FUNDING FOR THIS PROGRAMIS
PROVIDED BY...

Narrator: THE HUMAN SPECIES IS
ENGAGING
IN A VAST GLOBAL EXPERIMENT IN
CLIMATE CHANGE.

EACH DAY, MORE GREEN HOUSE
GASES
ARE BEING ADDED TO THE
ATMOSPHERE
WITH UNKNOWN CONSEQUENCES.

CLUES FOR WHAT THE FUTURE
MAY HOLD
ARE FROZEN DEEP WITHIN ICE ON
THE WORLD'S HIGHEST
MOUNTAINS.
LONNIE THOMPSON AND HIS TEAM
HAVE BEEN RISKING THEIR LIVES
FOR OVER THREE DECADES
DRILLING INTO MOUNTAIN
GLACIERS --
ICE THAT HAS REMAINED FROZEN
FOR THOUSANDS OF YEARS.

THE ICE CORES THEY RETRIEVE
CONTAIN A PERFECTLY
PRESERVEDRECORD
OF THE EARTH'S PAST CLIMATE.

LOOKING TOWARD THE FUTURE
CHRIS FIELD HAS CREATED A TIME MACHINE
IN A NORTHERN CALIFORNIA GRASSLAND.
THE JASPER RIDGE GLOBAL CHANGE EXPERIMENT
IS SUBJECTING AN ENTIRE ECOSYSTEM
TO THE PREDICTED CLIMATE CONDITIONS POSSIBLE
50 TO 75 YEARS IN THE FUTURE.
BOTH RESEARCH PROGRAMS --
ONE LOOKING INTO THE PAST AND THE OTHER TOWARD THE FUTURE
--
WILL ULTIMATELY PROVIDE US WITH BETTER WAYS
TO PREDICT AND COPE WITH EARTH'S CHANGING CLIMATE.

[WIND WHIPPING]

Man: I'VE CLIMBED A LOT OF MOUNTAINS
AND I'VE BEEN TOLD THAT I HOLD THE WORLD'S RECORD
FOR THE AMOUNT OF TIME A HUMAN BEING HAS SPENT
ABOVE 18,000 FEET, WHICH IS 3 1/2 YEARS OF MY LIFE.

BUT I'VE ALWAYS HAD A PURPOSE
FOR GOING UP THERE.
AND UNLIKE MOUNTAINEERS
I AM ALWAYS LOOKING FOR THE
SIMPLEST, SAFEST WAY
WE CAN GET OUR CREW UP
THERE AND ALL OF OUR
EQUIPMENT
'CAUSE WE HAVE TO MOVE 6
TONS OF EQUIPMENT TO THESE
MOUNTAINTOPS.
AND UNLIKE A MOUNTAINEER
WE SET UP CAMP AND WE LIVE
THERE
FOR SIX WEEKS OR TWO MONTHS
AND WE BRING FOUR TONS OF
FROZEN ICE BACK DOWN.

AND THE REASON WE DRILL AT
SUCH HIGH ELEVATIONS
IS THAT WE'RE TRYING TO GET TO
THE COLDEST PLACE
IN THOSE ICE FIELDS.
AND IF YOU GO UP TO WHERE THE
TEMPERATURE IS BELOW
FREEZING
NO MELTING OCCURS
AND YOU HAVE THE BEST
ARCHIVE OF THE PARAMETERS
THAT WE WANT TO MEASURE.
Narrator: LONNIE THOMPSON IS A

GLACIOLOGIST
WHO RESEARCHES THE EARTH'S CLIMATE HISTORY
BY READING INFORMATION TRAPPED IN ICE.
HE DRILLS ICE CORES HUNDREDS OF FEET DEEP
ALL THE WAY TO BEDROCK
AT ELEVATIONS ABOVE 18,000 FEET --
PLACES WHERE THE AIR IS VERY THIN AND EXTREMELY COLD.
EVEN IN THE TROPICS, THE TEMPERATURE AT THIS ALTITUDE REMAINS BELOW FREEZING YEAR-ROUND
SO THE SNOW THAT FELL CENTURIES AGO
HAS NEVER MELTED AND IS BURIED UNDER NEWER LAYERS.
WHEN THE ICE IS DRILLED OUT, IT CAN BE READ BACK IN TIME
MUCH LIKE THE RINGS OF A TREE.
HERE. HERE. HERE.
Thompson: THE BEAUTY OF THE ICE
IS IT RECORDS ANYTHING THAT'S IN THE ATMOSPHERE
AT THE TIME THAT THAT SNOW FALLS.
IF YOU'RE AT THE TOP OF THE HIMALAYAS

YOU CAN SEE THE DEVELOPMENT OF INDUSTRY IN INDIA.
YOU CAN SEE WHEN LEAD WAS PUT INTO GASOLINE.
YOU CAN SEE WHEN LEGISLATION WAS PASSED TO REMOVE IT.
ANYTHING THAT'S IN THE AIR GETS RECORDED.
AND PERHAPS, WITH THE ICE CORES
PROBABLY THE THING THAT REALLY MAKES THEM UNIQUE
IS THAT THEY RECORD THE HISTORY OF THE EARTH'S ATMOSPHERE.
AND YOU CAN SEE HOW THE EARTH'S ATMOSPHERE
HAS CHANGED THROUGH TIME.
AND OUR LIMITATIONS
IS JUST INTERPRETING HOW THAT RECORDER IS WORKING.

