

The University Senate of Michigan Technological University

Proposal 40-20

(Voting Units: Full Senate)

**Proposal for a Bachelor of Science Degree in Sustainable Bioproducts with Concentrations
in Bioproducts Business, Sustainable Construction and Circular Economy**

Developed by the College of Forest Resources and Environmental Science
Contacts: Drs. Andrew J. Storer (Dean), and Mark Rudnicki (Professor of Practice)

Submission date – February 25, 2020
Version – April 1, 2020

TABLE OF CONTENTS

I.	General Description of the Program	2
II.	Rationale	3
III.	Related Programs in the Region	5
IV.	Projected Enrollment	6
V.	Scheduling Plans (Extension, Evening, Regular)	6
VI.	Curriculum Design	6
VII.	New Course Descriptions	10
VIII.	Model Schedules	11
IX.	Existing Learning Resources, Equipment, and Space	14
X.	Program Administration, Policies, Regulations, and Rules	14
XI.	Accreditation requirements	14
XII.	Planned Implementation Date	14
XIII.	Program Costs and Justification for Years 1, 2, and 3	14
	Appendix A – Financial Documentation	i
	Appendix B – Sample Degree Audit	iv
	Appendix C – Complete List of Required Courses and Directed Electives	vi
	Appendix D – Course Add Proposals	xvii

I. General Description of the Program

- A. Mission** – To provide students with a broad understanding of bio-based resources, with an emphasis on lignocellulosic materials, and enable their ability to advance the role of renewable resources in a sustainable society. Sustainable bioproducts are materials systems based on woody plant biomaterials (lignocellulosic materials) such as wood, bamboo, hemp and flax, etc. used for construction and/or the production of consumer goods.
- B. Programmatic Goals** – The goal of this degree program is to give students a strong technical foundation in understanding natural biomaterials and how they perform as a basic building block for structures and products that society needs. Students can then build upon this technical foundation through one of three concentrations with which to further develop their knowledge base: 1) Bioproducts Business, 2) Sustainable Structures, and 3) Circular Economy. Respective learning outcomes in each of these concentrations leads to a deeper understanding of how 1) business, 2) structure technologies, and 3) closing material loops can influence overall sustainability issues when sourcing, using, maintaining, and recycling bio-based materials. These concentrations have been planned such that students gain an appreciation of how disciplines in engineering, marketing, product design, process technology, and management can contribute towards the best sustainable use of our natural resources in meeting the needs of society.

Practical hands on preparation is also a goal of the program and will be provided by the Enterprise program at MTU. Students will be required to join an Enterprise team to work on multidisciplinary teams that can function like companies and that take on real world projects in the form of national or international competitions, or collaboration with corporate clients who outline a challenge for the team.

The core, concentrations and enterprise components of the degree program is intended to create graduates in demand by a wide variety of employers in including the traditional forest products industry and those industries increasingly interested in bio-based alternatives such as automotive, chemical, biomedical, textiles and more.

- C. Learning Goals** – This Bachelor of Science addresses Michigan Technological University Student Learning Goals (USLG) as follows:

<https://www.mtu.edu/assessment/undergrad/resources/goals/>

At the completion of this degree students will be able to:

1. Explain wood anatomy along with the physical and chemical properties of lignocellulosic plants relevant to bio-based materials, energy production and engineered solid wood products. (USLG 1,2,7)
2. Apply knowledge in biology, chemistry, statistics, and math, needed to understand the nature and application of wood and other lignocellulosic materials. (USLG 2,4,7)
3. Apply developed project management and leadership skills gained from experiential learning through the MTU Enterprise program. (USLG 4,5,6)
4. Utilize business practices and communicate effectively. (USLG 4,5,8)

5. Infer the relevant contexts of sustainability and the role of the circular bioeconomy, in the development of a sustainable society. (USLG 3,4,6,8)

Concentration specific learning goals - Students will be able to:

1. Bioproducts Business: Implement business knowledge and proficiency to work as entrepreneurs, or in corporate management.
2. Sustainable Construction: Contrast and explain sustainable building techniques, and the use of engineered wood in buildings such as mass timber.
3. Circular Economy: Evaluate and apply concepts of circular economy concepts and constituents by learning about sustainable manufacturing, creativity and design, 3D printing, economics, and life cycle analysis.

D. Administration – Sustainable Bioproducts program will be administered through the College of Forest Resources and Environmental Science (CFRES). The CFRES academic advisor will assist students with scheduling and degree completion. Advice on directed electives and career choices will be provided by CFRES faculty and the academic advisor.

II. Rationale

The proposed Sustainable Bioproducts program will fill a disciplinary void at Michigan Tech and at the CFRES as there are no programs related to the technical knowledge of bio-based materials. While courses relevant to bioproducts, business and sustainability exist across campus and in CFRES, there is no BS degree that organizes them into a program at MTU or anywhere in Michigan.

We perceive this degree will serve the needs of Michigan's forest product sector which has a \$20 billion dollar a year economic impact to the State. This sector is optimistic for future growth nationally and globally as it offers society green and sustainable solutions in response to the public's demand for sustainable building materials, packaging, and a host of other product areas. Demand is also expected to increase since wood and other lignocellulosic fibers contribute to ending our dependence on fossil fuels and reducing dependence on other nonrenewable materials. Bioproducts are also a critical component to the emerging circular and bioeconomy concepts which both acknowledge that renewable bioproducts are fundamental to a sustainable future.

In addition, this degree will serve sectors well outside the forest sector in mobility, biomedical (devices), textiles, energy, office furniture, bioplastics and biochemicals, that are all found in Michigan and increasingly interested in bio-based material alternatives for their products. For valuable service to Michigan and beyond, this degree will provide students with regional, national and global perspectives as trends for using lignocellulosic fibers and materials in addition to wood are clearly showing a positive trend.

CFRES has a deep history of wood products research and education with course offerings since 1948 and a BS degree between 1975-2003 in 'Wood and Fiber Utilization'. Research in wood products has been ongoing at CFRES from 1945 till present day with currently the largest wood protection research group in the United States. This new degree program organizes and builds on our existing faculty capacity and brings back a contemporary outlook on the education needs of students for today and into the future. The design of this major, and minor that was approved last year, was conducted with the gracious input of a campus wide advisory committee with representatives from the departments of Civil and Environmental Engineering, Chemical Engineering, Mechanical Engineering, Materials Science and Engineering, Engineering Fundamentals, Social Science and the College of Business. Discussions took place over the course of three years with strong support that the program should be housed in CFRES.

The degree offers concentrations in Bioproducts Business, Sustainable Structures and Circular Economy that complement the core courses with deeper concentration areas.

Bioproducts business - Competing societal demands on forestlands for development, clean water, and raw materials have impacted land use and the way forest biomaterials can be utilized. However, novel, emerging biomaterials from the forest, other plant-based residues, and new processing technologies offer promising solutions for a sustainable environment along with business opportunities and economic development. Many of Michigan's existing forest products businesses tend to be family owned, relatively small in size, and lack the expertise to innovate and compete in a global economy. Yet, these small businesses can be flexible enough to develop critical new business models that are successful and sustainable. There are also large multi-national forest products companies in Michigan that are adopting more sustainable business practices. The Bioproducts Business concentration will produce graduates that will advance these industries. Trained individuals from our degree program can help these businesses take advantage of opportunities to make Michigan a leader in bio-based business, thereby sustaining the long-term balance between our natural resources, our economic aspirations, and our human needs.

