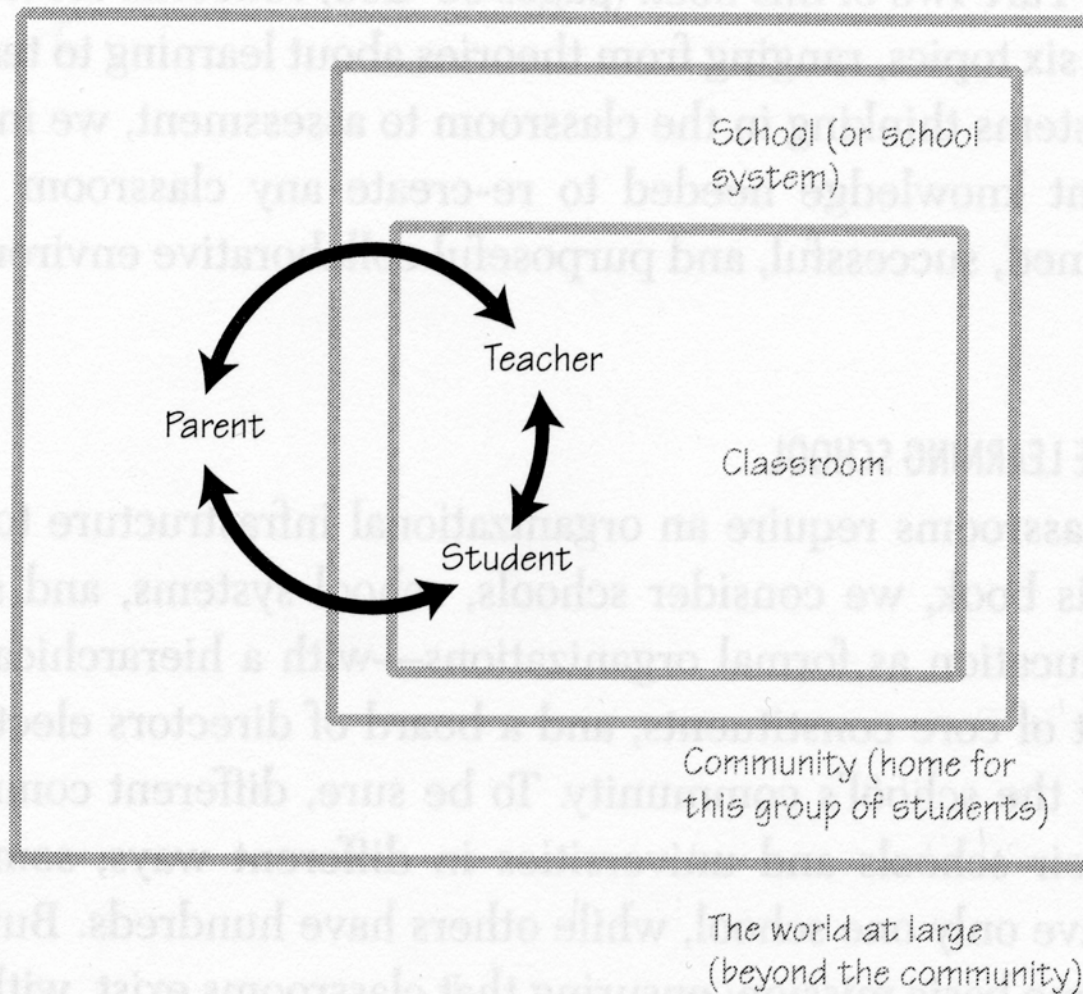


SYSTEM D - SYSTEMS THINKING AND SUSTAINABILITY EDUCATION