WHEN I CAME TO OHIO STATE UNIVERSITY
I WAS PRETTY CONVINCED
I WAS GOING TO BECOME A COAL GEOLOGIST.
BECAUSE, HAVING GROWN UP IN WEST VIRGINIA, I COULD SEE --
ONE OF THE REASONS OF GOING TO COLLEGE WAS TO GET A JOB.
AND I COULD SEE THE

APPLICATION THERE.
IN MY FIRST QUARTER HERE
I GOT A LITTLE NOTE IN MY
MAILBOX THAT SAID
"HOW WOULD YOU LIKE TO WORK
FOR A RESEARCH PROGRAM
IN THE INSTITUTE OF POLAR
STUDIES
LOOKING AT ICE CORES?"
AND SO I TOOK THIS POSITION.
IT TOOK ME ABOUT A YEAR, YEAR
AND A HALF
TO REALLY START TO REALIZE
WHAT WAS ARCHIVED
IN THOSE ICE CORES, OR THE
POTENTIAL.
AND AT THAT TIME
ALL THE WORK WAS BEING DONE
IN THE POLAR REGIONS.
Narrator: DURING THE 1950s AND
'60s
AMBITIOUS DRILLING PROGRAMS
IN THE REMOTE ICE CAPS OF
ANTARCTICA AND GREENLAND
PROVIDED AN IMPRESSIVE
RECORD OF PAST CLIMATE
SUCH AS ICE AGES AND WARMING
EVENTS
GOING BACK HUNDREDS OF
THOUSANDS OF YEARS.
BUT THESE RECORDS ONLY
PROVIDED PART OF THE

CLIMATE'S HISTORY.
AS A YOUNG MAN
THOMPSON'S INTERESTS LAY
OUTSIDE THE ARCTIC.
HE SET A GOAL --
TO DRILL ICE WHERE NO ONE HAD
EVER DRILLED BEFORE.
IN THE POLAR REGIONS AT THE
TIME
THERE WAS A LOT OF
COMPETITION
AND NO ONE WAS LOOKING
ANYWHERE ELSE.
AND SO I'M THINKING, "WELL,
HERE'S THE REST OF THE WORLD.
WHY NOT?"
AND THEN, OF COURSE, IF YOU
START THINKING ABOUT IT
YOU REALIZE THAT WE GOT
6.5 BILLION PEOPLE ON THE
PLANET.
70% OF THEM LIVE IN THE
TROPICS.
AND THEN YOU ALSO REALIZE
A LOT OF THE BIG WEATHER
PHENOMENA THAT IMPACT
PEOPLE --
EL NIÑO, MONSOONS -- THOSE
ARE TROPICAL PHENOMENA.
AND IF YOU REALLY WANTED TO
LOOK AT THE HISTORY OF THOSE
YOU NEED RECORDS FROM THAT

PART OF THE WORLD.
AND I WILL NEVER FORGET A REBUFF
WHEN WE PROPOSED TO DRILL THE QUELCCAYA ICE CAP.
AND IT BASICALLY SAID
"THE ICE CAP IS TOO HIGH FOR HUMAN BEINGS
AND THE TECHNOLOGY DOES NOT EXIST TO DRILL IT."
AND TOWARD THE END OF THE SEASON
I GOT A TELEX FROM THE PROGRAM MANAGER.
HE SAID THAT HE HAD FUNDED ALL OF HIS REAL SCIENCE PROJECTS
AND HE HAD $7,000 LEFT --
WHAT COULD WE DO ON THAT TROPICAL GLACIER FOR $7,000?
AND I REMEMBER TELEXING BACK AND SAYING
"I THINK WE CAN GET THERE."
THE IDEA WAS TO BRING A DRILL FROM ANTARCTICA
AND FLY THIS THING UP TO THE SUMMIT
DRILL THE CORE, PUT THE CORES IN A HELICOPTER
FLY IT OUT.
THIS HELICOPTER --
WE'D BE FLYING ALONG AT 19,000

FEET
AND IT WOULD JUST FALL LIKE A ROCK.
I MEAN, IT'S CLEAR AIR.
AND THE PILOT'S EYES WERE BIG.
I'M SURE OURS WERE, TOO.
AFTER TWO ATTEMPTS, THEY SAID, "THERE'S NO WAY.
WE CAN'T EVEN GET CLOSE TO THE ICE CAP."
YOU JUST COULDN'T DO IT.
SO WE FAILED IN OUR MISSION TO DRILL THE ICE FIELD.
AND THAT'S WHEN WE CAME UP WITH THE IDEA OF SOLAR POWER.