Sustainable Structures – This concentration will prepare students to enter the green building and mass timber job markets. Since construction is the #1 consumer of raw materials globally, is responsible for 30% of the world's greenhouse gas emissions, and produces 50% of the solid waste in the United States, opportunities and trends toward sustainability and resilience are tremendous. Biomaterials, specifically wood products, are the only structural building materials that use material certification systems for the procurement, sales and replanting of trees. These certified wood products are integral to most green building rating systems such as LEED, and the Green Globes system.

Rising awareness of the carbon emissions attributable to traditional building materials such as steel and especially concrete has propelled the growth of the mass timber market, especially in commercial construction. Mass timber construction is expected to deliver a compound annual growth rate of 15.1% from 2017-2025 and be valued at 2.07 billion globally by 2025. Remarkable growth considering this industry was basically non-existent outside of Austria 20 years ago.

Circular Economy – This concentration will prepare students to work in and contribute to the transformation of our current take-make-waste industrial model. The circular economy aims to transform business and manufacturing by decoupling economic activity from the consumption of finite resources. This transition is underpinned by a conversion to renewable resources.

The circular economy is expected to generate \$4.5 trillion by 2030 and as much as \$50 trillion globally by 2050. Corporations across the globe are eager to engage in the transition to circular economy for access to new markets, improve competitiveness, enhance their image and improved revenues. For program graduates to engage in this opportunity, it is critical that they understand the current industrial organization, supply chain and knowledge of tools for sustainability assessment.

These findings combined with the current and projected employment opportunities indicate a demand for students trained in sustainable bioproducts.

III. Related Programs in the Region

There are no similar programs in Michigan.

Partly Related program in the Michigan includes:

Michigan State University – School of Packaging, B.S. Degree in Packaging, concentrations in Packaging Science and Packaging value chain -

https://www.canr.msu.edu/packaging/education/undergraduate_information/curriculum

Related programs in the Midwest include:

Purdue University – Department of Forestry and Natural Resources, B.S. Degree in Sustainable Biomaterials: Process & Product Design.

<https://www.purdue.edu/woodresearch/subo-major/>

University of Minnesota – Department of Bioproducts and Biosystems Engineering, B.S. Degree in Bioproducts and Biosystems Engineering.

<https://bbe.umn.edu/undergraduate/bbe>

IV. Projected Enrollment

We anticipate a Program enrollment of approximately 60 students within 4 years. A class enrollment of 15-20 students is an ideal student to faculty ratio, particularly for courses that include a laboratory. We expect this program will raise the profile of technical sustainability offerings for CFRES and MTU and thus attract additional students to MTU.

V. Scheduling Plans (Extension, Evening, Regular)

Regular.

VI. Curriculum Design

Students will be required to take 20 credits of mathematics (calculus and statistics) and science (chemistry, physics, and biology) as preparation to the sustainable bioproducts core courses (37 credits). The program core also includes required courses in Enterprise with an additional 2-4 credits in experiential learning. All concentrations (Bioproducts Business, Sustainable Structures, and Circular Economy) contain 18 credits. With 11-13 credits of free electives, 120 total credits are needed to complete the degree.

1. General Education (24 Credits)

UN 1015 Composition (3)
UN 1025 Global Literacy (3)
Goal 4 Critical Thinking (3)
Goal 8 Social Responsibility (3)
HASS Electives (12)

2. Base Math and Science (20 Credits)

BL 1040 - Principles of Biology	4
CH 1150 University Chemistry I	3
CH 1151 University Chemistry Lab I	1
MA 1135 Calculus for life sciences	4
PH 1110 College Physics I	3
PH 1111 College Physics I Laboratory	1
MA 2720 Statistical Methods	4

3. Sustainable Bioproducts core courses (37 Credits)

BUS 1100 Introduction to Business	3
EC 2001 Principles of Economics	3
MKT 3000 Principles of Marketing	3
HU 3120 - Technical and Professional Communication	3
FW 2030 Conservation of Nature	2
FW/SS 3313 Sustainability Science	3
FW 4500 Circular Economy	3
FW 1050 The Natural Resources Professional	2
FW 1035 Wood Anatomy and Properties	4
FW 3097 Forest Biomaterials	3
FW 3098 Adding value to forest biomaterials	2
FW 3090 Mechanics of Wood Materials	3
FW 3500 Wood Decomposition and Preservation	3

Enterprise and elective experiential courses (8-10 credits)

Enterprise Project Work (6 credits)	
ENT 3950	1
ENT 3960	1
ENT 4900	2
ENT 4910	2
Electives: Choose 1	
Any Approved Study Abroad	3
FW 4840 Senior Thesis	4
FW 4000 - Professional Experience Program	2
UN 3002 Undergrad cooperative education	3

4. Choose 1 of 3 Concentrations: Bioproducts Business, Sustainable Structures, or Circular Economy

4.1. Bioproducts Business (18 Credits)

FW 4080 - Forest Economics & Finance	3
ACC 2000 Accounting Principles I	3
BUS 2200 Business Law	3
FIN 3000 Principles of Finance	3
OSM 3000 Operations & Supply Chain Mgmt	3
Electives (3 credits)	
MGT 3800 Entrepreneurship	3
MGT 3100 Leadership Development	3
MGT 2000 Team Dynamics and Decision Making	3
ACC 2100 Accounting Principles II	3
ACC 3500 Managerial/Cost Accounting I	3
MKT 3600 Marketing Data Analytics	3
OSM 3150 Intro to Supply Chain Management	3

4.2 Sustainable Structures (18 credits)

CEE 1001 - Sustainability and Civil Engineering Practice	1
CMG 2120 Statics and Strengths of Materials for Construction	4
CMG 3250 Structural Analysis and Design	3
CEE 4233 Structural Timber Design	3
CMG 4800 Sustainable Construction	3
any Enterprise (ENT)	1
Electives (3 credits)	
MGT 3100 Leadership Development	3
MGT 2000 Team Dynamics and Decision Making	3
ACC 2000 Accounting Principles I	3
BUS 2200 Business Law	3
FIN 3000 Principles of Finance	3
OSM 3000 Operations & Supply Chain Mgmt	3

4.3 Circular Economy (18 credits)

OSM 3000 - Operations and Supply Chain Management	3
EC 3300 - Industrial Organization	3
ENG 4510 Sustainable Futures I	3
Electives (6 credits)	
CMG 4800 Sustainable Construction	3
MSE 4777 Distributed additive manufacturing open-source 3-D printing	3
MEEM 4685 - Env Resp Design & Manuf	3
MSE 4760 - Environmental Engineering for Materials Processing Industries	3
MGT 2000 Team Dynamics and Decision Making	3
MGT 3800 Entrepreneurship	3
CM 3979 - Alternative Energy Technologies and Processes	1
any Enterprise (ENT)	1
any Enterprise (ENT)	1
Electives (3 credits)	
FA 2190 - Art and Nature	3
FA 2160 - Creative Practices	3
FA 2300 - Art + Design Studio	3
FA 2110 - Outdoor Sculpture	3