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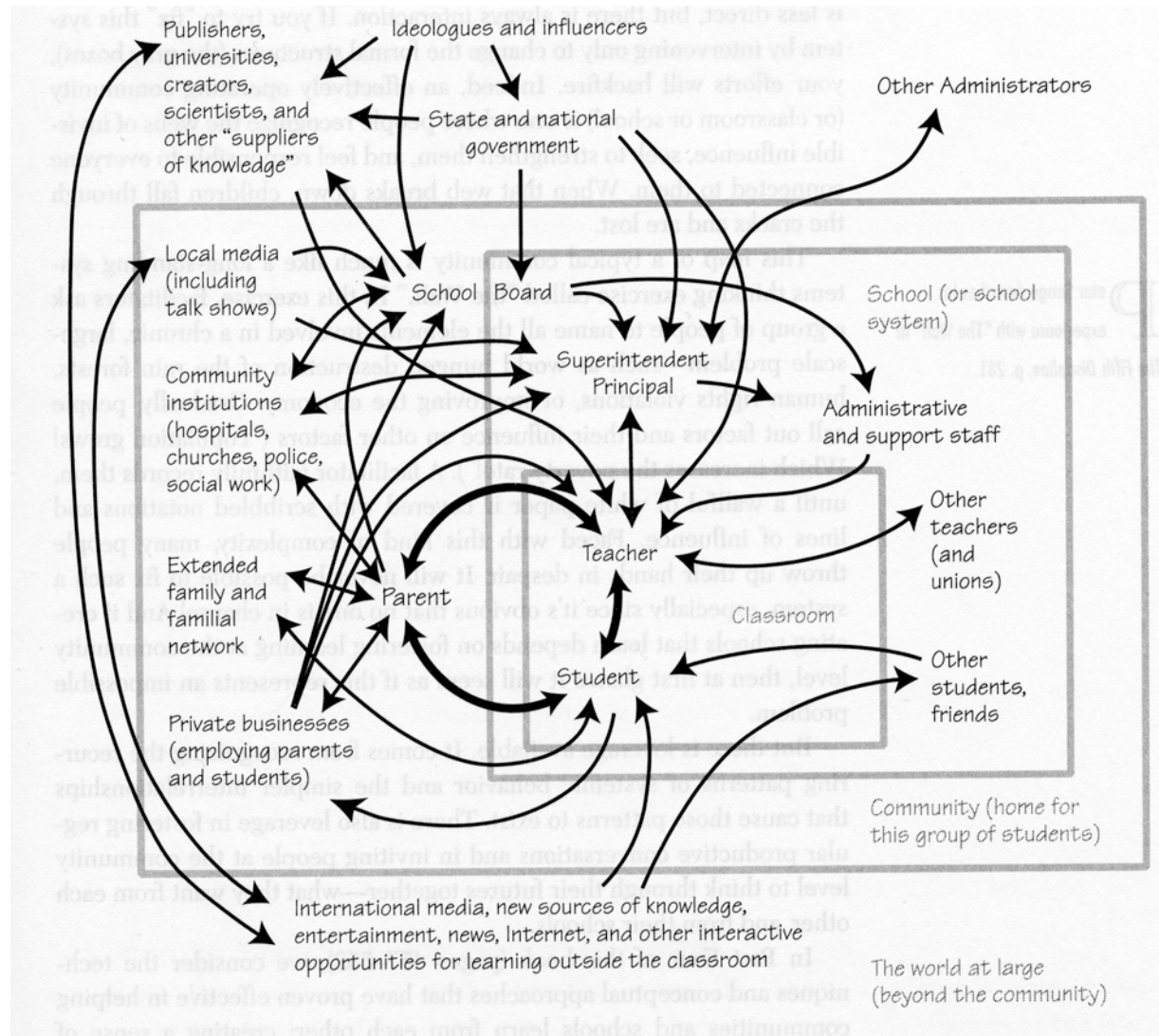