THE BEAUTY OF THAT IS THAT THEY'RE PANELS.
AND YOU CAN PUT SIX PANELS TO A HORSE
AND YOU CAN TRANSPORT YOUR POWER SUPPLY TO THE EDGE OF THE ICE
CARRY IT UP ON THE SUMMIT, ASSEMBLE THE ARRAY
AND POWER YOUR DRILL.
TURNED OUT THAT THAT SOLAR POWER WAS JUST BEAUTIFUL.
THE FACT IS, WE ACTUALLY DRILLED NOT ONE
BUT TWO CORES TO BEDROCK USING THAT SOLAR-POWERED

DRILL.
AND WE COULDN'T HAVE CHOSEN A BETTER ICE FIELD ON EARTH TO DO THIS
BECAUSE THE RECORD WAS SO STRAIGHTFORWARD.
QUELCCAYA WAS ANNUALLY LAYERED. YOU COULD SEE IT.
AND YOU COULD SEE IT IN THE DUST MEASUREMENTS.
SO IT WAS -- COULDN'T HAVE MADE A BETTER CHOICE.
Narrator: THE ICE CORES LONNIE'S TEAM RECOVERED
ON THE QUELCCAYA ICE CAP BECAME A MAJOR STEP FORWARD IN CLIMATE HISTORY RESEARCH
BECAUSE THEIR ANNUAL LAYERS COULD BE DATED SO ACCURATELY.
THE TROPICS HAVE ALTERNATING WET AND DRY SEASONS EVERY YEAR
AND THESE ALTERNATING SEASONS ARE CLEARLY MARKED IN THE ICE
CONTAINING VITAL INFORMATION ABOUT THE WEATHER IN THE REGION
SUCH AS MONSOONS, DROUGHTS, AND EL NIÑO.

EACH YEAR, THE WET SEASON
BRINGS A THICK SNOW LAYER
FOLLOWED BY A DARKER LAYER
CREATED BY DRY-SEASON DUST
CARRIED BY WINDS UP THE
MOUNTAIN.
THESE ALTERNATING WET AND
DRY LAYERS
CAN THEN BE LINKED TO
HISTORIC ATMOSPHERIC EVENTS
SUCH AS VOLCANIC ERUPTIONS,
GIVING A PRECISE ANNUAL
RECORD.
Thompson: AND SO THAT GIVES
YOU YOUR CALENDAR.
YOU CAN SEE IT ON THE MARGIN
OF THE ICE CAP
AND YOU CAN SEE IT IN THE ICE
CORES WHEN YOU DRILL
AND YOU CAN SEE IT IN THE
ANALYSIS
WHEN IT'S DONE IN THE LAB.
AND IF YOU WANT TO TALK ABOUT
RATES OF CHANGE
YOU NEED THAT ANNUAL
CALENDAR.
AND WE NOW KNOW, PROBABLY
25 YEARS LATER
THAT THAT ICE CAP CONTAINS
THE HIGHEST RESOLUTION
THE LONGEST ANNUAL RECORD
THAT WE WILL EVER FIND IN THE

TROPICS.
Narrator: THE PERUVIAN
EXPEDITIONS WERE THE
BEGINNING
OF AN AMBITIOUS WORLDWIDE
DRILLING PROGRAM.
OVER THE NEXT 30 YEARS
LONNIE AND HIS TEAM
CONTINUED TO MAKE TECHNICAL
IMPROVEMENTS
TO BETTER RETRIEVE
HIGH-RESOLUTION ICE CORES
FROM EXTREME LOCATIONS.
TO CREATE A GLOBAL ARCHIVE
OF PAST CLIMATE
LONNIE HAS MADE MORE THAN 50
EXPEDITIONS
TO AFRICA, ANTARCTICA, BOLIVIA,
CHINA, GREENLAND, PERU,
RUSSIA
AND THE UNITED STATES.

AT THE END OF EVERY
EXPEDITION
THE ICE IS RUSHED BACK TO THE
COLD ROOM
AT OHIO STATE UNIVERSITY
WHERE IT IS PRESERVED IN A
FROZEN LIBRARY
WAITING TO BE DECIPHERED.
Thompson: AND WE NOW HAVE
7,000 METERS OF CORE

WE STORE AT MINUS 30.
AND IT TURNS OUT NOW
THAT IT'S THE ONLY TROPICAL
ARCHIVE OF ICE CORES ON
EARTH.
Narrator: THESE CORES ARE
CRUCIAL LINKS
IN THE HISTORY OF CLIMATE
CONNECTING THE POLAR
REGIONS TO THE TROPICS.
BY ANALYZING THIS ARCHIVE
AND COMPARING IT TO OTHER
CLIMATE RECORDS
A GLOBAL UNDERSTANDING OF
PAST CLIMATE IS EMERGING.
Woman: WHAT WE WANT TO DO IS
GET IT BACK TO THE LAB
AND START WORKING ON IT AS
QUICKLY AS POSSIBLE
BECAUSE EVERYBODY'S REALLY
CURIOUS TO SEE
WHAT KIND OF INFORMATION IT
HAS.
AS A MATTER OF FACT, AS WE'RE
DRILLING THIS
WE'RE OFTEN TALKING ABOUT
WHAT INFORMATION
THIS RECORD MIGHT HOLD AND
HOW IT MIGHT FIT IN
WITH ALL THE OTHER RECORDS.