1. Free Electives (11-13 credits)

VII. New Course Descriptions

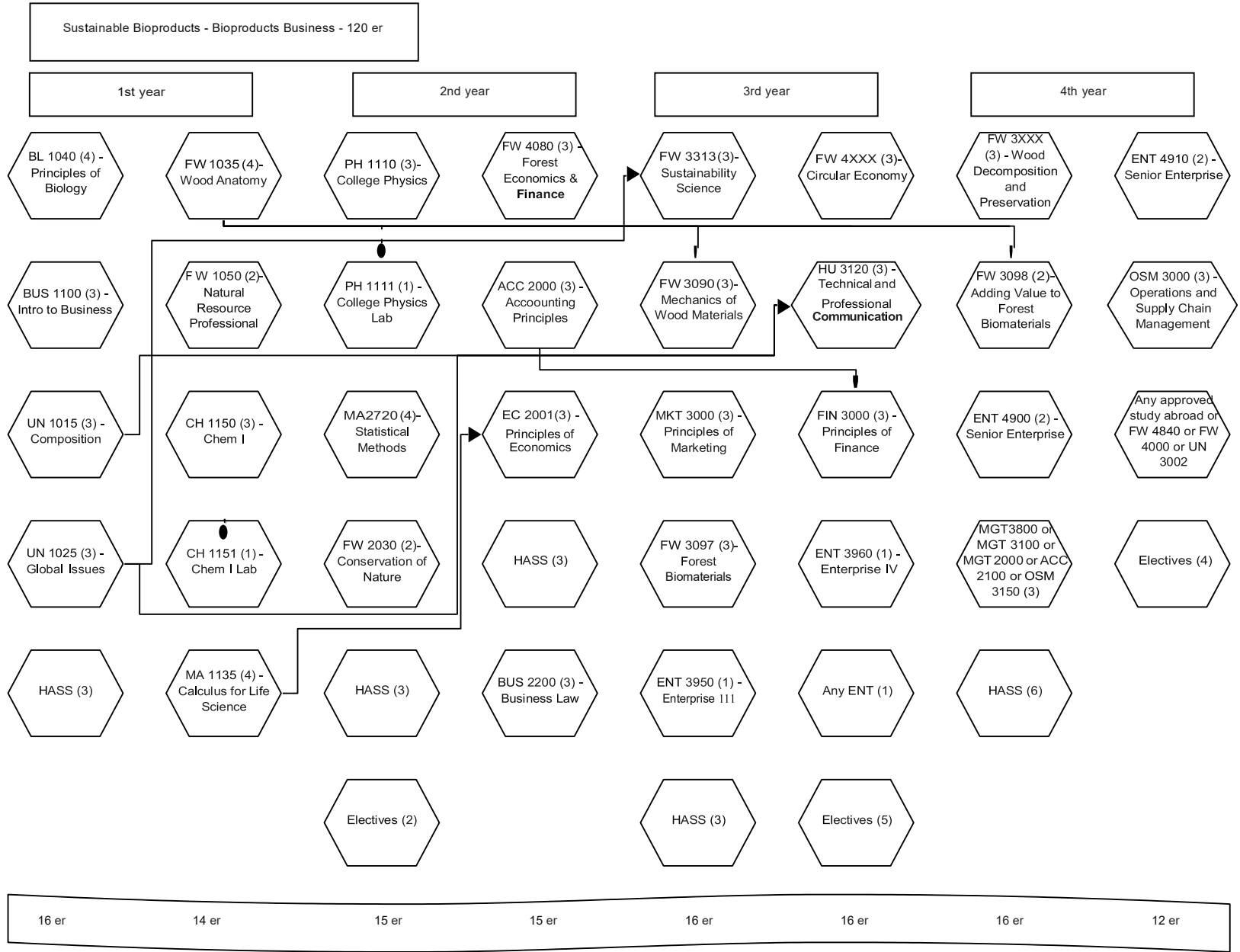
Two new courses are being developed that will be included in this degree. FW4XXX Circular Economy and FW3XXX Wood Decomposition and Preservation.

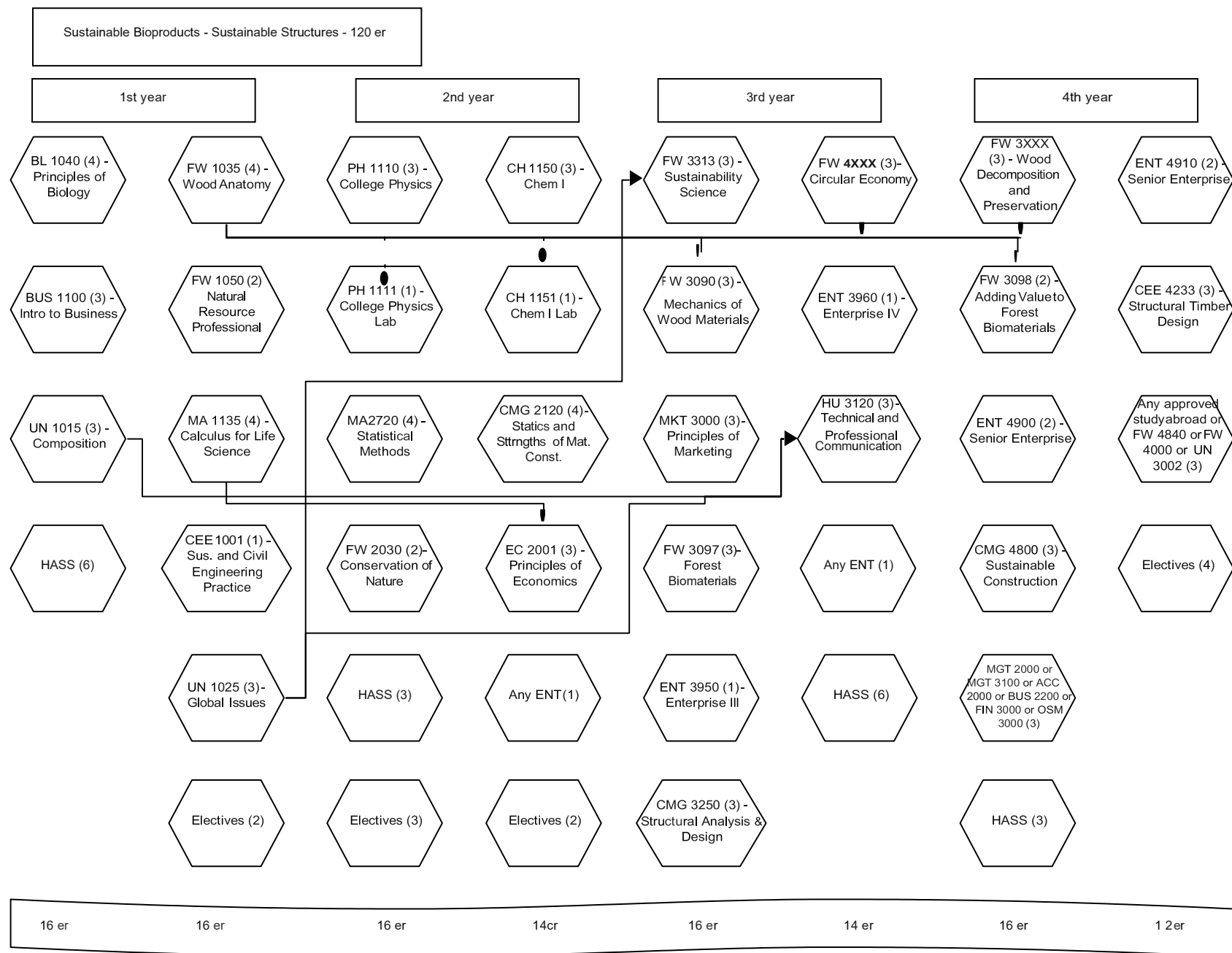
FW 3XXX Wood Decomposition and Preservation - This course will be proposed in the fall of 2020.

