Forty years of *Spartina alterniflora*’s plantation along coastal salt marshes in P.R. China

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Outline

1. Introduction background
2. Milestone of *S. alterniflora* in China
3. A dilemma for *S. alterniflora* assessment
4. Funding relating to scientific fields and application of *S. alterniflora*
5. Control measures
6. Discussion
1. Introduction background

- National strategic needs since 1960s
  - More people, more food, more land for plantation → Tidal flats reclamation
  - *S. anglica* was firstly introduced in 1963 from England
  - *S. alterniflora, S. patens, S. cynosuroides* introduced from US. in 1979

- Ecosystem services
  - Seashore stabilization
  - Tidal land reclamation
  - Saline soil mitigation
  - Greening tidal flats and improving P.P
  - Anti-typhoon for dyke protection
  - Adding blue carbon storage

- Current situation of *S. alterniflora* in China
  - *S. alterniflora* was firstly planted in 1980, following transplanted since 1982
  - *S. alterniflora*, fully dispersed along Chinese coast reaching 34,451 ha in 2007 (Zuo et al., 2013) and 55,181 ha in 2014 (Zhang et al., 2017)
2 Milestone of *Spartina* in China

### 1979–2003
- 1979, *S. alterniflora* was introduced
- 1996, Award for outstanding contribution of the International Ecological Engineering Society

### 2003–today
- 2003, *S. alterniflora* was listed as 1/16 invasive species in China (State Environmental Protection Adminstration, SEPA)
- 2008, Dr. Chung-Hsin Chung won the “Lifetime Achievement Award” (International Wetland Society), also was called “Father of *Spartina*” in China, for *Spartina* ecological engineering
- 2009, *Special Issue of Wetland Restoration and Ecological Engineering*
- 2009, *Spartina Salt Marsh Ecosystem Management in Chinese Coastal Wetlands*
Distribution (1980-2014)

- 1980, 0
- 1990, 3,956 ha
- 2003, 44,348 ha
- 2005, 38,718 ha
- 2007, 34,451 ha
- 2014, 55,181 ha
- Annual rate: 11.6%
- Variety along latitude

(Zuo et al., 2012)
(Zhang et al., 2017)
Publications

(Qin, 1992)

(Guan, 2009)

(Chung, 1985)

(Tian, 2009)

(Zhao, 2015)
# References in both Chinese and English

<table>
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<tr>
<th>Keywords</th>
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<td>20190601</td>
<td>CNKI</td>
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<td>“S. alterniflora”</td>
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<td>20190601</td>
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Should be more

| Total                                         | 1355       |         |                 |
## 3.1 References related to study fields

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<td>Invasive effects</td>
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<td>Applied study</td>
<td>All kinds of usage of <em>S. alterniflora</em></td>
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<td>Monitoring, survey and evaluation</td>
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<td>Moni. Surv.&amp;Eval.</td>
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<td>Control measures</td>
<td>Physical, chemical and biological measures</td>
<td>Cont. Meas.</td>
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3.2 Papers published in different scientific fields

1355 in all, 998 in Chinese, 357 in English
3.3 Papers published in chronical sequence

Listed as 1/16 invasive species

Nanjing University
3.4 Universities, Institutions involved in *S. alterniflora* study

- National Marine Environmental Center
- Tsinghua & Beijing Normal University
- Institute of Geographic Sciences and Natural Resources Research, Institute Yantai Coastal Zone Research, CAS
- Nankai University
- Qingdao Agricultural University
- **Nanjing, Nanjing Normal Univ.**
- Tongji, Fudan, Shanghai Jiaotong and East China Normal Univ.
- Fujian Normal Univ.
- The 3rd Institute of Oceanography
- Xiamei University………
3.1 Ecosystem dynamics: food web

