE REPRESENT THE AMOUNT OF LIGHT ENERGY AT DIFFERENT WAVELENGTHS THAT'S BEING ABSORBED AND REFLECTED BY THE PLANTS
SOMETHING WE CANNOT SEE WITH THE NAKED EYE. THIS INFORMATION CAN HELP DETERMINE IF THE WILLOW IS STRESSED OR HEALTHY. IN THIS IMAGE, WITHIN THE MARKED PLOT THE DARK GREEN REPRESENTS HEALTHY WILLOW THAT HAVE ESCAPED BROWSE HEIGHT. Dr. Crabtree: THIS IS WHAT'S CALLED RELEASED WILLOW. SO THIS IS HIGH-STATURE WILLOW THAT REALLY ERUPTED IN 1997 AND 1998 AND IT'S SURROUNDED BY SMALLER WILLOW THAT HAS NOT RELEASED.

Narrator: USING THE REMOTE-SENSING IMAGES IN CONJUNCTION WITH THE DATA GATHERED IN THE FIELD GIVES THE TEAM A BETTER UNDERSTANDING OF THE LANDSCAPE AND HOW IT IMPACTS THE VARIOUS TIERS IN THE FOOD WEB. THE RESEARCHERS HAVE FOUND
THAT WILLOWS THAT ESCAPE
BROWSING HEIGHT
CREATE A DOMINO EFFECT
WITHIN THE ECOSYSTEM.

SPECIES LIKE RIPARIAN
SONGBIRDS, INSECTS
AND, IN PARTICULAR, RODENTS
HAVE COME BACK INTO THESE
PREFERRED HABITAT TYPES
AND OTHER SPECIES ARE
STARTING TO RESPOND.
FOR EXAMPLE, FOX AND COYOTES
ARE MOVING INTO THESE AREAS
BECAUSE THERE'S MORE PREY
FOR THEM.
AND THERE'S BEEN AN ERUPTING
TROPHIC CASCADE
IN SOME OF THESE LUSH WILLOW
RIPARIAN HABITAT SITES.

Narrator: WHILE THE WILLOW
POPULATIONS APPEAR TO BE
REBOUNDING
SCIENTISTS ARE WORKING TO
DETERMINE
HOW MUCH OF THIS REGROWTH
CAN BE ATTRIBUTED TO THE
WOLVES
AS COMPARED TOO THEIR
CONTRIBUTING FACTORS.
Dr. Crabtree: WE'RE FINDING OUT
OF WILLOWS IN YELLOWSTONE AND STUART DAVIES' TREE CENSUS IN THE RAINFOREST WILL PROVIDE THE EVIDENCE NEEDED TO CREATE IMPROVED ECOSYSTEM MODELS TO BETTER INFORM POLICY-MAKERS ABOUT FUTURE PRESERVATION.

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