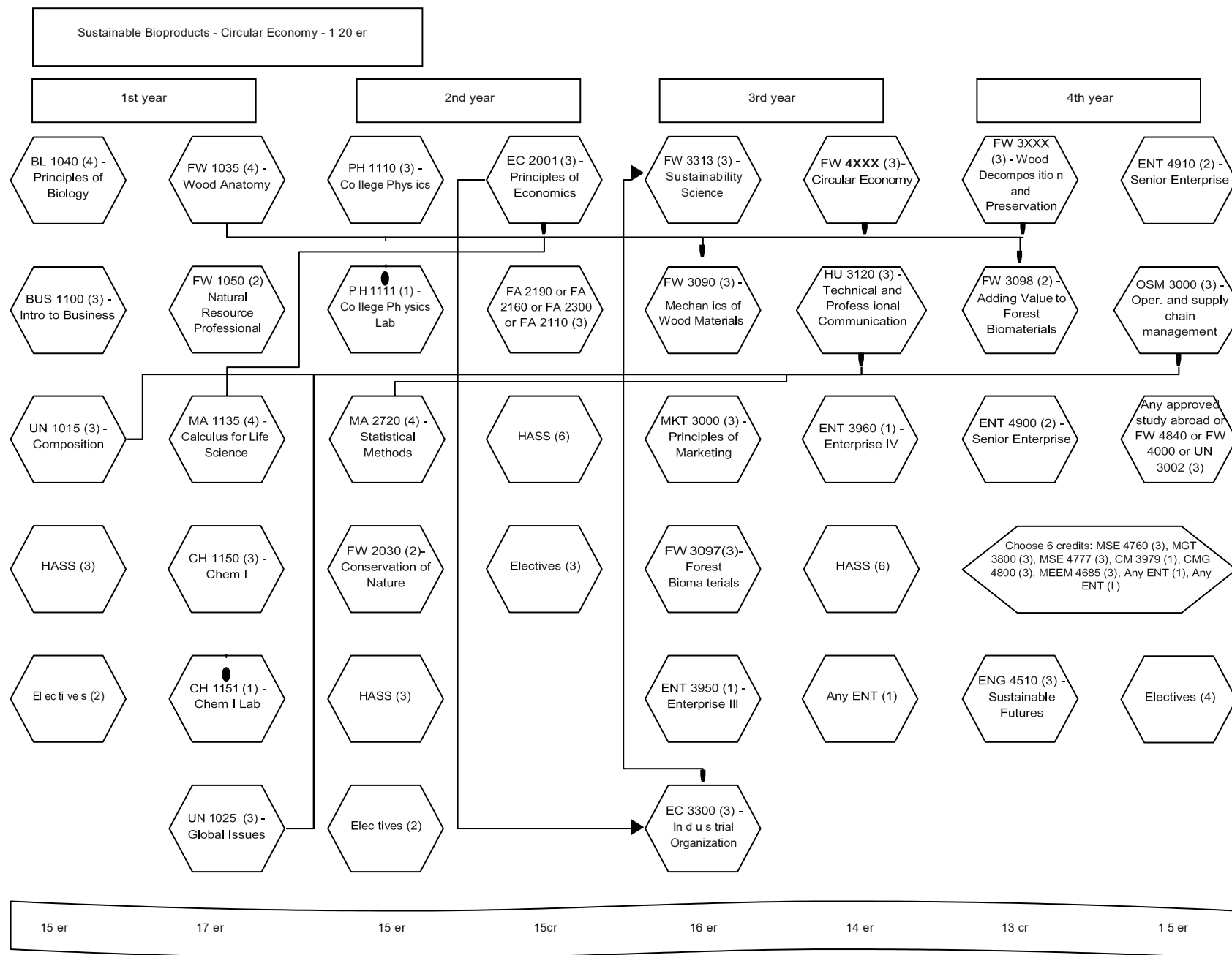
FW 4xxx Circular Economy

The circular economy is an emerging cross disciplinary field of study that maps a transition from current linear and unsustainable practices to those that are renewable and regenerative. Topics will include circular practices, role of consumers, policy, business models, bioeconomy, design, innovation and technological accelerators.

VIII. Model Schedules







IX. Existing Learning Resources, Equipment, and Space

Program students will have access to the existing wood science laboratory in CFRES, which has sufficient space and availability for laboratory sections for bioproducts courses.

No new space will be required by the program.

X. Program Administration, Policies, Regulations, and Rules

Administration of the Program will reside with the Dean of the College of Forest Resources and Environmental Science, who reports to the Executive Vice-President and Provost for Academic Affairs. Policies, regulations, and rules are those of the University.

XI. Accreditation requirements

There are no accreditation requirements for the Program

XII. Planned Implementation Date

We anticipate a Program starting date of Fall 2020. In addition, we will spend the next academic year working with University Marketing and communication on ideas and efforts on advertising and outreach package. We will also work with industry partners to establish an advisory committee and student scholarships for strong enrollment in the fall 2021 semester.

XIII. Program Costs and Justification for Years 1, 2, and 3

We expect that the only costs for the program will be advertising (including adjustments to MTU and CFRES websites, and recruiting). The expected costs are estimated to be \$1,000-\$2,000 per year.

Additional Courses: Since the role of Mark Rudnicki (Professor of Practice) is being realigned away from extension type activities, he is assuming a typical teaching load found in CFRES and the Circular Economy course falls within that load. In addition, Xinfeng Xie (Assistant Professor) is rounding out his teaching load with the addition of the course in Wood Decomposition and Preservation. Therefore, there are no additional costs associated with these two new courses.

Appendix A: Financial Documentation

I. Relation to University Strategic Plan

A. Relation of program to the University's educational and research goals.

The proposed Program conforms to the University Strategic Plan and includes a rigorous, interdisciplinary curriculum of classroom, laboratory, and experiential learning that will enhance student preparedness for the future job market or further education. Hence the major fits the Universities educational goal to "Provide a distinctive and rigorous action-based learning experience grounded in science, engineering, technology, sustainability, business, and an understanding of the social and cultural contexts of our contemporary world."

B. Consistency with the University's resource allocation criteria.

We are not requesting any allocation in salary or space for this degree. Program costs, years 1,2,3.

II. Impact on University Enrollment

A. Projected number of students in the program.

We project a class size of 15 students with an eventual Program size of 60 students.

B. Source of new students; in particular, will the students be drawn from existing programs, or will they be students who would otherwise not have come to Michigan Tech?

We expect that most of the students in this major will not otherwise have come to Michigan Tech. The possibility exists that students interested in the sustainable bioproducts will migrate from existing forestry and engineering programs at the University. This should help to improve overall retention at the University as these students may have left the MTU in search of alternatives.

C. What is the likely correlation between demand for the new program and existing enrollment patterns at Michigan Tech?

We anticipate the proposed Program will increase the enrollment in CFRES while undergraduate enrollments in many other academic units will remain in a steady state.

D. What is the current enrollment in the unit?

2019-2020: 183 undergraduate students, 68 graduate students.

III. Impact on Resources Required by Department in which the Program is Housed. (including but not limited to):

A. Faculty lines.

None.

B. Faculty and student laboratories, including ongoing maintenance.

The existing forest biomaterials laboratory has sufficient space and infrastructure for the wood decomposition laboratory classes.

C. Advising.

The CFRES academic advisor will assist students with scheduling and degree completion. Advice on directed electives and career choices will be provided by CFRES faculty.

D. Assessment.

The proposed Program will be assessed as part of the University's assessment activities. All of the University learning goals and those learning goals related to disciplinary knowledge will be addressed by the Program curriculum.

IV. Impact on Resources Required by other Units Within the University.

Including but not necessarily limited to impacts on:

A. Other academic (e.g., General Education) units with regard to faculty, laboratories, and assessment. (Note: The current student to faculty ratio for the university as a whole is approximately 12:1 per Institutional Analysis.)

The respective units have reviewed their courses and none have indicated insufficient capacity for students of this proposed Program.

B. Informational Technology, the Library, central administration and career planning with respect to the impact on the need for computing services, library resources, advising, record keeping, development of employer relations, etc.