(Gao et al., 2014)
3. Physiological ecology

- 2014_低温氧化_Improving abiotic reducing ability of hydrothermal biochar by low temperature oxidation under air,
- 2018_全川不同淹水条件下凋落物分解_Storage and release of nutrients during litter decomposition for native and invasive species under dil
- 2018_全川时间敏感性系统呼吸_Temporal variations and temperature sensitivity of ecosystem respiration in three brackish marsh comm
- 2015_南信磷形态_Comparison of phosphorus fractions and phosphatase activities in coastal wetland soils along vegetation zones of Yan
- 2012_李秀珍根系比較_Division of labor in rhizomatous species Comparative performance of native and invasive species in the tidal mar
- 2016_盐度对种子萌发影响_Effects of salinity and sulphide on seed germination of three coastal plants,
- 2016_李博凋落物分解动力学_Dynamics of litter decomposition of dieback Phragmites in Spartina-invaded salt marshes,
- 2018_王磊植物凋落物与C积累相互促进_Plant litter composition selects different soil microbial structures and in turn drives different litter de
- 2018_郁敏盐度特征_Characterization of soil salinization in typical estuarine area of the Jiaozhou Bay, China,
- 2018_王磊凋落物分解与C积累_Variable decomposition of two plant litters and their effects on the carbon sequestration ability of wetland s
- 2007_向开温盐压_Effects of salinity and temperature stress on Ecophysiological characteristics of exotic cordgrass, Spartina alterniflora
- 2010_向开米草氯盐压力_Interactive effects of salt and alkali stresses on seed germination, germination recovery, and seedling growth
- 2012_王磊土壤微生物呼吸影响_Effect of Spartina alterniflora invasion and its controlling technologies on soil microbial respiration of a tida
- 2010_米草生长有机质富含富集盐碱压力_Interactive effects of various salt and alkali stresses on growth, organic solutes, and cation accumulatio
- 2016_盐度梯度反应_Responses of growth, antioxidants and gene expression in smooth cordgrass (Spartina alterniflora) to various levels
- 2012_安树青N利用耐受性_Differences of tolerance to simulated leaf herbivory in native and invasive tall form Spartina alterniflora populati
- 2011_安树青N利用_Invasive and native tall forms of Spartina alterniflora respond differently to nitrogen availability,
- 2013_盐度对富集影响_Effect of NaCl on growth and Cd accumulation of halophyte Spartina alterniflora under CdCl2 stress,
- 2017_安树青TOCN动力学_Soil organic carbon and nitrogen dynamics following Spartina alterniflora invasion in a coastal wetland of easte
- 2011_米草对薰草化感效应_Inference of Allelopathy about Spartina Alterniflora to Scirpus Mariqueter by Effects of Activated Carbon on Soi
- 2018_李秀珍铁锰与重金属_Iron plaque formation and heavy metal uptake in Spartina alterniflora at different tidal levels and waterlogging
- 2018_重金属淹水对生理生态影响_Combined effect of water inundation and heavy metals on the photosynthesis and physiology of Spartina
- 2018_光合耐受性_Photosynthetic tolerance to non-resource stress influences competition importance and intensity in an invaded estuary
- 2012_李小然氮化菌丰度与组成_Abundance and composition of ammonia-oxidizing bacteria and archaia in different types of soil in the Yai
- 2006_崇明东滩反硝化_Denitrification in Chongming east tidal flat sediment, Yangtze estuary, China
- 2014_李文华磷富集影响_Influences of sediment properties and macrophytes on phosphorous speciation in the intertidal marsh
- 2013_营养滞留与生物量_Nutrient retention in plant biomass and sediments from the salt marsh in Hangzhou Bay estuary, China
- 2011_李秀珍植被与环境因子_Relationships between vegetation zonation and environmental factors in newly formed tidal marshes of the Y
- 2014_碳氮磷盐度光合作用影响_Effects of salinity on temperature-dependent photosynthetic parameters of a native C3 and a non-native C4
3. Blue carbon and global change

2006 王进欣 三氯甲烷_The flux of methyl chloride along an elevational gradient of a coastal salt marsh, Eastern China,

2015 陈光耀增加气排放气体温室捕碳_Prevention of greenhouse gas emissions from wetland soils but also increases sequestration capacity of tidal wetlands,

