FUNDING FOR THIS PROGRAM IS PROVIDED BY...

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 ECOLOGICAL PRESERVE
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
STUDYTHE 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
CENSUSOF 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.

Narrator: STEPHEN HUBBELL OF
THE UNIVERSITY OF GEORGIA
AND THE SMITHSONIAN TROPICAL
RESEARCH INSTITUTE
IS ONE OF THE PIONEERS OF THIS
STUDY
WHICH BEGAN ON BARRO
COLORADO ISLAND IN 1980.
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 NICHES 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 LEAVESOF 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

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
PARKWAS 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
WINDFALL 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 COMPRISE 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 REPRESENTATIVEOF 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 BROWNER, 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
FINDINGTHAT THE WILLOW
POPULATION
IS STARTING TO RECOVER IN
CERTAIN AREAS OF THE PARK.
Dr. Crabtree: IN PARTICULAR,
WHERE THE WOLVES HAVE

CREATED
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
HEIGHTH FROM THE ELK.
AND WE'RE SEEING THIS IN
SEVERAL AREAS
OF THE NORTHERN PART OF THE
PARK.

Narrator: SINCE THE
RESEARCHERS CAN ONLY
MONITOR
A FRACTION OF THE WILLOW
FROM THE GROUND
THEY MUST TURN TO THE SKY,
USING REMOTE SENSING.
RADAR AND ADVANCED-IMAGING
CAMERAS
MOUNTED ON AIRPLANES AND
SATELLITES
PROVIDE DATA ON MANY
FACTORS
INCLUDING TREE HEIGHT,SOIL
AND PLANT CHEMISTRY
AND EVEN THE HEALTH OF THE
VEGETATION.

Dr. Crabtree: THE MAJOR PART OF REMOTE SENSING FOR ECOLOGISTS
AND THE GREATEST UTILITY
IS THATTHEY 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 INFERENCE 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

THAT IT'S VERY COMPLEX.
AND WE ARE SEEING SOME VERY CLEAR IMPACTS
DUE TO THE WOLF REINTRODUCTION
BUT IT'S NOT CLEAN OR AS CLEAR AS WE'D LIKE IT.
ONE OF THE CONFOUNDING FACTORS HAS BEEN
IN 1995, 1996, AND 1997
WE HAD 25-, 50-, AND 100-YEAR FLOODS
RIGHT AT THE TIME WHEN WOLVES WERE REINTRODUCED.
BUT BOTH, ARGUABLY --
AND WHAT THE EVIDENCE IS INITIALLY SHOWING --
HAVE IMPROVED THE HEALTH OF THE RIPARIAN HABITATS IN THE PARK.
AND IT'S THE GREATEST CHARGE SENT TO US AS SCIENTISTS
TO TRY TO UNRAVEL THAT AND TEASE APART THAT COMPLEXITY
AND RIGHTFULLY ASSIGN THE BIG SIGNAL
THAT IS COMING FROM THE WOLF REINTRODUCTION
ON THE ENTIRE ECOSYSTEM AND FOOD WEB OF YELLOWSTONE.
AVERAGE HEIGHT -- 1.25.
Narrator: BOTH CRABTREE'S STUDY

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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