Existing resources are sufficient to support the anticipated enrollment.

V. Assessment of the Ability to Obtain the Necessary Resources Assuming Requested Funds are Obtained.

A. For high demand fields (e.g., business fields, etc.), will it be possible to fill allocated lines.

No faculty lines are needed to establish this degree.

VI. Past Proposals. Has the unit initiated any other degree programs in the last five years?

An undergraduate degree program in Natural Resources Management (NRM) was created in 2016.

A. Describe the extent to which the new programs have met the original goals with respect to:

1. Enrollment.

There are 6 students currently enrolled in the NRM program – which is not as expected. The Program is fairly new and requires more marketing to increase enrollment. The program is also considering some restructuring to increase its attractiveness.

2. Costs.

The NRM program has met its goals related to costs.

3. New faculty

No new faculty lines were required to initiate the NRM program.

4. Other resources required for the program

None.

B. How have degree programs added in the past five years affected total enrollment in the unit?

Unknown

VII. Departmental Budget Contribution

A. What is the department's total general fund budget?

CFRES General Fund Budget FY2018-2019: \$4,232,538

B. How much tuition does the unit generate? This information should be provided for both the credit hours taught by the unit and the number of credit hours taken by the unit's majors.

In FY 2018-2019, CFRES generated \$3,866,483 in tuition for credit hours taught by CFRES, and \$2,260,818 in tuition by the number of credit hours taken by CFRES enrolled students.

Appendix B: Sample Degree Audit

Academic Year 2020-2021
Bachelor of Science in Sustainable Bioproducts
College of Forest Resources and Environmental Science

					Estimated Graduation Date
Major Requirements: 57 Credits			Major Requirements: 8 10 Credits		
Course Number	Credits	Prerequisites	Course Number	Credits	Prerequisites
BL 1040 - Principles of Biology	4		Enterprise Project Work (6 credits)		
CH 1150 University Chemistry I	3		ENT 3950	1	
CH 1151 University Chemistry Lab I	1		ENT 3960	1	
MA 1135 Calculus for life sciences	4		ENT 4900	2	
PH 1110 College Physics I	3		ENT 4910	2	
PH 1111 College Physics I Laboratory	1				
MA 2720 Statistical Methods	4	MA 1032 or MA 1031 or ALEKS Math Placement	Electives: Choose 1		
			Approved Study Abroad	3	
BUS 1100 Introduction to Business	3	MA 1031 or 1032 or 1035 or 1160	FW 4840 Senior Thesis	4	
EC 2001 Principles of Economics	3		FW 4000 - Professional Experience Program	2	
MKT 3000 Principles of Marketing	3		UN 3002 Undergrad cooperative education	3	
HU 3120 - Technical and Professional Communication	3	na	Credit Subtotal	9	
				8-10	
FW 2030 Conservation of Nature	2				
FW/SS 3313 Sustainability Science	3				
FW 4XXXX Circular Economy	3	none			
FW 1050 The Natural Resources Professional	2				
FW 1035 Wood Anatomy and Properties	4				
FW 3097 Forest Biomaterials	3	CH 1130 or higher			
FW 3098 Adding value to forest biomaterials	2	FW 1035			
FW 3090 Mechanics of Wood Materials	3	FW 1035			
FW 3XXXX Wood Decomposition and Preservation	3	FW 1035			
Credit Subtotal	57				
Concentration Requirements: 18 Credits			Concentration Requirements: 18 Credits		
Course Number	Credit	Prerequisites	Course Number	Credit	Prerequisites
Concentration 1: Bioproducts Business			Concentration 3: Circular Economy		
Required Core Courses (15 credits)			Required Core Courses (9 credits)		
FW 4080 - Forest Economics & Finance	3		OSM 3000 - Operations and Supply Chain Management	3	UN 1015
ACC 2000 Accounting Principles I	3		EC 3300 - Industrial Organization	3	
BUS 2200 Business Law	3	na	ENG 4510 Sustainable Futures I	3	
FIN 3000 Principles of Finance	3	ACC 2000	Electives (6 credits)		
OSM 3000 Operations & Supply Chain Mgmt	3	MA 1135 or MA 1160 or MA 1161	CMG 4800 Sustainable Construction	3	Junior or Senior
Electives (3 credits)			MGT 2000 Team Dynamics and Decision Making	3	
MGT 3800 Entrepreneurship	3		MGT 3800 Entrepreneurship	3	
MGT 3100 Leadership Development	3		MEEM 4685 - Env Resp Design & Manuf	3	senior
MGT 2000 Team Dynamics and Decision Making	3		MSE 4760 - Environmental Engineering for Materials Processing Industri	3	No Freshman or Sophomores
ACC 2100 Accounting Principles II	3		MSE 4777 Distributed additive manufacturing open-source 3-D printing	3	Engineers only - junior or senior
ACC 3500 Managerial/Cost Accounting I	3		CM 3979 - Alternative Energy Technologies and Processes	1	CH 1150 and CH 1151) and (MA 1160 or MA 1161)
MKT 3600 Marketing Data Analytics	3		any Enterprise (ENT)	1	
OSM 3150 Intro to Supply Chain Management	3		any Enterprise (ENT)	1	
Credit Subtotal	18		Electives (3 credits)		
			FA 2190 - Art and Nature	3	
			FA 2160 - Creative Practices	3	
			FA 2300 - Art + Design Studio	3	
			FA 2110 - Outdoor Sculpture	3	
			Credit Subtotal	18	

Concentration Requirements: 18 Credits		
Course Number	Credits	Prerequisites
Concentration 2: Sustainable Structures		
Required Core Courses (15 credits)		
CEE 1001 - Sustainability and Civil Engineering Practice	1	
CMG 2120 Statics and Strengths of Materials for Construction	4	
CMG 3250 Structural Analysis and Design	3	
CEE 4233 Structural Timber Design	3	
CMG 4800 Sustainable Construction	3	Junior or Senior
any Enterprise (ENT)	1	
Electives (3 credits)		
MGT 3100 Leadership Development	3	
MGT 2000 Team Dynamics and Decision Making	3	
ACC 2000 Accounting Principles I	3	
BUS 2200 Business Law	3	
FIN 3000 Principles of Finance	3	
OSM 3000 Operations & Supply Chain Mgmt	3	
Credit Subtotal	18	
Credit Subtotal		
Bioproducts Business	84	
Sustainable Structures	84	
Circular Economy	84	
General Education Requirements: 24 Credits		
Course Number	Cre	Course Status Code
Courses used to complete General Education may not be used to complete other degree requirements.		
Core: 12 Credits		
UN 1015	3	
UN 1025 or upper level modern language	3	
Critical and Creative Thinking	3	
Social Responsibility & Ethical Reasoning	3	
HASS: 12 Credits		
👉 Students must complete 12 credits of HASS course work		
👉 Six of the 12 credits must be at the 3000- or 4000- level"		
👉 At least three credits each in the following: Communication/Comp, Humanities and Fine Arts, and Social & Behavioral Sciences.		
👉 No more than three credits may come from the Restricted List		
Communication/Composition	Min 3	
Humanities and Fine Arts	Min 3	
Social and Behavioral Sciences	Min 3	
Any List or Restricted List	0-3	

Free Electives: 11 13 Credits		
Course Number	Cred	Course Status Code
	3	
	3	
	3	
	3	
Credit Subtotal	12	
	11-13	
Co Curricular Activities: x Credits		
Required for graduation, but not included in the GPA calculation or in the overall credits required for the degree.		
Advisor Use Only		
Total Credits Required	120	
Total Credits Completed		
Total Credits Needed		
Additional Information		
(check all that apply)		
Currently Enrolled in:		
🕒 Double Major _____		
🕒 Minor _____		
🕒 Second Degree _____		
Departmental Approval		Date

Appendix C: Complete List of Required Courses and Directed Electives

I: List of Required Math and Science Courses

CH 1150 - University Chemistry I Introduces the foundations of chemistry, including electronic structure of atoms and molecules, intermolecular forces, states of matter, chemical reactions, organic chemistry, chemical equilibria, kinetics, and acid-base chemistry. Includes laboratory component that emphasizes lecture components.