UNIVERSITY
OF MANITOBA



From Senge et al, 2000

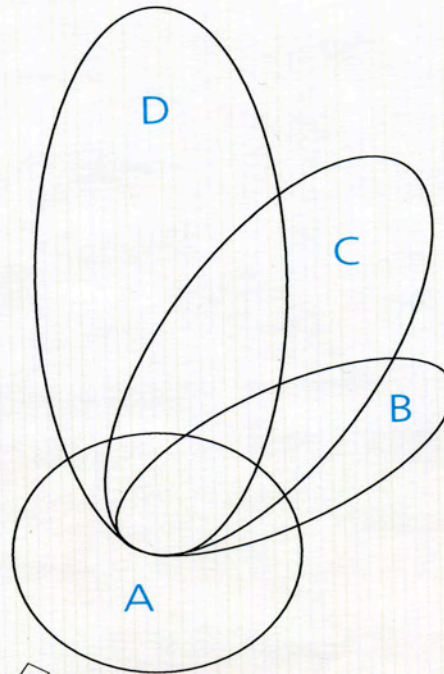




From Senge et al, 2000



SYSTEM INTERACTIONS



A = the individual learner as a system
B = the classroom and school system
C = the local system
D = the global system

Emergent Property =
Increased Success
in Science and
Mathematics



THE NESTED SYSTEMS (SUTHERLAND)

- (A) THE DYNAMIC SET OF COGNITIVE AND SOCIAL NEGOTIATIONS THAT A YOUNG PERSON MUST NAVIGATE (THE INDIVIDUAL LEARNER)**
- (B) THE DYNAMIC INTERACTIONS BETWEEN A YOUNG PERSON AND HIS/HER IMMEDIATE SURROUNDINGS (THE CLASSROOM AND SCHOOL SYSTEM)**
- (C) THE DYNAMIC INTERACTION WITH THE IMMEDIATE COMMUNITY IN WHICH A YOUNG PERSON LIVES AND PERFORMS (THE LOCAL SYSTEM)**
- (D) THE MUCH LARGER AND RAPIDLY CHANGING GLOBAL ENVIRONMENT FROM WHICH A YOUNG PERSON IS BY NO MEANS SEPARATED (THE GLOBAL SYSTEM).**



THE LANGUAGE OF BRONFENBRENNER (1979)

- (A) THE MICROSYSTEM
- (B) THE MESOSYSTEM
- (C) THE EXOSYSTEM
- (D) THE MACROSYSTEM



PRELIMINARY COMMENTARY

- LACK OF MEANINGFUL, IDENTIFIABLE CONTEXT IS A SUBSTANTIAL RISK FACTOR FOR BOTH T AND L.
- REDUCTIONIST PARADIGM STILL ALIVE AND WELL - SCIENCE CONDUCTED IN EVER-DECREASING DISCIPLINES AND SUB-DISCIPLINES.
- REALITY CAN SELDOM BE UNDERSTOOD WITHIN THE CONTEXT OF A SINGLE DISCIPLINE OR SUB-DISCIPLINE.
- HOLISTIC, INTERDISCIPLINARY/MULTIDISCIPLINARY APPROACHES MAY BE AN EFFECTIVE ALTERNATIVE FOR THE PROVISION OF CONTEXT.
- APPEARS TO CULMINATE IN “SYSTEMS SCIENCE” IN WHICH “HARD CORE” FACTS HAVE LITTLE CONTEXT ON THEIR OWN, BUT ONLY GAIN CONTEXT WHEN CONNECTIONS ARE RECOGNIZED - THE INTERACTIONS ARE SIGNIFICANT - MORE SO THAN THE INTERACTANTS.
- AS IT IS RECOGNIZED THAT REALITY IS AN EMERGENT PROPERTY OF LARGE NUMBERS OF INTERACTING SYSTEMS - COMPLEXITY SCIENCE AND THE SCIENCE OF COMPLEX SYSTEMS.