2016 李秀珍碳固定时间变化_Accumulation of soil carbon drives denitrification potential and lab-incubated gas production along a chronosequence,

2014 去除后温室气体排放_Greenhouse gas emissions following an invasive plant eradication program,

2011 王磊有机碳累积_Organic carbon accumulation capability of two typical tidal wetland soils in Chongming Dongtan, China,

2017 杭州湾TOC来源分布_Sources and distribution of sedimentary organic matter along the Andong salt marsh, Hangzhou Bay,

2014 孙欣庆温室气体_Seaonal and spatial dynamics of greenhouse gas emissions under various vegetation covers in a coastal saline wetland,

2016 金川影响群落结构_甲烷化因子_Factors regulating community composition of methanogens and sulfate-reducing bacteria in brackish marshes,

2010 王磊同济联合固定与微生物_Varibility of soil carbon sequestration capacity and microbial activity of different types of salt marsh soils at

2015 安树青温室气体排放_Spartina alterniflora invasions impact CH4 and N2O fluxes from a salt marsh in eastern China,

2008 沉积物有机碳沉积物埋藏_Sediment burial stimulates the growth and propageule production of Spartina alterniflora Loisel.,

2010 丁维新土壤有机碳积累_Changes in soil organic carbon dynamics in an Eastern Chinese coastal wetland following invasion by a C4 plant

2013 石灰喷射抑制甲烷释放_Lime pretreatment to improve methane production of smooth cordgrass (Spartina alterniflora),

2013 张永红辐射搁置对C4释放影响_Effect of elevated UV-B radiation on CH4 emissions from the stands of Spartina alterniflora and Phragmites

2017 王进欣DMC_甲烷_Spartina alterniflora alters ecosystem DMS and CH4 emissions and their relationship along interacting tidal and vege

2013 张永红入侵对N2O释放影响_Effects of invasion of Spartina alterniflora and exogenous N deposition on N2O emissions in a coastal salt

2017 金川TOC对C4本土植物改变_Changes in Soil Organic Carbon Dynamics in a Native C4 Plant-Dominated Tidal Marsh Following Sp

2010 丁维新甲烷外源氮_Response of methane emission to invasion of Spartina alterniflora and exogenous N deposition in the coastal salt n

2010 蔡祖聪氨基甲烷排放_Impact of permanent inundation on methane emissions from a Spartina alterniflora coastal salt marsh,

2011 丁维新甲烷释放_Diel methane emissions in stands of Spartina alterniflora and Suaeda salsa from a coastal salt marsh,

2017 李雪米草芦苇对C转移分配_The transfer and allocation of newly fixed C by invasive Spartina alterniflora and native Phragmites australis t

2017 金川甲烷向TOC分布与储存_Effects of exotic Spartina alterniflora on vertical soil organic carbon distribution and storage amount in

2015 丁维新甲烷释放时间序列_Invasion chronosequence of Spartina alterniflora on methane emission and organic carbon sequestration in a

2015 丁维新入侵改变气排放碳固定_Exotic Spartina alterniflora invasion alters ecosystem–atmosphere exchange of CH4 and N2O and carbon

2017 黄河N2O_Nitrous Oxide Emissions from Intertidal Zone of the Yellow River Estuary in Autumn and Winter During 2011–2012

2018 赵斌湿地碳通量观测_Field Observation of Lateral Detritus Carbon Flux in a Coastal Wetland

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3. Invasion ecological effects