Credits: 3.0

Lec-Rec-Lab: (3-0-0)

Semesters Offered: Fall, Spring, Summer

Co-Requisite(s): CH 1151

Pre-Requisite(s): MA 1031(C) or MA 1032(C) or MA 1160(C) or MA 1161(C) or MA 1135(C) or ALEKS Math Placement ≥ 56 or CEEB Calculus AB ≥ 2 or CEEB Calculus BC ≥ 2 or CEEB Calculus AB Subscore ≥ 2

CH 1151 - University Chemistry Lab I Laboratory to accompany CH1150.

Credits: 1.0

Lec-Rec-Lab: (0-0-3)

Semesters Offered: Fall, Spring, Summer

Co-Requisite(s): CH 1150

Pre-Requisite(s): MA 1031(C) or MA 1032(C) or MA 1160(C) or MA 1161(C) or MA 1135(C) or ALEKS Math Placement ≥ 56 or CEEB Calculus AB ≥ 2 or CEEB Calculus BC ≥ 2 or CEEB Calculus AB Subscore ≥ 2

PH 1110 - College Physics I An overview of basic principles of kinematics, dynamics, elasticity, fluids, heat, thermodynamics, mechanical waves, and interference and diffraction of mechanical waves.

Credits: 3.0

Lec-Rec-Lab: (3-0-0)

Semesters Offered: Fall, Summer

Restrictions: May not be enrolled in one of the following College(s): School of Technology, College of Engineering; May not be enrolled in one of the following Major(s): Physics, Applied Physics

Co-Requisite(s): PH 1111

Pre-Requisite(s): MA 1031 or MA 1032 or MA 1135(C) or MA 1160(C) or MA 1161(C)

PH 1111 - College Physics I Laboratory Experiments covering kinematics, forces, conservation of momentum and energy, waves, and thermodynamics are explored through guided construction. The course provides inquiry-based laboratory experiences for concepts explored in PH1110.

Credits: 1.0

Lec-Rec-Lab: (0-0-2)

Semesters Offered: Fall, Summer

Restrictions: May not be enrolled in one of the following College(s): School of Technology, College of Engineering; May not be enrolled in one of the following Major(s): Physics, Applied Physics

Co-Requisite(s): PH 1110

BL 1040 - Principles of Biology Basic principles through which biological systems operate. Topics include cell biology, structure, and function, energy production, genetics, physiology, diversity, evolution, and ecology.

Credits: 4.0

Lec-Rec-Lab: (3-0-2)

Semesters Offered: Fall, Summer

Restrictions: May not be enrolled in one of the following Major(s): Medical Laboratory Science, Biological Sciences

MA 2720 - Statistical Methods Introduction to the design and analysis of statistical studies. Topics include methods of data collection, descriptive and graphical methods, probability, statistical inference on means, regression and correlation, and ANOVA. Not open to students with credit in MA2710, MA3710, or MA3715.

Credits: 4.0

Lec-Rec-Lab: (0-4-0)

Semesters Offered: Fall, Spring, Summer

Restrictions: May not be enrolled in one of the following Major(s): Mathematics

Pre-Requisite(s): MA 1020 or MA 1030 or ALEKS Math Placement ≥ 61 or CEEB Calculus BC ≥ 2 or CEEB Calculus AB Subscore ≥ 2 or ACT Mathematics ≥ 22 or SAT MATH SECTION SCORE-M16 ≥ 540

II. Courses Core to the Degree

FW 1035 - Wood Anatomy and Properties

An introduction to the anatomical and physical nature of woody materials and how these characteristics are related to its applications as a sustainable raw material.

Credits: 4.0

Lec-Rec-Lab: (3-0-3)

Semesters Offered: Spring

FW 1050 - The Natural Resource Professional

Seminar introduces students to the various careers within forestry, conservation, ecology, and wildlife that represent specialties within natural resources. Students explore natural resource issues around the world, and practice effective written and communication skills.

Credits: 2.0

Lec-Rec-Lab: (2-0-0)

Semesters Offered: Spring

FW 2030 - Conservation of Nature

This course explores the history and evolution of conservation in thought and practice, with an emphasis on the writings and legacy of conservation pioneers such as Aldo Leopold.

Credits: 2.0

Lec-Rec-Lab: (2-0-0)

Semesters Offered: Fall

Restrictions: May not be enrolled in one of the following Class(es): Freshman

FW 3097 - Forest Biomaterials

Examines the nature and use of forest biomaterials and their role in the larger economy. Local and global advantages and challenges for using forest biomaterials will be addressed within the context of sustainability, covering topics such as economics, material and product engineering, policy, life cycle analysis, and supply chain management.

Credits: 3.0

Lec-Rec-Lab: (3-0-0)

Semesters Offered: Fall

FW 3098 - Adding Value to Forest Biomaterials

Examines how forest biomaterials are converted from raw forms into intermediary or final products that can support a sustainable future. Manufacturing sites in the upper Midwest are visited during the week prior to the start of fall semester. Lecture topics include the forest bioeconomy, emerging and export markets, and industry challenges.

Credits: 2.0

Lec-Rec-Lab: (1-0-3)

Semesters Offered: Fall - Offered alternate years beginning with the 2016-2017 academic year

Pre-Requisite(s): FW 1035

FW 3313 - Sustainability Science

Foundational scientific concepts (dynamic systems and catastrophe theory) as applied to socioecological systems. Use of indicators and indices to track progress towards sustainability goals. Review of local, national, and global sustainability policies to avoid catastrophes and guide sustainable development.

Credits: 3.0

Lec-Rec-Lab: (3-0-0)

Semesters Offered: Fall

Pre-Requisite(s): UN 1015 and (UN 1025 or Modern Language - 3000 level or higher)

BUS 1100 - Introduction to Business Introduction to planning, organizing, decision-making, leadership and control in a business. Business disciplines of accounting, finance, information systems, management, marketing, and operations are introduced, along with discussions of business ethics and social responsibility.

Credits: 3.0

Lec-Rec-Lab: (3-0-0)

Semesters Offered: Fall, Spring

EC 2001 - Principles of Economics An introduction to economics. The microeconomics portion covers consumer choice, the firm, value and price theory, and distribution theory. The macroeconomics portion

covers national income analysis, fiscal policy, money and monetary policy, the commercial banking system, and the Federal Reserve System.

Credits: 3.0

Lec-Rec-Lab: (3-0-0)

Semesters Offered: Fall, Spring, Summer

Pre-Requisite(s): MA 1020 or MA 1031 or MA 1032 or MA 1135(C) or MA 1160(C) or MA 1161(C)

HU 3120 - Technical and Professional Communication

A study of written and oral communication in technical and scientific environments; emphasizes audience, writing processes, genres of scientific and technical discourse, visual communication, collaboration, professional responsibility, clear and correct expression. Students write and revise several documents and give oral report(s). Computer Intensive.

Credits: 3.0

Lec-Rec-Lab: (0-3-0)

Semesters Offered: Fall, Spring, Summer

Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

Pre-Requisite(s): UN 1015 and (UN 1025 or Modern Language - 3000 level or higher)

ENT 3950 - Enterprise Project Work III

Interdisciplinary teams work as part of an enterprise to address real-world design projects or problems. Third-year students will practice designing approaches to solve problems and develop procedures to achieve specified project objectives.