A SYSTEMS - BASED MODEL FOR SUSTAINABILITY EDUCATION HYPOTHESES

- **SUSTAINABILITY IS A PROTECTIVE FACTOR FOR SCIENCE AND MATHEMATICS TEACHING AND LEARNING.**
- **SUSTAINABILITY CAN BE A SIGNIFICANT AND IMPORTANT CONTEXT FOR THE TEACHING AND LEARNING OF SCIENCE AND MATHEMATICS.**
- **SUSTAINABILITY UNDERSTANDING IS AN ESSENTIAL EDUCATIONAL ENDEAVOUR.**
- **SUSTAINABILITY IS THE EMERGENT PROPERTY OF A HIGHLY COMPLEX SET OF DYNAMICALLY, OFTEN NON-LINEAR, INTERACTIVE SYSTEMS.**



SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT

- LESTER BROWN - WORLDWATCH INSTITUTE
- WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT
- WHAT IS MISSING?
- ECOLITERACY?
- CAPRA (2002): *“THE HIDDEN CONNECTIONS: INTEGRATING THE BIOLOGICAL, COGNITIVE AND SOCIAL DIMENSIONS OF LIFE INTO A SCIENCE OF SUSTAINABILITY”*



A SYSTEMS - BASED MODEL FOR SUSTAINABILITY EDUCATION UNDERLYING PREMISES

- **THE ROOTS OF A LACK OF SUSTAINABILITY LIE IN THE STRUCTURE AND FUNCTION OF ECOSYSTEMS THAT COMPRISE THE ECOSPHERE AND THE SERVICES THEY PROVIDE.**
- **SUSTAINABILITY, HUMAN ACTIVITY AND HUMAN WELL-BEING ARE LINKED TO ECOSYSTEM SERVICES.**
- **DEGRADATION THAT DIMINISHES (OR ELIMINATES) ECOSYSTEM SERVICES CREATES UNSUSTAINABLE CONDITIONS ON DIFFERENT SPATIAL AND TEMPORAL SCALES - BUT ULTIMATELY GLOBALLY AND PERMANENTLY!**



A SYSTEMS - BASED MODEL FOR SUSTAINABILITY EDUCATION FRAMEWORK - 2005 UN MILLENNIUM ECOSYSTEM ASSESSMENT

KOFI ANNAN (2001)

“Only by understanding the environment and how it works, can we make the necessary decisions to protect it. Only by valuing all our precious natural and human resources, can we hope to build a sustainable future. The Millennium Ecosystem Assessment is an unprecedented contribution to our global mission for development, sustainability, and peace.”



MILLENNIUM ECOSYSTEM ASSESSMENT ECOSYSTEM SERVICES

- **FOOD PRODUCTION**
- **FRESHWATER SUPPLY**
- **CLIMATE REGULATION**
- **DISEASE REGULATION**
- **SOIL FORMATION**
- **NUTRIENT CYCLING**
- **POLLINATION**
- **ETC.**



MILLENNIUM ECOSYSTEM ASSESSMENT DIRECT AND INDIRECT SOURCES OF DEGRADATION (“DRIVERS”)

- DEMOGRAPHY
- ECONOMIC POLICY
- TECHNOLOGY
- LAND-USE CHANGE
- RESOURCE CONSUMPTION
- CLIMATE CHANGE
- CHANGES IN BIODIVERSITY
- ETC.



MILLENNIUM ECOSYSTEM ASSESSMENT EMERGENT CONSEQUENCES

- HEALTH
- POVERTY
- ACCESS TO FOOD AND SHELTER
- ACCESS TO RESOURCES
- SECURITY FROM “NATURAL” DISASTERS.
- ETC.