IT'S ANOTHER PIECE OF A GLOBAL

PUZZLE
AND WE FEEL THAT EVERY ONE
OF THESE PIECES IS CRITICAL.

Narrator: IN THE LAB, LONNIE'S
TEAM ANALYZES THE ICE CORES.
OXYGEN ISOTOPE RATIOS
PROVIDE A PROXY
FOR THE TEMPERATURE WHEN
THE ICE WAS FORMED.
THESE RECORDS ARE
CONSISTENT WITH OTHER
STUDIES THAT REVEAL
GOING BACK 1,000 YEARS, A
LONG-TERM WARMING TREND
BEGINNING ABOUT 150 YEARS
AGO --
THE DAWN OF THE INDUSTRIAL
AGE.

CARBON DIOXIDE
MEASUREMENTS
TAKEN DIRECTLY FROM BUBBLES
TRAPPED IN THE ICE
REVEAL EVER-INCREASING
CONCENTRATIONS OF CO2
OVER THIS SAME TIME PERIOD.

ADDING TO THIS WEALTH OF
INFORMATION
LONNIE'S TEAM CAN DETECT
DROUGHTS

BY MEASURING CHEMICAL
TRACES IN THE ICE
BLOWN IN FROM DRY LAKE BEDS.
Dr. Davis: WELL, THAT'S WHAT I
WAS JUST WONDERING ABOUT.
ONE OF THE EASIEST HISTORIC
RECORDS TO TRACK IN AN ICE
CORE
ARE DROUGHT EVENTS.
SO ANYWHERE YOU SEE
SULFATES
INDICATE THAT THE
ENVIRONMENT GOT VERY DRY.
HERE IT IS.
RIGHT HERE WAS A DROUGHT.
IN CALCIUM, THERE WAS AN
INCREASE HERE IN THE '60s.
AND THEN YOU GO DOWN.
HERE'S ANOTHER INCREASE IN
THE '30s.
IT WAS CONTEMPORANEOUS WITH
OUR DUST BOWL PERIOD.
ACTUALLY, YOU KNOW WHAT
THAT IS?
THAT'S THESE.
Thompson: WE'RE NOW FINDING
THAT THE REAL STORY OF
CLIMATE CHANGE
IS NOT IN THE SCIENCE OR
NATURE PAPER
THAT COMES FROM THE SINGLE
SITE

BUT IT'S IN THE CONNECTION,
PUTTING THESE RECORDS
TOGETHER
THAT YOU SEE THINGS THAT YOU
COULD HAVE NEVER FOUND
IN ONE OR TWO SITES.
Narrator: CONNECTING LONNIE'S
TROPICAL ICE-CORE DATA
WITH CORES TAKEN FROM THE
POLAR REGIONS
A RECORD OF THE EARTH'S
TEMPERATURE
AND CARBON DIOXIDE LEVELS
CAN BE ESTABLISHED
GOING BACK 650,000 YEARS INTO
THE PAST.
OVER THIS TIME PERIOD
EACH RISE IN CARBON DIOXIDE
LEVELS
IS ACCOMPANIED BY A RISE IN
TEMPERATURE.
IN THE MOST RECENT PERIOD
CARBON DIOXIDE LEVELS HAVE
BEEN RISING TO AN ALL-TIME
HIGH.
Thompson: HAVING THAT RECORD
NOW THAT GOES BACK 650,000
YEARS
AND KNOWING THAT CO2 IN THE
NATURAL WORLD
HAS VARIED BETWEEN 180, 190
PARTS PER MILLION BY VOLUME

DURING THE COLD PERIODS
WHEN WE HAVE LOTS OF ICE ON THE EARTH
TO 280, 290 PARTS PER MILLION BY VOLUME
WHEN THESE GLACIERS RETREAT
AND DURING THE WARM PERIODS
AND WE'RE NOW AT 380 PARTS PER MILLION BY VOLUME --
THERE IS NO ANALOGUE IN 650,000 YEARS.
AND THE CO2 IS RISING
AT 2 PARTS PER MILLION BY VOLUME EACH YEAR --
AND NOT BE CONCERNED ABOUT THAT.

Narrator: ICE-CORE DATA IS PERSUASIVE ON ITS OWN
BUT LONNIE HAS WITNESSED
THE CLEAREST EVIDENCE OF A WARMING PLANET
WITH HIS OWN EYES.
THE TROPICAL GLACIERS ARE MELTING.
THIS EVIDENCE IS CRITICAL
BECAUSE THE TROPICS
UNLIKE THE REST OF THE PLANET
NATURALLY EXPERIENCE VERY LITTLE TEMPERATURE VARIATION.
GLACIERS -- THEY DON'T HAVE A POLITICAL AGENDA.