Credits: 1.0

Lec-Rec-Lab: (0-0-3)

Semesters Offered: Fall, Spring, Summer

Restrictions: Must be enrolled in one of the following Class(es): Junior, Senior

ENT 3960 - Enterprise Project Work IV

Interdisciplinary teams work as part of an enterprise to address real-world design projects or problems. Third-year students practice designing approaches to solve problems and develop procedures to achieve specified project objectives.

Credits: 1.0

Lec-Rec-Lab: (0-0-3)

Semesters Offered: Fall, Spring, Summer

Restrictions: Must be enrolled in one of the following Class(es): Junior, Senior

ENT 4900 - Senior Enterprise Project Work V Non-Capstone

Interdisciplinary teams work as part of an enterprise to address real-world projects or problems of significance to industry, government and communities. Fourth-year students gain experience in defining project objectives and planning strategies to achieve these objectives, and leading teams to accomplish project goals. This course is for students who are not participating in Enterprise to fulfill their capstone requirements.

Credits: 2.0

Lec-Rec-Lab: (0-0-6)

Semesters Offered: Fall, Spring, Summer

Restrictions: May not be enrolled in one of the following College(s): College of Engineering;
Must be enrolled in one of the following Class(es): Senior

ENT 4910 - Senior Enterprise Project Work VI Non-Capstone

Interdisciplinary teams work as part of an enterprise to address real-world projects or problems of significance to industry, government and communities. Fourth-year students gain experience in defining project objectives and planning strategies to achieve these objectives, and leading teams to accomplish project goals. This course is for students who are not participating in Enterprise to fulfill their capstone requirements.

Credits: 2.0

Lec-Rec-Lab: (0-0-6)

Semesters Offered: Fall, Spring, Summer

Restrictions: May not be enrolled in one of the following College(s): College of Engineering;
Must be enrolled in one of the following Class(es): Senior

III. Courses required in at least one of the concentrations

FW 4080 - Forest Economics & Finance

Financial analysis and economic theory applied to forestry project analysis and selection, focusing on prices. Covers risk, capital markets, taxation, auctions, and non-market valuation.

Credits: 3.0

Lec-Rec-Lab: (2-0-2)

Semesters Offered: Spring

Restrictions: May not be enrolled in one of the following Class(es): Freshman

ACC 2000 - Accounting Principles I

Introduction to basic principles, concepts, and theoretical framework of financial accounting with the emphasis on its use by economically rational decision makers. Topics include the decision-making environment and the accounting cycles, processes, and statements.

Credits: 3.0

Lec-Rec-Lab: (3-0-0)

Semesters Offered: Fall, Spring

BUS 2200 - Business Law Provides an understanding of the legal basis of contracts and their enforcement in the areas of general contracts, contracts of commercial sales and of agency, and commercial paper.

Credits: 3.0

Lec-Rec-Lab: (3-0-0)

Semesters Offered: Fall, Spring

FIN 3000 - Principles of Finance

Introduction to the principles of finance. Topics include financial mathematics, the capital investment decision, financial assets valuation, and the risk-return relationship

Credits: 3.0

Lec-Rec-Lab: (3-0-0)

Semesters Offered: Fall, Spring, Summer

Pre-Requisite(s): ACC 2000 and (MA 1020 or MA 1030 or MA 1160 or MA 1161 or MA 2160 or ALEKS Math Placement ≥ 61 or CEEB Calculus AB ≥ 2 or CEEB Calculus BC ≥ 2 or ACT Mathematics ≥ 22 or SAT MATH SECTION SCORE-M16 ≥ 540)

OSM 3000 - Operations and Supply Chain Management

Fundamental principles of operations and supply chain management; includes strategic importance and relevant interrelated concepts and tools in product/process design, work systems, forecasting, inventory and materials management, just-in-time, scheduling, and capacity management.

Credits: 3.0

Lec-Rec-Lab: (3-0-0)

Semesters Offered: Fall, Spring, Summer

Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

Pre-Requisite(s): (MA 1135 or MA 1160 or MA 1161) and (MA 2710 or MA 2720 or MA 3710 or MA 3720 or EET 2010 or BUS 2100 or CEE 3710)

MKT 3000 - Principles of Marketing Emphasizes decisions made in developing both strategic and tactical marketing plans. Uses computer simulations, experiential learning assignments, and marketing plan development to demonstrate principles of market segmentation, product development, pricing, distribution planning, and promotion.

Credits: 3.0

Lec-Rec-Lab: (3-0-0)

Semesters Offered: Fall, Spring, Summer

CEE 1001 - Sustainability and Civil Engineering Practice

Course will focus on characterizing the motivation for and principles of sustainable engineering and provide an introduction to tools used in sustainable design. Course topics follow a logical and linear progression which includes the societal context, scientific motivation, and application of sustainable practices in civil engineering.

Credits: 1.0

Lec-Rec-Lab: (1-0-0)

Semesters Offered: Spring

CEE 4233 - Structural Timber Design

Introduction to the use of wood as a structural engineering material. Includes design of beams, columns, nailed and bolted connection, glulam members, including tapered beams, tapered and curved beam, and design of wood shear walls and diaphragms.

Credits: 3.0

Lec-Rec-Lab: (0-3-0)

Semesters Offered: Spring

Pre-Requisite(s): CE 3202 or CEE 3202

CMG 2120 - Statics and Strengths of Materials for Construction

Composition and resolution of forces and force systems, principles of equilibrium applied to various bodies, simple structures, friction, centroids, and moments of inertia. Mechanical behavior of materials, including calculation of stresses, strains, and deformations due to axial, torsional, and flexural loading.

Credits: 4.0

Lec-Rec-Lab: (0-3-2)

Semesters Offered: Spring

Pre-Requisite(s): PH 1110 or PH 1140

CMG 3250 - Structural Analysis and Design

Elastic theory analysis and design of steel structural components, including tension, compression, truss frames, flexural beams, and connections. Includes an introduction to reinforced concrete structures and timber. All work is according to current applicable code manuals. Design projects include computer applications.

Credits: 3.0

Lec-Rec-Lab: (0-3-0)

Semesters Offered: Fall

Restrictions: Must be enrolled in one of the following Class(es): Junior, Senior

Pre-Requisite(s): CMG 2120 or MET 2120

CMG 4800 - Sustainable Construction

An introduction to the philosophy and practice of sustainable building construction with emphasis on underlying socio-environmental philosophies, sustainable directed building technologies and materials, and case studies of contemporary green buildings to culminate in a simple sustainable design project.

Credits: 3.0

Lec-Rec-Lab: (0-3-0)

Semesters Offered: Spring

Restrictions: Must be enrolled in one of the following Class(es): Junior, Senior

EC 3300 - Industrial Organization Economic analysis of market power and industry structure. Topics include the goals of public policy toward business, antitrust policy, economic regulation, public enterprise, and social regulation of health, safety, and the environment.

Credits: 3.0

Lec-Rec-Lab: (3-0-0)

Semesters Offered: Fall

Pre-Requisite(s): EC 2001 and UN 1015 and (UN 1025 or Modern Language - 3000 level or higher)

ENG 4510 - Sustainable Futures I

Covers introductory and intermediate concepts of Sustainable Development. Explores methods/tools for assessing sustainability (economic, environmental, societal impacts) of current and emerging industrial technologies. Explores relationships between government policies and markets for introducing sustainable technologies into national economies and corporations.