CONSTITUENTS OF WELL-BEING

Security

- PERSONAL SAFETY
- SECURE RESOURCE ACCESS
- SECURITY FROM DISASTERS

Basic material for good life

- ADEQUATE LIVELIHOODS
- SUFFICIENT NUTRITIOUS FOOD
- SHELTER
- ACCESS TO GOODS

Health

- STRENGTH
- FEELING WELL
- ACCESS TO CLEAN AIR AND WATER

Good social relations

- SOCIAL COHESION
- MUTUAL RESPECT
- ABILITY TO HELP OTHERS

Freedom of choice and action

OPPORTUNITY TO BE ABLE TO ACHIEVE WHAT AN INDIVIDUAL VALUES DOING AND BEING

Source: Millennium Ecosystem Assessment

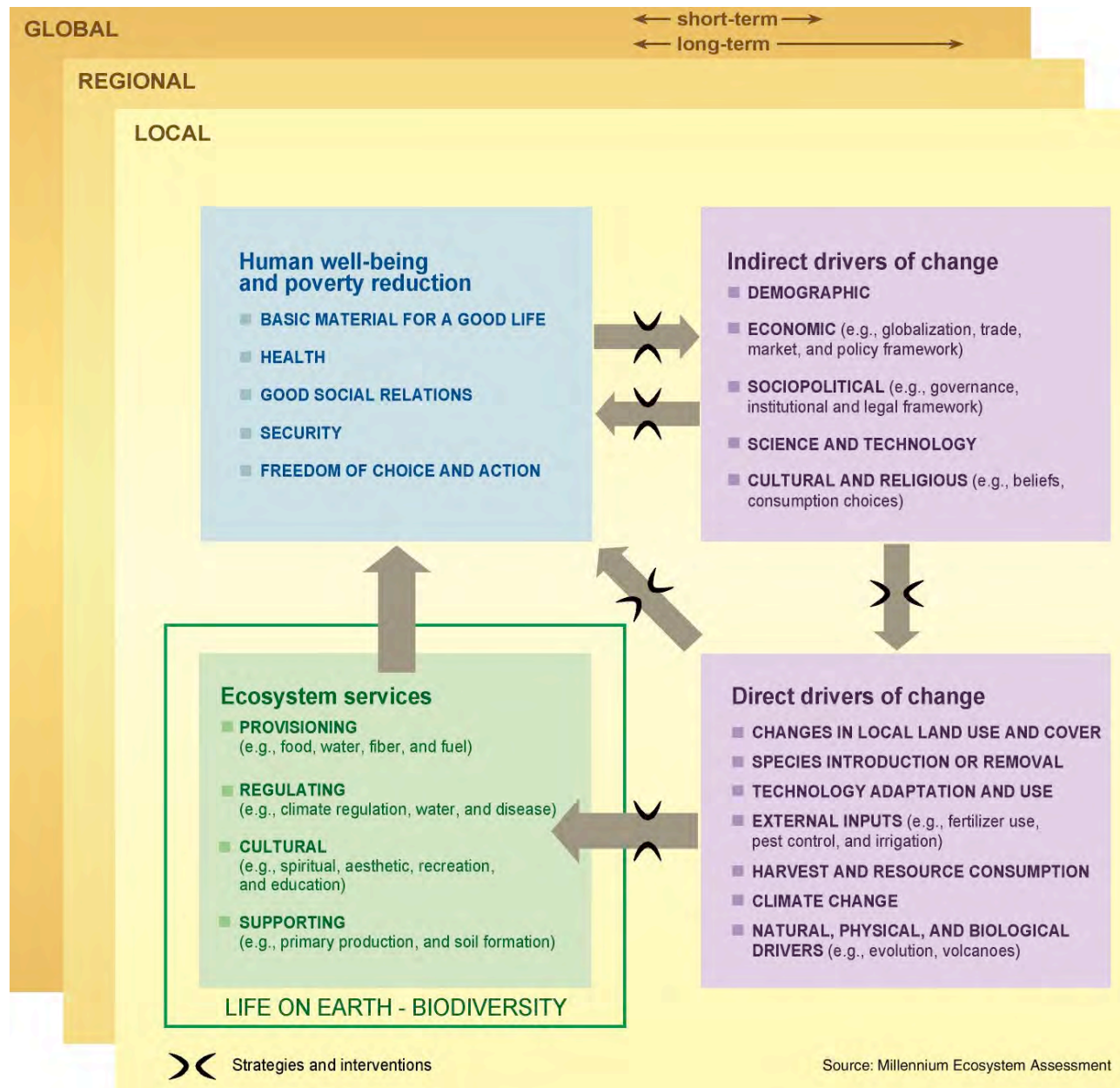
ARROW'S COLOR
Potential for mediation by socioeconomic factors