- 2018_入侵影响底栖_alterniflorainvasion stages on macrobenthic communities on a tidal flat in Wenzhou Bay, China
- 2006_草振鸣鸟类季节变化入侵效应_Seasonal change and habitat selection of shorebird community at the South Yangtze River Mout.
- 2013_李添生鸟群的形态影响修复_Habitat heterogeneity influences restoration efficacy Implications of a habitat-specific management r.
- 2007_李俊锦DNA.Characterization of Bacterial Community Structure and Diversity in Rhizosphere Soils of Three Plants in Rapidly.
- 2007_李俊锦入侵影响线虫_Exotic plant influences soil nematode communities through litter input,
- 2015_李俊锦植被对螃蟹洞穴影响_Plant effects on burrowing crab morphology in a Chinese salt marsh Native vs. exotic plants,
- 2009_李俊锦种子库动力变化_Determinants of seed bank dynamics of two dominant helophytes in a tidal salt marsh,
- 2018_严小军非原生大型底栖影响_Influence of two non-indigenous plants on intertidal macrobenthic communities in Ximen Island Special ...
- 2009_郑志军春季鸟类群落_Potential impacts of invasive Spartina alterniflora on spring bird communities at Chongming Dongtan, a
- 2007_李俊锦温室排放_CH4 and N2O emissions from Spartina alterniflora and Phragmites australis in experimental mesocosms,
- 2011_崔保山米草入侵与螃蟹_Spartina alterniflora invasions and effects on crab communities in a western Pacific estuary,
- 2009_李俊锦生理生态入侵_Ecophysiological characteristics of invasive Spartina alterniflora and native species in salt marshes of Yang.
- 2009_李俊锦去硫棚影响_Effects of salt marsh invasion by Spartina alterniflora on sulfate-reducing bacteria in the Yangtze River estua..
- 2014_钱宝文米草去除_Eradicating invasive Spartina alterniflora with alien Sonneratia apetala and its implications for invasion contr...
- 2016_全为民大型底栖影响_Does invasion of Spartina alterniflora alter microhabitats and benthic communities of salt marshes.
- 2016_入侵对共生菌影响_Effect of exotic Spartina alterniflora on fungal symbiosis with native plants Phragmites australis and Scirpu..
- 2017_入侵后硫化氢与效应_Sulfate reducer and sulfur oxidizer respond differentially to the invasion of Spartina alterniflora in estuar.
- 2011_全川米草扩散_Analysis of the Expanding Process of the Spartina Alterniflora Salt Marsh in Shanyutan Wetland, Minjiang River..
- 2016_入侵对氨影响_Effects of Spartina alterniflora invasion and exogenous nitrogen on soil nitrogen mineralization in the coastal s.
- 2017_林光辉短期入侵与红树恢复对TOCNP影_Effects of short-term invasion of Spartina alterniflora and the subsequent restoration o
- 2016_林尊山入侵空间变化_Spatial pattern changes of Spartina alterniflora with different invasion ages in the Yancheng coastal wetl..
- 2014_马志军入侵对草地鸟类影响_Effects of Invasive Cordgrass on Presence of Marsh Grassbird in an Area where It Is Not Native
- 2014_李俊锦耐盐竞争本地种_Spartina alterniflora with high tolerance to salt stress changes vegetation pattern by outcompeting nativ..
- 2017_林光辉红树恢复改变底栖食性_Restoration of native mangrove wetlands can reverse diet shifts of benthic macrofauna caused ...
- 2018_食草动物有助于红树抵抗米草_Herbivory enhances the resistance of mangrove forest to cordgrass invasion
- 2014_马志军黑腹滨鹬利用_The Habitat Use and Home Range Analysis of Dunlin (Calidris alpina) in Chongming Dongtan, China an.
- 2018_马志军中国鸟类保护_Population trends, threats, and conservation recommendations for waterbirds in China
- 2009_李俊锦水鸟种群变化_Waterbird Population Changes in the Wetlands at Chongming Dongtan in the Yangtze River Estuary, China
3. Ecological engineering with environmental benefits