THEY JUST KIND OF SUM UP
WHAT'S GOING ON OUT THERE
AND THEY RESPOND TO IT.
AND THEY ARE GIVING US A VERY
STRONG SIGNAL
THAT THE PLANET IS WARMING.
AND THE GLACIERS ARE
DISAPPEARING.
LIKE LOOKING AT AN AREA LIKE
THIS.
YOU MAY HAVE KNOWN WHERE
YOU WERE, BUT...
WE FIRST WENT TO KILIMANJARO
IN 1999.
AND IN 2000, WE HAD AERIAL
PHOTOGRAPHS --
FLOWN -- SO THAT WE COULD
MAKE A MAP
OF THE ICE ON THE MOUNTAIN IN
2000.
AND IT'S WHEN WE STARTED
COMPARING THE RESULTS OF
THAT MAP
WITH ALL THE OTHER MAPS THAT
HAD BEEN MADE
FROM THE MOUNTAIN, GOING
BACK TO 1912
THAT YOU COULD REALLY SEE
THE LOSS OF ICE
THAT HAS OCCURRED THERE.
AND SOME OF THE SKEPTICS
WILL LOOK AT A MOUNTAIN LIKE

KILIMANJARO, AND THEY SAY
"WELL, HOW DO YOU KNOW THAT
IT'S NOT LAND-USE CHANGES
"CHANGES IN MOISTURE SUPPLY
-- DROUGHTS AND THE LIKE?"
AND THE ANSWER TO THAT IS
THAT IT'S NOT JUST KILIMANJARO.
IT'S MOUNT KENYA. IT'S THE
RUWENZORIS.
IT'S ALL THE GLACIERS IN THE
ANDES OF SOUTH AMERICA
AND THROUGHOUT THE
HIMALAYAS
THAT ARE GIVING THE SAME
MESSAGE.
SO THE CONFIDENCE COMES
FROM THIS LARGE SCALE
EVIDENCE
THAT ALL POINTS IN THE SAME
DIRECTION.
TO ME -- AND PARTICULARLY THE
TROPICAL GLACIERS
ARE KIND OF OUR CANARIES IN A
COAL MINE.
SO THE FACT THAT EVERY
TROPICAL GLACIER IS
RETREATING, I THINK
IS OUR WARNING THAT THE
SYSTEM IS CHANGING.
IT'S IN LOOKING AT THIS HUGE
SYSTEM
AND HAVING THE OPPORTUNITY

TO WORK IN 15 DIFFERENT COUNTRIES
AND OBSERVE THE GLACIERS --
AND MANY TIMES ON AN ANNUAL BASIS --
TO SEE HOW RAPIDLY THAT CHANGE IS TAKING PLACE
THAT I THINK YOU HAVE TO BE CONCERNED ABOUT WHAT YOU SEE.

Narrator: WHILE THOMPSON'S WORK
IS DOCUMENTING THE GLOBAL CLIMATE CHANGE
THAT IS ALREADY WELL UNDERWAY
ONE OF THE GREAT UNKNOWNS
IS WHAT WILL BE THE EFFECTS OF THESE CHANGES ON ECOSYSTEMS.
OUTDOOR CARBON DIOXIDE ENRICHMENT EXPERIMENTS
AROUND THE WORLD
ARE SUBJECTING ECOSYSTEMS
TO THE KIND OF ENVIRONMENTAL CONDITIONS
THAT SCIENTISTS PREDICT 50 TO 75 YEARS IN THE FUTURE.
A STONE'S THROW
FROM STANFORD UNIVERSITY'S MAIN CAMPUS

CHRIS FIELD'S JASPER RIDGE
GLOBAL CHANGE EXPERIMENT
IS ONE OF THE
LONGEST-RUNNING AND MOST
COMPREHENSIVE
OF THESE STUDIES.

GLOBAL CHANGE IMPOSES A WIDE
RANGE OF STRESSES ON THE
FUTURE.
THAT ACTUALLY LOOKS JUST
ABOUT RIGHT.
EVERYTHING WE KNOW AT THIS
POINT INDICATES THAT THOSE
STRESSES
ARE LIKELY TO BE OF MAJOR
IMPORTANCE.
THEY ARE LIKELY TO
FUNDAMENTALLY ALTER
THE RANGE OF OPPORTUNITIES
THAT OUR CHILDREN AND THEIR
CHILDREN ENCOUNTER.
WE STARTED THE JASPER RIDGE
GLOBAL CHANGE EXPERIMENT
TO PROJECT THESE GRASSLANDS
INTO THE FUTURE.
WE WOULD HOPE THAT, AS YOU
WALK INTO THE PLOTS
YOU BASICALLY ARE SEEING
VISIONS OF CALIFORNIA FOR 2075.
Narrator: IN THE FUTURE
ONE OF THE MOST PROMINENT OF

GLOBAL CHANGE CONDITIONS
WILL BE INCREASED
GREENHOUSE GAS LEVELS.
OVER THE LAST 50 YEARS
CARBON DIOXIDE
CONCENTRATIONS HAVE
INCREASED EVERY YEAR.
IF THIS TREND CONTINUES
CARBON DIOXIDE LEVELS MAY
REACH TWICE WHAT THEY ARE
TODAY
BY THE YEAR 2100.
Field:WE KNOW THAT PLANTS
GROW
BY REMOVING CARBON DIOXIDE
FROM THE ATMOSPHERE.
THEY USE THE ENERGY FROM
SUNLIGHT
TO CONVERT CARBON DIOXIDE
INTO CARBOHYDRATES -- INTO
PLANT.
AND ECOSYSTEMS ON LAND
ARE TAKING UP A RELATIVELY
LARGE AMOUNT OF THE CARBON
THAT'S EMITTED BY HUMAN
ACTIONS, ESSENTIALLY
PROVIDING A SUBSIDY.
AND WHAT WE'D LIKE TO KNOW IS,
AS WE MOVE INTO THE FUTURE
WILL THAT CARBON UPTAKE --
THAT SUBSIDY -- INCREASE?
WILL IT DECREASE?