Credits: 3.0

Lec-Rec-Lab: (3-0-0)

Semesters Offered: Fall

Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

IV. Directed elective courses within any concentration

MKT 3600 - Marketing Data Analytics Focuses on data-driven consumer insights for marketing decision-making. Topics include scientific research methodology, survey research, social media data-analysis, multivariate data analysis, information visualization, and report writing and presentations.

Credits: 3.0

Lec-Rec-Lab: (0-3-0)

Semesters Offered: Spring

Pre-Requisite(s): (MA 2710 or MA 2720 or MA 3710 or BUS 2100) and MKT 3000

ACC 3100 - Intermediate Accounting II

A continuation of ACC 3000 with theories, concepts, and practices underlying financial measurement and reporting. Focuses on the measurement and reporting of liabilities and equities, and includes multinational issues.

Credits: 3.0

Lec-Rec-Lab: (0-3-0)

Semesters Offered: Spring

Pre-Requisite(s): ACC 3000 and FIN 3000(C)

ACC 3500 - Managerial/Cost Accounting I

The primary emphasis is on traditional and contemporary product costing techniques, cost allocation practices, and basic cost-management issues. Topics include process costing, standard costing, activity-based costing, backflush costing, cost allocation issues, balanced scorecard, strategic profitability analysis, and the role of accounting in contemporary management practices.

Credits: 3.0

Lec-Rec-Lab: (0-3-0)

Semesters Offered: Spring

Pre-Requisite(s): ACC 2100

OSM 3150 - Introduction to Supply Chain Management

An introduction to supply chain management to gain a perspective on integration and coordination issues. Topics include strategy, network design, facility design, sourcing, logistics, forecasting, inventory, relationship management, and global and sustainable supply chain management.

Credits: 3.0

Lec-Rec-Lab: (3-0-0)

Semesters Offered: Fall

Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

Pre-Requisite(s): OSM 3000(C)

MGT 2000 - Team Dynamics and Decision Making

Develops individual and group problem-solving skills using active, hands-on learning. Emphasizes problem identification and problem solution under conditions of ambiguity and uncertainty. Stresses

creativity, interpersonal skills and skill assessment, communication, group process and teamwork, and action planning.

Credits: 3.0

Lec-Rec-Lab: (0-3-0)

Semesters Offered: Fall, Spring

Restrictions: May not be enrolled in one of the following Class(es): Freshman

MGT 3100 - Leadership Development

Assesses students' current knowledge, abilities and values relevant to leadership and guides students in developing and implementing plans for new leadership abilities.

Credits: 3.0

Lec-Rec-Lab: (0-3-0)

Semesters Offered: Fall

Restrictions: May not be enrolled in one of the following Class(es): Freshman

MGT 3800 - Entrepreneurship

Covers management issues associated with establishing a successful new enterprise as a small businesses or part of an existing firm. Emphasizes learning through creation of a business plan as well as case studies that develop an understanding of opportunity recognition, entrepreneurial teams, reward systems, financing alternatives, family ventures, ethical and legal contractual considerations, and resource needs.

Credits: 3.0

Lec-Rec-Lab: (0-3-0)

Semesters Offered: Fall

Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

CM 3979 - Alternative Energy Technologies and Processes

This course covers a wide range of alternative energy technologies with an emphasis on chemical and biochemical processing. Technologies covered may include biofuels, solar power, fuel cells, etc.

Credits: 1.0

Lec-Rec-Lab: (1-0-0)

Semesters Offered: Fall

Pre-Requisite(s): CH 1112 or (CH 1150 and CH 1151) and (MA 1160 or MA 1161)

MSE 4777 - Distributed Additive Manufacturing Using Open-Source 3-D Printing

This course provides an overview of open-source hardware in theory and practice for an introduction to distributed additive manufacturing using open-source 3-D printing. Each student will build a customized RepRap and will learn all hardware and software for maintaining it.

Credits: 3.0

Lec-Rec-Lab: (3-0-0)

Semesters Offered: Fall

Restrictions: Must be enrolled in one of the following College(s): College of Engineering; Must be enrolled in one of the following Class(es): Junior, Senior

MSE 4760 - Environmental Engineering for Materials Processing Industries

Assessment and analysis of environmental impacts from materials processing industries. Regulations, permits, and industrial practices for monitoring and solving air, water, and solid environmental issues. Pollution prevention. Life cycle analysis. Material flow analysis.

Credits: 3.0

Lec-Rec-Lab: (3-0-0)

Semesters Offered: Fall

Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

MEEM 4685 - Env Resp Design & Manuf

Examines the impact of engineering and design/manufacturing, decisions on the environment. Topics include sustainability; energy and material flows; risk assessment; life cycles, manufacturing process waste streams, and product design issues, including disassembly and post-use product handling and techniques for pollution prevention.

Credits: 3.0

Lec-Rec-Lab: (0-3-0)

Semesters Offered: Spring - Offered alternate years beginning with the 2001-2002 academic year

Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

FA 2110 - Outdoor Sculpture

An introductory sculpture class focused on making works of art outdoors. Classes meet on the Michigan Tech trails or other outdoor locations. Students develop their own works of art and their own creative language. Includes conversations, local field trips, studio work, lectures, and readings.

Credits: 3.0

Lec-Rec-Lab: (0-0-3)

Semesters Offered: Summer - Offered alternate years beginning with the 2019-2020 academic year

FA 2160 - Creative Practices

Students will mindfully cultivate their creativity while making art connected to specific interests. Hands-on practice with basic photo, drawing, painting, and/or collage compliments theories of how artists/designers find inspiration. Prior drawing experience recommended.

Credits: 3.0

Lec-Rec-Lab: (0-0-4)

Semesters Offered: On Demand

FA 2190 - Art and Nature

Explore "nature" through art using materials ranging from what you find outdoors to digital media. Visits to natural sites provide inspiration and practice with creative fundamentals. Explore expressivity, brainstorming, project development, and collaboration.

Credits: 3.0

Lec-Rec-Lab: (0-0-3)

Semesters Offered: Fall

FA 2300 - Art + Design Studio

Introduction to art and design as visual art. Explores design principles and creative problem solving using multiple materials. Students also examine design's ability to shape and interpret information. Hands-on studio work, lectures and discussions. Emphasizes creativity, inventiveness, and experimentation.

Credits: 3.0

Lec-Rec-Lab: (0-0-4)

Semesters Offered: Fall, Summer

Restrictions: May not be enrolled in one of the following Class(es): Senior

FW 4000 - Professional Experience Program

Students create oral/written reports and reflection based on paid or volunteered work or field experience in natural resources.

Credits: 1.0; Repeatable to a Max of 4

Lec-Rec-Lab: (0-1-0)

Semesters Offered: Fall, Spring, Summer

Restrictions: Permission of department required

FW 4840 - Senior Research Thesis

An independent study or research project on an approved topic in Forestry, Applied Ecology and Environmental Sciences, Wildlife Ecology, or Natural Resource Management, under the guidance of a faculty member. Available only to students in their graduating year.

Credits: 4.0

Lec-Rec-Lab: (0-4-0)

Semesters Offered: Fall, Spring

Restrictions: Permission of instructor required; Must be enrolled in one of the following Class(es): Senior

Pre-Requisite(s): FW 3190

UN 3002 - Undergraduate Cooperative Education I

Credits may count as free or technical electives based on academic department. Requires good standing, registration with Career Services, and an official offer letter from the employer.

Credits: variable to 2.0; May be repeated

Semesters Offered: Fall, Spring, Summer

Restrictions: Permission of department required; May not be enrolled in one of the following Level(s): Graduate

Appendix D: Course Add Proposals

FW 3XXX Wood Decomposition and Preservation - This course will be proposed in the fall of 2020.

FW 4XXX Circular Economy – See below