2007_全为民_重金属富集_Uptake and distribution of N, P and heavy metals in three dominant salt marsh macrophytes from Yan
2014_张利权生态系统管理_Ecosystem-based coastal zone management A comprehensive assessment of coastal ecosystems in the
2015_张利权植被再植_Revegetation of a native species in a newly formed tidal marsh under varying hydrological conditions and .
2015_李小平添加脱硫石膏去盐碱化_Flu gas desulfurization gypsum application for enhancing the desalinization of reclaimed tidal l.
2015_碱性土壤中铜吸收_Alkali and alkaline earth metallic (AAEM) species leaching and Cu(II) sorption by biochar,
2018_崔宝山富营养化与米草根部生长_Effect of coastal eutrophication on growth and physiology of Spartina alterniflora Loisel,
2008_李博提供螃蟹生境_Exotic Spartina alterniflora provides compatible habitats for native estuarine crab Sesarma dehaani in the
2016_安树青入侵对CN影响_Impacts of Spartina alterniflora invasion on soil organic carbon and nitrogen pools sizes, stability, anc
2013_铜富集_Cu(II) removal from aqueous solution by Spartina alterniflora derived biochar,
2009_李昆全铝去除_Adsortive removal of Pb by activated carbon prepared from Spartina alterniflora Equilibrium,kinetics and th.
2017_高建华重金属富集与输出_Accumulation and Output of Heavy Metals in Spartina Alterniflora in a Salt Marsh,
2014_重金属富集与生态风险_Heavy metal contamination and ecological risk in Spartina alterniflora marsh in intertidal sediments o
2015_重金属时空分布_Spatial distribution of heavy metals (Cu, Pb, Zn, and Cd) in sediments of a coastal wetlands in eastern Fujiar
2018_氨氧化蛋白性对化反应_Response of ammonia-oxidizing betaproteobacteria to shortterm fertilization in a salt marsh in Chi
2009_李秀珍水处理工程_WATER QUALITY PROBLEMS AND POTENTIAL FOR WETLANDS AS TREATMENT SYSTEMS IN THE YANGT.
2016_崔保山中国湿地环境变化与人类活动_China’s Coastal Wetlands Understanding Environmental Changes and Human Impacts for
2017_重金属空间变化与毒性_Spatial variation and toxicity assessment for heavy metals in sediments of intertidal zone in a typical s
2013_刘志勇人类活动污染_Anthropogenic plutonium in the North Jiangsu tidal flats of the Yellow Sea in China
2014_李秀珍生物生态功能_The impact of the change in vegetation structure on the ecological functions of salt marshes the examp
2018_李秀珍抵制海平面上升弹性_Native and non-native halophytes resiliency against sea-level rise and saltwater intrusion
2016_高抒重金属富集反应沉积人类活动_Heavy metal accumulation reflecting natural sedimentary processes and anthropogenic act
2015_李博入侵利于底栖生物_Invasive cordgrass facilitates epifaunal communities in a Chinese marsh
2015_米草内PAH污染_A comprehensive study of the impact of polycyclic aromatic hydrocarbons (PAHs) contamination on salt ma
2017_重金属富集_Heavy metal distribution and accumulation in the Spartina alterniflora from the Andong tidal flat, Hangzhou Bay
3. Usage and Application

- 3.7 *Spartina* application: Beer, 1987
3. Positive impacts

3.7 *Spartina* application: Pharmacy, 1997
Improve immune function
3. Positive impacts

- 3.7 *Spartina* application: Solid and liquid drinks
New production of *S. alterniflora*

- Bio-Mineral Liquid
- Decreasing uric acid
- Gout treatment

- 30 ml/bottle
- 4 bottles/month
- About $12/box
3. Positive impacts

3.7 Spartina application: *Pleurotus ostreatus* production based on *Spartina* Residue

1995

2018
4 Usage and Application

Optimization of preparation of microporous activated carbon with high surface area from *Spartina alterniflora* and its *p*-nitroaniline adsorption characteristics (2013)

Feasibility of NaOH-treatment for improving biogas production of digested *Spartina alterniflora* (2014)

Development of novel sludge fiberboard combined with fibers of *Spartina alterniflora* and paper sludge (2014)

Study on co-liquefaction of *Spirulina* and *Spartina alterniflora* in ethanol-water co-solvent for bio-oil (2018)
4. Fundings: far more than 10 billion CN ¥

- **International level**
  - UNDP/GEP II Wetland Biodiversity Conservation and Sustainable Use
  - Asian Development Bank Yancheng project

- **National Level**
  - Ministry of Ecology and Environment Protection (EPB of China)
  - Ministry of Agriculture
  - Ministry of Science and Technology
  - Ministry of Education
  - Ministry of Natural Resources (SOA)
  - Natural Science Funds of China
  - Focusing on key projects with more than 10,000,000 CN ¥