WILL IT GO AWAY AND TURN FROM A SUBSIDY
INTO AN EXTRA BURDEN ON THE ATMOSPHERE?
BUT WE DON'T HAVE VERY GOOD MODELS
THAT ADDRESS THE FULL SETS OF THINGS
THAT OCCUR IN REAL ECOSYSTEMS.
AND THE JASPER RIDGE EXPERIMENT ALLOWS US THE OPPORTUNITY
TO GET AT THAT IN A VERY PRECISE WAY
THAT LETS US USE IT AS A MODEL SYSTEM
FOR UNDERSTANDING THE CONTROLS ON CARBON BALANCE IN OTHER ECOSYSTEMS.
Narrator: THE PRIMARY GOAL
OF THIS ELABORATE OUTDOOR LABORATORY
IS TO SEE HOW THESE FUTURE CONDITIONS
WILL AFFECT THE ABILITY OF ECOSYSTEMS
TO STORE CARBON DIOXIDE.
AS THESE PLANTS GROW
THEY PULL CARBON DIOXIDE OUT OF THE ATMOSPHERE
AND TRANSFORM IT INTO PLANT

STRUCTURE, OR BIOMASS.
THE MORE THESE PLANTS GROW, THE MORE CARBON DIOXIDE THEY STORE.
EARLIER EXPERIMENTS, DONE IN CONTROLLED ENVIRONMENTS SHOW THAT INCREASED CO2 LEVELS
LED TO MORE ABUNDANT PLANT GROWTH.
BUT THE ONLY FACTOR THESE EXPERIMENTS ACCOUNTED FOR WAS INCREASED CARBON DIOXIDE.
WOULD PLANT PRODUCTIVITY INCREASE IN REAL ECOSYSTEMS WHEN OTHER CLIMATE-CHANGE FACTORS --
WATER, HEAT, AND NITROGEN -- ARE ALSO TAKEN INTO ACCOUNT?
Field:BY THE TIME WE STARTED THIS EXPERIMENT IN THE FALL OF 1997
THERE WAS A LOT OF CONTROVERSY
ABOUT THE MAGNITUDE OF GROWTH RESPONSES
TO ELEVATED ATMOSPHERIC CO2.
MOST PLANTS INCREASE
THE INSTANTANEOUS RATE OF CO2 UPTAKE --
THE INSTANTANEOUS RATE OF

GROWTH --
WHEN THEY'RE EXPOSED TO
ELEVATED ATMOSPHERIC CO2.
BUT THERE WERE A RANGE OF
DIFFERENT RESULTS
ABOUT PLANT GROWTH.
INDIVIDUAL PLANTS IN POTS
OR INDIVIDUAL PLANTS,
SEPARATED, IN THE GROUND
TENDED TO GROW MUCH FASTER
UNDER ELEVATED ATMOSPHERIC
CO2
AND THE DATA FROM
ECOSYSTEMS WERE QUITE MIXED.
WE REALIZED OVER A PERIOD OF
YEARS
THAT THERE WERELOTS OF
ARTIFACTS
THAT WERE INTRODUCED BY
GROWING PLANTS IN ISOLATION
OR IN THESE
CONTROLLED-GROWTH CABINETS
AND WE'VE MOVED
PROGRESSIVELY TOWARD
MORE AND MORE SOPHISTICATED
DESIGNS
TO GET IT CLOSER TO THE WAY
THAT NATURAL ECOSYSTEMS
WORK.
IN ORDER TO CREATE A REALISTIC
POSSIBLE FUTURE ENVIRONMENT
FOR THESE GRASSLANDS

WE'RE MANIPULATING FOUR
ENVIRONMENTAL FACTORS.
Narrator: THE JASPER RIDGE
EXPERIMENT IS CAREFULLY
DESIGNED
SO THAT NOT JUST CARBON
DIOXIDE
BUT THE OTHER FACTORS
PREDICTED IN CLIMATE-CHANGE
MODELS
CAN BE MANIPULATED.
THE FIELD CONSISTS OF 32
CIRCULAR PLOTS
EACH 2 METERS IN DIAMETER.
EACH PLOT IS CUT INTO
QUARTERS
MAKING A TOTAL OF 128
DIFFERENT TREATMENT AREAS
WITH EACH OF THE POSSIBLE
COMBINATIONS
OF THE FOUR FACTORS...