- Low
- Medium
- High

ARROW'S WIDTH
Intensity of linkages between ecosystem services and human well-being

- Weak
- Medium
- Strong





A SYSTEMS - BASED MODEL FOR SUSTAINABILITY EDUCATION OUTCOMES

- **PROBLEM-SOLVING CURRICUM RESOURCES THAT PERMIT SUSTAINABILITY SCENARIO BUILDING/MODELING.**
- **MULTI-DISCIPLINARY CONTEXT FOR THE TEACHING AND LEARNING OF SCIENCE (THERMODYNAMICS, BIOGEOCHEMICAL CYCLING, HYDROLOGY, LIMNOLOGY, OCEANOGRAPHY, ATMOSPHERIC CHEMISTRY, DISEASE AND EPIDEMIOLOGY, RESOURCE MANAGEMENT, SYSTEMS SCIENCE.)**



A SYSTEMS - BASED MODEL FOR SUSTAINABILITY EDUCATION OUTCOMES

- **AMANDA TETRAULT: “WE ARE ALL DOWNSTREAM: TEACHING MIDDLE YEARS SCIENCE FROM A SUSTAINABILITY PERSPECTIVE” - PILOTED WITHIN MANDATED CURRICULUM (GRADE 8 “WATER SYSTEMS” CLUSTER)**
- **MONA MAXWELL: “SUSTAINABILITY-BASED LEARNING RESOURCE TO ADDRESS “UNINTERESTING” AND “COMPLEX” SECONDARY LEVEL SCIENCE: A CRYSTAL STUDY” - PILOTED WITHIN MANDATED CURRICULUM (GRADE 11 CHEMISTRY) & WITHIN STAND-ALONE CURRICULUM (GRADE 11 CURRENT TOPICS)**



SUMMARY OF MEANS (WITH SD) FOR PRE- AND POST-TESTS IN CONTROL AND EXPERIMENTAL SECTIONS OF “WE ARE ALL DOWNSTREAM”

AFFINITY FOR SCIENCE		AFFINITY FOR SUSTAINABILITY		KNOWLEDGE OF WATER SYSTEMS		ACTIONS RELATED TO SUSTAINABILITY	
PRE TEST	POST TEST	PRE TEST	POST TEST	PRE TEST	POST TEST	PRE TEST	POST TEST
CONTROL (MEAN VALUES ON SCALE OF 1 - 4)							
3.57	3.39*	3.69	3.46*	0.43	0.56	2.22	2.11*
				SD			
0.62	0.83	0.43	0.81	0.26	0.24	0.71	0.83
EXPERIMENTAL (MEAN VALUES ON SCALE OF 1 - 4)							
3.55	3.65*	3.73	3.72*	0.33	0.59	2.23	2.74**
				SD			
0.47	0.53	0.58	0.56	0.20	0.21	0.76	0.65

* P < 0.05 ** P < 0.01



**“SUSTAINABILITY-BASED LEARNING RESOURCE TO
ADDRESS “UNINTERESTING” AND “COMPLEX”
SECONDARY LEVEL SCIENCE: A CRYSTAL STUDY”
SUMMARY OF PRE- AND POST-TESTING**

- **ACHIEVED INCREASED AFFINITY FOR SCIENCE AND SUSTAINABILITY IN GRADE 11 CURRENT TOPICS.**
- **SAME TRENDS IN GRADE 11 CHEMISTRY, BUT REQUIRED REDUCTION AND/OR MODIFICATION OF CURRICULUM OUTCOMES.**
- **IN SENIOR YEARS SUSTAINABILITY AS A CONTEXT FOR SCIENCE TEACHING IS BETTER SUITED TO STAND- ALONE COURSES, AND LESS SUITED TO INTEGRATION WITHIN EXISTING DISCIPLINARY COURSES.**



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- DR. CHRISTINA McDONALD