- **Provincial and local levels**
  - Such as Shanghai: 1 030 000 000 CN ¥ (2008-2013) to eradicate 24.2 km² grass
  - Fujian Province:
  - Zhejiang Province:
  - Jiangsu Provinces: much land for reclamation.
## 5 Control or comprehensive measures

### Physical measures
- Cutting plus waterlogging with freshwater at early florescence
- Mowing plus shading
- Clearing and reclamation by machines

### Chemical measures
- Haloxyfop-P-methyl (高效氟吡甲禾灵)
- Glyphosate (草甘膦)
- Gibberellin (GA₃, 赤霉素)
- Imazapyr (咪唑烟酸)
- Cyhalofop-butyl (氰氟草酯)
- Herbicide for clearing *S. alterniflora*

### Biological measures
- *Fusarium* spp. (镰刀菌属)
- *Buergenerula spartinae* (某海洋真菌)
- Chaeopsisaenae（飞蝇幼虫）
- *Prokelisia marginata* (食草动物光蝉)
- Plants succession
5. Physical: cutting plus waterlogging


(C+W+Reinvaded after dam broken) (2008.06) (2008.10)

(Yuan et al., 2011)
“五朵金花”是南京大学这一时期科研工作的代表成果。这些科研项目始于20年代末，1955年在北京教育展上成果展会上展出。令人瞩目。

1955年，邓小平参观高校校展。
1965年，华罗根参观校展。

1965年：华罗根参观校展。
1965年：华罗根参观校展。

Dr. Chung-Hsin Chung 仲崇信（1908-2008）

Dr. Pei Qin 钦佩（1946—）
6 互花米草入侵中国东海岸盐沼湿地：机制、影响与管理
Forty years of ecological engineering with Spartina plantations in China

Chung-Hsin Chung

(2006)

Impacts of introduced Spartina alterniflora along an elevation gradient at the Jiuduansha Shoals in the Yangtze Estuary, suburban Shanghai, China

(2007)

A plant invader declines through its modification to habitats: A case study of a 16-year chronosequence of Spartina alterniflora invasion in a salt marsh

(2012)

Introduction and Spread of an Exotic Plant, Spartina alterniflora, Along Coastal Marshes of China

(2017)
Still playing the role of coastal stability
6 1/16 invasive species since 2003

- **Eupatorium adenophorum** Spreng. (紫茎泽兰)
- **Mikaina micrantha** H. B. K. (微甘菊)
- **Alternanthera philoxeroides** (Mart.) Griseb (水花生)
- **Ambrosia artemisiifolia** L. (豚草)
- **Lolium temulentum** L. (毒麦)
- **Spartina alterniflora** Loisel. (互花米草)
- **Eupatorium odoratum** L. (飞机草)
- **Eichhornia crassipes** (Mart.) Solms (凤眼莲)
- **Sorghum halepense** (L.) Pers. (假高粱)
- **Opogona sacchari** (Bojer) (蔗扁蛾)
- **Oracella acuta** (Lobdell) (湿地松粉蚧)
- **Dendroctonus valens** LeConte (强大小蠹)
- **Hyphantria cunea** (Drury) (美国白蛾)
- **Achating fulica** (Fochrussac) (非洲大蜗牛)
- **Pomacea canaliculata** Spix (福寿螺)
- **Rana catesbeiana** Shaw (牛蛙)
蓝碳监测与估

近海与海岸蓝碳监测与评估体系

海岸蓝碳监测体系

海面蓝碳监测

Temp, Chl a, U², Blue carbon species

SST, SSS, fCO₂, Chl a, U², CDOM, POC,

CO₂ fluxes
Chl, Biomass, Stoichometry, Sediment C, Respiration, Lateral C transport

SST, SSS, FCO₂, fCO₂, Chl, U²
AT, CT, Nutrients, plankton, bacteria, POC, DOC, CDOM

大陆架

盐沼

红树林

海草床
Thank for your attention