EACH PLOT COMBINATION IS
DUPLICATED EIGHT TIMES.
THE FACTOR OF EXTRA CARBON
DIOXIDE
IS DELIVERED WITH TUBING THAT
SURROUNDS HALF THE PLOTS.
CO2 LEVELS ARE CONTROLLED BY
SENSORS
THAT KEEP THE ENRICHMENT
TO DOUBLE CURRENT

ATMOSPHERIC LEVELS.
THE SYSTEM WAS DESIGNED SO THAT, AS A FUNCTION OF WIND DIRECTION
SOME EMITTERS COULD BE TURNED OFF
THAT WOULD BE ON THE DOWNWIND SIDE OF THE PLOT.
SO ONLY RELEASING CO2 ON THE UPWIND SIDE
AND THEN HAVING THE WIND CARRY IT ACROSS THE PLOT.
Narrator: THE NEXT FACTOR --
INCREASED TEMPERATURE --
IS DELIVERED TO HALF OF THE PLOTS WITH HEAT LAMPS.
Dr. Chiariello: BIRDS LIKE TO PERCH ON THESE HEATERS
AND BIRD DROPPINGS HAVE A LOT OF NUTRIENTS IN THEM.
SO ONE OF THE CONCERNS THAT WE HAD
WAS TO MAKE SURE THAT WE HAD A CONTROL
ON UNINTENDED EFFECTS OF THE HEATERS.
ONLY HALF OF THE PLOTS, OF COURSE, HAVE HEAT.
BUT IN DESIGNING THE EXPERIMENT
WE RECOGNIZED THAT IT WAS IMPORTANT

TO HAVE THIS INFRASTRUCTURE
PRESENT IN ALL OF THE PLOTS.
Narrator: THE FINAL TWO FACTORS
--
ADDITIONAL NITROGEN -- IN A
FORM SIMILAR TO THAT
EXPECTED FROM INCREASED AIR
POLLUTION --
AND WATER ARE ADDED TO
PLOTS INDIVIDUALLY.
Dr. Chiariello: THE PREDICTION FOR
CALIFORNIA
FOR THE NEXT CENTURY
IS THAT RAINFALL SHOULD
INCREASE.
THE OPTION THAT WE CHOSE
WAS TO SUPPLEMENT EACH
MAJOR RAINFALL BY ABOUT 50%.
Narrator: OVER THE GROWING
SEASON
THE RESEARCHERS ALLOW THE
PLANTS TO GROW TO MATURITY.
THEN THEY CAREFULLY HARVEST
10-CENTIMETER SQUARES OF
PLANT MATERIAL.
Dr. Chiariello: THE FIRST CUT AT
UNDERSTANDING
WHETHER OR NOT PLANTS ARE
RESPONDING TO ELEVATED CO2
OR TO ANY OF THESE OTHER
FACTORS
IS TO SEE HOW MUCH PLANT

BIOMASS THERE IS
AT THE END OF A GROWING SEASON.
THE PLANT BIOMASS IS PARTLY ABOVE GROUND.
IT'S WHAT WE SEE IN TERMS OF LEAVES AND FLOWERS AND STEMS.
AND PART OF IT IS BELOW GROUND IN THE FORM OF ROOTS AND CHEMICALS THAT HAVE LEAKED INTO THE SOIL AROUND THE ROOTS.
Narrator: ONCE THE PLOTS ARE HARVESTED
THE SAMPLES ARE DRIED AND THEN WEIGHED
TO CALCULATE THE AMOUNT OF CARBON
THE PLANTS REMOVED FROM THE ATMOSPHERE EACH YEAR.
THIS KEY MEASURE, KNOWN AS THE NET PRIMARY PRODUCTION
IS USED IN COMPUTER MODELS THAT PREDICT CLIMATE CHANGE EFFECTS
ON OTHER ECOSYSTEMS.
YEAH.
AFTER EIGHT YEARS OF CONDUCTING THIS EXPERIMENT
CHRIS AND HIS TEAM'S METICULOUS FIELDWORK

HAS BEGUN TO PRODUCE SOME
STARTLING RESULTS.
Field: ONE OF THE MOST
UNEXPECTED RESULTS
FROM THE JASPER RIDGE GLOBAL
CHANGE EXPERIMENT
IS THAT WE FOUND THAT
UNDER A WIDE RANGE OF
CONDITIONS
PLANT GROWTH WASN'T
INCREASED BY ELEVATED
ATMOSPHERIC CO2.
IN FACT, UNDER MANY
CONDITIONS
ELEVATED ATMOSPHERIC CO2
ACTUALLY PREVENTS PLANTS
FROM TAKING FULL ADVANTAGE
OF OTHER RESOURCES
THAT ARE AVAILABLE IN THE
ENVIRONMENT.
THIS HAS QUITE PROFOUND
IMPLICATIONS
FOR OUR UNDERSTANDING
OF ECOSYSTEM RESPONSES TO
GLOBAL CHANGE
AND FOR FUTURE CLIMATE
CHANGE.
IF PLANTS, IN FACT
DON'T GROW MORE UNDER
ELEVATED CARBON DIOXIDE
IT MEANS THAT ATMOSPHERIC
CO2

IS LIKELY TO GROW FASTER IN THE FUTURE
THAN WE HAVE BEEN ANTICIPATING.
BASICALLY, WHAT IT MEANS IS THAT
WE CAN'T CONTINUE TO DEPEND ON ECOSYSTEMS
TO SUBSIDIZE OUR EMISSIONS OF CO_2
FROM FOSSIL-FUEL COMBUSTION.
Narrator: THE RESULTS FROM THE JASPER RIDGE GLOBAL CHANGE EXPERIMENT
INDICATE THAT SOME OF THE PROJECTIONS
FOR FUTURE CARBON DIOXIDE CONCENTRATIONS
MAY, IN FACT, BE TOO LOW.
BUT WE COULDN'T BE CONFIDENT IN OUR ANSWERS
UNLESS WE HAD
COLLABORATORS IN MANY OTHER PARTS OF THE WORLD
WHO WERE DOING EXPERIMENTS
THAT ARE SIMILAR IN SOME RESPECTS.
WE HAVE COLLABORATORS AT THE UNIVERSITY OF MINNESOTA
WHO JUST FOUND THE SAME RESULT AS US --
THAT YOU DIDN'T SEE A BIG

GROWTH RESPONSE
TO ELEVATED ATMOSPHERIC CO2
UNLESS YOU ALSO PROVIDED
NITROGEN.
A GROUP WORKING ON A PINE
FOREST IN NORTH CAROLINA
RECENTLY PUBLISHED ALMOST
THE SAME RESULT.
A GROUP IN NEVADA FOUND THAT
EVEN THOUGH ELEVATED CO2
INCREASED PLANT GROWTH
IT INCREASED THE GROWTH OF
AN INVASIVE SPECIES
THAT TENDED TO BRING WILDFIRE
INTO DESERT HABITATS
THAT WEREN'T FLAMMABLE
OTHERWISE.
I THINK THAT, ACROSS THE
COMMUNITY
WHAT WE'RE SEEING IS THAT THE
RESPONSES TO GLOBAL
CHANGES
TEND TO BE COMPLICATED
THEY TEND TO BE PUSHING
ECOSYSTEMS IN THE DIRECTION
THAT TENDS TO MAKE THEM
MORE DISTURBANCE-PRONE
AND THEY TEND TO NOT BE
PROVIDING
THE ADDITIONAL CARBON
STORAGE THAT WE HAD HOPED
FOR

WHEN WE TOOK THE MOST
SIMPLEMINDED APPROACH
TO THIS KIND OF EXPERIMENT.
Narrator: CHRIS FIELD AND HIS
MANY COLLABORATORS
AT THE JASPER RIDGE GLOBAL
CHANGE EXPERIMENT
ARE EXPANDING THE SCOPE OF
THEIR RESEARCH
TO LOOK DEEPER INTO THE
MECHANISMS
THAT LIMIT PLANT GROWTH.
IN YEARS TO COME
THESE PROJECTS WILL PROVIDE A
WEALTH OF INFORMATION
ABOUT HOW ECOSYSTEMS
RESPOND AS A WHOLE
TO HUMAN-INDUCED CLIMATE
CHANGE.
Field: THESE STUDIES ARE
ONGOING.
THERE ARE A NUMBER OF
DETAILS
THAT WE'RE STILL TRYING TO
UNDERSTAND.
WE THINK OF THE JASPER RIDGE
GLOBAL CHANGE EXPERIMENT
AS SOMETHING MORE LIKE A
LABORATORY
THAN SOMETHING LIKE AN
EXPERIMENT.
WE ALL WORK TOGETHER TO SAY

"WHAT ARE THE BIG GOALS WE'D LIKE TO ACCOMPLISH?"
BUT THEN WE ENCOURAGE INDIVIDUAL INITIATIVE
IN ORDER TO FIGURE OUT HOW THE PIECES FIT TOGETHER.

FOR THE FUTURE
IT'S CLEAR THAT DECISIONS THAT WE MAKE COLLECTIVELY
AS THE HUMAN SPECIES
DETERMINE WHAT THE FUTURE LOOKS LIKE.
AGGRESSIVE EFFORTS TO LIMIT THE EMISSIONS OF CARBON DIOXIDE
AND OTHER HEAT-TRAPPING GASES TO THE ATMOSPHERE
WILL LEAD TO A WORLD THAT IS HOPEFULLY NOT TOO DIFFERENT
ONE THAT STILL PROVIDES, ESSENTIALLY
CONSISTENT GOODS AND SERVICES.
WITH A BUSINESS-AS-USUAL APPROACH
WHERE THERE'S AGGRESSIVE EXPLOITATION
OF FOSSIL-FUEL RESOURCES
AND UNCONTROLLED EMISSION
OF OTHER HEAT-TRAPPING GASES
I THINK WE'RE LOOKING AT A

FUTURE THAT'S MUCH BLEAKER
WHERE WE'RE LOOKING AT
TEMPERATURES THAT ARE
WARMER
THAN THE PLANET HAS SEEN FOR
THE LAST SEVERAL MILLION
YEARS
WHERE THERE ARE CRITICAL
SHORTAGES OF WATER
AND OTHER ESSENTIAL SERVICES
THAT ARE PROVIDED BY
ECOSYSTEMS
AND WHERE STRESSES ON
PEOPLE AND ECOSYSTEMS
AND THE GLOBAL HABITAT ARE
UNLIKE THE STRESSES
THAT WE'VE ENCOUNTERED EVER
AS A SPECIES.

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